Evaluation of DataGlove’s usability as Input Device for Virtual Reality System

Dun Mao
Msc Human Computer Interaction
School of Computer Science
University of Birmingham

Abstract—In this paper, we discover the design space of DataGlove by comparing some of the typical design prototypes and evaluate their usability as an input device for Virtual Reality. We start with summarizing the main feature of Virtual Reality and the advantage on using DataGloves. After comparing several designs, we analyze the strength and weakness of current DataGloves and propose our own design.

Keywords—DataGlove; fiber optic glove; Virtual Reality; HCI;

I. INTRODUCTION

Virtual Reality is one of the most hot debate topics in 2016. With Oculus VR and Sony releasing their commercial VR headset this year, Virtual Reality has become more than just fantasy in sci-fi movie. Virtual Reality technology can bring to the users the interaction experience in real three dimensions, which require more natural and more intuitive design for interaction methods. It would draw attention to research topics such as NUI design, 3D UI design, Eye-Gaze tracking and motion capture. The popularization of virtual reality will bring a new era to HCI research.

However as a new industry in its early stages of development, the design space of VR devices haven’t been fully explored. Although the output display device of the VR system is taking shape, the design of the input device is not yet standardized. The traditional input device such as mouse, keyboard and joystick has been proven not suitable for 3D manipulation and navigation. In recent years, many prototypes have been produced yet none shows an absolute advantage among all the competitors. For example the Leap Motion using two infrared cameras to capture the hand movement, the Razer Hydra uses magnetic field to locate the controller’s location and the Myo wristband using EMG to detect user’s hand gesture.

Although these prototypes are varied in methods, they share one thing in common which is the focus on hand motion capture. Hand is the primary tool we use in our everyday physics interaction, therefore it’s essential to acquire its motor information in order to create convincing virtual interaction experience. However, as the most common tool for hand motor control research, the DataGlove is not a popular choice in Virtual Reality system design. Even though DataGloves are widely used in scientific research and motion capture for 3D animation, it’s not specifically designed for the modern day VR device such as Oculus Rift headset. Which could be the reason why it’s been overlooked.

Therefore in this study, we collected some examples of different kinds of DataGlove design and evaluate their usability as input device for virtual reality system. Instead of discussing technique details about how those gloves work, we focused on what user experience can it produce and which part of the technique is responsible. Finally we produced a summary on what characteristics of the Dataglove are useful as VR input and what’s its drawbacks. Hopefully this will serve as a guideline for VR device design in the future.

II. VIRTUAL REALITY

A. What is Virtual Reality

The term “Virtual Reality” is clearly the combination of the words “Virtual” and “Reality” which implied its meaning. “Virtual” indicates its computer generated, artificial and “Reality” suggests it’s an environment in which the user can apply his sensory skills to gain experience. Together it’s the term used to describe a computer-simulated immersive environment that replicates the sensory experiences of the real world such as sight, touch, hearing, and smell.

And the Virtual Reality System refers to the hardware and software that’s been used to produce this artificial environment. It includes the processing unit, the output device and the input device. Processing unit can be either PC or Smartphone, which runs the simulation software. Currently the most popular output device is Head Mounted Display with inertial measurement unit inside to measure the user’s head movement.

B. Features of Virtual Reality

Compare to traditional User Interface such as desktop GUI, Virtual Reality has many unique features.

- Realistic: Although the virtual world is generated by computer, but it follows the a few rules as the real world such as gravity and perspective principle. The Virtual Reality environment is often powered by two software engines: the physics engine and the graphics engine. They handle collisions and rendering of the virtual objects in order to make their interaction believable.
• Immersive: Because of the realness of the Virtual Reality environment, VR can create immersive experience both mentally and physically. For example by using two separate screens, the HMD is capable to replicate the sense for depth of field. VR system is designed to block the sensory information from the outside world and feed the user with artificial feelings.

• Interactive: The difference between Virtual Reality experience and watching a 3D movie in the cinema is that user have some degree of freedom to explore the VR world. Actually commercial 3D HMD has already appeared even before 2000, but it’s not until the release of the Oculus Rift that HMD has officially become standard commercial VR Output device. What’s special about the Oculus Rift is that it can track the rotation of wearer’s head and rotate the field of view in the VR world accordingly. When the user move around, the VR world also move with the user.

Those features determines that Virtual Reality system requires different Human-Computer Interaction design.

III. DATAGLOVE

Dataglove refers to the glove-based interactive device which can be worn on the hand and capable of capturing its position and rotation. Depends on the sensor deployed, the Dataglove can provide information such as global/local position/rotation, finger abduction, perceive pressure, force and so on.

The first Dataglove is created in 1977 by Tom DeFanti and Daniel Sandin. It used the optical flex sensor for finger tracking and an inertial tracker for localization. After that the Dataglove has been developed rapidly and nowadays different Datagloves are very much different in design. However even till this day, engineers still haven’t reach a consensus on the design of Dataglove, some of them kept the shape of the glove, others become more like exoskeleton.

Although the design is inconsistent, Dataglove is widely used in all kind of area in scientific study. Since it’s one of the most efficient way to track the hand movement at real time, it’s be proven useful in haptic research. There’s also be plenty of research around using it for Human-Computer Interaction. However because of the high cost of the device, it’s rarely be used for commercial purposes. But with the progress of motion capture technology these year, the price has dropped down dramatically. It’s the right time to consider including it into the Virtual Reality system.

A. Why using Dataglove in Virtual Reality

As mentioned before, one of the unique feature of Virtual Reality compare to traditional computer system is realistic, which the user is exposed in a real three dimensional. But the traditional Input device, such as mouse, keyboard, gamepad, are not designed to navigate in 3D space. To manipulate a 3D object, the Input device should at least has three degrees of freedom, another three are needed for the rotation. Dataglove normally has 10-20 DOF, more than enough for simple 3D manipulation.

Another important feature of VR is immersive, which is the mean reason for Dataglove to be a good choice for VR system. The traditional GUI is based on the desktop metaphor, which map the user’s movement to the movement of the cursor. But in Virtual Reality environment, a virtual avatar is showed to the user, therefore there’s no reason to keep the metaphor since the user can directly see their hand. Our primary physical interaction with the world is through our hands, therefore in the Virtual Reality, an environment that’s designed to resemble to the real world, using hands is the most intuitive way for interaction. When the user is completely immersed in the VR world, the dataglove can free the user’s hands as well as allow for more delicate manipulation.

B. Tracking Technology

The primary technique used by Dataglove is the tracking technology, there’re five kinds of tracking that are able to acquire the accurate position of the palms and fingers. Different design has different advantage and disadvantage, but all have been widely used in Datagloves.

• Optical Solution: By using a depth camera and the computer vision technique, an optical tracking system can calculate the point cloud data to get the position of the hand. Optical tracking is very accurate and depends on the reorganization algorithm it can track as many joins as needed, and there’s no need for calibration. However the work space of the system is limited by the field of view of the camera. Also the reorganization might fail if the structure of the hand is partially blocked. Never the less, it’s the cheapest way to perform hand tracking.
• Mechanical Solution: mechanical tracking has to be the most traditional way for position tracking. It relies on a physical connection between the tracking target and a fixed reference point such as a connection of rigid arms. This kind of tracking is highly robust to the environment noise and only require one time calibration. It’s also the only way to apply force feedback though the glove. The main drawback is the device takes a lot of space and put too many attachments to the user’s hands.

• Inertia Measurement: Nowadays Inertia Measurement Units (IMU) are equipped in every smartphones. It measures the relative movement of the target by measuring the inertial force applied to it. The IMU chip is as small as a finger nail and there’s no limitation for its work space. However, because it can only measure the relative movement, a draft of the sensor’s reading is inevitable, calibration is required from time to time. There are however some better sensor that needs less calibration but cost way more.

• Magnetic Solution: Magnetic Solution is using the Hall Effect to measure the magnetic field generated from a base station in order to provide the global position of the target. The tracking error is less than 1mm and there’s no never going to be a draft on the reading. However the work space is limited around the base station and highly sensitive near electromagnetic field generated by other devices.

• Flexion Sensor: Also called bend sensor is used to measure the amount of deflection caused by bending the optical fiber embedded in the sensor. If you attach it to the finger, then it’s capable of telling how hard the finger is bent. It’s very light and flexible which suits perfectly to the design requirement of the Dataglove, therefore it’s been used since the first appearance of the Dataglove and still one of the most common tracking technique used on commercial Dataglove products. The main disadvantage is the cost of the device, which actually holds back the popularization of the Dataglove. At the meantime, it lack the ability to provide detail skeletal information of the finger, since it can only measure how much is the bend not how the bend is.

C. Other Devices

Besides from the Dataglove there’re many other input devices can be used for immersive interaction in Virtual Reality, although they’re all using one of the five tracking techniques mentioned above. These devices represent the current trend of the VR input device design, therefore is worth comparing them to the overall design of Dataglove before we discuss about the individual Dataglove design.

• Oculus Touch: the handheld controller developed by Oculus and is going to ship with the commercial set of}

![Figure 4. The Oculus Touch](image_url)

Oculus Rift. The tracking technology used by the Touch is called Constellation tracking, which is basically a kind of Optical tracking, using an array of infrared LEDs and a camera running image recognition algorithm, the Oculus Touch can provide information of position and orientation of the controller. Compare to the Dataglove, because it’s only tracking the controller, there’s no gesture recognition or finger tracking. The delicate interaction with virtual objects are still handled by pressing buttons, making it less interactive. Also because the controller needs to be hold all the time, when virtual avatar is performing other hand gestures such as waving, it conflict with the user’s intuition which reduce the feeling of immersive.

• Leap Motion: Leap Motion is probably the first commercial tracking device that’s been customized to associate with VR headsets. It’s also an Optical tracking device but instead of tracking any kinds of controllers or markers, it’s directly recognizing the user’s hands. It’s capable of tracking all the individual joints of each fingers and require no attachment to user’s hand. The
 latency and accuracy are remarkable, which makes it sounds to be perfect for VR input. However it suffers from all the problem that optical tracking has. First is blocking issue. It produce all kinds of error if one finger is blocked to the camera by other fingers of the palm. Then there’s the limitation of the working space. The device is designed to be put in front of the HMD headset and can only detect hand movement in the front. And once the hands leave the detectable area, it would take a while for the system to detect them again. These features severely jeopardized the user experience in VR environment.

- Razer Hydra: was designed to fill the gap in PC motion controls. It uses a weak magnetic field to detect the absolute position and rotation of the controllers in order to provide true 6 degree of freedom tracking. Compare with the Oculus Touch they have a lot in common and share the same defects regarding to its hand holding and button pressing user experience. But the most distinct difference is the tracking technique deployed in the Hydra. Even though Hydra still needs to set a base to generate the magnetic field, the work space is considerably larger than Optical tracking and it’s unrelated to the direction. But the fatal problem with the magnetic tracking is its distortion. Because the shape of the magnetic field is not a perfect grid. Although the device works fine in small range, the distortion accumulates and become significant in a large scale. The calibration is too elaborate and complicated thus limited its usability.

D. Sensory Feedback

Another unique feature of DataGloves is it not only can be used as an input device but also can function as an output device. DataGloves can be used to provide a variety of feedbacks including force, vibration and temperature. Feedback are particularly important in HCI design, because they give responds to user and give them a better understanding about the action they took. It helps the user to control their behavior so that they won’t under or over react.

Without feedback even simple task such as put the hand on the edge of a box would be very difficult. That’s actually happen very open in floating GUI design where users don’t get any respond when touching an icon and they end up penetrating through it. In the real world, human use a projectile-like way to move their hand most of the interaction tasks, which relies on the physical object to stop the finger movement when contacting the target. Which mainly relies on force feedback and partially on visual feedback. However it’s not the same case in Virtual Reality environment when manipulating Virtual objects. Without force feedback, user have to fully rely on visual feedback, which is considerably slower than force feedback and less accurate. That’s why for HCI design in serious application scenario such as medical instruments or control panel for heavy machinery, designer still insist on using real button rather than touch screen, just because of the feedback buttons can provide. If the Virtual Reality can’t include feedbacks, it only simulated part of the real life interaction.

Different from these input devices, DataGlove is capable of providing feedback to individual fingers, for an acceptable price. That makes DataGlove irreplaceable since it can provide this novice immersive experience while others can’t. Which expand the usage of DataGlove to more than just entertainment. There already have studies on using DataGlove with force feedback for rehabilitation or remote robot control.

IV. COMPARISON

In this section, we choose several representative Dataglove designs and compare their usability in Virtual Reality system. First we will start by discussing how to model our hand in order to determine what kind of interaction can be captured by Dataglove.

A. Hand Model in Virtual Reality

Essentially the usability of Datagloves are determined by the tracking techniques they applied. Different designs can be regard as different combinations of tracking techniques. Different combinations can produce different user experience which determined the usability of the device. Since Virtual Reality are dedicated to simulate the real world, as a hand

Figure 6. The Razer Hydra Controllers and the Magnetic Field Base Station

Figure 7. Hand model with 27 degrees of freedom
tracking device, the Dataglove should be responsible for simulating the realistic interaction of real hands. However human hand is a complicate organ with rich sources of sensory nerves. It provide a variety of sensory feedback such as posture, temperature, touch, pain. And it has 27 degrees of freedom (DOF), 5 for the thumb, 4 in each finger, and 6 for position and orientation of the palm. These DOFs represent the mobility of the hand’s joints. Different tracking technology has different coverage on DOFs, for example one IMU can cover 6 DOFs while a flexion sensor typically can only cover one DOF. However, those 4 DOFs of the fingers are refers to the flexion of three joints in each finger and the abduction of the last joint (metacarpals-phalangeal joint), but IMU can’t be used for flexion measurement, therefore 3 IMUs are required for full tracking of each fingers. The same goes to magnetic sensors as well.

To acquire a better interaction experience the design should cover more degrees of freedom. However, not all these features are relevant to Virtual Reality user experience. For example the temperature feedback is not necessary and not all those 27 DOFs are required for finger tracking. In fact due to the muscle structure of the finger, 3 out of 4 DOFs in each finger can be replaced by only one that represent the flexion of the finger, the rest 1 DOF for abduction and adduction is relatively insignificant. Therefore some designs could reduce the cost by simplify the hand model to reduce DOFs.

So which DOF can be ignored and which shouldn’t? There are several simplified hand model with only 24, 16, 14 or even only 9 DOF. But for the application in Virtual Reality, it depends on what interaction it responsible to.

Let’s begin with the 6 DOFs in the palms. Three of them are responsible to the translation and rotation of the entire hand, therefore is absolutely necessary. Otherwise the Virtual Hand would be fixed in the space unable to move around at all. These DOFs can be covered by one IMU sensor or one magnetic sensor, but can’t be covered by flexion sensor or mechanical structure since the flexion sensor is inadequate to track the position and both techniques can only measure the relative position and rotation.

Then for the 4 DOFs in each finger, three of them are for the flexion, which responsible for the bending of each fingers, the other one is for the abduction and adduction, which represent the ability to expand the four fingers. The abduction DOF can be ignore since we rarely intentionally expand our fingers separately in the daily life (unless you’re a fan of the Star Trek). The flexion is important because it allows fingers to bend and separate them from each other. Never the less, as mentioned above, those three joints in the finger are linked by the same muscle, therefore not all 3 DOFs are necessary. Most people can’t actually move their fingertip without moving the rest of the finger, which combine 2 DOFs into 1. Even so, it’s very rare that people only use the first two joints for real life interaction, thus for a low accuracy standard, even only tracking one DOF of flexion would be enough for each fingers. Since one flexion sensor can only cover one DOF, 1-3 sensors are required for tracking each finger. Another way to deal with the problem is to consider the position rather than flexion of each finger. Because the length of finger is constant, if the position of the fingertip is given, realistically there’s only one way to bend the joints and reach to that position, therefore we can use the position of the fingertip to specify the status of the finger. If we ignore the DOF of adduction, then the work space of the fingertip is a 2d surface, which only has 2 DOFs. Even if we include the DOF for adduction, we can still cover all the DOFs by using only one IMU/magnetic tracker or one 3 DOF mechanical arm. However this is only the minimum requirement to produce acceptable finger movement and might not work in all situations since someone can bend their fingers in unusual ways. For the maximum accuracy we still need 3 sensors for each finger.

Finally the thumb which has 5 DOFs, 2 for flexion and 3 for the rotation of its root. Since the thumb is the most flexible finger and is rapidly used to assist other fingers’ movement, it’s unreasonable to simplify its functionality. Therefore we would need at least one IMU or magnetic sensor for position tracking and one flexion sensor for bending.

There’s one tracking method I haven’t mention during the discussion, the Optical tracking technique. By using the image recognition, it can apply all kinds of skeleton model to the hand, no matter how many DOFs the model has, one pair of optical camera is enough for tracking all the finger movement.

To sum up, the minimum requirement for believable hand tracking in Virtual Reality is:

- One IMU/magnetic sensor for palm tracking + four IMU/magnetic sensors for four fingers + two IMU/magnetic sensors for the thumb.
- Or One IMU/magnetic sensor for palm tracking + four flexion sensors for four fingers + one IMU/magnetic sensor and one flexion sensor for the thumb.
- Or one optical camera array.

In addition to the DOFs, sensory feedbacks can also be achieved by using extra sensors. For Virtual Reality system we won’t care about posture and temperature, but would focus on touch and pressure feedbacks. These two provides the feeling of contact which is essential for physical interaction. One challenge of floating UI design is caused by lack of contact feedback, thus the user might penetrate the UI icons. Therefore it would be wonderful if we can replicate this feedback in Virtual Reality. There’re two kinds of contact in Virtual Reality, one is the user contact a physical object in the real world and trigger some respond in VR world, the other is the opposite which user contact a virtual object in VR world and trigger some respond in the real physical world. The first can be realize by putting pressure sensors on the Dataglove which would be trigger when user contact a real surface. The other one require the system to generate force feedback, and among all kinds of Dataglove designs, only the mechanical solution is capable. Although adding force feedback would definitely improve the immersive experience, but it would also increase the complexity of the device and raise the cost. That’s the reason why it hasn’t become the standard feature of Datagloves. However we can probably use a vibrate motor instead to provide some basic sense on impact.
B. 5DT Data Glove Ultra

Let’s begin our comparison with a commercial product, 5DT Data Glove, the most popular input devices in haptic application field. First released in 1995, the 5DT Data Glove is well known for its accuracy, therefore being widely used in scientific research, entertainment, training and rehabilitation areas. In 2011 the company introduced its newest model, the 5DT Data Glove Ultra, which comes with two version, one with 5 sensors and the other with 14 sensors. 5DT is a perfect example of Dataglove design based on flexion tracking. The 5 sensors version is pretty straightforward, with one flexion sensor on each fingers that can only measure the overall bending of fingers. Which means it only has 5 flexion DOF, this is far from enough for tracking actual finger movement, therefore unsuitable for VR Input. The 14 sensors version has 2 sensors on each fingers, ignored the first joint, which as mentioned before, cannot move independently. And four addition sensors between each fingers to measure the abduction and adduction. With these sensors the 5DT Data Glove can be used to perform grab, point, spread, almost all types of finger movement except for the thumb due to the lack of 2 position DOFs. The error margin is 2 degrees and the refresh rate is above 75Hz, which is unnoticeable to human in Virtual Reality environment.

But there’s one fatal problem with the 5DT Data Glove. It can’t be used for tracking hand position and orientation. This rendered the glove useless for VR Input, because without hand position tracking, the user won’t be able to move their virtual hand at all, all they can do is to bend fingers to make some gestures, but it can’t be called interactive if the virtual hand don’t move. In a recent paper, Ewout A. Arkenbout and his team managed to integrate it with an Optical tracker, thus solved the problem of positon tracking. However this solution included an extra equipment and due to the limitation of Optical tracking technique, it’s bounded by the camera’s work space.

Besides from that, there’s a price issue. The 5DT Data Glove with 14 sensors cost 5500$ for one hand. That’s totally unacceptable to ordinary customers. Therefore it’s not suitable to be the Input device for commercial level Virtual Reality systems.

C. IMU Smart Glove

IMU Smart Glove is a laboratory prototype developed by Brendan O’Flynn and his team in 2015 and evaluated against the 5DT Data Glove for accuracy and repeatability. The glove is designed to be compatible with the Virtual Reality system, which can measure finger movements include flexion, adduction and abduction. The Glove contains 16 IMUs each provides 6 DOF’s measurement.

The Glove needs to be calibrate every time before using, but it can obtain an overall accuracy of 93.3% compare to 82.9% of the 5DT Data Glove. However a weird thing about this glove is that using the IMUs for position tracking but rather just use them for calibration. We can deduce it’s caused by the draft of the sensor’s reading, it’s a common problem of the IMU sensor. Therefore the IMU Smart Glove can’t be used for hand position, which is a huge drawback for Virtual Reality application. But consider the fact that it’s more accuracy than the 5DT Glove in tracking finger rotation and the IMU sensors are considerably cheaper than flexion sensors, this device can serve as an alternative of the 5DT Data Glove.

D. VR Glove prototype

The VR Glove prototype is attempt to build a low cost DataGlove for Virtual Reality system. The Glove is developed on Arduino Micro platform and connected to the computer though USB port and would be recognized as a Human Interface Device (HID). The structure of the glove is simple enough, it has 5 flexion sensors on each hand and therefore it won’t be very accurate, but as we disused earlier, not all the DOFs are necessary for finger tracking, and it’s still possible to provide reasonable tracking. Another feature is that it has a Razer Hydra magnetic sensor attach to it, so it’s capable of measuring the absolute position of the hand.
Magnetic sensor out, so that they can reduce the volume of device. Never the less, it’s an inspiring way to implement magnetic tracking technique into the DataGlove. According to their report, the VR glove prototype manage to control the latency in less than 42ms, and they managed to operate an animation-blended hand in the Virtual Reality world simulated by Unity3D Engine. And by reducing the number of sensors, they lower the cost to only $215 compare to $500 for 5DT Data Glove with 5 sensors and no position tracking.

E. Rutgers Master II

Different from all above, Rutgers Master II is a Mechanical DataGlove with force feedback developed in the Human-Machine Interface Laboratory at Rutgers University in 1997. The glove is capable of measuring the position of user’s fingertips and provide forces at the same time. Its pistons can produce force up to 16N in both directions and the pistons are attached to the base through 2DOF spherical joints. The flexion and adduction/abduction are measured by Hall-effect sensors, which has a high angular resolution up to 0.075 degree. The position and orientation of the palm have to be measured through other sensors.

In 2000, Viorel G. Popescu and his team built a Virtual-Reality-Based Telerehabilitation System using the Rutgers Master II. The test subject was asked to perform tasks in the Virtual Reality environment such as squeezing rubber balls and using a gym finger exerciser. These were made possible only by the force feedback feature of the Rutgers Master II. Since then it’s been widely used for VR rehabilitation systems and become an unreplaceable component in this research area. This shows clearly the advantage of having feedback in the DataGlove. With the force feedback, Rutgers Master II produced a dynamic interaction experience, which can even be used in medical area. The feedback not only increase the accuracy of manipulation, but also bring the visual objects into life. Though the DataGlove, the user would be able to feel the texture of the object and to sense the deformation when apply force to it. These interaction would boost the immersive feeling and it’s only possible with the DataGlove.

V. FURTHER DISCUSSION

A. Strength

From the previous section, we has introduced several different Dataglove designs and through the comparison, we can see the common features shared by all Datagloves and certain unique features that can only achieved by certain design. For developing the proper device for Virtual Reality Input, we would like to combine all the strong points together to create a Dataglove that holds advantage among other types of input devices. So that it can’t be simple replaced by other devices.

Therefore we will summarize the strength the Dataglove holds compare to other kinds of input devices including mouse, gamepad, Leap motion and other devices we mentioned earlier.

- Delicate finger simulation. DataGloves can track up to 24 DOFs at the same time.
- High accuracy and low latency.
- Unlimited workspace.
- Portable. It won’t course any trouble to carry a pair of DataGlove since they’re light weight.
- Require no setup. They can used while walking or doing other activities.
- Capable of sensory feedback. The mechanical DataGlove is the only practical way to provide feedback at this moment.

B. Weakness

However, even with all those advantage, the fact is DataGloves still rarely used by ordinary users. Which
indicates they have some serious weak points that prevent it from replacing traditional controllers.

One of them is the price. You can buy a mouse for $10, although a DataGlove is considerably powerful than a mouse, nobody would like spend more than $100 for it. But this argument won’t hold in the case of Virtual Reality 3D Input. But compare to other 3D input devices the price is still too high. However, one of the major reason is the DataGlove used too many sensors to cover all the DOFs of hands. These DOFs are necessary for haptic research, but they are redundant for daily usage as an input device. We showed a design that did a good job on reducing the cost to about $200, with the manufacture skill of IMU and flexion sensor improved, the cost would drop further in the future.

The other problem is called technological inertia. It refers to the unwillingness to change after adapted to a certain design of technology. For example we know that “qwerty” keyboard is not the most efficient layout for typing, but because people customary to it, it’s now difficult to change this. So imagine that you have to move the cursor by waving your hands in the air and perform left click and right click by using different gestures, users would prefer to go back and use the mouse.

C. Our Design

By viewing the strength and weakness of different DataGlove design, we propose our own design as an attempt to balance between cost and performance. The idea is to design a low cost DataGlove input device that can be used for both VR/AR and traditional desktop scenario. When using it in VR environment, it resemble to a DataGlove which can track the position, orientation and finger movement of the user's hand. When using it for traditional PC input, it can deliver a similar user experience as the mouse, in order to overcome the technological inertia. It's capable of providing a seamless transition between 2D and 3D manipulation.

The main feature of this device is that it has pressure sensors or buttons on the fingertips and sensors on the knuckle to measure the angle between fingers and palm. To reduce the cost, we sacrifice some degree of freedom in finger tracking and only focus on 6 DOFs of the hand and 4 DOFs for the bending of each fingers. For 2D manipulation, the user can grab a bottle, a box or a phone and use it in the same way as a mouse on a desk surface to navigate the cursor on desktop. To use it in VR/AR environment, the user simply needs to raise their hand, then the sensors on the knuckle would track the bend of fingers.

There would be two major sensor implemented in this device, one for the position and orientation tracking of the hand, the other is the sensors on the knuckle. For the hand tracking, the best choice would be high accuracy IMU. For the sensors on the knuckle, instead of using very expensive flexion sensors, we planned to simply use the variable resistors for the angle measurement.

The design is aimed for the future where VR/AR devices such as Oculus and Hololens are getting popular, then this device can act as a replacement of the mouse for operating both VR and PC user interface.

VI. Conclusion

To sum up, DataGloves show a great potential in application in Virtual Reality. Compare to other current input devices, DataGloves provides more accurate finger tracking and have a unique advantage of supporting sensory feedbacks. However, the cost must be taken into consideration during the design. By simplify the model of hands, we can find ways to reduce the amount of sensors that’s been used, also we can replace expensive sensors with cheaper sensor though smart design.

REFERENCES


[16] O’Flynn, Brendan, Javier Torres Sanchez, James Connolly, Joan Condell, Kevin Curran, Philip Gardiner, and Barry Downes. "Integrated Smart Glove for Hand Motion Monitoring."
