Virtual Block Augmented Reality Game Using Freehand Gesture Interaction

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Abstract—**Augmented Reality (AR) manages to bring a virtual environment into a real-world environment seamlessly. As AR has been recognised as advancing technology, AR brings future changes to the learning process. The goal of this study is to use freehand gestures to create a virtual block game in AR. First of all, the stages of this study are to explore block games and freehand movements by using Leap Motion. Secondly, the design and development of Leap Motion virtual block games, and thirdly, the implementation of free-hand gesture interaction virtual block games. The paper explains about virtual blocks AR game using freehand gesture. AR tracking system with real hand gesture recognition system is merged to execute the freehand gesture. A prototype virtual block has been described in this paper. The paper ends with the conclusion and future works.**

Keywords—**Augmented Reality, Free-hand Gesture, Virtual Block Game, Gesture Inputs**

I. INTRODUCTION

One of the next generations of technology is augmented reality (AR). AR enables users to combine seeing the physical world with virtual objects that are used to inspire users and engage them. This strengthens AR, rather than replacing it, with the power of reality [1]. Through several techniques as well as AR, the transfer of data as a learning process can happen. For AR to work, it requires a computer device such as a laptop desktop or tablet, a web camera, a display device and software to read the environment and project images onto the screen. Using Leap Motion to play virtual block games ensures that the user does not have to communicate with the virtual object using the physical controller. This AR marker application is a freehand gesture where a particular hand and finger movement enables the user to communicate with the virtual object. This will give the user the real experience and allow the virtual object to be manipulated like real interaction.

One of the inputs that can be used in AR is the freehand gesture using Leap Motion, which enables gesture interaction to effectively perform path operation in replacement of the mouse and keyboard [2]. The gestures such as pinch and swipe gesture used by the user to improve user experience. The user was more interested in using natural human senses which reduce the gap between user and technology. Konrad *et al.* [3] used gestures to control the motion of avatars in a virtual environment,[4] used pointing gestures as an input to the VR game, and PlayStation 2 introduced the Eye Toy, an interactive game camera that captures hand movements.

The process of recognising human gestures can be referred to as gesture recognition, so that the corresponding action can be done by the machine [5]. Gestures input can be divided into gestures that are static and dynamic. A static gesture is defined as a still posture or pose, while a moving gesture is a dynamic one [6]. Haptic feedback systems based on fingertips have been used to allow the user to feel virtual objects. This enables users to use natural hand movements to communicate with virtual material [7]. By using two fingers to intuitively control virtual objects, the device allows users to communicate naturally with virtual objects in AR.

For surface reconstruction on a table top, the ARMicromachines [8] game uses a Kinect that allows players to drive virtual cars in the real world as shows in Fig. 1. In realistic physics simulation and interaction between real and virtual objects, players can position real objects for the cars to drive on or use gestures to manipulate the virtual content.

Fig. 1. Object Manipulation in ARMicromachines game [8]

Without any mechanical equipment directly attached to the user, freehand tracking is enable to be used. The 3D hand skeleton also provides different types of hand details, such as palm position, fingertip position and finger joint position [9]. The illustration is figured in Fig. 2.

Fig. 2. Hand tracking information [9].

METHODOLOGY

The layout of the project, which was divided into four stages, is shown in Fig. 3. The first phase was the analysis of the criteria, consisting of the analysis and planning phases. A development consisting of AR with freehand gesture and virtual block game was the second step. The third phase was AR implementation of virtual block game using Leap Motion, and the last phase was evaluation. In the second level, AR with freehand gesture involves the AR tracking system and interaction with freehand gesture. The virtual block prototype was split into two, which is the gameplay that shows the game and game part stage to play.

Phase 1 Requirement Analysis

The Step 1 requirement analysis was the method of evaluating user specifications used by the system or system function features to fulfil the system 's purpose. The overall comprehensive declaration of the project was an analysis of requirements. The focus of the analysis phase was on collecting requirements and project information. To understand the flow and implement it in Augmented Reality, the virtual blocks for games were studied. By reviewing the preliminary investigation in first phase, the technique for the interaction of

freehand movements using Leap Motion was discussed in detail. In addition, by analyzing the previous work, the feature that was introduced in this project was identified in order to support the transition from the analysis phase to the more technical and comprehensive design phase.
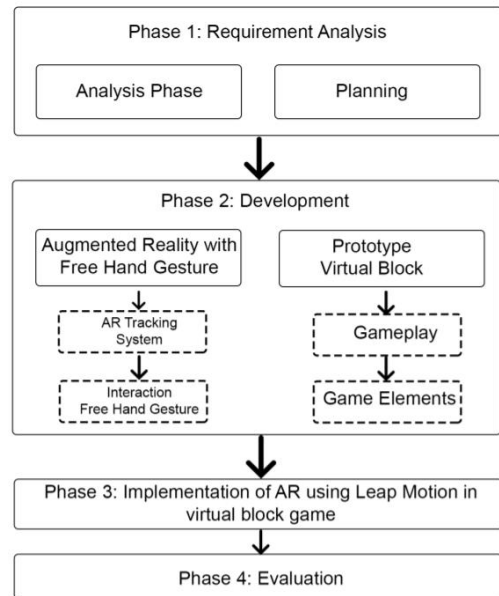

Fig. 3. Methodology

Phase 2 Development

In Unity 3D, the virtual block game project was developed. Unity 3D enables some visual enhancements which have become more precise in the graphical interpretation of the augmented object, and the appearance looks more realistic. The Vuforia SDK was exported to Unity 3D first. Vuforia is the AR tracking Software Development Kit (SDK) that was used in this project. In order to recognise it, it used computer vision technology, such as a real-time 3D object. The Leap Motion Unity Core asset package was also used on a Windows computer to integrate with the Leap Motion device. This package contains hand prefabs, script and demo scenes that help to quickly construct Leap Motion.

Without restricted time, the player is able to play as long as they want. It was possible for the user to pick the block and alter the content. The virtual block type used in this project is different. Fig. 4(a) shows the 1x1x1 size of the virtual block and next for Fig. 4(b) shows as 1x2x1 size, Fig. 4(c) shows as 2x2x1 size, Fig. 4(d) shows as 2x4x1 size and Fig. 4(e) shows as the cylinder. The colour can be selected by the player as well. Red, green, blue, yellow and black were the colours given.
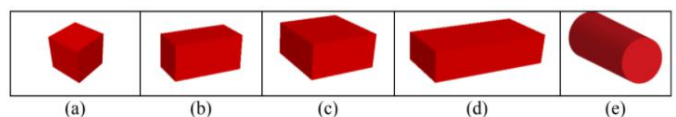

Fig. 4. List of blocks

Fig. 5 shows the diagram activity for the game. There are three modules, Choose Blocks, Choose Color and View Image. The user was given two options to choose between Choose Blocks and Choose Color. They may decide to reset the game or complete the level. There are three levels that were given for the user to complete. Three hints also are assigned to each level, if the user able to complete the game based on the given a hint, he succeeded to move to the next level.
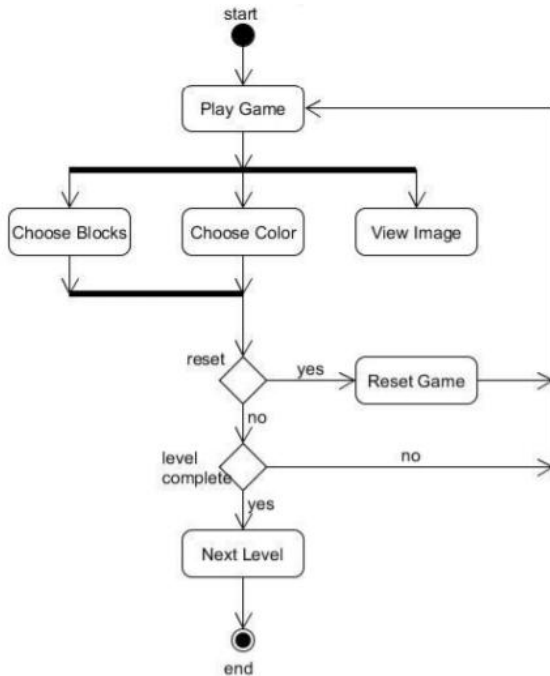

Fig. 5. Virtual Block game activity

Phase 3 Implementation Free-hand using Leap Motion for AR

Video acquisition, color of skin segmentation, foreground identification and context removal are the basis of the hand tracking system. The advantages of tracking systems are their speed, robustness against background noise, and the ability to track objects that undergo arbitrary rotations, movements, and rapid environmental changes. Where the device has perceptive capabilities that allow it to acquire tracking information is a specific significant direction of gesture recognition using hand tracking. In a right-handed coordinate system [10], hand and fingertip locations are detected in coordinates relative to the middle of the controller.

The workspace for the table was set up first. For this project, the setup table was shown in Fig. 6. The table workspace has a monitor, camera, marker and Leap Motion. In Unity 3D, the machine was the medium for running and displaying the project. The camera was used to capture the marker. The Leap Motion was connected to the computer unit and used as the input to detect freehand gestures. 3D modelling and interface is the approach involved in the creation of this Virtual Block Games concept. In Unity 3D, 3D virtual blocks were developed,

and some of them were modelled using 3D Maya as a base before the objects were imported into Unity 3D.
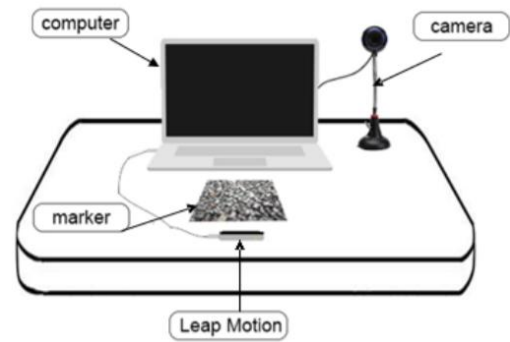

Fig. 6. Setup for Leap Motion device with AR

II. VIRTUAL BLOCK AR GAME

The input for this project was the freehand gesture that will be recorded by Leap Motion, and the marker will be scanned to display an object by the camera. A certain virtual 3D model was developed using 3D Maya and the texture was created using Adobe Photoshop. Afterwards, the virtual object was imported into Unity3D. The software and plug-in used to build the project were Unity3D and Vuforia SDK. Without any mechanical equipment directly attached to the user, freehand tracking enables control the AR scene. Different kinds of hand information, such as palm position, fingertip position and finger joint location[9], are also given by the 3D hand skeleton.
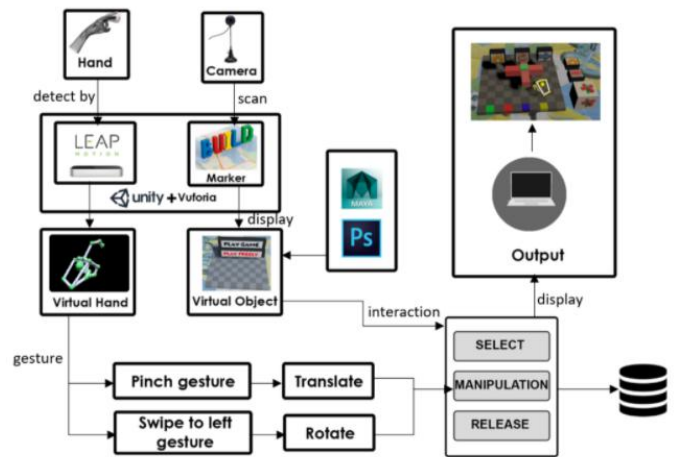

Fig. 7. The interface design for Virtual Block AR Game

From the main menu, the virtual block games start. The consumer used the Leap Motion input gesture to do the manipulation, such as selecting, rotating, and releasing. The main function of the virtual block games was to use a pinch gesture to pick the object or to rotate the object with a swipe to the left to place the object in the correct position. This game was played in AR. Control of objects, such as selecting,

translating, rotating and releasing them, was the primary function of this game.
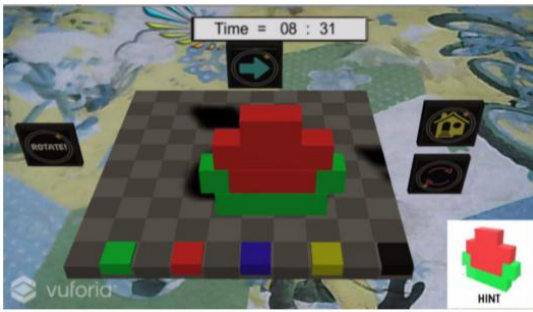

Fig. 8. Time appears on the top of the virtual board

In Table 1, the menu list is shown; the user has to complete the level within the specified time to win the game. The playtime was located at the top middle of the screen. The placement of 2D virtual buttons can be seen in Fig. 8.

TABLE 1. Elements in Virtual Block Game

Button	Function
Play Game Button **PLAY GAME!**	Button to start the game.
Play Freely Button **PLAY FREELY!**	Button to play freely
Home Button	Button to go to main menu
Play Again Button	Button to restart or reset the game.
Next Level Button	Button that only display when won to able to go to next level.
Rotate Button **ROTATE!**	Button to rotate the base

When playing, the player will see the real world, so the feeling of playing this game would look real. There are two choices in main menu, as shown in Fig. 9, which are Play Freely and Play Game. To select a virtual button, the user needs to press it. Before the 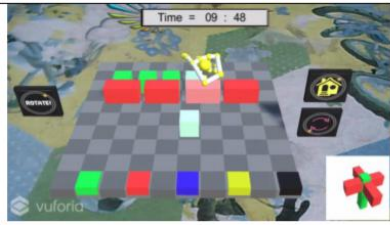next object can be placed, the user needs to select the right object and place it correctly. The user can also alter an object's materials, which are red , green, blue, yellow, and black. In order to select an object, the user used a pinch gesture and swiped to the left to rotate the object to the y-axis. There was a period time given, and the user must finish the game before the buttons put on the right, which is home and replay button.

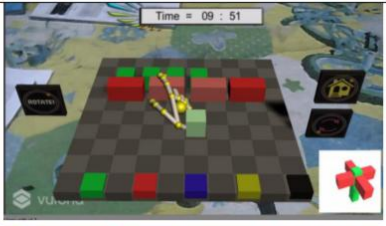Fig. 9. Two options provided for the user to choose

The hand gesture ought to be simple and easy to perform. This is significant , particularly if you are using Leap Motion as an input device for the first time. Relevant hand movements such as pinching were used by the user to translate and swipe left to rotate the virtual objects. The pointed gesture used to pick an object that can be manipulated with. The translation gesture step is shown in Table 2. To pick the block, the user used the pinch gesture, then moved the hand to do the translation. By placing it in the correct position, the block was released and the pinch gesture was disabled.

TABLE 2. Translation Method in Virtual Block AR Game using Free-hand Gesture

Translate Gesture	Picture
Select	
Translate	
Release	

As seen in Table 3, the block was rotated using a swipe to the left gesture. A rotating hand script has been applied to the an object that can be rotated. Leap Motion Core-Asset supplied the interaction side, and there were three forms of interaction: hover, touch, and grasping. The collider and the rigid body are applied to the object in order to enforce the interaction.

TABLE 3. Rotation method using freehand gesture

Rotate Gesture	Picture
Select	
Rotate	

The game begins with the main menu scene that shows the title containing the play button for five seconds. The user can decide to play the game or just play freely by pressing the button to choose. If the play button has been pressed by the user, the scene will change to Level 1, and the game will begin to appear. In the upper middle of the screen, the playtime was shown where the user must complete level 1 before the time reaches zero. The home button on the top right, just below reset button, was used to reset the game at that level.
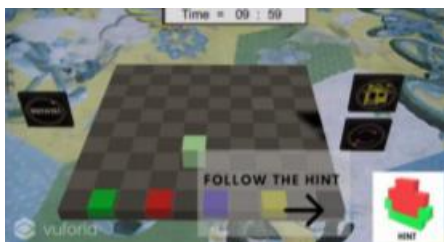

Fig. 10. Hint appears to alert player

In order to create the blocks within the time specified, there are hints for the user. Before they begin to play the game, the instruction for the hint will appear to guide the player, as in Fig. 10. The hint was placed at the bottom right for the object to be created. The left button is used to rotate the base. Users can change the colour by tapping the colour on the block. The user needs to select the correct block and place it on the given hint block. Start the game in the right position with a pick and drop block. The gesture for picking an object was a gesture of pinch. The block sequence needs to be correct for the creation of the object. A colour that can be selected by pressing the block to the colour at the front of the base.

If the user succeeds in completing the level before the end of time, the full level menu will appear. The user can then choose to go home, play again or continue to the next level. The new scene, which is Level 2, starts when the user clicks the next level. If they do not complete the game in time, the player loses. Users will win the game after all levels have been completed. In order to demonstrate the consumer winning the game (see Fig. 11a), losing the game (see Fig. 11b) or completing the game (see Fig. 11c), these three visual feedback will be displayed.
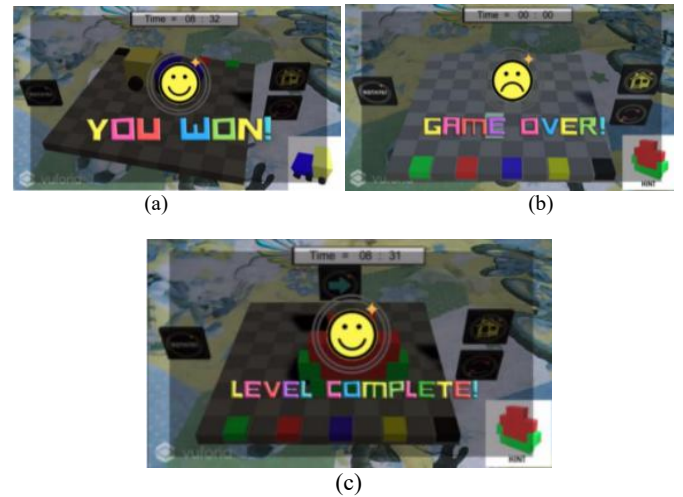

(a)

(b)

(c)

Fig. 11. Visual feedbacks

I. CONCLUSION

This paper aims to study the uses of Virtual Block Games in AR with FreeHand Gesture in interaction using Leap Motion depth sensor. The goal was achieved when block games and hand movements were successfully established using Leap Motion in AR. Using Leap Motion as a device, the project was based on AR. The interaction of the virtual block and the object's manipulation was easy to understand based on the user feedback. The limitation for the development of this virtual block game is the game only support single-player and does not need an internet connection to play. The game is in Augmented Reality, so the specific marker needs to be used to play. Besides, the game only design for Window PC with Leap Motion controller. The Leap Motion controller also lack the accuracy to do interaction between virtual hand and block make it hard to manipulate the block using gesture compare to playing the real block game.

The suggestion to improve this study in the future is to upgrade to colour palettes or colour swatch when changing the colour instead of tapping the block to the colour. This to make sure the colour change will become more natural. The failure to use that method is due to time constrain. Another recommendation for improvement is to make it easier to use

the project, especially since this project is focused on education and entertainment for all ages. Apart from the project implemented in AR with the freehand gesture, the design needs to be simple and easy to understand for the first time user. Interaction should be seamless for the user, such as selecting, manipulating, translating, rotating and releasing.

REFERENCES

[1] Ismail, A. W., & Sunar, M. S. (2015). Multimodal Fusion: Gesture and Speech Input in the Augmented Reality Environment. *Computational Intelligence in Information Systems*, Springer, Cham, 245-254.

[2] Tran, V. T., Lee, J., Kim, D., & Jeong, Y. S. (2016). Easy-to-use Virtual Brick Manipulation Techniques Using Hand Gestures. *The Journal of Supercomputing,* 72(7), 2752-2766.

[3] Konrad, T., Demirdjian, D., & Darrell, T. (2003, April). Gesture+ Play: Full-body Interaction for Virtual Environments. *CHI'03 Extended Abstracts on Human Factors in Computing Systems.* ACM, 620-621.

[4] Paiva, A., Andersson, G., Höök, K., Mourão, D., Costa, M., & Martinho, C. (2002). Sentoy in Fantasya: Designing an Affective Sympathetic Interface to a Computer Game. *Personal and Ubiquitous Computing*, 6(5-6), 378-389.

[5] Ahuja, M. K., & Singh, A. (2015). A Survey of Hand Gesture Recognition. *International Journal,* 3(5).

ACKNOWLEDGEMENT

[6] Ghosh, D. K., & Ari, S. (2016). On an Algorithm for Vision-based Hand Gesture Recognition. *Signal, Image and Video Processing*, 10(4), 655-662.

[7] Buchmann, V., Violich, S., Billinghurst, M., & Cockburn, A. (2004, June). FingARtips: Gesture Based Direct Manipulation in Augmented Reality. *Proceedings of the 2nd International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia*. ACM, 212-221.

[8] Piumsomboon, T., & Clark, A. (2012, July). ARMicroMachines: Natural Interaction With Augmented Reality Scenes. *Proceedings of the 13th International Conference of the NZ Chapter of the ACM's Special Interest Group on Human-Computer Interaction*. ACM, 99-99.

[9] Kim, M., & Lee, J. Y. (2016). Touch and Hand Gesture-based Interactions for Directly Manipulating 3D Virtual Objects in Mobile Augmented Reality. *Multimedia Tools and Applications,* 75(23), 16529-16550.

[10] Bachmann, D., Weichert, F., & Rinkenauer, G. (2014). Evaluation of the Leap Motion Controller as a New Contact-free Pointing Device. *Sensors,* 15(1), 214-233.