Challenges of Trustable AI and Added-Value on Health
B. Séroussi et al. (Eds.)

doi:10.3233/SHTI220544

iCompanion: A Serious Games App for the Management of Frailty

Antonios SYKOUTRIS, Angelina KOUROUBALI, Dimitrios G. KATEHAKIS and Haridimos KONDYLAKIS
FORTH-ICS, Heraklion, Crete, Greece

Abstract. The term frailty is often used to describe a particular state of health, related to the ageing process, often experienced by older people. The most common indicators of frailty are weakness, fatigue, weight loss, low physical activity, poor balance, low gait speed, visual impairment and cognitive impairment. The objective of this work is the creation of a serious games mobile application to conduct elderly frailty assessments in an accurate and objective way using mobile phone capabilities. The proposed app includes three games (memory card, endless runner, and clicker) and three questionnaires, aiming towards the prediction of signs of memory and reflection deterioration, as well as endurance and strength. The games, when combined with a set of qualified questionnaires, can provide an efficient tool to support adults in identifying frailty symptoms and in some cases prevent further deterioration. At the same time the app can support older adults in improving physical and mental fitness, while gathering useful information about frailty.

Keywords. Frailty, mHealth, questionnaires, digital health, serious games

1. Introduction

Frailty is a very common clinical condition for the elderly [1], [2]. It leads to the weakening of various functional areas, such as physical frailty which includes unintentional weight loss, self-reported exhaustion, weakness, slow walking speed and low physical activity; cognitive frailty which is a distinct clinical concept of simultaneous physical frailty and cognitive impairment in the absence of concurrent dementia; psychological frailty such as loss of resilience in cognitive, mood and motivational components; and social frailty which includes loss of social resources and behaviors that are important for an individual's social needs [3].

For the past few years, personal health apps [4] [5]and android/ios applications have exploded in popularity reestablishing and even reinventing the way people, connect, exchange information, interact and socialize. In recent years, various studies have been conducted considering the use of new devices that allow for the detection and monitoring of frailty without expensive facilities [6]. There is a great need to create applications specifically designed for pre-frail and frail older adults that focus on their unique needs and goals, as such software is currently not common in the market [7].

The aim of this work is to create a mobile application that provides a user-friendly interface to engage older adults in a comfortable way to spend time on serious games and other activities that could support the detection and improvement of frailty symptoms. Evidenced based questionnaires are incorporated in the software for the collection of older adult data that could assist healthcare professional in identifying signs of frailty

and assess the effectiveness of the treatment. iCompanion is a prototype that could provide the basis for a functional digital health app to be used in real-world scenarios.

The rest of the paper is structured as follows: In Section 2 we present an overview of the methods used for developing the app and then in Section 3 we present the serious games app that allows older adults to play games and answer daily questionnaires. The application, facilitates the interaction between older adults and healthcare professionals as it logs the progress of users engaging with the serious games. Also, it provides and overview of the answers to the questionnaires over time. A dashboard shows the effectiveness of the user interactions with the app in a monthly graph. Finally, Section 4 concludes this paper and presents directions for our next steps.

2. Methods

The focus of this work is the design and development of iCompanion, a digital health app prototype that uses SG to manage and support frailty in older adults.

Table 1. SG examples

Virtual Supermarket game[1]	The user must pick a list of items from the supermarket. It contains only a short shopping list to train the short memory.	This Game is used for diagnostic purposes, physical and cognitive status of older persons.
Frail Red Wings[2]	Flying a plane using a dynamometer in hand.	The user controls the plane with the dynamometer and applies pressure to avoid obstacles. The game targets grip strength and helps the user strengthen it.
FRED[3]	Exercise game that uses biofeedback to ensure that the game is performed under cardio-healthy conditions.	The game supports the users in finding meaning in the activity. Each movement is designed by considering both biomechanical and neuromotor parameters and evidence features of sufficient extent to be recognised by the Kinect sensor.

The methodology used included initially a review of selected serious games in the field to identify the most important elements that are important to be included in SG applications. In the last decades there has been a growing interest in employing Information and Communication Technologies (ICT) to facilitate the assessment of functional impairments of older adults and support them in their everyday activities [8] [9][10]. In addition to being important for health assessment, ICT can also play a key role in the treatment, stimulation, and rehabilitation of health conditions. Serious Games (SG) are digital applications specialized for purposes other than entertaining, such as education and information as well as enhancement of user aptitudes and/or cognitive and physical functions. SG have also been shown to facilitate improvement of different users' functional and cognitive traits in relation to a healthcare treatment plan. SG provide the opportunity for healthcare providers to monitor the player, while tracking game data that can be used for subsequent analysis and comparison [11]. Several SG applications for frailty have been developed that provide different features for engaging the elderly. FrailSafe, a Horizon 2020 research and innovation programme (https://frailsafe-project.eu/), has developed several mini-games for frailty detection and prevention. Within the suite of SG are memory games, reflexive games that are developed to evaluate and stimulate the visual reflex and motor speed of people afflicted by frailty and sound

[1] https://frailsafe-project.eu/news/59-supermarket
[2] https://frailsafe-project.eu/news/61-red-wings
[3] https://addi.ehu.es/handle/10810/22749

sequence games that use sound to create sequences that the patient can identify and replicate. Some SG examples are presented in Table 1.

However, in an ageing society, it is necessary to establish new alternatives that focus on the needs of older adults while increasing their perceived quality of life, combining SGs and established clinically validated questionnaires that are daily used in clinical practice [12]. Based on the survey, a list of features was developed that was then explored during in depth interview with healthcare providers. Overall, two interviews were conducted with three clinicians. During the interviews the list of features was presented to the clinicians that were then rated to identify the most useful ones to be included in a series of mini-games. In addition, the clinicians identified the most relevant questionnaires to be used for identifying prefrailty and frailty.

3. Results

Consolidating all requirements identified, the iCompanion mobile app was build using a modular architecture depicted in Figure 1. The mobile app includes the user management module, three mini-games for frailty assessment and three standard clinically validated questionnaires for monitoring citizen status. All data are stored in a secure repository online whereas users are authenticated using national infrastructures. In the sequel we describe in detail the various modules of the Mobile app.

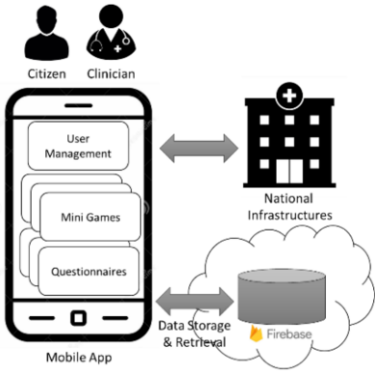

Figure 1. The High-level architecture of the mobile app.

User Management. The users of our application can be either clinicians or citizens. They can all select their role upon registration and be authenticated through the relevant national infrastructures. Currently the mobile app is connected to the Greek national infrastructures but can be easily extended to support other authentication services (e.g. Facebook, Google etc.). Citizens can track their own progress and play the mini-games which can then bring to the clinicians for discussing the graphs and their progress. For clinicians the mobile app allows adding supervised citizens, that can use the application while in the waiting room to check their progress. In addition, the clinician account has the option to complete the two STRATIFY questionnaires, whereas the citizens have the opportunity to complete the EQ-5D-5L self-reported questionnaire. All results are logged and the computed scales can be discussed with the clinicians. Further, the iCompanion mobile app includes three serious mini-games for assessing citizen status using a variety of tools:

Memory card game. Memory card games are games in which all cards are laid face down and each turn the player(user) flips two cards of his/her choosing trying to identify similar ones. The time in which the user finishes the game is very important because it stands as a good measurement of how fast the user can remember the correct pairs and how developed is a short memory. In our variance of the classic card game, the player has to identify the pair that is not identical, but where one card is similar to another card - for example, one card could be a monkey and the other card could be a banana. The reason behind this particular approach is that you tend to exercise the short memory a bit

more by forcing the user to correlate the two different items. Each time the user plays the score is saved and at the end compared with other players (anonymously) along with his own past performance. The user can gradually move to harder versions (10 pairs, 20 pairs etc.). User performance in similar games has been an indicator of Mild Cognitive Impairment (MSI) in the past [13], so by evaluating the results over time the clinicians can monitor the citizens memory performance and to identify signs of deterioration.

Endless runner game. Endless runner is a SG where the player character is forced to run for an infinite amount of time while dodging obstacles. Such SGs are proven to train the reflexes of the user, by procedurally generating more obstacles [12]. The gyroscope sensor of the mobile is responsible for the autorotation of the screen and view on the screen whenever a phone is rotated. Combining the endless runner subgenre with the gyroscope movement, in the implemented SG a ball moves in a linear path trying to avoid obstacles and can continuously assess and train the reflexes of the patient. Additionally, by collecting gold coins found within the game, the patient gains score points. The highest score is being saved by the software to keep track as a reflection measurement providing a mean to monitor reflection skills.

Clicker game. Clicker games are video games whose gameplay consists of the user performing simple actions such as tapping on the screen repeatedly. The reason behind making such a game is that elderly people with advanced forms of frailty are shown to lack grip endurance [13]. This is important considering that clicker games test grip endurance and strength. In our version, there is a sword stuck in a rock waiting to be lifted. The user must continuously press the pull button to reveal the sword. There is a countdown of 60 seconds that the task should be finished before resetting the sword. The more grip endurance the patient has the faster will be able to pull the sword. All scores are saved and can help the clinicians monitor grip endurance.

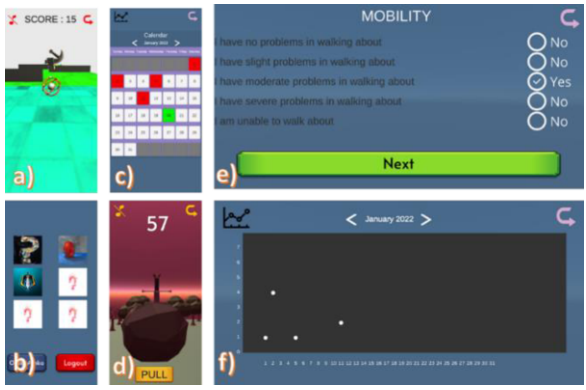

Figure 2. The GUI of the three mini-games, i.e. a) the endless run game, b) the memory game, c) the endless run, d) the mini calendar, e) a questionnaire and f) some statistics.

Questionnaires. Three clinically validates questionnaires have been implemented for risk assessment. The answers each user provides are analyzed and risk scores are calculated in each case based on the provided answers. After completing a questionnaire, the users can review the relevant scores and also view a monthly graph. The first two questionnaires are completed by nurses/clinicians based on their interviews with the citizens. STRATIFY [15] questionnaires, have been developed to predict patients at high risk of falling with clinically useful sensitivity and specificity. It is increasingly used routinely in elderly care departments for this purpose. The citizens on the other hand can complete the EQ-5D-5L, a self-assessed, health related, quality of life questionnaire. The scale measures quality of life on a 5-component scale including mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. As deteriorating quality of life has been highly related with frailty [15] the questionnaire provides a useful resource for monitoring citizens.

GUI. The GUI of the app is shown in Figure 2. All modules have been implemented using Unity, which enables delivering high-quality mini-games across all mobile devices.

4. Conclusion

Work conducted has incorporated gaming factors to enhance motivation towards frailty self-assessment. iCompanion is a low-cost tool that has the potential to support generalized frailty management without the need for expensive equipment. Additionally, the software resembles and functions as a medical software that can help patients with frailty prevent further deterioration. Moreover, the android/ios application supports a user-friendly, simple, and clean user interface that does not overwhelm the users. In future versions, users will have the ability to play a varied suite of serious games with more advanced features focused on frailty needs. Currently the app is loaded on tablets at the clinics. While patients are in the waiting room a nurse completes the questionnaires and gives the tablet to the patients for playing the mini-games. The results are collected and as soon as the patient is with the doctor, the doctor has in front of him a dashboard with the patient's progress over time in order to help him understand patient's status. Additionally, there are plans to expand and enhance the UI of the software. Finally, a detailed evaluation by both clinicians and citizens is already planned to follow, whereas a market research is being conducted to facilitate the development of a viable business.

References

[1] Clegg A, et al. Frailty in elderly people. The lancet. 2013;381(9868):752-62.
[2] Chen X, Mao G, Leng SX. Frailty syndrome: an overview. Clinical interventions in aging. 2014;9:433.
[3] Pilotto A, et al., A multidimensional approach to frailty in older people, Ageing research reviews 60 (2020).
[4] Katehakis DG, et al. Integrated care solutions for the citizen: personal health record functional models to support interoperability. EJBI 2017:13(1), 41-56.
[5] Maniadi E, et al. Designing a digital patient avatar in the context of the MyHealthAvatar project initiative. In 13th IEEE international conference on BioInformatics and BioEngineering 2013:1-4/
[6] Anabitarte-García F, et al. Early diagnosis of frailty: Technological and non-intrusive devices for clinical detection. Ageing Research Reviews. 2021;70:101399.
[7] Kouroubali A, Kondylakis H, Logothetidis F, Katehakis DG. Developing an AI-Enabled Integrated Care Platform for Frailty. In Healthcare 2022;10(3):443.
[8] Robert P, et al. Recommendations for the use of Serious Games in people with Alzheimer's Disease, related disorders and frailty. *Frontiers in aging neuroscience*, *6*,
[9] Smith J, Forster A, Young J. Use of the 'STRATIFY'falls risk assessment in patients recovering from acute stroke. Age and Ageing 2006;35(2):138-143.
[10] Kondylakis H, et al. Semantically-enabled Personal Medical Information Recommender.ISWC 2015.
[11] Shapoval S, et al. Biofeedback Applied to Interactive Serious Games to Monitor Frailty in an Elderly Population. *Applied Sciences*, 2021;11(8):3502.
[12] Mugueta-Aguinaga I, Garcia-Zapirain B. Is technology present in frailty? Technology a back-up tool for dealing with frailty in the elderly: a systematic review. *Aging and disease* 2017;*8*(2):176.
[13] Sood, Pallavi, et al. Nonimmersive brain gaming for older adults with cognitive impairment: A scoping review. The Gerontologist 2019;59.6:e764-e781.
[14] Herdman M, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Quality of life research 2010;20(10):1727-1736.
[15] Langlois F, et al. The multiple dimensions of frailty: physical capacity, cognition, and quality of life. International Psychogeriatrics 2012;24(9):1429-1436.