A Kinect-based Augmented Reality Game for Arm Exercise

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Abstract

Augmented reality (A.R.) is the underlying technique where 3D virtual objects are integrated in real-time with a real environment. Augmented reality applications such as medical visualization, maintenance and repair, robot path planning, entertainment, military aircraft navigation, and targeting applications have been proposed. This paper introduces the development of an augmented reality game that allows the user to carry out arm exercises using a natural user interface based on Microsoft Kinect. The system has been designed as an augmented game in which the user's hands are in a world augmented with virtual objects generated by computer graphics. The player is sitting in a chair, just grasping the yellow stars that are displayed in the stage. It encourages the activities of a large number of arm muscles which will prevent decay. It is also suitable for rehabilitation.

Keywords: Augmented reality, Arm exercise, Rehabilitation, Healthcare

1. Introduction

The modern age has become an aged society, and the proportion of old people is increasing. The opportunity to move the body decreases when we get old, and the use of the brain also decreases. Just walking your legs will give you exercise, but if you don't consciously move your arms, your muscles will gradually weaken without you even realizing it. Weakness of the arm muscles can lead to pain, such as a frozen shoulder. Besides, A typical rehabilitation program for stroke patients during hospitalization is paralyzed upper extremity functional training [1] (Figure 1). Also, when you stop using the brain, it may cause blur and dementia. Therefore, methods have been proposed to use the brain through games to prevent the hypofunction of the head and body of the elderly. For example, some traditional arcade games were used for rehabilitation purposes [2]. However, these arcade games are expensive and hard to relocate and use in a clinical space.

Augmented Reality (A.R.) systems have the advantage that information can be superimposed upon reality. The user can spatially relate virtual objects to the reality. Many researchers have proposed solutions for various applications, such as medical visualization, maintenance and repair, annotation, robot path planning, entertainment, military aircraft navigation, and targeting applications [3] [4]. Recently some Kinect-based AR systems were developed. Meng et al. [5] proposed a general method to interactively improve and correct the Kinect skeleton for A.R. Anatomy Learning. Anderson et al. [6] developed a system comprising a Kinect-based recording system and a corresponding training system with a large-scale augmented reality mirror.

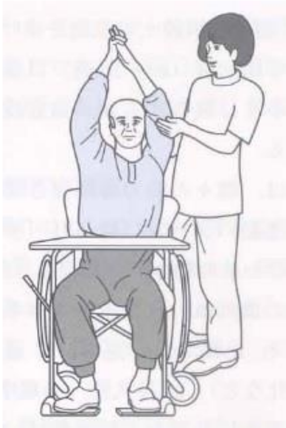

Fig.1 Elevation of both upper limbs

Casas et al. developed an Augmented Reality system for teaching key developmental abilities to individuals with A.S.D. The system has been designed as an augmented mirror where users can see themselves in a mirror world augmented with virtual objects [7]. Our previous work presented a framework for developing the Kinect-based augmented reality game for upper limb exercise and rehabilitation. We have got user opinions that were interesting and immersive [8].

In this paper, we present a Kinect-based augmented reality game for the exercise of the arms. The player is sitting in a chair and grasping the stars on the screen. It encourages the activities of a large number of the arm muscles. Using the Kinect device, the system can be operated with gestures. Another advantage of using Kinect is the simplified system improvement and the ability to modify the specifications at any time simply by rewriting the software source code. Therefore, although it is currently expressed only in Japanese, it is also possible to correspond to English or other languages.

2. System Overview

Figure 2 shows the experiment environment of playing our game for arm exercise. This is an augmented reality game in which gray stars and yellow stars are displayed on the stage, and users can naturally exercise their hands by grasping the yellow stars in turn (Figure 3, Figure 4). The purpose of the game in this study is to guide the participants to the movement of their hands naturally by making five reciprocations of holding the yellow star within the time limit. The stars are arranged in an arc along the Z-axis. As the level increases, the number of grab positions and the angle at which the arms are raised will increase. Figure 5 depicts the image of the Kinect device, and Figure 6 shows the flow chart of the game.

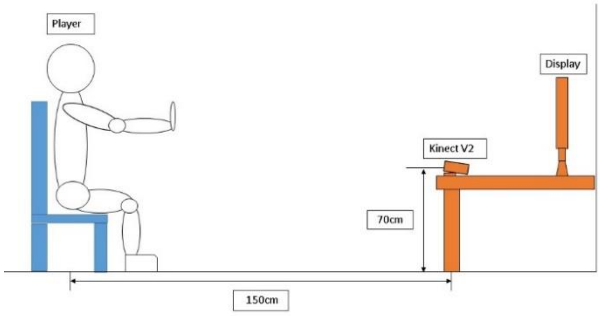

Fig. 2 Experiment environment

Fig. 3 Yellow star(left), Grey star(middle), left Hand model(right)

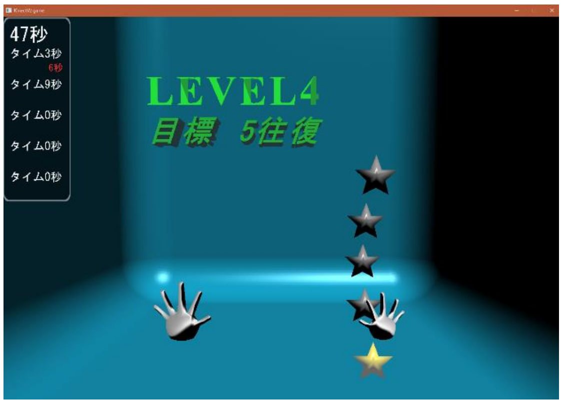

Fig.4 The game screen

Fig. 5 Kinect device

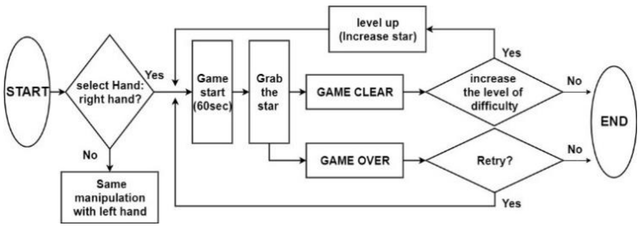

Fig. 6 Follow chart of the gameplay

2.1. *Arm coordinate position detection and placement of stars*

The game in this study is played with the arms outstretched. In order to reduce individual differences, such as difficulty in grasping stars due to differences in arm length depending on the body, we devised a method to detect the skeleton equipped with Kinect. We measure the coordinates of the neck, shoulders, elbows, and hands to determine the lengths of the upper arm, forearm, and shoulder width (Figure 7). Then, we calculate the arm length.

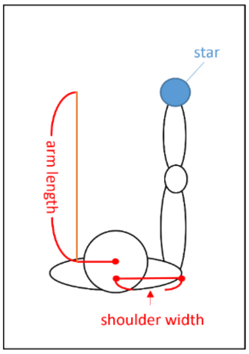

Fig. 7 Arm length calculation.

We position the stars along the arc marked by moving the stretched arm(Figure 8).

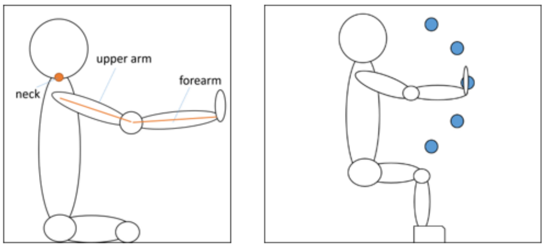

Fig. 8 The positions of stars

2.2. *Collision Detection*

The collision determination is defined when the distance between two centers is less than the sum of the radius of the two spheres which contain the object and palm Individually (Figure 9). Besides, we increased the judgment range to make it more responsive.

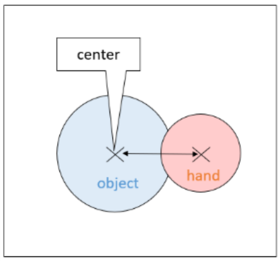

Fig. 9 Collision Detection

2.3. *Implementation*

This framework was implemented in Visual Studio 2010 development environment and used C++. And DirectX API is used for graphic rendering. To control the Kinect device, Kinect for Windows SDK toolkit is used in the implementations [9].

3. Results

Our framework was performed on a standard P.C. equipped with a 3.33 GHz Intel Xeon CPU and a NVIDIA Quadro FX 4600 graphics board with 768MB video memory. There are several characteristics that enhance usability, as stated in the following: Figure 10 shows the first screen that appears when the game is launched. At first, We measure the coordinates of the neck, shoulders, elbows, and hands to determine the lengths of the upper arm, forearm, and shoulder width (Figure 10).

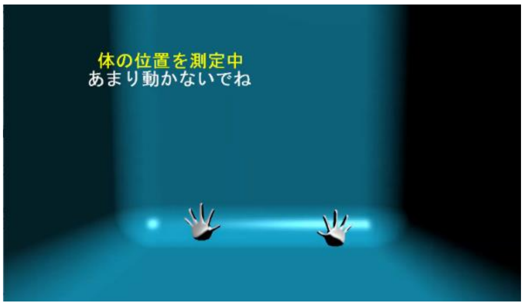

Fig. 10 Start Screen

Figure 11 shows the screen during the playing time. In the upper left position, the "time limit" and the time taken to grab each object is displayed. In the middle upper position, the current level and number of reciprocations for clear are displayed. In the middle lower position, two hands and the stars are displayed. If you clear the game for each level within the time limit of 60 secs, the "Goal Achievement" will be displayed, and you will be asked if you want to raise the level (Figure 12).

Fig. 11 Player Screen

The game ends when the user graps "no" at the right side of the screen. If you do not clear the game for each level within the time limit, you will be asked if you want to try again.

Fig. 12 Results Screen

In order to verify the usefulness of the proposed game, subjects (10 males and females of healthy subjects, all ages are in twenties) were asked to use the game and conducted a questionnaire about their feeling of use and concerns. Table 1 shows the results of that questionnaire.

Table 1. The result of the questionnaire

Good pinion	・Good for hand rehabilitation ・It can also be a hand gripper exercise ・Interesting to try
Point of concern	・Difficult to understand the depth ・Takes some time to get used to

4. Conclusion

In this paper, we have developed an augmented reality game for arm exercise through the use of a Kinect device. Hereafter, we will improve the concerns pointed out in the questionnaire. Since arm measurement is ambiguous due to camera blind spots, it is necessary to consider other measures, such as using two Kinect devices. It is necessary to make it easier for users to recognize the space in the game, such as changing the color of the stars when they enter the judgment range. Because the height at which the arm can be raised varies from user to user, it is necessary to match the placement of objects to the user. We will evaluate the affectivity of this game with the help of senior citizens in nursing homes and rehabilitation institutions. Future improvements and developments would be based on the requests of senior citizens or rehabilitation centers for specific exercise sessions.

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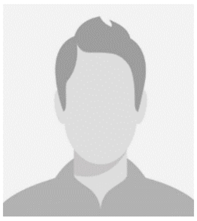

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