Healthcare of the Future
T. Bürkle et al. (Eds.)

doi:10.3233/978-1-61499-961-4-77

Intelligent Conversational Agents in Healthcare: Hype or Hope?

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Abstract. New developments in healthcare require an increased disease self-management of patients. Intelligent digital assistants equipped with a conversational user interface are intended to support patients in this challenging task by providing reminders, answering questions, or supporting in self-monitoring tasks. In this paper, we study the potentials of intelligent conversational agents in healthcare. We realized three systems for three different use cases (patient education, disease management, self anamnesis). Based on these implementations and experiences with usability tests, we performed an analysis of strengths, weaknesses, opportunities and threats (SWOT) using a questionnaire. The results show that conversational agents used in healthcare applications can be helpful. However, they have to be integrated into the healthcare process, supporting also the interaction between the healthcare team and a patient. In order to be attractive for a long-term usage, the scope of operation should autonomously adapt to the current health situation of a patient to provide relevant functionality as needed.

Keywords. Intelligent system, conversational agent, self-management

1. Introduction

Traditional models of care delivery basically base upon face-to-face interactions between clinicians and patients. The paternalistic model where the physician makes decisions for the patient is replaced by a collaborative model [1]. New technologies are augmenting this interaction model and fundamentally transforming the ways in which clinicians deliver care to individuals. The informed patient increasingly asks for applications that support in information gathering and that path the way through the health care system. Conversational user interfaces (CUI) in healthcare gained in interest in the last years, but it is still unclear whether it is just a hype or whether they are really useful. To address this question, we analyze in this paper strengths, weaknesses, opportunities and challenges of CUI towards their future implementation.

CUI or chatbots are programs designed to communicate with a user and to provide or collect information [12]. There are several mobile health applications available that are integrating CUI (e.g. CUI-based symptom checkers Babylon Health, or FlorenceChat). Further, this technology has been used in health related applications to achieve a health behavior change [2]. X2AI (https://www.x2ai.com/) provides mental health care, like cognitive behavioral therapy, in places where people would not

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otherwise have access. Lokman and Zain introduced a chatbot that serves as a virtual dietitian for diabetic patients [3]. The chatbot asks questions and gives at the end a diet advice suitable for the current diabetic situation. The conversation is going along a path that is remembered by the system to consider all answers in the decision making. Only few CUI-based applications have been studied with respect to efficacy in clinical trials [4]. The objective of this paper is to identify challenges and opportunities of CUI in healthcare applications and to come up with a roadmap for the future development.

2. Methods

In previous work, we developed three CUI-based mobile health applications. They are using different technologies and consider various use cases. Given these experiences, the authors did the SWOT analysis.

2.1. SWOT analysis

SWOT analysis is a method to identify strengths, weaknesses, opportunities and threats. The idea of a SWOT analysis originates in strategic management research [13]. Adapting this to chatbots in healthcare, we consider strengths and weaknesses as features of the chatbots themselves, or 'internal' features. Conversely, opportunities include the economic, technical, social, political, legal, and environmental features representing the context within which the chatbots are implemented. We thus consider opportunities to be 'external' features. Threats are, similarly, external features that may prevent the real-world implementation of chatbots in healthcare. To determine the strengths, weaknesses, opportunities and threats of CUI in healthcare, the four persons involved in the development of three applications with CUI described below (eMMA, Ana, CLAIRE) were asked to fill the SWOT analysis questionnaire in Table 1.

Table 1: Questionnaire of the SWOT analysis

Strength	**Weaknesses**
- What is unique about our chatbots? - How skilled are the implemented chatbots? - What are advantages of the systems? - What are the greatest achievements of the three systems and what could be achievements in future?	- What needs to be avoided in the systems and their implementation in practice? - Is the knowledge base of the systems sufficient? - What needs improvement in the chatbots systems? - What disadvantages do the chatbots have?
Opportunities	**Threats**
- What external changes will bring opportunities? - What are the current ongoing trends in the field of medicine? - What is the market missing? Can chatbots provide the missing link to customers? - Are there changes in the field (technology) that are of benefit for the use of healthcare chatbots?	- What are negative aspects in the current market? - Will political instability impact the success of healthcare chatbots? - Is there a change in consumer taste to be recognized and considered? - What are obstacles to be faced when implementing the systems in practice and integrating them in healthcare? - Are there any standards, policies, legislation, government regulations changing that might negatively impact the success of chatbots?

2.2. Conversational agents Ana, eMMA and CLAIRE

The electronic medication management assistant *eMMA* assists a patient in managing his medication via a CUI [5]. The dialogue management is frame-based, i.e. the user is asked questions that enable the system to fill slots in a template in order to perform a task. eMMA provides the following functionalities: 1) reminder, 2) information provision on the current medication including food-drug interactions and information on the relevance of the medication, 3) intake schema of current medication, 4) collection of compliance data, 5) information storage on an eHealth Platform. The current medication is integrated into the app by scanning the barcode on the "eMediplan" [6].

Ana is a mobile self anamnesis application with CUI implemented for the field of music therapy [7]. Self anamnesis is a procedure in which a patient answers questions about the personal medical history without interacting directly with a doctor or medical assistant. Thus, Ana is asking questions on a patient's music biography which forms the basis for a music therapy. Ana's dialogue management is finite state, i.e. the user is taken through a dialogue consisting of a sequence of pre-determined steps or states. The knowledge base was created using the Artificial Intelligence Markup Language (AIML). Ana (1) asks the anamnesis questions and collects responses, (2) provides support when the question is not understandable to the user and (3) asks the user on the wellbeing status during the conversation. Responses in the chat are collected depending on the query by one out of four different formats: free text, two buttons, three buttons, and a 4-level-scale. For encouraging the user to complete the queries, the chatbot posts from time to time motivational statements.

The interactive smartphone application *CLAIRE* is a patient education system. The application combines virtual reality, a chatbot and a voice user interface (VUI). In a virtual environment the user can move freely, interact with objects and talk to the character Claire in order to learn about a specific health topic. CLAIRE uses gamification elements to motivate users [8]. The VUI is intended to establish a human-like conversation with the user. The chatbot is based on Synthetic Intelligence Markup Language (SIML). CLAIRE provides a frame-based dialogue management: it is in its current implementation able to understand questions on donation of personal health data formulated in different ways and by a variety of synonyms. All three systems are task-oriented and enable written or spoken input and output. Table 2 characterizes the three applications.

3. Results

The questionnaire was filled by four persons separately in November 2018. The results are summarized in the following.

3.1. Strengths

Chatbot technology has reached the point to lead a user through a predefined conversation tree. These conversations are suitable for specific tasks in healthcare where it is necessary to collect data from the user or provide information on a specific medical topic. Our three chatbots support in one specific task each (medication management, self anamnesis, patient education). This creates the possibility to

automate data collection (for example regarding symptoms, medical history, compliance) where the bot guides the user, step by step, through the conversation. The chatbot accompanies the patient and can make explanations upon user requests and user needs. In the dialog, a user can be motivated and encouraged with appropriate statements in exercising or measure health parameters etc. The communication establishes a human-like interaction in which a bond of trust is created between them. Users who trust the application are more likely to provide an honest answer if the chatbot asks about symptoms or on compliance regarding medical treatment such as drug consumption. A future system could integrate different scenarios. E.g. the patient first uses the system to make a self anamnesis. After the patient-doctor discussion and diagnosing process, the system gets additional information on the health activities to be supported (e.g. medication self-management, continuous health monitoring), a health goal could be set and specific educational material tailored to the needs of the patient could be provided. One strength is the flexibility regarding implementation and deployment of the chatbot: Our three chatbots are implemented as smartphone applications; CLAIRE could be also used on a desktop computer, facilitating the use together with family members. This enables the developer to tailor the deployment according to the end user preferences. By linking the conversational agents with eHealth technologies such as electronic patient records they can be integrated into the care process.

Table 2. Characterization of the three conversational agents Ana, eMMA and CLAIRE along the criteria of [4]

Criteria	**Ana [7]**	**eMMA [5]**	**CLAIRE**
Type of technology	Mobile device	Mobile device	Mobile device with VR glasses
Dialogue management	Finite state	Frame-based	Frame-based
Dialogue initiative	System	User	User
Input modality	Written / spoken	Written	Spoken
Output modality	Written / spoken	Written	Spoken
Task-oriented	Yes	Yes	Yes
Underlying technology	AIML 2.0	Rivescript 2.0	SIML 1.0
Use case	Self-anamnesis	Monitoring, medication management	Patient education
Year of development and phase	2018, Prototype	2017, Prototype	2018, Prototype
Evaluation	Usability test with 22 healthy subjects	Usability test with 10 healthy subjects	Usability test with 30 healthy subjects

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4.2. Weaknesses

Conversations with chatbots can become exhausting when the system does not understand or too many interactions are necessary. In contrast, when a user is familiar with a common user interface, he might be faster in realizing tasks or in getting information. The interest in interacting with the chatbot can drop over time. To avoid this, the underlying knowledge base has to be comprehensive. Our systems rely upon manually created knowledge bases to ensure that the provided content is reliable. A self-learning system, optionally based on a neural network as offered by OSCOVA[2], would be helpful, but a high quality of content has to be ensured.

Depending on the scope of the bot, the range of possible questions from users will vary. The developer has two options, either set a clear scope of the chatbot and try to lead the users through the conversations. This limits the dynamic in the conversations and the bot risks to be perceived as unintelligent. The other option is to widen the scope

[2] https://oscova.com/

(and thus have a large vocabulary and knowledge base) and let the users steer the conversations, which will increase the complexity of the chatbot as it has to understand a wider range of inputs. However, this can interfere with the core function of the bot and the prediction model will be less accurate. Hence, to create a robust chatbot the developer need to cover a wide range of expressions of the same intents to ensure the chatbot's precision. This phenomenon could also create another issue, that the chatbot understands the user, but replies using a different vocabulary than the one of the user.

4.3. Opportunities

Numerous functionalities can be added into conversational agents which creates flexibility. Tailored functions (reading QR code, accessing eHealth platform, retrieving data) can be triggered by actions from the chatbot to react to input from the users. Repetitive tasks like anamnesis collection, or patient education can be supported by the system and in this way support patient-doctor consultations: physicians can concentrate on the verification of the collected data, its analysis and interpretation. The development of eHealth infrastructures in different countries and the digitalization in healthcare offers the opportunity to combine mobile applications and to share data when needed. Not only can an eHealth system help chatbots and other healthcare apps to be successful. Those apps can encourage the user to use an electronic health record [11]. The demand on mobile applications to manage health data is increasing since other managing tasks can already be realized efficiently in mobile applications (e.g. eBanking). Current trends in healthcare target at connecting stakeholders, enabling interoperability. The healthcare market is missing simple and sustainable applications that can be used over a long period of time while staying interesting for the user and still provide benefits. Chatbots could address this issue, but would have to adapt functionalities and content over time, to fit with the changing health situation of a user and stay interesting. The increased interest in HL7/FHIR offers the possibility to consider standards in chatbots, which in turn contributes to interoperability. A future goal has to be to develop more intelligent conversational agents. Potentially, conversations with chatbots should come closer to those with real persons. This would allow patients to interact much more naturally with chatbots, e.g. based on a voice user interface. As a result, conversation barriers can be minimized and the acceptance of this technology significantly increased. Therefore, chatbots could become conversational assistants to support patients in a major part of the interdisciplinary treatment pathway.

4.4. Threats

Adopting conversational agents in healthcare can affect the patient-doctor relationship which relies on trust and the face-to-face conversation. A challenge is to get users interested in CUI-based healthcare applications, since several healthcare app are already on the market. While CUI-based applications are interesting at the beginning, they have to provide also benefits over time to compete other apps. Our applications depend on third party services such as Google Speech to Text within CLAIRE or the medication knowledge base integrated into eMMA. The quality of external services can threat the success of the systems. The healthcare domain is massively influenced by politics. When chatbot technology is claimed either by politicians or by physicians to be useless, inefficient, insecure etc. the technology will not be implemented comprehensively. There are several regulations that need to be

considered: data protection regulations, medical device regulations on a national and EU level, recommendations of the ministry of health etc. An integration with other healthcare IT systems is indispensable.

5. Conclusion

There are many use cases, where conversational agents are useful in healthcare. It can be assumed that they will play a leading role by embodying the function of a virtual assistant and bridging the gap between patients and clinicians [9]. The technical possibilities are still improving given the developments of artificial intelligence methods [10]. A substantial benefit is that in contrast to standard user interfaces, conversations can be tailored to the particular needs of a patient and to his health literacy. Finally, through communication, satisfaction and adherence to treatment regimens could be increased. Success story WeChat (www.wechat.com/en), a very popular Chines mobile application, points into a direction where CUI-based healthcare application should move in future. WeChat integrates instant messaging with a broad range of functionalities (ordering food, pay bills, search for jobs and people, book appointments with physician, play games…). Transferred to healthcare and considering the results of the SWOT analysis as well as from usability tests with the apps, the future roadmap should be: Limit the complexity of the conversations to interactions that are safe to be performed by a digital assistant. Possible tasks are scheduling appointments based on severity of symptoms, monitoring health status, reminding, and notifying nurses when parameters run out of control, offering comfort and support until the next appointment with the doctor. Further, we should not miss to integrate the systems into the care process which requires integration with eHealth and IT healthcare systems.

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