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Designing Healthcare Relational Agents: A Conceptual Framework with User-Centered Design Guidelines

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***Abstract*—This paper presents a conceptual framework for designing relational agents (RAs) in healthcare contexts, developed through the findings from multiple user studies on RAs about their acceptance, efficacy, and usability. The framework emphasizes a user-centered design (UCD) approach that takes into account the unique needs and preferences of patients, non-patient users, and healthcare professionals (HCPs). Based on the results of these studies, we analyzed and refined the RA designs and proposed a UCD-based conceptual framework for designing effective and user-friendly healthcare RAs. The paper aims to provide an initial resource for researchers, designers, and developers interested in developing RAs for healthcare contexts by thinking of UCD techniques.**

***Index Terms*—framework, healthcare, relational agent, user-centered design**

I. Introduction

The use of technology in healthcare has been increasing rapidly, with the development of various applications that can aid in the delivery of healthcare services. One of the latest developments in this field is the use of relational agents (RAs), which are computer programs designed to interact with humans in a way that simulates interpersonal communication. RAs have shown potential for use in healthcare, particularly in improving patient engagement, self-care management, and mental health. However, designing effective RAs for healthcare requires a user-centered approach that takes into account the unique needs and preferences of stakeholders in the loop, i.e., patients, caregivers, and healthcare providers.

This paper presents a conceptual framework for the design of healthcare RAs that includes user-centered guidelines that emphasize the importance of understanding the user's context, preferences, and communication style in the design process. It provides a detailed description of the framework and guidelines, along with examples of their application in the design of healthcare RAs. The aim of the paper is to provide a resource for researchers, designers, and healthcare professionals (HCPs) who are interested in developing effective and user-friendly healthcare RAs.

II. Methodology

In designing RAs for healthcare contexts utilizing UCD approaches, there is an importance of creating designs that are tailored to the needs, preferences, and expectations of users. The first stage involved designing multiple RAs that targeted various healthcare service scenarios [1]–[3]. Each of these designs was created to support specific healthcare services and tasks, and the user interface (UI) was designed to be intuitive and easy to use. To gather feedback on the initial RA designs, multiple user studies [1]–[3] were conducted, which involved a diverse range of users including HCPs, patients, and non-patient users. These studies included usability testing, surveys, and interviews, and aimed to collect feedback on the acceptance, efficacy, and willingness to use of the RAs.

Based on the feedback collected from the user studies, we analyzed the results to identify areas for improvement in the RA designs. This involved making changes to the UI to improve usability, refining the functionality of the RAs to better meet the needs of users, and addressing any concerns or barriers to adoption that were identified during the user studies. Drawing upon our experience spanning from the initial phases of collecting design requirements to the final stages of evaluating the performance of the RAs, we have devised a UCD-oriented conceptual framework that will serve as a valuable guide for the developers when conceiving RAs.

III. Conceptual Framework

A. Establishing the Goal

The initial phase in the design process and the basis that would direct the design of the RA is a precisely defined goal. This process includes the following four interconnected aspects to take into account.

1) Defining the Objective: The target RA's objective must be established before the main design process can begin and it must be clearly stated so that both designers and developers understand why the RA is being built. The objective may be either short-term, long-term, or a combination of both. Specific tasks that must be finished in order to achieve short-term goals

are known as short-term objectives. Large accomplishments that you aim to attain over the course of several weeks or years are long-term objectives.

A consequence that has to be finished right away once the interaction with the RA is over, such as explaining hospital discharge information to patients, is referred to as a short-term objective [4]. On the other hand, a long-term objective would require multiple interactions between the RA and its users over a period of time to be fulfilled the target goal, such as reducing substance misuse in the general population [5].

2) Identifying Target Users: Identifying appropriate target users is crucial for designing a successful RA for the healthcare context. User personas can play a vital role in understanding the target users. Target users are those who will actually be benefited from the RA. A preliminary evaluation should determine if the RA will be made available to healthy users, those with a particular medical condition, or both groups of users. Moreover, it should also be identified if the RA is going to be used by caregivers, or HCPs as a supporting tool.

It is crucial to create a complete and precise portrait of the target users. Some factors should be taken into account while generating the profile or portrait of the target users, such as gender, race, age group, socioeconomic and sociotechnical concerns, cultural attitudes, technological and health literacy, and access to smart devices. Additionally, the profile of the target users must be thoroughly understood and validated with the aid of domain experts or relevant HCPs who have expertise in those areas if the RA in design targets to serve healthcare contexts where risk is associated with the health condition of the patients or target users.

3) Assessing Needs of Target Users: When the objective is defined and the target users are portrayed, the next essential stage is assessing the needs of target users, i.e., what the users expect from the RA is being designed and developed. Identifying and assessing needs is crucial since the needs define the features that the target RA will provide. An extensive requirements analysis should be conducted at the beginning of the need assessment to identify any gaps available in the state-of-the-art that might be filled by the target RA.

Target users are crucial in the UCD cycle for defining and determining user needs. User studies, focus groups, workshops, and other methods can be used to involve the target consumers in the design process and need assessment. A user assessment of an existing, comparable type of RA can also highlight any gaps and needs when the evaluation's results indicate that the user's expectations were not satisfied. In healthcare contexts, the caregivers or HCPs who served relevant patients can also define target users' or patients' needs since they have experienced the conditions of the patients.

4) Appearance of the RA: Users must form a positive view of the RA in order to build trust and a connection with it. The visual appearance of an RA is an important factor to be considered while designing. RAs embodied with a human-like character or avatar gained a more positive impression than nonembodied RAs in several healthcare contexts [6]–[8]. However, the embodiment of the RA must be selected depending on the users' needs and the RA's objective. Based on the target objective and health contexts, RAs can either be embodied or nonembodied.

B. Maintaining Design Principles

A set of factors called design principles serves as the foundation of any high-quality product. Maintaining these principles aid in defining user behavior in general, independent of the context. Based on the findings from our user studies, the following design principles should be maintained during the designing of RAs for healthcare contexts.

- RA is required to be knowledgeable about what its users are looking for depending on users' health conditions.
- RA has to ensure a goal-oriented and domain-specific conversation flow based on the user's current health condition and has an appropriate personality for the user.
- RA has access to interact with a range of input and output devices for interaction with its users so that it can adjust to user preferences and effectively interact through multimodal UIs where possible.
- RA should have the capacity to capture users' vital physiological data to analyze and offer personalized recommendations about the current state of health.

C. Defining Requirements

High-quality, comprehensive specifications aid in reducing financial risks and maintaining the project's timeline. The specifications for the functionalities of the product (the RA) are known as functional requirements (features). Functional requirements, to put it simply, specify what precisely a piece of the product must accomplish and how the system must react to inputs. Non-functional requirements specify how the system will perform this function, whereas functional requirements specify the system's core behavior. However, based on the analysis of the user expectations and literature in this work, in general, the target RA should have the following functional and non-functional requirements.

1) Functional Requirements:

- RA must have the ability to respond to the user messages immediately with rich content, such as buttons, utterances, and graphics.
- RA is capable to switch different contexts based on the user's demand.
- RA must have the ability to re-establish an interaction with the user if it is dropped or out of context.
- RA must keep a log of the interaction in a dedicated space, such as a database.
- RA should comprehend and manage small conversations and chitchat and refer to appropriate intent accordingly.
- RA should be able to recommend relevant contents that are appropriate to the current interaction context besides responding to the user's message.

2) Non-functional Requirements:

- A answer to a user's query or response to a message should arrive in a convenient time frame and it should not take an excessive amount of time.

- Users should be allowed to take frequent breaks from the interaction they are functioning on without interfering with the flow of interaction or conversation.
- Unless the user grants consent, the RA should collect user data by maintaining anonymity.
- Transcripts of conversations between the RA and the user must be secured against unwanted access.

D. Designing Appropriate Use Cases, Interaction Scenarios, and Conversation Sets

For successful interactions between an RA and its users, appropriate interaction scenarios need to be explored. Interaction scenarios can be developed by designing use cases of the RA for the target healthcare contexts. User studies with target users and domain experts or HCPs can refine the use cases and aid in developing interaction scenarios and conversations. It is first important to establish the topics around which the RA's dialogues should be structured to support target user personas in order to develop acceptable dialogue sets for the target RA to interact with the users. Conversation sets that target healthcare context should be validated by the domain experts who served the relevant patients and by the patients who have gone through that health context. Also, behavior change techniques and motivational interviewing techniques can be adopted for designing conversation sets for the RAs that are developed as any health behavior change intervention.

E. Defining RA's Identity

Users' interactions with RAs seem to be strengthened when they demonstrate a particular, enthusiastic, and caring personality [9], [10]. A human-like simulation with realistic characteristics, such as name, attire, personality, and speaking tone may enhance satisfaction among users. An appropriate identity of the target RA can establish a relational attitude towards the users and it may lead to greater user satisfaction.

1) Name, Attire, and Cultural Tailoring: For facilitating human-like face-to-face interaction between the RA and its users, the name of the RA may play a significant role. It is more realistic if the RA has a name and the users can call the RA by name. The name should reflect friendliness and can be pronounced easily.

RA's clothing should be carefully chosen so that it results in a realistic identity. If the target RA is embodied then the attire of the RA should be considered depending on the RA's objective and role. For instance, if a RA is intended to play the role of an HCP who assists patients in the diagnosis of a COVID-19 infection, the RA should appear professionally (virtually dressed in a medical apron).

For particularly specialized user demographics with different views, attitudes, languages, and cultural norms, RAs should be designed according to the demand of that communities. Inappropriate appearance may affect in experiencing poorer happiness, engagement, and use [11]. Culturally tailored RA will enable the target user community to accept the RA to a greater extent. Cultural tailoring can be conducted on several factors, such as race, language, religion, and social beliefs. In general, RA's conversation that *"recognizes and promotes a group's cultural values, beliefs, and behaviors and built upon those to offer context and meaning to the message regarding a certain health condition or behavior"* is considered to be culturally tailored [12].

2) Language, Tone, Verbal, and Non-verbal Cues: For a successful implementation of relational behavior, both verbal and non-verbal cues contribute essentially. Embodied with non-verbal cues such as options with pre-loaded utterances, hand gestures, eye blinking, lip syncing, etc. boost the efficacy of the RA besides its verbal communication. Non-verbal cues impact the engagement with the RA positively and it leads to feeling the interaction more realistic to the users or patients.

RA's language should be selected based on the demographics of target users and user needs. The RA needs to be designed in the native language of the target population except for the target users' demand for a specific language. RA should be able to express empathy during the conversation based on the user's health condition. RA's speeches should be short but understandable with ease by the users. The tone of the RA should be human-like with proper accents. The RA should constantly keep the conversation's volume and pace constant.

F. Interaction Delivery

1) Interaction Modalities: Multimodal interactions can enable the RA to achieve more attention from the target users and interactions may include voice input, buttons with options or short utterances, visuals, touch interface, gesture and gaze recognition, etc. Based on the preferred delivery platforms, the interaction modalities can be varied among the RAs.

2) Delivery Platforms: From our user studies, the majority of the participants preferred to have RAs on their smartphones or tablet computers. Many wanted to use the RAs on their laptops, voice assistants, and smartwatches. However, some delivery platforms have complexities in delivering RA's outputs. For example, the voice assistants can not show the RA's visual embodiment. Based on the user's needs, the delivery platform for the RA should be considered. Another efficient approach to consider is designing the RA as a web-based service so that it can be accessed from multiple platforms having capacities with a web browser. If the target RA is designed for a rural community having insufficient Internet connectivity, the RA should be designed and developed as standalone software or application.

3) Autonomy and Incorporating Peer Support: State-of-the-art presents that RAs can either be automatic, manual, or semi-automatic in terms of delivering interactions. For automatic RAs, the RA itself can identify the topics from the user inputs and respond automatically without any human assistance. On the other hand, manual RAs are fully dependent on human assistance where a peer or administrator controls what RA will deliver to its user. Semi-automatic RAs are mainly automatic RAs but sometimes they can be assisted by a human.

G. Trust Building Mechanisms, Security, and Privacy

RA's attitude toward the users is vital to the successful delivery of healthcare services. The RA's conversation is

the first element in building trust. Social dialogues based on the social psychology theory increase RAs' capacity for trustworthiness [13]. Also, providing accurate guidance and information about the target health context is another aspect of building trust. Goal-oriented conversations make the interaction more effective and by achieving those goals, the users can earn faith in the RA. Therefore, the RA should set such goals that are realistically possible for the user to accomplish.

Moreover, the privacy of the users and the security of their personal data is also crucial for accepting and relying on RAs [14]. The RAs must comply with the specific user data privacy and security laws according to the countries or regions. Healthcare data is classified as sensitive and confidential information that must always be secured and should only be disclosed to the user and appropriate authority on demand, e.g., HCPs those who care for the corresponding patients. Due to the sensitivity and confidentiality of the users' personal and health data, the collected data by the RAs must be stored with high-level encryption in secured databases. The data privacy statement should be disclosed to the users by the RAs at the very beginning of their interactions.

IV. Strengths and Limitations

The proposed conceptual framework is comprehensive, systematic, and considers various factors crucial for designing successful RAs for healthcare contexts. It provides a solid foundation for the design process and ensures that the RA's design decisions are aligned with the intended goals and users' needs. The framework enhances understanding of the various components of RA design, including purpose, functions, and features. It emphasizes the importance of the RA's appearance and communication style which ensures that the agent is perceived as trustworthy and credible by the users. Moreover, it provides clear guidelines that help to concentrate efforts on relevant aspects of RA design to achieve effectiveness. It promotes standardization in the design process to avoid oversight of crucial elements and ensure consistency with best practices. In terms of scalability, the framework is applicable to a broad range of healthcare contexts and populations, making it a valuable tool for practitioners and researchers.

However, it includes some limitations besides its strengths. Although the framework is based on user studies, there may be a lack of empirical evidence to support the effectiveness of certain design choices. Therefore, it is important to continuously refine and update the framework based on new research and user feedback.

V. Conclusions and Future Directions

RAs have shown great promise in improving healthcare services, particularly patient engagement, self-care management, and mental health. However, designing effective RAs for healthcare requires a UCD approach that takes into account the unique needs and preferences of stakeholders. This paper presented a framework that emphasizes the importance of understanding the user's context, preferences, and communication style in design of RAs. The framework was developed based on multiple user studies and feedback from HCPs, patients, and non-patient users. The proposed framework can serve as a valuable guide for researchers, designers, and HCPs in developing effective and user-friendly healthcare RAs.

Future implications of this research include the continued development and refinement of the proposed conceptual framework to address the dynamic nature of healthcare contexts and the evolving needs of users. Additionally, there is a need for further empirical research to validate the effectiveness of specific design choices and the impact of healthcare RAs on patient outcomes. Finally, the integration of healthcare RAs into existing healthcare systems and workflows remains a challenge that requires further investigation and development.

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