

# Gesture Control Technology:

## An investigation on the potential use in Higher Education.

### 1. Introduction

For decades, keyboards and mouse have been the main input devices for computers. However, with the rising popularity of ubiquitous and ambient devices, (i.e. PlayStations), and equipment which allows users to grasp virtual objects, hand or body gesture are becoming essential: gesture controls have become central to the human computer interaction system.

### 2. Gesture Control Technology

Gesture control technology is based on gesture recognition. Gesture recognition can be seen as a way for computers to begin to understand human body language. Compared to the primitive user interfaces, such as keyboard and mouse, it builds a richer bridge between the computers and humans. Gesture control devices recognize and interpret human body movements, allowing the user to interact with a computer system.

#### 2.1 Gesture Control Technology development milestones

Gesture control technology is developing quickly and changing many aspects of our life. Gesture control devices began from the very primitive input devices to fine detail recognition. These devices are used in a much wider range, from research experiments and prototypes to day-to-day commercial products.

Research on gesture control technology can be dated back to as early as the 1980s. The first step was to use voice control and special hand gloves to interact with objects on a large screen (1). From the 1990s, gesture control technology research began being used to help disabled people, including the camera based web interface by IBM (2), controlling home appliances using a wearable pendant (3). In 2004, Visual Touchpad was first introduced: a low-cost vision-based input device which allows fluid two-handed interaction with desktop PCs, laptops, public kiosks or large wall displays (4). In 2006, the gesture visualization method begins testing the implementation of accelerometer data, and the animation of hand movement performance during gesture control (5). A prototype of a hands-free intelligent wheelchair control system is introduced in 2007, where users can control the wheelchair using head gestures combined with laptop and webcam (6). User-defined gesture for surface computing was developed in 2009, which led to a user-defined gesture set, implications of surface technology, and a taxonomy of surface gestures (7). In 2011, research on mobile touch-screen gesture designs is published, leading to an industrial design perspective on pointing devices as an input channel (8).

Many commercial gesture control systems or prototypes have been developed in the recent years. **GestureTek** established in 2005 (<http://www.gesturetek.com/>) is one of the leading companies working on gesture control. The company's multi-patented video gesture control technology allows users to control multimedia content, access information, manipulate special effects, and immerse themselves in an interactive 3D virtual world by moving their hands and body. Secondly, **Eyesight** (<http://eyesight-tech.com/>). Since its founding in 2005, it has collaborated with many iOS developers, device and chipset manufacturers to implement the natural human interface in many devices and applications. **Mgestyk** (2008) (<http://mgestyk.com/>) developed 3D gesture control solutions based on 3D depth data using 3D cameras. **Samsung** ([www.samsung.com](http://www.samsung.com)) filed patents on gesture control for mobile phones and devices, where the predefined finger motions captured by the camera are translated into on-screen control. Besides from mobile phone and tablets, wearables – such as smart watches - are another hot area for gesture control. Gesture control can be used in automotive environments for controlling

application; a prototype implemented in a **BMW** limousine can recognize 17 hand gestures and 6 head gestures using IR light and camera. Google's project **Soli** (<https://www.google.com/atap/project-soli/>) is using radar to enable new types of Touchless interaction. The soli sensor can accurately track sub-millimetre motions at high speeds. It fits onto

a chip, and can be produced on a big scale. The project team plans to release a dev kit to allow developers to create new interactions and applications.

Besides from the commercial gesture control systems, a series of consumer electronics gesture control devices have been produced. The most popular are listed below:

- **Nintendo Wii** in 2006 announced a wireless and motion-sensitive remote for its game console. A main feature of the Wii Remote is its motion sensing capability, which allows the user to interact with - and manipulate - the items on a screen via gesture recognition and pointing, through the use of an accelerometer and optical sensor technology. The Wii remote offers users an intuitive, natural way to play games.
- **Sony PlayStation Eye** is a digital camera device for Sony PlayStation. The technology uses computer vision and gesture recognition to process images taken by the camera. This allows players to interact with games using motion and colour detection, as well as sound through its built-in microphone array.
- **Microsoft Kinect** is a motion sensing input device developed for Xbox consoles and Windows PCs. Based on a webcam-style, add-on peripheral, it enables users to control and interact with their console/computer without the need of a game controller, through a natural user interface using body gestures and spoken commands. Whilst, the first generation Kinect was first introduced in Nov 2010, Microsoft released the Kinect software development kit for windows on June 16, 2011. The SDK allows developers to write apps and games for Kinect.
- **Leap Motion** is a computer hardware sensor device that supports hand and finger motion as inputs, analogous to a mouse, requiring no hand contact or touching. Before Leap motion was officially sold, the company launched a software development program in Oct 2012 for developers to create applications, which would form the Airspace app store. While Kinect focuses more on body gestures, Leap motion specialises in detecting hand and finger movement.
- A new competitor in the gesture control market, “**Myo wristband**”, was announced on Feb 2013. Myo contains 8 pods with a proprietary EMG sensor on each, to be able to detect the muscle movements around user’s forearm and hand gestures. It also contains a gyroscope, an accelerometer and a magnetometer, to be able to track arm movements like spinning or moving.

## 2.2 Types of Gestures

Due to the increasing research and development of new gesture control products, different gesture functionalities have been explored; gestures can originate from any motion, such as face, hands and body.

Gestures are often language and culture-specific. Broadly, they can be classified into the following types:

- **Hand and arm gestures:** recognition of hand poses and arm movements, sign languages; people may wave an arm to say “hello”.
- **Head and face gestures:** Some examples are a) nodding or head shaking, b) face recognition, c) facial expression recognition and many others represent head and face gestures.
- **Body gestures:** involvement of full body motion, such as in a) tracking body movements against the music rhythm b) recognizing body gestures for medical rehabilitation and athletic training.

At the early development stages of gesture control technology, most of the research is based on hand gestures and head gestures. Direct control via hand posture and head gesture is immediate, but limited in the number of choices. The researchers use special gloves or headsets with micro controllers to detect these gestures. As the technology moves on, body gesture and finger point movement are introduced to the gesture controls. For instance, Wii and Kinect can recognize a player’s body gestures, while Leap motion can recognize the fine movement of all ten fingers.

## 2.3 Application areas for Gesture Control Technology

Gesture control technology has been used in many different areas, including, but not limited to, the entertainment sector, consumer electronics sector, automotive sector, healthcare sector and education sector.

- **Entertainment sector:** gesture technology can provide more entertainment opportunities for any type of user. Countless dance, music and sports games have been developed for Wii, PlayStation Eye and Kinect. On the other hand, companies like GestureTek have also developed interactive advertisements and museum/science centre guides using the technology.
- **Consumer electronics sector:** Gesture has been used extensively in consumer electronics, bringing dramatic changes to our day to day life. Since the first iPhone, released in 2007, gesture control has not only been used in mobile phones, but also in tablets, surface tables and so on.

- **Automotive sector:** In the automotive industry, many manufacturers believe that gesture control will be used to enhance dashboard controls and become the new interface between driver and car. For example, BMW will present a gesture-based car to the ‘Consumer Tech Show’ of 2016.
- **Healthcare sector:** Kinect has been extensively used in helping and training people with disabilities. Research and prototypes have been carried out by using a Kinect-based system for physical rehabilitation of people with motor disabilities, and to train people with cognitive impairments (9). One of the wide interest areas for Leap motion is in the field of surgery where a hands-free experience will allow more flexibility of cross-sectional image viewing during a surgical procedure. Julien Pauchot proposed an easy configuration of Leap Motion on a PC for optimized use with Carestream Vue PACS using a plug-in (10).
- **Education sector:** According to a 2011 Horizon Report, gesture-based computing is one of the key trends in education technology. One of the key benefits is that gesture control technology engages learners through movement, facilitating active learning, which in turn increases the academic and social performance of students.

### 3. Overview of the Experiments

As mentioned in the 2011 Horizon Report, gesture-based computing is one of the key trends in education technology, and we are soon to see the implementation of this technology as it develops further. In higher education, gesture control technology could not only improve the learning experiences for the students, but also provide a new teaching method for lecturers. For instance, a lecturer could explain a science concept or a practical lab in an easily understandable way. Moreover, for hands-on work such as applied engineering, design or construction, gesture-based computing may offer new ways to interact with immersive 3D content and allow students and staff to investigate immersive scenarios.

At the University of Birmingham, we carried out a few gesture control experiments using Microsoft Kinect, Leap Motion and Myo Bracelet for the teaching and learning environment. Based on the experiments results and the technical comparison of the three products, a SWOT analysis will be carried out to define the best user scenarios for each individual product in a higher education environment.

#### 3.1 Microsoft Kinect Experiment

Microsoft Kinect is a webcam-style add-on peripheral intended for the Xbox game console and PC. It is a motion sensing input device which enables users to control and interact with the PC through a natural user interface using gestures. The device comes with an RGB camera and a depth sensor, which in combination provide full-body 3D motion capture and gesture recognition.



*Figure 1: Microsoft Kinect*

In our Kinect experiment, we looked at the potential value of using Kinect in the lecture room to deliver PowerPoint presentations. We tested its feasibility and reliability to control MS PowerPoint slides using voice and gesture control.

In the gesture-controlled experiment, the main features tested were the swiping hand movements and the skeleton detection to control the slides. The swiping hand movements only detected the user’s arm movements. The algorithm is easy to implement, however, its accuracy was affected by the user’s body movement. So we changed the algorithm to detect the user’s skeleton, it improves the accuracy of controlling the slides. Although we succeeded in making these features work, there are outstanding issues regarding the user detection distance and the user subject identification. There was also a space limitation, as Kinect requires enough empty space between the sensor, user and the screen which might be difficult to find in some lecture theatres.

The voice-control experiment proved to be more positive, considering that it did not have any space limitations. It was relatively straight forward to train the system to recognise the keywords used to navigate through the slides, both backwards and forwards. However, its accuracy may be compromised a noisy environment.

The use of voice or gesture controlled technology such as Kinect has potential as a new, engaging way of delivering presentations. However, it still needs substantial amounts of testing and development to achieve a robust, reliable product. It also requires a fair amount of user training. Besides, to add value to the classroom experience we would recommend building extra features beyond the slide navigation function, such as zooming or pointer functions, as well as an improved interface.

As a teaching tool, Kinect is flexible and versatile. The lecturer can interact with contents via body movements, gesture and voice. Kinect can support various teaching activities. Special instructional design can be implemented to reinforce the connection between teaching contents and student physical responses. For instance, when students see a clue, they need to act out in order to proceed. If designed properly, the interactive contents can be used to greatly increase student engagement.

Kinect can be used to create interesting interactions to boost student motivation. Kinect can be developed with software programs to enhance its role as a learning tool. For example, students can utilize the information gathered by Kinect with software programs to create highly interactive multimedia works.

Priced just over one hundred pounds, Kinect XBOX 360 has potential as an affordable add-on tool for Higher Education. Kinect has potential to add value as a tool for teaching and learning. Nevertheless, further investigation is needed around the improvement of algorithm precision, creating a user friendly interface and adding extra functionality.

### 3.2 Leap Motion Experiment

Leap Motion is a hardware sensor that detects finger movement and allows users to interact with a computer by waving their fingers and hands with no need for touch or the use of a mouse. It has two monochromatic IR cameras and three infrared LEDs, which use a complex algorithm to calculate the position of the fingers and hands. The observation area covers a roughly hemispherical area. Leap motion offers a good precision and reliability (11, 12). It supports a reduced detection area of 8 cubic feet (0.227m<sup>3</sup>), an image refresh rate of 200Hz, 2 infrared cameras of 1.3 megapixel and a software optimization of Leap Motion controller in its V2 version.

In our Leap Motion experiment, we evaluated a range of apps and looked at the potential areas of using Leap Motion in the university. One main benefit of the Leap Motion is that besides from the developer SDK, Leap Motion has an app store called Airspace where the users can acquire new applications. These applications are already developed, and cover a number of areas including: games, music, science, entertainment, productivity and utility tools. We focused our evaluation on applications in computer controls, education and science area and creative tools.



*Figure 2: Leap Motion Airspace*

#### 3.2.1 - Computer Control Apps

These Leap Motion applications focused on the use of gestures to control computers, instead of using the mouse:

- **Examples of Apps:** Touchless, Handwave, Better Touch Tool
- **Functions:** users can lift their hands or fingers to browse the web, open applications and documents, zoom in and out with one or two hands; provides a configuration window to allow users to customize the commands with the gesture.
- **User experience:** a novel way to interact with the computer, although the reliability and precision will still need to improve, and the users will need a fair amount of self-training for better control of Leap Motion.
- **Potential use in the university:** provides hands free functions in some particular situations, like surgery labs and cash tills, which will save the operators to remove gloves and improve efficiency; it could also be used as an intuitive way to control computers, like web and photo browsing; for people who have hands or arm

disabilities, Leap Motion can be used as a way to control computers to enhance or replace the function of the mouse.

### **3.2.2 - Science and Educational Apps**

Most educational applications are developed for school age children, to help them develop counting, colouring, shape sorting and alphabet skills. Moreover, there are several science apps, used to explain sophisticated concepts, like molecules and skeleton/body structure, in an easier and interactive manner. A detailed, interactive virtual experience can effectively help students understand the concept more easily.

- **Examples of Educational App:** SORTEE, Caterpillar Count
- **Examples of Scientific Apps:** Cyber Science 3D Motion, Cyber Science 3D Motion Zoology, Frog Dissection
- **Potential use in the university:** these applications bring gamification into the teaching and learning environment, facilitating active learning, which in turn increases the academic and social performance of students. Particularly in museums and exhibitions, Leap Motion could be more widely adopted to enhance user experience.

### **3.2.3 - Creative Apps**

Leap is also used as a creative tool in music making. With the movement of fingers, Leap Motion collects the gesture information and transforms the information into the rhythm, which could be used to change and create music. Potentially it could be introduced in the Birmingham Music School as a new way of making and interpreting music.

In Feb 2016 - the time of writing this paper - Leap motion introduced Orion, a hand tracking for virtual reality - into the product development. Orion tracks the user's hands, and then projects the image in the virtual reality environment, so the users will see their virtual hands in front of them, which augments the user's presence in the virtual world: users can interact with virtual objects as if they were in the real world. Hand tracking has the potential to be a turning point in the interactive virtual reality, which can lead to the major use in the education environment, changing the way people learn.

Whereas the Kinect system was well suited to body movements, Leap Motion accurately recognises delicate hand and finger movements. As a device which sits on the desktop, it allows the device to be placed in or near the operating field, thus needs less working space. The cost of Leap Motion (including the developing bundle) is less than \$100. Similar to Microsoft Kinect, a relative amount of training is necessary in order to make the familiarise the user with the product. Although Leap Motion has an application store where users can download applications, in some special cases, developers may need to develop their own applications from scratch.

## **3.3 Myo Experiment**

Myo is a radical change from most gesture control products which detect movements with cameras. Myo uses *electromyography* to read electrical signals from the muscles in the wearer's forearm, mapping them with gestures made by the wearer's hand, and control other devices with those gestures. Unlike most gesture control products using cameras, it is not likely to be affected by factors such as poor lighting conditions, distance and obstructions.

Myo has eight different blocks, each contains a medical-grade EMG sensor. The armband also uses a three-axis gyroscope, three-axis accelerometer, and three-axis magnetometer to sense motion in any direction. Muscle activity and motion readings are handled by an on-board ARM Cortex M4 Processor, which communicates with the wearer's devices via Bluetooth. For devices that don't have Bluetooth functionality built in, Myo provides a USB Bluetooth dongle. Because Myo uses Bluetooth connection, it can not only connect to standard PCs and laptops, but also connect to the iOS and Android mobile devices.



*Figure 3: Myo in synchronization*

In our experiment, we used the Myo armband to create a software prototype to control 3D objects by rotating, zooming, moving and navigating. These 3D objects were created by 3D scanning fossils from the Lapworth Museum. The aim of the experiment was to provide an interactive user experience to observe the 3D objects.

Similar to Leap Motion, Myo comes with a developer SDK and the Myo Market to download apps. In our prototype, we used the mouse-control app to control the mouse. The implementation of the experiment included two main tasks: Firstly, read 3D objects and display them on the screen. Users will be able to manipulate the 3D objects with the standard mouse control. Python and the OpenGL were used to develop the software prototype. Secondly, replace the standard mouse control function with the Myo Mouse, so the wearer can use the Myo to manipulate the 3D objects. To activate the Myo, the wearer needs to raise their arm, make a fist, lower their arm and then release the fist. The Myo menu will appear on the screen, and the user can select the Myo Mouse function and confirm by spreading the fingers.

**The following gestures are defined in the experiment:**

- **Double-tap:** Enable or disable mouse movements
- **Fist:** Enable or disable rotation mode, rotate the objects by moving the arm
- **Spread fingers:** Go to the next object
- **Wave In:** Zoom in the object
- **Wave Out:** Zoom out the object



*Figure 4: Examples of 3D objects rendered by the prototype*

The experiment was successful for controlling the 3D objects, however, there were two limitations in the experiment. Firstly, there are a limited range of pre-set gestures defined in the Myo. It is possible to combine these pre-set gestures with arm motions to define new gestures, and developers can gain access to raw EMG data from the Myo to create their own custom gestures. Nonetheless, it will require a minimum understanding of the Myo SDK, and will need a developer to program the software. Secondly, Myo is user specific: users need to wear it on the forearm and adjust its length. By doing so, the user may need to calibrate the Myo a couple of times to get the best result, and also specify whether he or she is left-handed or right-handed.

Myo, as a new product in the gesture control technology, brings a different way to recognize gesture information. It uses electromyography technology to capture gesture instead of the camera, therefore it is less affected by the external factors such as light and obstruction. Myo supports five pre-set gestures which may not be enough commands to control some of the applications. Furthermore, Myo is user specific. On one hand, it improves its accuracy and reduces the possibility of other people gaining control; on the other hand, it needs more time to set up. Also, Myo uses Bluetooth connection, so it can be connected to a range of mobile devices. Similar to Leap Motion, it has a marketplace to download applications and SDK for developers to customize, if necessary. The cost is \$199, making it more expensive than the Leap motion, but less than Microsoft Kinect.

## 4. Analysis

In our experiments we tested the Microsoft Kinect, Leap Motion and Myo, which represent the most popular commercial gesture-control products. Although these products may achieve some similar functionalities, they have many differences. In the following table, we compared the technical differences of Kinect, Leap Motion and Myo.

Characteristics	Kinect	Leap Motion	Myo Wristband
Manufacturer	Microsoft	Leap Motion, Inc.	Thalmic Labs
Technology	1 Infrared transmitter 1 Infrared camera 0.3 megapixels 1 RGB camera (red, green, blue) 4 Directional microphones	3 Infrared transmitters 2 Infrared cameras 1.3 megapixels	8 medical-grade EMG sensors gyroscope, accelerometer and magnetometer Bluetooth
Image refresh rate	9 to 30 Hz	200 Hz	EMG data at 200Hz, IMU data at 50Hz (13)
Recognition	Body movements Facial recognition Voice recognition	Hand movements Finger movements	Hand movements Arm movements
Precision	In centimetres	Hundredth of a millimetre	N/A
Field of vision	Horizontal 57 ° Vertical 43 °	Anteroposterior 120° Left-right 150°	N/A
Captor's range	1.2-3.5m	0.002-0,61 m	Only the wearer
Workspace's floor surface	6 m <sup>2</sup>	1.16 m <sup>2</sup>	Bluetooth Smart coverage area, >100m in theory
Configuration	SDK for Windows by Microsoft	AirSpace Home Developer SDK by Leap Motion	Myo SDK Myo Marketplace

*Table 1: Technical Differences between Kinect, Leap Motion and Myo*

In our experiments, Microsoft Kinect was used to test the viability of supporting PowerPoint presentations in the Lecture room. Furthermore, we evaluated a range of Leap Motion applications and looked at potential areas of adoption in the university. Finally, we used the Myo to create a software prototype to provide an interactive user experience to manipulate 3D objects. These experiments represent some of the activities for which this technology can be adopted in the teaching and learning environment at the university. However, in order to adopt a new product in the academic environment, we will need to understand the product, address what benefits it could bring and what risks it will involve. A SWOT analysis of the three gesture control products, will examine the products strengths, weaknesses, opportunities and threats, in order to help minimize the risks and maximize the resources. This will allow us to define the best user scenarios for each individual product at the university.

Based on our experimental results and the SWOT analysis, each product has its own strength and weakness, therefore faces some different opportunities and threats.

- Microsoft Kinect has more functions including face, body and voice recognition, and is more suitable in designing educational games which include whole body movements. However, Microsoft Kinect has some limitation on accuracy. For instance, it requires certain spaces to detect the body movement. Han et al. (2013) presented a detail analysis on some of the major problems faced by applications that use Kinect, including:
  - difficulty of performing the human pose analysis in real applications, where the system has no information about the environment or about the users;
  - results are affected by the distance between the objects and the Kinect;

- precision errors increase as users get closer or move away from the camera;
- illumination can influence the final results (14).
- Leap motion can detect fine finger and hand movements. The recent release of Orion opens a new door to the implementation of its technology to the academic environment, connecting gesture-based computing with augmented reality and virtual reality. Embedding gesture control with virtual reality is the next technology trend. In education, potentially it could be used in virtual labs which could simulate the real lab, giving students an immersive laboratory experience.
- Myo is user specific. Due to the customization and training needed to use the device, we consider it to be more of a personal device. It can be connected to mobile devices and computers, which could be convenient in the office and at home.

	Microsoft Kinect	Leap Motion	Myo Bracelet
Strengths	<ul style="list-style-type: none"> <li>● Detects body gesture</li> <li>● Face recognition</li> <li>● Voice recognition</li> <li>● Kinect SDK for developers</li> <li>● Strong commercial support from entertainment sector</li> </ul>	<ul style="list-style-type: none"> <li>● Reduced work space</li> <li>● Greater precision of hand and finger movements</li> <li>● Reduced dimensions, allowing the device to be placed in or near the operating field</li> <li>● The convenience of the AirSpace store and Leap Motion SDK</li> <li>● A total cost of less than 100 dollars</li> <li>● Orion - new generation of Leap Motion: brings the virtual and mixed reality experiences with hand gesture control</li> </ul>	<ul style="list-style-type: none"> <li>● Less distraction from light, distance and obstruction</li> <li>● Gesture detection only links to the wearer</li> <li>● Bluetooth enables connection to mobile devices</li> <li>● Myo Marketplace to download already made applications</li> </ul>
Weaknesses	<ul style="list-style-type: none"> <li>● Space requirements to operate the Kinect</li> <li>● Substantial amounts of testing and development to achieve a robust, reliable product</li> <li>● Effectiveness of Kinect is affected by the depth sensor</li> </ul>	<ul style="list-style-type: none"> <li>● Limited numbers and varieties of applications</li> <li>● Lack of other commercial product support</li> <li>● User training is necessary to get familiar with the device</li> </ul>	<ul style="list-style-type: none"> <li>● Only five out-of-box hand gestures are supported, other gestures will need to read the raw data and programming to implement</li> <li>● User specific – need some time to customize and train the device</li> <li>● Limited numbers and varieties of applications</li> </ul>
Opportunities	<ul style="list-style-type: none"> <li>● Intuitive input interface for educational games which may involve the whole body movement</li> <li>● Gestures with voice recognition could be used together in many areas such as entertainment, smart kitchen and automated cars</li> <li>● Face recognition could be used in security and research</li> </ul>	<ul style="list-style-type: none"> <li>● Orion is the first kind of the gesture control product which brings gesture with augmented reality and virtual reality together</li> <li>● A potential method to replace or enhance keyboard and mouse in some situation, for instance, in an exhibition and for people with disability</li> </ul>	<ul style="list-style-type: none"> <li>● It is user specific so it could be convenient configured as a personal device at home and office</li> </ul>
Threats	<ul style="list-style-type: none"> <li>● Space requirements can limit usage in some circumstances</li> <li>● No Kinect application</li> </ul>	<ul style="list-style-type: none"> <li>● Lack of “the big application” either in software or embedded into other hardware products</li> </ul>	<ul style="list-style-type: none"> <li>● Lack of “the big application”</li> <li>● Limited user scenarios as a personal device</li> </ul>



	marketplace to compete with other providers		
--	---	--	--

*Table 2: SWOT Analysis of Kinect, Leap Motion and Myo*

## 5. Future Work

Gesture control technology has shown a great potential in education. Hui-Mei Hsu (2011) presented a complete analysis on the use of Kinect in education and concluded that it should really achieve the expected results, enhancing classroom interaction and participation, as well as improving the way that teachers can manipulate multimedia materials during the classes (15).

The future work of using gesture control technology in higher education is to increase experimentation in the teaching and learning environment. The experiments discussed above are implemented in the lab, however, they lack practice in real teaching and learning activities. In order to get the best results and user satisfaction, more calibration of the product and improvement of the accuracy of the software are also expected. Another direction of future work should include testing gesture control technology along with Augmented Reality (AR) and Virtual Reality (VR). This will be the next step for virtual labs, which have the potential to be used in many scientific subjects and engineering labs.

## 6. Conclusion

Since initial research in the 1980s, gesture control technology has come a long way. In the last a few years, advanced gesture control commercial products including Microsoft Kinect, Leap Motion and Myo are used in countless areas, including the entertainment, consumer electronics, automotive, healthcare and education sectors.

In this paper, our discussion has focused on the education sector. The Microsoft Kinect experiment looked at the potential value of using Kinect in the lecture room to deliver PowerPoint presentations. We tested its feasibility and reliability to control MS PowerPoint slides using voice and gesture control. In the Leap Motion experiment, we evaluated a range of Leap Motion applications and looked at the potential areas of using Leap Motion in the university. The Leap Motion evaluation was focused on the applications in computer controls, education and scientific creative tools. The aim of the Myo experiment was to provide an interactive user experience in observing 3D objects. We used the Myo armband to create a software prototype to control the 3D objects by rotating, zooming, moving and navigating.

Based on the experiment results and the technical differences of these three products, a SWOT analysis was carried out to define the best user scenarios for each individual product in the higher educational environment. Microsoft Kinect has more functions (i.e. face, body and voice recognition), making it more suitable in designing educational games involving whole body movements. However, it faces the issue of requiring space to detect body movement. Leap motion can detect the fine finger and hand movements. The recent release of their Orion product opens new doors, connecting gesture-based computing with AR and VR. Myo is user specific. Due to the customization and training needed to use the device, we consider it to be more of a personal device.

Gesture control technology shows a great potential in education. Although at this stage, practical usage of the technology in teaching and learning activities are not widely acknowledged. There are two reasons for this. Firstly, education content differs from subject to subject. In order to use the gesture control product in academia, it requires extensive customisation of software, often requiring developers. In most cases, the university does not have such resources to support the work. Secondly, the effectiveness of the gesture control products still need improving. It takes time to calibrate the product, and in order to control the product, users will need to spend time training and practicing. Gesture control products are not yet as intuitive as they claim to be or have the potential to be.

In order to adopt gesture control technology in education, we will need specialized application developed for educational content, which will save the cost of individual development. The application should be easy to use and set up, and should provide an accurate gesture control. Furthermore, the university should install gesture control products and provide support for configuration through training for staff and students. Nevertheless, technology is in continual development, thus the adoption of a more advanced version of the same technology could definitely be beneficial for the University of Birmingham in the near future.

## 7. References

1. Bolt RA. Put that there: voice and gesture. ACM SIGGRAPH Computer Graphics. 1980(ISSN:0097-8930, 1980, ACM, USA):P. 262 - 70.
2. V.L.Hanson JpB, S.Crayne et.al. Improving Web accessibility through an enhanced open-source browse. IBM System Journal,. 2005;44(3).
3. Maribeth Gandy TS, Jake Auxier, Daniel Ashbrook. The Gesture Pendant: A Self-illuminating, Wearable, Infrared Computer Vision System for Home Automation Control and Medical Monitoring. Proceeding ISWC '00 Proceedings of the 4th IEEE International Symposium on Wearable Computer. 2000:87.
4. Shahzad Malik JL. Visual touchpad: a two-handed gestural input device. Proceeding ICMI '04 Proceedings of the 6th international conference on Multimodal interfaces. 2004:Pages 289-96
5. Sanna K. JK, Jani M. and Johan M. Visualization of Hand Gestures for Pervasive Computing Environments. Proceedings of the working conference on Advanced visual interfaces, ACM, Italy. 2006:p480-3.
6. Jia PaHHH. Head gesture recognition for hands-free control of an intelligent wheelchair. Industrial Robot: An International Journal, Emerald. 2007:p60-8.
7. Jacob O. Wobbrock MRM, Andrew D. Wilson. User-defined gestures for surface computing. CHI '09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. 2009:Pages 1083-92
8. Andrew Bragdon EN, Yang Li and Ken Hinckley. Experimental Analysis of Touch-Screen Gesture Designs in Mobile Environments. CHI 2011 Session: Gestures, Vancouver, BC, Canada. 2011.
9. Yao-Jen Chang S-FC, An-Fu Chuang A gesture recognition system to transition autonomously through vocational tasks for individuals with cognitive impairments. Research in Developmental Disabilities 2011;32:2064–8
10. Julien Pauchot LDT, Ahmed Lounis, Mourad Benassarou, Pierre Mathieu, Dominique Bernot, Sébastien Aubry. Leap Motion Gesture Control With Carestream Software in the Operating Room to Control Imaging: Installation Guide and Discussion. Surgical Innovation 2015. 2015;Vol. 22(6) 615–20.
11. Weichert F BD, Rudak B, Fisseler D. Analysis of the accuracy and robustness of the Leap Motion controller. Sensors (Basel). 2013;13:6380-93.
12. Guna J JG, Pogačnik M, Tomažič S, Sodnik J. An analysis of the precision and reliability of the Leap Motion sensor and its suitability for static and dynamic tracking. Sensors (Basel). 2014;14:3702-20.
13. MyoCraft: Logging IMU and Raw EMG Data. 14th March, 2015.
14. J. Han LS, D. Xu, and J. Shotton. Enhanced Computer Vision with Microsoft Kinect Sensor: A Review. IEEE Trans Cybern. Oct. 2013;vol. 43(no. 5):pp. 1318-34.
15. Hsu H-MJ. The Potential of Kinect in Education. International Journal of Information and Education Technology. 2011;Vol.1(No.5).
16. Prindle D. Myo Gesture Control Armband Review. 2015.
17. Yao-Jen Chang S-FC, Jun-Da Huang A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities. Research in Developmental Disabilities 2011;32:2566–70.
18. Ling Shao CS, Jiebo Luo, Minoru Etoh. Multimedia Interaction and Intelligent User Interfaces: Principles, Methods and Applications 2010.
19. Zimmerman eA. A hand gesture interface device. Proceedings of the SIGCHI/GI conference on Human factors in computing systems and graphics interface. 1987(ISBN:0-89791-213-6, ACM, Canada):P.189 - 92.
20. KinectEDucation (2011) 5 benefits of using Kinect in education. Available at: <http://www.kinecteducation.com/blog/2011/07/02/5-benefits-of-using-kinect-in-education/> (Accessed: 2016).