A Pilot Study to Explore the Possibilities of an Interactive Multipurpose Exergaming Simulator for Senior Activation

Nurkkala, V-M.1, Kalermo, J.1, Endo Y.2 and Goto M.2
1 Kajaani University of Applied Sciences, Kajaani, Finland
2 Sendai University, Funaoka, Japan

Abstract – Globally, the population aging is causing increasing healthcare expenditure. It has been commonly recognized, that preventive actions that activate aging people to exercise more is the key to reduce the demand for health care. Our objective was to explore the possibilities of exergaming simulator as means of elderly activation and promoting physical activity. This paper presents the pilot study carried out in Funaoka, Japan, to explore the possibilities and usability of the exergaming simulator in activating Japanese elderly people in their physical and cognitive capabilities.

Keywords: Exergaming, interactive, aging population, senior activation, simulator

1 Introduction

Nearly all countries in the world are facing the phenomenon of population aging. According to the United Nations, the number of older persons (aged 60 years or over) is expected to more than double globally, from 841 million people in 2013 to more than 2 billion in 2050 [1]. The aging of the population is associated with higher health expenditure as elderly people are more likely to demand more health care than do younger adults. Japan, which is the most aged country in the world, spends about $3,120 per capita on health [1]. It has been commonly recognized, that preventive actions that activate aging people to exercise more is the key to reduce the demand for health care. This has motivated companies and research organizations to develop new products and services that activate physical and cognitive skills, and aim having a positive effect on the health and wellbeing of people.

New technologies and applications for health and wellbeing are introduced to markets in an increasing speed. Among others, exergaming is rapidly growing market sector. According to Oh and Yang, the most common definition of exergames is “video games that require physical activity in order to play” [2]. In this article, we define exergaming as playing a video game solution which inspires and motivates people to exercising by taking advantage of different technologies.

With the increasing fight against obesity, inactivity and increasing healthcare expenditure, as well as the trend of seeking for healthy lifestyle, the exergaming market is likely to expand quickly and create new markets. The market volume of serious gaming, in which exergaming plays a notable role, is estimated to be $4.8 billion up to $12 billion, and the markets are expected to have annual growth of 15% up to year 2017 [3]. Augmented and virtual reality, and the interaction enabled by these technologies, may well be the next revolutionary feature in fitness and wellness products and services. Since 2013, partly as a response to the prospects of future demands, we have been developing an interactive multipurpose simulator for exergaming.

The aim of the development was to provide motivating and inspiring content for people who exercise with cardio devices. Video films have been integrated with e.g., exercise bikes and treadmills, which are likely to make training more appealing than cardio training without the video scenes. However, most of the available solutions lack one widely appreciated feature, interaction. In addition, most of the available solutions are linked to a certain device. Our objective was to create a multipurpose solution that could be easily integrated with versatile cardio and rehabilitation equipment as well as be suitable for different target groups.

In this paper we will first discuss the existing research on exergaming. Next we will present the software and hardware of our exergaming solution. We have created different content and exercises for different target groups and integrated the software with various equipment such as treadmill, exercise bike, cross cycle, and restorator bike. With different screen solutions, varying from virtual reality goggles or one small screen to three wall projection cave, sounds of nature, and motion control with Kinect controller, we have been able to provide immersive and interactive exercising, rehabilitation or physical activation experiences to people of all ages. We have been exploring the utilization and usability of the exergaming simulator for different uses, such as gym training, senior activation, stroke rehabilitation, exercise testing and exergaming for children. We will briefly present the pilot cases that we carried out within the development process to explore the suitability of our solution for different target groups, and present more thoroughly the pilot case in which we explored the possibilities of our exergaming simulator for senior activation.
2 Research on exergaming

Several research groups, individual researchers and laboratories have concentrated on the scientific study, development, and/or testing of exergaming products in order to examine possible benefits of the use of the exergame devices. Yet, the experimental research on exergaming is rather limited. The research has concentrated, for example, on possible physical and psychological benefits of exergames for different ages (e.g., children, seniors) [4][5][6] and for different target groups (e.g., inactive children, rehabilitation groups) [7]. Also the use of virtual environments in exercising has been studied [8]. The results indicate generally that exergames have positive psychological and physical impact to the studied groups. The studies have shown, for example, an increase in the exercise motivation [9], physical activity [7] and energy expenditure while playing exergames [6][10] as well as improvement of the balance [5], mood and attention after playing [11]. However, also some studies exist with no clear evidence of the benefits [12], but no harmful effects have been reported.

3 Description of the interactive multipurpose exergaming simulator

Our exergaming simulator is based on Unity game engine. The software includes various virtual environments with a free run option in which the user can explore the area freely, or use several routes of different lengths and difficulty levels. The first available virtual environments included Finnish forest and city environments, a tropical island and mountain scenery, but recently several new virtual environments have been added to the software. The software also includes variety of exercising modes, such as jogging, biking, orienteering and adventure. Gaming plays a major role in all exercising modes. For example, it is possible to challenge a friend in an adventure game or in future, participate in competitions in which several people are participating via Internet. Also in fitness testing the users may challenge themselves or their friends by competing against avatar characters based on their previous exercise results. The different exercising and rehabilitation devices are integrated with the software with a small in-house developed device called Athene Communication Device (ACD). The ACD enables the connection between the cardio device and exergaming software in a way that the speed in the virtual environment corresponds with the speed of the cardio device. With Kinect motion controller, the users use gestures to control the direction in which the virtual environment moves (Figure 1).

4 Pilot cases

The exergaming simulator has been piloted for various target groups and purposes during its development in 2013-2014. First, the exergaming simulator was piloted in July 2013 as an orienteering simulator during the World Orienteering Championships in Vuokatti, Finland. The second pilot case was carried out in Health Club Hukka, Oulu, Finland for gym users, following by a pilot case in which the exergaming simulator was explored for exercise test use in Vuokatti Olympic Training Centre in Finland. The fourth pilot case was targeted to kids and youngsters while the exergaming simulator was tested in Angry Birds Vuokatti activity park in Finland. These pilot cases are presented in our previous article [13]. Finally, the exergaming simulator was piloted for stroke patient rehabilitation and senior activation purposes. In this paper, we concentrate on the pilot case in which we explored the possibilities and usability of the exergaming simulator for senior activation in Japan. The pilot study was made in collaboration with University of Sendai.

5 Methods

The aim of this pilot study was to explore the possibilities and usability of the exergaming simulator in activating Japanese elderly people in their physical capabilities. The experiment was carried out at Sendai University in Funaoka, Japan in September 2014. Subjects’ task was to explore the virtual city and play Collecting Bananas game. Some of the subjects also carried out an extra task, which included wandering in a virtual Finnish forest environment. The exergaming set up included OxyCycle 3 restorator bike for arms and legs, the legs-option was used in this study (Figure 2); PC and the exergaming software; Athene Communication Device (ACD) card to integrate the restorator bike with the exergaming software; video projector and screen; and Microsoft Kinect motion controller.
Twelve (12) Japanese elderly people participated in the study (8 females and 4 males). The average age of subjects was 75.4 years, the youngest being 64 years and the oldest 87 years. The subjects were divided into two groups. Group 1 consisted of subjects (n=5) who either lived or visited regularly in the elderly people day care center and were provided with relatively good facilities and possibilities for daily exercising and rehabilitation. Group 2 (n=7) consisted of people who were living in a Tsunami shelter, in where they had rather limited space and limited possibilities to do exercising.

Three of the subjects had played computer games, mobile games (mobile phone or tablet) and/or games with game consoles (e.g. Nintendo, PlayStation) before (one reported “I have tried a couple of times”, one reported “I play several times per month” and one reported “I play every week”). Two of the subjects had experienced virtual environments before. Four of the subjects had tried a restorator bike before.

None of the subjects reported having any illnesses or other constraints that prevent his/her physical activity nor any illnesses or other constraints that prevent using the restorator bike in the testing. A health check was carried out before the test (incl. blood pressure and questionnaire). After the health check, the exergaming simulator equipment and tasks were introduced to subjects.

The first task (Task 1) was designed to get the subjects familiarized with the exergaming simulator. The task was to navigate in the virtual City of Kajaani, where the route selection was made in the crossroads. The choice of the route was tracked with Kinect motion controller which recognized the body gestures. The left turn was caused by raising left hand and right turn by raising right hand. If the subject did not raise either hand, the route continued straight forward. The task lasted no more than three (3) minutes.

The second task (Task 2) was to collect as many bananas as possible within 2.5 minutes (Figure 3). Different routes were made in the virtual city of Kajaani. In each route, there was a certain amount of bananas in the middle of the street to be collected by going through them. Each banana was worth of one point and only a limited number of routes could be chosen. Depending on the route choices and the speed, it was possible to collect more or less points. The game stopped automatically when the time limit was reached or if the subject reached the last point in the virtual map. Each subject had three trials, thus it was possible to memorize whether the route selections in the previous trials were good or not. After each trial in this task, the number of collected bananas was shown on the result screen. The distance, max speed, time, collected points and average pace (minutes/kilometers) of the subjects were measured in each trial to see if there are some changes in these values between the trials.

After finishing the first two task, the subjects were interviewed about their experiment. The interviewer asked subjects’ subjective evaluations of the usability of the system and how fun did the subjects consider different features. The subjects were also asked for development ideas; what kind of features would they wish to see in this kind of exergaming simulator.

After the interview, the Group 1 (N=5) was offered the bonus task in order to get feedback of other kind of exercise. The bonus task included a Finnish forest route (Figure 4) in which the task was just to wander in the forest where the birds were singing. The route was so called restricted route, where it was not possible to choose the direction but the character followed the route automatically. This exercise lasted for 3 minutes.
6 Results

The aim of task 1 was to get the subjects familiar with the exergaming simulator. For some subjects there were some difficulties to change the direction in the crossroads, but in most of the cases the subjects did not encounter any difficulties performing the choice of direction. After performing task 1, all the subjects knew how to use the exergaming simulator and were ready to move to task 2. The task of exploring the virtual city was considered fun by the subjects. The grade for task 1 was 4.4 points (“Exploring the virtual city was fun”; on scale 1-5, where 1 = totally disagree, 5 = totally agree; N=12).

In task 2 (Collecting Bananas game), remarkable change of speed between trials was noticed (Figure 4). All of the subjects raised their speed during the three trials. Also the number of collected points increased along new trials. The average of collected points of all subjects was 13.7 points in trial 1 and 16.3 points in trial 3. Thus, the average increase in collected points was 2.6 points (19% increase in collected points). The average distance of all subjects in trial 1 was 550 meters and in trial 3 the average distance was 610 meters. Thus, the increase in distance was in average 60 meters (11% increase in the distance). This can be well seen in the decrease in pace between the trials. The Figure 5 shows the changes in the pace (seconds/kilometers) from trial 1 to trial 3. The smallest change was three seconds per kilometer decrease in pace whereas the biggest change was with one subject, who did the last trial with 2 minutes 24 seconds per kilometer faster pace than the first trial. The average change in the pace was 43 seconds/km. The decrease in pace could be related to subjects’ better understanding how to move and change the direction (learning effect); the increase in the encourage to use device, but also in the competitive instinct that aroused in some subjects.

The task 2, Collecting Bananas game, was considered fun by the subjects. The overall grade for Collecting Bananas game was 4.6 points (“It was fun to collect the bananas”; on scale 1-5, where 1 = totally disagree, 5 = totally agree; N=12).

Finally, the overall grade for wandering in Finnish forest environment (Task 3) was 5.0 points (“It was nice to move in the virtual forest”; on scale 1-5, where 1 = totally disagree, 5 = totally agree; N=5). None of the participants reported simulator sickness symptoms during or after experiments.

7 Conclusions

The Japanese seniors who participated in this experiment were in general in relatively good physical shape. They found the exergaming simulator as a motivating and appealing means to do physically activating exercises. However, in order to make better conclusions of usability and benefits of the exergaming simulator for elderly people, more research is needed. It would be interesting to add biometric measurements in the study protocol, such as heart rate monitoring, recording of muscular activity and tracking the eye movements. These biometric measurements could give a deeper insight for instance to user experience as well as physical and mental workload. It would also be very interesting to explore the differences between e.g., Japanese and Finnish cultures in the use of exergaming for seniors.

Subjects commented that they would wish to see e.g., flowers in the virtual environments. Many of the subjects mentioned in the interview, that seeing moving objects (e.g., cars, walking people, birds, squirrels and other animals) in the virtual environment would be nice. Exercising with the exergaming simulator and virtual environments was generally considered fun and motivating, and most of the subjects stated they would like to use this kind of exercising environment also in the future.
Acknowledgements

The multipurpose exergaming simulator has been developed at Kajaani University of Applied Sciences in collaboration with University of Jyväskylä and University of Oulu. Numerous companies have provided their expertise and resources for the R&D. We are grateful of all the support we have received from our partners. The research and development of the exergaming simulator has been funded by European Social Fund, European Regional Development Fund, Finnish Funding Agency for Innovation (TEKES), Joint Authority of Kainuu and numerous companies.

References


