Design of an Integrative System for Configurable Exergames Targeting the Senior Population

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Abstract. Physical activity plays a key role in the prevention and delay of health problems associated with sedentarism in the senior population. Configurable exergames that can be adapted to fit different needs have been proposed to address this issue because they are fun and enjoyable while promoting physical exercise. This paper describes the design process of an integrative system for Exergaming targeting the senior population that combines human-centred and software engineering methods. An initial requirements elicitation was carried out involving 12 health professionals. This resulted in a list of 110 design requirements, such as customization of games and activities, visualization of historical data, management of plans and sessions, and automatic recommendation of games. The software design was developed using the Unified Modelling Language (UML). Finally, we present two iterations with human-centred techniques, namely, card sorting and paper prototype evaluations, which will serve as basis for future implementations.

Keywords: Human-centred design · Integrative system engineering
Human computer interaction · Design for health professionals
Exergaming system

1 Introduction

Exercise videogames (Exergames) use physical activity as interface to foster enjoyment while working out [1]. Configurable bespoke exergames have been proposed as a solution for promoting physical activity among the senior population since its commercially-available counterparts raise many concerns, such as colorful and visually busy game interactions, unsuitable music, not being based on basic exercise principles, and demanding navigation through the user interface [2]. Exergames have been used in nursing homes and rehabilitation centers with similar or better effects compared to traditional forms of exercise [2]. However, configuration of these systems can be

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difficult and time consuming when faced with complex and a large amount of parameter choices. Previous research has focused on the design process and evaluation of the effects of exergames targeting the senior population [3, 4]. Despite its importance and significant evidence of effectiveness, the success and acceptance of such systems is highly dependent on the adoption by health professionals and caregivers [5]. Due to the negative impact that bad interfaces might have on user experience while interacting with configurable exergaming systems, a carefully designed interface that follows human-centered design guidelines is essential for technology adoption [5]. In this paper we propose an integrative platform which can aggregate independent exergames that are controlled by a common user interface (UI). The system will be able to incorporate data from physical and cognitive assessments from users to provide decision support on the creation of training/rehabilitation plans adapted for each end-user profile. The system will also be able to manage data that will be hosted both locally and in a cloud database to enable visualizing the historical progress of end-users and promoting ubiquitous access to data. Here, we describe the steps carried out to design the integrative system that involved the main prospective end-users of the configurable UI, namely health and sports professionals.

2 Procedure

Our methodology is structured in stages using techniques commonly found in the fields of systems engineering, human computer interaction, and action research. The output of each stage served as input for the subsequent ones (Fig. 1). The following subsections describe the steps carried out along the system design process.

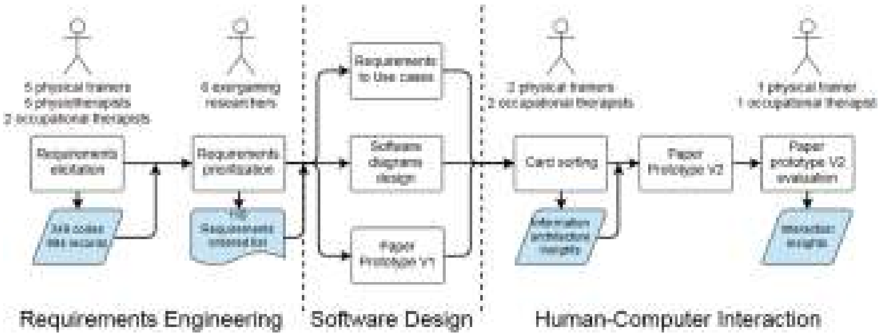

Fig. 1. Diagram showing the different design processes and participants involved.

2.1 Requirements Engineering

Literature supports that requirements engineering (RE) is a crucial step on the development cycle of a software system [6, 7], which helps to understand the user needs and therefore, assisting on designing a system towards its effectiveness.

2.1.1 Interviews with Health Professionals

For requirements elicitation we have chosen a conversational method, under the form of semi-structured interviews. 12 participants were invited to collaborate in the initial process of requirements elicitation: 5 physiotherapists, 2 occupational therapists, and 5 physical training instructors, with average age of 28.9 ± 5.4, and 5.6 ± 4.7 years of professional experience. Interviews were carefully planned to cover most of the topics that could help understanding the needs of the professionals. Questions included categories such as: (i) knowledge and opinions about similar systems, (ii) positive and negative aspects about these type of interactive systems, (iii) daily practices in terms of rehabilitation therapies and exercise prescription, (iv) expectations of the integration of this system including data visualization, technical assistance, concerns, and constraints. Qualitative data was collected under the form of written notes and audio files recorded along the interviews. Raw data was coded using the qualitive data analysis tool MAXQDA[1], resulting in 349 distinct codes with 994 records in all files. A code could correspond to a feature, a suggestion, a concrete answer, or even an insight that could be a suitable candidate for a requirement of the integrative system.

2.1.2 Requirements Prioritization

Requirements prioritization assists in making the right decisions when choosing the most important features to implement on a system [8]. From the data obtained on the previous step, a data cleaning step was manually performed merging similar codes and removing the ones which corresponded to suggestions and opinions that were not considered requirements for the proposed system due to their high diversity. A final list of 110 requirements was then shared with 6 exergaming researchers which evaluated each requirement with an eleven-point Likert scale considering two perspectives: (i) its cruciality for the system, meaning: "does this system work without this functionality?"; and (ii) its importance to fulfil the objectives of the system. The requirements were then ranked according to 3 results: the evaluation from the cruciality perspective (the mean of all participants), the percentage of interviewees that mentioned each specific requirement, and the evaluation from the importance perspective. The top five requirements are presented in (Table 1).

Table 1. Top-five requirements obtained from the prioritization step.

Requirement	Cruciality (mean)	Interviews (%)	Importance (mean)
Audiovisual feedback	8.3	69.44%	9.2
Variety of activities/games/exercises	8.2	68.06%	9.0
Store historical data	7.5	62.50%	7.0
Save routines and plans	7.0	58.33%	7.8
Activities recommendation based on user profile	6.8	56.94%	7.3

[1] MAXQDA: Qualitative Data Analysis Software (https://www.maxqda.com/).

2.2 Software Design

We followed an Object-Oriented design approach using UML notation while applying universal principles of software engineering [9]. The software design process started by creating the use cases based on the requirements list. Functional requirements were adapted and rephrased to represent atomic actions which users can perform with the system. Three main actors were identified: (i) professionals - the person in charge of prescribing activities, (ii) end-users - seniors who will play the exergames, and (iii) administrator - someone with full access to the system, mainly technicians or researchers. Use cases were crucial to the next steps, which assisted in identifying the main entities and their relationships, enabling the creation of diagrams such as high-level classes, activity, and architecture diagrams. User, session, plan, game, assessment, exercise, music, are some examples of entities identified along the software design process.

2.3 Human-Computer Interaction

In parallel with the software design process, a low-fidelity paper prototype was built to assist in the design of the software diagrams. This helped in visualizing the possible interaction flows with the users. Health and sports professionals participated in the validation of the initial designs, allowing the identification of possible preferences of interaction with the UI. For this, two traditional techniques were chosen and iterated: card sorting and paper prototype tests, which are described in the following subsections.

2.3.1 Card Sorting

Card sorting is a technique that assists understanding how information should be organized in the UI. Open card sorting sessions avoid biasing the participants by enabling them to group and label their own categories [10]. Four open card sorting sessions were performed with 2 sports trainers and 2 occupational therapists, who also participated in the requirements elicitation process. 51 topics were chosen, which corresponded to functionalities of the system, or actions that the user can perform with the system (e.g. “Create session”, “Create training plan”, “Define frequency”, etc.). Each session was video recorded, and the participants were asked to think aloud while they were organizing the topics (Fig. 2).

Fig. 2. Participants organizing topics along the card sorting sessions.

All participants organized cards in a sequential manner. Some of the new topics that participants created have already been considered on the prototype, other topics were used as inputs for modifications of the current prototype. For instance, the possibility to edit a training plan, duplicate a session, or creating experimental sessions without being associated with any user, are functions that were not considered before. Despite each user have labeled groups in a distinct manner, we observed a pattern in organizing by: “User and assessments”, “Training plan”, “Sessions and games”, and “Settings and help”.

2.3.2 Paper Prototype Evaluation

A paper prototype was built with sticky paper enabling interchanging elements during the prototyping and testing, where the features emerging from the card sorting sessions were considered. The low-fidelity prototype consisted of a mix of hand-written text and drawings, with printed elements, mostly icons, to evaluate how intuitive they could be if applied in the final UI. Two participants that participated in the previous design processes (one from each field: sports and health), were invited and asked to accomplish two tasks and to think aloud while they were performing the actions. Each session lasted about 30 min. Participants managed to successfully accomplish both tasks faster than expected. Overall, the steps were intuitively performed without the need of much support. Some modifications emerged to integrate in the final UI, such as: (i) recommendation of assessments after creating a new end-user, (ii) availability of an history of the settings previously chosen when creating or editing a plan, session, or activity, and (iii) automatic saving of data, without the need of having a save button.

3 Discussion and Future Work

The purpose of this work was to design an integrative exergaming system involving the main interactors with the UI, the health professionals. From the requirements elicitation process, we found it sometimes hard to differentiate the exergames from the integrative system. Specifically, participants tended to always answer considering the effectiveness and concerns of the exergames. However, in the later steps such as card sorting or the paper prototype evaluations, the image of the system and its specific functionalities became much clearer. As an insight from the paper prototype evaluations, we identified that there were too many options present on the system. A better approach would have been to start with a very simple interface with the basic functionalities and iteratively increment it along with the needs of the professionals. By involving the health professionals in the design process, we acknowledge that participants felt empowered by taking part of the various stages, and that they understood the importance and impact of their decisions on the envisioned system. As future steps, after implementing the digital interface with basic functionalities and navigation, we will run a usability test, which will serve as a basis for future implementations towards the deployment of a functional integrative system.

4 Conclusion

In this paper we presented the steps carried out to design an integrative system for Exergaming targeting the senior population combining human-centered and software engineer methods. We took advantage of techniques such as semi-structured interviews, card sorting, and paper prototyping to involve the main interactors of the envisioned system in the design process which allowed to design with the consideration of their preferences and needs. We believe that the performed steps are fundamental for the future adoption of the proposed system.

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