An Embodied Conversational Agent for Intelligent Web Interaction on Pandemic Crisis Communication

Ong Sing Goh, Chun Che Fung, Kok Wai Wong and Arnold Depickere
School of Information Technology,
Murdoch University, Murdoch, Western Australia 6150
Email: {os.goh, l.fung, k.wong, A.depickere}@murdoch.edu.au

Abstract

In times of crisis, an effective communication mechanism is paramount in providing accurate and timely information to the community. In this paper we study the use of an intelligent embodied conversational agent (ECA) as the front end interface with the public for a Crisis Communication Network Portal (CCNet). The proposed system, CCNet, is an integration of the intelligent conversation agent, AINI, and an Automated Knowledge Extraction Agent (AKEA). AKEA retrieves first hand information from relevant sources such as government departments and news channels. In this paper, we compare the interaction of AINI against two popular search engines, two question answering systems and two conversational systems.

1. Introduction

The outbreak of diseases, virus, natural disasters and terrorists attacks have caused much miseries, fear and confusion around the world. Examples of such crisis are the Severe Acute Respiratory Syndrome (SARS), bird flu, September 11, earthquakes and the recent tsunamis. In times of crisis, a lot of people will be looking for information. This ranges from management and decision-makers, frontline special or emergency services personnel who have to deal with the situation, citizens who are directly or indirectly involved, and the general public who would like to be informed of the situation and the development.

Due to the rapid advancement of network technology, availability of broadband services, mobile computing and convergence of voice communication and public broadcast into an internet based system, it is therefore foreseeable that the Internet will become the dominant communication system in the world. It is anticipated to overtake the traditional means of telecommunication such as voice networks and the public free-to-air broadcast. Hence, a global crisis communication system based on the internet has been proposed in this paper. One of the key components of the proposal is a computer-driven, natural language "chatterbots", capable of providing meaningful and quick responses to queries from the users in a conversational format. The prototype system is compared to two popular search engines – Google and Yahoo!, two question answering systems – START and AskJeeves and two conversational systems – ELIZA and ALICE. With more natural and meaningful responses, it is expected that the proposed ECA will provide assistance to her users during real-world crisis situations.

2. AINI's Conversational Agent

This research project involves the establishment of a Crisis Communication Network (CCNet) portal. The objective is to use an embodied conversational agent (ECA) based on an architecture called Artificial Intelligent Neural-network Identity (AINI) [1]. The real-time prototype relies on distributed agent architecture designed specifically for the Web. The software agent is based on a conversation engine using a multi-domain knowledge model and with multimodal human-computer communication interface. It also offers multilevel natural language query which communicates with one another via TCP/IP. AINI or AINI is a conversation agent (or chatterbot) which is capable to engage the user with a meaningful conversation on specific topic. In this particular application, the topic is on the possible pandemic virus, H5N1. From another perspective, AINI can be considered as a software conversation robot. It uses a form of human-computer communication system which is a combination of natural language processing and multimodal communication. A human user can communicate with the developed system using typed natural language conversation. The embodied conversation agent system will reply in text-prompts or Text-to-Speech Synthesis together with appropriate facial-expressions. Given a question, AINI first performs question analysis by extracting pertinent information to be used in query formulation, such as Noun Phrases and Verb Phrases. It also employs an Internet three-tier, thin-client architecture that may be configured to work with any web application. It comprises of a data server, application and client layers. This Internet specific architecture offers a flexible solution to the unique implementation requirements of the AINI system.

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3. Natural Language Query for the H5N1 Conversational Agent System

In this paper, Bird Flu pandemic is the Domain-Specific research focus. Research and information on H5N1 pandemic have become increasingly important as the pandemic will have dire global implications. Wall Street Journal Online [2] predicted that this pandemic could be worse than the one in 1918 which killed at least 20 million people. In addition, the World Health Organization estimates the H5N1 virus could infect up to 30 percent of the world's population. Shigeru Omi, a WHO official, also warned that an estimation of 2 to 7 million deaths are "conservative" and that the maximum figure could be as high as 50 million [3].

The AINI domain knowledge model incorporates several knowledge domains. This is analogous to the consultation of expertise knowledge from multiple experts. For example, a *sales* domain knowledge should contain expertise or knowledge on how to improve sales. However, the system should also incorporate Open-Domain knowledge to handle general or generic questions. By including multiple domain knowledge bases with AINI's single domain knowledge, the ECA will be able to hold meaningful conversations with the users. In this proposed system, the Open-Domain and Domain-Specific knowledge are pre-defined in the Data Layer. Depending on the user's input, the agent will respond or switch from one domain knowledge base and natural language query Level to another knowledge base. While the system is capable to communicate with the user beyond the domain knowledge, the conversational agent will continue to remind the user by bring the focus back to the current topic of interest. This is to direct the users' attention back to the system's Open-Domain or Domain-Specific state. However, the priority will always be Domain-Specific.

4. Experimental Setup to compare AINI ECA with other systems

In this experiment, three types of proprietary systems are compared. They are *search engine*, *question answering system* and *conversational system* (or, chatterbot). For each system, we compared two difference engines against AINI ECA. The two search engines compared are Google and Yahoo! due to their popularity. For the question answering engines, AskJeeves and START are supposed to use natural language processing for their queries. For the conversational engines, the well known chatterbots ELIZA and ALICE are selected. In particular, ALICE was ranked as the "most human computer" in the Turing Test competition [4].

Google is a well known search engine which determines relevancy of information primarily on their PageRank algorithm. In our experiment, we developed a search engine interface using Google SOAP Search API service [5] and Yahoo! [6] which enable us to query the vast amount of web pages directly from the CCNet portal. For the Question Answering system, the original idea behind Ask Jeeves and START was to allow users to get answers for questions posed in natural language. ASK Jeeves is the first commercially question answering system available on the Internet. START [7] is the world's first Web-based question answering system which commenced operation since December, 1993. ELIZA is a well known program in the discipline of Artificial Intelligence. Created in the early 1960's by MIT scientist Joseph Weizenbaum [8], ELIZA is also the oldest system of similar type. ALICE[9] is a general conversation chatterbot based on the Annotated ALICE Artificial Intelligence Markup Language (AAA). The knowledge base rule set consists of approximately 46,424 categories. In a way, AINI is an enhancement of ALICE with the inclusion of the Pandemic Domain-specific knowledge base which was extracted using AKEA, and parsing capabilities based on a full Natural Language Understanding engine for multilevel natural language query. In the present study, appropriate or accurate domain responses are expected to be important. The control question set was submitted to the seven URLs where the seven systems were located. The responses of the queries are then collected and displayed as shown in Fig. 1.

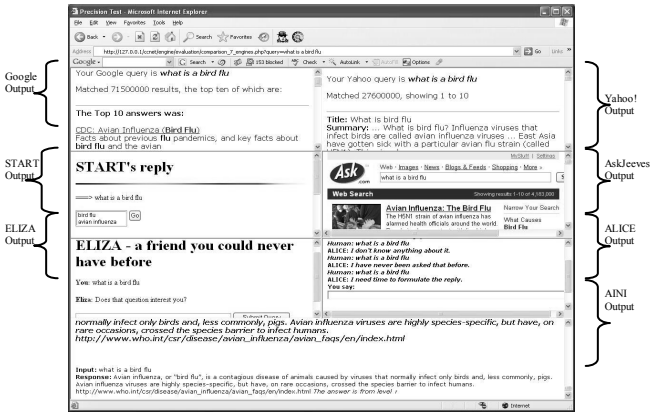

Fig. 1 Experimental Design Interface

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5. Results

It is expected that one may challenge any claims of technological superiority of proprietary technologies over other systems. For example, the issue on how to evaluate the relevant superiority between the results from search engines, question-answering systems or chatterbots? The answer could be revealed on the primary reliance on keywords. For example, if the question "*What is a bird flu*?" is asked, responses from the search engines, question-answering engines and conversational engines are summarized in Table 1, 2 and 3 respectively.

Table 1: Responses from the proprietary search engines

SEARCH ENGINES	
ENGINE	**RESPONSES**
Google	Reply 7.15 million pages. First hit was " Facts about previous flu pandemics, and key facts about bird flu and the avian influenza A (H5N1) virus.."
Yahoo	Reply 27.6 million pages. First hit was " Influenza viruses that infect birds are called avian influenza viruses ... East Asia have gotten sick with a particular avian flu strain (called H5N1). This virus has ..."

Table 2: Responses from the question answering engines

QUESTION ANSWERING ENGINES	
ENGINE	**RESPONSES**
AskJeeves	Reply 4.183 million pages. First hit was " The H5N1 strain of avian influenza has alarmed health officials around the world. People in close contact with live birds have contracted the disease, raising concerns that it may change into a highly contagious form that can be transmitted from human to human. ."
START	Main Entry: **bird flu** Function: *noun* : **AVIAN INFLUENZA** **Source:** Merriam-Webster Dictionary

The responses are noted as follows:

- **Search Engines** - pick out one key word/phrase and return documents that are relevant to the query. The results could be million of hits as shown in Table 1.
- **Question-answering Engines** - generate responses using NLP and return fewer possible answers and possibly within the context of the document as shown in Table 2.
- **Conversational Engines** - provide quick response from the stimulus. Simple pattern matching and substitution are used based on a surprisingly small number of pre-defined rules. This is shown in Table 3.

Table 3: Responses from the conversational engines

CONVERSATIONAL ENGINES	
ENGINE	**RESPONSES**
ELIZA	Does that question interest you?
ALICE	I haven't heard of bird flu.
AINI	Avian influenza, or "bird flu", is a contagious disease of animals caused by viruses that normally infect only birds and, less commonly, pigs. Avian influenza viruses are highly species-specific, but have, on rare occasions, crossed the species barrier to infect humans. http://www.who.int/csr/disease/avian_influenza /avian_faqs/en/index.html

6. Discussion

In this example, ELIZA responded with *"Does that question interest you?"* illustrating ELIZA tries to ask another question, instead of given the answer. The objective is to encourage the user to continue with the conversation. On the other hand, ALICE attempts to convince the user by generating randomly answer from AIML knowledge base. ALICE's response does not need a grammatical parser as her knowledge base contains the pattern "WHAT IS A BIRD FLU?" and the witty come-back is "XFIND *" with an AIML categories. By using "XFIND *" pattern, ALICE will randomly generated responses such as *"Is there only one", let me think about it.", "Have you tried a web search.", "I haven't heard of bird flu."* etc. The primary design feature of Artificial Intelligence Markup Language (AIML) is minimalism. AIML is an XML language, implying that it obeys certain grammatical meta-rules. The pattern matching language used in ALICE permits only one wild-card ('*') match character per pattern. Therefore, ALICE can respond a variety of inputs from the users. ALICE does not concern whether the robot really "understands" the input. This category elucidates a coherent response from the client, who might have the impression of the robot understanding the client's intention. For the Eliza and ALICE chatterbots, they are not able to handle or answer such "trick questions". However, there are three possible ways to handle these types of questions - (a) solving the problems with NLP, (b) depending on a good "botmaster" who reviews conversation logs and continually improves the knowledge base, or, (c) treating it as impossible and answer randomly.

For the AINI chatterbot, the response was *"Avian influenza, or "bird flu", is a contagious disease of animals caused by viruses..."* which is generated from the Domain-specific knowledge base using Natural Language Understanding parsing from

Level 1 [10]. In this query, the answers were discovered by AINI from the trusted sites such as WHO and the knowledge was extracted with Automated Knowledge Extracted Agent (AKEA)[11]. In addition, the response is based on the natural language understanding and reasoning. The reasoning mechanism of the AINI couples a novel idea of complexity reduction during answer discovery in a network-oriented knowledge base with two advanced reasoning features, namely, *relaxation of event constraint* and *explanation on failure*. These are used to provide higher quality responses. The advanced reasoning is carried out with the use of domain ontology and knowledge base. Another significant difference between AINI and the other chatterbots is that AINI uses the existing award winning Turing Test knowledge base as her open-domain knowledge. This trained Knowledge Base is also called Annotated ALICE Artificial Intelligence Markup Language (AAA) [9]. For the domain-specific knowledge, AINI uses existing online documents extracted using AKEA. AINI is also implemented using Top-down approach for the natural language query [10]. In this multilayer natural language query, plug-in module has been proposed. The plug-in module consists of spell-checker, Natural Language Understanding and Reasoning, FAQ Metadata and AIML engine module. This plug-in module can be integrated easily and therefore offer a much more scalable approach for the web context. Currently ongoing work includes quantitative measurement and assessment of the results and performance of these different systems.

7. Conclusion

In this paper, we have reported the use of an embodied conversational agent (ECA), AINI, as a tool for front end intelligent web interaction. AINI also consists of a knowledge acquisition tool for the gathering of conversation and domain-related knowledge called AKEA. The natural language dialog system has shown its potential in a domain specific application area. The study has demonstrated with one particular area of domain expertise - pandemic Bird flu. It is believed that the approach would be useful and applicable for other domains. We have also compared and tested the flexibility of AINI ECA against other popular search engines, question answering systems and chatterbots. Furthermore, we have found that domain-specific knowledge base has higher response satisfaction levels from the user than the corresponding conversational-style responses.

In conclusion, it can be anticipated that ECA will play an important role in increasing the acceptance and use of conversational agents. This will pave the way for more natural and intelligent web interfaces based on human language technologies. In this experiment, a top-down natural language query approach was used and it shows more natural and appropriate behavior. In this paper, we only worked on selected pandemic crisis websites where we performed knowledge extraction for the Domain-Specific databases on the server. Further work will be done on expanding the sources of knowledge and to provide quantitative measurements of the quality of responses from the ECA.

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