D Unterstützungssysteme

D.1   Design pattern for conversational agents handling data-driven requests

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The aim of this research project is to identify design principles for the development of CAs. In the context of this thesis, the research questions are: "According to which design principles are Conversational Agents developed?" and "How can these design principles be meaningfully categorized and described?". For the aggregation of the design principles, the first step was a systematic literature search according to Vom Brocke et al. (2009). The systematic literature review was followed by a qualitative literature analysis according to Kuckartz (2018). The result of this work is the identification of 15 meta-requirements that could be categorised by means of three main categories and a further seven subcategories. This was followed by the declaration of seven design principles based on the subcategories and their meta-requirements.

1   Introduction

Considering the period from the last decade until today, a positive trend in the field of research, development, and deployment of dialogue systems, especially conversational agents (CAs), can be identified (Allouch et al., 2021). The increasing interest in those systems can be traced back to the continuous development of technologies for natural speech recognition in recent years (Allouch et al., 2021). Due to technical progress, there is a permanent increase in demands for such systems, which go beyond the classically designed FAQ chatbot in the customer segment and enable interactively designed conversations with the user (Diederich et al., 2022). In this context, so-called CAs have been developed taking into account specific use cases. These collected meta-requirements get combined into design principles.

The analysis of the literature resulted in the identification of a research gap regarding the summary of design principles for CAs from different fields. This academic paper aims to provide a clear presentation of design principles for CAs. The following research questions were prepared to support the objective:

1. According to which design principles are Conversational Agents developed?

2. How can these design principles be meaningfully categorized and described?

To answer these research questions, a systematic review of literature according to Vom Brocke et al. (2009) was conducted at the beginning of the scientific work. At the end of the review of literature, 24 references were identified, which were subsequently examined for design principles of CA using qualitative content analysis, according to Kuckartz (2018). As a result, 15 meta-requirements could be identified and inductively categorized according to Kuckartz (2018). Subsequently, seven design patterns could be defined using these subcategories.

This paper serves as a categorized representation of identified design principles. To meet the objectives, the research paper is structured as follows. In Section 2 basic terminology for further understanding is first listed and explained, followed by a more detailed description of the methodological procedure regarding the analysis of literature and the subsequent qualitative content analysis. Section 4 explains the categories formed in Section 3 and their meta-requirements and design principles. In Section 5 the findings are summarized and future research using these obtained results is described.

2 Related Definitions and Terms

For better understanding, a defined terminology is obligatory. During initial research in the area of dialogue systems, especially CAs, a variety of terms emerge. The closely related terms are defined differently in the literature. The focus of this analysis is a holistic presentation of the following terms: dialogue system, conversational agent, chatbot, and design principle.

In the context of this scientific work, dialogue systems are defined as "human-computer interaction system that uses natural language to communicate with the user" (Allouch et al., 2021, p.3). These systems are facilitated by Natural Language Processing (NLP) (DeepAI, 2020). NLP is composed of Natural Language Understanding (NLU) and Natural Language Generation (NLG) (Wuttke, 2022).

The analysis of natural language and identification of its meaning is possible by the NLU concepts of intents and entities. Intents describe tasks whose execution is the user's goal (Microsoft, 2022a). The analysis of user statements using NLU always concludes on the intent with the highest accuracy only (Microsoft, 2022a). An intent can have no or several entities. Entities declare data types that are necessary for the execution of user intentions (Microsoft, 2022b). NLG enables natural language generation (Wuttke, 2022).

Various approaches to the classification of dialogue systems emerge from the literature. Jurafsky and Martin (2019) divide them into task-oriented dialogue systems and chatbots. For the rest of the procedure, dialogue systems are classified according to McTear (2020) and Young et al. (2021) into task-oriented dialogue systems (TOD) and open-domain non-task-oriented systems (ODD).

- TOD: "perform goal-oriented functions" (Young et al., 2021, p.1)
- ODD: "general conversational interaction" (McTear, 2020, p.29)

According to Young et al. (2021), these systems can be combined to improve the holistic perception of dialogue systems.

According to Allouch et al. (2021), CAs belong to dialogue systems and are defined as "dialogue systems that can also understand and generate natural language content, using text, voice, or hand gestures" (Allouch et al., 2021, p.3). Data-driven CAs describe task-oriented dialogue systems.

According to Hussain et al. (2019), chatbots are divided into task-oriented chatbots and non-task-oriented chatbots, which can be described as follows:

- Task-oriented chatbots: aiming for the achievement of a specific goal
- Non-task-oriented chatbots: entertainment conversation with the user

According to this view, chatbots can be counted as task-oriented dialogue systems. As the term chatbot is often not used within this classification, it describes simple bots that use pattern matching functions (Masche & Le, 2017).

Design principles are used in the design and development of CAs. Design principles are statements that contain information that must be considered to achieve predefined design goals (Chandra et al., 2015). According to Chandra et al. (2015), the reasons for formulating these design principles are knowledge transfer, abstraction, and generalisation of problems as well as the development of future design theories.

3 Methodology

For analysing the research questions, a systematic review of the literature was conducted according to the framework of Vom Brocke et al. (2009). In this context, the scope of the review was defined according to Cooper's (1988) Taxonomy. Subsequently, the literature was examined for design principles for conversational agents by the qualitative research method by Kuckartz (2018).

Research

3.1 Systematic Review

The procedure of the systematic review of literature follows the five phases described in Vom Brocke et al. (2009): Definition of Review Scope, Conceptualisation of Topic, Literature Search, Literature, Analysis & Synthesis, and Research Agenda.

According to Vom Brocke et al. (2009), the greatest challenge of the review of literature lies "in defining an appropriate scope and flavour of the review" (Vom Brocke et al., 2009, p. 8). For this reason, the taxonomy according to Cooper (1988) is used for the scope of review.

The characteristics and categories are shown in Table 1. The focus of the systematic review of literature is to analyse research outcomes, theories, and applications. This work aims to integrate identified design principles into main categories and subcategories. To guarantee the quality criteria, the aggregation and conceptualisation of design principles are carried out from a neutral perspective. The literature is analysed exhaustively as well as selectively and structured from a conceptual perspective. The target group of this systematic literature analysis is specialised scholars, general scholars, and practitioners.

Table 1: Classification according to Cooper (1988), shaded cells illustrating classifications

Characteristics	Categories			
Focus	Research Outcomes	Research methods	Theories	Applications
Goal	Integration	Criticism	Central issues	
Perspective	Neutral representation		Espousal of position	
Coverage	Exhaustive	Exhaustive and selective	Representative	Central/pivotal
Organisation	Historical	Conceptual	Methodological	
Audience	Specialised scholars	General scholars	Practitioners or policymakers	General public

The systematic literature search was conducted in the databases IEEE Xplore and PubMed in the period from April, 1 to May, 16. In the field of computer science, IEE Xplore is one of the top databases and provides access to more than four million full-text documents. PubMed provides a comprehensive insight into the current state of research in the field of medicine. Through these two databases, current research in the field of medicine and informatics can be recorded regarding the development of CAs. The search implies only publications in English, as relevant publications should be accessible for future research. The databases were limited to publications between 2010 and 2022, as the research and development of data-driven CAs have increased and achieved substantial results within this time.

To carry out an effective literature search, keywords and synonyms were first identified. The search string resulting from this process is composed as follows:

data-driven* OR data driven* OR human computer interaction AND Conversational Agent* OR Digital Assistance* NOT Online Learning* OR Online Collaborative Learning*

Table 2 shows the number of results of the search string.

Table 2*: Overview of the search steps*

Search step	Number of results	Number of relevant results
IEEE Xplore	284	20
PubMed	9	4
Total without duplicates	293	24

For the identification of relevant literature, the next step was the analysis of the full texts. No material was excluded by means of title or analysis of the abstract, due to the different terminologies of the chatbot and missing descriptions of the functioning of the systems. Therefore, the full texts were analysed for the following keywords: data-driven, goal-oriented, task-oriented, intents, and entities.

3.2   Categorization

At the end of this procedure, 24 relevant papers were identified. Based on this literature, the following main and subcategories were formed in Section 4 according to Kuckartz (2018).

4   Results

Based on the main and subcategories defined in Section 3.2 according to Kuckartz (2018), the main categories are first explained. In the next step, the subcategories are described, and the meta-requirements identified from the literature are assigned in descending order according to the number of occurrences in the literature. Subsequently, design principles are formed from the subcategories.

As a result of the qualitative content analysis, the following three main categories could be determined: (H) Humanity, (U) Usability, and (T) Technology.

(H) Humanity: Human perception of the system.

(U) Usability: Serves to support humanity. Includes those contents that support the communication flow between CA and user and exclude negative perception during the interaction.

(T) Technology: Collection of all necessary technical aspects whose integration corresponds to the continuous development and future implementation of emerging technical requirements.

4.1 Main categories and associated subcategories

The category **Humanity** can be divided into two subcategories: **Sociability (S)** and **Graphical representation (G)**.

Sociability includes those principles that aim to increase the acceptance of the conversational agent by the user by means of a human design of the system, around humanity, social presence, and pleasure (Stieglitz et al., 2022).

The **graphical representation** includes requirements for the system to be visually presented in the form of avatars or Embodied Conversational Agents.

The main category **Usability** consists of the subcategories **Privacy (P)**, **Proactivity (PR)**, **Feedback (F)**, and **Error Handling (H)**.

Privacy includes requirements for the system that address the privacy of the users.

Proactivity includes criteria that describe an active system.

Feedback describes requirements regarding feedback from dialogue systems.

Error Handling includes requirements that serve to maintain the functionality of the system

The **Technology** category is subdivided into **Reusability/Scalability (SR)**.

Reusability and **Scalability** contains requirements that enable the system to be reusable and scalable.

Table 3: Overview Humanity

Main categories	(Subcategories) Meta-requirements	Summary	Citation
Humanity	*(S)Personalized*	Provision of personalized suggestions and consideration of personal information serve the human perception of the conversational system	4, 5, 7, 10, 13, 15, 16
	(S)Empathy	Analysis of user messages and empathy enables the system to engage in an emotional conversation with the user, leading to human perception	2, 4, 12, 14, 17
	(S)Response Time	Matching the system's response time to that of a human	3, 5, 9
	(S)Smooth and natural conversation	Communication between the system and the user should be natural and not involve abrupt changes in topic	9, 13
	(S)User friendly	The system should interact with the customer in an appropriate and friendly manner	7, 14
	(S)Short responses	Responses should be short and concise	13
	(S)User greeting	Adherence to greetings at the start and end of user interaction	16
	(S)Chitchat	Enable further conversations that go beyond the actual application area	6
	(S)Grammatical spelling	Compliance with grammar	2
	(G)Avatar	Visual representation of the CA increases human perception and acceptance of the system	6, 12
Usability	*(P)Privacy*	Confidential treatment of user data and reference to the aggregation of personal information during the dialogue	1
	(PR)Proactive conversation	Sending active messages	4, 9, 15, 16
	(F)Feedback	Continuous feedback for the user during interaction	3, 5, 9
	(H)Robustness	The system should maintain functionality in the event of incorrect or unexpected input	9
Technology	*(SR)Reusability and Scalability*	Scaling and reusability of the system	9

5   Definition of Design Principles

Following the assignment of the 15 described meta-requirements to the respective listed subcategories, these seven design principles were established (Table 3).

DP1 is based on the Sociability subcategory and describes the design of the CA for improved human perception.

DP2 describes the benefits of visual representations of a CA, listed in the Graphical representation subcategory.

DP3 summarizes the privacy subcategory and focuses on the need for the proper handling of sensitive user data.

DP4 is based on the subcategory Proactivity together with the meta-requirements and describes the benefit of proactive actions of a CA.

DP5 includes the functionality of continuous feedback described in the subcategory Feedback.

DP6 is composed of the Error handling subcategory and enables a robust system against incorrect and unexpected input.

DP7 is based on the subcategory Reusability/Scalability and lays the foundation for a holistic system.

Table 4: Definition of design principles

Subcategories	Design principle	Description
Sociability	DP1	Provide the conversational agent with the conversational abilities to act human alike, create a pleasant chat experience
Graphical representation	DP2	Increasing human acceptance through visual presentation
Privacy (PR)	DP3	Enabling the system to handle sensitive data and alert the user to the collection of personal information
Proactivity	DP4	The ability of the system to send active messages and keep the conversation going
Feedback	DP5	Enable continuous feedback on system status and correctness of user inputs
Error handling	DP6	Enabling robustness to erroneous or unexpected inputs.
Reusability/ Scalability	DP7	Enable efficient reuse and scaling of existing systems

6 Discussion

This paper summarises the design principles of data-driven CAs. Fifteen meta-requirements were analysed in the literature. These were then systematized, and seven design principles were declared. The meta-requirements could be grouped into the following three main categories: Humanity, Utility, and Technology. Subcategories were then formed to summarise these meta-requirements and then to form design principles. The subcategories created for this are Sociability, Graphical representation, Privacy, Proactivity, Feedback, Error Handling, Reusability, and Scalability.

This paper presents a set of Design Principles, derived by literature review, which should be considered or implemented in concepts, as well as implementations of future CA.

In future work, these design principles can be evaluated for their feasibility in a wide variety of areas. Following this work, the knowledge gained will be examined in the field of pedagogy, especially in online collaborative learning environments.

A limitation of this work is that only the main categories, subcategories, and requirements have been created and assigned. However, it was always attempted to adhere to the quality criteria. Furthermore, a rapidly growing area was examined in this work. For this reason, it is not possible to be sure that all relevant research areas could be examined. Furthermore, design principles outside of pedagogy were explicitly sought. As a final limitation of this work, problems with the extraction of requirements and design principles can be mentioned. In the literature, these applied Design Principles are often mentioned in subordinate clauses, resulting in an rather implicit description. Thus, it cannot be assured that all implemented design principles have been identified in the literature.

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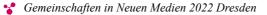
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