

Co-designing Interactive Technologies for Community Aware Physical Training and Rehabilitation in the VR2Care Digital Ecosystem

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VR2Care project aims an innovative approach for physical activity, training and rehabilitation, in smart living environments by providing intelligent interfaces in a single or multi-user environment. The solution combines virtual reality technologies for supervised exercise with natural interaction techniques, enhancing socialization with gamification aspects in the practice of physical activity in a metaverse context. VR2Care goes beyond the common requirements as it is co-designed with active participation of older adults, caregivers, therapists, community and clinicians to provide a full immersive multi-user experience. This paper discuss the system design options and the architectural challenges to support the VR2Care digital ecosystem.

CCS Concepts: • **Human-centered computing** → **Virtual reality**; **Collaborative and social computing systems and tools**; *Interaction techniques*; *User centered design*.

Additional Key Words and Phrases: natural interaction, socialization, physical activity, metaverse, gamification, co-design

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1 INTRODUCTION

Multiuser immersive experiences can provide an opportunity to leverage health results and quality of life in smart ageing care environments. The VR2Care project aims to provide a technological ecosystem populated with age-friendly virtual, immersive environments fostering the use of interactive technologies for the promotion of exercise, rehabilitation and socialization with natural interaction in a metaverse context. A realistic multi-user virtual reality environment with single user and multi-user approaches enables seniors to practice individually or in group to break isolation and distance constraints. Users are represented in the environment by real human forms (avatars) together with synchronized animation with natural movements (embodiment). They can interact through multi-modal channels that combine voice, gestures, and body movement. The multi-modal visualization uses a common TV set, which also acts as a physical

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sharing space for human contact. The environment also allows physical activity to be monitored and directed by an intelligent virtual assistant that combines artificial intelligence with direct human manipulation, according to the needs of each intervention, allowing for a variety of activities ranging from functional training to rehabilitation.

VR2Care followed a user-centered approach to define and design a common framework of requirements and standards. Hence, the project started with collecting up-to-date information from the literature, to determine what type of clients/patients of the pilot sites would prefer or would focus on, in terms of the new solution. Then, the pilot sites have organized structured focus group discussions with primary and, in some cases, also secondary users. The results were reported in the same format, including tables for the functional and non-functional requirements, and have been summarized in final lists of requirements from the users' perspectives. To meet these requirements, a vision rose to leverage for a system-of-systems approach [4], a set of independent, useful systems integrated into larger systems that deliver unique capabilities, where individual components are regarded as systems with independent operation, complemented by additional properties and features from the assemblage of components [3].

This paper presents the co-design approach applied to elicit end users requirements needed to create age-friendly virtual environments fostering the use of interactive technologies for the promotion of physical activity and social interaction. In addition to highlight the main elicited requirements, and discuss the future intended procedures for developing and piloting the VR2Care system.

2 USERS' REQUIREMENT DEVELOPMENT PROCESS

The main aim of this process was to implement a co-design approach to understand and clarify end user needs, concerns, and expectations regarding their interactive and functional preferential features on a virtual immersive physiotherapy and physical training system. In this research, a mixed methods approach was applied, as described in this section.

2.1 Materials and Methods

The four pilot sites (OSF – <https://ordemsaofranciscoporto.pt/>, COOSS – <https://www.cooss.it/>, UNINA – <http://www.unina.it/> and TL – <https://tantelouise.nl/>) located in Portugal, Italy and Netherland organized structured focus group discussions to ask primary users (seniors) a set of questions based on 4 personas and 3 scenarios. For secondary users (physical trainers and physiotherapists), personas and their use cases were used to describe typical situations and actions when using the VR2Care system in the different pilot sites for the different primary users.

2.2 Personas, Scenarios, and User Stories

A traditional end user categorization approach was followed [1], classifying end users under three sub-groups: primary users, secondary users and tertiary users (public and private subsidiary healthcare organizations, industry and business partners). Following these different types of VR2Care end-users, their representations via personas and typical scenarios were described [2]. In this research, personas' characteristics ranged from healthy, positive, social, and technology-minded individuals to those who have some impairments, are lonely and may feel depressed. It should be noted that the focus is on relatively healthy older adults with and without (temporary) physical impairments. Since personas have been created based on the elderly's need for physical activity as part of their rehabilitation or to maintain their physical and mental well-being along with the technological perspective, scenarios were also set in the same context and grouped in two clusters: game based single user experience and immersive multi-user experience. The project consortium partners, including industry, research, and end-users, agreed that for physiotherapy for rehabilitation scenarios the game-based

single-user experience is more effective. However, the physical exercise scenarios can use the game based single user experience or the immersive multiuser experience.

2.3 End Users Focus Groups

Participants were carefully selected for each end-user target group, considering different characteristics such as age, gender, level of education, etc., to ensure diversity within the targeted groups and represent the broadest range of potential end users of the VR2Care system. People with severe limitations were excluded in order not to burden vulnerable people and to ensure active participation.

2.3.1 Results from focus group sessions with primary users (older adults).

- (P1) Most older adults prefer to exercise in a group with other older persons. Furthermore, many of them feel that doing extra exercises in front of a TV screen in their own home would be beneficial.
- (P2) Most older adults are more interested in learning about their own progress more than competing with others.
- (P3) Vital signs should be measured and dealt with, either on a smartphone or remotely by the physical trainer.
- (P4) In general, one older adult is less interested in the avatar's shape in an immersive environment.
- (P5) The screen should have a quiet background and adaptable multimodal interfaces that are easy to access and modify.
- (P6) Most older adults are concerned about security issues when data is collected and stored, so measures to increase trust in the system's use will be critical when designing the system.
- (P7) Verbal/voice-based guidance by the trainer to correct the wrong postures.
- (P8) Simple navigation method to start an exercise or select a game.
- (P9) At immersive multiuser exercises, the user can see and speak to other users during the exercise.
- (P10) The older adult user has the option to switch from avatar to real image, and to see and/or listen to other patients.

2.3.2 Results from sessions with secondary users (physical trainers and physiotherapists).

For physical trainers:

- (ST1) In general, physical trainers think that VR training will reduce the time pressure for the trainer. Besides the advantage of multiple groups which is more efficient in their daily workload, and the possibility to replace components such as sitting exercises, the game element in the exercises and the stimulation of Activities of Daily Living (ADL) with a VR training.
- (ST2) Provide verbal explanation for equipment and game, preferably through video tutorial. However, it might be much more difficult for frail older people with dementia or memory loss.
- (ST3) Even though VR2Care should improve new social contacts remotely, some trainers are concerned about the lack of desired physical one-on-one contact, and whether it is possible to remotely correct and stimulate the motivation and posture of older persons, intervene in an emergency situation.

For physiotherapists:

- (SP1) In general, physiotherapists see a significant advantage of using VR as an extension of the homework exercises. where patients are given homework exercises to continue practicing at home to recover faster.
- (SP2) For patients who is undergoing extensive rehabilitation, it is crucial that the progress can be monitored to correct any mistakes they may make.

- (SP3) The system must allow clear breaks for patients, in addition to automatically analyzing the incorrect execution followed by a subsequent stop, or allowing (in-between) contact with the physiotherapist.
- (SP4) Physiotherapists realize that an avatar can make exercises more enjoyable for their patients. However, they want to be able to see afterward if the exercises were performed and where they improved or worsened. Physiotherapists want to see realistic camera images if this is not possible with avatars alone.

3 DISCUSSION

Prioritizing the elicited requirements was critical for VR2Care partners in order to understand the required efforts, time, and resources. As a result, end user requirements were prioritized as "should haves" or "could haves" if they could realistically be met within the VR2Care project time, or expected to be met in the future after the completion of this project. Other factors were considered for prioritizing such as the majority or minority of end users who reported the same requirement, as well as the impact of the requirement in relation to the expected system's functionality. Hence, (P3, P9) requirements were categorized under "could haves" requirements, while (P5, P6, P7, P8, P10, ST2, T3, SP2, SP3, SP4) requirements were categorized under "should haves" requirements.

The co-design process of the VR2Care digital ecosystem allowed to understand the primary users' expectations for the evolution of current (partners') interactive solutions for physical training, prioritizing the integration workflows. Training pathways, personalized to each user, drive the development of the interoperability layer to a solution that can support the trainers and physiotherapists requirements (secondary users).

4 FINAL REMARKS

The co-designed digital solution will be deployed and evaluated in four different sites representing different application scenarios. The planned evaluation aims to gather insights about how older persons living by themselves in rural areas, older persons living in a nursing home, those who need adapted physical training in a hospital and those who will need physiotherapy at home can benefit from VR2Care: more social contacts, better adherence to physical training and physiotherapy through the games, adequate and sufficient telemonitoring by their supervisors. The evaluation will be based on some 4 months of usage by a number of at least 60 older persons.

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