

# Flexible Remote Control Application for Virtual Reality using Virtual Graphic Driver and OpenCV

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## ABSTRACT

With the information age, "overcoming spatial constraints" that make everything possible anytime and anywhere has become a matter not to be neglected. A 'remote control application' that allows you to control your PC from the outside would also have been developed with this ultimate goal. This study proposes this method in order to compensate the shortcomings of the existing remote control method and suggest the possibility of future development. VR allows remote control within the virtual space to separate the display and the operation of the I/O device and improve the accuracy of the operation. Through the advantages in the space of secured virtual reality, it represents the possibility of additional functions such as multi-monitor. Furthermore, the control function of the device removes the I/O device for the increase of portability, and is replaced with OpenCV by recognizing the motion of the hand.

**Keyword:** Virtual reality, Virtual graphic driver, Remote desktop, Hand motion recognition

## INTRODUCTION

Virtual Reality (VR) is attracting attention as a potential field for IT (Information Technology) industry in 2016, and companies are increasing their investment while developing various contents. Zuckerberg, CEO and chairman of Facebook, said "Virtual reality is a next-generation social platform," and he predicted that VR would have great ripple effect in the future[1]. In addition, at the Consumer Electronics Show (CES) held in Las Vegas, USA and at the Mobile World Congress (MWC) in Barcelona, Spain, companies such as Samsung Electronics, Oculus, HTC, and SONY that have invested in many VR sectors participated and showed a great possibility in VR[2].

This study proposes a remote control application that can use an external PC anywhere with the core of "overcoming positional and spatial constraints" by exploiting the possibility of infinite development of VR and virtual space formation.

Conventional remote control applications are largely divided into mobile version and PC version. The mobile version of remote control application displays the display data of the external PC on the display of the mobile, and the I/O device such as the mouse and the keyboard is also controlled in a manner of recognizing through the touch. The PC version consists of control of display data and I/O devices imported in the same way as the mobile version. In both methods, there is a possibility that the input/output processing method may malfunction due to the overlap of the I/O device and the display device, as well as a disadvantage of always having to carry.

This study proposes an application that has overcome the limitations of the previous critical points as a disadvantage of the existing remote control application. Furthermore, this study discovers and presents the possibility of future development that remote control can go through a combination of virtual reality and remote control.

## RELATED WORK

### OpenCV (Open Computer Vision)

OpenCV[3] is an open source computer vision library. It can be used on multiple interfaces and platforms, and is developed with emphasis on computational efficiency and real-time applications. Therefore, various functions supported by the library and the mobile device to be mounted on the VR are used to recognize and track the user's hand in real time to judge the operation. This technology allows all functions to be controlled by the user's hand instead of an I/O device such as a separate mouse or keyboard.

### Virtual graphics driver

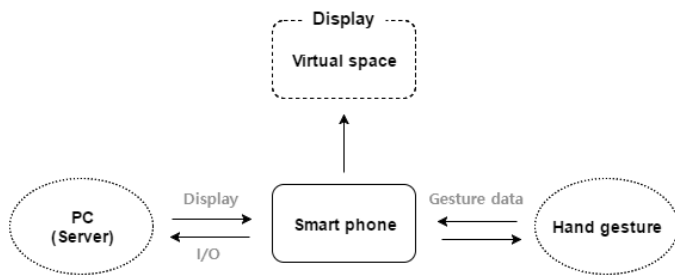
Virtual Graphic Driver[4] is a virtual graphic control technology that generates a graphics card without adding a separate graphics card, and can transmit and control a screen output signal through an interface. The virtual graphics driver

serves to fetch the display data of the external PC. The data imported by the application's internal command is transmitted through the network, allowing the user to view the external PC screen from anywhere.

## SYSTEM COMPOSITION

The relationship between the system areas is largely classified into a network area that allows the user to transmit display data and an operation control area that recognizes the user's operation as shown in [Figure 1].

The network area and the motion recognition area are composed of a server for providing display data of an external PC, a HMD for providing an image to the user, and a rear camera of a mobile device for motion recognition.



**Figure 1:** Structural diagram of Virtual remote control application

### Server

The virtual driver of the server is implemented by a program called 'Mirage Driver'[5] of 'Demoforge' company. The virtual graphics driver carries out a process of converting the display data of the PC into the byte format. When this process is completed, it is transmitted to the HMD and client through TCP communication. Also, when a client receives an I/O request in a waiting state, it analyzes the signal and processes the message.

### HMD (Head-Mounted Display)

The role of the HMD is to provide the user with display data received from the server. HMD devices to be used in this study are basically equipped with gyro sensors and acceleration sensors for VR devices, and head tracking is supported. Therefore, it is possible for the user to remotely control a more realistic application in the virtual space.

[Figure 2] shows the HMD to be used in this study and the body to which the mobile device is fixed.



**Figure 2:** HMD used for the application-Samsung Gear VR

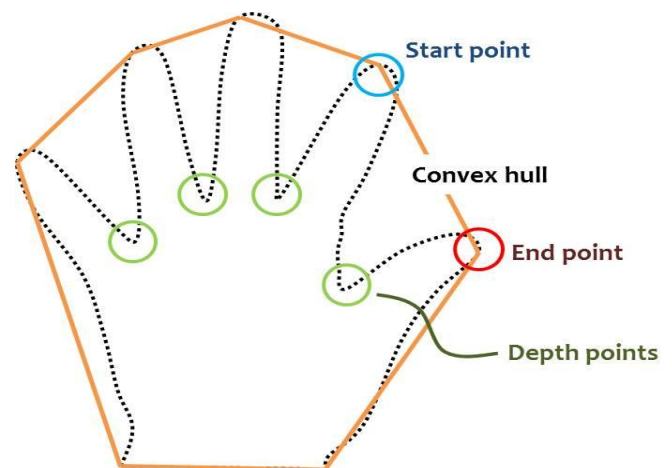
### Motion recognition

The motion recognition is recognized through the rear camera of the mobile device fixed to the VR device, and the process is as follows.

First, the ROI (Region Of Interest) region is extracted by removing the remaining colors except for the color applied at the beginning.

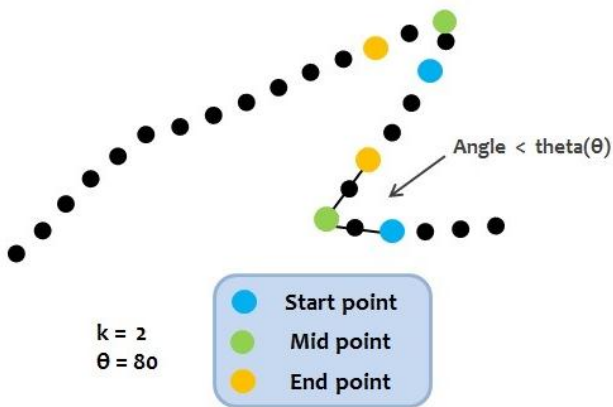
Second, this study compares the size and relative ratio of the bounding box to determine whether the extracted region is the user's hand.

Third, to confirm the fingertip position in the authenticated hand, the Convex Hull and the Convex Defects are processed as shown in [Figure 3].



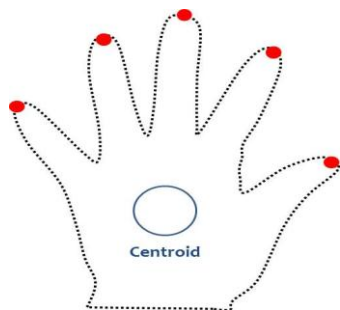
**Figure 3:** Finger position estimation using Convex Defects

Fourth, for the reliability of the function, the result is reconfirmed by analyzing the points constituting the border of the hand area. It uses a K-Curvature to find the degree of bending according to the angle formed by the points represented by the constant k. [Figure 4] shows an example of K-Curvature.



**Figure 4:** Finger position estimation using K-Curvature

Finally, since the remote mouse function is executed through the degree of bending of the identified finger, it is confirmed whether or not the position of each finger and the distance of the center point of the palm are checked.

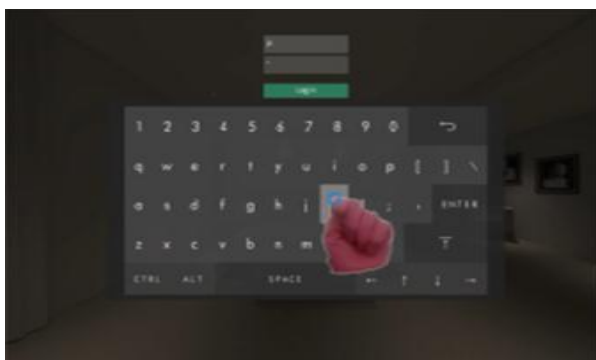


**Figure 5:** Finger position estimation using distance

**MAIN FUNCTION**

**Account**

Users have their own accounts. As shown in [Figure 6], by logging in into their accounts, they communicate with the PC (server) stored in their accounts. This makes it possible to connect with their PCs (Servers) without separate settings.



**Figure 6:** User's account sign-in screen

**Computing task**

After the user goes through the hand measurement and login process, they communicate with their PCs (servers) in full scale. As shown in [Figure 7], the screen of the user's desktop at home can be accessed. Thus, allowing the user to be able to perform computing tasks as in a desktop environment.



**Figure 7:** Initial screen of executed application

[Figure 8] is the screen which a user is using the virtual remote control application. As seen on the screen it is possible to run Microsoft's Internet Explorer and open a document. With its hand recognized by the rear camera, the application can also provide a function to the user to type down a letter to the remote desktop. The keyboard icon at the bottom of the screen will allow such function.



**Figure 8:** Screen of a user using the application

**Snapshot**

Working with two or more windows can increase a user's work efficiency when dealing with complex tasks. However, it is necessary for the user to purchase an additional desktop monitor. To solve this inconvenience, the application provides a snapshot function alternatively. It is possible for a user to take a snapshot of the user's main screen and arrange it next to the main screen in a virtual reality allowing a multiple screen at once. This study has taken into account the spaciousness of the virtual reality and complemented the possible downside, such as slowing the system down, of

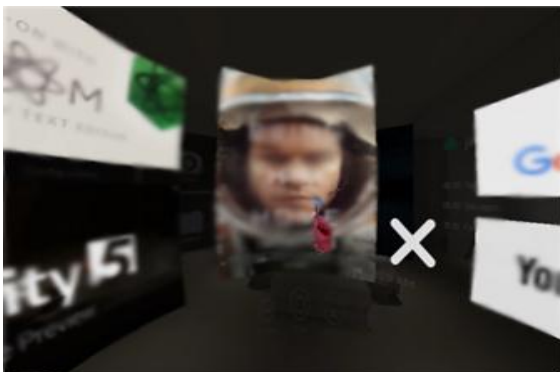
synchronizing multiple real-time synchronized screens concurrently. As shown in [Figure 9], this study applies the method that the main screen to be in the center and additional screens to be placed and displayed around the main screen by pressing the Snapshot icon at the bottom and referring to them whenever needed.



**Figure 9:** Screen with multiple snapshots

### Shortcut

As shown in [Figure 10], it is possible for a user to launch a program by pressing a shortcut icon. Without having the user to find and execute a desktop program one by one, user can directly run a program by clicking on a program from the initial virtual remote application screen.



**Figure 10:** Screen with multiple snapshots

### CONCLUSION

This study proposed a technology to enable remote control in virtual reality using virtual graphics driver and OpenCV. This study overcame the spatial limitations of existing remote control applications, and improved the portability by replacing the roles of mouse and keyboard by combining mobile phone camera and OpenCV technology, manually without any auxiliary device.

Moreover, the development and the usage of the cloud computing service are recently active and widespread. If the cloud computing service is shared with the active development, it can be expected that the communication between the user PC (Server) and the smart phone proposed in this study would be replaced by the communication between the cloud server and the smart phone. If cloud computing technology is integrated, we can expect an improved application added with the advantages of cloud computing's PC scalability and cost reduction.

### ACKNOWLEDGEMENT

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