User Interface Design for AI-Based Clinical Decision-Support System

Preliminary Study

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***Abstract* — This paper presents a case study about the initial phases of the interface design for an artificial intelligence-based decision-support system for clinical diagnosis. The study presents challenges and opportunities in implementing a human-centered design (HCD) approach during the early stages of the software development of a complex system. These methods are commonly adopted to ensure that the systems are designed based on users' needs. For this project, they are also used to investigate the users' potential trust issues and ensure the creation of a trustworthy platform. However, the project stage and heterogeneity of the teams can pose obstacles to their implementation. The results of the implementation of HCD methods have shown to be effective and informed the creation of low fidelity prototypes. The outcomes of this process can assist other designers, developers, and researchers in creating trustworthy AI solutions.**

Keywords - human-centered design; decision support systems; design for trust

I. INTRODUCTION

Artificial intelligence-based (AI) solutions have gained space in nearly every segment of society for the past decade. Despite the generalization of the term, these systems vary significantly in their goals, functioning and risk posed to the users. For instance, the European Commission proposal for AI regulation [1] categorizes AI technologies according to their risk, from 'minimal' to 'unacceptable'. Based on it, systems that pose a higher risk should be subjected to stricter regulations to ensure safety. Accordingly, from the users' perspective, these systems should also adopt strict and transparent processes in their development to be trusted, a key factor for their adoption and long-term usage [2][3].

The medical sector has seen benefits from using AI-based tools for diagnosis and, in general, as decision-support systems. However, the nature of the activity brings two major challenges: first, from the system development perspective, as it requires large amounts of medical data while following strict privacy regulations and preventing any bias, and the need for expertise from professionals from different fields to establish and assess the quality of the outcomes.

Second, apart from being successfully developed, these systems need to be adopted by their target, mainly clinicians and clinical researchers. Such specialized audiences have their concerns, from which two can be highlighted: the effectiveness of the tool and how its adoption will affect their current practice. Trust, in this case, becomes crucial.

This study presents the approach adopted for the initial phases of the user interface (UI) design of an AI-based decision-support system for clinical decisions, AI-Mind. The project aims to develop an AI-based system for assessing the risk of developing dementia in patients with mild cognitive impairment (MCI), reducing the time for diagnosis and enabling earlier intervention. Upon completion, it is expected that the system will be able to analyze multimodal data, including electroencephalogram (EEG) input, to assist clinicians and clinical researchers in the diagnosis procedures.

Due to the project's complexity, a plural team is involved to ensure that all aspects of development and usage of the tool are covered. Besides the multiplicity of specializations (e.g., neuroscientists, researchers, software developers, machine learning specialists, healthcare management specialists), the outcome needs to fulfill research and industry requirements. While this broad scope is essential for the quality of the final tool, it can pose challenges for the conciliation of internal processes.

II. OBJECTIVES

The current study unfolds during the early stages of the UI design for AI-Mind. It presents the procedures adopted for the development of UCD methods, namely (1) personas, (2) scenarios of use, and (3) journey maps. These methods are commonly adopted in HCD processes to ensure that the systems are designed based on users' needs; In this project, in addition, they aim to prevent potential trust issues by ensuring that the users' and stakeholders' concerns are adequately addressed. Additionally, they were used guide the development of the prototypes, a crucial phase in the development of the interface.

This study aims to present practical suggestions for adopting UCD methods in similar, heterogeneous projects and thus collaborate with other researchers and practitioners. In the face of the challenges posed by the heterogeneity of the teams' views and the uncertainty of the project's early phase, the authors had to explore alternatives to the usual approaches adopted for these methods. This article presents the results of the first out of a five years project. The following sections

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present the methods used, the challenges faced, and the strategies adopted to overcome them.

III. HCD METHODS

Human-centered design (HCD) refers to an approach to system design that places the users' needs at the center of the process, considering capabilities and psychological characteristics and involving them in the design process [4].

HCD overlaps with user-centered design (HCD) in relying on an iterative process to understand users and their context throughout the design and development process but emphasizes the fact that the user is not a generic figure but a human who can commit errors and whom the system can collaborate with. Such an approach is essential in developing the referred system, which addresses specialized users in a critical task.

Personas, scenarios and journey maps are artifacts commonly used in HCD to help teams in reaching a common understanding about the users and keep them at the center of the design.

A. Data Collection and Analysis

The development of the artifacts happened in two iterations, which included semi-structured interviews with users and stakeholders, data analysis, and the development or improvement of the design artifacts.

The interviews were conducted by one interviewer and at least one observer. Next, the interview data were analyzed using affinity maps. This method is inspired by the KJ technique [5], used for collaboratively analyzing qualitative data.

For the construction of the affinity map, two researchers analyzed the data collected from the interviews with clinical researchers. The conclusions were used to develop the initial artifacts in the first iteration and review them in the second.

The main challenge for the data collection and analysis was the conciliation of various views on the development of the system. Due to the different specializations composing the team, there are different interpretations of tasks due to the variation of the meaning of certain concepts across fields.

Besides, the large amount of data collected in the interviews required an extensive amount of time for interpretation and several iterations for grouping and regrouping findings. Nevertheless, the adoption of affinity mapping showed to be adequate, as it is less time consuming than other methods for qualitative data interpretation (i.e. thematic analysis) while allowing collaborative work and generating sound results.

B. Personas

User personas are a tool for Human-Centered Design (HCD) processes, defined as "hypothetical archetypes of actual users" [6]. The tool provides designers and other professionals with a clear description of the user and their goals, ensuring coherence to the design process.

The personas were developed from a role-based perspective [7] using a data-driven approach [8]. The process involved two iterations of data collection, artifact development, and internal validation with partners and potential end-users.

The outcome of this process is a total of three personas, being one primary persona and two secondary personas. Additionally, a 'personas constellation' was created to facilitate the understanding of their roles and relationships.

The main difficulty for the development of this artifact was the uncertainty regarding the outcomes inherent to the initial phases of large-scale projects. Although strategical decisions are taken at the project level, they are still vague in terms of 'personas'. The goal is to provide a clear depiction of a typical user, which in this case depends on results yet to be reached.

The solution, in such a case, comes in different steps. First, it comes to the researchers (and in this case, also designers) to interpret the existing data and draw the most accurate possible conclusions. Next, it is also essential to validate the artifacts across teams and incorporate the feedback. Finally, it is necessary to have a shared understanding that these personas will be revisited throughout AI-Mind development. They are thus dynamic and not static.

C. Scenarios of use

Scenarios are abstract stories that depict the users' interactions with the system, describing needs, context, and workflow. They can be used in different phases of the design process and serve different purposes. Regardless of the purpose, their simplicity also serves as a vehicle of communication between different teams and stakeholders, fostering cooperative effort [9].

Although scenarios are common in design processes, fields such as software engineering adopt other methods to explore how users will interact with the tools. A common method is Use-Cases, a systematic description of the user's steps that allow gathering the system requirements [10] and thus developing the system. It is noteworthy that within Use Cases, Scenarios have a different connotation: they refer to a specific flow followed by the user (i.e., main flow or alternative flow), presented step-by-step.

Another method adopted both in software development and in human-centered design are User Stories, short descriptions of features, usually following a set form of "As a <role>, I want <goal/desire>". Although there are some similarities between Use-Cases and User Stories, they are not interchangeable. They both describe goals, but they serve different purposes; User Stories are centered on the result and the benefit of the thing one is describing, whereas Use Cases can be more granular and describe how the system will act.

In this project, the Scenarios are meant to explore the design ideas from the users' point of view and help designers and developers to maintain focus on specific contexts and discuss different solutions [7]. The extensive discussion over this topic emphasizes obstacles regarding the terminology in teams with different specialties. On the other hand, Use-Cases were used to collect requirements and develop the system architecture.

In addition, both tasks had converging timelines, and due to the limited availability of (prospect) users, a single round of data collection was undertaken to inform both outcomes. Although challenging some interview principles, cooperative arrangements allowed the exploration of both topics: the users

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were first presented with stimuli about the system; Next, they were prompted to describe the steps they expected to follow in interaction, providing information for the Use-Cases. Finally, the researchers conducted a semi-structured interview to explore the context of system use further, complementing the information to create the Scenarios.

D. Journey maps

Journey Maps offer a timeline visualization of the user actions in a specific scenario and his/her mindsets, generating insights about the interactions with the system [11]. Besides complementing the personas and scenarios of use, journey maps ensure that the complete interaction between user and system is considered and help designers foresee users' emotional states and identify gaps and opportunities to be addressed [12].

Users' journey maps were developed only after the second iteration, for AI-Mind main and secondary personas. This artifact has a more detailed nature and thus required two rounds of data collection; Still, it was challenging to foresee the users' emotional states. On the other hand, mapping the touchpoints for each step of the interaction proved to be especially useful for guiding the development of the prototypes.

As the journey maps constitute the last of three user modelling artifacts developed in this project, the researchers had already a clearer understanding of the topic and generally about the interaction. Creating a journey map is an intuitive last step in the user modelling process, as it consolidates the user research findings. The data collected during the combined interview collecting requirements and understanding of the context was sufficient for the maps' development. The collaborative effort between the researchers showed to be essential for an accurate outcome.

E. Validation

Validation is a fundamental step of HCD methods. It usually includes testing the assumptions of real users, who can then help designers identify flaws and reassure the accuracy of the artifacts. However, in larger projects, before involving users, it is essential to ensure an internal agreement about the designers' assumptions.

In this AI-Mind, all the artifacts were developed based on research and the validation included members of other teams. However, it is problematic to assume a pre-existing shared understanding about users [7]. A way to overcome this concern is validating the artifacts internally.

Although validation is a recurrent topic in HCD, there is a lack of established instruments or procedures to do so with user modelling artifacts [13]. Alternatively, practitioners develop their procedures according to the goals of the validation.

The validation happened internally due to the project's stage and its goal: reaching a shared understanding of the end-users. It included members from software development, general management and direction, as they are directly involved in the process and are key for acceptance across other teams. Still, because, in general, the project includes (prospect) users in the team, these were also included in the validation.

The feedback provided was valuable for the artifacts and crucial for a more widespread understanding of the users, their needs and expectations, and thus a more human-centered system.

F. Prototype Development

The low fidelity prototype was developed after the validation of the user-modeling artifacts. The overall structure of the interface was first based on benchmarking similar systems. However, the references are scarce due to the novelty of the project in question and UI patterns are not always clear.

The developed artifacts were essential in this case, as they allowed the designers to foresee the interaction flow and tasks, and thus create the prototype. In this case, in which both the system and its users fall into particular categories, a HCD approach is necessary to overcome the lack of existing information.

The low-fidelity prototype is currently in its concept validation phase, and should, together with the other artifacts, inform the creation of the high-fidelity prototype.

IV. Key Lessons

The initial steps of user interface design for an AI-based clinical decision-support system showed the importance of adopting a human-centered approach to develop such systems. In the case of projects in which the outcome is by nature a complex system that implies considerable risks for users, stakeholders and users, there is a great emphasis on the effectiveness of the final product, that is, on its performance. Thus, much of the efforts are directed towards technical aspects.

Clinical decision-support systems can lead to changes in clinicians and researchers' practice, and as such, they need to ensure these professionals have enough control and understanding of the tools. They support adoption and use and, in this case, are also essential for fomenting trust. Nevertheless, other factors related to the interaction between the system and users are just as important.

As pointed out by [14], reliable, safe and trustworthy technology can offer high levels of computer automation and human control. In this case, however, control does not refer only to available mechanisms but also to providing users with adequate tools and enough understanding of the system functioning. This outcome can be achieved through good design decisions.

Most obstacles result from different interpretations of concepts or processes, which is expected due to the varied specializations involved. Such findings reinforce the need to adopt the methods mentioned earlier to ensure internal coherence. Besides, this obstacle was easily overcome by actively communicating with members and pursuing conciliatory solutions.

When it comes to the steps adopted in the project, they have achieved the expected results. Team members have a shared understanding of the users and acknowledge that the artifacts may have to be revisited during the project's development.

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V. Future Work

Within this project's scope, further assessment of the low-fidelity prototype is necessary to validate its structure. This assessment will happen internally, first with team members representative of users to assess the prototype adequacy to their needs, and then with technical teams to evaluate its feasibility. Such assessments and the procedures adopted for the development of the high-fidelity prototype can result in further studies about the opportunities and drawbacks of the procedures in later phases of the UI design, as well as the results of trust assessments.

From a broader perspective, more studies are needed to present practical applications of HCD methods to develop AI-based technologies. These systems are usually more complex, and thus the usage of existing methodologies often requires adjustments from the designers. Still, despite the vertiginous growth in this kind of application, there is a lack of literature on the topic.

VI. Conclusions

The process described shows how HCD methods could contribute to the user interface design of ai-based clinical decision-support systems. Although focusing on developing a specific tool, it aims to contribute to other categories of AI-based systems used in moderate and high-risk settings.

Although this article presents only partial outcomes, it is the result of several iterations, and the findings indicate that the method followed is adequate and leads to satisfactory results. It is an indication that similar approaches can be helpful for other practitioners in the community.

VII. Acknowledgement

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References

[1] European Commission. "Proposal for a Regulation Of The European Parliament And Of The Council Laying Down Harmonised Rules On Artificial Intelligence (Artificial Intelligence Act) And Amending Certain Union Legislative". 2020. Retrieved December 02, 2021, from https://ec.europa.eu/newsroom/dae/redirection/document/75788.

[2] Li, X., Hess, T. J., & Valacich, J. S. "Why do we trust new technology? A study of initial trust formation with organizational information systems". The Journal of Strategic Information Systems, 17(1), 2008, 39-71.

[3] Kassim, E.S., Jailani, S.F.A.K., Hairuddin, H., Zamzuri, N.H. "Information system acceptance and user satisfaction: the mediating role of trust". Procedia Soc. Behav. Sci. 57, 2012, 412–418

[4] Norman, D. "The design of everyday things: Revised and expanded edition". Basic books, 2013.

[5] Scupin, R. "The KJ method: A technique for analyzing data derived from Japanese ethnology". Human organization, 56(2), 1997, 233-237

[6] Cooper, A. "The inmates are running the asylum". Sams - Pearson Education, Indianapolis, 2004.

[7] Nielsen, L. Personas-user focused design. London: Springer, 2013.

[8] Pruitt, J. & Adlin, T. "The Persona Lifecycle: Keeping People in Mind Throughout Product Design". Morgan Kaufmann, 2006.

[9] Bødker, S. "Scenarios in user-centred design-setting the stage for reflection and action". In Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers (pp. 11-pp). IEEE.

[10] Kulak, D., & Guiney, E. "Use cases: requirements in context". Addison-Wesley. 2012

[11] Gibbons, S. "Journey Mapping 101". Nielsen Norman Group. 2018. Retrieved December 14, 2021, from https://www.nngroup.com/articles/journey-mapping-101/

[12] Howard, T. "Journey mapping: A brief overview". Communication Design Quarterly Review, 2(3), 2014, 10-13.

[13] Salminen, J., Kwak, H., Santos, J. M., Jung, S. G., An, J., & Jansen, B. J. "Persona perception scale: developing and validating an instrument for human-like representations of data". In Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems 2018, (pp. 1-6).

[14] Shneiderman, B. "Human-centered artificial intelligence: Reliable, safe & trustworthy". International Journal of Human–Computer Interaction, 2020, 36(6), 495-504.

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