

GameUp: Exergames for mobility – a project to keep elderly active

E. Brox¹, S. Th. Konstantinidis^{1,2}, G. Evertsen¹, L. Fernandez-Luque¹, A. Remartinez³, P. Oesch⁴ and A. Civit⁵

¹ Norut Northern Research Institute, Tromsø, Norway

² The University of Nottingham, Nottingham, UK

³ Ibernex, Zaragoza, Spain

⁴ Kliniken Valens, Valens, Switzerland

⁵ University of Seville Department of Computer Architecture, Seville, Spain

Abstract— A big challenge for Europe is the demographic shift towards an aging population. Resources in the health care sector are limited, so it is important that the seniors of tomorrow will be able to stay healthy and manage themselves as long as possible, preferably also with a good quality of life. Physical activity is very important both for mobility and for the general well-being, but it can be hard to find motivation to exercise alone at home. Also in rehabilitation there is a need for a more engaging approach than a sheet of paper describing exercises that should be performed. In the GameUp project we developed fun and motivational exergames particularly targeting elderly in a user centred approach. Physiotherapists ensured that the movements and exercises were good for flexibility, leg strength and balance. In addition to seven Kinect games, a walking app and a professional portal were developed. The Kinect games can be played in several levels, and those who are at risk of falling are able to play while seated. The professional portal ensures that the results of the project also can be used as a tool in rehabilitation. Test results from 20 elderly aged 65-95 as well as clinical trials of adherence to the exercises are encouraging, and the international and multidisciplinary team behind the project is now looking for ways to commercialize the project outcomes.

Keywords Exergames, active aging, elderly, mobility, serious games

I. INTRODUCTION

A. Challenges

Mobility problems are very common for elderly people [1, 2]. Studies [3] found that low self-efficacy (people's belief in their own competence) leads to reduced mobility and higher risk of falling that can ultimately lead to lower mobility, reduced quality of life and limitations in everyday activities and social participation. This is a vicious circle since physical exercise is important to maintain mobility and reduce risk of falling [4]. Our challenge was to find a way to motivate elderly to move more, preferably with

exercises that would help strength, balance, flexibility and endurance.

The GameUp project aimed to sustain mobility of senior citizens, prolonging the time they can live autonomously in their preferred home environment by encouraging them to be more physically active and motivating them to move more. The main target group has impaired strength or balance, some have a history of falls or are in risk of falling and some have gone through recent illness or surgery.

Exergames have been proven to be fun for elderly [5-9], but most commercial exergames are not suitable for elderly for several reasons [10-12]. Also the movements in most exergames are not the best to meet the physical needs of elderly.

To make successful exergames for our target group, we both have to make sure that the exercises are well suited when it comes to correct movements and that the games are fun and motivating. Also they have to be safe to play for the elderly. Most exergames today are made for children or younger adults, and speed, graphics, music and contents are not necessarily suitable for older people. Some games even require the players to jump to get started.

Another challenge is to involve professional users, such as physiotherapists, into helping patients or old users to choose the correct level of exergames and teach them how to use it.

B. Objectives

The main goal of GameUp was to promote mobility by encouraging elderly persons to be more physically active and motivate them to move more.

The objectives of the GameUp project could be summarised to:

- Sustaining mobility of older persons; prolonging the time they can live autonomously in their preferred home environment; enhancing quality of life.
- Strengthening the industrial base in Europe,

through developing emerging products, services and systems which meet the needs and wishes of end-users concerning mobility and have a high potential for a viable business case.

- Facilitating new European cooperation, including end-users and different stakeholders in the value chain.

Along these objectives the GameUp project developed an ecosystem of exercise games (exergames) that can motivate elderly to exercise more and correctly which again will increase their self-efficacy. Game-based technologies, social play, personalization and state of the art in persuasive technologies are used to motivate the elderly to perform exercises that are beneficial to them.

In the professional portal the clinical expert can follow up the progress of the elderly users, personalize their goals and give motivational tips.

This paper aims to provide not only the overall research framework of the GameUp project, but also to link the project with its research outcomes and contribute towards the active ageing and wellbeing research era of motivational and better healthcare services.

II. PROJECT DESIGN AND METHODS

A multidisciplinary team ensured that the project had the required competence. This included researchers in ICT specialising in serious games, gamification and social networks, game developers and game designers, researchers in physiotherapy, business partners both in serious games and health care systems, and end users participating in user centred design as well as usability and evaluation trials.

A. Example scenario

One year ago Anna (65) tripped over a curb and broke her right hip. The fall made her much more afraid of walking and moving around, and she developed serious mobility problems.

Her doctor told her to exercise at home to strengthen her legs and improve her balance. She had finished postoperative physiotherapy and had been given a leaflet instructing strengthening and balance exercises. However, these exercises were pretty boring and she lacked the motivation to train alone at home. She knew from her doctor that her municipality offered balance classes three times per week for one hour. She found a relative who could bring her to the training centre once a week and she joined a balance class.

The training centre was a member of the GameUp project. They offered Anna a fun and social exergame training program that she could do from home. Anna is running the

program on her own TV. She plays some exergames designed to strengthen her legs and enhance her balance, and she really enjoys this. She also likes a social walking game where she together with her friends has to reach a group goal while walking outdoors. She receives motivational messages and tips from the game, but she also can communicate with her friends and plan a walk together with them. Luckily, the program provides not only exercises but also feedback where she can view her progress, and she found this very encouraging and was always looking forward to see the new results.

Anna is very glad that she agreed to join the fun and social training program. She even has started to go for walks in the neighbourhood with two new friends she met in the training program.

B. Structure of work

The work was divided into four main activities: 1. requirements and user involvement; 2. design and development of an ecosystem of mobility games; 3. development and 4. piloting and evaluation.

a) Requirements and user involvement

This work gave input to the first design and involved the following activities:

- Analyses of the target group
- Considerations and requirements for professional users
- Recommendation of movements and exercises
- Involvement of elderly playing commercial exergames to learn about reactions and mastering

b) Overall design

The design of the GameUp ecosystem is based on requirements and state-of-the-art:

1. Requirements: Requirements for the user group to stay mobile were defined and suitable exercises were defined based on these requirements as well as on state-of-the-art in the field, also taking risk factors into account, particularly risk of falling
2. Ecosystem: Based on state-of-the-art of exergame hardware and sensors, we made an overall choice for the ecosystem of games including motion sensors
3. User involvement: A group of seniors have been playing commercial exergames regularly, and later participated in testing of all game elements and game versions in user centred design

c) Development

The physiotherapists in the project defined ten exercises for the user group. Test versions of these exercises were then developed for Kinect, but trials both with professional and end users showed that not all were suitable for Kinect.

Based on results from these trials one game was first developed and tested. Later six more minigames were developed, two with the same movements as the first game and four with exercises chosen from the most important movements of those suited for Kinect. Also a motivational walking app for endurance was developed where personal and group goals suitable for the senior users could be defined. 20 elderly aged 65-95 participated the in user centred design and development throughout the project.



Fig. 1 Playing an exergame for leg strength. The players can hold on to a chair for support

d) Piloting and evaluation

The exergames have been tested by real end users in real environments. See figure 1. The main trial arenas have been in a senior centre, particularly in the user centred design approach, and in a rehabilitation clinic in order to study adherence to exergames compared to the traditional methods where the users get paper instructions for exercise program.

III. ARCHITECTURE

The GameUp ecosystem is divided into devices and interfaces to be utilized by the elderly users, online components, and finally components and interfaces to be used by professionals, e.g. clinical experts and physiotherapists, to access the professional portal, as can be seen in Figure 2. The system consists of:

- Game Clients - The game clients constitute the interaction interface for the elderly user (GameUp Client in Fig 2)
- Online components - The online components in the GameUp ecosystem include servers with data storage, system-to-system interfaces, in/out-bound communication routes, the interface for the professional portal, the

game repository, and the motivational engine. (GameUp Server in Fig 2)

- Professional clients - The professional client is the main interface for the professional users from which they access, evaluate and alter data. (GameUp Portal in Fig 2)
- Administrative clients - Similar to the professional client, this client exists as a Web-interface that is accessed via a Web-browser. Administrative personnel (system administrators and similar) can access this portal in order to upgrade and maintain the system and perform housekeeping

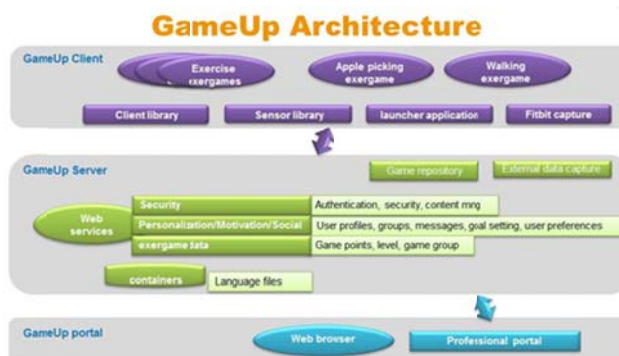


Fig. 2 Overview of where the GameUp components are located with the elderly users, online and with the professional users.

IV. RESULTS

One of the main outcomes of GameUp is the developed ecosystem which consists of:

- 7 minigames for Kinect, three for balance that use the same movements, but different graphics and story, one for flexibility and three for leg strength. In the balance games the users also have to use their arms. All games can be played in four different difficulty levels; the easiest can also be played while seated.
- A walking app using Fitbit where the users can set personal and group goals.
- A professional portal where users can be registered and monitored, and game levels can be chosen.
- An administrative portal where parameters can be set, for instance to make an exercise program consisting of a sequenced set of the minigames, the length each game should be played, etc.

To this extent, a number of research outcomes were utilised and contribute towards the creation of the GameUp ecosystem.

A. Usability testing of exergames

Both professional and end users participated in usability trials of the developed exergames to ensure that they met the requirements for exercises, and that they were easy and fun to play. This gave feedback to the developers who made several changes. A number of trials and usability testing were made and they are described in [13]. Several methods were used depending on what we were testing and at which phase, such as structured and semi-structured interviews, observations and group discussions. Questionnaires were filled in using structured interviews because of the age of the users.

B. Exergames development protocol

A protocol for developing exergames for elderly was developed during the project. The protocol is based on a user centred design protocol specifically developed for elderly since we realised that elderly are different from the young and follows a 4 phases approach. The GameUp project aims for the protocol to act as the pilot on developing exergames for elderly since it was proven successful in our case. It also emphasises the special needs of the elderly; for instance they get tired much faster, groups have to be smaller, etc.

C. Motivational framework

Motivation is important to be physically active, and a motivational framework was defined and used in the development of Kinect exergames. The Motivational framework utilised a number of persuasive strategies based on positive reinforcements, the users' past behaviour, social influence, feedback and personalisation. This is described in [14] and demonstrated in [15]. Also the walking app utilised a motivational framework using some of the aforementioned strategies.

D. Adherence to exergames in rehabilitation

In a rehabilitation setting, exercise programs should be performed at least 150 minutes of moderate intensity or 75 minutes of high intensity per week [16]. In order to increase the quantity and duration of therapy offered, patients are prescribed self-regulated exercises in addition to therapist supervised sessions. Exergames may be an attractive opportunity to increase the elderly's motivation for self-regulated exercises [17].

To evaluate whether elderly patients in rehabilitative settings show higher adherence to self-regulated training when playing Exergames than when performing conventional exercises we designed a clinical trial [18].

Preliminary results obtained from 51 patients (23 male, 28 female) with a mean age of 74 years (sd 6,3) showed in a per protocol analysis no significant differences between exergames and conventional training in mean exercise time (483 min. [sd 104] vs 563 min. [sd 189]), mean walking time (318 min. [sd 281] vs 238 min. [sd 174]) and a significant ($p < 0.05$) mean higher fun (24.3, [sd 6.5]) in the exergame group compared to the conventional exercise group (20.3 [sd 4.1]). Balance capabilities increased significantly ($p < 0.05$) within both groups.

V. DISCUSSION

The work plan of the GameUp project included an activity to design and generate a methodology and procedures for the testing processes of all developed applications.

The end users were central to the GameUp implementation. Initially partners defined and identified the kind of end-user that were involved in the project's tests by defining inclusion and exclusion criteria, as well as the modalities of their involvement. It was very important to take into account how the subjects were interacting with the serious games in a safe and comfortable way and which problems and conflicts occurred during these tests. The participation of the different tests was on voluntarily basis.

A. Sustaining mobility and improving quality of life

A regular exercise group was established that met for all the three years of the project's duration, and they participated in user centred design and development. For this group the social dimension was important, but also the regular physical activity most likely was a positive contribution for them. Many also commented that they had to use their mind while playing, and this was perceived as positive. GameUp results coupled the social dimension need in exergames [19, 20].

When playing exergames also those who wait for their turn to play are actively watching and commenting, so all participants are engaged even when they are not physically active.

Since the exercises are chosen because they can help to maintain or even enhance mobility of elderly, playing the games often should help the users to manage themselves longer [21-24], and since the games are more fun to play than following exercise instruction on a sheet of paper, the chance is also bigger that they will actually be performed [25-27].

The congregation that organised the gatherings plan to continue after the project is over, using the developed GameUp exergames because they observe the usefulness and attractiveness of the product.

We think that in addition of having exergames at home, this is a very good tool to activate elderly in senior centres, and can improve the quality of life of otherwise homebound and inactive elderly.

B. Strengthening the industrial base in Europe and facilitate European cooperation

A key aspect in the project is the commercialization and developing a sustainable business model. The partners of the project are together looking for ways to take the developed products into the market. The two SMEs involved in the project have been working closely with end users and researchers to identify a business model which can sustain in the long term the provision of GameUp services. Currently, we have presented the project to several investors and are planning to create a spin-off to commercialize the projects results.

C. Legal and ethical issues

The dignity and wellbeing of the end-users was important in all phases of the project as well as in the end services. All participation was voluntarily and based on informed consent. Participants in the project explained all the rights and obligations for the participants clearly and made sure that they understood what the project was about. Privacy and control of personal data was taken care of in accordance with the laws and regulations in the participating countries.

VI. CONCLUSIONS AND FUTURE PLAN

In this paper we have described how the work and results of the AAL GameUp project by developing exergames and a professional portal with the aim to keep elderly mobile and thus manage longer by themselves.

With the rapidly aging population, Europe as well as many other countries are in urgent need of tools to help the elderly keep healthy and fit without needing more carers in a sector that is already short of resources. We think that the results from GameUp are encouraging, and that exergames particularly targeting elderly and their functionalities can help cover some of the needs. With a professional portal, GameUp can also be utilised as a professional tool in rehabilitation, ensuring a better adherence to the exercise programs.

The GameUp partners are now working together towards commercialisation of the product as the funding scheme (AAL) encourages to. The group is looking at two different solutions; one for professional use and one for use in senior centres without the professional portal. The GameUp results

are aimed to contribute towards the development of further exergames which may act as benefit healthcare services.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Corresponding author:

Author: Ellen Brox
 Institute: Norut Northern Research Institute
 Street: Sykehusveien 21
 City: Tromsø
 Country: Norway
 Email: Ellen.Brox@norut.no