

INTERACTING WITH PHILOSOPHY  
THROUGH NATURAL LANGUAGE  
CONVERSATION

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## Declaration

I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.



Wang Xuan  
10 Sep 2014



To my parents

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## Summary

Cultural Computing is an emerging HCI paradigm that looks into how computers can help to communicate culture-related contents to people. It explores the use of computers beyond processing precise and quantifiable information, to the abstract, imprecise and unquantifiable cultural aspects. Philosophy - the most basic beliefs, concepts, and attitudes of a group, is an essential part of culture. It represents the cultural identity and diversity of mankind, and knowledge on philosophy can often help us to solve problems in our life and guide our conduct. Traditional Chinese philosophy used to be the most important subject of study in ancient China, but people have gradually forgotten it in our busy and fast-changing world today. The work described in this thesis started out by asking the following question: can we help people learn about philosophy through HCI?

By examining the nature of philosophy and philosophy learning, we propose a conversational approach to create an intuitive and appealing interface for communicating traditional Chinese philosophy to the general public. In particular, we created a new kind of non-task oriented conversational agent that emulates Confucius, the famous Chinese philosopher, to carry out au-

tomatic text-based conversation with users. Different from previous work on conversational agents that focuses on casual conversation or factual information, our agent models the abstract and unstructured philosophical knowledge of a real historical person, and it deals with unrestricted inputs and questions regarding subjective opinions in addition to factual, biographical information. This interdisciplinary research involves the design, construction and testing of the virtual philosopher agent, and it aims to answer the following research questions: 1). How do we translate philosophy texts into something understandable by a computer agent? 2). What technology should be used/developed for the virtual philosopher agent? 3). How do users interact with the philosopher agent? What do they think?

We took an iterative design approach, first started by working with domain experts to analyze the characteristics of the Chinese philosophy domain and construct the knowledge base of the virtual philosopher. Two iterations of prototypes were built, and user evaluations were conducted through lab studies with recruited subjects as well as through real-world deployment with spontaneous users. A combination of methods were used, including direct observation, post-test questionnaires, log analysis and interviews.

A systematic workflow which can be followed to build the knowledge base was developed, allowing the domain experts to collect and author the knowledge base content without the need of learning scripting language, thus facilitating interdisciplinary collaboration. By analyzing the real-world log data

collected through our prototype application, we derived a taxonomy of user utterances in an open conversation with a virtual philosopher. Based on it, an architecture of a virtual philosopher system for handling unrestricted conversation was proposed, and the effects of different answer finding and no answer strategies were examined. Our user studies showed that people considered the virtual philosopher as an appealing and enjoyable interface with good potential for philosophy learning, and our second prototype with a classifier to distinguish different types of utterances improved the response quality of the agent over the previous sequential model.

The work presented in this thesis took the first step in exploring the use of conversational agent technology for philosophy learning. Our findings suggest that cultural computing is a viable and promising approach for communicating philosophy, but there still remain many challenges to be tackled in future work. The proposed method and discussions in the thesis may lead to further exploration and improvement on conversational agent for philosophy interaction, as well as in other non-task oriented scenarios.

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# Chapter 1

## Introduction

Human-computer interaction (HCI) is a multi-disciplinary field that studies the interaction between human and computers. It endeavors to get an understanding of both the human and the computer system, such that the interactions between the two can be made more efficient and satisfying [46, 85]. Since it was formally founded in the early 1980s, the field has undergone rapid developments and paradigm shifts [34, 132]. Initially only accessible to information technology professionals, computers have now become much easier to use, multifunctional, and permeated into almost every aspect of our everyday life. The use of computers has also evolved from scientific purposes to entertainment and social communication. As computers get exceedingly good at processing data and numbers, we begin to probe into areas that they are not (or at least not yet) good at - things that are abstract, ambiguous or imprecise. The research field of Cultural Computing [124, 145, 146] is driven by such goals. It was started by researchers dreaming of computing culture, or in other words, representing culture

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through scientific methods. Different from conventional HCI research that aims to make computer interfaces more convenient and efficient to use, cultural computing attempts to introduce new contents - culture - to computer systems, and create new computer interfaces for people to interact and experience culture.

Is culture computable? This firstly begs the question, what is culture? In fact, the word *culture* has many different definitions in different contexts. Kroeber and Kluckhohn [81] compiled a list of more than 156 different definitions of culture. For example, German sociologist Georg Simmel described culture as “*the cultivation of individuals through the agency of external forms which have been objectified in the course of history*” [136], and for American anthropologist Hoebel Adamson, culture referred to “*the sum total of integrated behavior patterns which are characteristics of the members of a society and which are therefore, not the result of biological inheritance*” [66]. Another broad and ethnographic definition of culture, given by the English anthropologist Edward Taylor, is “*that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society*” [149].

Traditionally mainly studied in the sociology and anthropology domain, it is only recently that culture has become a formal subject of interest to computer scientists. For example, in a 2009 article, Wang [155] started an interesting discussion on the computability of culture, focusing particularly from the Artificial Intelligence (AI) and cultural heritage perspective. He recognized the difficulty in computing culture and pointed out that getting computers to reason and compute with common sense is one

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of the greatest challenge for cultural computing as well as in AI research. Nevertheless, he held a hopeful and optimistic view on this emerging field, and looked forward to a new era where information technology and social sciences can be seamlessly integrated.

So far, most of the research that treats culture-related issues has been on recording or restoring through computer simulations the cultural artifacts, usually tangible ones, like paintings, architectures, etc. Cultural computing goes beyond that and focuses on the more abstract part of culture - attitudes, values, norms, belief, actions, etc. [124]. Culture is not just about knowledge, but more importantly it is the understanding gained through individual experience and education. Cultural computing aims to build the breeding ground for such experiences. Instead of digitally replicating cultural artifacts, cultural computing helps to create new cultural experiences. It concerns not only about integrating cultural aspects into interaction, but also about allowing the user to experience the core elements of the culture through the interaction [45, 68, 124, 145, 146, 147].

As an emerging field, cultural computing still has no unified definition, scope or research methodology, and much of the research in this field has been experimental and exploratory. Pioneers in cultural computing research started by building projects that focus on their respective culture - two representative examples are Tosa's work on *ZENetic computer* [146, 147], which is about the Japanese Zen Buddhism, and Rauterberg's work on *project ALICE* [68, 124], which focuses on the western culture of logic and reasoning. Both projects create interactive systems for users to actively participate in a cultural experience. *ZENetic computer* allows users to create Sansui

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paintings with the guidance of an interactive computer system. It generates haiku, kimono patterns and Zen stories, which awakens users' unconscious self. In project ALICE, researchers build a mixed-reality installation based on the narrative of *Alice's Adventures in Wonderland*, and users can get immersed into the story world and be challenged on their logic and western reasoning. As early explorations, these works are very original and encouraging, yet a great many questions in cultural computing are still left unanswered. For example, can computers accurately simulate or convey every cultural element to people? What interaction modality should we choose for communicating culture? How effective is it? What are the challenges and where should we invest our efforts in?

The research described in this thesis is inspired by the above-mentioned work, and can be considered as another early exploration in the cultural computing domain. In particular, being in a Asian research environment, we choose to focus on ancient Chinese philosophy - an integral part of the Chinese culture, and investigate methods that can be employed for creating an interactive experience embodying Chinese philosophy. We propose to transform the static philosophy texts into an interactive dialogue in which the users can play a part.

## 1.1 Background and motivation

### 1.1.1 What is philosophy

The term *philosophy* comes from the Ancient Greek *φιλοσοφία* (*philosophia*) and was coined by the Greek Mathematician Pythagoras. It literally means “love of wisdom” [67, 72]. Like the term culture, philosophy has been given many different definitions. Aristotle considered philosophy as “*the systematic attempt on the part of the human mind to know and understand reality in rational and human terms whenever this attempt has as its chief end the acquisition of knowledge and understanding for their own sake.*” Under this view, philosophy includes all theoretical knowledge [32]. For Teichman [142], “*Philosophy is a study of problems which are ultimate, abstract and very general. These problems are concerned with the nature of existence, knowledge, morality, reason and human purpose*”. In the context of this thesis, we adopt a simpler and narrower definition from the Merriam-Webster on-line dictionary: “the most basic beliefs, concepts, and attitudes of an individual or group”<sup>1</sup>. Following Taylor’s definition on culture, we can consider philosophy as part of culture and thus a sub-domain in cultural computing.

### 1.1.2 Why is philosophy important

People from different culture tend to have distinctive beliefs, attitudes and values. Their philosophy represents the cultural identities and diversity of mankind, and it is a kind of valuable intangible culture worth being preserved and promoted. In ancient China, the

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<sup>1</sup><http://www.merriam-webster.com/dictionary/philosophy>

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first education Chinese children received was philosophy, and they studied it by means of reading the *Four Books* and *Five Classics*. At that time, philosophy was the top concern of every educated person [51]. By studying philosophy, we form the most basic beliefs and values that can be used to guide our decisions and actions. The principles and wisdom contained in ancient philosophy help us to solve problems in our everyday life. As Simon Leys remarked in his translation of the *Analects*, the most important book on Confucian philosophy, “*The analects is the single most important key that can give us access to the Chinese world... The content of the Analects is directly addressing the very problems of our age and of our society*” [91].

However, at the present time, systematic philosophy learning is typically constrained to a small number of students and professional researchers, whereas the majority of the general public do not get easy access to or are not interested in the philosophy materials in their everyday life. Philosophy learning takes time and effort, but in the increasingly modernized, globalized and rapidly changing world we have today, there is less chance for us to learn about traditional philosophy. It is even more difficult when it is cross culture, for example, for the westerners to experience and understand Chinese philosophy and culture. Many people would be intimidated by the idea of studying such a difficult subject, as philosophy seems to deal with a high level of abstract thought, and philosophers usually give people the image of being “out-of-touch” [156, 159]. The motivation of this research, therefore, is to introduce philosophy into our life with the help of information technology, so that we can better appreciate this legacy of humankind. We asked ourselves the following questions:



### **Can philosophy be treated as a topic in HCI?**

Or in other words, **can we help people learn about philosophy through human-computer interaction?**

### **1.1.3 How is philosophy learned**

To study how philosophy can be learned through human-computer interaction, first we need to look at how philosophy is learned in the conventional ways.

Jaspers [72] claims that systematic philosophy calls for study and such study consists of three parts: 1. Participation in scientific inquiry; 2. The study of great philosophers; 3. A conscientious approach to the conduct of daily life. Part 1 is perhaps particular to western philosophy only, because western philosophy was rooted in natural sciences and philology. On the contrary, eastern philosophy is “less scientific” and it puts human values and society as its main concern. Part 2, the study of great philosophers, is a crucial step that allows us to learn about the basic ideas, based on which we can begin to develop our own interpretation and comprehension. Finally, our own philosophical thinking can be awakened by the reflection and practice in our everyday experience. So philosophy is very much an individual experience that involves personal understanding and practice, and the study of famous philosophers forms the basis for such activities.

#### **1.1.3.1 Obtaining tacit knowledge**

Michael Polanyi [123] classified human knowledge into two kinds: explicit knowledge and tacit knowledge. According to him, the knowledge that can be represented in

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words and numbers can be considered as explicit knowledge, and it is only the tip of the iceberg of the entire body of human knowledge. A huge part of human knowledge is tacit - our skills, thinking, values, wisdom, etc. Such knowledge is deeply ingrained in our mind and actions, and is hard to formalize and communicate.

Philosophy, as we discussed, falls exactly in the category of tacit knowledge. “*Philosophy is an activity, a dynamic process, a way of thinking. It is not a body of facts that you memorize* [159]”. The Chinese philosopher Feng Youlan also made a similar comment on Chinese philosophy: “*the purpose of the Chinese philosophy is not to increase positive knowledge (information regarding matters of fact), but rather the elevation of the mind*” [51].

An effective way to communicate tacit knowledge is through socialization, dialogue, coaching and experience [113, 123]. Through such processes, the tacit knowledge gets externalized and absorbed. This also applies to the study of philosophy. For example, the Chinese scholar Lin Yutang commented on the study of the *Analect*, “*Readers cannot be entirely passive to read the book, the full participation of the reader is necessary and the truths must be apprehended by personal insight; the reader must draw upon his own personal experience.*” [93]. Therefore, to help people study philosophy, it is necessary to get people to be involved in a dynamic process in which they can actively participate and relate to their own experiences, and an interactive dialogue may be a good option.

### 1.1.3.2 Conversation

Conversation is the verbal exchange of information and ideas between two or more people, and it is one of the earliest form of human communication. Even in a modern world where plentiful forms of communication exist, conversation still plays a vital role. It is an important source for information - we know about the latest happenings by chatting with others, and learn new knowledge by listening to and discussing with teachers, friends and other people. We also know about a person by examining his/her words and deeds in our everyday life. Through conversations with a person, we know about his/her life, as well as his/her opinions on things.

Based on the discussion on tacit knowledge, we can see it is no coincidence that the ancient philosophers from different parts of the world used exactly the same approach - conversation - to communicate and disseminate their philosophy to other people<sup>1</sup>. Ancient philosophy itself is inherently oral in nature. True education is always oral because it is only through the interplay of questions and answers that one can discover the truth himself [39, 62]. Take the two representative schools of philosophy from the eastern and the western world for example: Confucius (551-479 BC), the Chinese philosopher and educator in ancient China, laid the cornerstone for Chinese culture. He himself, however, considered him not as the originator, but a transmitter of social values and wisdom, by going to different places, talking to the rulers, his disciples and civilians.

It is believed that he did not author a single book during his lifetime, but his philosophy

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<sup>1</sup>There are other branches of philosophy that employ totally different approaches, examples including the early Greek philosophers devoting to cosmological speculation. These kinds of philosophy are out of the scope of this thesis and not discussed here.

## 1. INTRODUCTION

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has been spread by word of mouth, and passed down from generation to generation. On the other hand, Socrates (469-399 BC), the Greek philosopher who was credited as one of the founders of western philosophy, also carried out his philosophy investigation through much discourse with people. Both Confucius' and Socrates' philosophy were recorded by their students in the form of dialogues. For Confucius, the *Analects* is a record of his conversations with his disciples and other people at the time; and for Socrates, his student, Plato, wrote the *Socratic dialogues* [122], depicting how Socrates carried out philosophical discussions with others.

To study philosophy, we need to be actively involved in the questioning and answering process. The Song scholar Cheng Yichuan made the following suggestion on how to study the *Analects*: “*Regard the questions by the disciples in the Analects as your own questions, and the answer of Confucius as answers to yourself, then you will get some real benefit.*” [93]. This has greatly motivated us to adopt a conversational approach in creating the interactive system for philosophy.

### 1.1.4 Conversational Interfaces

Conversational interfaces give computers conversational ability, and enables users to interact with them through speech or natural language text. A software program that talks like a person and acts on behalf of someone is often called a *conversational agent*. There has not been consensus among the researchers in the field on the criteria for an interface to be considered conversational [112]. In the author's opinion, as long as the interaction between the user and the interface involves sequence of natural language

pairs, the interface can be regarded as conversational. This includes interfaces that work on very limited sets of prescribed questions and answers or follow a strict routine, as well as those that have more complex structures. Though we may still be far from the day when computers can simulate the full conversational ability of real humans, research has shown promising results for natural language based human-computer interaction, especially in handling specific tasks or in restricted domains [74].

The conventional medium for people to learn about philosophy is books, but the sheer volume of those books can easily put off people. Documentaries about the philosophers also exist, but this kind of communication is one-way and the user is just a passive receiver. With the development of the Internet and search engines, computers have also become a major source of information for us. One may look up philosophy related information online, but few would take the initiative to do so if they do not have a genuine interest in it in the first place. Conversational interfaces have many benefits that may enhance users' experience with philosophy learning. As the conversation modality takes the natural form of communication that we are very familiar with, it requires less effort from the user as compared with traditional interfaces.

In a new framework for entertainment computing proposed by Nakatsu and Rautenberg [109], it is pointed out that for a user to enjoy an experience, he/she needs to be an active participator. A two-way communication, for example, a conversation, would not only make it easier to get to know about the person and his philosophy, as in the case of how we know about a person and his philosophy in our everyday life, but also have the potential to make people be more engaged and enjoy the experience.

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Based on these considerations, we decided to build a conversational agent to communicate the Confucian philosophy, one of the most dominant schools of philosophy in Asia. Research has shown that when interacting with a computer agent that presents personal, fictitious, human autobiographical stories, people show higher enjoyment and engagement when the agent is in first person as compared with third person [24]. Therefore, instead of building an agent to present the knowledge of Confucius in a third person’s perspective (for example, a virtual teacher teaching philosophy), we decided to directly give the agent the identity of Confucius himself.

### 1.2 Research focus

#### 1.2.1 Objective

In this research, we explore the possibility of conveying traditional Chinese philosophy to the general public through cultural computing. We hope to make philosophy learning more interesting and get more people to start appreciating traditional culture. We hypothesize that by presenting the “dry” contents of philosophy in a new medium and an interactive setting, it may attract people to try the system and possibly spark their interest on the subject.

Previous work in cultural computing has taken various approaches for creating interactive cultural experiences, including mixed-reality installations [68], media art works [146], modeling and reproductions [48, 146], etc. We agree that due to the diversity of culture, each cultural computing project should employ the most suitable

method for translating that particular cultural element. By examining how philosophy is learned in human-human communication, we propose to create a conversational agent that emulates the talking of a historical philosopher. This agent should be modeled upon the available documentations we have for the particular philosopher. Users would use it, at their leisure time, as a form of entertainment, to engage in a conversation with the agent through a computer interface, ask philosophy-related questions to the virtual philosopher, and get introduced about philosophy.

The idea here is to provide a new interactive and lightweight channel for people to learn about philosophy. The word “learn” is used in a very loose sense here - the system is not supposed to be used as a formal philosophy learning tool or to replace traditional philosophy learning methods, but rather as an entertaining platform for the general public to be exposed to philosophical content, in the hope that users, through a conversation with the agent, would know something about the philosopher and his philosophy, and be provoked for further exploration. The objective of this research, therefore, is to examine the feasibility of this approach by looking at how we can build such a system and how users use it.

Ideally, through the interaction with the system, users should be able to have an enjoyable, engaging and enriching experience, and have a better understanding of the philosophy, as if they have consulted the real philosopher. However, 100% accurate simulations of intelligent human thinking and language ability is still far from a solved problem. So the aim of this thesis is not to completely replicate the thinking of the real philosopher, but rather to simulate it to an extent that is sufficient to induce an

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engaging and enriching experience.

Creating a full-fledged conversational virtual philosopher requires work on many areas, including verbal behaviors as well as non-verbal behaviors such as facial expressions, emotions, body gesture, etc. As a first step, we focus only on the verbal behavior, and more specifically, the actual contents of the conversation.

### 1.2.2 Research questions

As discussed, the first and foremost question that drives us to start this research is:

**Can philosophy be treated as a topic in HCI? Or in other words, can we help people learn about philosophy through human-computer interaction?**

Human-computer interaction naturally involves two parties: human and computer. So to answer this question, we also need to look from two aspects: on the computer side, is it technically possible to create a computer system that teaches people philosophy? And on the human side, would people be interested to use it and enjoy using it? Would they really learn something substantial about philosophy through this system?

Inspired by how people learn about philosophy traditionally, we propose to simulate the experience of having a conversation with Confucius using conversational agent technology, and study the associated problems in the creation and improvement of the system. The design, development, and evaluation of a conversational agent that mimics a philosopher is a laborious task and an interdisciplinary research. It can be divided into three aspects: philosophy knowledge, technical development, and user evaluation. For each part, we have the following research questions to be answered:



1. On philosophy knowledge representation: **How do we translate philosophy texts into something understandable by the conversational agent?**

To create a conversational agent, we need to prepare a *knowledge base* - a repository that contains the knowledge the agent could draw upon in order to carry out conversation. Firstly, we need to understand the characteristics of Chinese philosophy, and decide what the philosopher's knowledge base is composed of. Secondly, conventional methods for conversational agent creation involve heavy scripting, which requires the person who prepares the knowledge base to understand some programming language. Philosophy domain experts usually have little computing experience, so we need to find a way for them to work together with us easily.

2. On technology for creating the virtual philosopher: **What are the suitable technologies to be used or new technologies to be developed in order to create a virtual philosopher agent?**

The state-of-the-art conversational agents can assume a variety of roles like personal assistants and museum guides, but none exists as a virtual philosopher. Different from personal assistants that are task-oriented, and from museum guides that deal with factual information about a museum, a virtual philosopher system deals with another kind of knowledge - knowledge that is abstract and unstructured. We need to carry out an investigation on the existing technologies and see which one(s) could be used in our specific application, or if there is any new

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technology or architecture that needs to be developed. For example, what is a suitable computational model for philosophy knowledge? How do we make the agent human-like? Previous work uses simple tricks like answering questions with questions, which can help maintain the conversation flow in a relatively natural way. However, as such responses do not contain new information, they are not so useful to users who are genuinely looking for an answer, and thus not sufficient to simulate the philosopher. To provide an engaging and enriching experience, the conversational agent should have a suitable computational model and a set of carefully designed conversation strategies.

### 3. On user study of a virtual philosopher: **How do people interact with such an agent? What do they think?**

We cannot claim to have built a good user interface without testing it with the users. As we are creating a new type of interaction, we cannot predict users' reactions. Many questions can only be answered through user studies: Do people accept it as a virtual Confucius and discuss philosophical questions? Do they enjoy using it? Would people voluntarily use it? How do they communicate with the agent? What questions do they ask? What is a good method to evaluate such kind of system?

### 1.3 Research methodology

Designing a conversational system is a complicated process, which involves the preparation of the knowledge base, design of the architecture, selection of dialogue strategies, prompts, error messages, etc. Jurafsky and Martin [74] suggested dialogue system designers could follow the iterative design principles of Gould and Lewis [58] (see Figure 1.1):

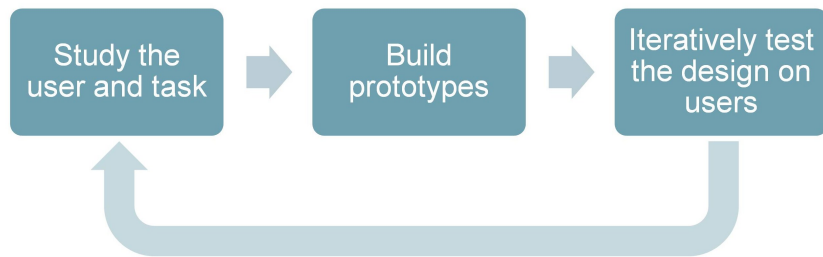


Figure 1.1: Iterative design for conversational systems

**1. Study the user and task:** To design a conversational system, it is important to understand the potential users and the nature of the task, through interviews with users, study of related human-human dialogues, and investigation of similar systems. For example, in order to create an automatic call routing system, researchers can start by studying large corpus of human-human dialogues [40].

**2. Build simulations and prototypes:** Simulations and prototypes can be built to test out with users and identify problems. Wizard-of-Oz (WOZ) is a commonly used research experiment method to test an application when certain functionality has not been built due to cost or time or when the technology does not exist [76, 132].

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In a WOZ experiment, users interact with a computer system that they believe to be autonomous, but it is actually being operated or partially operated by a hidden human being (i.e. “wizard”). However, the wizard may not be able to exactly simulate the errors and constraints of a real system, so in some situations it is important to build and test the working prototypes.

**3. Iteratively test the design on users:** It is essential to test the system with users iteratively to identify the problems and improve it over time.

We followed a similar approach to iteratively build the prototypes and carried out a series of user studies. Since we are trying to create a new kind of interaction, we do not have readily available data on how people communicate with a philosopher. The only existing human-human dialogue we have is the historical documentations, i.e. the classical texts on Confucius’s philosophy. Therefore, we start by analyzing these texts to get an idea of the common topics Confucius talks about, so that we can build a prototype to test it with users. The prototype can then be used as a tool to collect data on how people communicate with the system, which is valuable in understanding user behavior and helps us to further improve the system.

We worked with the domain experts (who were NUS scholars specialized in Chinese philosophy studies) to conduct an analysis of the domain knowledge (i.e. the classical texts). Details of this work is presented in Chapter 3. We also investigated similar systems through a comprehensive literature review (presented in Chapter 2).

Based on the domain analysis and study of similar systems, we built a prototype and tested it with different users. The development of the first prototype is described

in Chapter 4. WOZ method was not adopted for the following reasons:

1. In a WOZ experiment of a dialogue system, instead of having the system to carry out analysis and find out the answer, the wizard instead chooses the answer from a list of candidate answers. This method is a good choice when the task the wizard performs can be easily accomplished with high accuracy and short delay. As the Confucian philosophy knowledge is vast (in our system, we have more than 2000 candidate answers), it would be very difficult for the wizard to decide which one to use within a short time.
2. Secondly, the wizard cannot fully simulate the errors, limitations, or time constraints of a real system, therefore the results of WOZ studies are somewhat idealized. For example, Allen et al. argued that without a working system, we cannot make fair evaluations of the models and theories in dialogue management [8]. As one of the main purposes of this research is to develop the technology that can support a virtual philosopher system, the WOZ approach is not very useful for us.

User studies on the first prototype are presented in Chapter 5. Through a public user trial and a lab-based user study, we understand users' expectations and opinions on the system; and through the log analysis of an actual deployment of the system, we understand user behaviors, which helps us to further improve the system. The design of the second prototype and its evaluation are presented in Chapter 6 and 7, respectively.

Figure 1.2 summarizes the work carried out in this thesis guided by the research

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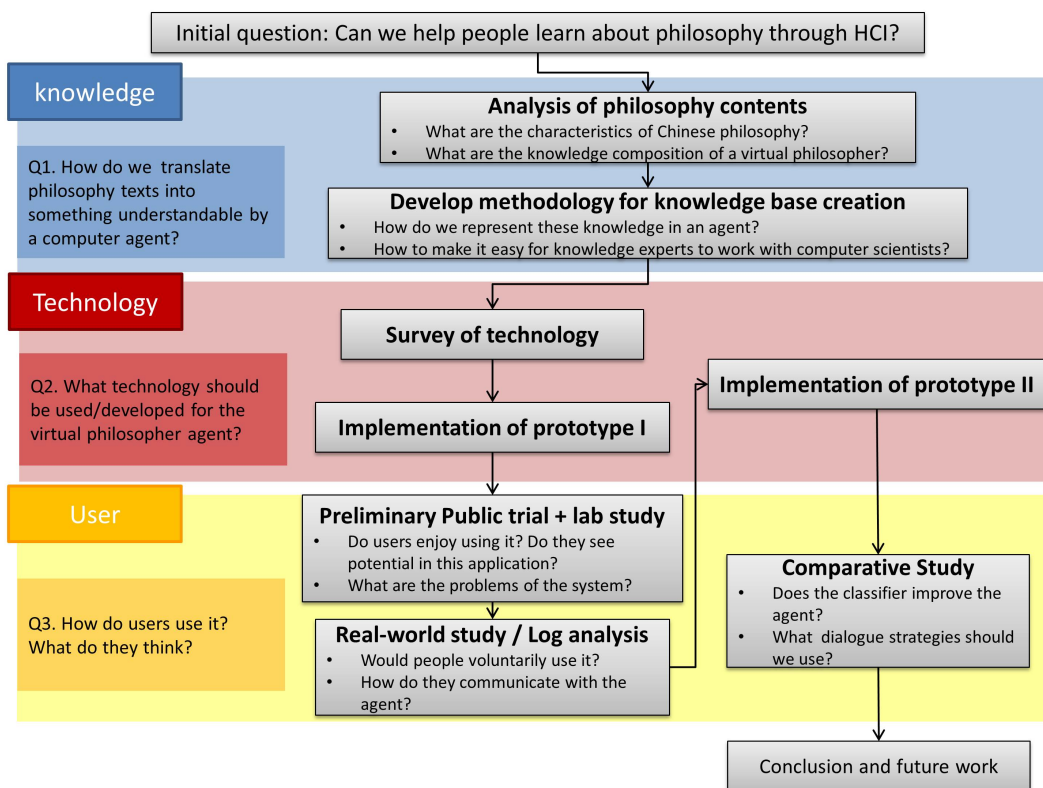


Figure 1.2: A summary of the work in this thesis

questions in section 1.2.2, following the methodology presented here.

## 1.4 Contributions

In HCI research, philosophy, as a kind of tacit knowledge, is a rarely addressed subject, probably due to its elusive nature that is hard to quantify and convey interactively. In this thesis, we make the first attempt in directly treating philosophy from cultural computing perspective, by building an interactive conversational system for users to experience the culture. Two prototypes were built iteratively and tested through lab studies with recruited subjects as well as through real-world deployment with spontaneous users. These user evaluations were conducted using a combination of methods, including direct observation, post-test questionnaires, interviews, and log analysis. A new architecture to support the virtual philosopher to handle unrestricted questions was proposed, and future directions were discussed.

Specifically, this thesis makes four main contributions that are relevant to cultural computing and HCI in general:

- **Contribution 1 (methodological)**

- **A systematic method for domain experts to author the knowledge base content for creating a virtual philosopher.** Knowledge base authoring is a laborious task and often requires programming knowledge. Our proposed method simplifies the authoring process and facilitates interdisciplinary collaboration between philosophy domain experts who prepare the knowledge base and

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the computer scientists who program the agent (*see chapter 3*).

- **A set of evaluation metrics that can be used to judge the quality of a virtual philosopher and the experience interacting with it.** Virtual philosopher is a new type of agent for philosophy learning, and new evaluation criteria need to be proposed. We proposed three different metrics based on the literature and specific characteristics of virtual philosopher (*see chapter 7*).

- **Contribution 2 (theoretical)**

- **A taxonomy of user’s utterances in an open conversation with a virtual philosopher, derived from real-world usage.** The data used to derive this taxonomy was collected from spontaneous users from the general public, rather than paid subjects. This taxonomy gives us a better understanding of how real users communicate with the virtual Confucius and helps to improve the agent’s algorithm by designing targeted strategies (*see chapter 5*).

- **A set of guidelines for the design of a virtual philosopher.** Based on our experience developing and testing the system, we point out a few issues to be considered and give our recommendations. Researchers developing similar applications can refer to this guideline to inform their design choices and direct their research efforts (*see chapter 9*).

- **Contribution 3 (empirical)**

- **Experiment results concerning the effects of different answer-finding and no-answer strategies on the evaluation of the virtual philosopher.**



The results give suggestions on how to design the strategies to handle unrestricted conversations, especially when the input utterance is out-of-domain (*see chapter 7*).

- **Contribution 4 (technical)**

- **An architecture of conversational virtual philosopher system for handling unrestricted conversation.** Combining existing technologies and new technologies we developed, this architecture is tailored to the virtual philosopher application (*see chapter 6*).

In the conclusion chapter, section 9.2, we will revisit these contributions and discuss their implications.

## 1.5 Dissertation structure

The rest of this thesis is organized as follows:

- Chapter 2 gives a detailed literature review on all the related work, including past and present work in cultural computing as well as natural language interfaces.
- Chapter 3 details how the knowledge base of the system was constructed by working together with the domain experts.
- Chapter 4 explains the design and implementation of the first prototype using the knowledge base built in Chapter 3.

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- Chapter 5 presents three studies carried out based on the first prototype, as well as the insights obtained for further improving the system. The first study is a public trial of an early version of the system to test the user acceptance. The second study aims to get a general idea on how people interact with this system, and find out potential problems, if any. The third study looks into how real-world users use the system, in order to derive more informed and targeted design choices.
- Chapter 6 describes the improved design and implementation of the system, based on the observations and findings in the previous studies.
- Chapter 7 then reports the evaluation study on the second prototype, focusing on the effectiveness of the new architecture and different strategies the agent employs.
- Chapter 8 presents the limitations of this work, and points out directions for future research.
- Chapter 9 concludes this dissertation by summarizing the findings in the research.

## Chapter 2

# Literature Review

### 2.1 Overview

In this chapter, we provide a detailed review on related literature. As this thesis studies the problem of presenting cultural contents (philosophy, in particular) in an interactive way (and more specifically, in natural language conversation), the literature review covers work from two bodies of research, namely, literature on work combining culture and computing, and literature on natural language interfaces.

In the first part of this chapter, we survey the literature related to culture and computing. We divide the work into two areas according to the characteristics of the culture content they address - tangible culture and intangible culture, while putting emphasis on the later, as it is most pertinent to our work. In the second part of this chapter, we survey past and current work on natural language interaction with computers. Two related fields are covered: the field of conversational agents, which

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allows users to converse, either in text or speech, with a computer program like talking to a person, and question answering systems, which provides short and precise answer to questions posed in natural language.

### 2.2 Culture and computing

In many ways, computing has transformed the way people preserve and disseminate culture. Scientific methods have helped in various stages in the identification, preservation, authentication, and retrieval of cultural contents, not only in the form of digital representation and recreation of physical cultural assets as online repositories, but also creating new forms of interactions with them. Culture, as a general term, can be divided into two categories: tangible culture and intangible culture. The UNESCO World Heritage Center defines *cultural heritage* as “the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations.<sup>1</sup>”. In this section, we provide a review on how computing technology is used for these two types of culture.

#### 2.2.1 Tangible culture

Tangible culture, or material culture as termed in social sciences, refers to culture that is tangible or touchable, such as sculptures, architectures, paintings, etc. Much of these tangible culture are considered worthy of preservation for the study and appreciation

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<sup>1</sup>Definition by the UNESCO World Heritage Center from <http://whc.unesco.org/>.

of human history and society. Computing methods have been utilized to help achieving this goal. One major research area is *digital cultural heritage*, which specifically concerns with digital recreations of historical sites or artifacts using 2D or 3D modeling techniques, or the management of such resources [30, 79, 90]. For example, Okada et al. used advanced analytic techniques to restore the historical scripts and illustrations to its original form [114], and the Virtual Kyoto project built geotemporal referenced 3D models of the entire city of Kyoto [110]. Some of the models built are accessible online as e-museums [134], where people can easily browse, retrieve and explore the tangible culture from a computer interface. Furthermore, interactive installations have been set up in physical museums, allowing easy access to the information in ways such as augmented reality [38] and natural gestures [6], etc.

### 2.2.2 Intangible culture

Intangible culture, such as oral traditions, customs, ways of life, traditional craftsmanship, performing arts, theater, social practices etc, represents cultural identities and diversity of mankind, and is also an important part of culture. Modern computing and interaction techniques bring new possibilities for its preservation and promotion, allowing not only easier access and retrieval of these intangible cultural contents, but also participation and learning through a simulated or recreated experience.

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### **2.2.2.1 Archiving and retrieval of intangible cultural contents**

Like the work on tangible culture, many of existing work on intangible cultural contents focuses on archiving and browsing, where the content structuring and accessibility are the major concerns. For example, Mallik et al. [96] created a repository that encoded domain knowledge with digitized records of Indian dance and music using an ontology-based approach. A browsing application is developed for semantically access the collection of Indian dance videos. Stavrakis et al. [139] created a public digital archive of video recordings and motion captures of Cypriot folk dances. In addition, a 3D video game was created for children to be more aware of their dance heritage. The Bulgarian Folklore Digital Library [117] offers a web-based platform for the documentation and access to a range of Bulgarian folklore objects. Similarly, Artese et al. built a web-based register for the intangible cultural legacy of the oral history of the Italian Lombardy territory [10].

3D modeling is usually used for virtual recreation of tangible cultural artifacts, but it can also be applied for intangible culture such as traditional festivals and ceremonies. For example, Choi et al. work on the digital reproduction of the Yamahoko parade in the Kyoto Gion Festival through motion data of the floats and crowds [37], which allows people to have a realistic view of how the parade is like during the festival.

### **2.2.2.2 Learning of intangible cultural contents**

Hiyama et al. explored new methods for archiving and transferring of craftwork skills. They built a wearable display system that can be used for the skill training on Kamisuki,

Japanese traditional papermaking [64], replacing the traditional skill-transfer with word-of-mouth between a master and apprentices. It provided first-person visual and audio information and biological information (myoelectric signals, breathing and the eye-gaze) of a craftsman. Similarly, calligraphic skills can be trained through system that records an expert’s movements and reproduces them through haptic devices [127]. Another work on calligraphy is [168], where an intelligent system was developed to learn the style of a particular calligraphist and automatically generate new calligraphy of the particular calligraphist.

### 2.2.2.3 Techno-spiritual research

Social values and beliefs are also an important component of the intangible culture. People from different cultural background inherently possess distinct way of thinking, feeling, and worldviews. However, the use of technology for them have been less explored, compared to other cultural contents described above. For example, despite the high-profile calls from Intel anthropologist Genevieve Bell to the HCI community for using technology in spirituality and religion [16, 17], research in this area is still rather sparse. In [28], Buie and Blythe discussed the importance of supporting spirituality and religious practices in the HCI community, and proposed a few reasons for the lack of research in this area. Although in their paper the term “spiritual” is used in a loose sense, referring to “a sense of deep connection to something larger than oneself, whatever that may be (a deity, nature, a cause, the Universe, an intimate group...)”, and covering “all user experiences that can be described as spiritual, religious, transcendent,

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or numinous”, thus it perhaps does not fully fit into the scope of intangible culture, we believe that the spirituality they talked about shares many common characteristics with intangible culture, and one of the important reasons for the lack of attention on them is probably the elusive nature that is hard to quantify, convey digitally and interactively.

Most techno-spiritual research mainly focuses on *facilitating* the spiritual practices using technology (e.g. using ICT for communicating religious messages [17], using telepresence to help physically isolated people mediate together [65], using sacred imagery in a mobile application to support Islamic prayer practices [167], and a special display device to suggest topics for prayers [55], etc.), rather than embedding the cultural content in the interaction itself and creating new experience. The later approach requires analysis and understanding of the particular cultural contents to reproduce them in the interaction, and we can call them Cultural Computing research.

### 2.2.2.4 Cultural computing research

Cultural Computing not only concerns about integrating cultural aspects into interaction, but also allowing the user to experience the core elements of the culture through the interaction. The target of cultural computing is to extract a basic structure underlying a specific culture and to develop systems that would let people understand this basic structure through interactive experiences.

Some work seeks to digitally model the intangible cultural contents, and allow people, especially novices to be able to participate in the creation process of the particular



cultural content. For example, Yao et al. [169] digitized Shadow Play, a traditional art performance in China, using multi-point interactive control, which can be easily manipulated by a performer with no prior experience. Hitch Haiku [148, 166] is an interactive system that supports the composing of Haiku, a Japanese minimal poem form. Using this system, users can choose arbitrary phrases from a repository, and the system generates the Haiku based on the essence of words in the phrases. Similarly, Poetry mix up [48] is a poetry creation system which models the words and structure of poetry. Users can get the system to generate their own poetry by simply sending an SMS to the system.

Another representative example is the project ALICE, which is an interactive installation that enables users to be immersed in a mixed reality environment featuring the story of the book *Alice's Adventures in Wonderland* by Lewis Carroll (See Figure 2.1). Scenarios are selected and implemented as an interactive experience composing six stages, in each of which the user gets immersed in the installation, experiencing and reflecting on the western culture determinant [68, 124]. Another work is the Mysterious Machines, an art installation including three physical robots autonomously talking to each other as well as to the audience about religion issues [128]. It uses the New Testament, the Koran and Rigveda as the knowledge base.

For eastern culture, Tosa created the ZENetic Computer [146, 147], which projects the style of Zen communication into computing world, letting people experience Zen Buddhism through sansui ink painting and construction of one's own virtual space. The system then generates a fragmented Zen story based on user's design of the virtual

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space, and poses zen questions to the user. Through this interactive experience, users are led to confirm his or her self-awareness, consciousness and unconscious imagination. Figure 2.2 shows the installation of Zenetic Computer. Also about eastern culture, Uriu and his colleagues looked at how entertainment computing can be used to support Buddhism practices [150]. They use Augmented Reality technology to help users learn about Todaiji temple, one of the world heritages in Nara, Japan, and a special ritual ceremony held at the temple. Inspired by these work, we attempt to further cultural computing research by looking into Chinese philosophy and studying how to provide an interactive experience for the general public.



**Figure 2.1: Project ALICE** - an interactive cultural computing installation, taken from [http://www.alice.id.tue.nl/press/Alice\\_Cursor\\_080221.pdf](http://www.alice.id.tue.nl/press/Alice_Cursor_080221.pdf)

### 2.2.2.5 Work related to philosophy

From the above described systems, we can see that the research community generally takes an interactive approach to convey unquantifiable values and beliefs. Besides interactive installations or applications, there have also been other endeavors that make



**Figure 2.2: Zenetic Computer** - Taken from <http://www.tosa.media.kyoto-u.ac.jp/zen/>

use of the computer and Internet for similar purposes, ranging from digital libraries to online forums.

To the best of our knowledge, there has been very few technical treatment on philosophy in the research domain. Kim et al. [77] presented a methodology for constructing an ontology (an explicit formal specification of concepts and semantic relations) for philosophy. They provided guidelines with 3 major steps and 14 minor steps to construct the ontology, and designed templates as well as an ontology management system for the construction, storage and retrieval of philosophy knowledge, such as name of philosophers, texts of philosophy, terms of philosophy, doctrines of philosophy, schools of philosophy, etc. Figure 2.3 shows the philosophy knowledge portal developed using this ontology. This ontology could be very useful for creating knowledge-based appli-

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cations like this, but it is more suited for people who formally study philosophy and cannot be easily used by the general public.

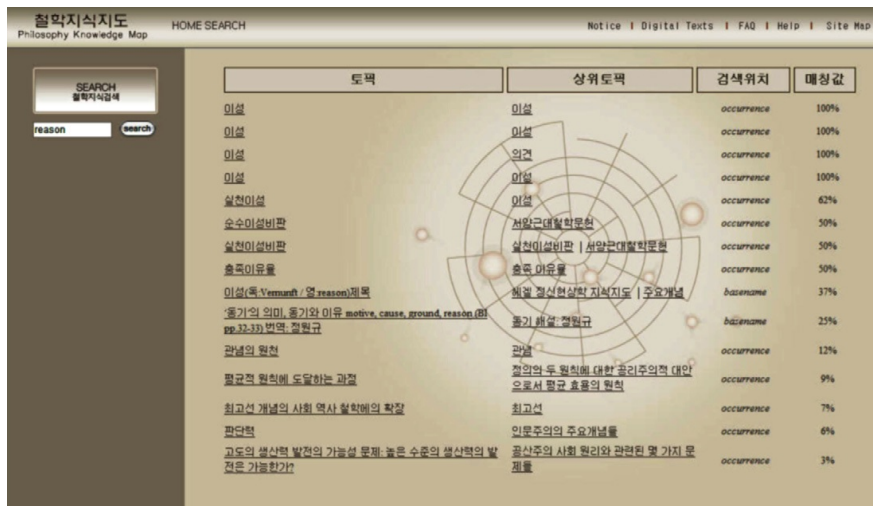


Figure 2.3: Search page to retrieve knowledge in the philosophy ontology - taken from [77]

Shuhai Wen Yuan [144] is an online library which offers access to classical Chinese texts and their English translations, along with a set of assistive tools<sup>1</sup>. Its target users are scholars and students interested in classical Chinese philosophy. As a result, it is difficult for the general public to easily grasp ideas from the sea of texts in the library.

Websites for similar purposes but designed for the general public also exist. AskMoses.com is a “hot line” website for people with questions about or related to Judaism or who has a moral dilemma and wish to solve through Judaism. It offers live chatting and a database of questions that have been asked. The advice is given from a strictly religious point of view, as the website’s goal is to educate people in Judaism. Questions are answered by employees of Chabad of California. Askphilosophers.org is a web

<sup>1</sup>It is no longer available, but the data and tools can be found in the Chinese Text Project website at <http://ctext.org/>

site that gathers talents and knowledge of trained philosophers to answer questions from the general public. The site has attracted people at all stages of life and successfully proves that philosophy can be explained in intelligible ways and be used to help people. However, this site also needs to be managed by people, and it takes time to get the answers, as it takes real philosophers to manually answer the questions.

Based on these observations, we are positive that a computer system that engages users in a dialogue experience and automatically answers philosophical questions could be of interest and help to the general public who wishes to learn more about philosophy. The work described in this thesis presents the first attempt in treating philosophy from cultural computing point of view, by building an interactive system for naive users to experience the culture. Next, we look into the computing literature for clues on how to realize it.

## 2.3 Natural language interfaces

For more than 40 years, researchers in AI and speech technology have been working towards the goal of getting computers to master human language and the art of conversation. Equipping the computer with natural language capability has many benefits. The most important one is that it is *natural*, which means users do not need to learn the control or adapt to a specific language, making the interaction almost effortless. However, getting the computer to fully understand and speak human language is a non-trivial task. Human language is a very complex system, and it is difficult to compactly characterize the mapping from the text surface to the underlying meaning. Ambiguity,

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under-specification, indirect speech acts, etc. can all contribute to uncertainty and thus problem in understanding.

In this section, we review the literature on various types of natural language interfaces and their technology, including systems that are able to carry out extended conversation with the user, as well as question-answering systems that answer one question at a time. In the review, we put more emphasis on the technologies that are directly related and informative to the work in this thesis, i.e. the natural language understanding and the response generation, leaving out other enabling technologies such as speech recognition and synthesis, lip syncing, emotion modeling, etc.

### 2.3.1 Conversational agents

Conversational Agents, or Dialogue Systems, are computer programs that can communicate with human users in the form of a dialogue. A typical dialogue system contains the following components [102]:

- *Speech recognition*: Converts user's input utterances into a sequence of words.
- *Natural language understanding*: Analyzes the input sequence of words to produce a meaning representation.
- *Dialogue management*: Controls the interaction between the system and the user, and coordinates various components of the system.
- *Communication with external system*: Communicates with external systems such as a database or other computer application.

- *Natural language generation*: Formulates the reply to be output to the user.
- *Speech Output*: Synthesizes the speech to output to the user.

These are some basic components of a typical dialogue system. A system can have more functionalities depending on the design, or can omit some of the components as well. For example, for systems that use a text interface, the speech-to-text and text-to-speech module are omitted. Some systems can have implicit dialogue management, or do not rely on external system.

We group related work in Conversational Agents in the following four different classes: Chatbots, Task-oriented systems, virtual human and intelligent tutoring systems. Here, we gave a detailed review on chatbots and virtual human, which are two most related fields, and for completeness, we also briefly review the work on task-oriented systems and intelligent tutoring systems. We make the distinction between chatbot and virtual human, in that a chatbot is mainly a computer program with a text interface that can carry out casual conversation with human, whereas virtual humans are usually multimodal systems that also employ 3D modeling of the body, facial expressions, etc, and are usually built for specific purposes.

### 2.3.1.1 Chatbots

Chatbots, sometimes also called chatterbots, or chat bots, have a long history. ELIZA, created by Joseph Weizenbaum in the 1960s [158], is one of the earliest chatbots. It is a computer program simulating a Rogerian psychotherapist. Here is a sample conversation with Eliza, obtained from Weizenbaum's original paper (C represents the

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human user and R represents ELIZA):

C: Men are all alike.

R: In what way?

C: They're always bugging us about something or other.

R: Can you think of a specific example?

C: Well, my boyfriend made me come here.

R: Your boyfriend made you come here.

C: He says I'm depressed much of the time.

R: I am sorry to hear you are depressed.

C: It's true. I am unhappy.

R: Do you think coming here will help you not to be unhappy?

C: I need some help, that much seems certain.

R: What would it mean to you if you got some help?

C: Perhaps I could learn to get along with my mother.

R: Tell me more about your family.

C: You are like my father in some ways.

R: What resemblance do you see?

C: My father is afraid of everybody.

R: What else comes to mind when you think of your father.

C: Bullies.

R: Does that have anything to do with the fact that your boyfriend made you come here?



The technology behind ELIZA is very simple: it analyzes the input sentence by keywords and decomposition rules, and generates the answer by corresponding reassembly rules. For example, using the decomposition template (*0 YOU 0 ME*) (0 means “any indefinite number of words”) and the reassembly rule (*WHAT MAKES YOU THINK I 3 YOU*) (3 here means the third component of the decomposition), the system is able to provide an answer by asking back a question which transforms the input sentence. In writing these templates, some clever techniques are employed, such as *pronoun reversal*: e.g. If the client says anything with the prefix “I need some X”, the robot would reply with “What would it mean to you if you got some X?”, irregardless of what X is, being it help, money, food, love or time. Another trick is *keyword recognition*: e.g. if the user’s sentence contains the word “mother”, this word is recognized, and a response “Tell me more about your family.” is triggered, irregardless of what other words in the sentence are. In effect, ELIZA works by a cascade of regular expression substitutions: for example, the answer to “men are all alike” can be expressed in regular expressions as:

```
s/.* all .*/IN WHAT WAY/
```

In addition, when no keyword or template match can be found, some fixed phrases are used to keep the conversation going, such as “*Very interesting. Please go on.*”.

Using “tricks” like including substrings of the user’s input in the program’s output, answering questions with questions, recognize keywords and use widely applicable conversation continuers, the system is able to create the illusion of listening and understanding, and continue the conversation, even though it does not understand the input

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sentence at all, as there is in fact (almost) no knowledge in the system. While it may work under the cover as a Rogerian psychotherapist (in fact, it did successfully trick a few people into thinking that they were talking to a real human in Weizenbaum's study), the program itself has little or no real contribution to the conversation [100].

Based on the idea of ELIZA, many chatbots have been developed. Some of the early examples include PARRY [41], which simulates the behavior of a paranoid patient. PARRY is able to track its own internal emotional state. Like Eliza, the identity of a paranoid patient gives the system a good cover for its lack of real language understanding capability and general knowledge, as the unusual behavior can be explained by its paranoid nature. Indeed, PARRY successfully fooled the doctors into thinking that it is one of the paranoid patients. Mauldin [100] created a chatbot that exist in the world of TINYMUD, a multiuser dungeon. The conversation module has a prioritized layer of mini-experts, each of which contains an ordered collection of input patterns and a set of possible responses. It also encodes many fragments of directed conversation in an activation network, so as to keep track of the user's responses by activating and inhibiting certain responses, resulting in a more coherent conversation. MegaHAL [71] took a completely different approach, which learns the language model from the training data and the users, and mimics their language style using Markov models. This gives the bot learning ability so that it can expand its vocabulary. Again, as there is no real understanding, most of the time, the responses from MegaHAL are gibberish.

A more recent development is Richard Wallace's ALICE (Artificial Linguistic Internet Computer Entity) [154]. It uses a markup language called Artificial Intelligence

## 2.3 Natural language interfaces

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Markup Language (AIML), an XML dialect, to encode knowledge. In AIML, knowledge is encoded in what is called **categories**. A category consists of a **pattern** - which is used to match what the user says to the system, and a **template** - which is the response to this user input. The box below shows an example AIML category. The AIML package freely available online contains a knowledge base of approximately 41,000 such categories.

```
<category>
  <pattern>WHAT ARE YOU</pattern>
  <template>
    <think><set name="topic">Me</set></think>
    I am the latest result in artificial intelligence ,
    which can reproduce the capabilities of the human brain
    with greater speed and accuracy .
  </template>
</category>
```

Though the technology behind is very simple, it is one of the top performing chatbots and has won a few times the Loebner Prize, an annual competition for the chatbot that is most human-like considered by the judges<sup>1</sup>. However, this competition has been criticized for encouraging people to use tricks to fool the judges rather than furthering the field of Artificial Intelligence [135].

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<sup>1</sup><http://www.loebner.net/Prizef/loebner-prize.html>

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Though early development of chatbots focuses on fooling people into thinking they are talking with a human, chatbots have recently proved to be useful in many other ways, both in the industry as well as in research. Example industrial applications include customer service bots, online shopping assistants<sup>1</sup>. In research, chatbots have been studied as a natural interface for accessing information [2, 131], learning languages [50, 73, 162] and social theories [105], and as virtual doctors [95].

Chatbot has the advantage of being easy to construct (in small scale) - one can simply add more scripts to expand the bot's capability, and it is not too difficult to build one's own chatbot as long as one can write the scripts. However, hand-crafting chatbot knowledge is also a time-consuming process, and it is almost unfeasible to prepare an answer to every possible question. It took Wallace years to gradually build up the categories in the ALICE bot, and there are still many questions that it cannot answer well. Recent research starts to look for alternative sources of knowledge for chatbots, such as annotated dialogue corpora [133]. Others try to directly mine the information from unstructured texts, examples including mining factoid question-answer pairs from declarative sentences in standard texts such as Wikipedia [170]<sup>2</sup>, from community question-answer websites [163],  $\langle thread - title \rangle \langle reply \rangle$  pairs from online discussion forums [69], and news topics and human-written comments for online articles [98].

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<sup>1</sup><http://www.virtuoz.com/>

<sup>2</sup>In this paper, they used the Simple English version of Wikipedia

### 2.3.1.2 Task-oriented systems

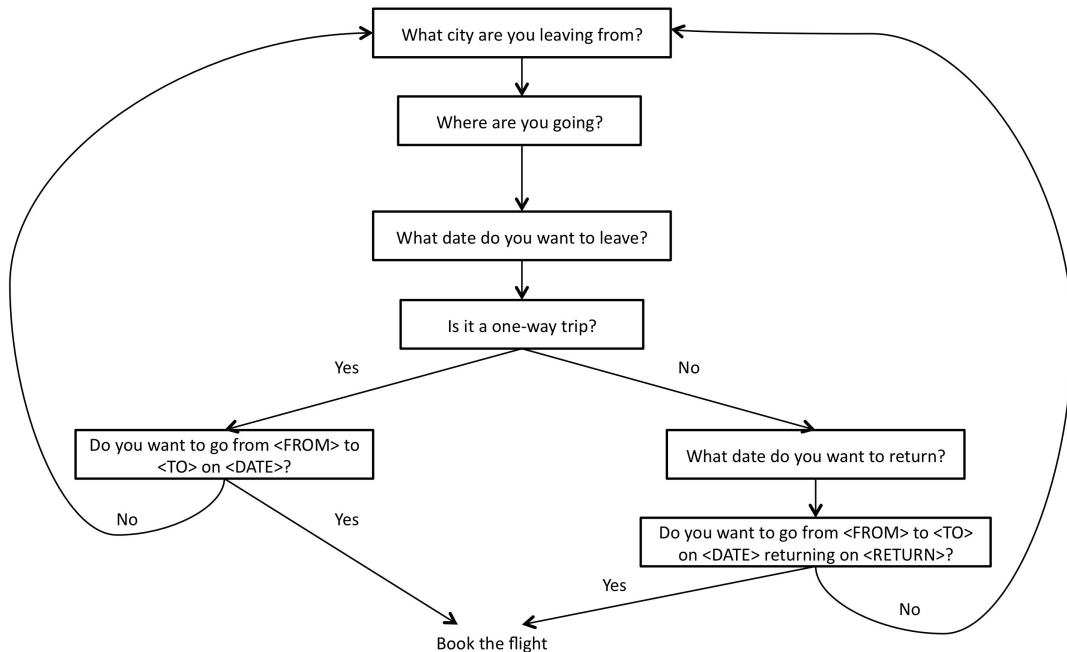
Task-oriented dialogue systems have been an intensively researched area due to its perceived usefulness in replacing human operators. Such systems work in a specific domain and the system's capability is usually restricted within the completion of the task. In such systems, there is a clear common goal that is shared between the user and the system, such as booking a ticket. As a result, the dialogue in a task-oriented system is highly structured. With the presence of certain task, the design of the system is centered around achieving this goal, and the evaluation is also targeted at task completion.

**Finite state-based systems** contain sequences of predetermined states constituting the flow of the dialogue. The system takes control of the dialogue, taking the user to go through the steps based on a predefined sequence, and according to the recognized words and phrases in the user's utterance. The dialogue structure is represented in a state transition network, where the nodes represent the "states" (associated with the system's questions), and the transitions between these nodes depend on user's responses. Figure 2.4 shows the architecture of a very simple flight booking system using finite-state automaton. A number of early systems have been developed based on this approach [172]. Such systems has the advantage of being relatively easy to design and construct, as long as there is a finite and well-defined set of information items to be sought for in a natural order, and the task can be subdivided into a hierarchy of sub-tasks [101]. As a result, it is particularly suitable for modeling dialogue flow in highly structured tasks. However, the disadvantages are that the system lacks flexibility, er-

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ror correction could be troublesome, and users do not have the opportunity to take initiative.



**Figure 2.4:** A simple finite-state automaton architecture for a dialogue manager  
- Reproduced from [74]

**Frame-based systems** offers more flexibility compared to state-based systems. There is a predetermined set of information required from the user to perform the task, but the dialogue flow is not pre-determined. Information are stored as slots in a frame (or template), and the system operates like performing a form-filling task. The system is able to adapt its response according to the amount of information provided by its user, asking for information that is still missing or start to perform the task if all information has been collected. Examples of frame-based systems include the Philips train timetable system [15], and more complex ones like [57]. The flexibility of this

approach enables more efficient and more natural dialogue. However, its capability is still limited, and therefore not useful for more complex dialogue that involves more than elicitation of predetermined information.

More complicated frameworks have also been designed, to handle tasks that are more than a pipeline of procedures, such as those involving negotiation [33], planning [7, 102] and reasoning [4, 5, 29].

### 2.3.1.3 Virtual humans

Virtual humans can be considered as more sophisticated and more full fledged chatbots designed for special purposes. A virtual human usually exists in a virtual environment with a 2D/3D embodiment, and is able to communicate with people through not only text/speech, but also non-verbal behaviors such as facial expressions and gestures. As a result, this research area can be divided into various sub areas, such as its cognitive architecture, embodiment, emotion, natural language processing, etc. In terms of application, virtual humans usually are virtual avatars that is capable of performing certain role, like museum guide, soldier, etc. Though, ideally, for people to experience the conversation with a virtual philosopher, it would be good to have all above-mentioned abilities, this thesis only concerns the conversation content part. In this section, we review a few virtual human systems, mainly focusing on their conversation abilities.

Synthetic Interview is a technology developed by the Entertainment Technology Center at Carnegie Mellon University [99]. Figure 2.5 shows the installation of the system for people to ask questions to the famous naturalist Charles Darwin. The

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system matches its input to a pre-constructed list of possible questions a guest may ask, and outputs the corresponding pre-constructed answer. To make the system more realistic, instead of building 3D models of the character, they got real actors to play as Charles Darwin and recorded all the replies as videos. For each question asked, the selected video is played back to the user, simulating a real interview experience. Other than Darwin, other famous people have also been featured using the Synthetic Interview technology, such as Benjamin Franklin and Albert Einstein. It should be noted that one key characteristic that makes the problem studied in this thesis different from the synthetic interview technology is that the questions addressed by the characters in synthetic interview are mostly biographical and factual questions, whereas in the case of the virtual philosopher, in addition to biographical questions, one main area to model is the philosopher's knowledge on philosophy.



**Figure 2.5: Darwin Synthetic Interview** - Synthetic Interview technology developed by Carnegie Mellon University's Entertainment Technology Center, taken from [http://www.sepa.duq.edu/darwin/dsi\\_photos.html](http://www.sepa.duq.edu/darwin/dsi_photos.html)

The NICE HCA system creates a virtual representation of the famous fairy tale





**Figure 2.6:** The virtual Hans Christian Andersen - The virtual HCA is talking to a user, taken from [22]

author H.C. Andersen [19, 20]. It is an edutainment system for children and teenagers to learn about life and work of Andersen, by enabling natural communications through spontaneous speech and 2D gesture. Conversational skill is modeled by templates and topic-centered mini-dialogues. Their first prototype contained fairly limited domain knowledge (300 response templates and 100 primitive non-verbal behaviors), and a cover story was used to tell users that HCA is back, but he still has to re-learn much of what he once knew. This helped to explain the limited capability of the prototype.

Ada and Grace [3, 140] are two virtual human museum guides developed by the virtual Humans Group in USC Institute of Creative Technologies. They are two life-sized, photo-realistic characters that interact in natural language, complete with gestures and other forms of non-verbal communication. They have been installed at the Museum of Science in Boston to engage young people in science. Figure 2.7 shows the virtual human deployed in the museum. The questions to the agents were asked by human

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handlers who are trained staffs of the museum. This helped to increase the speech recognition accuracy, as well as restrict the topics and phrasings to those that can be answered by the system. The system works by having a statistical text classification algorithm to map the utterance text to the pool of pre-constructed character responses. A library of scripted question and answer pairs are authored by the domain expert to train the classifier. A software called NPCEditor [89] is created to facilitate the content authoring and rephrasing. The classifier treats each response as a category, and classifies the input based on the statistical cross-language translation model learned from the training texts [89].



**Figure 2.7: Ada and Grace** - Two virtual museum guides at the Museum of Science, Boston, taken from [140]

Here's an example scenario of a handler talking to the system:

HANDLER: What are your names?

ADA: My name's Ada.

GRACE: And I'm Grace. We're your Virtual Museum Guides. With your help, we can point you towards exhibits that will get you thinking! Or answer questions about things you've seen here.

ADA: What do you want to learn about?

HANDLER: I'm interested in computers.

GRACE: Here at Cahners ComputerPlace, you can build your own model computer, solve a puzzle like a computer, examine computer brains, and learn how to think like a computer. Which one of these do you want to put through your processor?

HANDLER: I want to learn how computers think.

GRACE: At Logic Land you can learn how computers think by trying to decode a bitmap, and interacting with Boolean logic gates.

HANDLER: What are Boolean logic gates? GRACE: Boolean logic gates are the basic building blocks of computing! Remember ... (the rest of the reply is omitted)

The virtual Humans Group in USC Institute of Creative Technologies has developed various other virtual humans using similar technology<sup>1</sup>, including virtual soldiers (Sergeant Blackwell [88], Sergeant Star [12]), and virtual coach to help people learn

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<sup>1</sup><http://ict.usc.edu/groups/virtual-humans/>

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about programming a robot<sup>1</sup>.

Other virtual human museum guides include Pixie [18], which was part of an 2003 exhibit in the Swedish Telecom museum called “Tnk Om” (“What If”). In the exhibit, visitors can experience a full-size apartment of the year 2010, get information about the agent or the exhibition, and help Pixie perform certain tasks in the apartment. Another example is Max [80] at the Heinz Nixdorf Museums Forum (HNF), which provides information about the museum, the exhibition, or other topics of interest. However, Max only allows keyboard input, and the image is static. Similar works are virtual information kiosks, such as MACK (Media Lab Autonomous Conversational Kiosk) [35], which gives directions to visitors of the MIT Media Lab based on a repository of user queries and system responses, and August [61], a talking head representing the Swedish author August Stringberg, displayed at the Stockholm Cultural Center to answer questions by predefined answers.

As discussed, virtual humans are usually built for practical purposes - most of the virtual humans reviewed here have been deployed in a real world setting. As a result, such systems aim at robustness and good user experience, while the domain is usually shallowly modeled.

Besides the textual content of the conversation, other aspects of conversational agents are also being studied. For example, Greta [120] is an exploration of emotional interaction between agents and human through nonverbal behaviors. The interaction modality goes beyond text - facial expressions, gestures, speech synthesis and lip syncing

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<sup>1</sup><http://ict.usc.edu/prototypes/coach-mike/>. It also has components of a intelligent tutoring system.

are introduced to increase the expressiveness of the agent. There are also various other studies investigating other attributes of an agent such as gender [151] and personality [43].

### 2.3.1.4 Intelligent tutoring systems

Natural language interface has also been used in Intelligent Tutoring Systems. An intelligent tutoring system is a computer system that is able to guide students through the process of learning. Like task-oriented system, as ITS systems are built to teach certain concepts or knowledge, the dialogue between a human student and a computer tutor is highly structured [157]. In addition, the tutor usually takes the initiative to ask questions and guide the students to proceed in the learning process. Below is an excerpt of the conversation between a student (U) and the tutor system (S) from [74].

S: I didn't understand. What force acts on all objects within close proximity to earth?

U: uh the force of gravity.

S: Fine. Besides the Earth's gravitational force, are there any other forces acting on the person, keys, and elevator after the release?

U: no.

S: Yep. Thus, keep in mind that after the release, the only force on the person, keys, and elevator is the force of gravity. If gravity is the only force acting on an object, will it be moving or staying still?

U: it will be moving.

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S: Fine. Not only are the person, keys, and elevators moving, they have only gravitational forces on them. When an object is falling and has only gravitational force on it, it is said to be in what?

U: freefall

### 2.3.1.5 Summary

In this section, we have reviewed four main types of conversational agents. To summarize, table 2.1 shows a detailed comparison of the above mentioned types of systems, adapted from the table in [54].

This categorization provides us a general view of the existing conversational agent technology. It is worth noting that the above categories of conversational systems are not mutually exclusive. There can be many things a conversational agent can do, and therefore it can lie at the intersection of the categories. For example, Siri<sup>1</sup> is a virtual assistant that can communicate with its user through voice. It has the characteristics of a task-oriented system (though the tasks are limited to simple ones such as sending a message at present), but it can also handle some amount of casual conversations like a chatbot. Another is [108], which combines task-oriented and non-task-oriented capabilities in its humanoid robot by using a multi-expert model, which dynamically changes dialogue strategy based on speech recognition results. There are also extensive research studying the multimodality of conversational agents (e.g. [120]), which are

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<sup>1</sup><http://www.apple.com/ios/siri/>

## 2.3 Natural language interfaces

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	Chatbot	Virtual Human	Task-oriented	Tutorial	My research
Domain	Unrestricted	Somewhat restricted	Restricted	Restricted	Hard to define
Goal	Be human-like and converse with user	Perform certain role	To replace human operators	Instruct user	Be like a particular person, converse with users and provide knowledge/opinion
Models what	Common sense/human knowledge/-general conversation	Information about certain place, events, etc.	Steps required to achieve goal/data needed to achieve goal	underlying process/pedagogical theory	General knowledge of a particular person
Dialogue structure	Conversation is casual, unstructured	Unstructured / semi-structured	A clear procedural pattern can be observed	Somewhat sequential, with tutor explaining in detail and asking questions, student answering with short utterances.	Unstructured
Knowledge source	Fixed scripts	Scripts + pool of candidate answers	Relational database, ontology, web	The particular knowledge points to be taught	Scripts + pool of candidate answers
Output Considerations	human-like conversation	Information providing	Clarity, verbosity	Clarity, Step-wise presentation of concepts	Useful human-like conversation about a person and his/her subjective opinions
Evaluation	Human likeness	User satisfaction	Task completion, user satisfaction	Learning gain	User satisfaction
Example	Eliza, ALICE chatbot	Museum guide, QA characters	Travel arrangement, auto call routing	ITSPOKE, AutoTutor, Beetle II, Research Methods Tutor	iSage

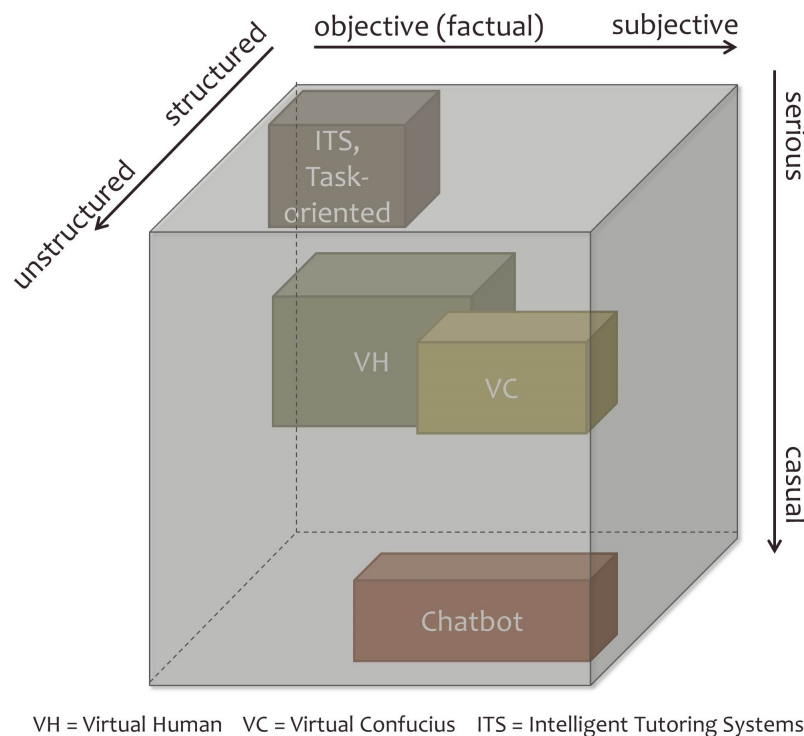
**Table 2.1: A comparison of various conversational agents**

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beyond the scope of this thesis.

Figure 2.8 further demonstrates the uniqueness of a virtual philosopher system by comparing it with the four main types of conversational agents from three dimensions: the degree to which the dialogue is structured, the subjectiveness of the answers, and the seriousness of the application. From this graph, we can clearly see that chatbots are designed for casual conversation, whereas task-oriented conversational agents and intelligent tutoring systems are serious applications which handle highly structured dialogue, and the responses are objective. Virtual humans are somewhere in the middle, and virtual Confucius can be considered as an extension of virtual human, because it handles more subjective questions and the dialogue is more unstructured.



**Figure 2.8: Comparison of various conversational agents and the Virtual Confucius**



### 2.3.2 Question answering systems

Question Answering (QA) is also a widely-researched field related to natural language interfaces. With enormous growth of the amount of digital information available, QA systems are designed to facilitate people in more accurate localization and retrieval of digital information. As opposed to search engines which only provide a list of documents containing the words in the search query, a QA system tries to automatically find the exact answer to a question posed in natural language.

A typical QA system contains the following three modules:

- *Question-Processing module*: Classifies the question, determines the expected answer type, the keywords to search for the answer, and formulates the search query.
- *Document-Processing module*: Searches through the knowledge sources for plausible paragraphs for the answer
- *Answer Extraction and Formulation module*: Extracts a text snippet that answers the question and presents it to the user.

There are many ways to categorize different QA systems. For example, Sanda Harabagiu and Dan Moldovan categorized QA systems according to the question types the system handles, the type of document collection available and how the answer is phrased in the text. Their taxonomy of QA systems contain the following 5 classes: 1) QA systems capable of processing factual questions; 2) QA systems enabling simple reasoning mechanisms; 3) QA systems enabling answer fusion from different documents;

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4) QA systems enabling analogical reasoning; 5) Interactive QA systems. For simplicity, we provide a brief review of QA in two broad categories: restricted domain QA and open domain QA.

### 2.3.2.1 Restricted-domain QA

Early QA system focuses on building natural language interfaces to databases [9]. As a result, the questions the system can handle is restricted to the domain knowledge encoded in the database. By confining the questions to a restricted domain, we can exploit the characteristics of the domain, determine the types of information needs in the domain, study the format of questions asked, and leverage the domain-specific ontological information. This allows us to represent a conceptual model in the database structure, and use advanced techniques such as theorem proving and deep reasoning [104]. For example, in the medical domain, the questions are likely to contain medical terminology. Therefore, special ontology for medicines can be constructed, and the system can use reasoning to find the relationships in the question asked by consulting the ontology [1, 14, 31].

One of the earliest example of restricted-domain QA is BASEBALL [59], which answers questions about baseball games played in the the US baseball league for one year. Information contained in the question is converted to a specification list - a list of attribute-value pairs. This is done by looking up a dictionary, which is coded specifically for the domain, also expressed in attribute-value pairs. LUNAR [165] answers questions about the chemical analyses of the Apollo 11 moon rocks. It uses a set of semantic inter-

pretation rules for interpreting requests, and transforms the natural language question into a database query to retrieve the answer. The Berkeley Unix Consultant project [161] answers questions about the UNIX operating system. User's question is analyzed and converted to certain knowledge representation formalism. It also incorporates a user model and carries out goal analysis to tailor its results to the user's expertise and goals. START (SynTactic Analysis using Reversible Transformations) [75] initially was launched online in 1993 as a restricted-domain QA system that can answer questions about faculty members of the MIT Artificial Intelligence Laboratory and their research. Its knowledge base is pre-compiled in the form of subject-relation-object tuples. START evolves with continuous development over time, and now the domain of questions that it can answer has been greatly expanded, which includes questions related to Geography, Arts and Entertainment, Science and Reference, History and Culture<sup>1</sup>. EnquireMe [164] is a interactive question answering system in the health domain. Instead of providing a one-off answer, it allows users to engage in conversation with the system about their health concerns.

### 2.3.2.2 Open domain QA

In recent years, the explosion of digital information has helped researchers to go beyond question answering in a restricted domain and try to answer questions about a variety of topics instead. Different from restricted-domain QA, open-domain QA approaches the problem from an Information Retrieval (IR) perspective. Large collection

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<sup>1</sup><http://start.csail.mit.edu/>

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of unstructured text documents [152] or the web [82, 83] are used as the knowledge base, which reduces the task of question-answering to the task of finding the text that contains the answer to the question and extract the answer.

The rich knowledge base that open-domain QA systems have access to makes data intensive methods possible. Redundancy-based technique is commonly used in open-domain QA system [104]. It leverages the huge size of text corpus to find answers rather than building complex languages models. Though the information on the web is not entirely reliable, open domain QA systems assume that truth will prevail and select answers that occur most often.

Mulder [83] is the first general-purpose, fully-automated QA system that uses the full web as its knowledge base. The types of questions MULDER deals with is factual questions (or sometimes called factoid questions) such as “*what is the longest river in the world?*”. The answers to factual questions are simple facts that can be found in short text strings, and correspond to a specific, easily characterized, category. The method for processing this kind of questions is usually by classifying the question based on the 5W1H words (who, where, what, when, how) and on the category of the Named Entities (NE), such as Person, Organization or Location. Figure 2.9 shows the architecture of the Mulder QA system, which is a typical architecture for open domain QA. It consists of a *natural language parser* to determine the question’s syntactic structure, a *question classifier* to determine the type of answer, a *query formulator* to translate the input question into a series of queries, a *search engine* as the knowledge base, an *answer extractor* to extract relevant snippets from the search results, and an *answer selector*

to sort and select the answer.

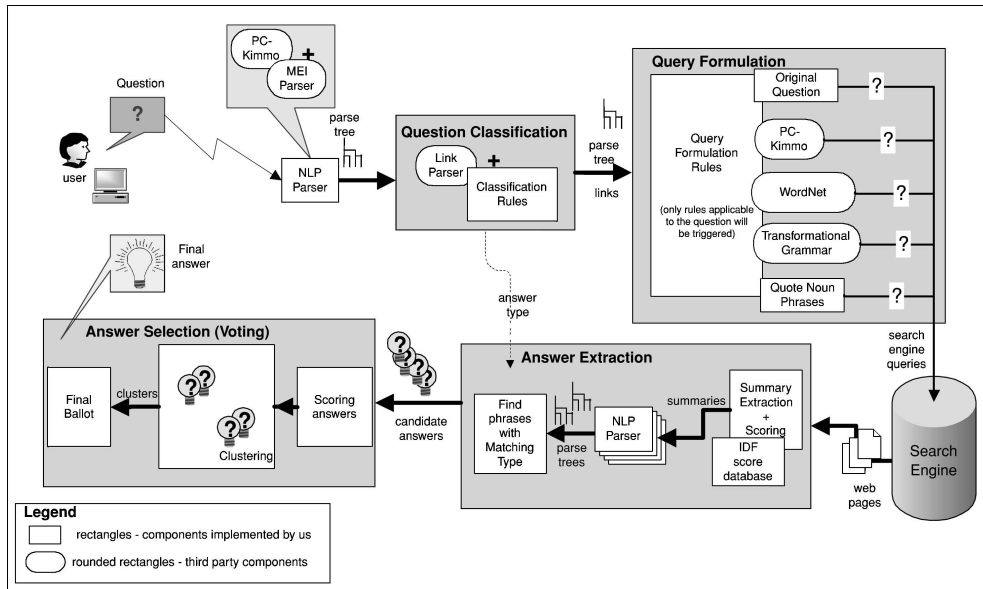


Figure 2.9: Architecture of the Mulder QA system - Taken from [83]

From factoid or definitional questions [160], in recent years, the target question type a QA system handles gradually shifted towards more complex questions such as FAQ-like QA [138] and opinion questions [92, 171], where data-intensive methods is still the main technique used.

The main difference between a virtual philosopher and a QA system is that the virtual philosopher has a real identity, and it represents a person rather than a machine. Therefore, a virtual philosopher needs more capabilities besides question-answering - for example, mimicking human-human chit-chat, responding in a cohesive and human-like manner, etc.

### 2.4 Chapter summary

With the rapid development of technology, computers and new media are seeping into every aspect of our life, including our culture. We can see rising appearance of work that intersects computing and culture, ranging from digital representation of tangible cultural artifacts, to new interactive systems that facilitate or create the cultural experience. It is noticed that cultural values and beliefs, especially philosophy, is an under-explored area. Encouraged by previous cultural computing works such as ZENetic computer, we see a possible avenue to promote philosophy through an interactive experience. Philosophy is a special domain, because it is intangible and unquantifiable, and is often deemed as esoteric to the general public. Looking back in history, we see that philosophical knowledge could be efficiently taught through conversation. Therefore, we decided to simulate the experience of having a conversation with a real philosopher. To achieve this, we need to utilize natural language processing and other technologies, and we need to design algorithms appropriate for our application.

From the literature review on natural language interfaces, we notice that there has been little research on natural language interaction in the domain of philosophy. Part of the reason might be that this is a highly specialized domain, and the subjective nature makes it hard to measure the effects of the system. Unlike task-oriented systems where there is a clear goal to reach, the interaction with a philosophy chat agent is much less clearly defined. A philosophy chat agent aims to model how a philosopher would respond to various types of questions. It offers free conversation with the aim of

imparting philosophical knowledge. One distinctive nature of the philosophy domain is its *subjectivity* - there is no clear right or wrong answer, and the same sentence can be subject to interpretation in different ways. Unlike QA systems which finds existing answers from the knowledge base, a philosophy chat agent finds the links between concepts dynamically and generates the answer on the fly. It is then left to the users to think and reflect on the meanings behind.

As we all know, language understanding has always been a holy grail since the early development of AI. Even today, the state-of-the-art system still cannot understand and think 100% like human. From the literature review in natural language interfaces, we can see that getting the computer to think and talk like a human is far from a solved problem. In restricted domains, even though the systems can achieve relatively good performance, most of them are still not on par with human<sup>1</sup>. It is even more difficult to handle open questions. The research problem now is, among these techniques that are available, which one(s) are suitable in our application? And in face of technical limitations, how should we design the system such that it can still offer a relatively good experience for its users?

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<sup>1</sup>There are exceptions, where the computer can do better than human in tasks that is well defined and knowledge intensive. One such example is the IBM Watson's winning in the quiz show *Jeopardy!*.

## **2. LITERATURE REVIEW**

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## Chapter 3

# Building the Knowledge Base

The information about a historical philosopher and his philosophy is stored in the form of text. We have documentations such as the biography of the philosopher, and the record of the conversations he had with people of his time. However, these texts are usually lengthy and tedious, which are not so easily accessible and appealing to the general public. In this research, we seek a way to transform the static texts into an interactive system. To do this, we need to examine the contents of these texts, and find out appropriate models that can support autonomous conversation using these texts as knowledge base.

### 3.1 Characteristics of Chinese philosophy

Philosophy is different from other subjects in science and engineering that are characterized by progressive development with objective, precise knowledge. There is no single, correct answer, and philosophical questions do not get solved as empirical ques-

### 3. BUILDING THE KNOWLEDGE BASE

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tions do [159]. To better understand the contents and characteristics of the philosophy domain and guide the interaction design and algorithm design, we firstly worked together with scholars studying Confucian philosophy (whom we call “*domain experts*”) to analyze the knowledge space.

The writings of Chinese philosophy is not formal philosophical works, but rather the records of philosophers’ sayings. Through relevant readings and discussions with domain experts, we summarized the following characteristics of Chinese philosophy, and in particular, the Confucian philosophy:

- **Contents mostly about human matters.** Different from western philosophy that is rooted in science, Chinese philosophy, especially Confucian philosophy, concerns largely about the virtue, society, human relations and human affairs. This makes it perfect for the material of casual conversation, as it is easy for users to relate to their everyday experiences.
- **Suggestiveness rather than articulateness.** Chinese philosophers tended to express themselves in special but interesting ways. The ideal of all Chinese art is not articulateness, but rather suggestiveness. For example, in Taoism, it is said that “*the Tao (the way) cannot be told, but only suggested*” [51]. Chinese philosophers were accustomed to use aphorisms, apothegms, or allusions, instead of giving a plain direct answer to the question asked [51]. This may result in two consequences:

1. **Disconnectedness.** The “indirect” answer given by the philosophers in the

### 3.1 Characteristics of Chinese philosophy

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form of aphorisms and allusions may induce a sense of disconnectedness, as if the philosopher is not answering the question. Indeed, Lin [93] commented that the Analects is “*abrupt and jumpy, requires hard thinking on the part of the reader*”. It is natural to encounter seemingly disconnected or ambiguous answers when one converses with a Chinese philosopher.

2. **Boundlessness.** Indirect, ambiguous sayings are open to interpretations and are usually applicable in many contexts. As Feng [51] commented, “*The sayings and writings of the Chinese philosophers are so inarticulate that their suggestiveness is almost boundless.*” This means many sayings are widely applicable, and we may use the same saying to answer many different questions. At the same time, it also implies that it would be hard to define a scope of the philosophy knowledge or the boundary of the domain.

- **Many short sentences, difficult to interpret literally.** In line with the suggestive use of aphorisms, a notable style of Chinese philosophers is to use short sentences. The Analects, for example, is full of sentences of four or five words [93]. A problem coming with this is that it would be difficult to get the (implied) meaning of the sentence, even for a human. So the few words in a sentence would be too little information for a computer to process for anything useful. Therefore, human expert annotation is necessary to interpret the sayings.

With these observations in mind, we carried out the knowledge base construction process, which included the collection of processing of materials, segmentation of the

### 3. BUILDING THE KNOWLEDGE BASE

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knowledge components and human annotations.

#### 3.2 Material collection and processing

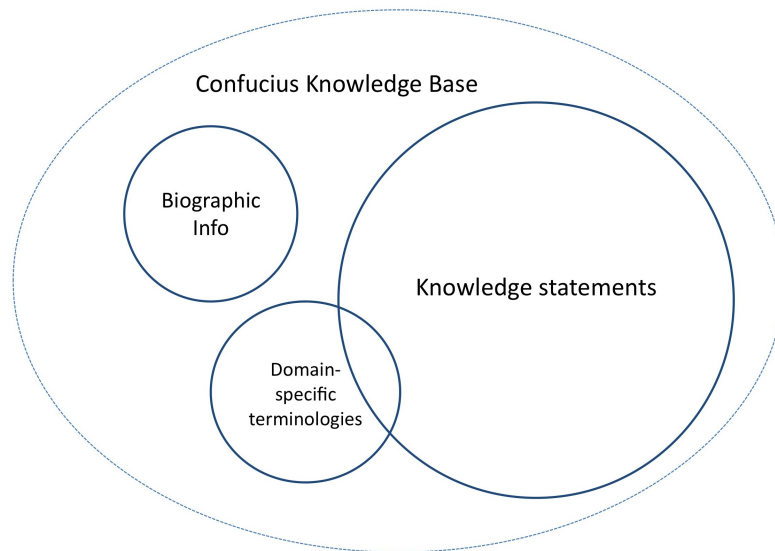
A database of Confucian statements was collected from classical Confucian texts by the domain experts. The *Analects* was the most important source. As Simon Leys put it, “*The Analects is the single most important key that can give us access to the Chinese world*” [91]. Besides, we also incorporated Confucius’s sayings in the *Mencius*, the *Book of Rites* and the *Classic on Filial Piety*. These four texts constituted a major part of educational curriculum for children in imperial China [143]. We chose to use the freely available James Legge’s translation for all four texts. On encountering disputable interpretation, the domain experts consulted two other popular translations in the field by D.C. Lau and Simon Leys to derive at what they think was an appropriate, and more pertinent to modern user translation.

As these materials were to be used for supporting conversation, we separated them into short sentences - they constituted the knowledge base, the collection of utterances the virtual Confucius could say in the conversation. We defined each sentence as an “entry” in the knowledge base. Since many of the passages were pretty long (especially those in the *Book of Rites* and the *Classic on Filial Piety*), and were comprised of several parts each with a distinct meaning, instead of transporting the whole paragraph of text into the database as one entry, we separated them into short but self-sustained statements. For instance, the opening passage of the *Analects* became three entries in our database: 1. Is it not pleasant to learn with a constant perseverance and

application? 2. Is it not delightful to have friends coming from distant quarters? 3. Is he not a man of complete virtue, who feels no discomposure though men may take no note of him?

### 3.3 Segmentation

Traditionally, authoring the knowledge base for a conversational character is a tedious task, and often requires the knowledge of scripting language. To make the authoring as easy as possible for the experts, we developed a process and designed the structure of knowledge base such that minimal input from the experts is needed, and they can segment and annotate the knowledge base in natural language, without writing scripts.



**Figure 3.1: Segmentation of the Confucius knowledge base**

From the literature review on natural language systems, we see that each type of

### 3. BUILDING THE KNOWLEDGE BASE

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system use different method to handle their targeted type of questions. For example, chatbots are well suited for chit-chat or other casual conversation, whereas question answering systems use information retrieval techniques to find answers from a collection of texts. A virtual philosopher system simulates the conversation with a philosopher, which means it needs to handle a mix of these question types, just as how humans are able to do chit-chat and also conduct serious discussion on knowledge-intensive topics. Through analysis of the collected knowledge base and heuristics on the types of information that people would ask the virtual Confucius, we divided the whole set of Confucius knowledge base into three distinct categories. Figure 3.1 shows the composition of the whole Confucius knowledge base. We believe that due to the distinctive nature of the information in each of these categories, they should be treated separately both in terms of knowledge representation as well as retrieval methods.

#### 3.3.1 Biographical information

The first category is domain specific factual knowledge, or in other words, biographical information about Confucius and related figures. This includes information about Confucius as an individual, for example, his age, his date of birth, his hometown, etc., as well as introductory statements about the figures appearing in Confucius's responses (mostly Confucius's disciples). We gathered this information from the earliest reliable historical text of *Shiji* by Sima Qian (ca. 110 B.C.). As information in this category is straightforward factual knowledge, we choose to store them as question-answer pairs in Artificial Intelligence Markup Language (AIML) scripts [154], which is good for

handling such query. For instance, if the user asks “*who is Yan Hui*”, Confucius’s reply will directly be taken from the scripts saying, “*He is my favorite disciple.*”. The corresponding representation using AIML is as follows:

```
<category>
  <pattern>Who is Yan Hui</pattern>
  <template>
    He is my favorite disciple.
  </template>
</category>
```

A total of 211 Q&A pairs were prepared by the domain expert. A partial list is presented in Appendix C-1.

#### 3.3.2 Knowledge statements

The second category is the major part of the knowledge base, which contains all Confucius’s sayings collected from the above-mentioned four classical texts. We call them *knowledge statements*. We eliminated passages that were too historically specific in nature and out of which no real meaning can be extracted. An example of such elimination was “to Zhou belonged the eight officers, Bo Da, Bo Kuo, Zhong Tu, Zhong Hu, Shu Ye, Shu Xia, Ji Sui, and Ji Gua”<sup>1</sup> A total of 2069 entries were collected, indexed and stored in an SQL database. These entries were further annotated by the domain experts to reveal their meanings in the context, which will be explained in the next

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<sup>1</sup>Analects, 18.11, James Legge tr.

### 3. BUILDING THE KNOWLEDGE BASE

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section.

Some samples of knowledge statements are:

-Sincerity is the end and beginning of things; without sincerity there would be nothing.

-Never swerving from the Mean.

-When occupy a high situation, you should be free from pride.

-For changing the manners of the people and altering their customs, there is nothing better than music.

-They who know the truth are not equal to those who love it, and they who love it are not equal to those who delight in it.

-A Junzi is careful in his speech.

-When among your equals, you should not be quarrelsome.

-The gentleman considers the whole rather than the parts. The small man considers the parts rather than the whole.

#### 3.3.3 Domain terminology

The domain of Confucian philosophy also contains special terminologies, which are not captured in the general ontology such as WordNet [47]. Therefore, it is necessary to create a separate knowledge base with domain-specific terminologies. For instance, names of classical texts from which Confucius often quotes, and Confucian terminologies such as Junzi (the morally ideal man in Confucian philosophy) and Ren (benevolence,



or the “way of being” that of an exemplary person), etc., need to be identified and denoted specifically.

### 3.4 Annotation

#### 3.4.1 Knowledge statements annotation

For each database entry in the knowledge statements, the domain experts annotated it with a number of topic(s), usually 1-3, to denote the subject(s) the entry talks about. This manual work is necessary, because we are working on a special domain, which is philosophical text. Such texts often contain implicit meanings that are impossible to be deduced from the literal understanding of the sentence using natural language processing techniques such as Word Sense Disambiguation [119] or Topic Modeling [27]. One such example is the sentence “*Advance the upright and set aside the crooked, then the people will submit*”, which talks about how to govern a country. By only analyzing the literal meaning of the words, it is difficult for a computer algorithm, or even a human without proper domain knowledge, to deduce that this sentence is about “*governance*”. Another example is “*what I do not wish men to do to me, I also wish not to do to men.*”, which talks about “*reciprocity*”. The domain experts’ input helps to make sure all the sentences are correctly interpreted, especially those with implicit meanings.

The expert annotations not only allow us to understand the knowledge statements better, but also encode the literal strings into formats that is easier to compute. Current

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work on conversational virtual human requires the experts to manually author many pairs of questions and answers (e.g. [89]), and we took similar approach in handling biographical information. However, this method has a significant drawback: it is very labor intensive and not scalable. Moreover, the wisdom in the knowledge statements are widely applicable in many situations, which means one knowledge statement can be used to answer a variety of questions, making it simply impractical for manual authoring of Q&A pairs. Another approach is to mine useful information on the internet (e.g. [170]), but this method is also best suited for factoid questions. As discussed previously, in the case of the philosophy domain, human input is necessary in providing more accurate understanding, at least at the current state-of-the-art. Therefore, instead of thinking about the possible questions that can be answered by each knowledge statement, we asked the domain experts to annotate each of the knowledge statement with its topics, and the task of relating questions to the answers is left to the computers.

With the topics annotated for each knowledge statement, it effectively transforms the strings of texts into points (or vectors) in a high dimensional space, where each dimension represents one topic. This high dimensional space covers all the topics that the virtual Confucius may be able to talk about. Such information can then be used in the computation process to calculate the suitability of one entry as the answer to a particular input sentence, based on certain relevance/similarity measures. It should also be noted that on the other hand, by digitizing the sentences into discrete points, we inevitably lose the rich information that is contained in the original sentence. Nevertheless, this added ambiguity to some extent echos the spirit of the Chinese philosophy.

**Table 3.1:** Top 10 most frequent topics in the Confucius knowledge base

Topic	Count
Rites	185
Gentleman	184
Superior	140
Governance	127
Conduct	103
Learning	98
Parents	97
People	96
Way	88
Propriety	85

Chinese philosophers tend to use suggestive expressions, which are often perceived as disconnected and are subject to different interpretations. As Feng pointed out, "The sayings and writings of the Chinese philosophers are so inarticulate that their suggestiveness is almost boundless".

A total of 268 topics were identified for the entire collection. Table 3.1 shows the top 10 topics that are mentioned most frequently in the knowledge base and the corresponding count of sentences tagged with it. A full list of topics can be found in Appendix C-2.

The 268 topics form a 268 dimensional space, and through annotation, each sentence becomes one point in this space. For example, the first entry in the knowledge statements - "*Is it not pleasant to learn with a constant perseverance and application?*" was labeled with three topics, namely, *learning*, *practice*, and *joy*. They are topic No. 18, No. 19 and No. 196 respectively. So this sentence is seen by the virtual Confucius

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as a vector  $\vec{d}_1$ :

$$\vec{d}_1 = \vec{t}_{18} + \vec{t}_{19} + \vec{t}_{196} \quad (3.1)$$

where  $\vec{t}_n$  is the basis vector representing the  $n$ th topic.

In this example, it is relatively easy to see the topics from the sentence itself. However, in other cases, the annotated topics may not be so evident. For example, entry No. 683 “*When there is action to be taken, give your best.*” was labeled as topic No. 14 (*governance*) and No. 158 (*loyalty*). In such sentence, it is hard to deduce the actual topic from the literal words in the sentence, and domain expert’s input helps us to see the real context. Another example is entry No. 768 “*Determine to be sincere in what you say, and to carry them out.*”, which was labeled as topic No. 4 (*conduct*), No. 25 (*speech*), and No. 173 (*scholar*).

A partial list of the topic annotation is shown in Appendix C-3.

Besides identifying topics for each entry, the domain experts also tagged each topic with specific senses in the context of Confucius’s teaching. This is necessary, because many of the topics in this domain have particular meanings, and literal word level tagging cannot convey the precise meaning and would lead to confusion. For example, the topic “way” in Confucian context means “a course of conduct”, rather than direction or path. We used the WordNet lexical database [47] to record the senses. Therefore, for the topic “way”, it is tagged as “*way#n#5*”, which is the fifth meaning of the word “way” in the WordNet. We chose to use WordNet because of its comprehensiveness

and its ontology that makes possible the comparisons of semantic similarities between words.

### 3.4.2 Domain terminology annotation

In addition, some of the terms in the knowledge base have domain-specific meanings which are not captured in WordNet. Therefore, for the domain terminologies that do not have semantic meanings, corresponding entries were tagged with the terminologies (in literal word strings) and stored in the SQL database. Some entries from the knowledge statements category were also tagged with keywords if they contain certain terminology.

For example, the entry No. 168, “*The superior man thinks of virtue; the small man thinks of comfort.*”, was tagged with three terminologies: *small man*, *mean man*, and *junzi*. Another example is the entry No. 60, “*In the Book of Poetry are three hundred pieces, but the design of them all may be embraced in one sentence - Having no depraved thoughts.*”, which was labeled with *Book of Poetry* and *Odes*.

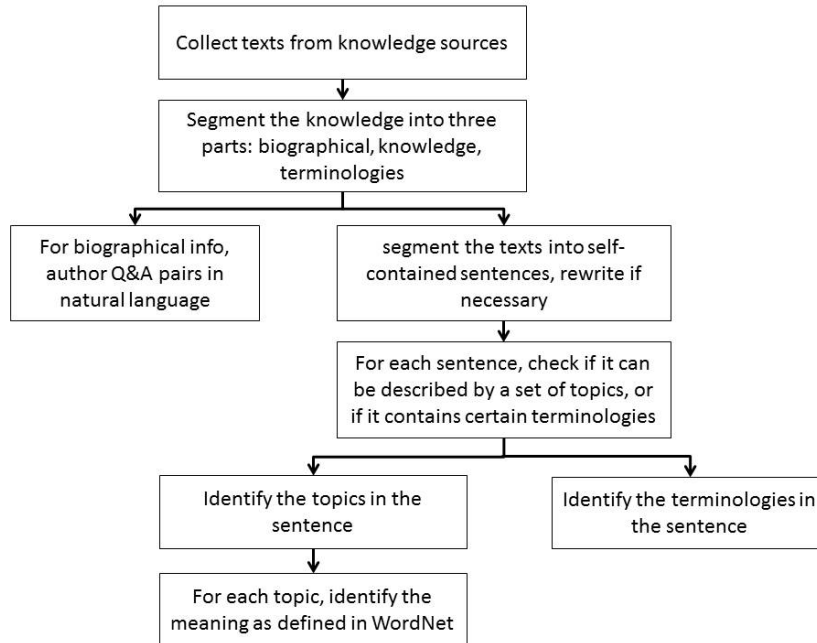
A total of 319 sentences were tagged with such keywords. A partial list of the tagging can be found in Appendix C-4.

## 3.5 Chapter summary

Building the knowledge base is the first step in creating a conversational system mimicking Confucius. Due to the highly specialized nature of the domain, we worked with the domain experts for the collection, segmentation and annotation of the text mate-

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**Figure 3.2:** Workflow for the domain experts to author the knowledge base

rials. The segmentation helps to make the knowledge base more structured and the algorithm design more targeted. Keeping all three kinds of knowledge in the system helps to provide the user a more holistic view of Confucius and his teachings - the system is no longer a dry information system that reacts passively to user inquiries, but a person in the virtual world that one can naturally talk to. Though Confucius's philosophy is thousands of years old, the wisdom in these sentences are still widely applicable today, directly addressing the very problems of our age and of our society [91].

The process of knowledge base creation requires intensive interdisciplinary collaboration. Usually, domain experts have limited knowledge on programming, whereas the computer scientists developing the system have limited understanding of the domain.

Existing work focuses on creating tools for easy authoring of the knowledge base contents for domain experts (e.g. [89]). However, the drawback is that it requires intensive human effort, especially for large domains. Taking a different approach, the method we developed requires minimal input from the domain experts, and they can complete authoring using software they are already familiar with (Microsoft Word, Excel, etc.), without the need to learn scripting language as in the case of authoring a chatbot.

The workflow for domain experts is summarized in Figure 3.2. The domain experts first divide the entire knowledge base into three parts: biographical information, knowledge statements, and terminologies. For biographical info, they only need to provide question and answer pairs in natural language, which will be automatically converted to the AIML using a script we wrote. They then segment the text collections into self-contained sentences, and for knowledge statements, identify the topics and their meanings in WordNet; for terminologies, identify the specific terminology in the sentence. They can finish most part of the annotation purely using their domain knowledge, only having to familiar themselves with WordNet, which is essentially like a dictionary in this case and thus very easy to use. The rest of the work will be handled by the program. This process has the advantage that it is easy to follow for people with little programming knowledge, allowing easy collaboration for people across disciplines.

### **3. BUILDING THE KNOWLEDGE BASE**

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## Chapter 4

# Design and Implementation

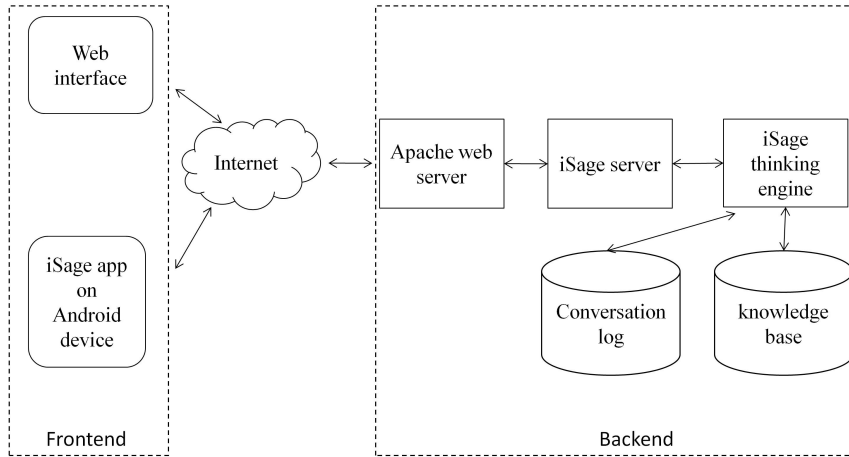
With the knowledge base constructed, a prototype system was developed. It consists of two main parts, a frontend interface from which users can input the utterance they would like to say to the virtual Confucius, and a backend processing unit for analysis of the input utterance and selection of response from the knowledge base. In this chapter, we will describe the design and implementation of each part of the prototype system in detail.

### 4.1 Overall architecture

Figure 4.1 shows the architecture of the overall system. Two frontend interfaces were developed: a web interface, and an Android application interface. User utterance received in the frontend interface, together with an anonymous user identifier are sent as an HTTP request to the server through the Internet. An Apache web server receives the incoming request, and forwards it to the iSage server we developed. The iSage

## 4. DESIGN AND IMPLEMENTATION

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**Figure 4.1: Architecture of the iSage system**

server talks to the iSage thinking engine, which is essentially a dialogue manager for the virtual Confucius. It conducts analysis of the incoming utterance, and chooses an appropriate answer from the knowledge base. It also logs the conversation to the database.

## 4.2 Backend

### 4.2.1 Dialogue manager design

The most important part of the backend program is the dialogue manager, named as the iSage thinking engine in Figure 4.1. It consists of three different modules: a pattern matching module, a semantic closeness matching module, as well as a keyword matching module. Each of these module is used to handle the different types of domain

knowledge as analyzed in the previous chapter. The user utterance goes through a sequential process through these three modules, stops for output whenever a suitable response can be found. Figure 4.2 shows the flow diagram of this process. Suitability of the output is evaluated by computing a quality score. If the quality score is above a certain threshold, the answer is used as the output. Otherwise, it goes to the next module. The three modules handle different types of inputs and thus complement each other.

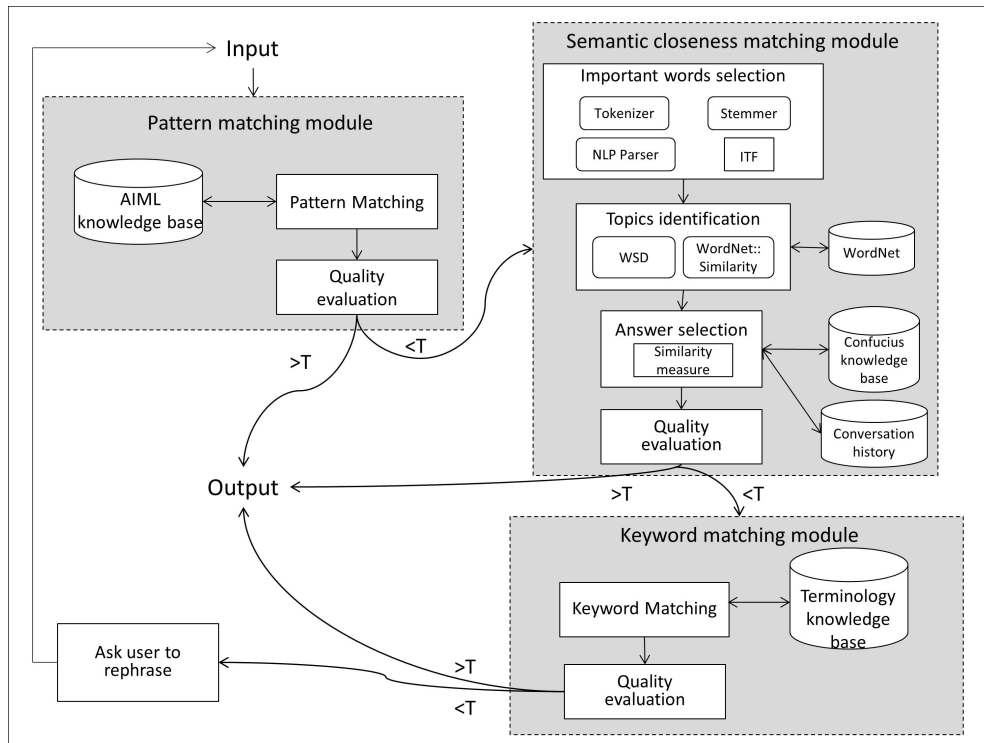


Figure 4.2: A flow diagram of the answer selection process

Table 4.1 summarizes the commonly used answer retrieval technologies in conversational agents and question answering systems. Based on the characteristics of the three kinds of knowledge we identified in the previous chapter, in each of the modules,

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we selected the technology that suits best the design of a virtual philosopher.

Firstly, as a virtual philosopher is a non-task oriented conversational agent and it does not have a well-defined domain, technologies used in task-oriented systems are not suitable for us. We assume that the conversation with a virtual philosopher is mainly an information seeking process. In this situation, common methods for dealing with conversation such as identifying the speech acts [42] are not applicable, because the main speech act would be asking for information/opinion. The system needs to have the ability to find a relevant answer to the question. In this sense, it is more like question answering. For this reason, we choose to model the problem of finding answers from the knowledge base as an information retrieval problem. Among the information retrieval techniques, the vector space model is selected as the retrieval method, because as an algebraic model, it does not require a huge amount of training data. Philosophy is subjective, so it is difficult to provide a fixed one-to-one mapping of QA pairs for all possible questions, which means we cannot easily get a large set of training data. Therefore, we choose an algebraic model which allows us to dynamically search the knowledge base and find relevant answers without the need for preparing QA pairs beforehand.

Secondly, the system is also different from a question answering system, because it has an identity and represents a particular person who many people know and are likely interested in knowing more about his personal life. That means the system should also be capable of handling such requests. Therefore, we chose to adopt the pattern matching technique, as it is a simple and proven method for dealing with such use

**Table 4.1:** Commonly used answer retrieval technologies

Technology	Mainly used in	Conditions
Keywords matching	Early chatbots, search engines	Need to be able to anticipate the questions (for chatbots)
Pattern matching/scripts	Chatbots, virtual humans	Need to be able to anticipate the questions
Belief-Desire-Intention (BDI) model	Task-oriented systems	Event-driven, goal-oriented decision-making tasks
state machines	Task-oriented systems	when the task can be broken down into sub-tasks (states)
frame-based slot filling	Task-oriented systems	when the task can be represented as a list of items
probabilistic models (e.g. belief network, language models)	Virtual humans, QA systems	when sufficient training data (QA pairs) is available
Algebraic models (e.g. vector space model)	QA systems	need to consider synonym terms in lexico-semantic resources in order to reduce false negatives
logical models	QA systems	when the query can be represented in logical forms

cases.

Lastly, the terminologies are handled using the simple keyword matching technique.

Details on the design of these three modules are presented below.

#### 4.2.1.1 Pattern matching module

As presented in the previous chapter, the biographical information is stored in AIML patterns and templates. In terms of the actual implementation, we adopted the Python ALICE chatterbot which is available online<sup>1</sup>, and modified it according to our requirements. Biographical knowledge was added, unrelated templates were deleted, and many of the templates were modified to be more Confucius-like. Although the design of AL-

<sup>1</sup><http://pyaiml.sourceforge.net/>

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ICE chatterbot allows it to provide an answer to any question using templates with wildcards, we do not want to rely on it too much, because the ultimate aim of the system is not to continue the conversation irregardless of the conversation content, but rather to provide useful information whenever possible. Therefore, we developed a quality evaluation measure to decide whether or not the template answer should be used as an output. The basic idea is to penalize the “tricks” used in chatbots, as discussed in Chapter 2. We consider the general answer template for patterns with wildcard as less constructive, and exert certain penalty to it. In addition, a penalty is imposed on templates that were randomly selected from a few candidates. If the quality score is above a empirically chosen threshold value, the answer is selected as Confucius’s reply. Otherwise, the answer is discarded and the system calls the next module for a more informative answer.

### 4.2.1.2 Semantic closeness matching module

The main purpose of the system is to allow users to know more about Confucius’s philosophy through a conversation with him. As it is, if at all possible, extremely time-consuming and labor-intensive to put all the knowledge into AIML templates and prepare answers for every question, automatic methods should be used to achieve this goal (at least partially). Therefore, we developed a semantic closeness matching module, which uses a series of natural language processing techniques to analyze the user utterance and select the answer automatically. In this module, the user utterance is syntactically and semantically analyzed to extract important words as well as their

meanings. The topics of this sentence are then compared with a list of domain topics, and a relevant answer is retrieved based on the semantic closeness.

The problem of finding a relevant answer from the knowledge base is modeled as an Information Retrieval (IR) problem [86]. Essentially, IR aims to identify the most relevant document/text to answer a user's query, based on certain similarity measure. In the context of our system, the user's query is the user's utterance to the virtual Confucius, and the document/text is the sentences stored in the knowledge base. We adopt the Vector Space Model, a classical approach to text information retrieval [86, 137]. In Vector Space Model, each document and each query is represented as a vector in a (very) high dimensional space, where each dimension of the space represents one topic/word. The dot product of the vectors, also referred to as the cosine similarity (when the vectors are normalized), measures the angle between the vectors, reflecting how much the two vectors diverge or tend to be similar. In our case, the high dimensional space is formed by the collection of 268 topics identified by the domain experts, and each user utterance is transformed as a vector in this space through the following process.

There are three stages in the process: important words selection, topics identification, and answer selection. In the Important Words Selection stage, the user input is first fed into a parser [78] that analyzes the grammatical structure of the sentence. We then select the head words [70], the last noun of each noun phrase, as the important words. In addition, we look up an Inverse Term Frequency (ITF) [26] database to select the less frequent words as the important words, based on the heuristics that

#### 4. DESIGN AND IMPLEMENTATION

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the frequent words such as “the”, “my” do not contain much information, whereas the less frequent words, for example, “loyal”, “conflict”, are more important. The ITF database is built by calculating the frequency of appearance of each word in a large corpus. Combining the results from the above two methods, a list of important words can be extracted from the user input. Furthermore, the user input is passed through a Word Sense Disambiguation (WSD) module [119] to get the meaning of these words in the context.

Next, we need to compare the semantic relatedness of the words selected from the input sentence, with the list of topics in the knowledge base, in order to find the topics of the input sentence. This is done using a WordNet-based similarity module `WordNet::Similarity` [118], which computes a semantic relatedness score for any given pair of words. WordNet is a lexical database of English, a project initiated in the 1980s and carried out for several decades by researchers from Princeton University [47]. It organizes concepts in *is-a-kind-of* hierarchy (e.g. *apple* is a kind of *fruit*, *drive* is a way to *operate*), and also provides non-hierarchical relations (e.g. *has-part*, *is-made-of*, *is-an-attribute-of*, *similar-to* etc.) between concepts. In addition, for each unique meaning of each word, a synonym set (also called *synset*) is given, and each synset has a definition or gloss that explains its meaning. In our work, we used WordNet version 3.0, which contains 155,287 words, 117,659 synsets, and a total of 206,941 word-sense pairs (It can be obtained freely from <http://wordnet.princeton.edu/wordnet/download/>).

Based on the definitions and relational information provided by WordNet, it is possible to develop a measure to determine how similar or how related two concepts



are. Many measures have been proposed, some based on the path length between concepts, and others based on the text of glosses of the concepts [118]. Some of the measures can only calculate the similarity of concepts with the same part-of-speech. In our system, we used the *vector* measure [116] implementation in WordNet::Similarity, which represents each gloss as a vector in the space made up of all the WordNet glosses, and calculates the cosine between the vectors. This method is able to calculate the relatedness of any pair of concepts, irregardless of their part-of-speech. The relatedness score is in the range of 0 to 1.

For each important word selected, we calculate the relatedness score between it and each topic in the topic list. In order to reduce noise, an empirically determined threshold is applied, which set the relatedness score to 0 if it is not significant. The final value for each topic is the summation of its relatedness scores for each important word. Through this step, the input sentence is digitized as a point in the high dimensional space of topics. It can be represented as a vector  $\vec{v}_i$ :

$$\vec{v}_i = \sum_{k=1}^m \varphi(\text{sim}(w_k, p_1)) \vec{t}_1 + \dots + \sum_{k=1}^m \varphi(\text{sim}(w_k, p_n)) \vec{t}_n \quad (4.1)$$

where  $m$  is the number of important words extracted from the input sentence,  $n$  is the total number of topics,  $\vec{t}_n$  is the basis vector representing the  $n$ th topic,  $\text{sim}(w, p)$  is the similarity score between word  $w$  and topic  $p$  using WordNet::Similarity, and

$$\varphi(x) = \begin{cases} x & \text{if } x > \text{threshold} \\ 0 & \text{otherwise} \end{cases}$$

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Finally, the process enters the answer selection stage. The fitness of a sentence as an output to a certain input is assessed by the cosine similarity of the two vectors. The score  $S$  for a database entry  $j$  (represented as  $\vec{d}_j$ , see Chapter 3 for more details) is

$$S_{ij} = \frac{\vec{v}_i \cdot \vec{d}_j}{|\vec{v}_i| |\vec{d}_j|} \quad (4.2)$$

The database entry with the closest and sufficiently small distance is selected as the output.

In addition, a non-repeat feature was implemented. A human would seldom answer the same or similar questions with exactly the same response. Therefore, for the system to be more human-like, it should not blindly repeat itself. To realize this, whenever a candidate answer is found, the system searches through the conversation history of this particular user. If the same sentence was used as a reply in the past one hour, the system chooses the next best new answer in order not to repeat itself. This helps to make the conversation less machine-like and more natural. In the end, if no suitable answer can be found, the process enters the next stage.

**Incorporating more experts' opinions** The initial annotation of the database was done by one domain expert. As the understanding of Confucius philosophy is subjective, different people may have different interpretations of the same sentence. Ideally, to avoid bias from a particular person, it is better to have more domain experts to work on the annotation. With data provided from a few experts, k-nearest neighbor algorithm (KNN), a simple and widely used algorithm in text classification, can be

added to the system, and the final answer selection follows the majority vote of the results obtained from each experts' annotation. Figure 4.3 shows the flowchart of the semantic closeness matching module with KNN. We have implemented a sub system based on this idea. Due to time and resources constraints, it was only performed on a subset of the whole knowledge base that we have built, where we had 5 Confucius scholars to manually annotate 108 knowledge base entries about *family issues*. There are a total of 23 sub topics used here (shown in Table 4.2).

The example below shows a walk-through of a retrieval using the Semantic Module with KNN. In this example, the input sentence to the system is “*What would cause the instability of a family and how should we stay united?*”. Following is the output generated from each step of the Semantic Module. The corresponding functions responsible for each intermediate step are noted with alphabetic labels as in Figure 4.3.

```
Input :
What would cause the instability of a family and how should we
    stay united?
Parsing the sentence ... (a)
Headwords selected :
[instability , family]
Finding inverse term frequency for each word in the sentence
    ... (b)
Other keywords selected :
[united]
```

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**Table 4.2:** List of topics in the sub system on family issues

Topic No.	Topic Description
1	Entry is related to parents.
2	Entry is related to the children in a familial context.
3	Entry is related to sibling.
4	Entry makes references to the young in the general sense or as a collective group of people.
5	Entry is related to the elderly.
6	Entry is related to the ancestors.
7	Entry is related to rites and ceremony.
8	Entry is related to obedient behavior or conduct.
9	Entry is related to either conflict or harmony in the family.
10	Entry is related to love.
11	Entry is related to respect or reverence.
12	Entry is related to treat or serve another person.
13	Entry is related to death.
14	Entry is concerned about being morally upright.
15	Entry is related to marriage.
16	Entry is related to food.
17	Entry is related to the transmission or acquisition of knowledge.
18	Entry is related to money.
19	Entry is related to filial (Only if the entry is directly talking about filial and not for those that implied filial).
20	Entry is related to relatives or neighbors.
21	Entry is related to health or well-being.
22	Entry is related to family (Only for general entry that refers to family. If the entry refers to specific family members like father and mother, please choose other topics)
23	Entry is related to friends or peers.

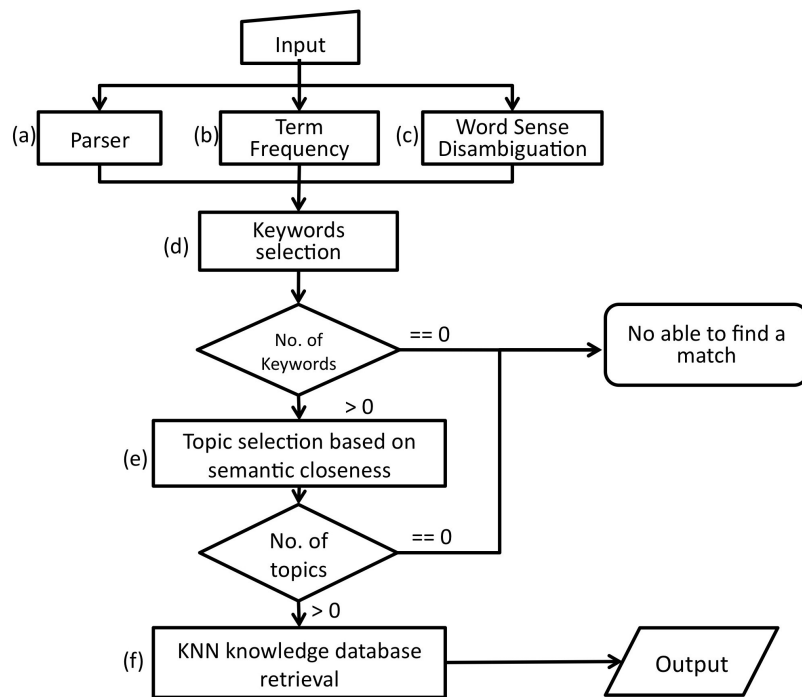


Figure 4.3: A flow diagram of the semantic module with KNN

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```
Running WSD module...(c)
Sense of each word in the sentence:
[cause#n#5, instability#n#3, family#n#5, stay#v#1, unite#v#1]
All the keywords selected from this sentence and their senses:
    (d)
[instability#n#3, family#n#5, unite#v#1]
Calculating relatedness score for each topic...(e)
Scores for each topic (in order of topic number):
[0, 0, 0, 0, 0, 0, 0, 0, 1.000000000000003, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0.37791696839380001, 0.40501119228353599,
    1.5631383835016111, 0]
Calculating similarity between the input sentence and
    knowledge base entries...(f)
Top three entries selected using k-NN:
[1283, 1970, 1283]
System output:
1283 A family must first destroy itself before others can
    destroy it.
```

The system selects the keywords of the input sentence using two methods, head-words and inverse term frequency. The output of WSD module is in the format *word#part\_of\_speech#sense\_number*. For example, *instability#n#3* is the third

sense of the noun instability, which is “a lack of balance or a state of disequilibrium”. The selected keywords with their corresponding senses in the sentence are *instability#n#3*, *family#n#5*, *unite#v#1*. Based on the keywords, the system identifies the topics through the semantic similarity of the keywords and topics. In this example, the system is able to correctly determine the topics based on the input sentence. The topics with highest scores are No. 22 and No. 9, which correspond to the topic “family” and “harmony” respectively. The input sentence is then transformed as a vector, with the relatedness score as the weight for each topic. The system then calculates the score for each of the database entry, using equation 4.2. In this case, the three closest entries are two votes for entry No. 1283 (which corresponds to the entry “*A family must first destroy itself before others can destroy it.*”, and one vote for No. 1970 (which corresponds to the entry “*It is said in the Book of Poetry that happy union with wife and children is like the music of lutes and harps. When there is concord among brethren, the harmony is delightful and enduring.*”). The number (e.g. 1283) refers to the index of the entry in the knowledge base. Based on the majority votes from the three closest neighbors, 1283 is the entry selected for output.

#### 4.2.1.3 Keyword matching module

In the keyword matching module, a simple string comparison between the keywords in the database and the user input is carried out. Each matched word would increase the matching score for that database entry by 1. The entry with the highest score is selected for output. If, at this stage, still no suitable answer can be extracted, the

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system will ask the user to rephrase the question. This is done by simply outputting a predefined sentence saying “I’m sorry, I don’t quite understand. Could you rephrase your question please?”.

### 4.2.2 Implementation

The backend programs were developed on a Dell Server with Intel Core i5-2310 CUP @ 2.90 GHz and 16 GB of RAM, running Windows Server 2008 R2 Standard edition. The main backend programs were written in Python (version 2.5), a language that is very suitable for text processing. In addition, the following open source packages were used: NLTK version 2.0b8, WordNet v3.0, WordNet::Similarity v2.05, WordNet::SenseRelate v0.19, the Stanford Parser version 1.6.1. MySQL 5.5.8, Apache 2.2.17, PHP 5.3.5, and Perl 5.10.1.

### 4.2.3 Comparing the performance of the agent with human experts

To determine the effectiveness of the KNN approach and get a general idea of how the system performs as compared to human experts, we conducted a test to check the accuracy of the classifier. The same five domain experts who worked on the annotation were asked to provide a set of input-output pairs. For each knowledge base entry, the experts composed an input sentence, which in their opinions should trigger the entry as the virtual Confucius’s response. The input sentence could be either a question or a statement. For each of the 108 input sentences, the scholars identified two to three keywords. Then, for each keyword, they identified at least one topic from the list in



**Table 4.3:** Accuracy of the system using different training sets

Training set	Total number of output entries	Number of output matched	Accuracy
Set 1-4 (KNN)	108	46	42.59%
Set 1	108	36	33.33%
Set 2	108	35	32.41%
Set 3	108	26	24.07%
Set 4	108	35	32.41%

Table 4.2. A maximum of three topics were allowed to be assigned to an input sentence.

Out of the five sets of input-output data provided by the domain experts, one was randomly chosen as the test set. We trained the system using each of the remaining four set as well as using all four sets, and we compared the output accuracy, which was defined as the fraction of outputs that were the same as those selected by the expert in the test set. The result is shown in Table 4.3. With the KNN method, an accuracy improvement of 12.04% was observed when compared with average performance of Set 1 to 4. Comparing to the worst case Set 3, an improvement of 18.52% was observed.

Note that even though the KNN method improves the output accuracy, the number is still not very high. We argue that this number is only partially indicative of the *relative* performance of the different methods, and should not be considered as a good indicator of the *actual* performance. As discussed, the understanding of philosophy is subjective and there is no single right answer. In fact, we also checked the keyword and topic identification accuracy, and the results were encouraging - the former being 88.72% and the later 81.2%. This means that the system can, in most cases, identify the topic of the user input and output a relevant sentence, which may or may not

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be the exact same sentence chosen by the expert. The fact that the performances of the system trained by each individual annotation differ reveals that even the experts themselves disagree from time to time. So sometimes even when the system output is different from the expert's selection, it does not necessarily mean that this is a bad output. A manual investigation on the answers provided by the system showed that in some of such cases, the outputs are still quite reasonable. For example, one input sentence given by the expert is, "*What kind of action should a son uphold for him to be considered filial?*" The answer selected by the expert is "*If the son for three years does not alter from the way of his father, he may be called filial*". The answer selected by our algorithm is "*A filial son does not transgress what is due from him in all the sphere beyond himself*", which is also a reasonable output. Therefore, we expect the actual performance of the system to be better than the figures reported here.

In traditional information retrieval scenarios, the retrieved answer can easily be determined to be relevant or irrelevant, correct or incorrect, and we can build a gold standard dataset, test and compare different algorithms on this same set (for example, the TREC datasets<sup>1</sup>). For answer retrieval in the philosophy domain, the rigid performance indicators are not very suitable, as each answer is subject to personal interpretation, and different people may have different opinions. So what is more important is not how well the answer tallies with one or a few experts' opinions, but rather what the person who actually uses the system thinks. Therefore, in our subsequent research, instead of evaluating the system using the common metrics in question

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<sup>1</sup><http://trec.nist.gov/data.html>

answering (e.g. precision, recall, F1 score, etc), we focused on user evaluations through quantitative and qualitative feedback.

### 4.3 Frontend

Two different frontend interfaces were developed for users to easily access the system via internet. As this is our first prototype, we wanted to focus on the main feature, which is conversation. Therefore, we chose to simplify other aspects of the frontend interface. For both interfaces, text input instead of speech is used, and a still picture of Confucius is displayed, rather than fancy animations. Technology such as speech recognition, lip syncing, and animations are quite mature, and they could be added to the system later.

#### 4.3.1 Web interface

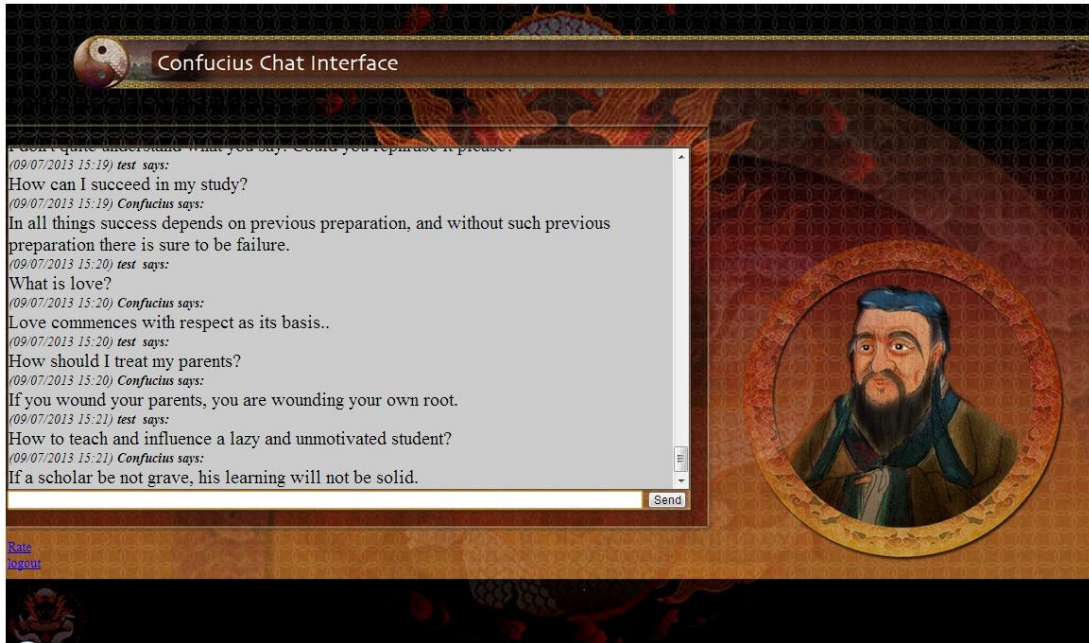
Initially, a web interface (Figure 4.4) was built to allow people to access the system. It is designed to be like a typical chat interface that people use to talk to real person in everyday life. A user name and password are required to log into the system.

#### 4.3.2 Mobile interface

In order to make the system more accessible, a mobile version was developed (Figure 4.5). The mobile application runs on the Android platform. In this mobile version, in addition to the main function for conversation with the virtual Confucius, a few other features were also incorporated.

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**Figure 4.4:** A screenshot of the web interface

Figure 4.5 (a) shows a screenshot of the application when it is opened for the first time. Users are informed that this application is part of a research project and the data will be logged anonymously for research purpose. After they acknowledge it, the main page is shown as in Figure 4.5 (b). To chat with the virtual Confucius, users can type in the question in the text box, and press the green “Ask” button next to it (Figure 4.5 (c)). The question is then sent to the server, which sends back Confucius’s answer after processing. The answer is displayed in the area above the text input, as shown in Figure 4.5 (d). Users can share the answer to their friends on their social networks, such as Facebook, Twitter (Figure 4.5 (e)). We hope to leverage the power of social networks to further promote the interaction with culture.

Users can also rate the given answer if they think the answer is funny, profound,



Figure 4.5: Screenshots of the Android interface

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or bad, by pressing the corresponding icons at the bottom of the screen. The “Bad” rating works as a feedback to us to help find out the problem of the algorithm so that we can improve it further. By tapping the “Top” icon, users are led to another page where they can see the top 10 most funny and most profound question and answer pairs from all the users (Figure 4.5 (f)). The latest 10 question and answer pairs can also be viewed (Figure 4.5 (g)). This allows users to see what other people are asking the virtual Confucius, so that they can get more inspirations or just to have a laugh. Users can also vote for the question and answer pairs here, simply by tapping the area they are displayed (Figure 4.5 (h)).

### 4.4 Example output

Table 4.4 shows some sample answers of the system, returned by invoking each of the modules in the virtual sage thinking engine.

### 4.5 Chapter summary

In this chapter, we gave a detailed description of the prototype system of a virtual Confucius capable of having text-based conversation with human users. The system consists of a backend program which selects the answer from the knowledge base using various methods, and two frontend interfaces that can be used to access the system. This prototype system, though not able to fully replicate the conversation ability of the real Confucius, serves as a testbed for studying people’s interaction with the virtual

**Table 4.4:** Example answers from the system

Dialogues	Method
Q: What is your name? A: My formal name is Kong Qiu, also known as Zhong Ni. I am commonly known in the West as Confucius.	Pattern matching
Q: How old are you? A: I am about 2500 years old.	Pattern matching
Q: How should I treat my parents? A: A son of all comprehensive virtue serves his parents as he serves Heaven.	Semantic closeness matching
Q: What kind of action should a son uphold for him to be considered filial? A: A filial son does not transgress what is due from him in all the sphere beyond himself.	Semantic closeness matching
Q: Tell me something about the Book of Poetry. A: It is said in the Book of Poetry: be always studious in order to be in harmony with the ordinances of Heaven, you will certainly get for yourself much happiness.	Keyword matching

philosopher, and the studies based on this prototype will be presented in the next chapter.

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## Chapter 5

# Evaluation Studies on Prototype

## I

For task-oriented conversational systems, a standard way for evaluation is to measure through a set of metrics, such as task correctness, time, error rate, time to learn, etc. Such metrics are appropriate and useful only in situations where the usage of the system can be broken down into specific and quantifiable tasks. On the contrary, non-task oriented systems do not have a specific task, and some don't even have a well-defined domain. Thus, different evaluation measures are needed, and qualitative analysis, such as observations, interviews are often useful. In this chapter, we present three evaluation studies carried out on different sub-versions of the first prototype.

### 5.1 Public user trial

#### 5.1.1 Participant demography

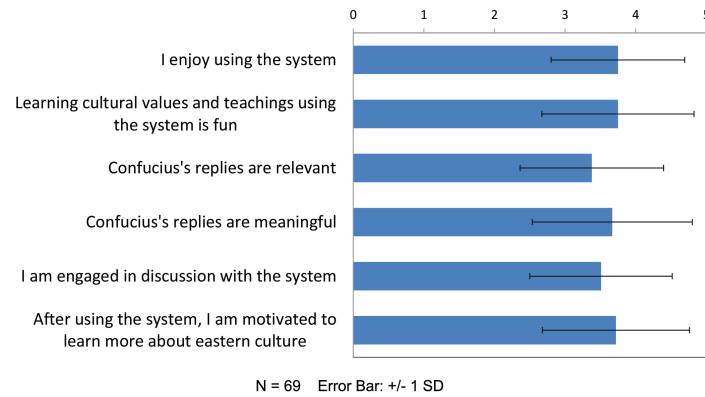
We carried out a public trial of the system in 2010 during a community event in a local residential estate, Punggol, in Singapore. Residents in the area were free to participate in this event, and we invited them to try our system. A total of 69 users participated in the study, ranging from young children to middle-aged people. The demographic information showed generally good English comprehension skills (3.72/5) and familiarity with online chat application (3.66/5) on a 5-point scale.

#### 5.1.2 Procedure

We set up a booth with four computers running the KNN version of the system with a knowledge base on family-related topics (described in Figure 4.3 in Section 4.2). The participants were first briefly introduced about Confucius and the system, and were asked to use the system to talk to the virtual Confucius about family-related topics for about 10 minutes (or longer if they want). After that, they were asked to fill in a questionnaire and do a short interview about their experiences and their opinions on the system.

#### 5.1.3 Results and discussions

The trial was successful and the system appeared to be well received by the public. Many participants were curious and excited to try the system, some even queued up. The participants' quantitative and qualitative evaluations of the system were generally



**Figure 5.1:** User evaluation results from the questionnaire.

positive. Figure 5.1 shows the scores for the statements in the questionnaire, with 1 being strongly disagree, and 5 being strongly agree. It showed that users in general enjoyed and engaged in the interaction.

Though we told the users to use the system for about 10 minutes, many users, especially young users, used it for longer period of time and frequently discussed in excitement with their friends during the interaction. There was also one user, a young Singaporean women, who continued to talk to the virtual Confucius for as long as half an hour. She appeared to be very focused and drawn to the chat process, and would often ponder on the system's responses for some time before continuing the conversation. When she finished, she explained to us that she was currently having some problems with her family, and talking to Confucius really helped her to understand how the Chinese perceive the family relationships. This allowed us to see the value of this system, and it has greatly encouraged and motivated us to continue the development so that it can help more people who are genuinely interested in learning about Confucius's philosophy.

## 5. EVALUATION STUDIES ON PROTOTYPE I

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We found that users had the tendency to anthropomorphize the agent and treat the virtual Confucius as a social actor [111, 125]. They observed social etiquette with Confucius and exchanged social greetings, e.g. hello, thanks, bye, etc. They also tried to find out about Confucius as a person by understanding his background, asking questions about his name, his age, his family, etc. In addition, some of the users, especially young users, engaged in playful casual conversation with the virtual Confucius. This indicates that the mere presentation of the chat interface with a still image of Confucius is enough to elicit anthropomorphic attributes, and users are willing to talk to the agent as if they are talking to a real person. Regarding the virtual Confucius as a social actor motivates users to ask the agent questions and further their interactions with the virtual Confucius, mimicking human-to-human conversations. Each interaction presents an opportunity for the agent to introduce users to Confucian values.

During the interview, when asked about their opinions on the real Confucius and his books, many users expressed the stereotypical view of him being “a lofty ideal”, “serious”, or “boring”, and the books “difficult to read/understand”, and they did not actively seek to learn about Confucius’s philosophy or discuss it with other people. However, in our study, we found when given the opportunity to “speak to Confucius directly”, many people were excited and eager to try it out. During the interview, most users also expressed their preference for using the virtual Confucius system to learn about traditional cultural values over books or other media, because the interactive element of the system makes it more interesting. One user commented, “*Confucius Chat is better as there is two-party communication.*” Others mentioned “*(it is) faster*

*to get answer compared to other media*”, “*(I like the system) because we can ask any question (to the virtual Confucius)*”. These user feedback suggests that the unique identity and interactivity afforded by the system makes it more appealing to the users. By allowing users to directly have a casual conversation with the virtual Confucius, it adds entertainment value to the interaction, and makes users to be more willing to learn about his philosophy. As also reflected in the questionnaire, many users agreed that they were motivated to learn about eastern culture after using the system.

Besides casual conversations, users also engaged in more serious conversations with the virtual Confucius to get his advice on family interpersonal relationship, for example “*how to be filial*”, or “*conflict between siblings*”. A young user mentioned during the interview, “*When I get scolded from my mother, I can tell Confucius!*” In the following example, this user was experiencing frustration because her parents scolded her. She tried to ask the system for help in resolving the tension.

User: *my sister always share things with me but my parents will scold me some time*

Confucius: *If you wound your parents, you are wounding your own root.*

In this case, this interaction serves as an opportunity for user to learn about Confucius values by relating to their own experiences. The statement “*if you wound your parents, you are wounding your own root*” is merely a statement suggesting that one should not hurt one’s own parents because it is like hurting a part of oneself. However, when the user received the response, the statement was put into the context of

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the question and the interpretation became more nuanced. Based on the question, the interpretation of the statement becomes something like “Even if I am sad that I was scolded by my parents, I should not do anything to hurt them because it would be like hurting myself. I need to find another way to resolve the problem instead of getting upset or doing something that will hurt my parents”. The conversational nature of the interaction with Confucius motivates users to reflect upon the meaning of the classical Confucian text and contextualizing it. As users try to relate it back to their own context, they are internalizing Confucius teachings, in this case, filial piety, one of the essence in traditional Chinese culture, thus leading to more effective learning.

In addition, the philosophical output of Confucius is thought-provoking and this encourages further interaction, as demonstrated in the example below:

User: *How do you deal with people who are rude to you?*

Confucius: *When punishments are not properly awarded, the people do not know how to conduct themselves.*

User: *when is punishment too much*

Confucius: *If good men were to govern a country in succession for a hundred years, they would be able to dispense with capital punishments.*

The question triggered a response “*When punishments are not properly awarded, the people do not know how to conduct themselves*”. The user was apparently intrigued and continued with a follow-up question, “when is punishment too much?” In this way, the system can extend the interaction and prolong engagement with the user. Further queries about Confucius’s original response may also lead to a better understanding of

the cultural values.

From this public trial of the early prototype, we found that the anthropomorphism and interactivity of the system make it appealing to users, and being engaged in a conversation allows contextualized understanding and learning. This suggests the conversational agent approach is a promising way for people to learn about philosophy. However, we also found that although we explicitly told the users to restrict their conversations to topics related to family, many of them did not follow this rule. Some even asked why there was such a restriction and suggested it would be better to be able to ask any questions. It was also apparent that our knowledge base was not big enough to handle the variety of utterances from the users. Therefore, in our next step, we decided to focus on building an agent that handles open conversations.

## 5.2 Lab-based user evaluation

In this study, we carried out a lab-based user evaluation on the system with the complete knowledge base. This allows us to have an idea of how the whole system performs and gather feedback on how to improve the system.

### 5.2.1 Participant demography

Twenty participants (15 male and 5 female) were recruited through an email invitation about the study. All of them were university researchers or students, and were under the age of 35 (5 were 18-25, 14 were 26-30, 1 was 31-35), representing the relatively younger generation who are not so familiar with traditional culture, but are frequent

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users of the Internet and multimedia [141]. Nineteen of them had experiences or were very familiar with mobile applications. The participants came from a variety of ethnic groups, but were all Asian except one.

### 5.2.2 Procedure

The participants were first informed that they were going to interact with a virtual Confucius, which was a computer program that tried to mimic the real Confucius. They could ask the virtual Confucius questions, through a text-based interface - a mobile application running on a Samsung Galaxy 10.1 Tablet. They could ask any questions they like to Confucius.

The participants were asked to interact with the system for about 10 minutes and fill in an online questionnaire afterwards, where they were asked to rate their experiences and opinions based on a 5-point Likert scale. A few open-ended questions about the system were also asked. The questionnaire used in the study is shown in Appendix B “User study for iSage: An Interactive Virtual Philosopher”.

### 5.2.3 Results and discussions

The user evaluation was generally positive and encouraging, and it also revealed a number of problems. When asked about the merits of the system, users gave answers such as “*mobile client*”, “*philosophical answers*”, “*getting intelligence from any problems around me*”, “*tries to bring ancient knowledge about good way of living into modern world where everything runs on money and culture is forgotten*”, “*It’s a good app for*



*people to make fun and kill time*".

A summary of users' responses to the rating questions are presented as bar charts in Figure 5.2.

### 5.2.3.1 Hindrances to philosophy learning

The background survey showed that 90% of the users knew nothing or only a little about Confucius' philosophy. When asked what may have hindered their philosophy learning, more than half said it was because of lack of time (see Figure 5.3 for details). Other reasons provided by the users included "*not enough interest to look for information on my own*", and "*not enough reported in the media*". This suggests that time and interest are the main problems.

### 5.2.3.2 Users' perception on the prototype

#### Usability of the system

95% of the users considered the interface easy to understand and easy to use. The design resembled the chat interface we use on our mobile phone, so it was very clear to the users how to use it. After some brief explanation and demo, all users could use the system without any problem. A most frequently mentioned advantage of the system was its usability: "*The user interface is simple and easy to use*", "*Nice, easy to use system. Everybody would like to chat with the Confucius*".

One user mentioned that it would be good to show the chat history with a scroll function instead of showing only the most recent answer, and another pointed out a

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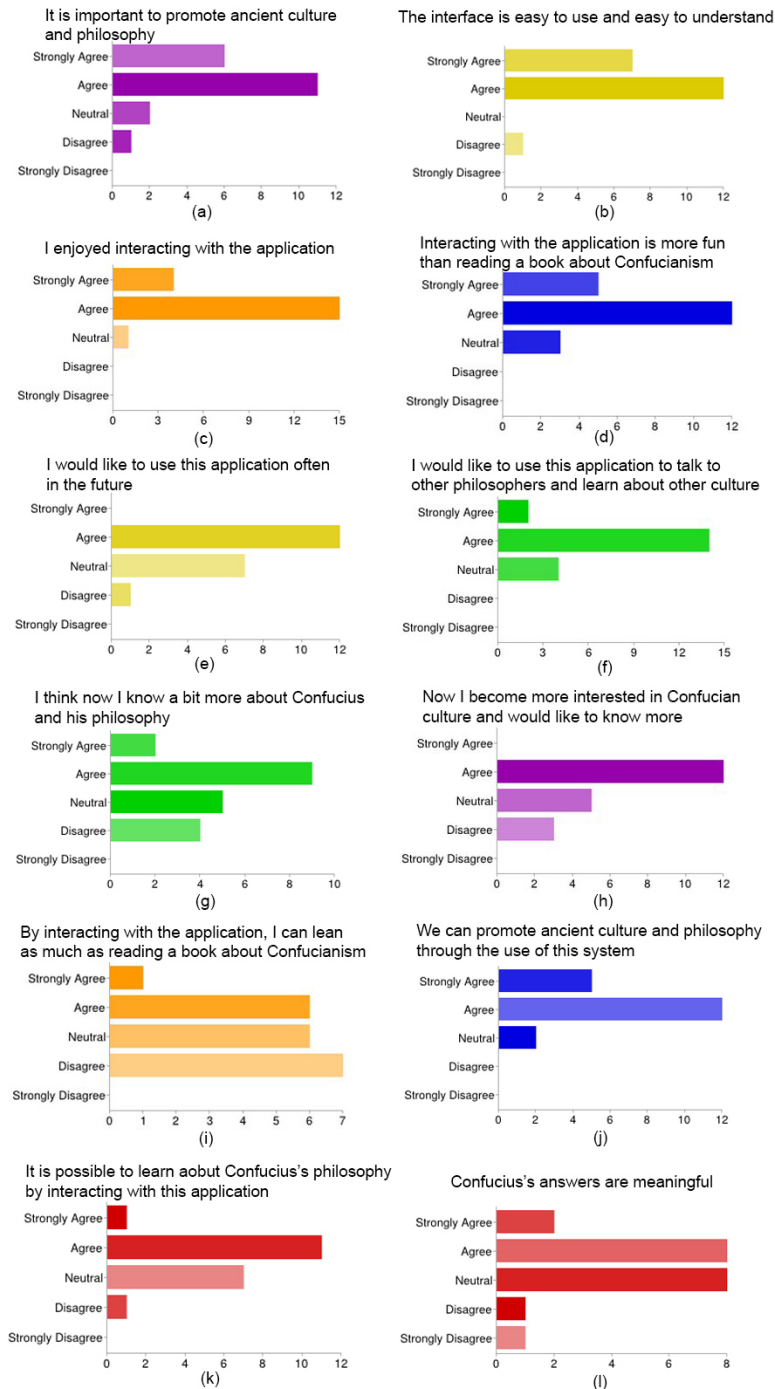
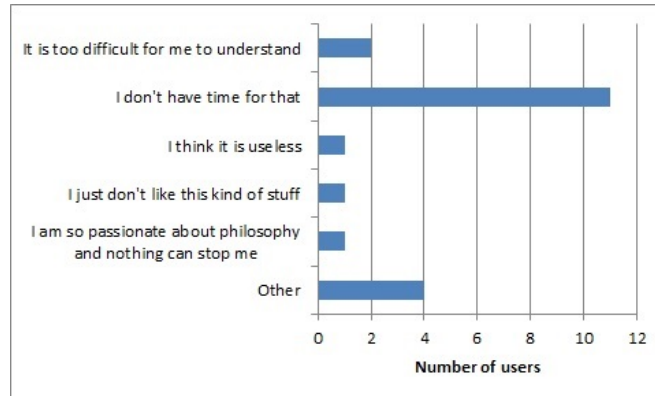


Figure 5.2: Results of the questionnaire from the user study



**Figure 5.3: Hindrances to learning about philosophy**

few improvements that could be made on the GUI such as increasing the size of the text box.

### **Enjoyment**

During the experiment, we could often observe users showing excitement when introduced about the system, and they sometimes smile or laugh when they received the response from the virtual Confucius. In the post-test questionnaire, all participants except one reported that they enjoyed interacting with the application. 85% of the users thought that interacting with the application is more fun than reading a book about Confucius. We also got positive responses from majority of the users indicating that they would like to use this application again and also use it to talk to other philosophers. Some comments from the participants were *“it is very user friendly and interesting”*, *“the idea and the vision is interesting”*.

### **Efficacy**

As book reading is a traditional way of learning philosophy, in the questionnaire, we also asked the users whether they thought the application could achieve the same

## 5. EVALUATION STUDIES ON PROTOTYPE I

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learning effect as reading a book. Most of them held a conservative view: only 7 out of 20 agreed or strongly agreed. This is perhaps not surprising, as book reading has always been considered the proper way to acquire knowledge, especially for this kind of philosophical knowledge which requires one to take time to delve into, to reflect and distill. This is in accordance with a similar previous study by Mori et al. [106], who conducted a between-subjects experiment to compare the learning quality of having a conversation with a NPC in a game to learn about the life and art of the artist Luca Cambiaso, versus reading a short note with the same information. It was found that the learning quality of reading a text was significantly higher. However, the interactivity afforded by the system does help to make the contents more appealing and accessible. Through the interaction, they can learn a little bit more than they previously do about philosophy, and hopefully, some people can get aroused in philosophy and proceed to a proper study through traditional means. In our study, though users may not be able to learn much in a 10-minute session, many of them (60%) reported an increased interest in Confucian philosophy, and that is a promising sign for the potential of this application.

It is perhaps unfair to compare this system with books, as they are fundamentally different things and serve different purposes. Book reading requires a considerable amount of dedicated time, and it is often driven by interest (or need). By carefully reading a book, one can learn a lot of things from its rich content. Chatting is a casual activity that many people do everyday, and it can be as short or as long as one want. But chatting is not useless: through the conversation with a person, we can learn about

this person, obtain new information, get advice, support, etc. For some people, they may never pick up a book and read the *Analects*, but if they are presented with an entertaining interactive system, they are much more likely to try it out and play with it. For example, one user commented “*youth can be interested learn these philosophical thinking via digital technology, which they are much more familiar now*”. Our system, though it cannot yet simulate the full capability of chat (since right now it is only question and answering), it may still serve as a starting point for people to get to know about philosophy and culture.

### Meaningfulness

Any good conversational agent should always respond in a sensible way, just like any intelligent human beings. In our questionnaire, we asked users to rate to what extent they consider the virtual Confucius’ answer to be “meaningful”, which means it is sensible, not nonsense. Although some users commented positively on the meaningfulness of the answers given by the system, for example, “*answered some of my questions pretty logically, and seem to comprehend the nature of my question*”, half of the users were either neutral or disagree. During the study, we could observe users sometimes appeared to be confused - they frowned when reading the response or slightly shook their heads. The most frequently mentioned problem in the open question section was about the answer quality. One user commented, “*Confucius does not have an answer for modern era related questions*”. Another said, “*some of his answers are vague sometimes I am not sure if Confucius misunderstood my question*”. Besides the benefits, the study also helped us to find limitations of the system. Though the rating results on

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answer quality is positive, they are relatively lower as compared to other ratings (see Figure 5.1). A few users reported in the interview that sometimes it was difficult to understand Confucius’s response. This is partly attributed to the inherent suggestive nature of Chinese philosophy, and partly to the deficiency of our current algorithm. Getting a computer to talk (even just in text format) like a human is an extremely challenging task, especially in the philosophy domain. It is revealed through the study that there are still many problems with our current algorithm and the AI should be improved to provide a better user experience.

### 5.2.3.3 Users’ expectation of a virtual philosopher system

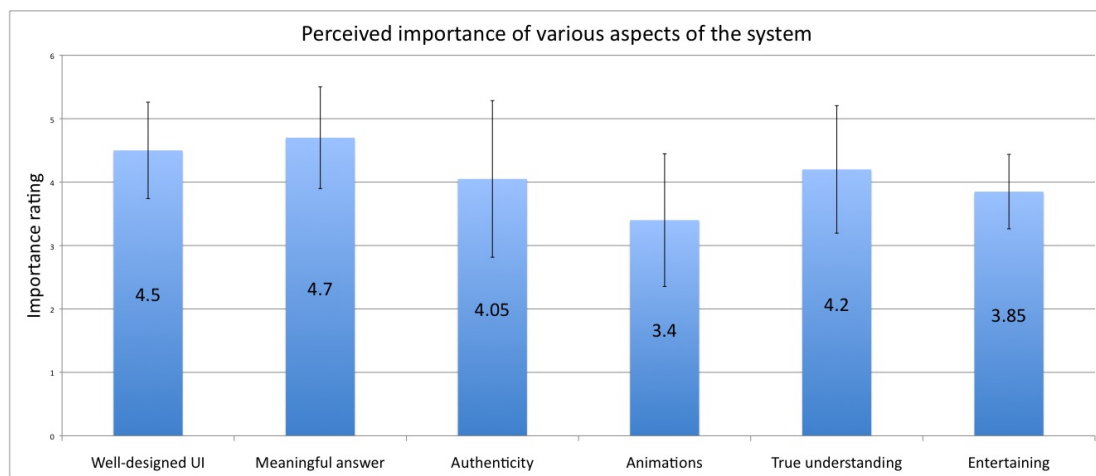


Figure 5.4: Users’ perceived importance of various factors of the system

We asked users to suggest the improvements that can be made to the system. Many users seemed to be very interested in the idea of embedding philosophy into interaction, and were enthusiastic on the possibilities it can bring. A few users suggested we should add “*voice-based interaction*” to make the interaction more natural and easy

to use. One user gave the example of Siri and suggested we make a “*Siri-Confucius version*”. Some recommended to use information in addition to the text input from user, such as “*sensors, time, weather, seasons, social network activity, etc.*” to give more contextualized answers. Another suggested other interactive experiences: “*Not only simply ask questions you also can implement several other interaction possibilities such as generating a ‘quote of the day’, ‘mood messages’, and ‘quote SMS messages to friends’, etc.*”. Mood was also mentioned by another user: “*I would like to see the output according to different contexts or modes. For example, if the user is in angry mode, he can choose the angry mode and the Confucius answer to make him cool... etc.. Nevertheless it is a good and understandable.*” Some other users talked about 3D character, animations, and making an iPhone version.

To help us directing our future efforts, we also asked the users to give a rating of the importance of various factors of the system based on a 5-point Likert scale, with 1 being the least important and 5 being the most important. The candidate options were: well-designed UI, meaningfulness of the answer, authenticity (i.e. whether it truly represents the opinion of Confucius), animations of Confucius showing emotions, true understanding (note that this is different from meaningfulness, as the system can have no understanding of the user but still output a sensible answer, as in the case of many chatbot systems), and entertainment value. Users were explained in more detail if they were not sure what the option meant. The results of the average ratings are shown in Figure 5.4. Quality of the answer, or the meaningfulness of the answer is deemed as the most important aspect of the system, and plays an important

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role in providing a satisfying experience. Users expect the answers to be *meaningful*, but they care relatively less about whether the system truly understands them or not. In terms of “authenticity”, participants hold a more varied view, with some thinking it is very important, but some not care much. UI design is also considered an important factor, as people expect to have an easy-to-use system. Entertainment value is somewhat important, but much less so as compared to the answer’s meaningfulness. Other interaction modalities, for example, the use of animations, are deemed as the least important compared to other factors. From this comparison, we can see that people have high expectations on the answers given by a virtual sage, and the meaningfulness is deemed as the most important factor. This gives us indication that in future work we should first focus on improving the AI algorithm so that it can better understand the input question. If we have additional resources, we can then think about other improvements, such as incorporating other input information, adding animations, etc.

### 5.3 Log analysis on public data collection

Like most previous work, the first preliminary study was carried out in a lab environment. While it can provide us useful insights on the use of the system, the user study subjects were confined to university students and staffs, and the experiment was carried out in an environment that was different from its intended usage. For the results to be more generalizable, it is best to collect more data from a wider range of users. Furthermore, our current algorithm is designed according to the characteristics of the knowledge base. A good understanding of the types of questions that may be posed to



### 5.3 Log analysis on public data collection

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the system would enable us to devise more targeted mechanism for answering the questions. Such user question analysis is also a common strategy used in many Question Answering systems [104].

Based on these considerations, we released the Android application to the public and collected the conversation log data. Participants of this study were spontaneous users who voluntarily downloaded and used the application. We assume that the results from this study would be an useful addition to the understanding of people's interaction with a virtual conversational agent in a real-world setting, towards the ultimate goal of creating conversational agents that are able to talk freely with uninformed naive users in everyday situations.

Three previous studies [60, 80, 126] focus on conversational systems that had been put on trial in a public setting. Following their methods, a content analysis of the conversation log files between the users and the system was carried out. Through the analysis, we wanted to see

- 1) whether people perceive and treat the system as a virtual philosopher;
- 2) what kind of questions are asked by the users;
- 3) how the system performs in terms of appropriately answering the questions: whether users are satisfied with the answer, and if not, what are the causes and how we can improve it.

## 5. EVALUATION STUDIES ON PROTOTYPE I

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### 5.3.1 Data collection

The application has been published in Google Play Store for free download since September 2011. All conversations are logged anonymously, and users are notified of this the first time they open the application. Each user is identified by a UUID (Universally Unique Identifier). As of the end of 2012, the application has been downloaded 315 times, and a total of 1500 conversation turns collected. A turn is defined here as one utterance from the user and one response from the virtual Confucius.

To get meaningful log data for analysis, we removed early data when the system was still in beta, and only kept the log files collected during the year of 2012. We then screened these log files and removed occasional wrong data that are caused by bugs introduced in the updates (e.g. some of the log information was not complete, due to an accidental change of the SQL query. Such incomplete records were removed from the analysis.). This left us with a total of 1029 turns coming from 115 different user IDs. The average number of turns is 8.95 (min 1, max 42), assuming each user ID corresponds to a different user.

### 5.3.2 Method

Users may have different interest and could input a wide range of questions or statements to the virtual Confucius. Following the data-driven method in [80], we also tried to analyze if these utterances can be grouped into different categories. Different from [80], we distinguish the categories based on the nature and content of user utterances. The rationale for such classification is that the agent needs to be equipped with differ-

### 5.3 Log analysis on public data collection

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ent techniques to respond to user utterances of different types and scope. Knowing the distribution of utterances can inform algorithm design to improve the agent’s ability in carrying out open dialogues.

To derive the classification scheme, two coders skimmed through all the log data and jointly came out with the initial categories. The coders are computer science researchers with basic knowledge of Confucian philosophy. Since the purpose of the coding is for us to get a picture of the types of user utterances so that we can design more targeted answering strategies, the coders’ computer science background is useful. Then the coders coded the first 100 turns, discussed and modified the categories if necessary. After the categories were finalized, the coders independently coded the first 200 turns, and the inter-coder agreement was checked. A Cohen’s Kappa value of 0.642 was computed, indicating satisfactory inter-coder agreement [49, 84]. The coders then proceeded to code the rest of the log files, each responsible for half of the data.

#### 5.3.3 Classification scheme

The resulting categories, selected examples and their frequencies are shown in Table 5.1. There are altogether 6 high-level categories, classified based on the nature and scope of the user utterances. Some of the high-level categories are further classified into low-level categories to reveal more details. The meaning of each of the high-level category is explained as follows:

1. *Confucius and Confucianism*: This category contains user utterances that are directly related to the agent. This is an important part of the intended usage

## 5. EVALUATION STUDIES ON PROTOTYPE I

**Table 5.1:** A taxonomy of user utterances and their corresponding frequency in the corpus

No.	Categories	Examples	Count (%)
	<b>Confucius and Confucianism</b>		<b>172 (16.7%)</b>
1	1A. Biographical info.	Were you ever married? What was your reputation during your lifetime?	168 (16.3%)
	1B. Domain specific terms in Confucianism.	What is the Way? What is Confucianism?	4 (0.4%)
2	<b>Factoid</b>	How many miles is it to Jupiter. Is $b = a$ the same as $a = b$ ?	<b>47 (4.6%)</b>
	<b>Subjective</b>		<b>546 (53.1%)</b>
	3A. Definition/explanation of abstract concepts	What is wisdom?	115 (11.2%)
	3B. Reasons	Why is life so complicated? Why do most people do not like me?	36 (3.5%)
3	3C. Judgments, Predictions	Can machines love? Will he ever be mine? Could a person who has no father enjoy father's day.	114 (11.1%)
	3D. Advice	I need a girlfriend, what should I do? How can I be successful?	105 (10.2%)
	3E. Statements	I am depressed.	61 (5.9%)
	3F. Single word, word phrase	love	115 (11.2%)
	<b>Conversational</b>		<b>147 (14.3%)</b>
4	4A. Feedback/acknowledgement to agent	This is amazing. You are wrong. OK. I see.	91 (8.8%)
	4B. Greeting, goodbye	Hi. Bye.	56 (5.4%)
	<b>Nonsense</b>		<b>115 (11.2%)</b>
5	5A. Mistyped, meaningless	How many studenrs you have? Mjfhgkfjf	95 (9.2%)
	5B. Pornographic/abuse	Obscene language	20 (1.9%)
6	<b>Others</b>	What is the point of this app? Can I go to main menu?	<b>2 (0.2%)</b>
<b>Total</b>			<b>1029 (100%)</b>

### 5.3 Log analysis on public data collection

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of the application - to know more about Confucius and Confucianism through conversation. Many of the conversational agents reviewed in the related work section are designed to mainly handle this kind of questions.

2. *Factoid*: This category contains factoid questions that have a definite answer (which have been the subject of study in many question answering systems, e.g. [153]). Such questions are not related to the agent and are considered out-of-domain.
3. *Subjective*: As opposed to factoid questions, this category contains questions that do not have a definite answer. This is also an important part of the intended usage of the application - to get Confucius's subjective opinion on things, or in other words, his philosophical thoughts. For utterances that contain only a single word or word phrases about abstract concepts such as 'love', we assume that users expect Confucius can give some comments on it. So we include such utterances in this category as well.
4. *Conversational*: This category contains user utterances which serve the purpose of starting a conversation and maintaining the flow of the conversation. Such utterances are a main indicator of social interaction.
5. *Nonsense*: This category contains utterances that do not have any meaning or contribution to the conversation, as well as malicious use of the application.
6. *Others*: Two of the utterances turn out to fall out of the above 5 categories, so we put them in a separate category called others.

## 5. EVALUATION STUDIES ON PROTOTYPE I

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### 5.3.4 Discussions

#### 5.3.4.1 How people use the system

Both category 1, 3 and 5 can all be considered the intended use of the virtual philosopher system. We can see that they together constituted 84.1% of the total utterances, indicating that most users understood well the purpose of the system - Category 1 and 3 (69.8% in total) are about philosophy or Confucius as a person, and Category 4 (14.3%) contains the conversational sentences/phrases people would use when talking to a human.

The percentage of utterances (72.5%) that humanize the agent is about the same as observed in the Sgt Blackwell study [126], and much higher than [60, 80]. The identity of the agent seems to play an important role here - as in the case of our agent and the Sgt Blackwell, both have a distinctive identity and are user initiative systems that do not have a clear functional domain, whereas the latter two are more likely to be perceived as information providers like a kiosk, due to the set up and environment where the agents exist. For example, we found that besides asking about personal information about Confucius (e.g. “*How old are you*”) and direct philosophical questions (e.g. “*What is love*”), an interesting use of the system is seeking counseling or advice. Users revealed their personal feelings, problems in life to the virtual Confucius (e.g. “*I have problem closing deals*”, “*I feel bad*”). This may be due to the image of Confucius being a “sage” and therefore a good person to go to when they have problems. This is one characteristic of a virtual philosopher that is different from other virtual humans, as

### 5.3 Log analysis on public data collection

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no such usage were reported in previous studies (except those dedicated for counseling purposes). From the perspective of supporting the learning of philosophy, this is a good sign, because in philosophy study, it is important to relate the philosophy knowledge with one's own experience, and the fact that people indeed use the system this way gives opportunity for the system to be a good platform for learning about philosophy. On the other hand, this tendency to humanize the agent, especially as a sage, leads to higher expectations for the agent to be human-like. This also agrees with our previous study, where users tend to consider meaningfulness of the answer as the most important quality of the agent.

On the other hand, utterances that are used for communicating with machines rather than humans, such as single words and word phrases still account for 11.2% of the total utterances. Reasons for this may be due to purposeful testing of the system.

Like many other public conversational agents (e.g. [60, 80, 126]), we also observed 'flaming' - hostile or insulting utterances from the user. Besides one user who was hostile from the start and throughout the interaction, such utterances often occurred when users could not get a reasonable response for two or more turns.

Some utterances were mistyped and thus cannot be recognized. It could be that users either entered the wrong words by mistake, or they were trying to test the system's ability to handle abnormal inputs. A spell checker should be integrated into the system to automatically correct the mistyped words.

In summary, there appeared to be the following main kind of usages of the system among the spontaneous users we had:

## 5. EVALUATION STUDIES ON PROTOTYPE I

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- Learning about philosophy and Confucius himself.
- Asking for advice / looking for counseling.
- Testing the intelligence of the system.

### 5.3.4.2 User satisfaction

From the content of user’s replies, we can have a partial idea of whether they enjoyed using the system. Some users appear to be satisfied with the answer given by the virtual Confucius, as we can observe them replying “*Oh I see.*”, “*This is amazing.*”. Enjoyment can also be observed: “*Hahaha*”, “*Funny*”. On the other hand, we also observe frustrations from users when the system was not able to give a good answer, or completely misunderstood user’s question. Users expressed their unhappiness using utterances like “*You are not making any sense*”, “*You are faked*”, and some may even use abusive phrases. It is observed that after getting two or more irrelevant responses, or when the agent repeatedly answered “I don’t quite understand what you say. Could you rephrase it please?”, users would exhibit such behavior, or stop using the system. Answer quality has a strong effect on user’s satisfaction and keeping users engaged.

The sentence asking for rephrase was set as a default response when the algorithm failed to find a relevant answer. Robinson et al. showed that in cases of non-understanding, requests for repetition were usually perceived as more coherent than other types of off-topic responses [126]. However, this judgment was based on the perception of the current utterance only, and no information was provided on what would happen next, especially if the agent failed the second time. So while this strategy



### 5.3 Log analysis on public data collection

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may (or may not) work on a voice-based system, it did not seem to work well in the text-based case. From the log analysis, we found that this strategy is not effective, as it can often result in frustrations when it fails continuously. In fact, to our surprise, not many people would actually follow the advice and rephrase their questions. Some would either repeat the same question (which will not change the answer retrieval process and therefore still results in a “asking-for-rephrase” answer), or simply completely change the topic instead. Reasons for such behavior may be attributed to the perceived trouble to type the question again, or the users may think that it is out of the boundary of the agents’ knowledge and they would rather try another topic and see if it works. To reduce users’ negative feelings, better strategy in handling such “out-of-domain” questions is necessary.

#### 5.3.4.3 Engagement

The average length of interaction (number of turns) per user is about 9. In the literature, the interaction length with publicly available agents varies. For example, in both the August system (a publicly displayed virtual guide) and the Sgt Blackwell (a publicly displayed virtual soldier), the average number of turns was about 4. In the Max system (a publicly displayed museum guide), the average number of turns was 22.6. This number included the cases when users chose to play a guessing animal game (similar to the 20 questions game) with the agent, which could significantly lengthen the interaction. Compared with these agents, we can say that our agent is able to maintain a moderate level of engagement with the user.

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### 5.3.4.4 Difficulties in dealing with open conversation

From the logs of utterances, we can see that when users are presented with an interface that accepts free input, they expect the agent to be able to respond to a wide variety of questions. Here is an example conversation showing a variety of questions from one user (U denotes user, and A denotes agent).

*U: am i stupid.*

*A: You seem intelligent to me.*

*U: why do most people do not like me.*

*A: By treating the masses of the people as children, they will be led to exhort one another to what is good.*

*U: how can i be happy.*

*A: Have faith.*

*U: am i crazy.*

*A: Have you ever been to a psychiatrist or psychologist?*

*U: what do you think about war.*

*A: The state of armed conflict between nations or parties.*

*U: what do you think about imaginary friends.*

*A: When those in high stations perform all duties to their social relations well, the people will be aroused to virtue.*

*U: are you lonely.*

*A: I am simply a man who in the joy of my attainment of knowledge forget*

*his sorrows.*

*U: what is true friend*

*A: Hold faithfulness and sincerity as first principles - this is the way to exalt one's virtue.*

It is well-known that understanding unconstrained human language is a difficult task. For non-task oriented dialogue systems, the absence of a common user-system goal renders the dialogue strategies in task-oriented dialogue systems non-effective, and the lack of specific scenarios makes it hard to predict the contents and topics of user utterances and carry out use case analysis [21, 63]. Additionally, we also observed a few other factors that may have contributed to the difficulties in dealing with open conversation in a virtual philosopher system:

- **Mismatch between the quantity of inputs and candidate answers.** There can be infinite number of input questions, but as a virtual philosopher can only be modeled from a limited set of available documentations about the particular person (in our case, we have 2000+ lines of Confucius's sayings), there is a huge mismatch between the quantity of inputs and candidate answers. Although Confucius's philosophy can be widely applicable to many aspects of our life [173], which means the output-input mapping can be one-to-many, it is still quite common that user's questions is out-of-domain, i.e., it is impossible to find an answer from the knowledge base. One example is the user's question from the above sample conversation: "*what do you think about imaginary friends*". It is unlikely

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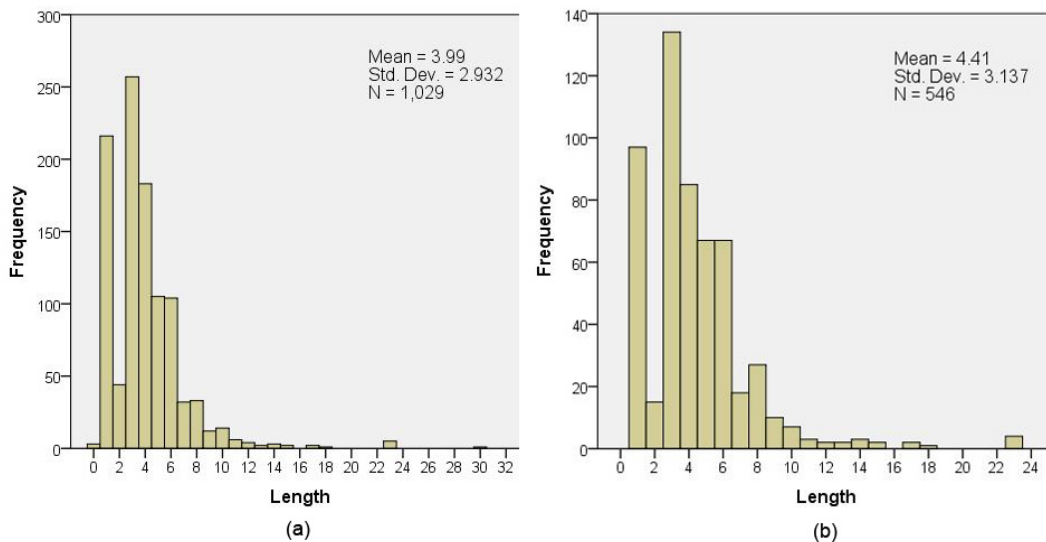
that the knowledge base contains an entry about such topic. In this case, an irrelevant answer was wrongly identified.

Besides the mismatch in content, there is often a mismatch in terms of phrasing. In some cases, there may exist a line in the knowledge base that talks about the same thing as user's input utterance, but the way the original sentence is phrased is not suitable to be used directly as an answer, resulting in a seemingly awkward transition in the conversation. In such cases, it may seem evident to the users that the system mechanically selects one related sentence as the output, which, though related, is not coherent or does not answer the question. For example, one user asked "*why do I need to study*", and Confucius replied "*Some are born with the knowledge of virtues; some know them by study; and some acquire the knowledge after a painful feeling of their ignorance. But when it comes to the knowledge being possessed, it is the same thing*". This reply is actually relevant to what the user asked, and we can deduce from it that we need to study to know the knowledge of virtues. A more direct and easy to understand answer would be "You need to study because ...". This kind of indirect answers, though reflected the inarticulateness of Chinese philosophy, may be disliked by some users.

- **Short length of utterances.** From the log files, we found that a majority number of user utterances are rather short. Figure 5.5 shows the histograms of the length of the all utterances, and in particular, the length of category 3 (Subjective) utterances, a major class of questions that our system is targeted to handle. We can see that both distributions are positively skewed with a long

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tail to the right. The average length for all utterances in the data set is 3.99, and the average length for category 3 (Subjective) utterances is only slightly longer than the overall average, with the mean being 4.41. As a result, the information contained in a sentence of about 4 words is very limited, which makes it difficult to directly deduce useful and correct semantic information from such short utterances like “*Why are we here*”.



**Figure 5.5: The distribution of utterance length in the data** - (a) shows the distribution of all utterances, and (b) shows the distribution of category 3 (subjective) utterances

This is in line with the result found in a previous study by Gustafson and Bell [60], who showed that the average number of words per utterance was about four in conversation data collected from the public through their August system. Note that even though people use speech instead of text to talk to the system, which makes it easier to use long utterances, the sentence length still tends to be rather short. In another study with the museum guide Max, the average number of

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words per utterance was even shorter (2.52). It appeared that users tended to use syntactically simple sentences while conversing with an agent, and majority of the utterances contained only a single clause. One possible explanation to this phenomenon might be that even though the agent is humanized, people are still aware that they are conversing with a machine, so they tend to use shorter sentences that they consider “easy to understand” (for human, not necessarily for machines).

- **Mixed utterance types.** As shown from the taxonomy presented in the previous section, user utterances could be of vastly different types and contents. The types of utterances used by each individual users vary, and there were no generalizable patterns. In accordance with the findings in [22], we found that users tended to change the domain and topic quite frequently, which adds to the difficulty in keeping track of the conversation and predicting user behaviors. Reasons for such user behavior may be they are trying to explore the boundary of the intelligence of the system. Conversation with computers is still not a mature domain and a commonplace interaction, so it is natural for people wanting to test out how good it is.

In addition, the system sometimes is not able to distinguish between the different types of questions. For example, in the example dialogue given above, the user asked “*what do you think about war*”, and the answer given is a definition of war, obtained from the scripts in the pattern matching module. It is very likely that the user who asked this question expected a personal opinion about war, rather

### 5.3 Log analysis on public data collection

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than a standard definition. Another example is one user asked “*Were you ever married?*”, as this information was not included in the biographical knowledge base, the reply from the system is a sentence about the marriage rituals in ancient China. Though in this case the answer is somewhat relevant to what the user asked, it does not provide the information that the user wanted to know, and thus can cause frustrations from the user.

#### 5.3.5 Limitations

In this study, we used the data collected “in the wild”, where the subjects are not hand-picked but users who are interested in the system and voluntarily downloaded the application. They are free to interact with the system as they please without any external social pressure. This has the benefit of being able to get the most real usage of the application, as compared to a study conducted in a lab environment.

However, there are limitations of our method as well. Firstly, the only information we have about the user is a randomly generated user ID, we did not collect more detailed demographic information, such as user’s cultural background, prior knowledge about philosophy, etc.<sup>1</sup>. We did not directly interview the users about what they were thinking when they used the app, so we can only make reasonable speculations, which might not completely reflect the real situation.

Second, we do not have the information on the context when users interacted with

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<sup>1</sup>We could have requested such information at the beginning of the application, but even if we do, it may not be accurate, because we have no control of the person(s) using the application. A user can use the application with another person with different demographic background, and ask questions on his/her behalf.

## 5. EVALUATION STUDIES ON PROTOTYPE I

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the application. For example, we do not know if the user used the system alone or with others - the inputs coming from the same user ID might actually be from several people, which may have contributed to the lack of coherence in the user's sequence of input. Neither can we be sure about the reason why user ended the conversation - it could be that they are not satisfied with the system's performance, or it could be that something else interrupted the conversation.

In order to better understand users' mental models, follow-up interviews should be conducted if possible. For example, we may implement functions in the app to ask for more demographic information from the user, and ask if they would like to be interviewed. However, the response rate of such requests is typically low, so we may need to get more users to be able to collect enough samples.

### 5.4 Chapter summary

In this chapter, we presented three different studies on three versions of the first prototype. The first public trial allowed us to gather early feedback from the potential users, and gave us confidence in pursuing the conversational agent approach to communicate to people about cultural values. The results from lab study further confirmed the validity of the interactive approach and gave indications on needed improvements. Finally, we analyzed users utterances collected from real-world data, and discussed the sources of difficulties in handling open conversation. An utterance taxonomy is built to better understand the types of user utterance so that we can devise more targeted strategies. In the following chapter, we present how we attempt to improve the answer



quality based on these findings.

**5. EVALUATION STUDIES ON PROTOTYPE I**

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## Chapter 6

# Improving Response Quality

### 6.1 The “no answer” problem

For a conversational system that is deployed in the real world, inevitably it will face all kinds of questions, many of which are unseen to the system or even out-of-domain. Here, we define “out-of-domain” utterances as user utterances that are outside the knowledge space of the agent and therefore something that the agent is not supposed to answer. Though not often discussed in the literature, out-of-domain utterance is a common problem for every conversational system that does not put constraints on user input, especially those where the output is highly constrained [53]. As reported in previous studies [13, 106, 115], if these questions are not handled properly, it can cause frustration with the user and break the sense of immersion. For example, in [126], it was observed that poor agent response was likely to discourage user from continuing the conversation.

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Furthermore, the boundary between out-of-domain and in-domain questions is usually hard to define, especially when the agent is very much humanized. For example, as in the Sgt Blackwell study [126], it seems that since the agent represents a soldier, even though it is mainly supposed to answer questions about the army, people would naturally expect it to answer any questions regarding his personal information, his experiences, feelings, etc. And when the agent is not able to answer such questions, the suspension of disbelief can be easily broken and people would realize it is a machine.

Similarly, for agents that do not have a well-defined functional domain, for example, in the case of a virtual philosopher, it is impossible to draw a hard boundary on what types of questions the agent should be able to answer. Sometimes even if the user utterances are in domain, the agent may still not be able to find a satisfactory answer due to limitation of the knowledge base or problem in understanding. In such cases, how the agent responds is very important in keeping users engaged.

In our first prototype, we used a very simple strategy to deal with such “no answer” problem arisen from the above situations, which was to simply tell the user that it does not understand the utterance and ask for a rephrase. Our preliminary study (see Chapter 5) showed that it did not seem to be a good strategy, as many users would not follow this advice, and the repeated occurrences of such sentence can lead to frustration. In this chapter, we take a closer look on this problem. We first provide a review of the state-of-the-art on dealing with open questions, and present our solution which adds a classifier to the system to classify the user utterance according to the taxonomy we proposed in the previous study, and directs the system to use different strategies for

dealing with each type of question. A set of “no answer” strategies were proposed to deal with the situation when the agent is not able to find an answer.

## 6.2 Related work on handling open conversation

Though the “out-of-domain” or “no answer” problem is a practical and important one, there have been little research reported in the literature. The reasons may be twofold: firstly, they are difficult to handle; secondly and more importantly, most of the agents studied were either task-oriented or non-task oriented but with a relatively well-defined functional domain, which means users tend not to deviate from the intended usage and therefore out-of-domain utterances are not that common. In the case of non-task oriented conversational agent that does not have a clear functional domain, such as a virtual soldier or virtual philosopher, off-topic responses is an inevitable problem [13]. In this section, we provide a review on how the “no answer” problem is reported and dealt with in some of the non-task oriented systems.

In synthetic interview systems, the strategy for dealing with out-of-domain questions was to randomly select one response from a pool of default responses [99]. For example, “*I don't have anything to say*” Or “*Please repeat yourself*”. In [80], a study carried out at the Nixdorf Museum showed that the recognition rate (including possibly wrongly recognized ones) was 63%, which means that users got sensible answers from the museum guide agent Max less than two out of three times at best. When the agent failed to recognize the user utterance, it simulated small talk behavior. However, it was not reported whether this strategy is accepted by the user, or whether it affected user's

## 6. IMPROVING RESPONSE QUALITY

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enjoyment and engagement. Similarly, for the virtual HCA system, the study showed that when faced with sudden and frequent user-initiated domain and topic shifts, the system’s limitations in handling such input became evident [19, 21]. When the agent did not understand what the user said, it would ask for repetition or indicated that the input was not understood. Besides, it also had a rhapsodic escape by jumping to something completely different and out of context, such as saying “*In China, as you know, the emperor is Chinese.*”, or “*Do you think that my nose is too big?*”. It was reported [21] that if this happened too often, users tended to get annoyed. A later development tried to solve this problem by using Google’s directory to associate unknown words with the knowledge of the agent, thus increasing the chance of finding an answer [103]. Web-based QA systems were also used to generate answers, but this can only work for the questions which can be handled well by web QA systems (e.g. factoid questions), and such questions only account for part of the no-answer scenarios.

Patel, Leuski and Traum [115] explicitly studied the problem of dealing with out-of-domain questions by experimenting the effectiveness of classifying the user utterance into a taxonomy of out-of-domain response classes. Similar to Synthetic Interview, their strategy for answering out-of-domain questions was to pre-author a set of default responses and randomly select one from the pool. They took one step further to classify the out-of-domain responses into eight categories: Don’t Understand, Out of Domain, Unknown, Restriction, Pass, Leave to Human, Negative, and Positive. They confirmed that training the classifiers for the different off-topic categories was indeed useful in increasing the appropriateness of the response. However, some of the classes they

## 6.2 Related work on handling open conversation

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derived were highly specific to the particular character, Sgt Blackwell, a soldier, and thus cannot be easily generalized to other characters. Moreover, the appropriateness for the highest rated architecture was still not quite satisfying - the average score for off-topic answers was 3.62, out of a 6-point scale (see Figure 6.1, with 4 meaning “Response does mostly address the question, but with major problems in the coherence between question and response; seems like the response is really addressing a different question than the one asked.”)

#	Description
1	Response is not related in any way the question
2	Response contains some discussion of people or objects mentioned in the question, but does not really address the question itself.
3	Response partially addresses the question, but little or no coherence between the question and response.
4	Response does mostly address the question, but with major problems in the coherence between question and response; seems like the response is really addressing a different question than the one asked.
5	Response does address the question, but the transition is somewhat awkward.
6	Response answers the question in a perfectly fluent manner.

**Figure 6.1: A 6-point scale for appropriateness of agent response** - developed by Gandhe et al. [53]

In [11], Artstein et al. investigated three kinds of strategies when the agent did not understand user’s input: ask for clarification, indicate misunderstanding, and move on with the conversation. They showed that the combination of these strategies, together with prompts for new topic, could improve the overall dialogue coherence. On the other hand, prompts were found to be non-effective in the Sgt Blackwell study, as a majority of users rejected the prompts and pursued their own topics instead [126].

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Mori et al. [106] took a different approach. They cleverly tried to avoid the problem of out-of-domain questions by situating the study in the context of a game. In the game, users talked to a virtual representation of a XVI century Genoveses artist, Luca Cambiaso, to learn about his life and artworks. Users needed to ask “the right questions” in order to score points. This effectively turned the limitations of the system into an interesting aspect of the gameplay itself, and transformed the possible frustration into the challenge of the game. In this way, users were encouraged to explore the boundary of the character’s knowledge base, to find out the correct way to ask questions through trial and error. However, they also reported that the low accuracy affected users’ appreciation of the system, and several users expressed frustration despite a 75% recognition rate.

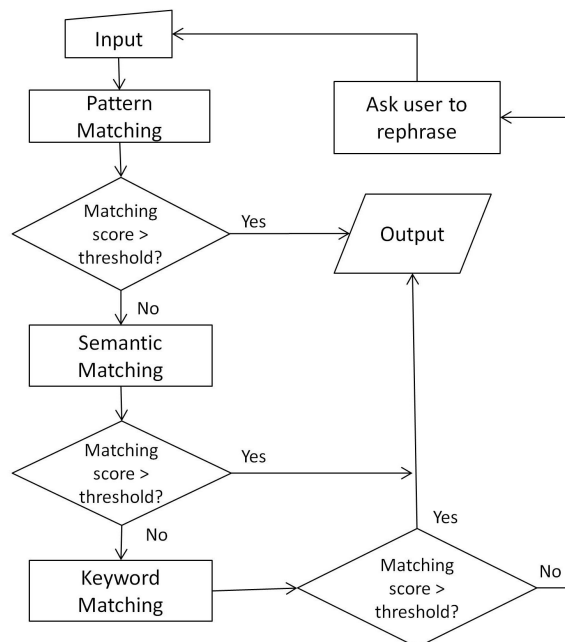
In summary, though various strategies have been mentioned in previous works, no study was conducted to systematically examine the effectiveness of these strategies. Different from previous work, we argue that we need to take into account the different types of utterances that may be posed to an agent and treat them with different answer-finding and no-answer strategies.

### 6.3 Utterance classification

A typical method used by many conversation systems is to detect the dialogue act of the utterance, and find suitable response to that dialogue act. As the main purpose of using a virtual philosopher system is information-seeking or advice-seeking, traditional dialogue acts are less useful in this case. Instead, when designing the strategies for



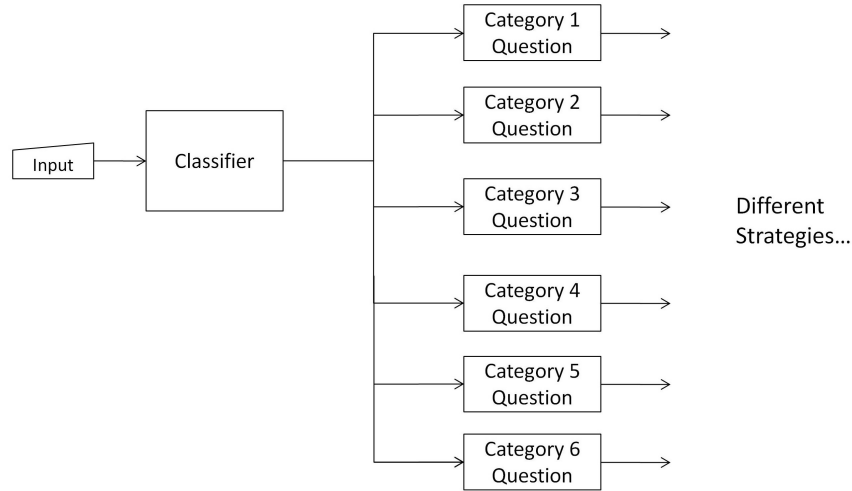
answering, it may be a good choice to refer to the types of utterance observed from real user data. It is important for the agent to know the type of input utterance, so that it can either invoke appropriate answer finding technique, or to provide an appropriate reply when no answer can be found in the knowledge base. In the study described in Chapter 5, we constructed a taxonomy of user utterances. Each utterance category, depending on their characteristics, should be treated with corresponding answer retrieval method as well as no-answer strategy. Our study also revealed that the current prototype, which is based on a sequential architecture (see Figure 6.2), lacks the ability to distinguish the utterance types. Therefore, in the second iteration of prototype development, we decided to build a classifier to classify the utterances. Figure 6.3 shows the new architecture with the classifier added.



**Figure 6.2: Simplified architecture of prototype I** - user utterances go through each module sequentially

## 6. IMPROVING RESPONSE QUALITY

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**Figure 6.3: Simplified architecture of prototype II** - A classifier is applied before feeding the user utterance to each module

Users' utterances collected from the previous study were used as training data to build the classifier. Considering compatibility and performance issues, we used the built-in text classifier in the NLTK toolkit<sup>1</sup>, as it allowed us to quickly realize the classification function and seamlessly integrate it with our previous prototype without resorting to external classification packages such as LibSVM [36]. Among the four classifiers supported by NLTK, namely, `NaiveBayesClassifier`, `DecisionTreeClassifier`, `ConditionalExponentialClassifier`, and `WekaClassifier`, we chose to use Naive Bayes classifier. Though it assumes independence among the features (which is rarely true in real applications), Naive Bayes classifier has been proved to perform well for many text classification tasks [97]. Moreover, as a probabilistic classifier, the classification takes into account of the prior probability of a class, which makes it suitable for our application where the distribution of classes is uneven.

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<sup>1</sup><http://nltk.org/>

### 6.3 Utterance classification

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For the training, we used 10-fold cross validation [25], where the entire corpus was randomly divided into 10 parts, and in each training, 9 out of 10 parts were used as training set, whereas the remaining part was used as a validation set. The final accuracy score was calculated by averaging the accuracy in each training. This helps to eliminate bias that may be introduced in dividing the data, thus providing a more fair estimate of the performance of the classifier.

**Table 6.1:** Accuracy of classifier trained with different feature and combination of features. (LEN: Sentence length, QM: Question mark, WH: Wh-words, UG: Unigram, BG: Bigram, TRG: Trigram)

Feature(s)	Accuracy
LEN	0.532912
QM	0.539708
WH	0.548603
UG	0.708375
BG	0.650819
TRG	0.641189
UG+LEN	0.7142
UG+LEN+QM	0.7142
UG+LEN+QM+WH	0.716103
UG+BG	0.724919
UG+BG+LEN	0.7269
UG+BG+LEN+QM+WH	0.72791
UG+BG+TRG	0.733696
UG+BG+TRG+LEN	0.730744
UG+BG+TRG+LEN+QM	0.735638

In addition, in a preliminary experiment we found that removal of stop words decreases classification accuracy (Figure 6.4 shows a list of stop words in NLTK). Though stop words are usually considered as useless, they contain useful information in our classification. Therefore, stop words are retained for feature extraction.

Table 6.1 shows the accuracy of the Naive Bayes classifier trained with different

## 6. IMPROVING RESPONSE QUALITY

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['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she', 'her', 'hers', 'herself', 'it', 'its', 'itself', 'they', 'them', 'their', 'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', 'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after', 'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further', 'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more', 'most', 'other', 'some', 'such', 'no', 'nor', 'not', 'only', 'own', 'same', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will', 'just', 'don', 'should', 'now']

**Figure 6.4: A list of English stop words in NLTK**

feature or feature combinations. The accuracy value is obtained using 10-fold cross validation. We can see that the best accuracy obtained is by using a combination of unigram, bigram, trigram, sentence length, and question mark features. We used the data collected previously (which contains 1029 sentences) to train the classifier. We expect that with more training data, the accuracy can be further improved.

### 6.4 Response strategies

A good conversational system should not only provide the most relevant answer when possible, but also be able to give a sensible reply when no suitable answer is found in the knowledge base. Each utterance, depending on its type, should be treated with different answer-finding and no answer strategy. Table 6.2 summarizes the proposed strategies for each type of utterance, based on the literature review of strategies used.

## 6.4 Response strategies

**Table 6.2:** Proposed strategies for each category in the user utterance taxonomy

No.	Category	Answer finding Strategy	No answer strategy
1	Confucius and Confucianism	1. Experts prepare templates 2. Connect to question-answering engines to search for answers on the web	Author suitable off-topic answers
2	Factoid	1. N/A 2. Connect to QA engines to search for answers on the web	Author suitable off-topic answers
3	Subjective	Find related answer in the knowledge base through semantic similarity	1. Author suitable off-topic answers 2. Use Eliza-like techniques to elicit more information from the user
4	Conversational	Use chatbot’s techniques	N/A
5,6	Nonsense and others	N/A	Author suitable off-topic answers

### 6.4.1 Answer finding strategies

For a virtual philosopher, the most important two categories of utterances are category 1 & 3. Category 1 (Confucius and Confucianism) utterances can be handled easily using templates authored by domain experts, provided that sufficient information are authored by the domain expert. Another method is to look for information on the web using Question Answering (QA) engines. However, as discussed previously (Chapter 5), when users humanize the agent, they tend to ask all sorts of questions that a person is supposed to be able to deal with easily, but hard for computers with limited data [126]. For example, it might be difficult for a QA engine to find out the answer to “what color does Confucius like”, or even “what is Confucius’s favorite movie”. In such cases, the agent should still provide a sensible response.

Category 3 (Subjective) utterances are more difficult, which require semantic and pragmatic understanding to select the best answer from the repository of candidate

## 6. IMPROVING RESPONSE QUALITY

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answers. As discussed, the length of utterances are usually short and contains limited information. A possible solution is to use the utterance as a query to search the web, use relevant information to expand the query, and then try to find a related answer.

Communication among human is not just about the content [129], and correct handling of utterances from other categories is also important. For example, Category 4 (Conversational) utterances is important because it is essential in making the agent human-like. The ability to handle small talk is helpful in reducing interpersonal distance [23]. Category 2 (Factoid) questions can be either ignored, as it is not the intended use of the system, or it can be handled by consulting existing QA systems.

### 6.4.2 No answer strategies

In our first prototype, when the agent is not able to find any good answer, its strategy is to honestly tell the user that he does not understand and ask the user to rephrase the question. The log analysis revealed that it is not effective. Very few people would rephrase the question as the agent requested. Instead, some of them keep asking the same question again and again, always getting the same do-not-understand answer, and give up in the end. For those who do rephrase, it is likely to cause more frustration if the agent is still unable to provide a satisfactory answer. Therefore, in our second iteration, we want to explore the different “no answer” strategies, and find out the most appropriate ones.

Table 6.3 shows five different response strategies the agent can undertake in situations where there is no suitable reply. Most of these strategies have been used in the

literature, but it is still not clear how effective they are, and in what situation they are most effective. We also added a new strategy called PROFOUND, which is special to our application. Now we will explain each strategy.

1. **ELIZA** One strategy many chatterbots use for handling out-of-domain questions is to transform the user input and ask the question back [154, 158]. This helps to create the illusion of understanding and encourages users to talk more about the topic at hand, making the conversation flow. We may utilize this strategy to elicit more information from the user when the current information is not enough for the agent to deduce a suitable answer. However, the drawback of this method is that it does not offer new knowledge to the user. As such, we need to limit its uses and carefully balance between maintaining a smooth conversation and providing knowledge. When the agent does not have enough information to answer, it can ask user questions, collecting more information, and once there is enough information, it should give the answer.
2. **UNKNOWN** This category contains responses that acknowledge ignorance, and directly tell users that it has problem understanding.
3. **PROFOUND** One interesting finding in our log analysis is that, sometimes, even if the agent's response is not a direct answer to the question, the user seem to be able to digest it and interpret it in a way that makes sense to him/her. One example is:

*U: After my graduation what do I have to do?*

## 6. IMPROVING RESPONSE QUALITY

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**Table 6.3:** Pool of no answer strategies

Strategy	Examples
ELIZA	<p>Can you elaborate on that?</p> <p>Why do you ask that?</p> <p>What exactly do you want to know?</p>
UNKNOWN	<p>I'm afraid I have no comment on that.</p> <p>Please bear with me. I have trouble understanding you.</p> <p>You know, I am a very old man. Sometimes I don't get what you guys are talking about.</p> <p>I have no idea.</p>
PROFOUND	<p>What the superior man seeks is in himself; what the small man seeks is in others.</p> <p>Real knowledge is to know the extent of one's ignorance.</p> <p>Sometimes I cannot tell you the answer. You have to find it yourself.</p>
PROMPT	<p>Why don't we talk about something more interesting, like how to be a gentleman?</p> <p>You can ask something that I know about, like filial piety, life, study, etc.</p> <p>Em... Shall we talk about music instead? That seems more interesting.</p> <p>Shall we talk about family instead? I have a lot to tell you about how to serve your parents.</p>
ASK	<p>-Do you know how to serve your parents?</p> <p>-If, in serving your parents, you can exert his utmost strength, although men say that you have not learned, I will certainly say that you are learned.</p> <p>-What would you do if you find that your father did something that is against the law?</p> <p>-In my village, the son will cover for his father, and father covers for his son. Do you know what is righteousness?</p> <p>-What is right is what is best appropriate in a specific situation.</p> <p>-What do you think of human nature: good, bad or a mixture of both?</p> <p>-I refrain from talking about human nature, but if you really want my opinion, I think men are alike by nature, but by practice, they grow to be wide apart.</p>



*A: In the regulation of their love of men, the ancients in their practice of government consider the rules of ceremony the greatest point.*

*U: You mean do I have to be a politician?*

Here, the agent was not able to understand the user and gave an irrelevant answer, but the user interpreted it as a meaningful response. This might be an extreme example, but similar conversation may indeed occur in philosophical dialogue, where the sage answers the question with seemingly completely irrelevant answer, which require one to think deeply and attain enlightenment. For example, once a student asked Confucius, “what is the meaning of the passage - ‘The pretty dimples of her artful smile! The well-defined black and white of her eye! The plain ground for the colors’?”. Confucius replied, “The business of laying on the colors follows the plain ground.”<sup>1</sup>. Therefore, we may try to exploit people’s ability to interpret ambiguous information in similar ways as in [56], which diverts the responsibility for interpretation from the system to the user. We prepared a few philosophical answers that are general and can be applied or interpreted in different ways.

4. **PROMPT** With the PROMPT strategy, the agent would suggest possible topics for the users to ask, in the hope that users would take the advice. This is one of the attempts to direct the conversation into its proper domain.

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<sup>1</sup>This is also seen in many Zen dialogues, for example, the Zen master answers the question “What is the Buddha?” with the reply “Three pounds of flax.”, and the question “What is the essence of Zen Buddhism?” with a variety of replies “I am tired, having been sitting for a long time.”, “Today and tomorrow.”, “There being no water during a long drought, rice plants withered in the fields.”, etc.

## 6. IMPROVING RESPONSE QUALITY

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5. **ASK** This represents a strategy where the agent would ask user a question when it does not have an answer for the input question. In other words, the agent takes initiative and actively changes topic. Ideally, users can respond to the question posed by the agent, and enters a mini-dialogue where the agent takes control to provide useful knowledge in the domain. Table 6.3 shows three example mini-dialogue authored by the domain expert.

In the second prototype, we integrated the classifier, and selectively implemented the strategies proposed in Table 6.2 for each utterance type, and the new system architecture is shown in Figure 6.5. As we do not know which no answer strategy works best in each situation, we randomly pick one strategy from the pool when there is no answer. ELIZA strategy is only used in case of *Subjective* questions, because it is apparently not suitable for other types. For each of the no answer strategies, 10-18 different responses were authored to provide variety in the responses, and one of the responses is selected randomly when such strategy is triggered.

### 6.5 Chapter summary

From the review on conversational systems that deal with open question, we can see that out-of-domain question is a common problem, and currently there are little research to systematically study this problem. Therefore, in our second iteration to improve the system, we first built a classifier using the data collected in the previous study. We incorporated a classifier to identify the type of utterances, and selectively implemented

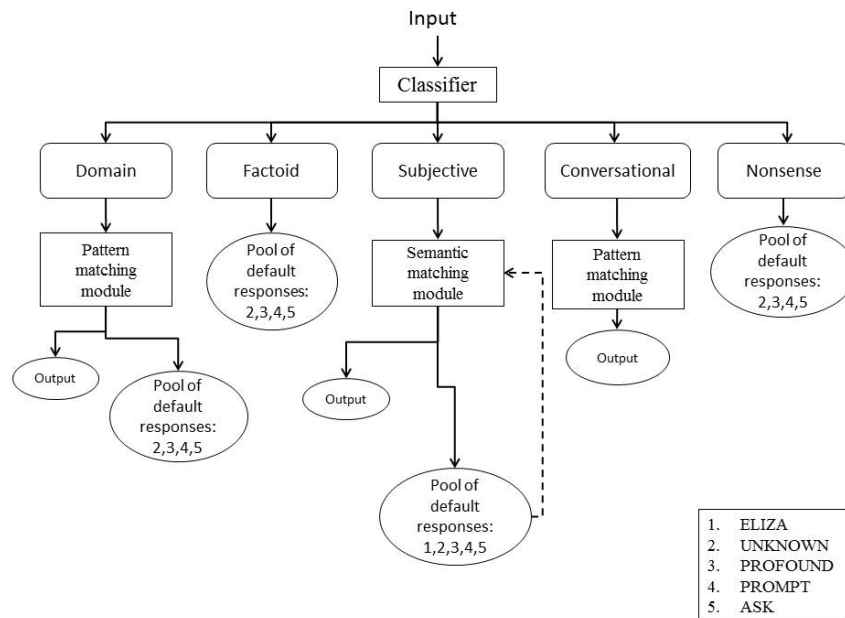


Figure 6.5: New architecture of prototype II

the strategies proposed in Table 6.2 for each utterance type. We expect to conduct a second round of user evaluation to assess the effectiveness new architecture and the use of various strategies.

## 6. IMPROVING RESPONSE QUALITY

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## Chapter 7

# Evaluation Studies on Prototype

## II

In our previous studies, we found that a major problem for a conversational agent accepting unrestricted input is to deal with a wide variety of utterances for which the knowledge base may or may not contain an answer. It is important for the agent to respond to each user utterance in a cohesive manner, as coherence of the agent (i.e. appropriateness of the agent's responses) has a direct positive correlation with the engagement of the users [11]. This entails the agent should: decide whether the utterance is in-domain or out-of-domain; when the utterance is in-domain, retrieve the best answer; when the utterance is out-of-domain, respond with a suitable strategy. We constructed a simple taxonomy of utterances from the real user data collected using the first prototype, trained a classifier using the data, and incorporated it in our second prototype iteration. We also applied a few strategies for handling out-of-domain

## 7. EVALUATION STUDIES ON PROTOTYPE II

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questions, based on a survey of related work. In this chapter, we report two further user studies on the prototype II we developed. In these studies, we want to find the answer to the following two questions:

1. Does the new architecture with the classifier improve the answer quality and user's overall opinion on the system?
2. What no answer strategies are perceived as most appropriate and acceptable by the users? Are there any difference in user's preference for the strategies in the case of different utterance types?

### 7.1 Evaluation criteria

The evaluation of conversational agents largely depends on their design and purpose [44]. In a task-oriented conversation system or a standard QA system, the answer quality is judged by its *correctness*, i.e. whether it can correctly respond to the user request or answer the user's question. However, in a non-task oriented scenario, correctness of response is not the central focus and is not a good measure for judging the quality of response. Therefore, when evaluating non-task oriented conversational agents, traditional evaluation metrics (e.g. task-completion time, error rate, etc.) for task-oriented systems are no longer applicable, and we need to define new measures that are more pertinent to the application.

Dybala et al. distinguish the areas of evaluation into linguistic (grammatical correctness, semantic naturalness, vocabulary richness, etc.) and non-linguistic aspects, and argue that non-linguistic evaluation for non-task-oriented conversational agents

“must focus on the user’s impressions of the features of the interaction that make it more pleasant, natural and generally ‘better’ in the eyes of the user” [44]. Linguistic aspect is only relevant when the agent’s utterances are generated by combining words under certain rules. In our system and many other conversational agents, we employ the technique of “generation by selection”, which means the output utterance is guaranteed to be linguistically correct, as all utterances are human-authored sentences or phrases. For non-linguistic evaluation, human-likeness, the will to continue the dialogue, engagement in the conversation, funniness and emotive response are identified as the aspects to be measured, and such measures are usually obtained by user’s subjective report through questionnaires, quantified using a Likert scale. In [53], Gandhe et al. proposed a 6-point scale to assess the appropriateness of agent’s response. Artstein et al.[11] specifically studied the coherence of off-topic responses and used the same scale. Besides such quantitative measures conducted through questionnaires, qualitative, interview-based method has also been used (e.g. in [21]) to evaluate user’s opinion on the system as a whole, by asking questions regarding their enjoyment, the agent’s language ability, etc.

For a computer program emulating a person, naturally, one very important goal for the agent is to give a *human-like* response. Unlike task-oriented agents which focuses on the correctness of the answer, non-task oriented agents focuses on the *appropriateness*. A human-like agent should be able to provide an appropriate response, no matter an answer is available or not. We adopt the scale proposed by Gandhe et al. [53] to assess *appropriateness*, or *coherence*. The scale is reproduced here in Table 7.1.

## 7. EVALUATION STUDIES ON PROTOTYPE II

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As a conversational agent for philosophy interaction, another important goal for the agent is to provide useful answers. That is, it is not enough for the agent to be able to continue conversation without actual knowledge contributions (as what many chatbots do), it should, whenever possible, select useful response from the knowledge base to provide the domain knowledge to the user. Based on such consideration, we define another evaluation metric called *usefulness*, and in accordance with the appropriateness scale, we also make it 6-point, as shown in Table 7.2. It is important to note that *usefulness* is necessary and different from *appropriateness*. A human-like conversational agent may fail a knowledge test, but still pass the conversational one [126]. For example, for a conversational agent that has an identity, it is common that users would ask questions that are reasonably in-domain, such as questions about the agent’s personal information or experience, but the answers are not in the knowledge base. In such case, a response saying “*I do not have an answer*” is a sensible and appropriate answer, as it is conversationally and pragmatically coherent. However, such response is not *useful* to the user, as it does not provide the information the user is looking for. In some sense, the *usefulness* metric measures the coverage of the knowledge base and the ability to associate the input utterance to the corresponding knowledge base entry.

In addition, we would like to know whether users likes the response or not. So a 6-point Likert scale is used to indicate how much users like the response, with 1 being “I do not like it at all”, and 6 being “I like it very much”. Besides these three metrics for judging the quality of each individual response, we also designed a questionnaire for users to report their overall impression on the system.



**Table 7.1:** A 6-point scale for assessing appropriateness of response

Rating	Description
6	Response answers the question in a perfectly fluent manner.
5	Response does address the question, but the transition is somewhat awkward.
4	Response does mostly address the question, but with major problems in the coherence between question and response; seems like the response is really addressing a different question than the one asked.
3	Response partially addresses the question, but there is little or no coherence between the question and response.
2	Response contains some discussion of people or objects mentioned in the question, but does not really address the question itself.
1	Response is not related in any way to the question.

**Table 7.2:** A 6-point scale for assessing usefulness of response

Rating	Description
6	Response gives me very useful information on the question I asked, enabling me to know more about Confucius as a person and/or his philosophy.
5	Response gives me useful information on the question I asked, even though it is not exactly what I asked for.
4	Response gives me partial information on the subject I talked about, and they are of some help to me.
3	Response gives me some amount of useful information on the subject or other related subjects.
2	Response is of little help to me.
1	Response is not useful to me at all.

### 7.2 Controlled lab study

#### 7.2.1 Experiment details

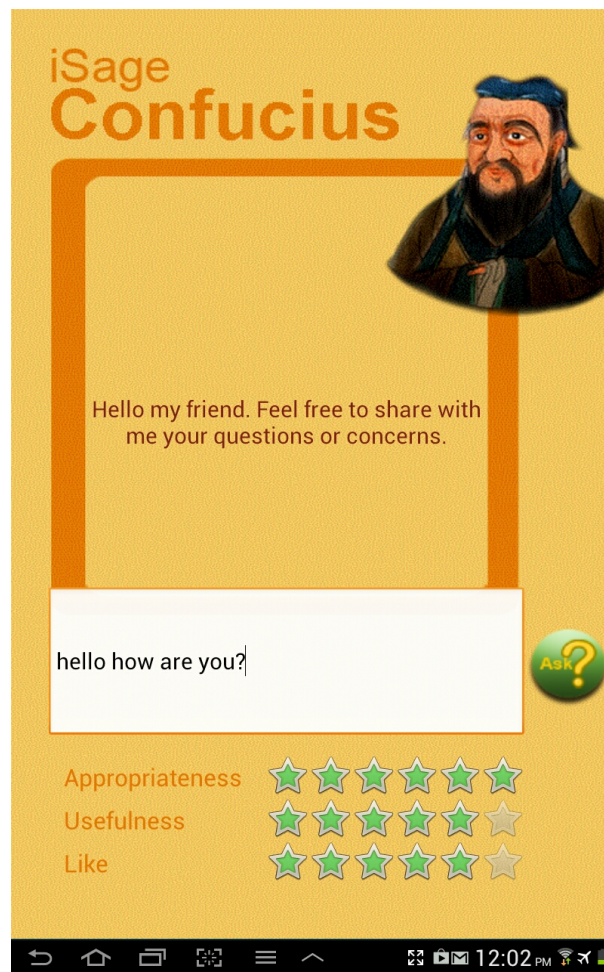
##### 7.2.1.1 Participants

A total of 18 participants (10 males and 8 females) were recruited through an email advertisement about the study. All of them were university researchers, and the average age was 29 (SD = 6.5). The self-evaluation on their familiarity with Confucius and his philosophy, on a scale of 1 to 5, showed that the average familiarity is 3.28 (SD = 0.96).

##### 7.2.1.2 Apparatus

An android application running on a Samsung Galaxy 10.1 Tablet was used in the study. A screenshot of the Android interface for the user study is shown in Figure 7.1. Similar to the previous interface, it includes a text box for users to enter the questions, a display area for displaying Confucius's answer, below which there are three rating bars for users to rate the response in three aspects: *Appropriateness*, *usefulness*, and *like*. The app is designed such that users have to give their ratings before they can proceed to ask the next question, to prevent the situation that they forget to rate. Similar evaluation interface was used in [130, 131], where they ask users to rate their satisfaction level on a 7-point scale for each response.

The server hosts two versions of the system, where system A is our prototype I that uses a sequential structure, and system B is prototype II with a classifier and various no-answer strategies. The architecture of system A and B are shown in Figure 7.2 and



**Figure 7.1:** A screenshot showing the interface used for the study - Users can rate the response by tapping the stars

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Figure 7.3 respectively. Both systems can connect to the same Android interface. The experimenter can control at the server to select which system to run, and this process is hidden from the participants.

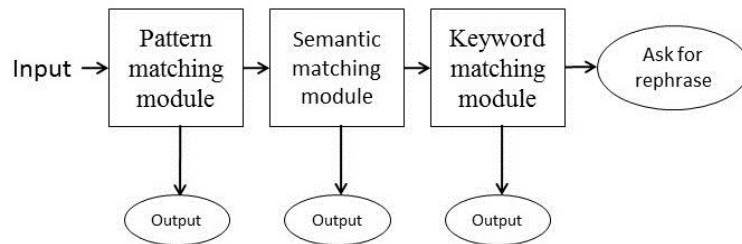


Figure 7.2: Architecture of system A - prototype I

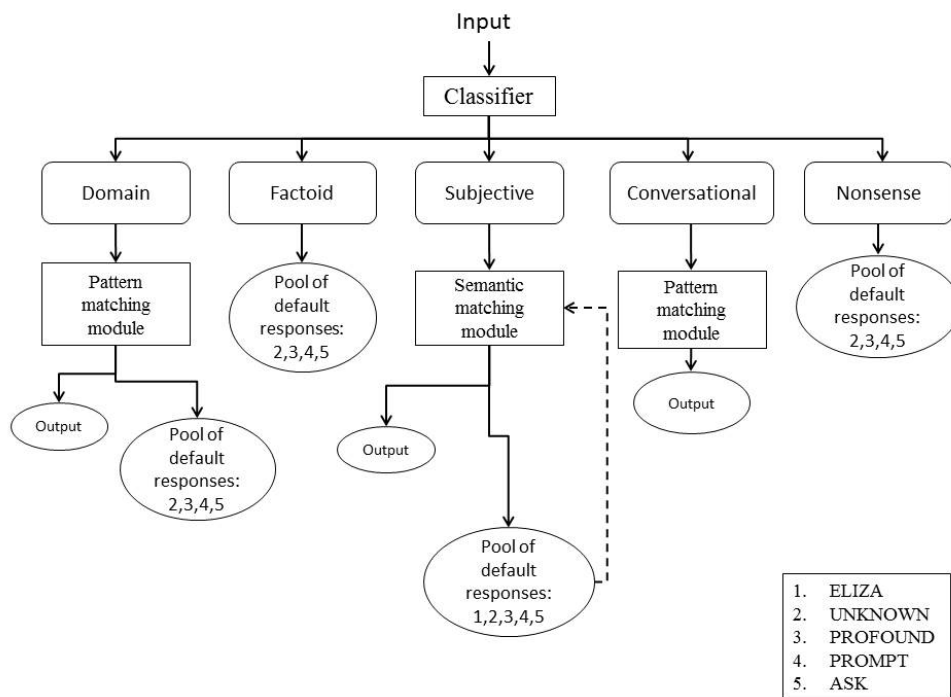


Figure 7.3: Architecture of system B - prototype II

### 7.2.1.3 Procedure

The experiment uses a within-subject design. The procedure of the experiment is as follows: The participants were first given a brief introduction about Confucius and the virtual Confucius system. The experiment procedure as well as the meaning of the three rating metrics were then clearly explained to them. The instruction sheet given to the users before the study was included in Appendix B “User Study for iSage Confucius”. They were informed they would be using two different versions of the system, but were not told the difference and blinded about the order. Each participant then interacted with both system A and B, in random order. After the participants got a response for each utterance, they needed to rate the response on the three aspects as described above. The participants were asked to use the system for about 15 minutes. After finishing the interaction with each of the system, they were asked to fill in an short online questionnaire to report their experience and opinion on the overall system. The questionnaire contained basic demographic information about the user, and a set of statements about the system, which were evaluated based on a 5-point Likert scale, with 1 being “Strongly Disagree”, and 5 being “Strongly Agree”. The questionnaire used is included in Appendix B “Questionnaire for iSage study”. At the end, a short interview was conducted, where the participants were asked about their impressions on the two systems and gave additional feedback or comments. The set of questions asked in the interview were included in Appendix B. Follow-up questions were asked to users for clarification and justification on their answers.

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**Table 7.3:** Participants' ratings to system A and system B

Statement	System A: Mean (SD)	System B: Mean (SD)	Sig. (2 tailed)
I enjoyed the interaction with the system.	3.22 (1.06)	3.72 (1.01)	0.003
The conversation with the virtual Confucius is interesting.	3.50 (0.99)	3.83 (0.99)	0.055
The conversation with the virtual Confucius is inspiring.	3.11 (0.96)	3.16 (1.34)	0.772
I was engaged in the conversation.	2.89 (1.32)	3.44 (1.10)	0.056
I would like to use the system again in the future.	3.11 (1.28)	3.67 (1.24)	0.020

### 7.2.2 Results and discussions

#### 7.2.2.1 Users' opinions on the two systems

The questionnaire results about users' opinion on system A and B are shown in Table 7.3. Statistical significance is tested using repeated measures t-test.

We can see that users expressed significantly higher enjoyment for system B (3.72/5) than system A (3.22/5). They also tended to perceive system B as more interesting (3.83/5) and more engaging (3.44/5) than system A, and the difference was marginally significant. Users were significantly more willing to use system B again (3.67/5), as compared to system A (3.11/5). This shows that the new architecture with more directed response strategies effectively improves the system's overall likability.

In the post-session interview, when asked about whether there are the differences they felt about the two systems, one user commented, "*the second system (system B), when it does not know how to answer, it asks you a question. I think that is better [than always saying it does not understand]*". Another said, "*I got a lot of 'I don't know'*".

*answers (for system A). It's quite annoying*". Many other users also expressed that system B "*seems to make more sense*". However, there were also 4 users who reported that they did not see much difference between the two systems. In these cases, the no-answer situation did not appear often, which may have contributed to the reason why the two systems seems the same to these users. One user preferred system A. He explained, "*I like it that when it does not know the answer, it just says 'I don't know', instead of giving some strange answers.*" So while it is good to employ different strategies, we should be careful in choosing which no answer strategy to use.

### 7.2.2.2 Comparison of effectiveness of various strategies

In system B, in addition to the original answer-finding strategies, we also developed a few no-answer strategies, which was described in Chapter 6. Users' rating scores for each response help us to know the effectiveness of each strategy by comparing the average score it received. Table 7.4 shows the average scores for all responses. As utterance type 1 and 3 are the main intended use of the system, we look into the effectiveness of strategies in more detail in these two cases. Table 7.5, Table 7.6 show the average score for the strategies in the case of utterance type 1 and 3, respectively.

We can see that in general, responses produced by the method "ALICE" received high coherence scores. This is perhaps not surprising, because "ALICE" uses human-authored templates, which is to some extent "guaranteed" to be coherent. As we coded important biographical information about Confucius in the ALICE knowledge base, the responses were also regarded as helpful and enjoyable.

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**Table 7.4:** Score for each strategy in system B, given by the users

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
ALICE	4.19 (1.68)	3.47 (1.69)	3.69 (1.61)
SIM	3.13 (1.45)	3.28 (1.42)	3.27 (1.49)
ELIZA	3.63 (1.64)	2.89 (1.32)	3.00 (1.63)
UNKNOWN	3.00 (1.41)	2.00 (1.18)	2.33 (1.27)
PROFOUND	3.19 (1.64)	3.12 (1.93)	3.38 (1.78)
PROMPT	3.47 (1.77)	2.82 (1.85)	2.94 (1.89)
ASK	3.11 (1.45)	2.72 (1.45)	2.78 (1.48)

**Table 7.5:** Score for each strategy used for responding Type 1 utterance in system B, given by the users

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
ALICE	4.05 (1.72)	3.20 (1.62)	3.50 (1.48)
UNKNOWN	3.40 (1.17)	1.90 (0.88)	2.20 (0.79)
PROFOUND	2.14 (1.68)	2.43 (1.81)	2.14 (1.46)
PROMPT	2.70 (1.77)	2.50 (1.78)	2.40 (1.58)
ASK	2.58 (1.31)	2.17 (0.94)	2.25 (1.06)

**Table 7.6:** Score for each strategy used for responding Type 3 utterance in system B, given by the users

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
SIM	3.13 (1.44)	3.28 (1.53)	3.27 (1.54)
ELIZA	3.63 (1.64)	2.89 (1.67)	3.00 (1.63)
UNKNOWN	2.71 (1.54)	2.07 (1.38)	2.43 (1.55)
PROFOUND	4.00 (1.12)	3.66 (1.94)	4.33 (1.41)
PROMPT	4.57 (1.13)	3.29 (1.98)	3.71 (2.14)
ASK	4.17 (1.17)	3.83 (1.72)	3.83 (1.72)



Similarly, “ELIZA” also received relatively higher coherence scores, but was perceived as less useful, because no knowledge was contained in the “ELIZA” response. The original intent for the ELIZA strategy was to ask the question back, in the hope of eliciting more information on the subject being discussed, so as to increase the chance of successfully finding an answer. For this method to work, users need to be highly cooperative. Unfortunately, in this study, it seems that it is not an effective strategy. Some people simply ignored the question and changed subject; for people who did “play on” and replied, very few offered new information. Some responded with sentences like “I am asking you.”, “You are avoiding my question”. It appears that when people pose a philosophical question to the virtual Confucius, they expect an *answer*, rather than a question back.

The other four strategies, “UNKNOWN”, “PROFOUND”, “PROMPT”, and “ASK”, all received low scores in the case of type 1 utterances. When biographical questions are posed, it appears that users prefer the agent to address the question, rather than changing the topic. In the case of type 3 utterances, users’ preferences are different. “UNKNOWN” received very low scores, whereas “PROMPT” and “ASK” were evaluated much more positively in all three aspects. This result is partly similar to that of Artstein et al [11]. who found that “prompts” were rated much higher than other off-topic responses such as “didn’t hear”, “didn’t understand”, and “move on”. However, after inspecting user’s following utterance, we found that even though prompts were considered as relatively more coherent, not many people follow the suggested topics of “PROMPT”. This is in accordance with the results in [126], where they found a

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majority of users rejected the prompts and pursued their own topics instead. On the contrary, when the agent asked a specific question, most users would answer it, and the agent could continue the pre-designed mini-dialogue. This sometimes resulted the users replying “I see.”, “Thank you.”, indicating they were satisfied with the conversation. However, caution should also be taken when designing such mini-dialogues. One user reported that she thought it was very rude for the agent to ask her “*What would you do if you find that your father did something that is against the law?*”. Therefore, it may be better not to put the user himself/herself in a bad hypothetical situation, and probably we can use third person instead.

In addition, surprisingly, “PROFOUND” also received relatively high scores, even in some cases when the response did not really address the question. This might be due to people’s stereotype of Confucius as being philosophical, therefore they accept profound answers and enjoy reading it. It should be noted that though it is OK to allow a few seemingly irrelevant philosophical answers, such cases should not appear often, especially not in early stages during the course of conversation. Some users reported that when they got irrelevant philosophical answers to their first few questions, they got disappointed. This also makes them less cooperative in the later course of the conversation. This suggests that when users first started using the system, the priority should be given to keeping users engaged and maintaining the conversation. In such cases, techniques such as asking the question back, clarifying with the user, or suggesting suitable topics might be better choices than a philosophical sentence. In future work, we can investigate the effectiveness of time-varying strategies.

**Table 7.7:** Correlation between users' familiarity of Confucianism and their opinion on the system

	I enjoyed the interaction with the system	The conversation with the virtual Confucius is interesting.	The conversation with the virtual Confucius is inspiring.	I was engaged in the conversation.	I would like to use the system again in the future.
Pearson Correlation	.504*	.543*	.437	0.525*	0.475*
Sig. (2-tailed)	.033	.020	0.70	.025	.046

Among users' reported scores, coherence, usefulness, and enjoyment of "SIM" is at medium level. As we use the sentences in the knowledge base directly as the answer, it may happen that even though the sentence contains the right information to answer the question, but due to the way the sentence is phrased, the transition can be awkward and it is still perceived as less coherent. One solution to this problem is to use linking dialogues to facilitate the transition, which is discussed in [53].

### 7.2.2.3 Effects of users' prior knowledge

We found there is a positive correlation between user's prior knowledge on Confucianism and user's opinion on the system in general. Table 7.7 shows the Pearson's  $r$  correlation coefficients calculated. This indicates that users who are more familiar with Confucianism tend to evaluate the system more positively. During the interview, a few users commented that when suddenly asked to talk to Confucius, they had no idea what to ask, because they did not know about him and his philosophy very well. One user said, "*I don't know much about Confucius and I hope to know through this*

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*application. But I don't know where to start.*" Some users suggested that instead of a very brief introduction about Confucius before people start to use the application, it is better to "*prime the users a bit more*". Therefore, depending on user's prior knowledge on the subject, the agent may employ different tactics, such as taking a more proactive role at the beginning of a conversation with users who are less familiar with the subject by initiating the conversation or introducing basic concepts. This may help to get users started and lead them onto the right track.

### 7.2.3 Limitations

In our study, we asked the subjects to rate each response immediately after they received it. This has the drawback that the rating activity might disrupt the flow of conversation and negatively influence the smoothness of interaction and user engagement. An alternative option may be to separate the talking and rating process by having the user to rate each response after they finish the whole interaction. However, this may also bore the user, especially if the conversation is long. Another method is to give the conversation log to a third person to evaluate, and this method has also been used in a number of studies [44, 115]. A third person evaluation is more objective, as the evaluators are not involved in the conversation but purely judge it from an outsider's view. But on the other hand, it is the actual users' opinion which matters most, because they are the ones who use the system. There are inherent advantages and drawbacks of each of the evaluation methods, and we should be aware of the trade-offs.

In the analysis of effective strategies, we focus on utterance type 1 and 3, as they

are most important for the experience with the virtual philosopher. There are other types of utterances, such as factoid, conversational, etc. Since they were less frequently asked, we did not collect enough data for analyzing the strategies. In future work, with more data collected, we can analyze the strategies for these utterances in the same way.

In addition, we only tested the strategies in the broad categories in our taxonomy. Within each category, there are finer distinctions, which may also require different strategies for better response quality. In future work, it may be helpful to further investigate the strategies' effectiveness based on the finer categories. For example, one important problem we are not able to solve at the moment is the problem of answering follow-up questions. In our taxonomy, this type of questions is grouped under 4A. conversational-feedback/acknowledgement to agent. Some of the utterances in this category express users' doubt on the response of the agent, e.g. "*I don't understand.*", "*What do you mean?*". In future work, such follow-up questions should be distinguished from acknowledgement such as "I see", and the agent should employ different answering strategies as well. One solution could be to keep track of the previous question and topic, and when it finds that users ask follow-up questions, it can continue the previous discussion or elaborate the previous response.

### 7.3 Mechanical Turk study

In the previous study, the subjects were university staff and students, and the quality of responses were evaluated by the users themselves. To make our results more generalizable, we carried out another rating study with 3rd party raters. The rating activity

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was carried out through the online service Mechanical Turk<sup>1</sup>, where random users from the public were recruited.

### 7.3.1 Experiment details

The conversation logs collected from the controlled lab study were broken down into segments containing around 20 conversation turns each, and each of the conversation segments was published as a HIT (Human Intelligence Tasks). The HIT required users to read each pair of questions and answers, and give ratings on how good they think the responses are. Same as the rating activity in the previous study, they were asked to rate each response on a 6-point Likert scale from three different aspects: appropriateness, usefulness, and how much they like the response.

Registered users of Mechanical Turk (also called “workers”) could choose to work on any of the HITs, and the completion of the HIT would award them with a small remuneration. To ensure the quality of the ratings, only workers with HIT Approval Rate greater than or equal to 99% and more than 5000 approved HITs are eligible to participate in the study. High approval rate and high number of approved HITs are good indicators showing the worker is experienced and always complete their tasks with high quality. During a 10-day period, a total of 137 HIT assignment were collected, out of which 120 were approved and used in the analysis, and 17 were rejected due to unusually short task completion time (implicating poor rating quality).

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<sup>1</sup><https://www.mturk.com>. Mechanical Turk is a crowdsourcing “artificial intelligence” service.

**Table 7.8:** Score for each strategy in system B, given by 3rd party raters

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
ALICE	3.79 (0.80)	3.74 (0.72)	3.79 (0.76)
SIM	3.23 (0.62)	3.43 (0.64)	3.32 (0.57)
ELIZA	3.60 (0.66)	3.64 (0.72)	3.72 (0.59)
UNKNOWN	3.29 (0.65)	3.12 (0.47)	3.23 (0.50)
PROFOUND	3.34 (0.84)	3.43 (0.71)	3.40 (0.60)
PROMPT	3.22 (0.60)	3.26 (0.50)	3.40 (0.50)
ASK	3.40 (0.80)	3.43 (0.72)	3.43 (0.70)

**Table 7.9:** Score for each strategy used for responding Type 1 utterance in system B, given by 3rd party raters

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
ALICE	3.82 (0.77)	3.79 (0.77)	3.85 (0.71)
UNKNOWN	3.10 (0.79)	2.92 (0.58)	3.10 (0.65)
PROFOUND	2.97 (0.63)	3.22 (0.71)	3.04 (0.37)
PROMPT	3.04 (0.48)	3.15 (0.44)	3.23 (0.52)
ASK	3.52 (0.82)	3.52 (0.74)	3.48 (0.71)

### 7.3.2 Results

Each of the conversation turn was rated by 10 different workers. Similar to the previous study, we calculate the average scores of each strategy type received for all utterance types, for type 1 utterances and for type 3 utterances. The results are shown in Table 7.8, 7.9, 7.10, respectively.

Comparing with the results in Table 7.4, 7.5, 7.6, we can see the ratings for each strategy in each situations generally follow the same pattern, although the differences between the scores appear to be smaller. The strategy “ALICE” is rated more positively than other strategies, especially in the case of type 1 utterances.

In the case of type 3 utterances, like the results from the previous study, “PRO-

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**Table 7.10:** Score for each strategy used for responding Type 3 utterance in system B, given by 3rd party raters

Strategy	Coherence Mean (SD)	Usefulness Mean (SD)	Like Mean (SD)
SIM	3.24 (0.60)	3.43 (0.59)	3.33 (0.55)
ELIZA	3.60 (0.66)	3.24 (0.72)	3.72 (0.59)
UNKNOWN	3.43 (0.52)	3.07 (0.31)	3.32 (0.37)
PROFOUND	3.62 (0.91)	3.60 (0.71)	3.68 (0.60)
PROMPT	3.47 (0.70)	3.41 (0.57)	3.63 (0.40)
ASK	3.20 (0.79)	3.26 (0.73)	3.33 (0.76)

FOUND” and “PROMPT” received relatively higher scores, suggesting they are better strategies than simply saying “I don’t know”.

However, different from the previous study, for type 3 utterances, “ASK” received low ratings from 3rd party raters. This may be because the 3rd party raters judge the quality purely based on how good it is as an *answer*, so when the agent provides no answer and asks a different question instead, it may be perceived as not coherent and not liked by the 3rd party raters. In fact, in our everyday conversations, it is common for one of the conversation party to suddenly change topic. So when one is actually participating in the conversation instead of seeing it from an outsider’s perspective, such topic changes may be more acceptable.

### 7.3.3 Limitations

In this study, we tried to validate the results regarding the effectiveness of different no answer strategies tested in the controlled lab study. Sections of logs from the study were presented to the individual Mechanical Turk workers and they were asked to rate the responses. These workers were randomly self-selected from the public, thus the results



are more general. In each HIT, workers were shown a pair of question and answer, and were asked to give three ratings for the response before proceeding to read the next conversation pair. In this way, workers tend to rate the response purely in the context of the current conversation pair, whereas in the controlled lab study, the actual user's rating may be affected by the previous answers, because he/she was in the conversation process. Therefore, in these two studies, the ratings were performed in different setups, which may contribute to different perceptions on the response quality.

## 7.4 Chapter summary

In this chapter, we described an evaluation study conducted on the second iteration of our prototype, and a rating study using Mechanical Turk to further validate our results. Based on the literature and our system's characteristics, we proposed three evaluation metrics to evaluate each of the response from the agent, and designed a questionnaire to compare user's subjective opinion on the two prototypes. The results showed that the new architecture with more directed answering strategies could improve the user experience in general. We also compared the effectiveness of various strategies and gave our recommendations.

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## Chapter 8

# Limitations and Future Work

### 8.1 Regarding the knowledge base

Though we tried our best to simplify the process of knowledge base construction to reduce the workload of domain experts, it is still quite time-consuming to build the whole system from scratch. This is probably unavoidable, as philosophy, or culture at large, is intricate and complicated. To bridge the gap between elusive cultural contents and quantifiable data to be used in computers, human efforts are necessary to enable this transition process. More semi-automatic methods may be developed in future work to facilitate this process, such as mining information online and getting it checked by human experts. In addition, human work is prone to error and personal bias. Therefore, if time and resources permits, it is better to get a few more domain experts' input for the knowledge base construction, so as to reduce this negative effect.

In our knowledge base construction process, in order to induce a historic experience -

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the feeling that one is talking to someone walking out of history, in the initial knowledge base collection, we chose to use James Legge's translation, one of the earliest English translations. However, we found through the user study that this might not be a good choice, because users reported the answers sometimes were a bit too difficult to comprehend due to the use of archaic English. Besides, some of the sentences are short and concise, with deep meanings behind, which are difficult to comprehend if no further explanations are provided. One such example is "A gentleman is not a pot". The presence of these factors may have resulted in a less satisfying user experience. In future work, it would be good to replace the knowledge base with a modern translation or do some rewriting, or to prepare more detailed explanations when users request further elaboration.

In our first prototype, we segmented the knowledge base into three parts, biographical info, knowledge statements, and domain terminologies. We treated the third part, domain terminologies, with simple word-level tagging. It was later found in our user study that the percentage of questions asked by the general public regarding domain terminologies is extremely low. As a result, in our second iteration, we chose to focus on the retrieval of the knowledge statements. Ideally, better algorithm should also be designed for handling domain terminology related questions, probably by building an ontology of the concepts in the domain. Such improvements might be useful for expert users who are interested in having a more holistic understanding of the domain.

### 8.2 Regarding user studies

In our research, though we carried out a series of user studies, users were involved only after the first prototype was built. They could be brought into the picture much earlier in the design process, following the “user-centered design” principle. For example, before we start diving into the analysis of domain knowledge, we could also study how human converse with others face to face and via electronic media, or how people pose questions using search engines, etc. Such studies about the users could help us better understand how people use these media, their expectations, tolerances and needs, which helps to design prototypes with better usability.

In addition, although in our studies we employed a variety of evaluation methods, including direct observation, questionnaires, log analysis and interviews, in some cases we had to make our own speculations for possible explanations to the user behaviors. To better understand users’ mental models, more in-depth and follow-up interviews with the user should be carried out.

Due to time and resource limitations, we were not able to examine the long-term effects of the system. In our studies, users only interacted with the application for a brief period of time, but ideally, the interaction with the virtual philosopher should not be just a one-time experience, as it takes time - months, or even years, to know about a person and his philosophy, and to know about a culture. People should be able to have access to the system and develop a long term relationship with it, have conversation with it whenever they feel like. It is also the reason why we developed the

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mobile application in addition to the web version - to increase the accessibility of the system.

On the other hand, assessing how much one learns about culture is in itself a difficult and interesting research problem. Unlike sciences where there are always a precise answer and one can assess the knowledge simply by a test, culture is hard to quantify. It is hard to give a score to indicate how much one knows about a culture, or how much one has improved. In future work, it would be ideal to carry out a longitudinal study (possibly for at least a few months) to examine the effects on long term users of the system, and perhaps through pre and post interviews conducted by researchers and domain experts.

### 8.3 Dissecting the problem of handling open questions

It is hard to build a non-task oriented conversational agent that appropriately handles unconstrained inputs. There has been a number of work trying to solve the problem of out-of-domain questions [11, 103, 107, 115] on certain aspects. In our work, we examined the effectiveness of different strategies under different situations. Here, we give a detailed analysis on the causes of ‘bad’ responses to open questions, and point out the directions of research effort to improve the response quality.

Essentially, the problem of answering an incoming question can be modeled as an information retrieval problem, where the goal is to find the most suitable text in a repository of candidate answers. Figure 8.1 shows the 6 different situations that could occur when a conversational agent tries to relate one of the candidate answers to an

### 8.3 Dissecting the problem of handling open questions

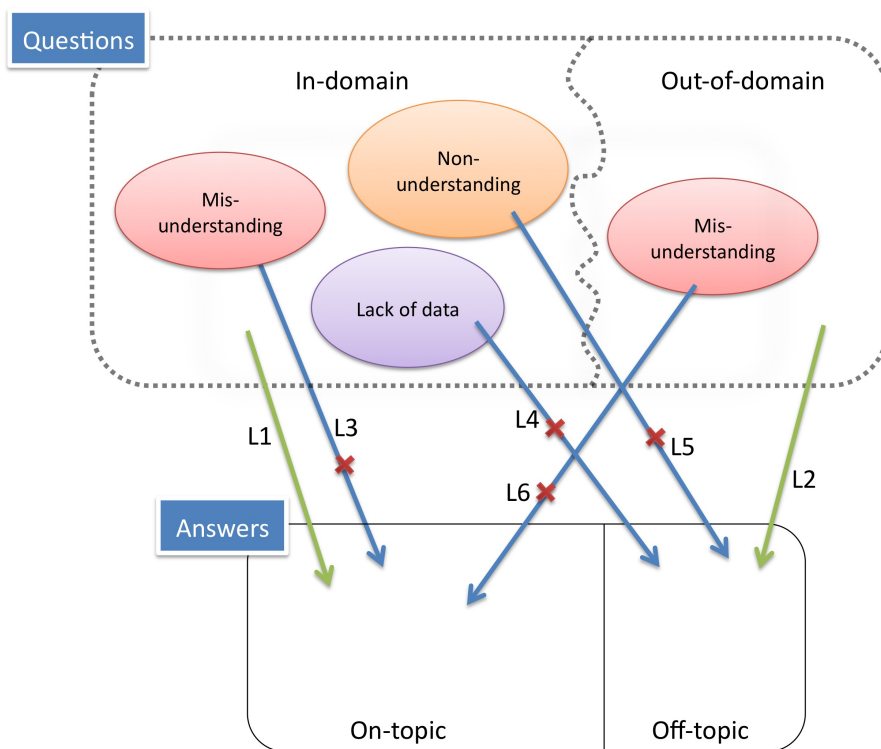


Figure 8.1: A graph showing the possible scenarios in linking the candidate answers to questions - size of the shapes is not drawn to scale

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incoming question, each of the situation is labeled as L1, L2, ..., L6. The dotted area on top represents the possible utterances. For a system with unconstrained input, this area can be infinitely large. It is divided into two parts: in-domain, which are the questions that fits the intended purpose of the system, and are supposed to be answered by the agent; out-of-domain, which are questions that are not supposed to be answered. For many non-task oriented systems, the boundary between the two is not very clear, as the usage of such systems is not clearly defined as in the case of task-oriented systems. The rounded rectangle below represents the repository of answers for the agent. Typically, the size of the answers repository is not large, ranging from tens to thousands. The answers can also be divided into two types: on-topic, which are the major part of contents in the agent's knowledge base; off-topic, which are usually human-authored responses to handle out-of-domain questions. The scenarios of the possible links are described below:

- L1: user asks an in-domain question, the agent perfectly understands user's question, and finds a good answer in the knowledge base.
- L2: user asks an out-of-domain question, the agent perfectly understands user's question, and responds with an off-topic answer.

Both L1 and L2 are what should happen in the ideal case.

- L3: user asks an in-domain question, but the agent misunderstands the meaning of the question, and replies with a wrong/inappropriate response. This happens when the agent has limited natural language understanding ability. Human



### 8.3 Dissecting the problem of handling open questions

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language is very complex and ambiguous, especially in casual conversations. Currently, the state-of-the-art still cannot perfectly understand unconstrained human language, so this type of error is unavoidable for now. To reduce this type of error, we need better NLU algorithms operating on syntactic, semantic, pragmatic, and discourse level, as well as comprehensive common sense knowledge, which may seem trivial to the user and are omitted in the conversation, but are not understood by the computer. WordNet [47] is a knowledge base that we used to provide some sort of common sense knowledge, and there are other common sense knowledge base such as Cyc[87], ConceptNet[94], and Google's recent work on Knowledge Graph<sup>1</sup>. It is worth comparing the comprehensiveness and suitability of these common sense knowledge bases, and even develop new ones if necessary.

- L4: user asks an in-domain question, the agent understands it correctly, but it is not able to find a suitable answer in the knowledge base, because the answer is simply not there. This happens when the coverage of knowledge base is not wide enough. Solutions to avoid this type of error is to expand the knowledge base, either by manual work to collect more information, or search online to expand the knowledge base. The work in [126] addresses this problem by collecting lots of user data, analyzing the contents, finding out the commonly asked information not covered by the current knowledge base, and expanding it. The work in [107] solves this problem by searching for the answer online. As the amount of information

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<sup>1</sup><http://www.google.com/insidesearch/features/search/knowledge.html>

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available on the web are getting exploded, we see data mining as a promising approach for solving this problem.

- L5: user asks an in-domain question, the agent is not able to understand it, and replies with an off-topic answer. This situation is similar to L3, and to reduce this type of error, the agent needs to improve its NLU ability. When such error occurs, the choice of off-topic response can also affect the coherence of the response. Therefore, care much be taken in authoring and selecting the off-topic responses. The same applies to L4 as well.
- L6: user asks an out-of-domain question, the agent misunderstands it and replied with a on-topic answer. Like L3 and L5, it is also due to the NLU ability of the agent. Users in our study frequently mentioned the frustration caused by this type of error. Responding with too many knowledge-intensive answers which are not related to what is asked can easily bore the users.

The solution proposed in this thesis, i.e., the use of a classifier, can only help to reduce the errors caused by misunderstanding (i.e. L3 and L6) to some extent. And the no-answer strategies helps to make the agent produce better off-topic responses. To further improve the quality response, we need to equip the agent with more comprehensive common sense knowledge, the ability to understand casual conversational language that may not strictly follow the grammar, and expand the agent's knowledge base by having more domain expert inputs or searching for information online. This thesis gives a comprehensive exploration and discussion on the issues and problems

involved in the process of creating a virtual conversational agent for a philosopher, and each sub-problem mentioned, such as knowledge representation and how to understand the input and link it to a response in the knowledge base, on its own is an interesting research problem and can be further explored in more depth in future work.

### 8.4 Creating agents for other philosophers

This research serves as an attempt to expand the current interaction modalities in the area of Cultural Computing by introducing natural language interaction. Due to time and resources limitation, the subject of study in this thesis is constrained to one philosopher. However, we believe that our method is generalizable to other philosophers (at least for those of Eastern origin), with small adaptations if necessary. One can easily imagine creating conversational agents of Mencius, Laozi, Mozi, Buddha, etc., using the same technique we described in this thesis. Even western philosophers may be created using similar models<sup>1</sup>. The strategies for answering (or asking) may be adapted depending on the conversation style of the particular philosopher, especially if the philosopher has a distinctive way of talking. One such example is Socrates, who is famous for his “Socratic method”<sup>2</sup>. Instead of a passive strategy as in the case of Confucius, the virtual agent for Socrates can employ a more active strategy, to ask questions to stimulate critical thinking.

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<sup>1</sup>However, further investigation should be conducted, as Western philosophy seems to concern more about logic and reasoning, which may be better represented using a different model.

<sup>2</sup>[http://en.wikipedia.org/wiki/Socratic\\_method](http://en.wikipedia.org/wiki/Socratic_method)

### 8.5 Exploring philosophy through other interactions

In this thesis, by studying how people learn about philosophy in the traditional way, we propose to recreate the experience of talking to a philosopher for people to learn about philosophy. Though this is one possible method, there may be other approaches that are equally or even more effective. For example, we can create serious games with specially designed scenarios, where users need to make decisions based on Confucian philosophy, and these decisions can result in different consequences. The agent developed here can also be integrated in the game, and users can consult the virtual Confucius to make the right decision.

In addition, “user-centered design” method could be adopted to find out other interesting interactions. For example, we can find out the potential users, conduct interviews or form focus groups to better understand what problems users have when studying philosophy, what they want to learn about philosophy and how they want the interaction to be like. By listening to the desire of users right from the beginning and throughout the design process, such user-centered design method could let us find out more real user needs and open up more interaction possibilities.

### 8.6 Towards an impersonating conversational agent

In this thesis, we studied a special kind of conversational agent which has the following properties:

1. It has a real identity and simulates a particular person;

## 8.6 Towards an impersonating conversational agent

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2. It accepts unconstrained natural language input;
3. Unlike other conversational agents that are task-oriented or answer factual questions, the agent tries to answer questions regarding one's subjective opinions on certain things.

We can call this kind of agent *Impersonating Conversational Agent*, which means it aims to impersonate a particular person by modeling that person's knowledge and talking like him/her. Though the agent we developed still has limited ability in simulating the thinking and conversational ability of a real philosopher, it inspires us to ask the bigger question: can we create a conversational agent to simulate anyone we like? The original intent of our work is to provide an interactive way for people to learn about philosophy and culture, but we can imagine similar agents being created to support other human needs, such as having the agent to talk on one's behalf when one is not available, getting expert advice from successful people, or even communicating with the deceased family members for moral support<sup>1</sup>, etc.

To achieve this, there are two main problems to be solved:

1. What are the knowledge sources and where can we get them? How do we model the knowledge/behavior/personality/emotion/etc. of a person? Each person is a unique individual, how can we represent them digitally and simulate their talking through a computer agent? In our work, the person to be simulated is a philosopher, and we have the historical texts that can be used as the knowledge base.

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<sup>1</sup>An interesting prospective of this is depicted in the popular TV series, Black Mirror, produced by BBC. [http://en.wikipedia.org/wiki/Black\\_Mirror\\_\(TV\\_series\)](http://en.wikipedia.org/wiki/Black_Mirror_(TV_series))

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We gave our solution to model the knowledge and use it to answer questions. However, there are other dimensions to the simulation of a person's conversation, such as personality, emotion, etc. Nowadays, people share abundant information online with others through social networks and other communicating devices, and within such information, the personality, habit, may be traced. Particularly, the mobile phone is becoming one of the central point of interaction in our daily life - we use it to communicate with others by phone calls, messages, and we use it to read news, search for information, listen to music, watch videos, play game, and many other daily activities. Can an agent residing in one's phone monitor the activities and mimic the conversation style, preference, personality of a person?

2. How do we understand the user utterances? In our work, we mainly focused on distinguishing the basic types of user utterance (based on our taxonomy) and finding and relating the topics of the utterance. But utterances in conversation is more than that. For example, the 'four-ear-model' proposed by Schulz von Thun [129] argues that each utterance in conversation simultaneously contains four messages: Factual information (which I am informing about), self statement (what I show of myself), relationship indicator (what I think of you and how I relate to you), and appeal (what I want you to do). The approach we took in this thesis largely focuses on the so-called 'factual information' level, i.e. the literal contents of the utterance. To make the agent more versatile and more human-like, communication models such as this should be consulted, and more sophisticated models should be built, not only for the agent, but also for the user.

## 8.6 Towards an impersonating conversational agent

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Furthermore, to create believable agent, just focusing on the conversation content is far from enough. Each person has his/her unique style in communication, which includes the common phrases one likes to use or other habits one has when talking to others, whether humors should be used, how one displays his/her emotions, etc. Existing work handles this by carefully crafting the knowledge base rules and hard coding the personality into the scripts of the agent [52, 121], modeling the agents' emotions with transitional states [20] or explicit personality model [43]. Designing a virtual human is essentially not only a technical endeavor, but also an art. In the case of the virtual philosopher, to make it more personalized, we need more inputs from the experts who are familiar with the communication style of the philosopher and prepare templates for the agent. One very simple solution to create a more personalized feeling, as suggested by one of the users, is to add some starting phrases to the current response, such as "*As I always tell my disciples, ...*". But we also need to consider the coherence issue when we concatenate the sentences in this way. More sophisticated models on affect, personality, mood, etc. could also be explored in future work.

Given our current understanding in human language and knowledge, a true impersonating conversational agent may still be a far-fetched goal, but as technology in natural language understanding, knowledge representation, data mining, etc. develops, we believe we are making small steady steps towards it, approaching full simulation of human-like communication.

## 8. LIMITATIONS AND FUTURE WORK

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## Chapter 9

# Conclusion

In this thesis, we took a first step to look at the problem of conveying cultural contents, namely, traditional Chinese philosophy, from a cultural computing perspective. We proposed to build a conversational agent that emulates the philosopher to create an interactive experience conversing about philosophy. We built two prototypes of the virtual philosopher and conducted five user evaluations through observation, questionnaires, log analysis and interviews. This virtual philosopher we created is a unique kind of conversational agent that has the following distinctive properties:

- Different from chatbots which are used for pure entertainment, the system has a serious purpose - letting people to experience philosophy. It also employs more advanced techniques than pattern matching to reduce the workload of the knowledge base authoring process and make the agent more flexible.
- Different from search engines which people usually use to search for factual in-

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formation or explicit knowledge by providing some key terms, our system tries to convey tacit knowledge by offering a more personal and interactive experience. Users can converse in natural language and get back a single human-like response, unlike in the case of search engine where substantially more efforts are required from the users to look through information in the ranked list of web pages returned.

- Different from many other virtual humans which are generic characters for providing factual information (e.g. information about a museum), the virtual philosopher has a unique identity and a special domain. It works on abstract and ambiguous philosophy knowledge, and people use it to learn about Confucius's subjective opinions on philosophy and things in our everyday life.

### 9.1 Back to the research question

Back to the research questions raised at the beginning of this thesis - can we help people learn about philosophy through HCI? We can now answer affirmatively. Through our investigation on the philosophy material, building of the agents and testing with users, we can see that conversational agent is a promising approach for communicating philosophy, because:

- Philosophy is a kind of tacit knowledge that is gained through dialogue and experience. The conversational agent offers an opportunity for users to engage in such a dynamic experience.

- Our real-world study showed that people would voluntarily use the system to ask questions about philosophy and for advice on their own problems. The concept and purpose of the system can be easily understood and accepted by users from the general public.
- Our lab study showed an increased interest in the subject after using the system, and we received positive feedback on the idea of communicating philosophy through HCI.

Regarding the specific research questions, we can now give the following recommendations:

1. *How do we translate philosophy texts into something understandable by the conversational agent?*

We propose to segment the knowledge contained in the text documentations into three distinct parts: biographical info, knowledge statements, and terminologies. Each type of the knowledge can be encoded differently in the knowledge base: biographical info as AIML patterns and templates, knowledge statements as vectors in a high dimensional topic space, and terminologies as literal strings. Domain experts can follow a workflow that we developed to prepare the knowledge base, as shown in Figure 3.2.

2. *What are the suitable technologies to be used or new technologies to be developed in order to create a virtual philosopher agent?*

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The problem of finding relevant answers to a question can be modeled as an IR problem, and the vector space model together with semantic relatedness measure based on WordNet can be applied. In addition, simple pattern matching technique can be handy in encoding factual biographical information about the agent.

The agent should be able to distinguish different types of utterances, and have suitable strategies to respond to each type of utterances both in cases when an answer can be found in the knowledge base, as well as in cases when no answer is available. We proposed strategies for answering each type of utterances in Table 6.2.

Out-of-domain question is a common problem, and we should be careful in designing the strategy in such cases in order to engage the user. We found that for category 1 and 3 utterances, the two main target utterance types of our application, different no-answer strategies should be used. For category 3 utterances, ASK appeared to be a good strategy, where the agent actively changes the topic by asking the user a specific question related to philosophy. In addition, the use of PROFOUND strategy can also help, but it should be used with reservation not to cause boredom. For category 1 utterances, it is best handled using the pattern matching technique. More sophisticated strategies (for example, time-varying, user-dependent) on finer utterance categories can be explored in future work.

### 3. *How do people interact with such an agent? What do they think?*

In an unconstrained conversation, user utterances can have totally different char-

acteristics. From user data collected using our prototype system, we classified the user utterances into the following categories: 1. Confucius and Confucianism; 2. Factoid; 3. Subjective; 4. Conversational; 5. Nonsense; 6. Others. Despite the variances in the types of utterances, we found that most users could understand easily the purpose of the system and ask about Confucius and his philosophy, or ask for advice on their personal problems.

Majority of the users reported that they enjoyed using the system, and they became more interested in philosophy after using it. People have high expectations on an agent claiming to be a philosopher, and it was found that our first prototype had problem handling the variety of user utterances sensibly, which resulted in frustrations. The second prototype with more targeted strategies improved on the first one and received better evaluations.

### 9.1.1 Guidelines for designing virtual philosopher agents

We summarize a set of guidelines for designing a virtual philosopher agent, based on our findings in the user studies. Researchers working on similar problems could refer to these guidelines to make their design choices and decide where to invest their efforts.

- *Use a mixed initiative.*

In our study on the effectiveness of various no-answer strategies (section 7.2.2.2), we found that when the agent asks a question, people are likely to respond to it and continue the discussion with the agent. This suggests that instead of just passively responding to the user's questions, the agent can also proactively start

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the conversation regarding a particular topic with the user.

- *Consider varying the agent's proactiveness and contents depending on users' prior knowledge. Be more proactive when the users have little knowledge on the subject.*

Furthering the suggestion on mixed initiative, we think that the proactiveness of the agent could also be varied, depending on the user's prior knowledge on the subject. In our study (section 7.2.2.3), we found positive correlation between user's prior knowledge and their satisfaction in using the system. The interview with users with less domain knowledge revealed that they expected the agent could lead them in the discussion.

- *Prepare a wide list of biographical information for the philosopher, or connect to a QA service to answer such questions.*

Throughout our series of studies (chapter 5), we found that our current knowledge base on biographical information is not sufficient to answer all users' queries. One possible solution is to collect large amounts of such questions and prepare the answers for them, as in [126]. Alternatively, QA services could be used to search on the Internet for answers to such factoid questions.

- *Use semantic closeness measure to retrieve answers to questions regarding subjective opinions.*

By calculating the semantic closeness/relatedness of the key concepts in the utterance with the topics in our knowledge base, we can find the most relevant sentence and use it as the reply (see section 4.2.1.2). This process partially mimics what

happens in human to human conversation - when the conversation partner talks about certain things, we often reply, from our own “knowledge base” (our own explicit and tacit knowledge), with something that is either directly or indirectly related to the current topic. In this regard, the semantic closeness approach is perfect for building philosopher agents. However, one important point to take note is the coherence problem resulted from this approach - humans are able to change their phrasing so that the conversation flows naturally, but it is difficult for a machine to do so. Therefore, to improve the utterance coherence of the agent, we may need to adopt methods such as using linking dialogues [53] or even dynamically reorganizing and reconstructing the response sentence based on the particular context in which it will be used, which may require linguistic analysis and inference.

- *Be careful in designing no-answer strategies. Use a variety of answers, and use different strategies for different types of utterances.*

Out-of-domain question is a common problem to all conversational agents, but there has not been extensive study on the strategies to deal with this problem or recommendations on what strategy should be used. Our studies showed that the selection of no-answer strategies is vitally important in affecting user’s experience, and the different strategies are preferred by human users in different situations (section 7.2.2.2).

- *Consider how to handle follow-up questions.*

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The virtual philosopher designed in this research has very limited capability in handling follow-up questions. We recommend future work should improve from this aspect. This can be achieved by keeping track of the current topic and having a mechanism to detect follow-up questions (for example, by detecting certain patterns commonly used when asking follow-up questions).

- *Give users choices of different interaction modalities. For example, provide speech input if possible.*

From the feedback from our users (section 5.1 and section 5.2), we think it is good for the agent to provide extra interaction modalities, so that users can choose to interact with the agent in the way they like the most.

### 9.2 Contributions and implications

The work described in this thesis has the following contributions and implications:

- **Contribution 1 (methodological)** We provided a **systematic method for domain experts to easily author the knowledge base contents for creating a virtual philosopher, facilitating interdisciplinary collaboration.**

The creation of virtual agents requires collaborative work between computer scientists and the experts in the domain the agent operates. Previously, the knowledge base creation is a laborious task that often requires the content preparers to manually author large amounts of question and answer pairs and encode them using scripting language. For example, the ALICE chatbot contains 41,000 man-



ually authored rules. The method we developed greatly reduced the workload of the domain experts by distributing part of it to the computers. They can work with the technology they are already familiar with, without learning complex computer skills such as scripting. Though there have been research on using conversational agents to convey information and knowledge, to the best of our knowledge, this thesis presents the first comprehensive analysis and step-by-step recipe for creating a conversational agent in the philosophy domain.

We also proposed **a set of evaluation metrics that can be used to judge the quality of a virtual philosopher and the experience interacting with it.**

Different from task-oriented conversational agents which emphasizes the efficiency and task completion, virtual philosopher agent is a special kind of agent that aims to introduce philosophy through casual conversation. Therefore, traditional evaluation metrics is no longer applicable, and a new set of evaluation metrics is needed to assess how well the agent can achieve this goal. The agent, firstly as a virtual human, needs to be able to talk like a rational human being, which means the responses should be *appropriate*. Secondly, as a virtual philosopher, the response should be able to provide some *useful* knowledge on philosophy. And thirdly, as a lightweight interactive learning platform, the interaction should be *enjoyable*.

- **Contribution 2 (theoretical)** From real-world user data collected through our developed prototype, we derived **a taxonomy of user utterances in an open conversation with the virtual philosopher (Confucius)**. Users who

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contributed these data were spontaneous users, and they were free to interact with the system as they please without any external social pressure. This has the benefit of being able to get the most real usage of the application, as compared to a study conducted in a lab environment.

This taxonomy, together with their frequencies in our collected corpus, give a good picture of how people communicate with the virtual philosopher agent (Confucius) in the real world. It also adds to the currently limited body of knowledge on how people interact with conversational agents in unconstrained real-world situation. From this taxonomy, we can start designing more targeted strategies to handle each unique type of utterances. We found that in addition to asking the virtual philosopher biographical questions and subjective opinions on philosophical concepts, many users would approach the virtual philosopher when they had problems in their life and look for advice, which is something people normally would not talk about to other kinds of virtual humans (except those dedicated to counseling purposes). This shows the agent has the potential to maintain a long term relationship with the user, because users can relate new happenings in their daily life to the philosophy, which helps to prolong the interaction beyond the novelty effect.

We also summarized **a set of guidelines for the design of virtual philosopher** from our experience designing and testing the agent with users. Researchers exploring this area could refer to these suggestions to make their design choices and direct their efforts.

- **Contribution 3 (empirical)** We provided **experimental results concerning the effects of different answer-finding and no-answer strategies on the evaluation of the virtual philosopher**. In an unconstrained conversation scenario, it is unavoidable that some of the user utterances may be out of the knowledge base of the agent. How the agent handles such cases is crucial in maintaining user satisfaction and engagement. Therefore, it is an important problem to solve. However, there had not been any systematic studies comparing the effects of the strategies that could be used by the agent. Our experiment results showed users' ratings on various strategies and recommended suitable ones for selected types of utterance. For example, in the no-answer case, for biographical questions, the ALICE technique is a good choice; and for questions asking subjective opinions, we recommend to use a mix of PROFOUND and ASK strategies. Though our study is situated in the case of a virtual philosopher, the results may be helpful for designing other virtual humans as well.
- **Contribution 4 (technical)** We created a new type of non-task oriented conversational agents, which operates in the philosophy domain and deals with unrestricted input, focusing on answering questions regarding one's subjective opinions. Because of the special domain it deals with, this agent is different from other existing conversational agents that are either for pure casual conversation or for communicating factual information. Consequently, existing conversational agent techniques are not sufficient to support our application. Based on our analysis of the special characteristics of philosophy and how people talk to a philosopher, we

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proposed **an architecture that utilizes an utterance classifier and fuses different answer-finding techniques as well as no-answer strategies to handle unrestricted conversation.** Our comparative user evaluation showed that the hierarchical architecture using the classifier to distinguish the utterance types outperforms the sequential one in terms of answer quality.

We hope the work presented in this thesis can widen the path of interactivity in cultural computing and give a fresh perspective to researchers and practitioners interested in the intersection of culture and computing. As a huge part of culture is intangible and elusive, the conversational approach may be a promising interaction modality for interaction with cultural contents. Though we constrained our analysis on one particular philosopher, we believe that the method described here can be adopted or modified by other researchers to create interactive dialogue system with other philosophers and explore the area in more breadth and depth. As research on artificial intelligence develops, we foresee that in future, natural language interaction can play an important role in cultural computing applications, as stand-alone conversational agents or being embedded in interactive games or installations.

For computers to fully simulate human conversation, especially in the philosophy domain, there are still many technical challenges and we still have a long way to go. Though we cannot give a perfect solution for now, we believe the findings and discussions in the thesis can be a stepping stone and shed some light on the problems, leading to further exploration and improvement on conversational agent for philosophy interaction, as well as in other non-task oriented scenarios.

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# Appendix A

## List of Publications

### Thesis-related publications:

**Xuan Wang**, Eng Tat Khoo, Ryohei Nakatsu, and Adrian Cheok. Interacting with Traditional Chinese Culture through Natural Language. *Journal on Computing and Cultural Heritage (JOCCH)*, Volume 7 Issue 3, Article 18, August 2014, 19 pages.

**Xuan Wang**, Ryohei Nakatsu. iSage: A Virtual Philosopher System for Learning Traditional Chinese Philosophy. In *International Journal of Philosophy Study (IJPS)*, Volume 2, Issue 1, pp 1-8, 2014.

**Xuan Wang**, Ryohei Nakatsu. How do people talk with a virtual philosopher: Log Analysis of a Real-World Application. In *Proceedings of the 12th international conference on Entertainment Computing (ICEC 2013)*, Lecture Notes in Computer Science, Volume 8215, pp 132-137, 2013.

**Xuan Wang**, Eng Tat Khoo, Courtney Rong Fu, Adrian David Cheok, Ryohei Nakatsu. Confucius Chat: Promoting Traditional Chinese Culture and Enhancing Intergenerational Communication through a Chat System. In *Proceedings of 2013 International Conference on Culture and Computing*, pp 123-128, 2013.

**Xuan Wang**, Eng Tat Khoo, Jun Wei, Adrian Cheok. Reviving Traditional Chinese Culture through an Interactive Chat Application. *ACM Computers in Entertainment*, 2013. (Accepted)

## A. LIST OF PUBLICATIONS

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**Xuan Wang**, Eng Tat Khoo, Sanath Siriwardana, Horathalge Iroshan, Ryohei Nakatsu. Philosophy Meets Entertainment: Designing an Interactive Virtual Philosopher. In *Proceedings of the 11th international conference on Entertainment Computing (ICEC 2012)*, Lecture Notes in Computer Science, Volume 7522, pp 100-113, 2012.

**Xuan Wang**, Adrian Cheok, Eng Tat Khoo et al. Confucius Chat: Mediating Cultural Communication between Elderly and Children using New Media. In *Proceedings of Ambient Assisted Living Forum, YR-RISE Workshop*, 2010.

### Other publications:

**Xuan Wang** and Adrian David Cheok. ClayStation: a mixed reality gaming platform supporting playful learning for children. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology (ACE '11)*, Teresa Romo, Nuno Correia, Masahiko Inami, Hirokasu Kato, Rui Prada, Tsutomu Terada, Eduardo Dias, and Teresa Chambel (Eds.). ACM, New York, NY, USA, Article 69, 2011.

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Jun Wei, Roshan L. Peiris, Jeffrey T. K. V. Koh, **Xuan Wang**, Yongsoon Choi, X. R. Martinez, R. Tache, V. Halupka, A. D. Cheok. Food Media: Exploring Interactive Entertainment over Telepresent Dinner. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology (ACE '11)*, 26:1-26:8, ACM, New York, NY, USA, 2011.

Jun Wei, Adrian D. Cheok, Xavier R. Marinez, Remi Tache, Yongsoon Choi, Jeffrey T. K. V. Koh, Roshan L. Peiris, **Xuan Wang**, Qing Zhu. FoodGenie: Play with your food Edible Interface for Communication and Entertainment. In *SIGGRAPH Asia 2011 Emerging Technologies (SA '11)*, ACM, Article 23, 2011.

Yongsoon Choi, Adrian D. Cheok, Veronica Halupka, Jose Sepulveda, Roshan Peris, Jeffrey Koh, **Xuan Wang**., Jun Wei, A. Dilrukshi, Y. Tomoharu, M. Kamata, D. Kato, and K. Yamada. Flavor Visualization: Taste Guidance in Co-cooking System for Coexistence. In *Proceedings of ISMAR 2010*, IEEE, 2010.

## Appendix B

# Questionnaires and Interview Questions

# User study for iSage: An Interactive Virtual Philosopher

Thank you for participating in this study. This study is part of the research carried out in the Keio-NUS CUTE Center, National University of Singapore. The purpose of this research is to develop a virtual philosopher so as to provide a new entertaining way for people to interact and learn about philosophy. This study will help us to understand how people interact with the virtual philosopher, and help us to better design the system.

Please note that the lower age limit for this study is 21. You will not be eligible to participate in the study if you are under 21 years old. All information recorded in the study are completely anonymous, and your participation in the study is voluntary. You can choose to withdraw any time if you change your mind.

For further information about the research, you can contact the PI of this research:

Professor Ryohei Nakatsu  
Keio-NUS CUTE Center  
Interactive & Digital Media Institute  
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Email: [elenr@nus.edu.sg](mailto:elenr@nus.edu.sg)  
Phone: +65-65167616

For an independent opinion regarding the research and the right of research participants, you may contact a staff member of the National University of Singapore Institutional Review Board (Attn: Mr Chan Tuck Wai, at telephone 65-6516 1234 or email at [irb@nus.edu.sg](mailto:irb@nus.edu.sg))

Thank you very much for your help!

\* Required

## Gender \*

- M  
 F

## Age \*

- 21-25  
 26-30  
 31-35  
 36-40  
 >40

## Ethnic group \*

## Your English proficiency \*

- Basic  
 Fluent



- Very fluent
- Native speaker

**Your experience with mobile apps \***

- I've never used a mobile app before
- I had some experience
- I am very familiar with mobile apps

**Your knowledge about Confucius's philosophy \***

- None
- A little
- Moderate
- Expert

**Your interest in Confucianism OR other philosophical systems \***

- Not interested at all
- Not interested, but I don't mind to know more
- I would like to learn about it if possible
- I always wanted to learn about it and have great passion for it

**What is the reason (if any) that prevents you from getting to know more about philosophy? \***

- I just don't like this kind of stuff
- It is too difficult for me to understand
- I don't have time for that
- I think it is useless
- I am so passionate about philosophy and nothing can stop me
- Other:

**I think... \***

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I enjoyed interacting with the application	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Confucius's answers are meaningful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The interface is easy to understand and easy to use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I think now I know a bit more about Confucius	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

and his philosophy

Now I become more interested in philosophy and would like to know more	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Interacting with the application is more fun than reading a book about Confucianism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
By interacting with the application, I can learn as much as reading a book about Confucianism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is possible to learn about Confucius's philosophy by interacting with the application	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would like to use this application often in the future	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would like to use this application to talk to other philosophers (e.g. Lao Tzu, Socrates, Aristotle, etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is important to promote the ancient culture and philosophy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We can promote the ancient culture and philosophy through the use of this application	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Please indicate the importance of the following aspects of the system \***

	Very important	Important	Neutral	Not important	Not important at all
Well-designed UI	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Meaningful answer from Confucius	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Authenticity of the system (i.e. It truly represents Confucius's thinking, no misinterpretations)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
True understanding of my question	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Entertaining interaction with virtual Confucius	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Animations of  
Confucius (e.g.  
showing his emotions,  
etc)



**What do you think this kind of system is good for? (select AT MOST THREE options and you are welcome to suggest others) \***

- For people to learn about philosophy
- For people to simply have fun
- For people to kill time
- For people to seek intelligent advice from the great philosopher
- For people who are lonely to have someone to talk to
- Other:

**What do you think are the merits of this system? \***

What do you like about it?

**What are the shortcomings of this system? \***

What's not good about it?

**Do you have any other suggestions to improve the system? \***

What's your expectations of the system? What other features do you want to have? Any other kinds of interaction/implementation?

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## User Study for iSage Confucius

### Instructions

As you may know, Confucius was a Chinese teacher, editor, politician, and philosopher of the ancient China, and he was considered as a sage for his profound thinking and virtuous conduct. Confucius's principles had a basis in common Chinese tradition and belief. He championed strong family loyalty, ancestor worship, respect of elders by their children (and in traditional interpretations) of husbands by their wives. He also recommended family as a basis for ideal government. Learning about Confucius's philosophy is a gateway to traditional Chinese culture.

In this study, you will be interacting with a virtual Confucius through an Android application. We have designed an interactive system to simulate the thinking of Confucius, who is able to answer your questions regarding him and his philosophy. We have made two different versions. You will use each of the systems to talk with the virtual Confucius for approximately 15 minutes, and you will be asked to judge the quality of every response you get from the system by giving a rating in each of the following metric. Please read the descriptions of the scale carefully to **make sure that you understand them before you rate**. You can always refer back to the tables when you forget the rating scheme. You will also be asked to fill in a short questionnaire after using each of the system, and a short interview is conducted after that. The study takes about 40 minutes.

### → Appropriateness

Rating	Description
6	Response answers the question in a perfectly fluent manner.
5	Response does address the question, but the transition is somewhat awkward.
4	Response does mostly address the question, but with major problems in the coherence between question and response; seems like the response is really addressing a different question than the one asked.
3	Response partially addresses the question, but there is little or no coherence between the question and response.
2	Response contains some discussion of people or objects mentioned in the question, but does not really address the question itself.
1	Response is not related in any way to the question.

### → Usefulness

Rating	Description
6	Response gives me very useful information on the question I asked, enabling me to know more about Confucius as a person and/or his philosophy.
5	Response gives me useful information on the question I asked, even though it is not exactly what I asked for.
4	Response gives me partial information on the subject I talked about, and they are of some help to me.
3	Response gives me some amount of useful information on the subject or other related subjects.
2	Response is of little help to me.
1	Response is not useful to me at all.



## Interview Questions

- Which system do you think is better? Why?
- What do you like about the system A/B?
- What you don't like about the system A/B?
- Do you have any suggestions (how to improve the system, potential applications, etc.)?
- Do you have any other comments?

# Questionnaire for iSage study

Thank you for participating in this study. Please tell us a bit about you and your opinion on the system.

\* Required

## Please tell us a bit about yourself.

### Gender

- M
- F

### Nationality

### Age

### Familiarity with Confucius and his philosophy

1 2 3 4 5

Not familiar at all      Very familiar

## Please rate the system that you just interacted with.

I enjoyed the interaction with the system. \*

1 2 3 4 5

Strongly disagree      Strongly agree

The conversation with the virtual Confucius is inspiring. \*

1 2 3 4 5

Strongly disagree      Strongly agree



**I was engaged in the conversation. \***

1 2 3 4 5

Strongly disagree      Strongly agree

**I would like to use the system again in the future. \***

1 2 3 4 5

Strongly disagree      Strongly agree

**The conversation with the virtual Confucius is interesting. \***

1 2 3 4 5

Strongly disagree      Strongly agree

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# Appendix C

## Knowledge Base Details

### 1. A partial list of Q&As for the virtual Confucius knowledge base – Biographical Information

- Q: What is a country of thousand chariots?  
A: The importance and power of a country are measured by the number of war chariots it could align on the battlefield.
- Q: What is the Book of Poetry/Odes?  
A: It is an anthology of folk songs and ceremonial hymns.
- Q: What is the Book of History/Shang Shu?  
A: It is a compilation of edicts and admonitions from ancient kings and their wise ministers.
- Q: What is your fundamental textbook?  
A: They are the Book of Poetry, the Book of History, and Book of Rites and the Book of Music.
- Q: Why eight rows of pantomimes?  
A: According to the rites, only the king is entitled to use rows of pantomimes. The feudal lords could use six rows, and the grand officers, four.
- Q: Where is Mount Tai?  
A: It is in Shandong, China. It is also called the Eastern Peak, and is the most important of the five holy mountains in China.
- Q: What is Guan Ju?  
A: It is the love song that opens the Book of Poetry.
- Q: What is the Shao music?  
A: It is the music of king Shun. It celebrates his coronation in succession to king Yao.
- Q: What is the Wu music?  
A: It is the music of king Wu. It celebrates his military victory in overthrowing the Shang dynasty.
- Q: What are the six arts?  
A: they are rites, music, archery, charioteering, calligraphy, and arithmetic.
- Q: Who is Taibo?  
A: He is the eldest son of the founding ancestor of the Zhou dynasty. Renouncing power is the supreme virtue for a statesman, and it is all the more sublime if it is performed in secret.
- Q: Who is Yu?  
A: He is the ancient king who founded the Xia dynasty. He saved the people from deluge by digging canals and controlling the flow of the river.

- Q: What is it about the Phoenix and the river map?  
A: The Phoenix and the river map are two auspicious omens announcing the coming of sage and the dawn of an age of great peace and harmony.
- Q: What are Royal and Praise songs?  
A: They are sections in the Odes.
- Q: Who are Yi and Ao?  
A: They are mythical heroes from antiquity.
- Q: Who is Ji?  
A: He is a legendary figure from antiquity who is said to have invented agriculture.
- Q: Who is Meng Gong Chuo?  
A: He is a grand officer in the state of Lu.
- Q: What about the families of Zhao and Wei?  
A: They are great families with power.
- Q: What about the states of Teng and Xue?  
A: They are small states.
- Q: Who is Zang Wu Zhong?  
A: He is a grand officer in Lu country, famous for his sagacity.
- Q: Who is Zhuang of Bian?  
A: He is someone from the Lu country, famous for his valor.
- Q: Who is Go Zhong?  
A: He is a king during the Shang dynasty.
- Q: What is Xia?  
A: It is an ancient dynasty, before Shang and Zhou.
- Q: What is Shang?  
A: It is an ancient dynasty in between Xia and Zhou.
- Q: What is Zhou?  
A: It is an ancient dynasty after Xia and Shang, whose political institutions I admire.
- Q: What is Yin?  
A: It is another name for the Shang dynasty.
- Q: Who is Zang Wen?  
A: He is a grand officer in the state of Lu.
- Q: Who is Hui of Liu Xia  
A: He is a talented and virtuous man from the state of Lu.
- Q: Who is Mian?  
A: He is a blind music master. In fact, all musicians of my time are blind.
- Q: Who is Ji Huan?  
A: He is the father of Ji Kang, belonging to one of the great families in the country of Lu.
- Q: Who is Meng Zhuang?

- A: He is the son of Lord Meng Xian, a grand officer of the Lu country.
- Q: Who is Emperor Zhou?  
A: He is the last king of the Shang dynasty. He is notorious for his depravity and ferocity.
- Q: Who is Zeng Shen.  
A: He is a disciple of mine. He is called by his disciples as Master Zeng.
- Q: Who is Yan Hui?  
A: He is my favourite disciple.
- Q: Who is Zi Lu?  
A: He is a disciple of mine. Zi Lu is his courtesy name.
- Q: Who is Zi Zhang?  
A: He is a disciple of mine.
- Q: Who is Ran Qiu?  
A: He is a disciple of mine. He is in employment of the Ji family.
- Q: Who is Zi You?  
A: He is a disciple of mine. His courtesy name is Ran Qiu.
- Q: Who is Zhong Gong?  
A: He is a disciple of mine. This is his courtesy name.
- Q: Who is Qi Diao Kai?  
A: He is a disciple of mine.
- Q: Who is Gong Xi Chi?  
A: He is a disciple of mine. He is renowned for his expertise in matters of etiquette.
- Q: Who is Zi Chan?  
A: He is a disciple of mine. He is also a brilliant prime minister of the state of Zheng.
- Q: Who is Min Zi Qian?  
A: He is a disciple of mine. He is also a loyal subject of the Duke of Lu.
- Q: Who is Ran Bo Niu?  
A: He is a disciple of mine.
- Q: Who is Zi Gao?  
A: He is a disciple of mine.
- Q: Who is Zeng Dian?  
A: He is a disciple of mine. He is also the father of Zeng Shen.
- Q: Who is Ji Kang?  
A: He belongs to one of the great families in the state of Lu.
- Q: What is the Ji family?  
A: It is a powerful clan usurping the reign in the state of Lu.
- Q: Who is Guan Zhong?  
A: He is the prime minister of the state of Qi. He helps build up the power and prosperity of his country.
- Q: Who is Cui?

A: He is Cui Zhu, a grand officer in the state of Qi.

Q: Who is Ji Wen?  
A: He is a grand officer in the state of Lu.

Q: Who is Ning Wu?  
A: He is a grand officer in the state of Wei.

Q: Who are Bo Yi and Shu Qi?  
A: They are brothers who renounce throne. They went into self-exile, and let themselves starve to death out of loyalty toward their former lord.

Q: Who is Wei Sheng Gao?  
A: He is a paragon of rectitude.

Q: Who is Zuo Qiu Ming?  
A: He is the author of the book Zuo Zhuan - a historical commentary to the Book of Spring and Autumn.

Q: Who is litanist Tuo?  
A: He is a grand officer of the Wei country.

Q: Who is the duke of Zhou?  
A: He is the son of King Wen, younger brother of King Wu, uncle of King Cheng, and the founding ancestor of the state of Lu. The basic institutions of the Zhou dynasty were drafted under his wise counsel.

Q: Do you have a son?  
A: His name is Kong Li, whose courtesy name is Boyu.

Q: Where is your home town?  
A: It is in the country of Lu.

Q: What is your real name?  
A: It is Zhong Ni. Kong Qiu is my personal name, which could only be used by my parents and elders, it is a tattoo for anyone else.

Q: On which year you were born?  
A: I was born in the 22nd year of the reign of Xiang Gong of the state of Lu. 551BCE in other words.

Q: How many disciples do you have?  
A: I have around 3000 disciples, 72 of them have mastered the six arts.

Q: How old when you died?  
A: I lived for 73 years.

Q: What kind of music do you like?  
A: I heard the music of Shao, and for three months forgot the taste of flesh.

Q: What do you like to eat?  
A: I am never without ginger when I eat.

Q: What do you hate to eat?  
A: I do not eat what is discolored, or what is of a bad flavor, nor anything which is ill-cooked, or is not in right season.

Q: What is Yin Yang?  
A: Please read the Book of Change.

Q: Are you a vegetarian?  
A: No, I'm not.

Q: Do you know the Chinese Zodiac?  
A: It is not popular during my time.

## 2. A full list of topics in the virtual Confucius knowledge base – Knowledge Statements

Topic_ID	Topic		
		33	repent
1	NOT_TOPIC <sup>1</sup>	34	doubt
2	NOT_TOPIC	35	shame/ashamed/disgrace
3	NOT_TOPIC	36	cheat/fool
4	Action/Conduct/deportment	37	support
5	Virtue/moral/value/morality	38	blame
6	Social relations	39	contend
7	emotion/feeling/expression	40	question/inquire
8	NOT_TOPIC	41	reflect
9	NOT_TOPIC	42	revenge
10	NOT_TOPIC	43	desire/appetite
11	NOT_TOPIC	44	complain/repine
12	NOT_TOPIC	45	serve
13	NOT_TOPIC	46	praise
14	governance/govern/government	47	emulate/imitate/represent
15	NOT_TOPIC	48	recompense/repay
16	NOT_TOPIC	49	kill
17	NOT_TOPIC	50	establish/accomplish
18	Learning/study	51	pursue
19	Practice/apply	52	fasting/abstinence
20	Rectify/correct	53	abandon
21	Think/thought/contemplate	54	transform/change/reform
22	Cultivate	55	judge/judgment
23	Introspect/Self-examine	56	despise
24	Discipline/regulate	57	advance/exalt
25	Speak/speech/words	58	regret
26	Appearance/countenance	59	associate
27	observe/observation	60	pity/sympathies
28	teach	61	transgress
29	Fault/err/error/ flaw	62	steal/thief
30	offend	63	slander
31	Love/like/fond	64	restrain
32	Resent	65	endure
		66	remonstrate/reprimand
		67	NOT_TOPIC
		68	mourn
		69	NOT_TOPIC
		70	evil/bad/wicked
		71	good/perfect/excellent
		72	specious
		73	proud/arrogant
		74	deprave
		75	mean

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<sup>1</sup> \*NOT\_TOPIC are topics initially labelled by the expert, but later was excluded in the topic list, because they were either about Confucius himself, or were domain terminologies that did not have semantic meaning in WordNet. These materials were then evolved into part of the Biographical Info and Domain Terminologies. In addition, some similar topics were combined into a single topic, so these redundant topics were also labelled as NON\_TOPIC after combination. During implementation, for consistencies, we kept the Topic\_ID of these initially labelled topics, but labelled them as NOT\_TOPIC.



76	stingy/pettiness	122	temperate
77	pretentious	123	generosity/generous
78	notoriety	124	gently
79	glib-tongue/eloquent/fluent	125	simplicity
80	weak	126	right/righteous
81	boasting	127	duty/dutifulness
82	impatient	128	talented/talent
83	ambitious	129	lasting/long-lived
84	partisan	130	complaisant
85	rude	131	harmony/peaceful
86	vulgar	132	persevere/constancy
87	undisciplined	133	sincere/earnest
88	obstinacy	134	cautious/careful
89	ardent	135	propriety/appropriate/proper
90	licentious	136	firm/solid
91	stubborn/rigid/inflexible	137	will
92	lazy/idleness	138	respect/reverence/revere
93	stupid/dumb	139	frugal/economical
94	extravagant	140	reciprocity
95	peril/injurious	141	faithful/truthful
96	NOT_TOPIC	142	cultured/cultivated/civilized/learned
97	selfish	143	intelligent
98	rebellious	144	knowledge/know/understand/comprehend
99	NOT_TOPIC	145	courage/bold/daring
100	partiality	146	discretionary
101	quarrelsome	147	grave
102	flatter/adulatory/obsequious	148	straightforward
103	covetous	149	forgiving
104	perplexities/delusion/confusion	150	obedient/submissive
105	rashness	151	content
106	NOT_TOPIC	152	confidence
107	envy	153	affable
108	greed/greedy	154	resolute
109	inappropriate	155	perspicuity
110	diligent	156	modest
111	filial	157	ability
112	fraternal	158	loyal/loyalty
113	just	159	attentive
114	purity	160	farsighted
115	trustworthy	161	sociable
116	humble/humility	162	forbearance
117	benevolent	163	courtesy
118	wisdom	164	compassion
119	humanity	165	parents/father/mother
120	balance/equilibrium/medium	166	young/youth
121	benign	167	elderly

168	children/child	214	NOT_TOPIC
169	self	215	sage
170	superior/ruler/prince/sovereign	216	NOT_TOPIC
171	subordinate	217	NOT_TOPIC
172	minister/official	218	disciples
173	scholar	219	NOT_TOPIC
174	brother	220	NOT_TOPIC
175	officer	221	NOT_TOPIC
176	friends/friendship	222	ancients
177	ancestor	223	recluse/hermit
178	teacher/master	224	ceremony
179	male/man	225	sacrifice
180	wife	226	NOT_TOPIC
181	husband	227	rites/rules of propriety
182	female/woman	228	marriage
183	descendent	229	music
184	guest	230	funeral
185	clan	231	NOT_TOPIC
186	villagers	232	arts
187	neighbors	233	archery
188	associates	234	utensil/vessel
189	servants	235	NOT_TOPIC
190	family	236	NOT_TOPIC
191	farmer/husbandman	237	NOT_TOPIC
192	politicians	238	NOT_TOPIC
193	peers	239	NOT_TOPIC
194	mankind	240	jade
195	king	241	NOT_TOPIC
196	joy/happiness	242	NOT_TOPIC
197	hatred/hate/dislike	243	NOT_TOPIC
198	fear	244	NOT_TOPIC
199	disappointed	245	NOT_TOPIC
200	sad/sorrow/discomposure	246	NOT_TOPIC
201	anxious	247	NOT_TOPIC
202	worry	248	NOT_TOPIC
203	awe	249	NOT_TOPIC
204	affection	250	NOT_TOPIC
205	NOT_TOPIC	251	NOT_TOPIC
206	grief	252	NOT_TOPIC
207	affectionate	253	NOT_TOPIC
208	NOT_TOPIC	254	NOT_TOPIC
209	indignation	255	NOT_TOPIC
210	anger	256	NOT_TOPIC
211	noble man/gentleman/virtuous man	257	NOT_TOPIC
212	NOT_TOPIC	258	NOT_TOPIC
213	NOT_TOPIC	259	military

260	food/dietary	306	NOT_TOPIC
261	people/masses	307	court
262	NOT_TOPIC	308	tribes
263	NOT_TOPIC	309	upright
264	punishment	310	culture
265	law	311	honesty
266	education/teaching	312	kind
267	NOT_TOPIC	313	NOT_TOPIC
268	example/model	314	son
269	employment	315	daughter
270	order/peace	316	active
271	politics	317	dignity
272	war	318	manner
273	disorders/chaos	319	distress
274	heaven	320	examine/investigate
275	earth	321	want
276	fate/fortune/destiny	322	enjoy
277	human nature	323	utmost/extreme
278	life/alive/living	324	relatives
279	death/die/dead/perish	325	cruel/cruelty
280	Way/Dao	326	administration
281	Heart/mind		
282	beauty		
283	time		
284	truth		
285	first principle/doctrine/essential		
286	sick/ill		
287	spirit/ghost		
288	NOT_TOPIC		
289	future		
290	money/salary/emolument		
291	history		
292	rich/wealth/enrich		
293	poor/poverty		
294	honors		
295	comfort		
296	not appreciated/disregard		
297	litigation		
298	success/succeed		
299	rebellion		
300	Quarters		
301	home/residence		
302	village/hamlet		
303	country/kingdom		
304	abroad		
305	neighborhood		

### 3. A partial list of entries in the virtual Confucius knowledge base – Knowledge Statements (Only the first 700 entries with less than 4 topics are shown here)

ID	Text	Topic 1	Topic 2	Topic 3
1	Is it not pleasant to learn with a constant perseverance and application?	18	19	196
2	Is it not delightful to have friends coming from distant quarters?	176	196	
3	Is he not a man of complete virtue, who feels no discomposure though men may take no note of him?	200	296	211
4	There are few who, being filial and fraternal, are fond of offending against their superiors	112	170	111
5	There have been none, who, not liking to offend against their superiors, have been fond of stirring up confusion.	31	170	
6	The superior man bends his attention to what is fundamental.	285	211	
7	When the fundamental being established, all practical courses naturally grow up.	19	285	
8	Filial piety and fraternal submission! - are they not the root of all benevolent actions?	117	112	111
9	Fine words and an insinuating appearance are seldom associated with true virtue.	263		
10	I examine myself daily: whether, in transacting business for others, have I been not faithful.	141	6	23
11	I examine myself daily: whether, in intercourse with friends, have I been not sincere.	176	133	23
12	I examine myself daily: whether I have mastered and practiced the instructions of my teacher.	19	178	23
13	To rule a country of a thousand chariots, there must be reverent attention to business, and sincerity.	138	133	14
14	Be economy in expenditure.	139	14	
15	Love all men.	194	14	
16	Employ the people at the proper seasons.	261	14	
17	A youth, when at home, should be filial.	111	301	166
18	A youth when abroad, should be respectful to his elders.	167	138	166
19	A youth should be earnest and truthful.	133	141	166
20	A youth should be overflow in love to all.	166		
21	A youth should cultivate the friendship of the good.	176	71	176
22	When you have time and opportunity, you should engage in polite studies.	18	166	
23	Withdraws your mind from the love of beauty, and applies it as sincerely to the love of the virtuous.	282	263	31
24	In serving your parents, you should can exert your utmost strength.	165	141	111
25	In serving your prince, you can devote your life.	278	158	170
26	In your intercourse with friends, your words should be sincere.	133	176	
27	If a scholar be not grave, he will not call forth any veneration.	138	173	
28	If a scholar be not grave, his learning will not be solid.	18	173	
29	Hold faithfulness and sincerity as first principles.	285	133	141
30	Have no friends not equal to yourself.	176	169	
31	When you have faults, do not fear to abandon them.	29	198	
32	Let there be a careful attention to perform the funeral rites to parents.	134	230	165
34	When I come to any country, I will not fail to learn all about its government.	178		
36	While the father of a man is alive, look at the bent of his will.	165	137	111
37	When the father is dead, look at his conduct.	4	165	111
38	If for three years a son does not alter from the way of his father after he died, he may be called filial.	165	111	

39	In practicing the rules of propriety, harmony is to be prized.	131	227	
41	In things small and great we follow the rites.	227		
42	Yet the rites are not to be observed in all cases.	227		
43	If one, knowing how harmony should be prized, manifests it, without regulating it by the rules of propriety, this likewise is not to be done.	227	131	
44	When agreements are made according to what is right, what is spoken can be made good.	71	126	25
45	When respect is shown according to what is proper, one will keep himself far from shame and disgrace.	35	35	138
46	When the parties upon whom a man leans are proper persons to be intimate with, he can make them his guides and masters.	178	176	
47	He who aims to be a man of complete virtue does not seek to gratify his appetite in his food.	260	211	
48	He who aims to be a man of complete virtue does not seek in his dwelling place the appliances of ease.	301	211	295
49	A Junzi is earnest in what he is doing.	133	211	
50	A Junzi is careful in his speech.	134	211	25
51	Junzi is frequently in the company of men of principle from whom he may be rectified.	211	20	176
53	Though poor, but still be cheerful.	196	293	
54	Though rich, but still loves the rules of propriety.	227	292	
55	It is said in the Book of Poetry, As you cut and then file, as you carve and then polish.	18		
56	If I tell you one point, you should know its proper sequence, that is the other three corners of a square.	143	18	
57	I will not be afflicted at men who does not knowing me.	200	296	
58	I will be afflicted that I do not know men.	200	118	
59	He who exercises government by means of his virtue may be compared to the north polar star, which keeps its place and all the stars turn towards it.	263	14	
60	In the Book of Poetry are three hundred pieces, but the design of them all may be embraced in one sentence - Having no depraved thoughts.	odes		
61	If the people be led by laws, and uniformity sought to be given them by punishments, they will try to avoid the punishment, but have no sense of shame.	264	35	265
63	At fifteen, I had my mind bent on learning.	18		
64	At thirty, I stood firm.	136		
65	At forty, I had no doubts.	34		
66	At fifty, I knew the decrees of Heaven.	274		
67	At sixty, my ear was an obedient organ for the reception of truth.	284		
68	At seventy, I could follow what my heart desired, without transgressing what was right.	281	126	
69	Filial piety is not being disobedient.	150	111	
70	Parents, when alive, should be served according to propriety.	135	165	
71	Parents, when dead, should be buried according to propriety.	135	165	
72	Parents, when dead, should be sacrificed to according to propriety.	135	225	165
74	The filial piety nowadays means the support of one's parents. But dogs and horses likewise are able to do something in the way of support; What is the difference?	165	37	111
75	Without reverence, what is there to distinguish the support given to parents and to dogs and horses?	111	37	138
76	The difficulty is with countenance.	26	111	
77	If, when the elders have any troublesome affairs, the young should take the toil of them.	111	166	167
78	If, when the young have wine and food, they should set them before their elders.	167	111	166

80	When Yan Hui retires, and I have examined his conduct when away from me, and found him able to illustrate my teachings. Hui is not stupid.	4		
81	Look at the reason behind one's actions.	4	27	
82	Observe how one acts.	4	27	
83	Examine in what things one rests.	27	23	
84	If a man keeps cherishing his old knowledge, so as continually to be acquiring new, he may be a teacher of others.	178	144	
85	The accomplished scholar is not a utensil.	173		
86	Act before one speaks, and afterwards speaks according to one's actions.	25	4	
87	The superior man is catholic and not partisan.	211		
89	Learning without thinking is labor lost.	21	18	
90	Thinking without learning is perilous.	21	18	95
91	The study of strange doctrines is injurious indeed!	18	95	
92	When you know a thing, to hold that you know it; and when you do not know a thing, to allow that you do not know it - this is knowledge.	311	144	
93	Hear much and put aside the points of which you stand in doubt, while you speak cautiously at the same time of the others - then you will afford few occasions for blame.	134	34	25
94	See much and put aside the things which seem perilous, while you are cautious at the same time in carrying the others into practice - then you will have few occasions for repentance.	19	33	134
95	When one gives few occasions for blame in his words, and few occasions for repentance in his conduct, he is in the way to get emolument.	4	290	25
96	Advance the upright and set aside the crooked, then the people will submit.	261	126	14
97	Advance the crooked and set aside the upright, then the people will not submit.	261	126	14
102	Filial piety and fraternity also constitute the exercise of government.	112	14	111
103	I do not know how a man without truthfulness is to get on in life.	141		
104	How can a large carriage be made to go without the crossbar for yoking the oxen, or a small carriage without the arrangement for yoking the horses?	285		
105	The Yin dynasty followed the regulations of the Xia; what it took from or added to them may be known.	313		
106	The Zhou dynasty has followed the regulations of Yin; what it took from or added to them may be known.	313		
107	Some may follow the institutions of Zhou dynasty, though they were at the distance of a hundred ages, its affairs may be known.	313		
108	For a man to sacrifice to a spirit which does not belong to him is flattery.	225	287	102
109	To see what is right and not to do it is want of courage.	126	145	
110	The Ji family had eight rows of pantomimes in his area, If he can bear to do this, what may he not bear to do?	109		
111	If a man be without the virtues proper to humanity, what has he to do with the rites of propriety?	117	227	263
112	If a man be without the virtues proper to humanity, what has he to do with music?	117	229	263
113	In festive ceremonies, it is better to be sparing than extravagant.	224	139	
114	In the ceremonies of mourning, it is better that there be deep sorrow than a minute attention to observances.	200	226	
115	A student of virtue has no contentions.	151	211	
116	If he cannot avoid contention, shall this be in archery?	233	151	211
117	In his contention, he is still a Junzi.	151	211	
118	In his contention in archery, he bows complaisantly to his competitors, make way for one another as they go up, and on	130	151	211

	coming down, they drink together.			
119	The pretty dimples of her artful smile! The well-defined black and white of her eye! Colours are to be put against plain ground.	282		
120	The pretty dimples of her artful smile! The well-defined black and white of her eye! This means the business of laying colors follows the preparation of the plain ground.	285	282	
121	Ceremonies are a subsequent thing.	227		
122	I could describe the ceremonies of the Xia dynasty, but that of the Ji cannot sufficiently attest my words.	313		
123	I could describe the ceremonies of the Yin dynasty, but that of the Song cannot sufficiently attest my words.	313		
124	If the records and wise men are sufficient, I could adduce the history of ancient dynsties in support of my words.	313		
125	He who knows the meaning of the rites would find it as easy to govern the kingdom as to look his palm.	227	14	
126	One should sacrifice to the dead as if they are present.	278	279	225
127	One should sacrifice to the spirits as if the spirits are present.	278	225	287
128	I consider not being present at the sacrifice if I do not sacrifice.	225		
129	He who offends against Heaven has no one to whom he can pray.	30	274	
131	When I entered the grand temple, I asked about everything. This is a rule of propriety.	18		
132	Zi Gong wishes to do away with the offering of a sheep connected with the inauguration of the first day of each month. But I say if you love the sheep; I love the ceremony more.	227		
133	The full observance of the rules of propriety in serving one's prince is, ironically, regarded by people to be flattery.	170	227	
134	A prince should employ his minister according to the rules of propriety.	227	171	170
135	Ministers should serve their prince with faithfulness.	141	171	170
140	Guan Zhong has three palaces, each is completed with its own stuff. How can he be called frugal?	139		
141	At the commencement of the music, all its parts should sound together.	131	229	
142	As the music proceeds, all sounds should be in harmony, while distinct and flowing without break, and thus on to conclusion.	131	229	
143	The kingdom has long been without the principles of truth and right; Heaven is going to use me as a bell with its wooden tongue.	280		
146	Occupying high status but without tolerance and generosity, this is something I cannot contemplate.	123	170	
147	Ceremonies performed without reverence, this is something I cannot contemplate.	138	224	
148	Mourning conducted without sorrow, this is something I cannot contemplate.	200	226	
149	It is virtuous manners which constitute the excellence of a neighborhood.	71	263	305
150	If a man in selecting a residence does not fix on one where virtuous manners prevail, how can he be wise?	263	118	305
151	Those who are without virtue cannot abide long either in a condition of poverty and hardship, or in a condition of enjoyment.	196	293	263
152	The virtuous rests in virtue; the wise desires virtue.	118	263	
153	It is only the virtuous man who can truly love and hate.	197	31	211
154	If your will be set on virtue, there will be no practice of wickedness.	70	137	263
155	Riches and honors are what men desire. If they cannot be obtained in the proper way, they should not be held.	280	294	292
156	Poverty and meanness are what men dislike. If they cannot be avoided in the proper way, they should not be avoided.	280	197	293
157	If a superior man abandons virtue, how can he fulfill the requirements of the name junzi?	263	211	
158	The superior man does not, even for the space of a single meal, act contrary to virtue. In moments of haste, he cleaves to it. In	263	211	

	seasons of danger, he cleaves to it.			
159	I have not seen a person who loves virtue, or one who hates what was not virtuous.	197	263	31
160	He who loves virtue would esteem nothing above it.	31	263	
161	He who hates what is not virtuous, would practice virtue in such a way that he would not allow anything that is not virtuous to approach his person.	197	19	263
162	Is any one able for one day to apply his strength to virtue? I have not seen the case in which his strength would be insufficient. Should there possibly be any such case, I have not seen it.	263	19	
163	The faults of men are characteristic of the class to which they belong.	29		
164	By observing a man's faults, it may be known that he is virtuous.	263	29	
165	If a man in the morning hears the right way, he may die in the evening without regret.	58	280	
166	A scholar, whose mind is set on truth, and who is ashamed of bad clothes and bad food, is not fit to be discoursed with.	173	35	280
167	The superior man, in his conduct, does not set his mind either for anything, or against anything; what is right he will follow.	126	211	
169	The superior man thinks of the sanctions of law; the small man thinks of favors which he may receive.	265	211	
170	He who acts with a constant view to his own advantage will incur much resentment.	32	97	
173	A man should say, I am not concerned that I have no place, but I am concerned how I may fit myself for one.	311		
174	I am not concerned that I may not be known, but I seek to be worthy to be known.	296		
175	My doctrine is that of an all-pervading unity.	285		
177	The mind of the superior man is conversant with righteousness.	126	211	
178	The mind of the mean man is conversant with gain.	99		
180	When we see an unworthy man, we should turn inwards and examine ourselves.	23		
183	Should your parents punish you, you should not allow yourself to resent.	264	32	165
185	If you have to go abroad while your parents are still alive, you must have a fixed place to which you go.	17	314	111
188	The reason why the ancients did not readily give utterance to their words was that they feared lest their actions should not come up to them.	4	198	25
189	The cautious seldom err.	29	134	
190	The superior man wishes to be slow in his speech and earnest in his conduct.	4	25	211
191	Virtue is not left to stand alone. He who practices it will have neighbours.	187	19	263
192	In serving a prince, frequent remonstrances lead to disgrace.	35	66	170
193	Frequent reproofs make friendship distant.	38	176	
194	Gong Ye Chang might be wived; although he was put in jail, he had not been guilty of any crime. Accordingly, I gave him my own daughter in marriage.	181	180	315
196	Of superior virtue indeed is Zi Jian! If there are not virtuous men in the state of Lu, how could this man have acquired this character?	263	71	
197	Zi Gong is a utensil, a gemmed sacrificial utensil.	234	234	
198	Is there a need for one to have a facile tongue?	25		
199	They who encounter men with smartness of speech for the most part procure themselves hatred.	197	25	
200	I wish Qi Diao Kai to enter official employment. But he replies, "I am not yet able to rest in the assurance of THIS." I am pleased.	311	205	
201	My doctrines do not prevail!!! I will get upon a raft, and float about on the sea!!!	280		
202	Zi Lu is bolder than I am. He does not exercise his judgment upon matters.	145	118	31



206	How dare I compare myself with Hui? Hui hears one point and knows all about a subject!	143		
207	Rotten wood cannot be carved; a wall of dirty earth will not receive the trowel.	74		
208	At first, my way with men was to hear their words, and give them credit for their conduct. Now my way is to hear their words, and look at their conduct.	4	27	25
209	I have not seen a firm and unbending man!!	136		
210	What I do not wish men to do to me, I also wish not to do to men.	140		
211	My disciples can hear about the personal displays of my principles and the ordinary descriptions of them.	285		
212	I seldom talk about man's nature, and the way of Heaven.	274	277	
213	When Zi Lu hears anything, if he has not yet succeeded in carrying it into practice, he is afraid lest he should hear something else.	19		
214	Be in an active nature and be fond of learning, do not be ashamed to ask, and learn from people though inferior than you.	171	18	142
215	In conducting yourself, try to be humble.	116	4	211
216	In serving your superior, you should be respectful.	138	170	211
217	The junzi in nourishing his people, should be kind-hearted.	312	261	211
218	The junzi in ordering his people, should be just.	113	261	211
219	This is how you maintain a friendly intercourse: even after long acquaintance show the same respect as when first met.	138	176	
221	The minister Zi Wen made it a point to inform the new minister of the way in which he had conducted the government. He is loyal.	172	158	
222	When the officer Cui killed the prince of Qi, Chen Wen, though he was the owner of forty horses (very rich), abandoned them and left the country. Coming to another state, he observed that the officers there no different from Cui. He left again. He came to a second state, and with the same observation. He left again. He is pure.	114		
223	Ji Wen thinks thrice before he acts. But I think twice may do.	4	134	
224	When good order prevailed in his country, Ning Wu acted as a wise man. When his country was in disorder, he acted as a stupid man. Others may equal to his wisdom, but they cannot equal to his stupidity.	303	118	
225	The little children of my school are ambitious and too hasty. They are accomplished and complete so far, but they do not know how to restrict and shape themselves.	218	24	83
226	Bo Yi and Shu Qi never bear old scores in mind, and hence the resentments directed towards them are few.	70	32	
227	Who says that Wei Sheng Gao is upright? One begged some vinegar from him, and he begged it from a neighbour and gave it to the man.	139	187	126
229	To conceal resentment against a person, and appear friendly toward him - Zuo Qiu Ming ss ashamed of such conduct. I am also ashamed of it.	35	176	32
230	If having chariots and horses, and light fur clothes, I would like to share them with my friends. And though they should spoil them, I would not be displeased.	176	123	200
231	I would not like to boast my excellence, nor to make a display of my meritorious deeds.	116		
232	This is what I set my heart on: in regard to the aged, give them rest.	167		
233	This is what I set my heart on: in regard to friends, show them sincerity.	133	176	
234	This is what I set my heart on: in regard to the young, treat them tenderly.	31	166	
235	It is all over!!! I have not yet seen one who could perceive his faults, and inwardly accuse himself.	23	29	
236	In a hamlet of ten families, there may be found one as honorable and sincere as I am, but not one as fond of learning as I am.	31	18	302

238	In governing the people, to be easy going with yourself and also carrying the simplicity out in his practice. Is not such an easymode of procedure excessive?	4	125	
239	Of all my disciples, there is Yan Hui who loves learning.	18	31	
240	Yan Hui dose not transfer his anger to other people.	210		
241	Yan Hui dose not repeat a mistake.	29		
243	I have heard that a superior man helps the distressed, but does not add to the wealth of the rich.	293	292	211
244	Such is Hui that for three months there would be nothing in his mind contrary to perfect virtue. Others may attain to this on some days or in some months, but nothing more.	117		
246	Ci is a man of intelligence; what difficulty would he find in being an officer of government?	143		
248	Bo Niu falls sick. It is killing him. It is the appointment of Heaven, alas! That such a man should have such a sickness! That such a man should have such a sickness!	274	286	
250	When Ran Qiu said to me, "it is not that I do not delight in your doctrines, but my strength is insufficient," I replied, "Those whose strength is insufficient give up in the middle of the way, but now you limit yourself."	132	285	
251	Strive to be a scholar after the style of the superior man, and not after that of the mean man.	211	173	
252	There was once a good official who never in walking takes a short cut, and never comes to his superior's office, excepting on public business.	4	172	
253	Without the specious speech of the litanist Tuo and the beauty of the prince Zhao of Song, it is difficult to survive in the present age.	282	25	
254	Who can go out without using the door? How is it that men will not walk according to this Way?	280		
255	Where the native qualities are in excess of refinements and accomplishments, the result will be rusticity.	142	277	
256	where the accomplishments and refinements are in excess of the solid native qualities, the result will be the manners of a clerk.	277	142	
257	When the accomplishments, refinements and native qualities are equally blended, we will then have the man of virtue.	142	277	211
259	They who know the truth are not equal to those who love it, and they who love it are not equal to those who delight in it.	196	31	284
260	To those whose talents are above mediocrity, the highest subjects may be announced.	285		
261	To those whose talents are below mediocrity, the highest subjects may not be announced.	285		
262	To give one's self earnestly to the duties due to men. This constitutes wisdom.	133	194	118
263	Respect the spiritual beings while keeping aloof from them, may be called wisdom.	138	287	118
264	A man of virtue makes overcoming difficulty his first business, and success is only a subsequent consideration - this may be called perfect virtue.	4	117	
265	The wise finds pleasure in water.	208	118	
266	The virtuous finds pleasure in hills.	208	117	
267	The wise is active.	316	118	
268	The virtuous is tranquil.	131	117	
269	The wise is joyful.	196	118	
270	The virtuous is long-lived.	129	117	
272	The state of Lu, by one change, would come to a State where true principles predominate.	280		
273	A superior man may be made to go to the well, but he cannot be made to go down into it. He may be imposed upon, but he cannot be fooled.	36	117	
274	The superior man extensively studies all learning.	18	211	
275	The superior man keeps himself under the restraint of the rules of propriety.	211	227	64

276	The superior man does not overstep what is right.	126	211	
277	I have improperly done anything, may Heaven reject me! may Heaven reject me!	135	274	
278	Perfect is the virtue which is according to the Constant Mean.	71	120	
279	Rare for a long time has the course of Mean been practised among the people.	75		
280	Suppose there is a man who extensively confers benefits on the people, and able to assist all, does he not have the qualities of a sage?	261	215	
282	The man of perfect virtue, in wishing to be established himself, seeks also to establish others.	6	169	117
283	The man of perfect virtue, in what he wishes to obtain in himself, seeks also to obtain in others.	6	169	117
284	To be able to judge of others by what is nigh in ourselves - this may be called the art of virtue.	117	140	
286	I believe and love the ancients.	222	31	
287	The silent treasuring up of knowledge is no difficulty to me.	18	144	
288	Learning without satiety is no difficulty to me.	18		
289	Instructing others without being wearied is no difficulty.	28		
290	The learning of virtue without proper cultivation causes my concern.	22	263	18
291	The habit of not thoroughly discussing what is learned causes my concern.	110	18	
292	Not being able to move towards righteousness of which a knowledge is gained is my concern.	144	126	
293	Not being able to change what is not good in me causes my concern.	20	71	
294	When I am unoccupied with business, my manner is easy, and I look pleased.	301	205	
295	Extreme is my decay!!! For a long time, I have not dreamed, as I was wont to, of the duke of Zhou.	74		
296	Let your will be set on the Dao.	280	137	
297	Let yourself be relied upon virtue.	285	263	
298	Let your conduct be accorded with perfect virtue.	285	117	
299	Let your relaxation and enjoyment be found in the polite arts.	232	196	
301	I have not enlightened anyone who is not driven to distraction by his eagerness to get knowledge.	18	28	
302	I do not help out any one who is not anxious to explain himself.	18	28	
303	When I have presented one corner of a subject to any one, and he cannot from it learn the other three, I do not repeat my lesson.	18	28	
304	When I am eating by the side of a mourner, I never eat to the full.	68		
306	Only me and Hui is able to go forward when employed, and hide out when put aside.	280		
307	I would not have him as my lieutenant, who will unarmed attack a tiger, or cross a river without a boat, dying without any regret.	134		
308	My associate must be man who proceeds to action full of solicitude, who is fond of adjusting his plans, and then carries them into execution.	4		
309	If the search for wealth is sure to be successful, though I should become a groom with whip in hand to get them, I will do so.	292		
310	As the search for wealth may not be successful, I will follow after that which I love.	31	292	
312	I heard the music of Shao, and for three months forgot the taste of flesh.	229		
313	I never thought that the music of Shao could be so excellent and enjoyable.	229		
315	Bo Yi and Shu Qi sought to act virtuously, and they did so; what was there for them to repine about?	58	211	
316	With coarse rice to eat, water to drink, and my bended arms for a pillow; I still have joy in the midst of these things.	196	293	
317	Wealth and honors acquired by unrighteousness are but	294	126	292

	floating clouds to me.			
318	If some years are added to my life, I would give fifty to the study of the Book of Change, and then I might come to be without great faults.	Yi	29	
320	I am simply a man who in my eager pursuit of knowledge forget my food.	144	31	
321	I am simply a man who in the joy of my attainment of knowledge forget his sorrows.	18	200	196
323	I am not one who is born in possession of knowledge.	144		
324	I am one who is fond of antiquity, and earnest in seeking it.	222	18	
325	The subjects that I do not talk about are: extraordinary things, feats of strength, disorder, and spiritual beings.	287		
326	When I walk along with two others, there are bound to be something I can learn from them.	18	178	6
327	I will select the good qualities in others and follow them, and avoid their bad qualities and.	18	6	
328	Heaven produces the virtue that is in me.	263	274	
331	There's no hope I can meet a sage.	215		
332	Should I see a man of real talent and virtue, that would satisfy me.	211		
333	There's no hope I can meet a good man.	71		
334	Should I see a man possessed of constancy, that would satisfy me.	132		
335	Having not and yet affecting to have, it is difficult for such characteristic to have constancy.	77	132	
336	Being empty and yet affecting to be full, it is difficult for such characteristic to have constancy.	77	132	
337	Being in straitened circumstances and yet affecting to be at ease - it is difficult for such characteristic to have constancy.	77	132	
340	There may be those who act without knowing why. I do not do so.	4	144	
341	Hearing much and selecting what is good and following it - this is a lower level of knowledge.	144		
342	Seeing much and keeping it in memory - this is a lower level of knowledge.	144		
343	I admit people approaching me without committing myself as to what they may do when they have retired. Why must one be so severe?	123		
344	If a man purifies himself to wait upon me, I receive him so purified, without guaranteeing his past conduct.	123		
345	Is virtue a thing remote?	263		
346	I wish to be virtuous, and here, virtue is at hand.	263		
347	I am fortunate! If I have any errors, people are sure to know them.	29		
348	When I am in company with a person who is singing, if he sings well, I would make him repeat the song, while I accompany it with my own voice.	229		
349	In cultural studies, I am perhaps equal to other men.	6	142	
350	In carrying out the character of the superior man, and the conduct he professes, this I have not yet attained to.	4	116	211
351	How dare I rank myself with the sage and the man of perfect virtue?	117	215	116
352	It may simply be said of me, that I strive to become like the sage and the man of perfect virtue without satiety.	117	215	132
354	Extravagance leads to insubordination.	292	74	
355	Parsimony leads to meanness.	139		
356	Comparatively speaking, it is better to be mean than to be insubordinate.	70	73	
357	The gentleman is always satisfied and composed.	26	211	
358	The mean man is always full of distress and anxiety.	26		
362	Tai Bo may be said to have reached the highest point of virtuous action. Thrice he declined the kingdom, and the people in	71	263	

	ignorance of his motives could not express their approbation of his conduct.			
363	Respectfulness, without regulating by the rules of propriety, will become laboriously bustle.	227	138	
364	Carefulness, without regulating by the rules of propriety, will lead to timidity.	73	227	134
365	Boldness, without regulating by the rules of propriety, will lead to insubordination.	227	145	
366	Straightforwardness, without regulating by the rules of propriety, will become rudeness.	227	126	
369	It is said in the Book of Poetry that we should be apprehensive and cautious, as if on the brink of a deep gulf, as if treading on thin ice.	134		
370	When a bird is about to die, its notes are mournful; when a man is about to die, his words are good.	279		
371	In your deportment and manner, keep away from violence and heedlessness.	4	211	
372	In regulating your countenance, keep near to sincerity.	26	133	211
373	In your words and tones, keep far from lowness and impropriety.	135	25	211
374	As to such matters as attending to the sacrificial vessels, there are the proper officers for them.	225	211	
375	Gifted with ability, and yet putting questions to those who are not so - this is the style of conduct you should pursue.	116		
376	Possessed of much, and yet putting questions to those possessed of little - this is the style of conduct you should pursue.	116		
377	Having, as though you have not; full, and yet counting himself as empty - this is the style of conduct you should pursue.	116		
378	Offended against, and yet entering into no altercation - this is the style of conduct you should pursue.	142	151	
379	Suppose that there is an individual who can be entrusted with the charge of a young orphan prince, is such a man a superior man? He is a superior man indeed.	211		
380	Suppose that there is an individual who can be commissioned with authority over a state of a hundred miles, is such a man a superior man? He is a superior man indeed.	211		
381	Suppose that there is an individual whom no emergency however great can drive him away from his principles - is such a man a superior man? He is a superior man indeed.	211		
382	A Confucian scholar cannot be without breadth of mind and vigorous endurance.	137	211	
383	The burden of a Confucian scholar is heavy and his course is long.	127	211	
384	Perfect virtue is the burden which a Confucian scholar considers as his duty to sustain - is it not heavy?	127	211	117
385	Only with death does the course of a Confucian scholar stops - is it not long?	280	279	211
386	It is by the Odes that the mind is aroused.	28		
387	It is by the Rules of Propriety that the character is established.	22	227	
388	It is from Music that personal cultivation is completed.	22	229	
389	The common people may be made to follow a path of action, but they may not be made to understand it.	261	14	
391	When you carry your dislike to a man who is not virtuous, he will proceed to unruly behaviour.	70		
392	Though a man may have abilities as admirable as those of the duke of Zhou, yet if he be proud and niggardly, those other things are really not worth being looked at.	75	73	
393	It is not easy to find a man who has learned for three years without coming to think of earning a salary.	18		
395	Holding firm to death in perfecting the excellence of your course.	71	136	280
396	Do not enter a tottering state.	303		
397	Do not dwell in a disorganized country.	303		
398	When the right principles of government prevail in a kingdom, you should show himself.	288	280	

399	When the Way is prostrated, you should keep yourself concealed.	288	280	
400	When a country is well governed, being in poverty and a mean condition is to be ashamed of.	35	293	280
402	He who is not in any particular office has nothing to do with the administration of its duties.	14		
403	When the music master Zhi first enters his office, the performance of the Guan Ju is magnificent - how it filled the ears!	229		
404	Ardent and yet not upright - such persons I do not understand.	144	126	
405	Stupid and yet not attentive - such persons I do not understand.	144	159	
406	Simple and yet not sincere - such persons I do not understand.	125	144	133
407	Learn as if you could not reach your object.	18		
408	Learn always with a fear that you would lose what you learnt.	18		
409	How majestic is the manner in which Shun and Yu hold possession of the empire, as if it were nothing to them!	14	215	
410	Great indeed is Yao as a sovereign! How majestic he is!	14	215	
411	It is only Heaven that is grand, and only Yao corresponds to it.	274	215	274
413	How majestic is Yao in the works which he accomplished!	215		
414	How glorious are the elegant regulations which Yao instituted!	227	215	
415	Is the saying not true that talents are difficult to find?	128		
416	The virtue of the house of Zhou may be said to have reached the highest point indeed.	71	5	
424	The subject which I seldom discuss is profitableness.	99		
425	The subject which I seldom discuss is the appointments of Heaven.	276		
426	The subject which I seldom discuss is benevolence.	117		
427	My learning is extensive, and yet he does not render his name famous by any particular thing.	18		
428	The linen cap is that prescribed by the rules of ceremony, but now a silk one is worn. It is economical, and I follow the common practice.	139		
429	The rules of ceremony prescribe the bowing below the hall, but now the practice is to bow only after ascending it. That is arrogant. I continue to bow below the hall, though this is oppose to the common practice.	19	227	73
430	I have no foregone conclusions.	118		
431	I have no arbitrary predeterminations.	118		
432	I have no obstinacy.	118		
433	I am not egoistic.	116		
434	Is not the Way lodged in me after the death of King Wen?	127	280	
435	If Heaven wishes to let the Way perish, then I, a future mortal, should not be invested with that cause.	279	274	280
436	If Heaven does not want the Way to perish, what can the people of Kuang do to me?	279	274	280
437	People say that I am a sage due to my various abilities.	128	215	
438	People say that Heaven has certainly endowed me unlimitedly.	128	274	
439	When I was young, my condition was low, and therefore I acquired my ability in many things, but they are low skill menial matters.	293	166	
440	Must the gentleman have such a variety of abilities? No, he does not need to have a variety of abilities.	211		
442	Am I indeed possessed of knowledge? No, I am not knowledgeable. if a rustic asks anything of me, my mind goes blank.	144	116	
443	If a question is posted to me and I have no answer, I set it forth from one end to the other until I exhaust it.	21	18	40
444	The phoenix does not come; - it is all over with me!	280		

445	The river sends forth no map - it is all over with me!	280		
446	When I see a person in mourning dress, on observing him approaching, though he is younger than me, I would rise up.	119	226	163
447	If I have to pass by a person in a mourning dress, though he is younger than me, I would walk by hastily.	119	226	163
448	When I see any one in ceremonial dress, on observing them approaching, though they were younger than himself, I would rise up.	119	163	
449	If I have to pass by any one in ceremony dress, though they are younger than himself, I would walk by hastily.	119	163	
450	If I see a blind person, on observing him approaching, though he is younger than me, I would rise up.	119	163	
451	If I have to pass by a blind men, though he is younger than me, I would walk by hastily.	119	163	
452	My doctrines, upon looking up to them, seem to become higher.	136	285	
453	My doctrines, in trying to penetrate them, seem to become firmer.	136	285	
454	My doctrines, upon looking at them right before you, suddenly they seem to be behind.	285		
456	I enlarge people's mind with learning and literature.	18		
457	I teach my disciples the restraints of propriety.	64	227	
458	When Yan Hui wishes to give up the study of my doctrines, he cannot do so.	18	285	
459	My disciples find that having exerted all their ability to study my doctrines, there seems something to stand right up before them; though they wish to follow and lay hold of it, they really find no way to do so.	18	285	
460	When I was very ill, Zi Lu wished the disciples to act as ministers to me. His conduct is deceitful! By pretending to have ministers when I have them not, whom should I impose upon? Should I impose upon Heaven?	286	311	
461	Is it not better that I should die in the hands of you, my disciples, than in the hands of ministers?	218	279	
462	Though I may not get a great burial, shall I die upon the road?	230		
463	There is a beautiful gem here. Should I lay it up in a case and keep it? or should I seek for a good price and sell it? I think I should sell it! Sell it! But I would wait for a good price.	118	282	
464	I wish to go and live among the nine wild tribes of the east. If a gentleman dwelts among them, what rudeness would there be?	301	211	
465	After I returned from the state of Wei to the state of Lu, the music was reformed, and the pieces in the Royal songs and Praise songs all found their proper places.	229		
466	When abroad, serve the high ministers and nobles.	127	170	304
468	in all duties to the dead, I do not to dare not to exert myself.	177	127	
469	I will not be overcome by wine.	64		
470	When I stood by a stream, I said, It passes on just like this, not ceasing day or night!	283		
471	I have not seen one who loves virtue as he loves beauty.	282	5	31
472	The prosecution of learning may be compared to what may happen in raising a mound. If there want but one basket of earth to complete the work, and I stop, the work shall never be completed.	18	132	
473	Learning may be compared to throwing down the earth on the level ground. Though only one basketful is thrown at a time, the advancing with it is my own going forward.	18	132	
474	Never flagging when I set forth anything to him - that is Hui.	110	132	
475	I saw Hui is constantly advancing. I never saw him stop in his progress.	110	132	
476	There are cases in which the blade springs, but the plant does not go on to flower!	284	278	128
477	There are cases where the plant flowers but no fruit is subsequently produced!	284	278	128
478	A youth is to be regarded with respect. How do we know that	138	166	

	his future will not be equal to our present?			
479	If one reaches the age of forty or fifty, and has not made himself heard of, then indeed he will not be worth being regarded with respect.	138	166	
480	Can men refuse to assent to the words of strict admonition? But it is the reforming of conduct due to them that is valuable.	20	66	
481	Can men refuse to be pleased with words of gentle advice? But it is the unfolding of their aim that is valuable.	46	144	205
483	The commander of the forces of a large state may be carried off, but the will of even a common man cannot be taken from him.	285	137	
484	Dressed in a tattered robe quilted with hemp, yet standing by the side of men dressed in furs, and is not ashamed - it is Zi Lu who is equal to this!	35	293	317
485	If one dislikes nothing and covets nothing - what can he do but what is good!	71	107	
486	Only when the cold season comes, then we know how the pine and the cypress are the last to lose their leaves.	129	132	
487	The wise are free from perplexities.	34	118	
488	The virtuous are free from anxiety.	201	211	
489	The courageous are free from fear.	198	145	
490	There are some with whom we may study in common, but we shall find them unable to go along with us in the pursuit of the Way.	280	18	
491	There are some with whom we may go together in pursuing the Way, but we shall find them unable to get established in the Way with us.	50	280	
492	There are some with whom we may get established in the Way, but we shall find them unable to weigh occurring events along with us.	146	6	
493	There's a passage in the Odes, "how the flowers of the aspen-plum flutter and turn. Do I not think of you? But your house is distant." I'd say that he does not really love her. If he does, How is it distant?	182	179	31
494	When in my village, I am unassuming and inarticulate, as if I am not able to speak.	125	302	
498	When the ruler is present, my manner is respectfully uneasiness. I am grave, but self-possessed.	138	170	
500	I will incline myself to the other officers among whom I stand, moving my left or right arm, as their position required, but keeping the skirts of my robe before and behind evenly adjusted.	193		



#### 4. A partial list of entries in the virtual Confucius knowledge base – Terminologies

(Only entries numbered 1000 – 2069 with less than 4 keywords are shown here. Very few entries that contains a lot of names or other terminologies can have as many as 8 keywords)

ID	Text	keyword1	keyword2	keyword3
1012	Bo Yi and Shu Qi died of hunger at the foot of the Shou Yang mountain, and the people, down to the present time, praise them.	Bo Yi	Shu Qi	worthy man
1040	The Odes serves to stimulate the mind.	Book of Poetry	Odes	
1047	The man who has not studied the Zhou Nan and the Shao Nan (passages in the Odes) is like one who stands with his face right against a wall.	Book of Poetry	Odes	
1053	Having not yet got what he want, the small man's anxiety is to think of how to get them.	Mean man	Small man	anxious
1054	When the small man has got what he want, his anxiety is lest that he should lose them.	Mean man	Small man	anxious
1071	It is not until a child is three years old that he is allowed to leave the arms of his parents.	three year mourning	parent	child
1072	The three years mourning is universally observed throughout the empire.	three year mourning		
1073	Did you not enjoy the three years love of your parents?	three year mourning	love	parents
1091	Hui of Liu Xia, being chief criminal judge, was thrice dismissed from his office.	Liu Xia Hui	office	
1107	Bo Yi refuses to surrender his wills.	Bo Yi	worthy man	dignity
1108	Bo Yi refuses to submit to any taint in his person.	Bo Yi	purity	worthy man
1109	Shu Qi refuses to surrender his wills.	Shu Qi	dignity	worthy man
1110	Shu Qi refuses to submit to any taint in his person.	Shu Qi	purity	worthy man
1111	It may be said of Hui of Liu Xia and of Shao Lian that they surrendered their wills, and submitted to taint in their persons; but their words corresponded with reason, and their actions were such as men are anxious to see.	Liu Xia Hui	Shao Lian	
1112	It may be said of Yu Zhong and Yi Yi, that, while they hid themselves in their seclusion, they gave a license to their words; but in their persons, they succeeded in preserving their purity, and, in their retirement, they acted according to the exigency of the times.	Yu Zhong	Yi Yi	wisdom
1125	The superior man honors the worthy man.	worthy man		
1141	The mean man is sure to gloss his faults.	Mean man	small man	fault
1155	Zi Zhang can do things which are hard for other people to do, but yet he is not perfectly virtuous.	Zi Zhang	virtue	
1156	How imposing is the manner of Zi Zhang! It is difficult to practice virtue along with him.	Zi Zhang	virtue	manner
1158	The filial piety of Meng Zhuang is shown in his not changing the ministers of his father after his death, nor his father's mode of government. This is difficult to attain to.	Meng Zhuang	filial	
1161	Emperor Zhou's wickedness is not so great as the name implies.	King Zhou	wickedness	
1166	The doctrines of king Wen and king Wu have not yet fallen to the ground.	ancient kings	doctrine	
1167	The doctrines of king Wen and king Wu can still be found among men.	ancient kings	doctrine	
1168	Men of talents and virtue remember the grand principles of king Wen and king Wu.	ancient kings	talents	virtue
1169	Men not possessing much talents and virtue will remember the smaller doctrines of king Wen and king Wu.	ancient kings	talents	virtue
1228	Zai Wo and Zi Gong are skillful at speaking.	Zai Wo	Zi Gong	speech
1240	Comparing me with Bo Yi and Yi Yin, are we to be placed in the same rank?	Bo Yi	Shu Qi	worthy man
1256	Great indeed was Yao as a sovereign!!!	Yao		
1257	It is only Heaven that is great, and only Yao corresponds to it.	Yao	Heaven	
1258	How vast is the virtue of emperor Yao! The people could find no name for it.	Yao	virtue	

1259	Princely indeed is emperor Shun! How majestic he is, having possession of the kingdom, and yet seeming as if it is nothing to him!	Shun		
1260	In their governing the kingdom, emperor Yao and Shun did not employ their minds on the cultivation of the ground.	Yao	Shun	governance
1261	When I died, after three years had elapsed, my disciples collected their baggage, and prepared to return to their various homes.	three year mourning	disciple	
1262	When I died, after three years had elapsed, my disciples collected their baggage preparing to leave. As they looked towards one another, they wailed, till they all lost their voices.	disciples	mourning	three year mourning
1263	After my disciples returned home after three year mourning, Zi Gong came back, and built a house for himself on the altar-ground beside my grave, where he lived alone other three years, before he returned home.	Zi Gong		
1271	Yang Huo wished to get me to go to see him, but disliked doing so by any want of propriety.	Yang Hou	propriety	
1273	Yang Huo watched when I was out, and sent me a roasted pig. In return, I watched when Huo was out, and went to pay me respects to him.	Yang Hou	rite	
1274	The world falls into decay, and principles fade away. Perverse speakings and oppressive deeds are pervasive. There are instances of ministers who murder their sovereigns, and of sons who murder their fathers. I am afraid, and hence edited the book of Spring and Autumn.	Book of Spring and Autumn	Chun Qiu	disorder
1275	What the Book of Spring and Autumn contains are matters proper to the sovereign.	Book of Spring and Autumn	Chun Qiu	
1276	It is the Book of Spring and Autumn that will make men know me.	Book of Spring and Autumn	Chun Qiu	praise
1277	It is the Book of Spring and Autumn that will make men condemn me.	Book of Spring and Autumn	Chun Qiu	condemn
1278	I completed the Book of Spring and Autumn, and rebellious ministers and villainous sons are struck with terror.	Book of Spring and Autumn	Chun Qiu	
1288	I praise Yu and Ji, who in an age when the world was being brought back to order, thrice passed their doors without entering them.	Yu	Ji	responsible
1325	Shun is indeed perfectly filial! And yet, when he is fifty, he is full of longing desire about his parents.	Shun	filial	
1339	Qin Zhang, Zeng Xi, and Mu Pi, are those whom I styled as ambitious.	disciples	ambitious	
1361	In the three years mourning, I follow the extreme demonstration of sorrow and courtesy.	three year mourning		
1363	I have heard that the ancients made graves only, but raised no mound over them.	ancients	grave	
1366	I wailed for Zi-lu's death in my courtyard.	Zi Lu	death	
1367	When the messenger told me that they have made Zi Lu into pickle, I ordered all pickle in the house to be thrown away.	Zi Lu	death	
1369	When the ancient kings framed their rules, they might have said that they could not bear to cease mourning even for ordinary men along the roads.	ancient kings	humanity	
1399	Under the Yin traditions, people presented condolences to the mourner immediately at the grave.	Zhou	funeral	
1400	Under the Zhou traditions, people presented condolences to the mourners after they come back from the grave.	Yin	funeral	
1401	Under the Yin traditions, people presented condolences immediately at the grave; under the Zhou traditions, after the mourners come back from the grave; I think Yin is too blunt; I follow the Zhou tradition.	Yin	Zhou	funeral
1402	Under the Yin traditions, the tablet was put in its place on the change of the mourning at the end of twelve months.	Yin	mourning	
1403	Under the Zhou traditions, the tablet was put in its place when the (continuous) wailing was over at the ceremony.	Zhou	mourning	
1404	Under the Yin, the tablet was put in its place on the change of the mourning at the end of twelve months; under the Zhou, when the (continuous) wailing was over. I approve the practice of the Yin tradition.	Yin	Chou	mourning
1405	He who made the vessels that resemble the real things know the principles underlying the mourning rites. The vessels are complete (to all appearance), and yet could not be used.	vessel	sacrifice	dead
1406	If for the dead vessels of the living are used, would there not have been a danger of this leading to the interment of the living with the dead?	vessel	sacrifice	dead

1414	There was an old acquaintance of mine called Yuan Zang. When his mother died, I assisted him in preparing the shell for the coffin.	Yuan Zang	assistance	funeral
1416	The people of Wei, in burying husband and wife together in the same grave and shell, leave a space between the coffins. The people of Lu, in doing the same, place them together. I think Lu's way is better.	Wei	funeral	Lu
1448	Ah! Alas! I look at the ways of Zhou. The kings You and Li corrupted them indeed. But if I leave Lu, where shall I go and to find them better?	Zhou	way	
1449	The border sacrifice of the Lu state is contrary to propriety - how have the institutions of the duke of Zhou fallen into decay!!!	Lu	Zhou	Duke of Zhou
1460	When I was eating with the head of the Ji family, I made no attempt to decline anything, but finished my meal with the rice and liquid added to it, without eating any of the flesh.	Ji family		
1462	The pantomimes of the ancient musical performances stand with their shields, each erect and firm as a hill, representing the attitude of king Wu.	Wu	ceremony	
1463	The violent movements of the arms and firece stamping in the pantomimes of the ancient musical performances represent the enthusiasm of Tai-gong.	Tai-gong	ceremony	
1464	The kneeling of all at the conclusion of the ancient musical performance represents the government of peace, instituted by the dukes of Zhou and Zhao.	Duke of Zhou	ceremony	
1465	The pantomimes of the ancient musical performance in their first movement proceed towards the north to imitate the marching of king Wu against Shang.	Wu	Shang	ceremony
1467	In the pantomines of the ancient musical performance, two men, one on each side performers, would excite the audience with bells, and four times they stop and strike and thrust, showing the great awe with which king Wu inspired in the Middle states.	Wu	awe	
1471	Guan Zhong was a worthy Great officer, but he made it difficult for his superiors to distinguish themselves from him.	Guan Zhong	officer	
1472	Yan Ping-zhong was a worthy Great officer, but he made it difficult for his inferiors to distinguish themselves from him.	Yan Ping Zhong	officer	
1480	When you enter any state, you can know by observation what its people have been taught. If they have a wide comprehension (of things), and know what is remote and old, they have been taught from the Book of History.	Book of History	Shang Shu	
1484	When you enter any state, you can know by observation what its people have been taught. If they suitably adapt their language to the things of which they speak, they have been taught from the Chun Qiu.	Chun Qiu	Book of Spring and Autumn	speech
1486	The fault that may arise in connection with the study of History is duplicity.	Book of History	Shang Shu	duplicity
1490	The fault that may arise in connection with the study of Chun Qiu is insubordination.	Chun Qiu	Book of Spring and Autumn	
1492	Those people who have a wide comprehension (of things), and know what is remote and old, and yet are free from duplicity, their understanding of the Book of History is deep.	Book of History	Shang Shu	
1500	At his entertainments, the Son of Heaven listens to the singing of the Odes of the Kingdom and the Odes of the Temple and Altar.	Odes	Book of Poetry	
1803	From the Son of Heaven down to the common people, there never has been one whose filial piety is without its beginning and end on whom calamity dose not come.	Son of Heaven	people	
1806	The ancient kings imitated the brilliant luminaries of heaven and acted in accordance with the varying advantages afforded by earth, so that they were in accord with all under heaven.	ancient kings	heaven	emulate
1889	Manifest the utmost reverence in the ancestral temple to show that you do not forget your parents.	ancestral temple	reverence	
1891	When in the ancestral temple you exhibits the utmost reverence, the spirits of the departed will manifest themselves.	ancestral temple	reverence	
1903	The period of mourning does not go beyond three years, this is to show people that it must have an end.	three year mourning		
1905	People prepare the ancestral temple to receive the tablet of the departed, and there they present offerings to the disembodied spirit.	ancestral temple	sacrifice	
1922	Emperor Shun is indeed greatly wise! He loves to question others, and to study their words, though they might be shallow.	Shun	wise	
1925	All men tends to say,"we are wise." But when it comes to choosing the course of the Mean, they are not able to keep it for a round month.	Constant Mean	Due Mean	mankind

1927	The kingdom, the states, and its families may be perfectly ruled; dignities and emoluments may be declined; naked weapons may be trampled under the feet; but the course of the Mean cannot be attained to.	Constant Mean	Due Mean	Course of Mean
1972	How greatly filial was emperor Shun! His dignity was the throne; and his riches were all within the four seas.	Shun	four seas	
1992	The duties of universal obligation are five: those between the sovereign and minister, between father and son, between husband and wife, between elder brother and younger, and those belonging to the intercourse of friends.	five cardinal social relations		
2053	Never swerving from the Mean.	Constant Mean	Due Mean	Course of Mean
2059	It is the way of the mean man to seek notoriety.	Small man	mean man	