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Conference Paper · November 2013

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The Leap Motion controller: A view on sign language

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ABSTRACT

This paper presents an early exploration of the suitability of the Leap Motion controller for Australian Sign Language (Auslan) recognition. Testing showed that the controller is able to provide accurate tracking of hands and fingers, and to track movement. This detection loses accuracy when the hand moves into a position that obstructs the controller's ability to view, such as when the hand rotates and is perpendicular to the controller. The detection also fails when individual elements of the hands are brought together, such as finger to finger. In both of these circumstances, the controller is unable to read or track the hand. There is potential for the use of this technology for recognising Auslan, however further development of the Leap Motion API is required.

Author Keywords

Gesture recognition; Leap Motion; Deaf children; sign language.

ACM Classification Keywords

HCI: Interaction techniques – gestural input

INTRODUCTION

This paper presents the early findings of an exploration into the suitability of the Leap Motion controller for recognising Australian Sign Language (Auslan). The Leap Motion controller is a small device that can be connected to a computer using a USB. It can then sense hand movements in the air above it, and these movements are recognised and translated into actions for the computer to perform. The Leap Motion controller is said to be highly sensitive to very small movements, and is capable of mapping movements of the entire hand above it. This paper looks at whether it can map sign language movements.

This research is part of a larger research project called Seek and Sign. The Seek and Sign project explores the use of technology in supporting young Deaf and hard of hearing children while learning sign language, and specifically Auslan (Potter et al. 2012). The aim is produce efficient, affordable technology applications that can be easily accessed by the families of these children.

A large percentage of hearing-impaired children are born to hearing parents, with statistics reported ranging from 70% to 90% of hearing-impaired children belonging to

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OzCHI'13, November 25 - 29 2013, Adelaide, Australia
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hearing households (GRI 2008). For most of these households sign language is a new experience, and this situation can lead to delays in language development for the child. It has been demonstrated that early exposure to language is critical for language development and ongoing literacy outcomes for young hearing-impaired children (Moeller 2000), even when assistive technologies such as hearing aids and cochlear implants are adopted.

The Leap Motion project has a high level aim of producing an application that can recognise Auslan signs. This functionality could then be incorporated into a system to help young Deaf and hard of hearing children to learn Auslan signs. The system would be able to demonstrate specific signs using video and images, and provide feedback to the child on their own Auslan sign accuracy through the Leap Motion controller. This project is aimed specifically for Australian Sign Language (Auslan) and the principles will be relevant to any sign based communication system.

This paper reports the findings of the first phase of the Leap Motion project. This focuses on evaluating the Leap Motion controller for its ability to recognise Auslan signs made in the field-of-view of the controller. The second phase of the project will look at the ability to record Auslan signs and to train the system to recognise Auslan signs for later recognition and identification.

The Leap Motion controller was released in July 2013, and it presents the opportunity for a new way of interacting with technology that is yet to be evaluated. This paper provides an early evaluation of the technology specific to its recognition of hand and finger movements as they are required for Auslan. We will first explore the use of gesture recognition technologies with sign language, before describing the Leap Motion controller in more detail. We will describe the approach taken in this evaluation and then present the strengths and weaknesses of the controller that are key to its suitability for sign language recognition.

GESTURE RECOGNITION AND SIGN LANGUAGE

Gesture recognition is concerned with identifying human gestures using technology. This is an established research area with a broad background and many gesture recognition systems have been developed. The Seek and Sign research project is specifically interested in gesture recognition technologies that may be suitable for recognising sign language.

Research has been conducted in this area, with the most promising technology to date being glove technology, wrist sensors, 2D and 3D cameras, and the Kinect platform.

Traditional gesture recognition involves algorithms in conjunction with technology, and several applications of this have been developed for signing. [Vamplew and Adams \(1998\)](#) developed the SLARTI (Sign LAnguage RecogniTion) system using neural networks with gesture recognition for Auslan. SLARTI consisted of a CyberGlove and two sensors on each wrist with a switch on the user's left hand to help the system identify the start of a gesture. This system demonstrated a high level of recognition: 94% for signers that had been trained with the system and 85% for non-trained signers. [Kadous \(1996\)](#) explored the use of PowerGloves in conjunction with a neural network algorithm for recognition of Auslan. This system was less accurate, and he noted that there were significant problems with the system. [Holden and Owens \(2001\)](#) developed the Hand Motion Understanding (HMU) system, which incorporates hand tracking with a colour-coded glove and fuzzy logic, and applied it to Auslan. This system was accurate with a range of simple gestures, but was unable to recognise complex gestures. Further systems have been developed, with similar attributes and issues.

These systems all show promise, however they require specific additional technology in order to be useful. There is a need for a system that can utilise simpler technology such that a family with a Deaf or hard of hearing child can easily access it within their own home or school. The Microsoft Kinect platform was launched at the end of 2010 with the ability to detect motions, and a software development kit was released mid 2011. Several projects have explored the use of the Kinect for sign language recognition, with early findings indicating that while the system can recognise broad gestures, it is not capable of recognising smaller hand gestures.

LEAP MOTION TECHNOLOGY

The Leap Motion controller is a sensor device that aims to translate hand movements into computer commands. The controller itself is an eight by three centimetre unit that plugs into the USB on a computer. Placed face up on a surface, the controller senses the area above it and is sensitive to a range of approximately one metre. To date it has been used primarily in conjunction with apps developed specifically for the controller. As of September 2013 there were 95 apps available through the Leap Motion app site, called Airspace. These apps consist of games, scientific and educational apps, and apps for art and music.

While the potential for the technology is great, some early criticisms have emerged in product reviews in relation to app control, motion sensitivity, and arm fatigue. One factor contributing to the control issues is a lack of prescribed gestures, or set meanings for different motion controls when using the device ([Metz 2013](#)). This means that different motion controls will be used in different apps for the same action, such as selecting an item on the screen. Leap Motion are aware of some of the interaction issues with their controller, and are planning solutions. This includes the development of standardised motions for specific actions, and an improved skeletal model of the hand and fingers ([Metz 2013](#)).

A LEAP MOTION EXPLORATION

This paper presents an initial study exploring the functionality of the Leap Motion controller with a focus on its suitability for use with Auslan. A Leap Motion controller was used by two members of the research team in conjunction with a laptop and the Leap Motion software development kit. Initial tests were conducted to establish how the controller worked and to understand basic interaction. The controller was then tested for its recognition of sign language. For the purposes of this exploratory study, the Auslan finger spelling alphabet was used to test the functionality of the controller. The alphabet was chosen for the relative simplicity of individual signs, and for the diverse range of movements involved in the alphabet. The focus of these tests was to evaluate the capabilities and accuracy of the controller to recognise hand movements. This capability can now be discussed in terms of the strengths and weaknesses of the controller.

THE STRENGTHS OF THE LEAP MOTION CONTROLLER

A strength of the Leap Motion controller is the accurate level of detail provided by the Leap Motion API. The API provides access to detection data through a direct mapping to hands and fingers. Data provided by the API is determinate in that a client application does not need to interpret raw detection data to locate hands and fingers.

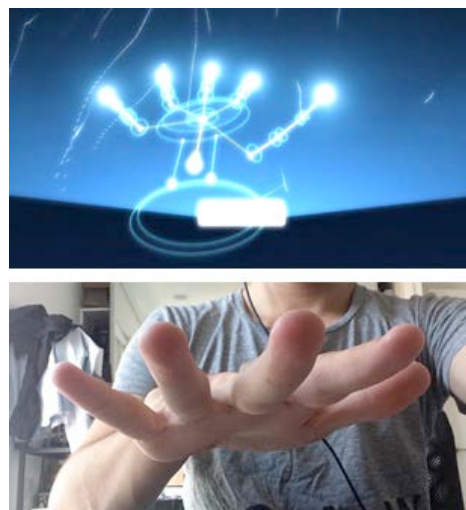


Figure 1 - Leap API output data

In Figure 1, the API recognises one hand with five digits. This contrasts with other available 3D sensory input devices, such as Microsoft Kinect - where sensory data is returned in a raw format, which must then be cleaned up and interpreted. The benefit of strong API preprocessing is that error reduction can be abstracted away from client applications meaning client applications can be built faster and with consistently accurate data.

The granularity of the Leap Motion controller is an asset toward detection of Auslan signs. The controller can consistently recognise individual digits in a hand (as shown in Figure 1 above). Being able to identify, address and measure digit and fingertip location and movement is

critical for accurately tracking of sign language motions. The controller is also capable of tracking very small movements, another essential capacity for accurate sign language recognition.

While the technical specifications for the Leap Motion controller cite a range of up to one metre, in our testing we found that the device performs accurately within a field-of-view approximately 40cm from the front and sides of the device. Many Auslan signs depend on hand movements around the upper torso, and the closeness and field of view for the controller is an asset for this need.

THE WEAKNESSES OF THE LEAP MOTION CONTROLLER

The Leap Motion controller has difficulty maintaining accuracy and fidelity of detection when the hands do not have direct line of sight with the controller. In practice this means that during detection, if a hand is rotated from a position of palm parallel to the flat surface of the controller (as in Figure 1) to a position of palm perpendicular to the flat surface of the controller the detection can often deteriorate entirely. The controller is often unable to distinguish digits and those it can recognise jump wildly in their position on the hand, as shown in Figure 2.

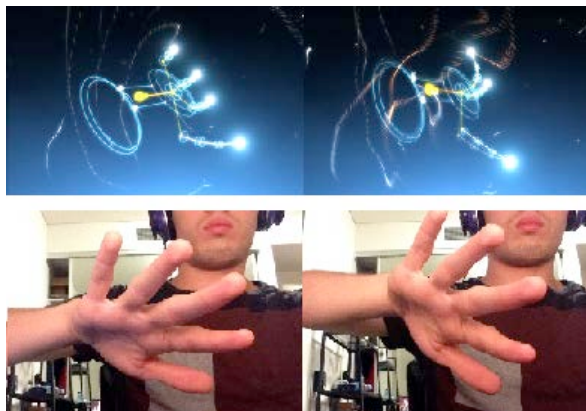


Figure 2 – Line of sight problems

When the hand is tilted completely on its side, the controller is unable to detect it, as shown in Figure 3.

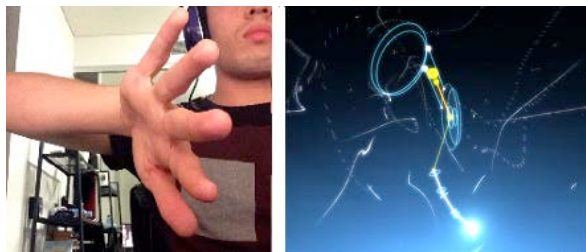


Figure 3 – Hand on side

Even simple Auslan symbols require significant hand rotation, including almost all of the A to Z symbols tested from the Auslan alphabet. Accurately tracking of even the most basic of signs is difficult as this requires inferring the position of fingers that have an indirect or obscured line of sight for the Leap Motion controller.

The controller loses recognition capabilities when two fingers are pressed together, come into contact or are in a very close proximity. The closer two fingers become the more inaccurate and jumpy the overall detection becomes.

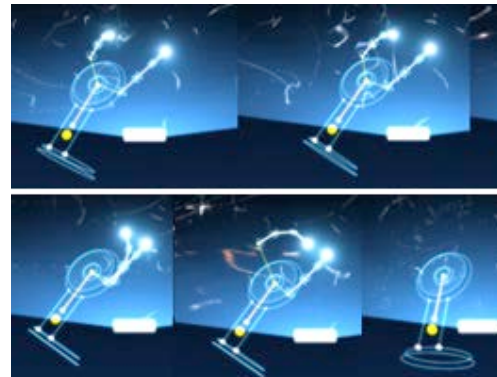


Figure 4 – Progression of pinching movement

Figure 4 illustrates detection of a thumb and finger pinching together on the left hand. Initially (in the first two frames) detection is smooth, but as the finger tips get closer together the finger's detected position jumps erratically (frames 3 and 4). Finally when the fingers touch they are unable to be detected at all, leaving just a fingerless hand in detection.

This limitation makes it extremely hard to make an accurate recognition of a sign. Within the Auslan alphabet, only one of the 26 characters does not involve touching fingers (the letter C).

As mentioned previously, we found that the Leap Motion controller operates in a 3D box of around 40cm around the device. It is notable that accuracy of the detection is lost closer to the edge of the detection area. Many Auslan signs require complex combinations of hand actions as well as gestures that involve parts of the body and face. The limitations of the Leap Motion controller in this are twofold: firstly, the controller only detects hands and fingers and while a prototype application may be able to estimate (using distance) when a hand touches a mouth or nose it would not be able to distinguish between the two. Secondly, several Auslan symbols are performed closer to the face or top half of the torso. These gestures may fall outside the controller's field of view and not be able to be detected accurately.

The Leap Motion is a first generation device and one of the first consumer sensory input detection devices available on a mass-market scale. Because of this the Leap Motion API can be limiting and underdeveloped at times. While the API supports multiple platforms, without multiple iterations of the platform or a significant time in the marketplace, API functionality and data is often limited. A specific API issue is that hand data is non-modifiable. The API stores detected information in a constructed data type called LeapHand. LeapHand is not modifiable and as such there is no easy way to potentially correct detected data. A client application would need to

create a custom cloned LeapHand data type to store modifiable data that the client application could then use.

FUTURE POSSIBILITIES

Inferencing (detection limitations)

In an attempt to overcome the device's limitations particularly in regards to hand rotation and digits touching, it may be possible to infer the location of fingers, fingertips and movements in periods where we are able to assume the fingers are still present but the controller is failing to detect them. For example, if we were making the sign for 'A' by touching the right index finger to the left thumb, at the point of contact the device would lose sight of both the index and thumb, however the other digits being detected would remain relatively stationary. At the point when contact is broken detection of the index and thumb would resume fairly close to where it was lost at the point of contact. Therefore, we may be able to infer that the fingers did in fact touch and factor that into our assessment and identification of the sign. The downside of this strategy is that sign recognition would need to be delayed until after the fact when we have assessed inferences like digits touching and digits dropping in and out of signal, potentially delaying real time feedback.

Artificial Neural Network Training

Using an Artificial Neural Network with the controller to recognise Auslan symbols is possible provided that each symbol is trained before use and attempted recognition. The network would then be able to assess a symbol and output with a degree of certainty that a particular sign is correct (between 0 and 1).

This is a good way to assess data provided by the Leap Motion API as the network will input training data without finite limits or expectations on the data format, or recognition state and end points, instead considering only the differences in training data. An obvious drawback is that a training data set is required and additionally that a user not proficient in Auslan would be unable to train the network with accurate signs for later accurate recognition. It may be a possible solution in a school setting, where a teacher could provide the training data set.

Using a training set would require a defined start and stop point for gestures (perhaps an idle hand position). While this is acceptable when recognising signs individually, it would not be able to be used in a conversational Auslan setting, where many signs can often be strung together without clearly defined start and stop positions.

CONCLUSION - SUITABILITY FOR AUSLAN

Based on the evaluation testing of the Leap Motion controller, it appears that while the device has potential, the API supporting the device is not yet ready to interpret the full range of sign language. At present, the controller can be used with significant work for recognition of basic signs, however it is not appropriate for complex signs, especially those that require significant face or body contact. As a result of the significant rotation and line-of-

sight obstruction of digits during conversational Auslan, signs become inaccurate and indistinguishable making the controller (at present) unusable for conversational Auslan. However, when addressing signs as single entities there is potential for them to be trained into Artificial Neural Networks and assessed for recognition against a training set.

The problems we encountered may simply be due to the early stage of development of the technology, and some issues may be rectified by the improvements that Metz (2013) cited as currently in development.

Based on our testing, we have developed a set of criteria that a device and system must meet in order to be able to interpret Auslan. It will:

- Discretely address and identify all 10 individual digits. This includes rotation and relative positioning from the centre of the palm.
- Be able to extrapolate positioning data accurately for digits that may not have a direct line of sight to the device.
- Accurately detect data in a field of view that extends to the upper torso, head and face.
- Have an API that allows active data correction or modification that is reflected in later data throughput.
- Allow recognisable signs to be programmed or trained into the device for future recognition
- Be able to identify preprogrammed signs in conversation using a 'best bet' strategy.

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