

An Approach of Indoor Exercise: Kinect-Based Video Game for Elderly People

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Abstract. Exercising is essential for elderly people to maintain their health in a good condition. However, elderly people usually have a tendency to stay at home due to their physical limitations or limited weather conditions in which they are willing to go outside for exercise. In addition, elderly people are easily injured with heavy exercise equipment, which also makes them reluctant to exercise. In this study, we followed the process of “user-centered design” in developing an indoor exercising video game using the Kinect system to overcome aforementioned problems. We first investigated user requirements based on interviews with real users and then developed a Kinect-based game for elderly people. We lastly evaluated the usability of the game; the results show that the Kinect-based indoor exercising game can be effectively used for better exercise, entertainment, and communication.

Keywords: Kinect, elderly people, indoor exercise, augmented reality, user-centered design.

1 Introduction

Because an adequate volume of physical activities everyday helps individuals keep healthy, physical exercise could be crucial to people’s health, especially to those who are older than 65. However, it’s really challenging to maintain a tight exercise schedule for them [1]. Elderly people are often unwilling to go outside considering their limited physical conditions. In China, the situation of severe air pollution becomes another reason. Although elderly people hold a positive attitude toward exercise, they can hardly find any motivation for sports, and the fear of injury could be another hindrance [2]. Thus, there is a potential demand of designing an interface to take indoor exercise for elderly people who are either unwilling or not able to go outside.

The key procedure of designing such an exercising interface is to find motivation factors for elderly people [3]. Previous studies [4, 5] showed that games are effective in motivating exercise and increasing exercising time. We used the user-centered design approach to innovate an interactive sports game for elderly people to encourage their exercises at home and meanwhile provide them with great entertainment. Their body movements in front of the Kinect sensor are tracked and projected to a TV

screen where they can see themselves in the game background. The Kinect-based video game, both easy and interesting to play, is considered to be very helpful in motivating elderly people to exercise at home as well as enriching their daily lives.

This article firstly introduces an analysis of interviews we conducted with elderly people. We collected their opinions and preferences for both outdoor and indoor exercise to generate a list of requirements which is used in the later design of the game. Shortcomings of current indoor sports equipment are summarized with a brief introduction of the Kinect-based game in Section 3. A detailed illustration of the design of the Kinect-based video game is then presented. Some improvements based on a usability test are suggested. Discussion and conclusions are summarized in the last section.

2 User Requirement Gathering: Interviews

To study user behaviors of outdoor activities and demands for indoor exercise, we conducted a series of interviews with 10 senior citizens in March 2013. 4 males and 6 females, in the ages of 65 to 80, participated to answer a list of 22 questions about their current exercise situations and concerns they had when doing sports. All subjects were recruited and interviewed in a local park in Beijing, China.

During the interviews, we mainly investigated their hobbies, frequency, duration, and volume of exercises, influence of air pollution, attitude toward indoor exercise, and type of indoor exercise they prefer. Since peer motivation can be quite significant in doing sports, we also surveyed their relationship with children and other citizens around the same age. Additional concerns about exercise they had were also included in generating a list of requirements we need to consider in designing the game.

As identified, most subjects enjoy having exercises before breakfast in the morning or after lunch in the afternoon because the exercises do not only provide them with a way to keep fit, but also an opportunity to meet some friends and chat. As for the type of exercises, they often prefer easy and light exercises, such as taking a walk around or practicing Tai Chi in a park, because they fear to be hurt by heavy exercises and equipment that they cannot handle. Eight subjects reported themselves doing exercises for half to one hour every day while the others exercised about twice a week with less than one hour each time. All subjects complained that the serious air pollution had great impact to their exercise schedule, causing them either to decrease the frequency, duration, or the volume of outdoor exercises. When indoor exercise was mentioned, they worried about whether the atmosphere at home is suitable, since they may focus on housework and forget about exercises if they stay at home. They further added a requirement to meet old friends even though they could not go outside.

Results from the interview shed light on the demand of a new application for indoor exercise. All subjects showed interests in the idea we put forward about a video game for exercises at home and were willing to have a try. They expected to have a gaming device of good usability, great entertainment, high safety, and social connectivity at an affordable price. A list of user requirements for the indoor sports game is summarized as below.

- The game should have adequate volume of exercises to be effective, but the duration of each game round should be limited to avoid overtiredness.
- The game should be easy to start with and self-explainable. It should be easy for elderly people to understand.
- The game should have voice messages or controls considering the low-vision of elderly people.
- The game should provide different scenes for different game tasks. Different tasks should enable users to exercise different body parts, especially their legs.
- The game should encourage users to maintain a healthy schedule by doing exercises every day. But if users do not have a big progress, the punishment should not be too big.
- The game would be better if social connectivity is provided between neighborhoods, or users could share their scoreboards with each other.

3 Improvement of Existing Indoor Exercise Equipment

There are globally 841 million people who are more than 60 years old in the world today [6]. Solving exercise problems for them will give a way for them to keep fit and enjoy daily life. Currently, besides some drugs are argued to have effectiveness in keeping people fit, rare products are found to be especially designed for elderly people. However, we proposed that with the help of some well-designed devices and exercises, elderly people could be guided and encouraged to exercise safely, correctly and persistently. And most important, they could get all this done just at their own home.

3.1 Shortcomings of Existing Equipment

Current indoor exercise devices, such as the stepper, ergometer, and treadmill, do not limit their targeted users as elderly people. Thus when these devices are trimmed into an environment for elderly people, they could have several inherent drawbacks as follows.

- First, these devices basically consist of mechanical parts, and are leveled up by adding loads through fictions or masses. However, the mechanical parts of these devices or the loads may hurt them accidentally, as elderly people may have limited control abilities of body movements.
- Second, since these devices focus only on exercise itself without offering any kinds of entertainment or rewards, users could hardly find any motivation to have long-term exercise. Thus, it's hard for elderly people to cultivate a regular exercise behavior.
- Third, these devices are mainly designed for an individual user. However, people may feel lonely when they practice only themselves. Most people may have fun if they could exercise with their close friends.

3.2 Improvement Using the Kinect System

The Kinect is a world-leading sensor that has enabled a series of applications in video games. Its unique advantages over traditional indoor exercise devices could be summarized as below

- The Kinect enables elderly people to interact with game system by recognizing their natural gestures and body movements through a camera and IR sensors without a traditional hand-held controller [7] or complex operation commands, which contributes to the learning easiness for elderly people.
- Besides color map data, the Kinect could also provide depth map data and skeleton position data. By interpreting the 3D information, user's image can be easily captured, recognized and extracted from the background, which can be used in creating an augmented reality environment. Substituting the background also provides a privacy protection for the user.
- The Kinect can be connected to a PC via an USB port [7]. Because it has an SDK for application developers, more marvelous features could be developed and realized on the PC.

As a result, the Kinect has been chosen to realize most of the functions elderly people preferred, with its strong abilities in recognizing people's natural gestures and skeletons, as well as providing a user-friendly and extensible interface for elderly people. Users need no more objective game controllers. In addition, voice commands are supported, which makes Kinect the perfect choice to fit into an indoor environment in front of a TV. The prototype game is revised and improved from a set of sample codes in the Kinect for Windows Developer Toolkit, with changes to improve the game experience.

4 Prototype Design and Development

4.1 Apparatus

As shown in Fig.1, the Kinect-based prototype consists of four parts: a player, a Kinect sensor, a PC, and a display screen. The Kinect and the display screen are connected to the PC where the prototype software is running. Real-time data of image, depth, and skeleton position is obtained from the Kinect sensor and processed by the PC software. The player just needs to stand three to four meters away from the Kinect sensor in order that his or her whole body can be captured. Few seconds after the game software is started, the player skeleton will be tracked and on screen there will be a hand image to represent the mouse in a normal PC environment. The player is able to move one of his or her hands to "click" on any buttons to configure game difficulties, duration, or background music – just move the hand image onto the button and hold it for a few seconds. This set of gestures is inherited from the Kinect system library and proved to be quite natural to users. Later if a commercial game is released, an Xbox can substitute the PC and the display screen can be any displays such as a TV or a projector.

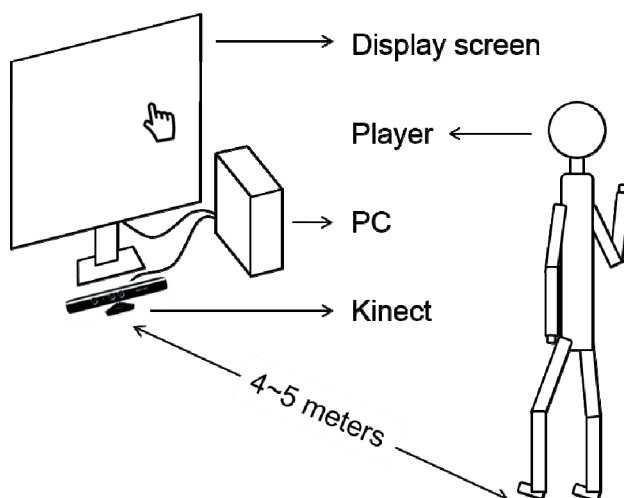


Fig. 1. Prototype apparatus

4.2 Game Design

This game has special designs for elderly people to provide exercise and fun, as well as a chance for users and their friends playing together.

Before the game starts, players could configure game intensity and duration so that it fits their individual condition. During the game, to better provide an exercise environment and protect the privacy of all players, the system plays background music and cuts the player out of his home environment, setting him on a green grass or a playground where he prefers. Then he is challenged to get as many points as possible in a given period of time (2 minutes), by hitting twice of bubbles that keep falling down from the sky. Because hitting falling objects to gain points is a common sense, it is easy for elderly people who have limited game experience to notice and understand. To increase fun during the game, bubbles are engraved with different points, both positive and negative, but covered with a question mark when first falling down. When the player hits the bubble with his or her body for the first time, the question mark disappears and the real point is shown. The player is then challenged to react soundly in order to avoid negative points and to get more positive points. Bonus points are awarded depending on different body parts the player uses to hit the bubbles. Each time the player hits the bubble, there will be appropriate a text message and ringtone to give direct feedback. The time left and score gained are shown at the corner of the screen as a motivation source. Voice commands are also supported to either pause, stop or restart the game.

Moreover, social influence is deliberately designed so that multi-player game mode generates more motivation on an individual and all players could share their best scores with friends through an online score board after the game. By setting suitable background and music to create an atmosphere for exercise and establishing a platform for players sharing their scores and view rankings, elderly people are encouraged to exercise at home for a while every day.

5 Prototype Evaluation: An Experiment

In order to check whether our design has met elderly people's demand and evaluate its usability, a prototype game was developed and evaluated by 6 elderly people (2 males and 4 females, aged from 55 to 80) in June 2013. All subjects were randomly contacted in a local park in Beijing, China.

The evaluation experiment consisted of three steps: a brief introduction to the game, one-minute game trial, and a follow-up interview to collect their comments. One experimenter firstly introduced the game, and then the subject could have a try and ask any questions. After that, the player should play the prototype game for one minute, then answered a list of open-ended questions and gave any suggestions to the game design. The game duration was set to one minute in consideration that we had one subject of 80 years old and other configurations (intensity and background music) were set the same to waive any deviations and random factors to the evaluation experiment.

Usability issues and suggestions from the subjects are summarized in the following form according to the usability dimensions (effective, efficient, engaging, easy to learn, and error tolerate) [8].

Table 1. Usability issues and suggestions from the evaluation experiment

Usability dimensions	Usability issues	Suggestions	Count
Effective	No choice on exercise intensity and duration.	Provide choices on exercise intensity and duration. (already implemented, but not available in the experiment)	3
	The sound of hitting different bubbles is the same. It's hard to distinguish.	Select different ringtones music for different bubbles.	2
Efficient	The player may need to "press" several times to start the game.	Add "quick start" mode in the menu.	1
	Setting web connections with friends is too complex.	Simplify the procedure and add appropriate voice commands	4
Engaging	Selection of background images is quite limited.	Add more options for background images.	5
	Selection of background music is quite limited.	Add more options for background music.	5
	It's boring just to hit the bubbles all the time.	Add more types of exercises and design new and difficult game levels.	2

Table 1. (*continued*)

Easy to learn	There are no teaching videos or tutorials at the first time of playing.	Add a teaching video to introduce the game	3
Error tolerant	There is no warning if the player stands too close to the Kinect sensor.	Provide a text or an audio message if the player stands too close or is untracked	1
	The negative point for “bomb” bubbles is too big.	Reduce the negative point from -100 to -50.	2

6 Discussion and Conclusions

Compared with current indoor exercise devices, the Kinect-based video game is better for elderly people in the following three aspects.

First, the video game exposes its player to less danger. Because elderly people have limited control abilities, traditional indoor exercise devices may accidentally hurt users. However, using Kinect as a sensing device, players are free to interact with the display with their body as the controller. No more physical controllers are needed.

Second, the video game offers more entertainment and thus motivations. Unlike traditional devices that focus only on heavy exercises, this game has successfully created an augmented reality environment in which players may feel relaxed and attracted by the background image and music. The mechanism of getting points and awards by exercising has helped players to increase exercise volume unconsciously. To win, as a strong motivation, also helps to maintain a long-term exercise habit for elderly people.

Third, via the online platform of the video game, players can still have fun together with their friends, just like when they exercise together outside. Current devices all work individually and keep elderly people away from their peers, which may exert a negative influence to their social life. However, the online platform offers players an access to share their scores and comments on their friends. This has not only increased entertainment of the game, but also added peer competition into the motivation, thus having a positive effect on prompting elderly people to exercise.

Although all subjects showed their great interests in the game and evaluated it highly successful, feedbacks from the evaluation experiment pointed out the directions we need to consider to further improve our game design. The game should have more deliberate designs to have levels of different difficulties and game tasks. Messages in the game should have more clear instructions than only information. And feedback should be distinguishable and consistent with what shown on the display. We are also challenged to balance between the functionality and simplicity: at one hand, we need to provide kinds of exercises that could help exercise different body parts; at the other hand, we need to keep it simple stupid in order it is easy to learn and understandable for elderly people.

To summarize it up, in this study we have carried out a “user-centered design” for the elderly people in developing a Kinect-based indoor exercise video game. User

requirements collected from an interview of 10 elderly people for indoor exercise were studied and a prototype video game based on the Kinect sensor has been designed and developed to satisfy these demands. An evaluation experiment was conducted on 6 elderly people and further improvement suggestions were given. Compared with existing indoor exercise devices, this video game has better safety, entertainment, motivation, and social connectivity in promoting elderly people's long-term indoor exercise.

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