RESEARCH ARTICLE

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EXERCISE FOR ELDERLY BASED ON VIRTUAL REALITY

Settanan Trakoolvorapanya, Wacharanont Aransarikrikun, Monmanas Rampungsuk,
Bhusana Kong-on, and Prajaks Jitngernmadan*

ABSTRACT

This work aimed to design and to develop exercise programs for the elderly. The idea is to focus on the health problems of the elderly, who lacks doing exercises due to a lack of interest in participating in physical activities. This behavior has negative effects on their health and daily lives. To solve this problem, we proposed a solution based on Virtual Reality (VR) technology. We aimed to create a game encouraging the elderly to pay more attention on exercise activities. The VR game allows the seniors doing exercise activities in a virtual environment. They can immerse themselves in a new atmosphere by seeing and interacting with virtual 3D objects in this virtual reality environment. The game allows the elderly to stretch their arm muscles with concentration on color and words. The game also stimulates the brain activity with coordination of eyes, hands, and cognition. The results show that the elderly has good experiences with the exercises and the SUS score is 92.5.

Keywords: Exercise, Elderly, Virtual Reality, Stretch, Attention

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Settanan Trakoolvorapanya
Department of Information Technology for Digital Industry, Faculty of Informatics, Burapha University, Chonburi, Thailand
(62160048@go.buu.ac.th)

Wacharanont Aransarikrikun
Department of Information Technology for Digital Industry, Faculty of Informatics, Burapha University, Chonburi, Thailand
(62160042@go.buu.ac.th)

Monmanas Rampungsuk
Department of Information Technology for Digital Industry, Faculty of Informatics, Burapha University, Chonburi, Thailand
(62160039@go.buu.ac.th)

Bhusana Kong-on
Department of Information Technology for Digital Industry, Faculty of Informatics, Burapha University, Chonburi, Thailand
(62160125@go.buu.ac.th)

Prajaks Jitngernmadan*
*Department of Information Technology for Digital Industry, Faculty of Informatics, Burapha University, Chonburi, Thailand
(prajaks@buu.ac.th)
**Corresponding Author*

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1. INTRODUCTION

Currently, Thailand is entering an aging society. According to the survey of the elderly population in Thailand by the National Statistical Office between 2017 and 2022 (Yunprayong. 2021), it was found that the number of elderly people increased by 16.7 - 19.6 percent, making in 2022 the number of elderly people reached 13,358,751 people from the total population of the country is 66,171,439 people and there may be elderly people who lack exercises. This includes the elderly who take part in exercise but are still addicted to sedentary behavior. It can negatively affect their health and well-being. This is mainly due to the lack of motivation to exercise (Park et.al., 2015).

Motivation, therefore, is one of the important factors that will encourage the elderly to participate in more exercises, by way of increasing the motivation of the elderly to pay more attention to exercise. This can be done by making exercise more fun and more colorful through games. Virtual Reality (VR) games are one of the options that can increase both the player's motivation and level of physical movement.

Virtual Reality (VR) technology is a technology that is used to simulate the real environment into a virtual one. This is possible through the perception of sight, sound, touch and even smell. It will cut the users off from the real environment and it will bring the users to enter the simulated environment with virtual objects and images.

In this work, we aimed to develop exercise games based on virtual reality (VR) technology. The main objective is to help motivate and get older people to exercise more by having them do physical exercises with appropriate game activities in a virtual environment.

2. THEORETICAL BACKGROUND AND RELATED WORKS

A. The Virtual Reality

Virtual Reality (VR) technology is to create realistic virtual environment where a user can have immersive experiences interactively. When comparing exercise on virtual reality to exercising outdoors, exercising on virtual reality is as good as physical exercise (Bruin et al., 2010). However, the VR exercises can be applied well to both indoor and outdoor activities. And it can help improve the mobility behavior of the elderly. This is caused by the feeling of being immersed in a virtual interactive environment. Within this concept, it is a great interest in the practice of movement control using VR (Brooke, 1995). Therefore, virtual reality is one of the most promising options that can be used to help reinforce consistent exercise habits of the elderly by being able to keep the user's attention on the exercise.

B. The Exercises of the Target Group

The user research involved 47 elderly women, who are regularly doing aerobic exercises. To determine the changes and differences of doing exercises, they were divided into 3 groups.

The first group was the uncontrolled exercise group (C), which was assigned to do the aerobic exercises for 1 hour 3 times a week. The second group was the group that does regular exercises (EN). And the third group was the group that does the light exercises on the wrist and ankle (EW). The user research showed no difference between the three groups in baseline exercise. However, the EN and EW groups showed more significant improvement than the C group in elbow extension, internal shoulder rotation, shoulder external rotation, and knee flexion. The findings suggest us that our participants can significantly improve their arm and leg muscle strength doing these regular light exercises. We, therefore, see the importance of light exercises in this section and apply it to our work to have the arms and legs stretched mainly. These exercises also help to prevent various NCD diseases that may occur to the elderly if there is no regular stretching of the arms, such as joint disease (Brooke, 2013).

C. Related Works

This work that we have developed are mainly based on the works of the prior students (Agre et al., 1988) that have been initiated and developed previously. Mainly, that work used physical therapy exercises in order to have a body movement that is not harmful to the elderly for better physical and mental health. It also helps with memory and learning, so that the elderly can perform their daily activities as usual. In terms of technology, virtual reality has been used to add interest and it is very safe to exercise. The original work had a total of 2 games, an archery game and a coin collecting game. In this version, we have chosen to develop further by turning the coin collecting game into a stretching game, due to the extreme head movement. Furthermore, the coin collecting game could easily cause confusion and dizziness for users. Sometimes, it can be dangerous for users. In addition, the archery game was redesigned and optimized using the Design Thinking Framework.

3. APPROACH

A. Overview

The VR exercise training game we created supports for playing on MS Windows 10 operating system. It also requires VR equipment such as VR controllers with an HTC Vive device to control the game. The system was developed using Unity and Visual Studio. For monitoring and controlling purposes, the Steam VR is used. It communicates with the HTC Vive device during the gameplay, as shown in Figure 1.

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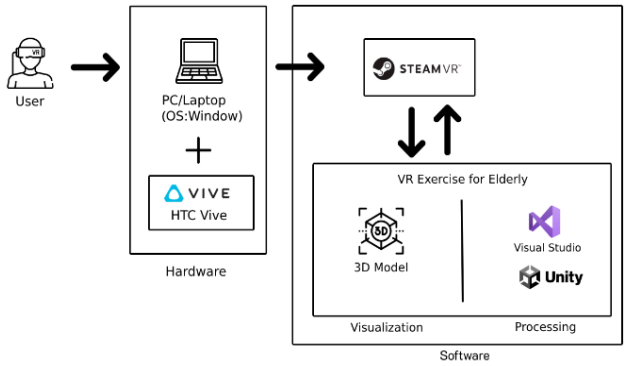

Figure 1 Overview of the development approach.

B. Game Design

The light exercise games were designed and developed. They focus on stretching the arms and shoulder muscles. In the main gameplay, there are pictures of the poses that the player must follow. The player's poses will be saved and analyzed. When the player posed correctly according to all pictures, they will pass the game's conditions. The images used for the player to follow are simple poses for stretching the muscles of the arms and shoulder muscles. The selected 5 poses are proofed that the elderly can follow easy by stretching their muscles by themselves. The poses are shown in Figure 2, including:

- Pose 1 Extend your arms to either side.
- Pose 2 Raise both arms above the head.
- Pose 3 Stretch your right arm to the side and lift your left arm above your head while leaning to the right.
- Pose 4 Straighten your arms in front of both sides.
- Pose 5 Stretch your left arm to the side and lift your right arm above your head while leaning to the left.

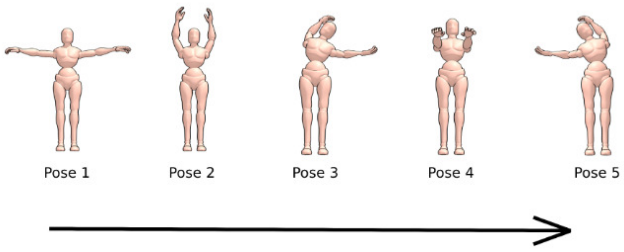

Figure 2 Exercise poses used in the game.

C. Design Thinking Framework

Design Thinking Framework is a tool that helps in general design work with analytical process that allows for experiment. The main purpose of design thinking is to summarize and synthesize design thinking research in order to better understand the characteristics and conceptual processes. The design thinking framework has 5 processes as shown in Figure 3, which includes 1) EMPATHIZE is the first step in observing to understand that "Who is the user?" and "What does the user want?", 2) DEFINE is the stage where the information from the

previous step must be summed up in order to explain the user's problem as clearly as possible, 3) IDEATE is the stage where all members are involved in proposing ideas for solving problems, 4) PROTOTYPE is the step, in which the best idea from the previous step is created as a prototype used to solve the problem, and 5) TEST is the prototype testing stage to collect data to find points that need to be improved. After doing these steps, you can go back to the previous step to propose new ideas or improve the result that can solve the problem most effectively.

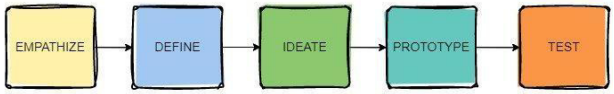

Figure 3 Design Thinking Process.

D. System Usability Scale (SUS)

The System Usability Scale is an evaluation method based on a standardized 10-question questionnaire that use to measure the usability of software for how easy to use (M.T.S. Costa et al., 2019). It consists of 10 questions with answers ranging from 1 to 5. Detailed SUS score calculation will use raw data to convert through a statistical process that can be calculated using a mathematic formula in Figure 4.

X = Sum of the points for all odd-numbered questions – 5	(1)
Y = 25 – Sum of the points for all even-numbered questions	(2)
SUS Score = (X + Y) x 2.5	(3)

Figure 4 System Usability Scale normalization

When obtaining SUS score from the normalized scores from the questionnaire, the interpretation can then be used according to the SUS score in the Table 1. Stated below.

Table 1 SUS Score interpretation.

SUS Score	Grade	Adjective Rating
>80.3	A	Excellent
>68 - 80.3	B	Good
68	C	Okay
51- <68	D	Poor
<51	F	Awful

From Table 1, if the SUS score of a software test is 68, it can be interpreted as “Okay”, which means the usability of that software is in the average group. The higher the SUS score, the better the software usability. A recommended score is 80.3 or higher. This is the point that users are likely to recommend this product to others (N.S.O. Social Statistics Division, 2021).

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4. IMPLEMENTATION

A. The Workflow

In our game operation process, at the beginning, the system will display an image, and then it will detect the player's posture. The player's posture then will be analyzed for the correctness according to the given image. If the player's posture is correct, it will proceed to the next gesture. If the player acts incorrectly, it will keep making that gesture until the player does it correctly. And when the player has done all the correct gestures, it will end the game. The player can then either go back to play another game or return tothe main page. Figure 4. depicts the flow of the gameplay.

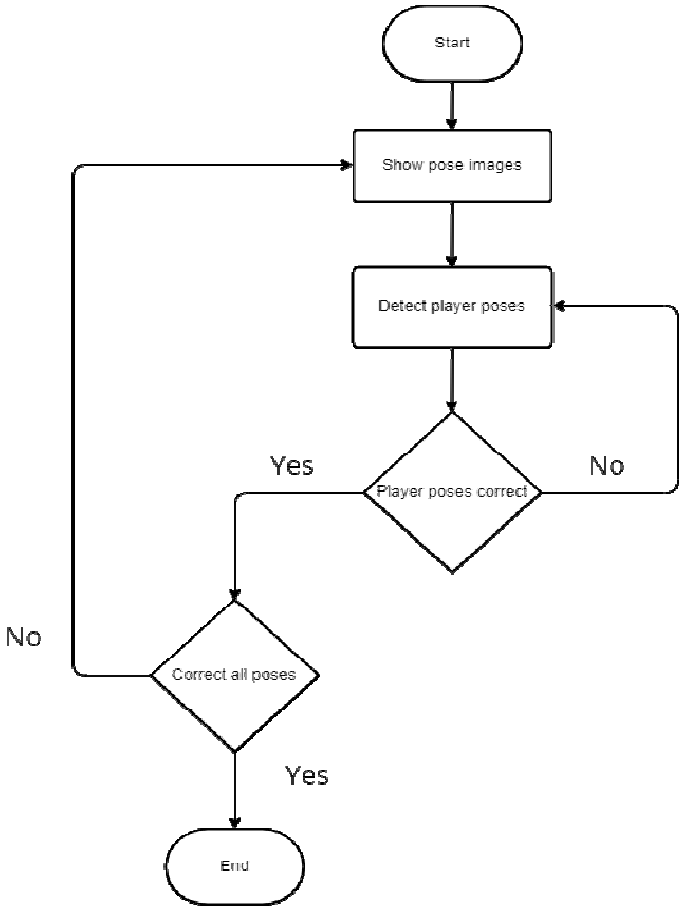

Figure 5 The game workflow.

B. Unity Program

In Unity Game Engine program, the 3D models from the Unity asset store were used forcreating a park-like environment. Furthermore, the 3D model figure was used for creating exercise poses. The Figure 5. depicts the scenery of the light exercise game. The interactive part of the game was developed using the coding scripts to access to 3D objects in the game. And these scripts can also manage the game process during the gameplay. The scripts were done in C# within the Visual Studio environment. The Figure 6. shows an excerpt of the codes.

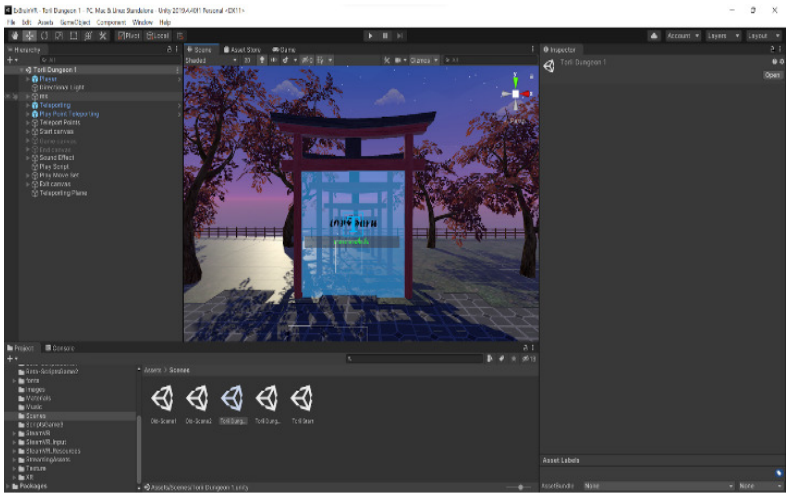

Figure 6 The Unity game engine environment.

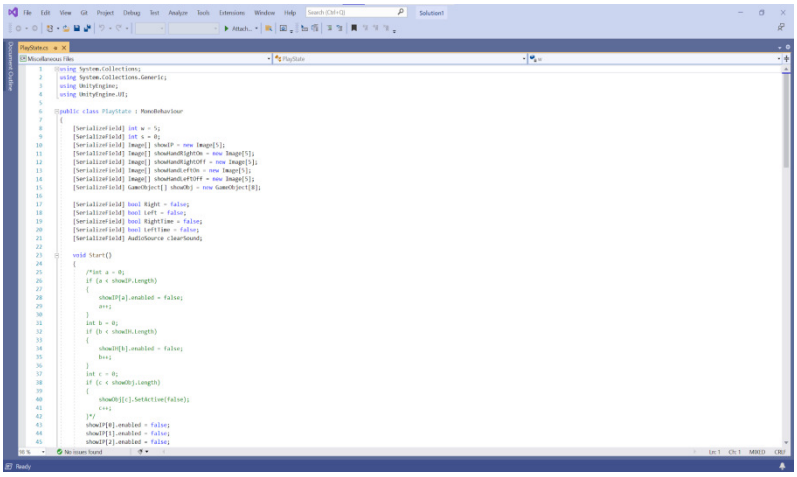

Figure 7 The excerpt of C# script in Visual studio.

5. RESULTS

The stretching game we have developed has two main UI pages: Main menu and Main game. The Main menu is a large park where players can enjoy the surrounding environment. And there will be a door to the main game in the center of the area, as shown in Figure 7. On the main game page, there is a large door in the middle that shows players posing after finishing the game as shown in Figure 8. and Figure 9.

Figure 8 Main menu scene.

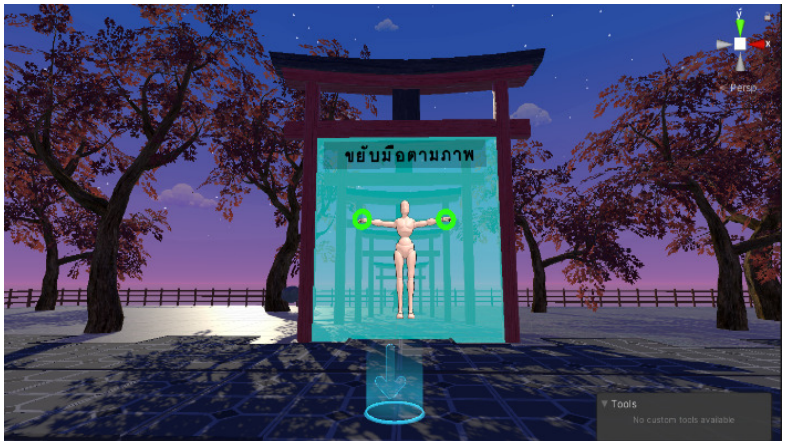

Figure 9 The main game scene.

Figure 10 The player is playing the stretching game.

From a questionnaire survey using the SUS evaluation method obtained from 23 elderly people who participated in the stretching game test, the total scores were obtained as shown in Table 2. The calculated SUS score is then also 92.5, which is at the excellent level according to the SUS Score interpretation.

Table 2 The SUS questionnaire survey results.

No.	Question list	Level of satisfaction					Total score
		5	4	3	2	1	
1	I think that I would like to use this system frequently.	3	8	4	7	1	74
2	I found the system unnecessarily complex.	8	3	2	6	4	64
3	I thought the system was easy to use.	3	4	5	7	4	74
4	I think that I would need the support of a technical person to be able to use this system.	1	10	3	4	5	71

No.	Question list	Level of satisfaction					Total score
		5	4	3	2	1	
5	I found the various functions in this system were well integrated.	5	5	4	3	6	69
6	I thought there was too much inconsistency in this system.	6	6	2	4	5	65
7	I would imagine that most people would learn to use this system very quickly.	4	5	5	3	6	71
8	I found the system very cumbersome to use.	4	5	3	7	4	71
9	I felt very confident using the system.	3	6	4	8	2	69
10	I needed to learn a lot of things before I could get going with this system.	7	4	1	7	4	69

6. DISCUSSION

The HTC Vive device must always be connected to a base tower to play the game, so it can be difficult to reach the general group due to the expensive device. The exercise system for the elderly based on virtual reality is a game that uses high computer resources. As a result, the operating system of some low-spec computers cannot be played. And the stretching game, the height of the hit block cannot be adjusted according to the actual height of the player, so there may be a problem when the height of the player is too tall or too short and may not be able to meet the game conditions in playability.

7. CONCLUSION AND OUTLOOK

In this work, we developed an exercise VR game successfully according to our objective. That is, developing an exercise program for the elderly based on Virtual Reality technology. This event received the attention of the elderly who had tested it. Therefore, it can encourage the elderly to exercise more. And in the part of the problem that is encountered, there will be a matter of the height of the user that the game is still unable to adjust the level according to the height of the player (The standard height in the game is set at around 170 cm.). In this matter of fact, the height of the player must be adjustable in the game settings. Furthermore, we plan to add more exercises to the game such as leg exercises in the near future.

8. ACKNOWLEDGMENT

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