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Holographic Projection System with 3D Spatial Interaction

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Abstract. We propose a Holographic projection system that has direct and natural interaction technology between 3D contents and users using voice and motion. For this, we had to regard user space and holographic image space as three-dimensional cube. And we use a depth camera to track user's voice and motion. The information obtained is used to manipulate the state of the holographic contents.
The proposed method allows users to interact directly with the holographic projection contents. Through this spatial interaction research that combines 3D stereoscopic images and 3D interface, the user is immersed in the content through sensory experience. And two-way communication between user and 3d images is also possible.

Keywords: 3D Spatial Interaction, Depth Camera, Holographic Projection

1 Introduction

Lately, 3D image display technology has developed from stereoscopic method based on binocular disparity into a Hologram display over convergence of IT and Arts. By using a variety of interaction devices, it is trying to make a new way of communication with the user.
While playing video games at home, full body interaction like the actual situation, as the advent of low-cost commercial video game sensor. Some sensors Such as Microsoft's Kinect are designed to interact with the user directly.
A study on direct interaction between the user and the holographic images are still in its early stages as with Hologram application research. The most interactions in Holographic performances or exhibitions perform while maintaining some distance between the user and the contents.
We propose a Holographic projection system that has direct and natural interaction technology between 3D contents and users using voice and motion. This method sees its surroundings of holographic contents as computing surrounding and translates the motion to spatial. For this, we use 3D (depth) camera that can recognize the depth of where the people's behavior and motion is located. Holographic contents will be controlled by spatial information that is

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obtained from depth-camera. In addition, depth camera is used for the user's speech recognition and output.

2 Backgrounds

3D spatial interaction is human and computer interaction that included 3D UI and technology to effectively control computer-generated 3D contents.
In space with 3D interaction, users motion information is divided into 4 steps such as Navigation, Selection, Manipulation and System Control.
Navigation is for physical movement without any special motion, Selection is approaching object with intention, and Manipulation is taking an action of changing objects property. Generally, Selection and Manipulation occurs simultaneously. System Control means changing the contents condition when particular motion is sensed.

2.1 3D User Interfaces

3D user interface (3D spatial interaction) is a UI that involves human computer interaction where the users tasks are carried out in a 3D spatial context with 3D input devices or 2D input devices with direct mappings to 3D. In other words, 3D UIs involve input devices and interaction techniques for effectively controlling highly dynamic 3D computer-generated contents[7].
3D user interface with tactile interface and non-tactile interfaces, depending on the relationship of contents and user interface types can be classified. Of course, the role of the interface and type may vary, depending on the intent of the contents provider that are inherent in the contents.
In this study, it has classified the following four types of interfaces.
The first interface is to detect hand gesture using controller and joystick based on motion recognition sensor. Users enter their information by direct manipulation of touch devices such as sensor attached Gloves and Nintendo's Wii.
The second interface is to detect body movement using the video input on the camera based on vision system. In order to obtain information on the behavior of the user and the user in 3D space, video camera-based object tracking method is typically used.
The third interface is using smart devices Due to the development of the internet, smart devices have become a medium to exchange information and share the user's experience and senses through a variety of applications. For example, with one touch on the smart devices, people are able to connect and communicate beyond the temporal and spatial constraints.
In particular, user's interactions with smart devices are quite natural without reluctance because the user is familiar with smart devices.
The last method is using a combination of several interfaces. The touch screen or the user's general possession can also be used as an interface for interaction.

Motion Recognition Equipment, the physical input devices and spatial interaction techniques are needed for 3D interaction. Motion recognition is to measure the location and coordination for the movement of people in 3D space and record the types of information that can be used by computer. Of course, the information obtained from motion recognition tasks are also possible to play back the three-dimensional.

2.2 Holographic Projection System

Holographic technology allows users to see 3D stereoscopic images without special glasses. However, there are several technical problems using the hologram. The standard holographic image representation has not yet been established.
In recent performances or exhibitions, similar hologram technology has been implemented but not real. The similar hologram technology doesnt use real laser equipment. It is holographic projection technology to project 3D images on a two-dimensional transparent screen from a high-resolution projector.
This research offers reflective holographic projection display unit. The composition for the display unit is beam projector and transparent screen which is made up of Musions floating hologram which is based on principle of regeneration[11].

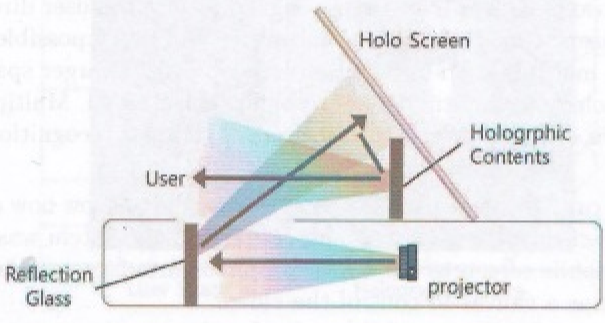

Fig. 1. Holographic projection system architecture

2.3 Related Work

Now, we will describe artworks using the spatial interaction technology on a case-by-case.

Virtual Sculptures using CavePainting. CavePainting is an application of CAVE in the field of Art and Design. [7]s 3D virtual sculptures are an artwork utilizing CavePainting system.

This system is to provide an environment that is familiar with artist using traditional desktop modeling tools. Feature of this system is designed to select the tools such as brush by artist directly for creating 3D sculpture.

Video Games using Wii Remote. The Video Games in [10] has the design of a low-cost 3D spatial interaction approach using the Wii Remote for immersive Head-Mounted Display (HMD) virtual reality.
If the user has the controller in both hands and moves, the video of the user changes real-time depending on the recognized direction

Building block tracking system using Kinect. [1] is a prototype system for interactive construction and modification of 3D physical models using building blocks. This is characterized by implementation of World-In-Miniature(WIM) technique. The WIM technique uses a miniature version of the world to allow the user to do indirect manipulation of the objects in the environment.
This system uses a depth sensing camera and a Lattice-First algorithm for acquiring and tracking the physical models. Users can interactively construct the models using their hands while the system acquires additions or deletions to the model.
Depth camera is monitoring the physical structure of the block in the pile to determine the status of the removal or additional state of blocks. Depth sensors such as Microsofts Kinect have been designed to face the user directly for interaction. But users want to be able to move freely in every possible direction.
Especially in multiple users Interaction environment, a larger space and an advanced technology for multiple users recognition is needed. Multiple Kinects are interworked in order to overcome the limits of the rear recognition.

Interaction on Mobile Devices. [8] is the system to show how a large number of users interact directly using the smart devices This system was to extend the individuals mobile screen to the touch projector interface to take advantage of the city walls as a canvas to control the video.
The significance of this research is media facades in urban space which can be manipulated by the collaborative multi-user scenarios.
Images shown in the media facade appear in each mobile screen immediately. Users interact freely with each other using desired colors by changing the LED colors shown on the wall. However, its too bad that interface does not recognize a particular user, if multiple users access at the same time.

3D interaction with fabric. General media, such as cloth can be used as 3D input device. As an input device, fabric holds potential benefits for three dimensional (3D) interaction in the domain of surface design, which includes designing objects from clothing to metalwork[2].
This system supports recognition of a point:a flexible curve, and a flexible surface. According to the direction of the fabric, Users Interact in real time with the screen in the video via physical user movement.

3 Design Considerations

For interaction between user and holographic contents, we defined the user space and the space of holographic contents as a three-dimensional cube type. We traced the occupied state of cube and the user's behavior using a depth camera. If the user approaches within the depth camera recognition range, two tasks come into action. For one thing, the occupied space of the user and the occupied space of the holographic image are activated. Another depth camera begins to track the status of the occupied space.
Fig. 2 is an overview of three-dimensional space in the cube form for obtaining 3D spatial information in this research. The size of the user space and the holographic space is designed to the maximum size of the holographic images by considering gesture recognition such as the move and rotate of the object.

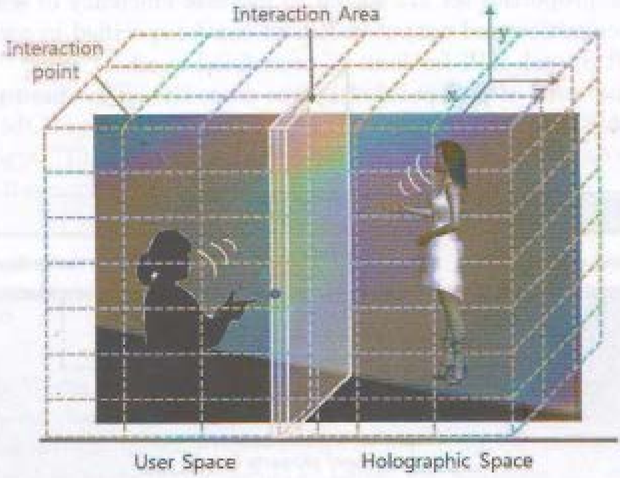

Fig. 2. Design of 3D interactive space

In the figure above, the holographic space is a virtual 3D space, 2D space that is occupied by the holographic projection images. We use virtual z-axis for manipulate the size of the image in application program.
The user can access directly in the interaction region, intersection region of the user space and the holographic space. The area, in which users and holographic content direct contact between, is called the interaction area. And we define the interaction point as the hand point of the user.
By comparison with predefined gesture operations to manipulate video information to take advantage of the user's behavior in interaction area is determined whether or not.

4 System Framework

In this research, we use Kinect for interaction with the hologram. Kinect is one of the integrated sensing devices and uses the skeleton algorithm for the motion capture.

Kinect consists of RGB camera, depth perception sensors and multi-array microphone. And using this system, the overall shape of the person's Kinect 3D motion capture, facial recognition, and voice recognition is possible.

First, obtained image from depth-camera will be used to track users fingers tip to get two interaction points space coordinate and create status graph. Tracking interaction point will be continued until user selects specific object.

Selecting object seems the user is approaching interaction point that is in the object range. Approaching interaction point shows the difference with object range which is less than a critical value. Selected object gesture is expressed in the form of gesture group and vector. To change holographic contents property with recognition gesture of users, we use Bruteforce method to search gestures/properties set. Gestures/properties set are sorted to increase efficiency of searching.

The voice recognition and output in Kinect can be specified in conjunction with the Microsoft Speech API for limit of predefined words.

If you say one word of pre-specified by the user, Kinect is able to recognize the voice and the correct the answer.

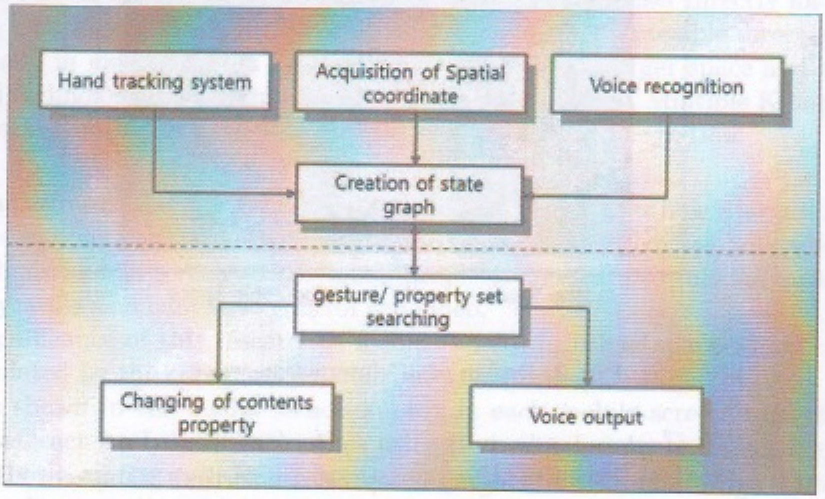

Fig. 3. 3D interactive system model

5 Conclusion

We propose a Holographic projection system that has direct and natural interaction technology between 3D contents and users using voice and motion without

any special portable devices.
The proposed interactive holographic projection system allows users to interact directly with the holographic projection contents.
Through this spatial interaction research that combines 3D stereoscopic images and 3D interface, the user is immersed in the content through sensory experience. Two-way communication between user and 3d images is also possible.
Furthermore, if an abundant education about operation method (gesture) is achieved, users flexibility of input will be provided and recognize an error with users satisfaction will be increased. From now on, suggested interaction method will be applied to holographic art field.
In addition to the user's interface in conjunction with a wide variety of objects, such as the user's belongings and more familiar and easy, and you will be able to provide a natural interaction.
In order to encourage the active participation of the user, it is necessary to design of the optimized information structure and select the interface for smooth communication between the users.

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