Experience with a 3D Kinect Exergame for Elderly

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Keywords: Exergames, Serious Games, Senior Gamers, User Centred Design, Elderly, Kinect, 3D.

Abstract: Physical activity is important for all, but for the elderly balance and sufficient strength is vital to function in daily life. It can be difficult for all of us to find motivation to exercise at home, and seniors are no exception. We have experienced that exergaming can be motivational for elderly since it is fun, but most commercial games are not optimal for elderly due to speed, required movements, colours, the amount of information, etc. In a project we designed an exergame specifically with the elderly in mind based on user requirements both for specific needs for elderly, for games in general and for good exercises. A first prototype of an online 3D exergame using Kinect™ was developed and tested on a group of six seniors. Kinect™ was chosen since after our experience users in the target group can handle exergaming with this technology, and also it is possible to control that the exercises are performed correctly. Our aim was to investigate how seniors would react to a 3D first person environment before we continued the development. A user centred method was applied in the design and development, and the user test is part of that. The results are encouraging.

1 INTRODUCTION

Physical activity is important at all ages, but elderly often get into a vicious circle where fear of falling leads to less physical activity and reduced strength and balance, which again lead to a greater risk of falling. Falls are among the most common reasons for medical intervention in the old (de Bruin, Schoene, Pichierri, Smith, 2010). To motivate to do physical activity in a fun way, some senior centres and old people's homes are using exergames (Brox, Luque, Evertsen and Hernandez, 2011).

Exergames is a term used for video games that are also a form of exercise, and it relies on technology that tracks body movement or reaction. Particularly two platforms are being used: Nintendo® Wii™ and Kinect™ for Xbox. The exergames made for these platforms are made for a younger audience, and there are several obstacles for elderly users. Speed can be a problem (Wollersheim et al, 2010, Theng et al, 2009), the games can be too difficult (Anderson et al., 2010), or the games do not satisfy specific needs of elderly regarding for instance eyesight, fine motoric skills, the need for less information and more time to get an overview, etc. (Brox et al., 2011, Gerling et al., 2010). Studies show that exergames can be used for balance and physical exercises (Wollersheim et al, 2010, Rendon et al, 2012, Chao et al, 2013, Williams et al 2010, Billis et al, 2010, Jung et al, 2009, Theng et al, 2009). Also (Larsen et al, 2013) made a review study of controlled trials where six out of seven papers showed a positive effect of the intervention with elderly using exergames.

Our aim is thus to make an exergame for elderly that gives good exercises that are beneficial for the elderly and, at the same time is both suitable for the target group and fun to play. The game must be easy to use for the target audience but, at the same time give users enough challenge to want them play several times. According to our user tests seniors enjoy both some of the commercial Nintendo® Wii™ and Kinect™ exergames in tests we have performed but, we have also experienced that many have problems of the aforementioned types. Particularly it can be difficult to understand what the game is about and be able to notice information that is popping up for instance in the corners.

Playing an exergame can be a way of motivating elderly to exercise more, since this is perceived both as fun and useful by the elderly that we have talked to during the project.

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2 METHODS

User centred design was used in the development. End users participated in the requirement phase, as well as in the design and the development phases of the first prototype. Typically a mixed method is used in user centred design.

2.1 User Requirements

The first step in the game design was to collect basic requirements for our target group. We started with collecting requirements from literature, and together with our own experiences this forms the background for the game design. In the project we have experience in playing commercial Nintendo® Wii™ with seniors, and, in addition we have also had two groups of old seniors trying both Wii™ and Kinect™. The movements of the game story were accepted by the physiotherapist in the project. Via observations, group discussions and interviews, these experiences also contribute to the requirements.

2.2 Design and First Tests

A game story was developed that took into account the requirements and exercises that are suitable for the target group. The story was discussed and adjusted in the project group, and a first version of a game was designed and developed.

Early versions, also multiplayer, were tested on senior colleagues (60 and above) since the versions were too unstable to test on even older persons. A group of six seniors with an average age of 80 were then recruited to test an early demo in single player mode. They gave valuable feedback, particularly on the colours and graphical layout. Several graphical elements were changed before the lab trials.

2.3 Lab Trials

The same six seniors later participated in a lab trial where they played the first prototype consisting of three mini-games. The game was also this time played in single player mode. Only two had tried Kinect™ before (in our first test), but all of the participants had been playing Nintendo® Wii™ games. Since the main goal was to test the gaming concept, researchers handled the technology and the participants only had to use their hand and body movements to give input to the game.

The players would come one by one into the test lab. First a researcher explained the gameplay to the participant, and then the play started. The players also got some instructions during the gameplay if they had problems.

Ideally, the Kinect™ should be calibrated for each user since the body is used for input. This calibration includes the height of the person and the length of the arms. This means that each user calibrate and adapt to the game before they play, and possibly also create personal user profiles for later use. This was not done for our game; instead it was developed to not be very sensitive. Still this could mean that the gameplay was biased and would be easier for some than for others. Our game tracked the users' movement ranges: how far they put their hands above their heads, how close their knees were to their hips in a vertical axis, etc. These parameters were not registered or analyzed; they were only used to perform actions within the exergame.

2.4 Data Collection

All participants signed an informed consent before the trials. They also filled in a questionnaire with background information such as age, gender, game experience, exercise habits, etc. The study was accepted by the Norwegian Social Science Data Service.

During the lab test researchers filled in an observation protocol for each of the players. After the testing the participants went through a structured interview where questionnaires regarding their experience were filled in with the help of the researchers.

When the lab test was over we had a group discussion where all six players were asked about the game and how they felt when they played.

3 THE USERS

The participants were recruited at a senior centre offering weekly Nintendo® Wii™ exergaming for seniors. The members of the group that was playing were informed about our work and were first invited to participate in a pre-trial, then a lab trial with a slightly moderated version. The users participated at their own will and there were no health care personnel involved in this phase.

We only managed to recruit six users for the lab trial. They were between 76 and 83 years old, two men and four women.

All of the participants had a mobile phone, all of them used it for calling, five for messages, four used the clock function and the calendar. None of them

were using the phone on Internet. Four in the group had a PC but only three were using it, two of them several times per week, the latter more seldom. The PCs were used for e-mail, paying bills, reading local news, and one was on Facebook.

4 BASIC USER REQUIREMENTS

Basic user requirements when designing games for elderly were identified. For instance, seniors we have talked to say that they want to feel that the game is good for their health, so the game must be designed with exercises that are useful for their balance, flexibility, strength or endurance. For the exergame to be a game, it should also have some challenges and be fun to play.

For this target group it is also important that it is playable with a variety of physical and cognitive ailments. For instance the players should be able to play in their own pace, so the speed should be adjustable. The game should also allow the players to take pauses, and there should be different levels for people with varied physical abilities. The game should of course also be safe to play.

Also there must not be too much information at the time, and there should only be one focus of attention, meaning that the players shall be able to play without having to consider extra information for instance in screen corners. The graphics should be designed so that elements are big and clearly visible. In addition we wanted a game that could enable communication and social contact, so that it can be played together from different locations.

5 THE GAME

5.1 AntiqueHunt - the Game Story

A game story including both social elements and selected exercises was made. In the game the seniors were supposed to collect antiques in an old house, and different rooms give different exercises, for instance stretch to get items from a shelf, bend down to pick up items from a chest, walk up the stairs to the attic, etc. The first scene was also supposed to work as a lobby where players can meet each other if they play P

The players meet outside in a garden. In the multiplayer mode they can see each other and hug and wave at each other. A key is hidden somewhere. The players have to turn around and look for it, and

then walk up to it. When the first person reaches the key, the house is opened and the players will find themselves in the next scene which is a room in the house. They will no longer see other players. One reason is that this makes it easier to focus on the gameplay. Another reason is that some might find it embarrassing if others see how they perform.

The players will move from room to room to collect items. In one room they are supposed to stretch to collect things from shelves, in another to bend down to pick items out of a chest, and in yet another room they are supposed to stand on a chair to stretch to take pictures from the wall. The story also contains stairs where they can climb to the attic. When the players have gone through all the rooms, they meet again in the garden to see what they have gathered and get their game rewards. They again have to look around to find the collected items and walk up to them to get an overview of what they have gathered – and get the game rewards.

The game shall be customizable, meaning that the number of scenes (rooms) and the duration or number of items can be adjusted to each (group of) player(s). The game proceeds at the speed of the players. For instance when they are looking for the key, they can take the time they need, and when they look for antiques in the room, a new item will not appear until the previous is taken.

5.2 Game Design and Platform

The game was designed according to a physiotherapist's recommendations. The elderly first perform "warm up" exercises where they do soft exercises like hugging and walking. Then there are exercises for stretching and bending their body. Finally, there is a cool down phase where they can discuss how they felt and exchange their experience in the game.

From a technological point of view, the game was developed using a full JavaScript stack. To store the user's information, such as their name, their previous scores and what group they were prescribed to play with, we needed a database. To keep in line with the JavaScript stack we used MongoDB, a cross-platform, document-oriented, NoSQL database.

We used Node.js as the server side platform along with SocketIO as a method to network the data. Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient, perfect for data-intensive real-time applications that run across distributed devices, making it perfect for streaming real time joint data to multiple clients. The

rendering of the data was handled in any WebGL capable web browser by a WebGL wrapper called Three.js, which was then displayed via HTML5. These coupled with the Kinect SDK and OpenNI to gather the joint data of the users made up the full list of the main technologies used.
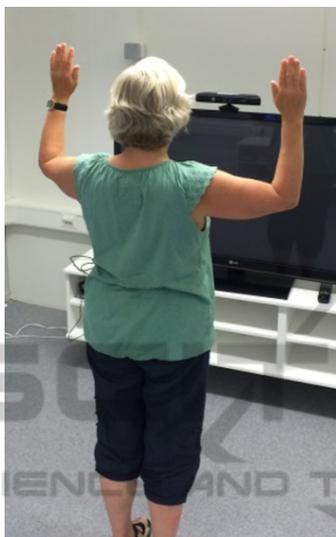
Figure 1: The start pose.

5.3 Game Poses

To start the game, both arms should be lifted as shown in figure 1. A pause pose is implemented, and this is the standard pause pose for Kinect^{TM} – i.e. the arm is held in 45 degrees from the body. This is shown in figure 2.

Figure 2: The pause pose.

To turn to the left, the player has to lift the left arm, and to turn right the player has to lift the right arm. To move forwards, the player has to step in

place. To grab items coming towards them from the ceiling, they have to lift both arms.

5.4 The First Demo and Prototype

A first demo was made and tested on a user group. The demo was pretty rudimentary, but enabled us to try out the concept on end users as part of a user centred design and development. This demo consisted of three scenes: the first was in the garden where the players should find the key, the second was in a room where items were collected from above the player and, the third was back in the garden, but this time the players had to search for the items that they had collected and walk up to them. The game was played in single player mode, since we first wanted to capture the reactions on playing a 3D game, and the main game concepts. The game requires correct movements, for instance items can only be collected if the arms are raised. It is possible to register game activities, but this was not done in the first prototype.

Graphical elements of this first demo were changed after a session with seniors. Please see figure 3 that shows colour and texture of the lawn, figure 4 shows that we made changes in the room and, figure 5 shows the colour and size of the key and the avatar. Still the graphics will need to be changed in a later version. After the changes were done, we had a lab test with six users.
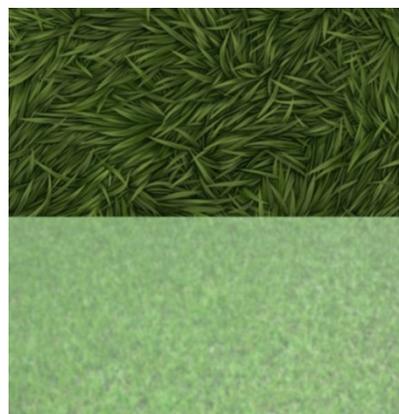

Figure 3: Grass on the lawn before (top) and after changes. The dark colour and texture of the grass made it hard for the elderly to see, so we made the grass lighter and with less texture.

5.5 The Lab Test Setup

The lab test was performed in the premises of the researchers. Three rooms were set up for the lab test:
1. A lab where the tests were performed.

2. An interview room where one researcher would be together with the user who had just performed the test
3. A waiting room with coffee available for those who either waited for their turn or were finished with the trial.

Figure 4: The walls in the room before (top) and after changes. Also here the users found the pattern too dark and disturbing.

Figure 5: The avatar and the key in the lab test version.

Also the lab test was performed in single player mode since adding remote players would make the game more confusing, and we wanted to test how they reacted to the 3D game environment.

One researcher was taking care of the technology for all the participants in the trial. One researcher would watch and fill in the observation protocol.

6 RESULTS

All six got help to select player and start the game and all played the game to the end without any other help than oral guidance. The users did not operate any menu buttons in this first prototype, all gameplay and interactions were via poses and body movements. The main results of the trial were encouraging, the players both found it fun and easy

to understand how to play, and they also found that the exercises were useful.

6.1 Interacting with the Game

All agreed (one strongly) that it was easy to navigate in the game, but all except one also agreed that it was confusing with all the different poses. One also said that it was difficult to see, and particularly to read the text, because of cataract. However two found it difficult to understand the rules at first.

These findings were confirmed by the observation protocols. Some players had initial problems, three out of the six had to repeat actions, but we observed a learning effect by all the players except one who did not have problems. The players found the avatar ugly, but they still understood that the avatar was mimicking their own movements.

6.2 Game Exercises

Since this was a lab test to see how the players react to this kind of exergame, there were no physical measurements and also no physiotherapist present during the testing. However, we wanted to know whether the seniors themselves perceived the exergame as real exercises, and their perceived usefulness of the game is summed up in Table 1. All six found that the exercises were good for them and that a game like this was useful. We also wanted to know if they would recommend the game to friends, since this gives an indication about how they find it. One would not recommend it, the other five would.

One also said that it is important to move all the time, and that through exergaming they would do exercises they would not have done otherwise.

A woman who had osteoarthritis said that the exercises were good for her. One even said that she got exhausted because it was so hard to get the key and therefor she had to walk a lot.

Table 1: Perceived usefulness of the game as physical exercise. Number of persons who **1**: disagree strongly, **2**: disagree, **3**: neither agree nor disagree, **4**: agree, **5**: strongly agree.

	1	2	3	4	5
It is easy to perform the exercises				2	4
The exercises are good for me				1	5
I feel safe when I play the exergame				2	4
The game is useful for me				2	4
It is easy to understand the game rules		2		2	2
I liked to play the game				2	4
I would recommend this game to friends		1		4	1

We asked what they liked the most, and we got two replies; one said the arm movements were the best while another one liked best to find the key; and this latter was the one who had the biggest problems finding it.

We also asked whether they would prefer to exercise at regular times, and four out of six confirmed that they would.

6.3 Other Issues

Some other issues also emerged during the observations and interviews. The main impression based on the observation protocol is that all were very eager during the play. They seemed interested, and played through the entire game.

All six found that the graphics were OK in the new version and, that it was easy to get an overview (three agree and three strongly agree), but one out of the six thinks there was too much information. Five also agreed that they liked the music while one was neutral – he told that he had not noticed that the game had background music, since he was preoccupied with the gameplay.

One person would like more rhythm in the game and one had problems catching the key. Another one tended to walk forwards and had to move back. One person also forgot how to turn, but all learnt during gameplay.

A general observation is that all the players seemed to find the game fun. We noticed that our game had problems registering the walking of particularly two women. We don't know why, but it could be that the game was not calibrated to their bodies. They did not wear skirts or clothes that might disturb the way they are tracked by the Kinect™ camera.

Also at the end they wanted to stay in the garden and walk around after they had found their collected items and received the final reward.

In the group discussion we tried to get some comments about the difference between the Wii 2D games they were used to play, and this new 3D game. Some had not noticed the difference and some said the 3D game was more challenging. All the players agreed that the avatar was ugly, but they liked that they could play at their own speed.

7 DISCUSSION

7.1 Playing a 3D Game

The participants enjoyed the game prototype, but they also found it challenging. This is in our opinion a good thing, since gameplay is about learning and mastering. If it is too easy the first time, they will get bored quickly.

Also the interface gave some challenges. To start with the participants had some problems moving around in a 3D environment. However, they seemed to learn pretty fast, although some of them moved too much around on the floor and ended up too close to the camera. One participant even wanted to move around in the 3D environment to search for the key, and the others wanted to stay in the game garden after the game was over. We think this shows that the players liked the 3D environment. Maybe this environment gives the game more life and in particular makes the game environment more similar to real life? We feel that a 3D exergame can be further investigated for this target group.

Figure 6: Collecting items in the room.

Some found the different poses confusing. Since this was the first time most of the players tried Kinect™, it was probably a bit overwhelming both to learn how to control the avatar and to play the game. (Juul and Norton, 2009) point out the border between interface and gameplay is not always clear, and when the interface is a totally new technology for the players this is important. Since they learned during the gameplay, we think that they also will get familiar with the poses if they play regularly.

The game should also have been calibrated to each person, which we did not do because of time constraints. This fact could explain the previously stated difficulties a couple of our players had.

Many in our target group have problems with lifting one or both arms, particularly above the shoulders. It should be possible to personalise the game, for instance, by calibrating each user's possible range to lift the arms. In this way we can ensure that all are able to play with their abilities.

7.2 Graphics

The first graphics were not made particularly with elderly in mind. In the first version it was more important to make the game mechanics work. The graphics of this version were thus rudimentary and the players had problems to see items due to patterns, colours and sizes. We also had some comments about the ugly avatar that was basically an avatar skeleton mimicking the users' movements.

7.3 Exercises and Usefulness

The main purpose of the exergame is to motivate to physical activities. The players reported that they felt that this game gave good exercise, and they particularly liked that they had to use their arms.

We could observe that some got exhausted by walking, since they had to step in place in all three scenes. In this first version they can wave and hug themselves in the first scene, but it is only in the room scene that they really get to use the arms. With a careful design of more scenes, we think that this game can give a varied set of exercises and still be fun to play. However, this must be tested with a more mature version and with a larger number of players over time.

7.4 Social Gaming

The game was originally designed as a multiplayer game, and this has been tried by researchers, but not yet by the main target group. So as to not embarrass or disturb the players, they are only supposed to see the other players in the first and last scenes, while in the "real" exercise scenes they can perform the exercises at their own speed and level without anyone seeing what they do.

To be able to play simultaneously, the players have to agree upon a time to play. We think that it can be motivational to see that others also are coming to the training sessions, but this still remains to be demonstrated. Also most of our test persons said that they would prefer to train at appointed times. In a multiplayer mode you can play at set times, and also see who else are playing.

7.5 Other Issues

One of the players wanted the game to contain more rhythm. This is not in the current game design, but for instance, it could be possible to include a room with dance music where the players can move to the rhythm.

One person also asked for the key to be randomly placed, and maybe it would also be possible to create an exercise scene where the players have to search for items behind things. This can also be considered in a future game design.

8 CONCLUSIONS

The main conclusion is that seniors can grasp a 3D gaming environment as in our game quite easily, and they can learn how to navigate around and play with different poses and body actions. They also find it challenging and fun, and many would recommend it to friends. This means that the game could be motivational to play. We also see that they actually have to perform the correct movements to achieve the game goals.

We know that many elderly play commercial exergames regularly on senior centres and nursing homes, also Kinect[TM] games. We do however think that many of those games are not suitable for our target group. The game prototype gave the players the possibility to have only one focus of attention, and they can take the time they need to manage the tasks, and the trials were promising. In a later version we must however spend more time on graphics and colours. Also the avatars should get a facelift since they actually represent the players.

We also think that this gives a better opportunity to implement exercises that are useful for the elderly, and they will be able to perform more controlled movement. It should, however, be possible to have a chair for support for those who might be afraid to fall. Nevertheless, we realize that we need to spend time on calibrations, since some had problems interacting properly with the game.

Last but not least – a game must still be a game even if the players are old. There should be goals that are hard, but not impossible to reach, there must be challenges, and a game both needs good feedback during play and rewards when the goal is reached.

In future work the game should be further developed with more scenes, better graphics and the possibility to make user profiles and maybe personal avatars. Studies should both consider whether the game can motivate to increased physical activity, including in multiplayer mode as well as if the game has a physical effect.

ACKNOWLEDGEMENTS

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