An Investigation into Virtual Objects Learning By using Haptic Interface for Visually Impaired Children

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***Abstract* –It is well known that visually impaired children have limited opportunities in learning new things compared to normal sighted children as visually impaired children do not have one of the important senses of human being. Computer simulated virtual reality environment can provide better opportunities for visually impaired children especially in learning the shapes of new objects. An application utilizes the force feedback technology i.e. haptic, together with an aid of audio has been developed in this research project. This allows visually impaired users to have a better learning environment. It assists visually impaired children in learning the shapes of different objects and also memorizing the shapes of different objects. In addition, the program will help users to train their memory by memorizing the names of different objects together with the shapes. This creates a new application in a novel research area which will help the visually impaired children in their learning process.**

Keywords- Haptic, virtual objects, learning, visually impaired children, auditory

I. INTRODUCTION

Learning at the young age is crucial for visually impaired children because they gain knowledge by learning, playing, touching, seeing, listening and interacting with things that they show interests in. However, visually impaired children do not have the privilege of sight and because of this; learning new thing is very much different for these children. According to world health organization, there are approximately 19 million children [1] are visually impaired worldwide. Therefore, allowing visually impaired children to learn new objects by providing virtual environment of the objects is one of the alternative solutions for them to continue learning. Virtual interface application which is connected with haptic device can assist them to improve their learning process and provide them better learning environment without requiring the physical presence of the objects and without going outside to learn new things. The application can also help them to improve in remembering shapes of different objects together with them names of the objects.

In addition to audio and visual information, the provision of haptic feedback (the sense of touch) can profoundly improve the way children interact with virtual environments. Systems that support interfaces between a haptic device and a virtual environment are called Haptic Virtual Environments (HVEs). Recent research [2][3] has shown that to have a satisfying experience in interacting with a HVE, the graphics and haptic update rates need to be maintained at around 30Hz and 1 KHz respectively.

In this paper, a brief review of related literatures will be discussed and followed by methodology where the detailed development and assessment methodology such as testing procedure will be discussed. Detailed discussion of the application and test results will be presented in the session after methodology and followed by conclusion and future work.

II. RELATED WORKS

Different researches have been proposed to help visually impaired people as they have limited opportunities in seeing new things. One of the studies has done on the experience of haptic interface environments by visually impaired children aged between 3.5 to 7.5 years old [1]. Based on their result, computing environments will be usable by visually impaired children if the tasks of computing environments are carefully designed with the assist of haptic and auditory features. However, the applications they proposed were not emphasizing on teaching shapes of object to visually impaired children. Another approach is teaching shape information to visually impaired users [2]. PHANTOM OMNI device, which was developed by SensAble Technologies [3] were used by both sighted and visually impaired users in their

study. The study involved asking the users to feel the 2D trajectory by using haptic device and the user will then be asked to redraw the shapes. Their test results proved that visually impaired computer users can perform better if they are provided a multimodal haptic device together with audio playback of the shapes rather than haptic device only.

Nikolaos kaklanis *et al.* [4]were trying to transform the normal web pages into 3D based haptically enhanced widget (hapget) web pages for visually impaired users. The users of the application are required to provide the URL of the webpages that they would like to browse and then the application will transform the webpages into 3D haptic web pages. The idea of the project was good however, there are some limitations in generating 3D based web pages from normal webpages.A research on how gaming can be used to help visually impaired individuals has done with the assistance of haptic technology[5]. Haptic glove was used to allow visually impaired students to access the pointing behavior of instructor in mathematics and science instruction and solve problems for blind students as they do have the capabilities of reference when the lecturer is using instructional material during the class and to improve the embodied skills of communication between the tutor and student in the class.

Another research to provide the geographical information with the sense of touch or hearing by using mobile device when the user is having limited eyesight (eg. when the user is exploring the environment or the user is visually impaired) to acces the information [6]. However, their system has become vaporware because of lack of knowledge and tools to practice, cost and time in order to develop the project. A study on assessing haptic properties for data representation was done to provide a flexible way for blind people to have access to graphical information. Phantom device was used to explore the haptic graphs which includes, height and shape of haptic graphs, however the research was mainly for blind people who want to learn mathematics and science related subjects and there are no specific features for visually impaired children especially those who are learning the new objects at their young age.

Another approach of study has done to allow the blind individuals to have perception and basic information in assessing different colors [8]. For visually impaired individuals, learning colors is more difficult than learning shapes and textures of the objects as the features of colors are purely vision where the shapes and textures can be learned via touching. Because of this, they used the temperature based color representation, for example red is hot, green is cool. Even the idea of the study did not provide any interest in learning shapes of different objects. Another approach of haptic emulation of games was conducted by using Sudoku as a game paradigm [9]. However, it would not help much for visually impaired children in learning the shapes of different objects.

A study to test the hypothesis of using audio and haptic together compared to using them separately in haptic based virtual environments for blind people [10]. A virtual-environment video game was developed by using both audio and haptic interfaces that allows the stimulation of orientation and mobility skills of blind people. Nevertheless, the research result has shown that their research program was less effective for blind users in identifying complex shapes. Wai Yu *et al.* [11] developed a system which helps blind people to create virtual graphs on the web by using low-cost haptic device, the Logitech WingMan Force Feedback Mouse, and web audio. They have tested the system with both blind and sighted people by using audio only, haptic only, and audio with haptic. Based on their results, audio with haptic condition has highest accuracy and helpful for blind users.

III. METHODOLOGY

Virtual reality haptic application is implemented by using OpenHaptics API and C++ programming language with the help of audio API called irrKlang. The application provides five different common objects and visually impaired users to be able to feel the shapes of the objects with the help of PHANToM Omni device and hear the names of the objects with the help of audio device. PHANToM Omni is a stylus-based haptic device which is developed by sensable technologies and it allows users to touch and manipulate virtual objects. Following figure is shown the high level architecture of the system.

Figure 1: High-Level Architecture of the system

The application will be deployed on desktop or laptop PC and the desktop or laptop PC will then be connected to stylus-based haptic device. Finally, visually impaired users will be able to use the application with the help of stylus-based haptic device called PHANToM Omni. User interfaces of the system are shown in figure 2.

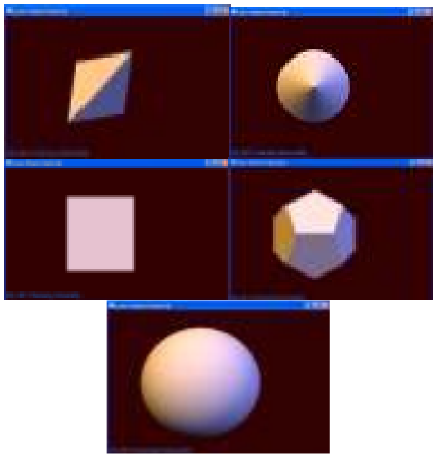

Figure 2: User Interfaces of Virtual objects for Visually Impaired Children

The system was evaluated with a sample of 13 visually impaired users' ages within 8 to 12 years old. The research subjects are only visually impaired and do not have any other additional disabilities. The users are allowed to play with stylus-based haptic device for three minutes in order to get familiar with the device. They are briefed on what is the application and device.

Once user is slowly adapted to the usage of device, the testing on the application is started. Users are asked to move the device around on the computer screen and let them experience the application which provides the sense of touching the objects. The name of the corresponding object will be spoken out in audio format when the user uses the stylus-based haptic device and touches the object. So that users will able to know what is the shapes that they are touching together with the name. Once users become familiar with the shapes and names, audio will be switch off. The users will then be asked to touch the shapes again and ask the name of objects that he/she is touching. This testing is carried out to know whether the application can help the users in training their memory on how well they can remember the shapes of objects together with names. The users are also asked the questions based on questionnaires.

Questionnaires are used to test the user perception on learning shapes of different objects by using stylus-based haptic device. It also allows testing on whether set, size of 3D shapes, types of shapes, etc are effective for visually impaired users.

IV. DISCUSSION

Experimental testing was done on thirteen visually impaired users. The aim of the experiment is to find out how well the application can help visually impaired users in learning the shapes of new objects in virtual environment and how well the users can use the virtual interface application with the help of stylus based haptic device. Users are also tested on how accurately they can guess the correct shapes of the objects together with the names. The results of users who guess the shapes of objects and names correctly are shown in figure 3. Based on the result, 13 out of 13 users correctly guessed the shapes of the common objects such as sphere, cone and cube together with the names. However, only 3 out of 13 users correctly guessed the shape of tetrahedron and 5 out of 13 users correctly guessed the shape of dodecahedron as these types of shapes are complex for young learners.

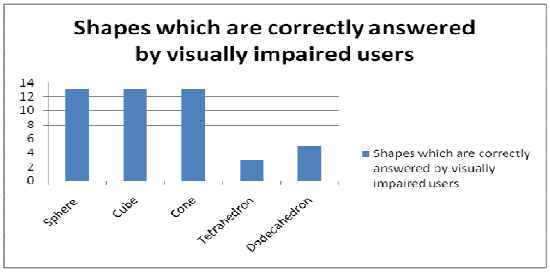

Figure 3: Numbers of users who correctly guess the names and shapes of objects

Users are also asked to rate their satisfaction on the application and haptic device in terms of clearance of provided audio, ease of use of stylus based haptic device, performance of application in helping the users to remember the shapes of the new objects and improving the imagination of the shapes of different objects. The ratings are 1 to 10 in terms of 1 for the least and 10 for the most satisfaction. The results of the contents mentioned are shown in figure 4. The rating on the audio which speak out names of the objects that users touch is 6.5. Users experienced quick familiarity with haptic device

and their rating for haptic device is 7.6. The rating on the helpfulness of application for users to remember the shapes of new objects and effectiveness of application in improving the imagination of the shapes of different objects are 6.5 and 6.6 out of 10 respectively. In summary, 77% of the visually impaired users agreed that virtual reality learning is useful in learning the shapes of new objects

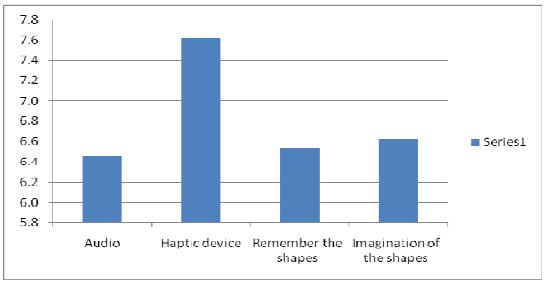

Figure 4: Summary of user satisfaction on application with haptic device

V. CONCLUSION AND FUTURE WORK

In this paper, a system which allows visually impaired users to learn the shapes of new objects in virtual reality environment has been proposed. The system uses stylus based haptic device in order to allow user to feel the shapes of virtual objects and provide the names of the objects with the help of audio. Majority of the users agreed that the system can help visually impaired users to remember the shapes of new objects and virtual reality environment is useful in learning the shapes of new objects. As for future extension, the system will be used on more than one networked computers and allow users to communicate through the application.

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