Unifying Platform for the Physical, Mental and Social Well-Being of the Elderly

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Abstract. Aging deteriorates cognitive and physical abilities. Besides this, social activities decline in older ages. However, it is possible to slow down the deterioration of these abilities and to prolong the time elders live independently at their homes by proper training plan exercises. Existing tools offer very limited support as their design does not take into account elders as target users and the motivational factors that following training plans poses on them. In this paper we present a unified platform that hosts training games and physical exercises and leverage them with social, motivational and monitoring instruments.

Keywords: training plans, games, motivational instruments, well-being

1 Introduction

There is a consensus in the literature of certain key factors that contribute positively to happiness: experiencing life events and emotions, interacting socially with others, and contributing to society [11]. Many older adults are challenged in these activities because of cognitive and physical impairments. However, studies revealed that performing cognitive exercises slow down the deterioration of brain functionality [7], also physical exercises improve the physical abilities and these affect the social connectedness of the elderly and eventually improves their well-being. Thus, many technologies and tools have been developed to enable people train their physical and mental abilities: Mobile application for healthcare, virtual reality games, Exergames, Wii games and brain training applications are some of these examples. Most of these tools were successfully tested [6] in supervised environments like rehabilitation clinics or hospitals. The lack of success and commitment typically occurs when the elder is back home to their routine life and need to perform the exercises autonomously. Due to repetitive nature of training exercises, lack of awareness about their benefits and the long term period to reach the results, the plan becomes uninteresting and the trainees are not eager to continue following them. Hence, in order to reduce this undesirable effect several studies propose games as a successful motivational strategy since they are challenging and have the ability to stimulate the user to interact with different tasks. A study already 20 years ago discussed that game playing can improve hand-eye coordination and reaction time [14]. Jesselsteijn et al [10] reviewed game playing for elderly and stated that elders are interested to engage in playing digital games that support social contacts and connect people with similar interests. Apart from the motivational aspects, the elders generally are not aware about which kind of exercises or activities they need to perform, how they should do that, and in which frequency. On the other side, elderly people, especially those who are socially excluded and have impairments are not able to interact with current technologies, aging degenerates vision, hearing and memory ability [5]. In short, all the aforementioned items contribute to reduce the adherence of any kind of training plan autonomously at home. In this paper we present a method and platform for the development of ActiveLifestyle programs for elders. The distinguished characteristics of the platform are i) the ability to support an extensible set of different social inclusion and persuasion strategies, mutually reinforcing each other so that social inclusion is both a *mean* (for motivation) and a *goal* (as social inclusion increases activity, desire for life participation, and emotional wellbeing); and ii) a design that is human-centered, based on repeated trials with various groups of elders in different countries and that also caters to people in the 80+ range, including subjects over 100 years old with no computer literacy at all.

2 Related Work

Serious games have been widely used in various domains (i.e, health, military training, education, cultural training) [13]. In particular, healthcare serious games can be categorized in two general domain of cognitive and physical games. Green et al [9] explained that any game that requires the player to perform quick response, improves the alertness of the user. Thus, several serious games in the category of cognitive games were developed to stimulate the functionality of brain in different cognitive portions and prevent dementia in the elderly. There are several gaming platforms that contain multiple cognitive games for the elderly. Eldergames09 [6] delivers an interactive multi-touch platform equipped with four cameras that capture the user's activity while playing and provides several cognitive games for the elderly. HERMES11 Project [8] developed a variety of cognitive games for elderly people. The platform captures the users' daily life activities and extracts its contextual information. Based on this, the multi-touch interactive, offers multiple cognitive games for the user. In addition to these, puzzle games, crosswords and many other stimulative games can also fit in cognitive games category since they all stimulate brain functionality.

For the physical games, a study [2] provided a narrative review on Exergames and how they can motivate elderly to exercise more. They explained Exergames as games that need the user to perform physical exercises to control the game. Nintendo Wii and Virtual reality games are other types of physical games that motivate the elderly by providing them real and interactive environment. However, the article states that there is a lack of co-playing in current Exergames and claimed that social factor is very important in motivating the elderly. Exergames demand expensive hardware. However, today there is a large set of on the shelf and cheap, or even free, solutions based on sensors (e.g., pedometers, accelerometers, GPS) to monitor physical exercises and promote well-being.

Regarding the motivation instruments, Flowie [1] is one of the few examples, where the authors leverage on positive reinforcement, goal-setting and self-monitoring to motivate old age adults to walk more. Another example is the FishnSteps [12] also aiming to make people in general, not specifically elders, walk more. Both adopted a pedometer to collect the amount of steps covered by the trainers per day, process this information, and present it using a metaphor (i.e., a flower or a fish).

The aforementioned games and exercises presents some examples of well-being applications. These can be used in a planned training program for independent elderly to keep them physically and mentally sharp.

3 ActiveLifestyle: Training Plans at Work

The overall approach, captured in Figure 1 can be described as a human-centered design. It servers the needs of the upper layer via a series of supporting applications, targeted at training partners, their friends and family, healthcare experts and developers. These applications are in turn supported by the ActiveLifestyle platform.

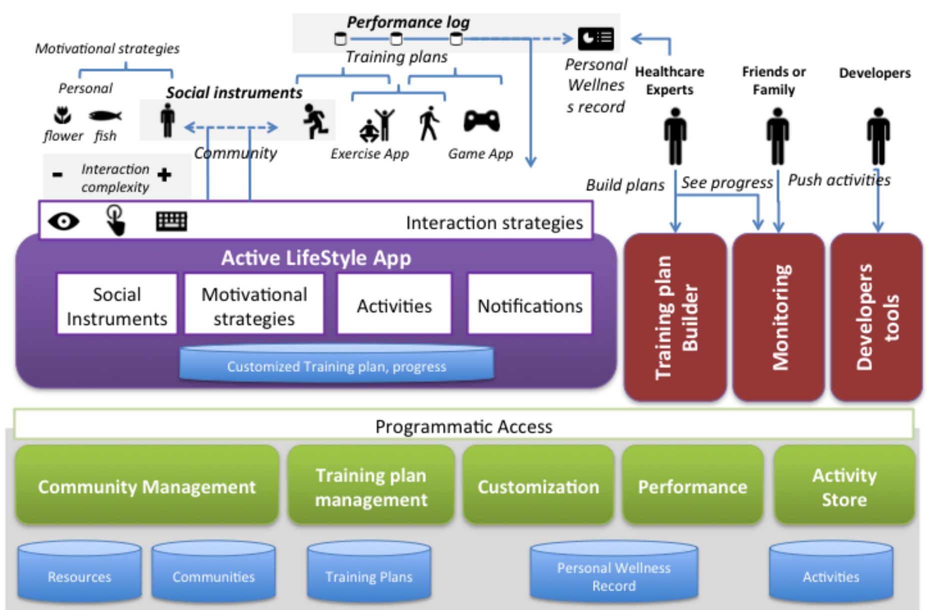

Fig. 1. ActiveLifestyle High Level Architecture

The ActiveLifestyle platform was designed with a clear separation of *services* implementing basic primitives that allow interfacing and operating on the training model, and the *medium* used to support the activity.

At the very bottom of the architecture, the structure of the training plan model is translated in a database schema to store and query training data. This schema is leveraged by a set of modules on top, offering programmatic interfaces:

- **Community management**: creating groups to participate in plans and activities, sharing resources (e.g., text, performance, score of the games).
- **Training plan management**: provides services for building training plans.
- **Performance module**: services for collecting performance information and getting the PWR.
- **Customization**: Based on the past usage, performance and parameters (profile), recommends the complexity, interaction metaphors and parameters of activities.
- **Activity store**: services for pushing, querying and loading activities.

On top of this, the user interface is implemented by a particular *medium*. In our current implementation, an iPad application provides participants with support in the training plan. The application, named after the platform, ActiveLifestyle essentially has the following components: i) *social instruments*, *motivational strategies*, *activities*, *interaction strategies*, and a *local storage* to keep a local copy of the training plan and the progress.

In the following, we describe the core ingredients of ActiveLifestyle platform.

3.1 Training Plans and Personal Wellness records

Training Plan Model. Activities such as *one leg stand* or the *dance dance revolution game*(DDR)[1] can really help in addressing some problems related to aging as, in this example, reducing mobility problems and divided attention. We define "activity" as a tuple $A =< N_a, P, WF, T, IR >$ where

- N_a: refers to the group of people performing the activity. For example, the elders performing and engaging in the *one leg stand* activity together.
- P: refers to a set of activity-specific tuning parameters. It can be, for example, the *song* to play in *DDR*.
- WF: refers to the list of well-being features that the activity addresses. These features are related to the impairments that once reduced will positively impact the well-being of the subject.For example, according to previous studies DDR addresses *divided attention* and *balance*.
- T: refers to the type of activity. An activity can be an *exercise* (e.g., one leg stand), a *game* (e.g., DDR), or more generally a *task*.
- IR: refers to interaction or performance requirements that the activity impose on the elder. These requirements can be based on the supporting technology or the activity itself. For example, assuming the activity is the DDR game running on an iPad, the requirements that it poses on the elder will be "touching" (medium-related), "hear" and "see" (activity-related).

[1] http://en.wikipedia.org/wiki/Dance_Dance_Revolution

Table 1. Example of cognitive and physical training plans

	Cognitive training	Physical training
Activities	Dance dance revolution	one leg stand, full tandem
Activities per session	10 x 1.5 mins	1 x 15 minutes
Number of sessions	24 x 15 mins	1 x 15 mins x exercise
Schedule	3 sessions per week	5 sessions per week
Overall plan duration	8 weeks	6 weeks

– C: refers to the difficulty levels envisioned for the activity. It can be related to the game level in *DDR* or variations from simple to more difficult in the *one leg stand* exercise.

Activities are usually organized in sessions in the context of *training plan* designed to improve certain well-being features (Example in Table 1). We (formally) define training plan as a tuple $TP =< S, N_T, R, F >$ where

– S: refers to a set of training sessions $s_i =< A_i, DR, V >$, composed of a set of activities to be performed (possibly) on a certain order A_i, to be performed on a particular date / time DR and a set of activity parameter values V. As the name suggest, is a time period in which the elder perform the set of exercises with the particular tuning parameters set during the design time.
– N_T: refers to the group of people participating in the training plan, playing a particular role. Roles can be *participant*, *subscriber*, *trainer*.
– F: refers to the focus of the training plan: *physical*, *cognitive*, *social*.

Personal Wellness Record Another fundamental component of the model has to do with tracking the performance of the training plan participants. Collecting, storing and processing this data will enable the creation of Personal Wellness Records (PWR). The PWRs are composed of well-being indicators derived from metrics computed based on the participant's performance. Each indicator represent one or more impairments that can be improved with the training plan. As well as our previous work Daniel et al. [3], the PWR can be used together with the traditional Personal Health Records (PHRs) to support healthcare experts, family members, and caregivers with a detailed and richer source of information about the elder's physical, mental and social health.

3.2 Individual and Social Motivation Instruments

Motivation is a broad, complex and multifaceted topic largely discussed on sociology and psychology without reaching an agreement how individual feel more or less motivated. Though, in the IT field, J.B. Fogg lead of the Stanford lab of Persuasive Technology, has developed successful studies to discover how to motivate people to follow a certain behavior. As a first attempt we follow his approach regarding individual (intrinsic) and social (extrinsic) motivation instruments.

The individual motivation instruments [4] are: *awareness about the benefits:* of being physical active thought short text messages and recent on-line news, *positive and negative reinforcement:* based on a metaphor (flower) that changes size and mood according to the users compliance and performance toward the plan; *goal-setting:* before start the plan the users are aware about their goal, which is also represented using the flower metaphor; *self-monitoring:* along the time the user can monitor his/her performance looking to the size of the flower metaphor.

The social motivation instruments [4] are based on a training plan community, where the elders are training partners and the healthcare experts and developers are experts. To support the communication the app contains a bulletin board where only training partners have access, and an inbox where each user can exchange private messages with other trainers or experts. We define the social instruments as: *Comparison:* trainers can compare their performance with their partners by means of the metaphor, *Collaboration:* whenever all trainers performed the scheduled workout session they improved or succeed in the collaborative environment, *Social responsibility:* each trainer has pre-defined tasks, *Emotional support:* trainers, experts and friends/family members can monitor the user's performance and send motivational and emotional text messages to support this person.

3.3 Activities: StepMania and Mobility Program

To address the training program for divided attention we present a simplified version of StepMania. StepMania[2] is a distribution of DDR game. In the game, four objects $\Leftarrow\Downarrow\Uparrow\Rightarrow$ fall down from top to bottom in front a *background* while a *song* is played and the players needs to press the corresponding button when an object overlaps with it. Taking into account the elderly's limitations, we developed a simplified version of the game[3] following the model of activity and exposing the "tuning parameters" shown in italics (song, background). We report on usability test of the activity in Section 4.

The physical mobility program is a set of training videos that displays the correct physical activity in the iPad. It contains seventeen exercises, in which six are for warm-up, nine for strength, and two for stretching. Elders will be alerted about their following training exercises. All exercises must be performed according to the same instructions. After each exercise, they can submit their feeling about the exercise, the actual amount of performed sets, repetitions and post their comment. After each completed workout sessions, an automatic post message alerts the training community that one of the users just completed the scheduled exercises. Hence, at the end of the day all training partners can compare the results and check how has the most beautiful and bigger flower. In addition, experts, friends, and trainers can exchange private messages in order to clarify doubts or details problems. Examples of typical physical exercises and how the users access the ActiveLifestyle app are available on the web [4]

[2] `http://www.stepmania.com/`
[3] Cognitive training demo video: `http://youtu.be/0Cn6in7-e0w`
[4] Physical training demo video: `http://youtu.be/Akvs13UMvfc`

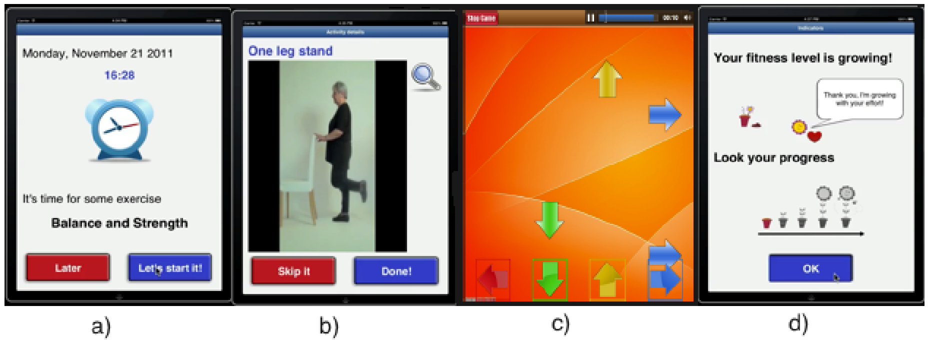

Fig. 2. a) alerts to start a session; b) video demonstrating the *One leg stand*; c) DDR game; and d) positive reinforcement and self-monitoring using the flower metaphor

4 Findings and Impact

The evaluation of our approach is two-fold. We have first validated the model and platform from the point of view of the *trainers* and then the reaction of the *trainees* to the ActiveLifestyle application and activities.

From the trainer perspective, the model and platform have been validated by the Institute of Human Movement Sciences from the ETH Zurich, which work closely with elders developing training activities. Indeed, at the time of the writing, we are running a pilot[5] on using ActiveLifestyle for physical training, and others that are in process.

From the trainee perspective, we are currently going through a round of tests, named Feasibility Study, in which 15 independently living and health Swiss elders are using the app during two weeks[6]. The focus of the test is to evaluate the social and motivational instruments from a quantitative and qualitative point of view. Early results are very promising and point to the importance of the social instruments they are using to stay connected and in a way compete. This motivated a second and longer round of tests, named Physical Study, to be performed at the end of this year, focusing on the physical effects.

As for the cognitive training, a low fidelity test was performed to identify the usability of the simplified StepMania game among the elderly as the interface required more interaction with the application. A group of 6 elders, ranging from 77 to 104 year old, played 4 test games on an Apple's iPad. The test games were examining the effect of simple and confusing backgrounds, speed of falling objects and size of the acceptance area for overlapping. In addition, we examined the initial time needed by the elderly to understand the game and play it independently. The results show us a greater usability and ease of learning with respect to the original version but most importantly helped us to

[5] Press `http://lifeparticipation.org/ActiveLifestyle/homeImages/news.pdf`
[6] Teaser video of the Feasibility test `http://youtu.be/pgyYSjAR6h4`

identify the tuning parameters and the complexity that we'll later use to adapt the interface and normalize the difficulty level according to their abilities. From the social and motivational point of view, the results as exciting as the ones from the other study: they are eager to know about the average performance in their community and it is also very competing for them to achieve high score and share it with people in their age.

In summary, we discussed current games and exercises in the area of welfare, we also mentioned the current challenges in regard to designing technologies for the elderly with impairments. We proposed a model for typical training plan and their activities and finally we presented a training platform to leverage the usability of serious games and training exercises for autonomous elderly by using motivational and social instruments. Nevertheless, there is a lot more work on understanding the proper motivational and social instruments that can enhance the usability of the system. Besides this, feasibility study on different games and their welfare effect on the elderly and realtime monitoring of the performance are two more important dimensions of the future works.

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