Journal of Korea Game Society 2015 Feb; 15(1): 27-34
http://dx.doi.org/10.7583/JKGS.2015.15.1.27

게임 기획 및 디자인

A Gesture Interface based on Hologram and Haptics Environments for Interactive and Immersive Experiences

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상호작용과 몰입 향상을 위한 홀로그램과 햅틱 환경 기반의 동작 인터페이스

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요 약

본 논문은 기존 립모션 장비에 홀로그램과 햅틱 장비를 결합함으로써 향상된 몰입감과 사용용이성을 제공할 수 있는 사용자 인터페이스를 제시한다. 립모션은 사용자 손동작의 물리적 행동이 직접 가상의 화면상에 영향을 주는 장치인데, 화면상의 가상 손모양을 제어해야 한다는 점과 가상환경에서의 영향을 사용자에게 전달할 수 없다는 한계를 가진다. 우리는 홀로그램을 립모션과 결합시켜 사용자로 하여금 실제 손과 가상 화면을 같은 공간에 배치함으로써 몰입감을 향상시킨다. 아울러 사용자의 손에 촉각을 전달할 수 있는 햅틱 장비를 장착하여 감각의 상호 작용을 실현하는 프로타입을 제시한다.

ABSTRACT

This paper proposes a user interface for enhancing immersiveness and usability by combining hologram and haptic device with common Leap Motion. While Leap Motion delivers physical motion of user hand to control virtual environment, it is limited to handle virtual hands on screen and interact with virtual environment in one way. In our system, hologram is coupled with Leap Motion to improve user immersiveness by arranging real and virtual hands in the same place. Moreover, we provide a interaction prototype of sense by designing a haptic device to convey touch sense in virtual environment to user's hand.

Keywords : Gesture Recognition(동작인식), Hologram(홀로그램), Haptics(햅틱), User Interaction(사용자 상호작용), Immersion(몰입감)

Received: Dec. 22, 2014 Revised: Jan. 27, 2015
Accepted: Feb. 11, 2015
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ISSN: 1598-4540 / eISSN: 2287-8211

I. Introduction

Traditional input devices such as keyboard and mouse face new requirement for natural reflections while they still have been widely used for input of user. Keyboard and mouse have been considered as common and unequaled input devices for typing and selection. Keyboard is powerful device for predefined key mapped table. However, it is restricted only to the mapped table. Mouse shows almost perfect performance for 2D screen manipulations such as selection and clicking. However, mouse is insufficient and unnatural for 3D control since it depends only on wheel movement for zoom-in/out.

In recent years, several remarkable input devices have been designed for recognizing user's gesture. Kinect released by Microsoft recognizes user's body gesture using reflected infrared rays from user body and has achieved big success for Xbox game contents[1]. However, Kinect is available only for human sized gesture and shows limitation to be applied to finger sized control by the recognition accuracy. Recently, Leap Motion has attracted attentions as a finger sized control device[2]. Leap Motion is specialized equipment in finger sized recognition and is meaningful as the input devices since human finger is an important means to convey human intention and emotion. Speech-impaired people communicate by sign language with their hand gesture. With watching the virtual hands in monitor screen, user makes gestures like swaying hands or building specific patterns with hands.

We propose an immersive user interface based on hand gesture using Leap Motion. The interface system conveys user's intention to the computer in hologram environment and can gain the haptic output applied to hand as well as monitor screen. Concerned user intentions include movement such as affine and shear transformation, selection of virtual objects, and predefined patterns with hand and finger shapes. Here, the hologram implies fake or floating hologram since the state-of-art real hologram still has the technical limitation for real-time performance. The combination with the hologram environments enhances immersion for users by reducing the gap between virtual and real objects and focusing on their hand manipulation. In addition, our interface system accompanies haptic tools that bring the feedback results to user's hand according to the touching virtual objects.

Compared to naive Leap Motion, the advantages of the proposed user interface system can be summarized as follows. First, we establish a hologram structure where user can control directly virtual objects while watching her real hands. However, Leap Motion is designed to control virtual hands yet, it has psychological gap between virtual and real scenes. Second, we combine the haptics concept with original Leap Motion. The user hands wear a designed haptic device with cheap vibrators for associating with Leap Motion system which shows the results only on the monitor.

II. Related Work

Nowadays, there has been a growing

interest in communication between human and computer, and there were various attempts to solve the problems which are about the computer processing speeds in today's digitalized world. To approach these issues, many people studied about the hand gestures in diverse aspects. Gestures are greatly meaningful for people today when they communicate or deal with their works. Also they show the different effects compared to the other conventional input devices such as mouse or keyboards. Some current research presented a review of vision-based hand gesture recognition methods[1]. Also, statistical modeling, particle filtering and condensation algorithm[2] are presented for the gesture recognition. Furthermore the research of hand recognition[3] presented a real-time algorithm to track and recognize hand gestures for human-computer interaction. On the other hand, people employ the Wii-controller (Wiimote) as an input device to interact with an application instead of using their hand gestures[4]. In this research, using Wiimote's acceleration sensor, people could train arbitrary gestures in the field of interfaces such as visual, acoustic and haptic I/O. In this interface, gestures are not confined to the predefined gestures, but they can allow user to train and use user-chosen gestures[4].

To recognize the gesture, people use Kinect which is low-cost and allows the efficient use of images to capture the gestures. One research is about the gesture recognition using Microsoft Kinect[5]. In this research, it is possible to classify hand gestures using simply the depth images. Without the complicated theories, sensors or markers, users can control the virtual hand by their fingers' movements moving in front of Kinect[6]. Also a theoretical and experimental accuracy analysis of depth data can be acquired by the Kinect sensor[7]. It does not contain large systematic errors when compared with laser scanning data. In addition, the research[8] suggests that Kinect technology can be used to solve the problem of very poor sensing in wearable haptics.

There have also been several efforts to utilize holograms. Usually, holograms are designed by computer-generated hologram (CGH) and the key technology of CGH is calculation process time which is inferior to the current high resolution color display. In this case, a polygon-based method in hologram greatly makes the object fields in a shorter computation time compared with the conventional point-based methods[9]. The method is purposed to overcome a previous problem in which the pixel size is limited to a value dependent on the memory size installed in the PC. Abookasis and Rosen's research [10] developed a new procedure for generating a CGH of general 3D objects by fusing multiple angular projections of computer-designed objects. This method offers the computation load effectiveness to that of CGHs of 2D objects, and more importantly, it enables us to synthesize a hologram of both realistic and computer-generated 3D objects. Jung et al.[11] proposed a gesture recognition based system for serious games and Jang[12] studied physical experiences for traffic safety education using serious game design based on gesture recognition techniques.

III. Our Method

3.1 Hologram

Previous people experienced digital contents from flat screens since 2D graphics contents are displayed on monitors of PC and TV. However, limitations of media occurred since recent trends would like to express the contents with real 3D. Current 2D display devices show limitations in delivering stereoscopic feelings since 3D contents are projected on 2D screen. Therefore, we seek to overcome such limitation, bring 3D contents effectively to users and reduce the barrier between user and contents.

Two problems should be tackled for overcoming the limitation. The 3D contents should be displayed in real 3D space rather than 2D display device and a user interface should be designed to control the contents directly by users.

We utilize hologram for expressing 3D contents as themselves. A fake hologram, floating hologram, is used since state-of-art computer generated hologram is far from expressing real hologram with interactive performance [Fig. 1]. As mentioned in Section 2, state-of-art computer generated hologram is far from realtime performance and suitable quality for our application.

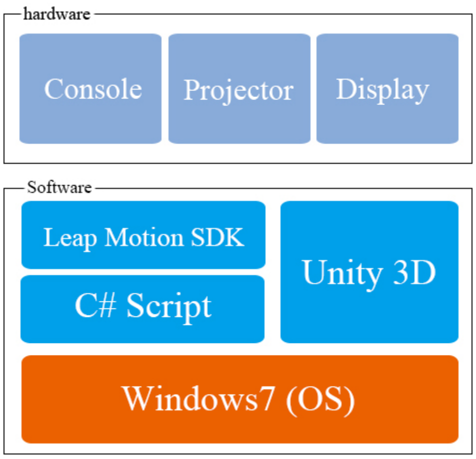
We utilized Leap Motion, a gesture recognition device, for communicating users with generated 3D contents. Compared to Kinect, the sensor range of Leap Motion is relatively small, about 60cm. The final result is an application with which users can handle the illusion objects projected onto real 3D space by their hands.

(a) (b)

[Fig. 1] (a) schematic diagram of our hologram equipment (b) our physical hologram setting with Leap Motion and projector

Our equipment consists of hardware and software. The hardware consists of three parts: a console by which the application is performed, a monitor as a hologram projector, and a designed display device with acrylic panel and peripheral frame.

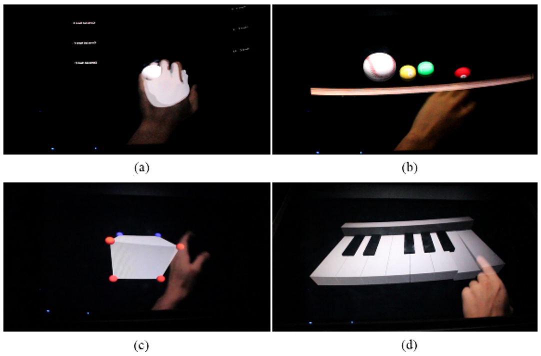
We implement our system by C# scripts and Leap SDK in Unity 3D engine. Since the projected images onto acrylic panel are flipped left and right, our application is constructed to consider such flip[Fig. 2].



[Fig. 2] System architecture of our hologram application

A preprocessing step is to synchronizing positions of hand and virtual hand which is projected onto the panel[Fig. 3](a). We translate the hologram hand projected on the panel to match the position of real hands. After the synchronization, we hide the virtual hand and user can watch the real hand.

A basic example shown in [Fig. 3](b) deals with basic interaction such as touch receives, throw. For the first scene, user can move various balls. When a user sways left and right, the touched balls are scattered. For the second scene, it begins to rain when a user clenches her fist. A user can receive or accumulate the rain drops, and watch scattered scene if she throws the drops. The last basic example includes pick up. A user picks up and move dice.

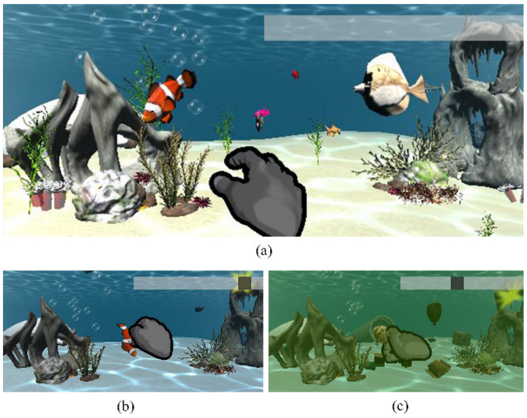


[Fig. 3] Interactive hologram example: (a) hand coordinate synchronization, (b) touch ball, (c) polyhedron vertex movement and (d) piano playing

We generate complex interaction example with practical scenes. [Fig. 3](c) shows our system can be applied to 3D model manipulation. User can move projected vertex of cube to change the shape of the cube. The last piano playing scene demonstrates our system can be applied for generating practical contents. When a user bangs on the piano keys, the pressed key sounds and she can feel play real piano[Fig. 3](d).

3.2 Haptics

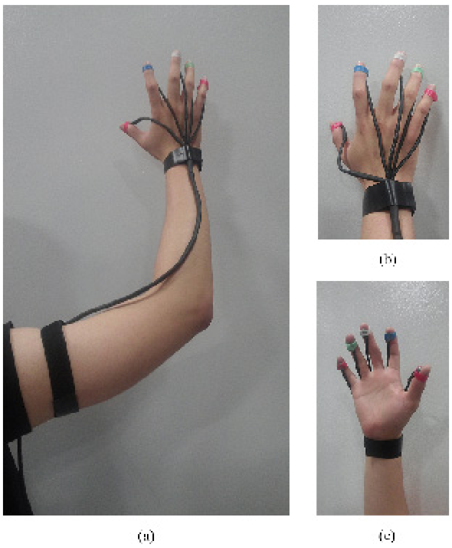
Application “Feel the Fish” is an interactive media art and user can involve with the gesture recognition device Leap Motion. User can touch or grip swimming fishes through the designed haptic device with Leap Motion. The application provides users three interactive factors for supporting the communication with the application: visual sense through the monitor screen, auditive sense through sound, and tactile sense through our specific haptics hardware.



[Fig. 4] Haptics example (a) overall scene (b) grasping a tropical fish (c) grasping fugu

When user touches or grips a fish, diverse vibrations are delivered to her according to the type of fish objects and their motions. For tropical fish, weak vibrations are delivered as soft touch[Fig. 4].

When user grips a fish, irregular and strong vibrations are passed on as the fish flaps. For a fugu, a kind of blowfish, short and strong vibrations are delivered as thorns when a user touches the fish. If a user grips the fugu, then she can feel very strong and irregular vibrations.

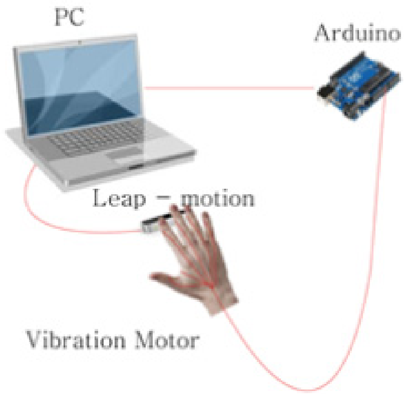


[Fig. 5] Our designed haptics device with five-finger motors

Our haptic equipment consists of 5 small vibration motors which are attached on user's hand and delivers vibrations on fingers by controlling each motor through Arduino[Fig. 5].

Arduino with the uploaded code for our application connects the computer and our haptic glove. The computer gets the recognized hand gesture from Leap Motion and generates suitable vibration signals according to the situation[Fig. 6].

The application "Feel the Fish" shows the development possibility of natural user interface as well as those interests. While previous gesture based user interfaces only recognize the user motion and make a role of input device, our system demonstrates the future of natural user interface which implies the two way interface with input and output results such as touch sense.



[Fig. 6] Overall diagram of haptics application

For expanding the range of application, the proposed system with vibration motors as output device can be extended to combine various tactile equipment. Enhanced two way interfaces are expected to be applied to diverse fields. Game entertainment would have interests on the interface since the new interface shows easy control and immersive environment. The interface would be widely utilized in educational fields since the two-way coupled interface provides realistic touches to children. As media artists have curiosity on novel electronic equipment, they would examine and utilize our interface for their art works.

IV. Conclusion

We have proposed a gesture user interface for enhancing user interactivity and immersion.

Based on Leap Motion, a recent hand gesture recognition device, the proposed interface has developed two applications including hologram environment and haptic technology. Hologram environment with gesture recognition takes out virtual objects from 2D screen into real 3D space. Haptic application transforms the characteristic of Leap Motion controller into two way interaction I/O interface with our specially designed haptic device. Our applications were recently awarded bronze prizes in apps contest hosted by Leap Motion [13].

We tested our system for five users and collected strengths and drawbacks. For strengths of our system, most of them agrees that our system enhances immersiveness and interactivity compared to Leap Motion itself. They commented our prototype provides intuitive and realistic user interface. However, users pointed out that our provided haptic should include more various touch senses because vibration is just one of many touch senses. In addition, for the hologram device, they complained the projected images onto user hand hinder their immersion.

When developing the proposed interface, we were faced with several obstacles. The underlying recognition device, Leap Motion, has inevitable recognition accuracy limitation even with the latest driver. Due to this limitation, user makes mistakes in handling small or elaborate virtual objects. Hidden figures are not recognized by the controller since the figures are invisible from the controller lying on floor. While our hand gesture recognition system based on Leap Motion controller elevates user interactivity and immersion, we are not convinced that our proposed gesture based user interface is superior to common input interfaces such as keyboard or mouse yet. However, our approach is believed to be considerable attempt for opening novel user interfaces beyond traditional input paradigm.

REFERENCES

[1] http://www.microsoft.com/en-us/kinectforwindows

[2] https://www.leapmotion.com

[3] P. Garg, N. Aggarwal, S. Sofat, "Vision Based Hand Gesture Recognition", World Academy of Science, Engineering and Technology, Vol. 49, pp. 972-977, 2009.

[4] S. Mitra and T. Acharya, "Gesture Recognition: A Survey", IEEE Trans. Systems, Man, and Cybernetics, Part C: Applications and Rev., vol. 37, no. 3, pp. 311-324, May 2007.

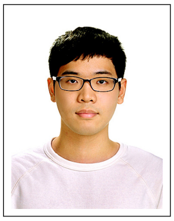
[5] C. Manresa et al., "Hand Tracking and Gesture Recognition for Human-Computer Interaction", Electronic Letters on Computer Vision and Image Analysis, vol. 5, no. 3, pp. 96-104, May 2005.

[6] T. Schlomer, B. Poppinga, N. Henze, S. Boll, "Gesture Recognition with a Wii Controller", Proceedings of the Second International Conference on Tangible and Embedded Interaction (TEI'08), Feb. 18-20, 2008.

[7] K. K. Biswas, S.K. Basu, "Gesture Recognition using Microsoft Kinect", IEEE, Automation, Robotics and Applications (ICARA), 2011 5th International Conference on, pp. 100-103, Dec. 6-8, 2011.

[8] J.L. Raheja, A. Chaudhary, K. Singal, "Tracking of Fingertips and Centres of Palm using Kinect", In proceedings of the 3rd IEEE International Conference on Computational Intelligence, Modelling and Simulation, Malaysia, Sept. 20-22, pp. 248-252, 2011.

[9] K. Khoshelham, "Accuracy Analysis of Kinect Depth Data", International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XXXVIII-5/W12, 2011 ISPRS Calgary Workshop, pp. 29-31, Calgary, Canada, August 2011.
[10] V. Frati, D. Prattichizzo, "Using Kinect for hand tracking and rendering in wearable haptics", IEEE World Haptics Conference (WHC), Istanbul, pp. 317-321, June 21-24, 2011.
[11] Guan-Feng He, Jin-Woong Park, Sun-Kyung Kang, Sung-Tae Jung, "Development of Gesture Recognition-Based 3D Serious Games", Journal of Korea Game Society, Vol. 11, No. 6, pp.103~114, 2011.
[12] Chang-Ik Jang, "A Study of the Physical Experience Using Serious Game Design Traffic Safety Education for Children applied using 3D Depth Gesture Recognition Technology", Journal of Korea Game Society, Vol. 12, No. 6, pp.5~14, 2012.
[13] Super Nova team, Bronze prize, https://www.leap-motion.kr/index.php/contest-finalresult



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