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performed a very in-depth survey of the material connected to his research question. He stayed focused and on schedule with his development of his essay. After a narrowing of his research question, he developed his essay in a very professional manner using the relevant topics (both pro and con) in an effective manner. Through the development of his essay, demonstrated a good working knowledge and understanding of the topic. His ideas and thoughts are presented clearly and in a logical and coherent manner. He used a well-developed set of arguments to support his conclusion. His conclusion is relevant to the research question and consistent with the evidence presented in the essay.

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Criteria	Achievement level				
	Examiner 1	maximum	Examiner 2	maximum	Examiner 3
A research question	0	2		2	
B introduction	0	2		2	
C investigation	2	4		4	
D knowledge and understanding	1	4		4	
E reasoned argument	0	4		4	
F analysis and evaluation	0	4		4	
G use of subject language	2	4		4	
H conclusion	1	2		2	
I formal presentation	2	4		4	
J abstract	0	2		2	
K holistic judgment	1	4		4	
Total out of 36	9				

IB Computer Science Extended Essay

Multitouch Interaction

Word Count: 3440

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Abstract

In modern countries, technology is a vital part of the everyday life of the people. Either using it for business purposes or just for personal pleasure, technology's demand has risen over the past years. More and more people are now used to having either a smart phone, a tablet, or any touchscreen device available to them. Even small children are now demanding parents for the newest technological gadget that is on the market. Touch screens were a great advancement in technology, but recently there has been a possibility of a new advancement, multitouch interaction. Such software lets people have a touchscreen anywhere they go, and is therefore a progression from the current touchscreen system. It does not have to be on the actual device, but on any flat surface. Multitouch interaction is more efficient than a touch screen because it is more user friendly, sold at an affordable price, could enhance learning and help people expand touch screen interactions outside of confined spaces.

Background

It is necessary to explore the different types of touch screens to know how it compares to the interaction used by a multitouch software. There are three basic electronic systems that recognize a person's touch: resistive, capacitive, surface acoustic wave, and virtual touchscreens. In a resistive screen, an electrical current runs through the layers and at the touch, the electrical field is noted and the exact coordinates of the point of contact are calculated. In a capacitive system, the layer that stored the electrical charge helps to determine when a finger has touched the screen because of the transfer of charge. Both this systems need of special materials to make them transparent and conductive. A surface acoustic wave uses ultrasonic waves to detect the touch in a screen. The finger absorbs the portion of the wave where it is touched thus the point of contact is exactly determined. Lastly, the virtual system uses camera and image processing techniques to determine the actions of a person, such as the famous Microsoft software Kinect. Such system, launched in Novermber 2010, offered different advantages such as putting the camera and video projector in the same side of the user, camera can be placed in any direction toward the screen, easy scale up and down for different sizes of the screen, and very easy system calibration and setup. (Soleimani)

The first discussion about multitouch interaction dates back to 1982 in the University of Toronto, where they developed a touchscreen that could be controlled by more than one hand. These scientists knew that human interaction with technology should not be confined to a predetermined space, but available in any surface around the people. A step further was taken in 1999 when John Alias and Ronnie the Westman developed the iGesture, a multi-spots touch control board and a multi-spots touch control keyboard. The patent used was then bought by Apple in 2005. This background history led to three main advantages that multi touch interaction offers to the public. Interaction is direct, there is no need for intermediary tools such as mouse or keyboard, for the person to interact with the screen, which can bring the user the most natural and quick operation feedback. Also, it supports the multi-spot operation. This means that the user can be in contact at different points with the screen and it should register all those spots. Contrary to a normal touch screen which only lets the user touch the screen at a single point. Lastly, it supports a multi-user activity which lets multiple people be in contact and interacting with the screen at the same time. (Yingying)

Current Applications

The idea that multiple people can interact in the same screen can be exciting to the public. Many television shows have shown versions of the newly multitouch interaction with screens. Normally people seemed to have a positive response at these expositions. The fact that movies and TV shows are using this way of interaction shows that this system will eventually overpass the idea of having a confined screen. Although technology can be viewed mostly as an individual way of interaction, multitouch modifies this idea to that of multiple individuals working with technology.

Exploring the current multitouch interactions will determine what needs to be improved, but also the great advantages it offers over touch screen. First, the electric capacity control technology, which forms the matrix formed distribution. It takes the electric capacity matrix by X axis and Y axis cross distribution. In 2007 the iPhone was launched at it used a form of multi touch interaction through this electric capacity controls technology. (Rong) When the user touches the screen, this develops a signal that is then transferred toward the central processor. Because this processor depends on the human body micro electric current, the screen needs to be in direct contact with the finger and not wear a glove or something similar to it. The popularity of

such product is also a result of the unique ways of interaction offered by such at the time. Pinching two fingers to minimize or maximize, rotating the screen to accommodate the user, these are just some ways that made this touch screen technology exciting to the public. (Yingying) Making a touch screen available at any time for a person could be even more exciting for the people in the future.

Another current multi touch technology is called the piezoelectricity type which is controlled through the voltage actuation. This technology is situated between the resistance type and the electric capacity type, the technical core is one kind of touch control chip. This technology combined the best aspects of the resistance and electric type touch control, which means that it might respond to any willfully touches and it can also realize from 5 to 10 spots to touch controls. Its screen is able to support hard objects such as pens, gloves, but the screen must stay clean at all times since the dirt might be registered as a hot spot on the screen. (Yingying) The piezoelectricity type multi-touch platform offers to recognize various finger touching path's at the same time as well as acting according to the finger effort, if there is more pressure the finger would write in bold letters. Such technology offers high discrimination, quick feedback speed, the finger and tool's union operation brought the nature and joyful interactive experience to the user.

The last current multi touch technology would be through infrared control. The screen is densely covered by infrared matrix on both x and y axis to determine the exact spot where the screen was contacted. Any touching object may change in the infrared electronic contact as to realize the touch screen operation. It would appear as the screen could understand the user's hand signals. Microsoft Corporation, which now promotes this product, pointed put four mayor points, easy reduction or enlargement, smooth translation of target touch, rotation of targets with two fingers, and click on screen while holding another object. Essentially all three of these current multitouch technologies show greater advantages that what a normal touch screen can offer, but they still have their own faults within the system. (Yingying)

Through these three mayor incorporations of multitouch software to current systems one can identify why such systems are more efficient than a current touch screen. The new interaction that the systems offer is popular to people because it is more user friendly. The pinching with two fingers to maximize or minimize the high discrimination, and smooth translation of target touch

shows the advantages that make a multitouch system more attractive and efficient than a normal touchscreen. The user doesn't not really are about the technical side of the production of systems, but more on what it offers them and how. A system's effectiveness can relate to how user friendly it is and therefore, since these three systems were very attractive to the public one can infer that the system was more effective and appealing than an average touchscreen.

An experiment took place in Shanghai, China where students got offered the new multi touch interaction to enhance their learning. For a tool of technology to serve positively in a child's education process it must be toy related. The interaction must be a fun one or else the child will be bored and in need of a change. As a child it is easy to lose focus, but the curiosity that technology arises in them can be used in an educational way. The improved human interaction that multitouch software offers over a normal touch screen allows for every child to be completely focused on what is being displayed on the screen. A virtual learning tool has more convenient advantages over a normal material tool. With a virtual learning tool it is easy to get multi-dimension perception and experience thanks to multi-media technology. Also, there are no limits in quantity and opposed from material tools virtual ones have unlimited reusability and expandability.

A prototype of the name e-Wa Sketchpad was used for the trial interaction of multi touch with small children. After the children were done with the prototype a few conclusions were derived from the previous interaction. Children love drawing, when a child saw that their finger left a color trail on the LCD screen they were all astonished. They started exploring all the coloring and drawing options that were provided. At the same time, the e-Wa proved to be a great support for fantasy and imagination. It automatically turned on the creative side of the children. Another point observed in the experiment was the hunger for tactile perception. (Xiaohua) Children enjoyed the multi-user finger interaction with the board, but what the creators are working on and what is needed is a more sensitive type of touch. The children would be fascinated if the thickness of the colors that they use would change according to the pressure applied by their finger. This will not only bring more excitement to this process of leaning, but it will offer us more vivid real user experience along with rich material tactile feeling.

As opposed to a normal touchscreen the incorporation of multitouch interaction to the learning experience of young children makes this experience more attractive. When a certain idea

is popular within small children, they tend to focus harder on it and therefore get more productive outcomes from it. (Scharf) Because the idea of having multiple touches being sensed by the computer without being limited to a single space is appealing to little children, they pay more attention to it than an average touchscreen. Children do not like to be restricted to stay in a single space and that is one disadvantage of touchscreen interaction. The incorporation of having any flat surface be appropriate to have a multitouch interaction is also a great appeal towards children in the process of learning.

Microsoft also launched the newly Kinect for Xbox 360 that uses a form of multitouch interaction. In this new system, the user can control the game without the need of a specific remote control. It solely uses the movement of one's body as the inputs to manage the videogames. The system uses cameras, infrared sensors, and microphones to judge where the person is standing and to be able to identify what he or she is saying. As for pricing, the sensor alone will cost about $150, which is still lower in price than the newest iPhone. The sensors will enable multiple people to interact in one screen. This makes the videogame experience more appealing to the whole family. It is an affordable price and it could even be beneficial for small children. A child can enjoy the interaction with the system while learning basic knowledge. It expands the idea of playing with a small screen into a bigger screen, but where more people can play together. Although the system was not meant for furthering the research of multitouch interactions, the Kinect offers an idea of the advantages the new system could provide and its manageable price.

Another project that is being worked on involving multitouch interaction is the OmniTouch software. The creator Chris Harrison believes that the small touchscreen and keyboard options available in a normal mobile device alter the user experience. The OmniTouch would allow graphical interaction with multitouch input into an everyday surface including a desk, out hand, or simply a wall. However, turning any surface into a touchscreen down require a sophisticated hardware and sensing. The idea resides on the user wearing a wearable system on its shoulder that projects the desired images.

The hardware of the Omnitouch system contains three mayor components to it. The first is a depth camera that allows a 320x240 depth map at 30 FPS. This allows objects up to 20 cm to be detected by the sensor. The only limitation of this camera is the fact that as the object goes

farther away there is a distortion on the sound and sensing. However, for he trials of this hardware a 1m radius was used and the limitations were minimal. This is essentially what was used by Microsoft when launching the Kinect. The second component of the hardware is the Microsoft Microvision ShowWX+ laser pico-projector. This projector allows for wide angle views and accurate depth perception. Together both the camera and the projector are mounted on top of a desktop computer, but solely for prototyping purposes. (Harrison)

For indentifying the actual finger input, it has a multistep process. First, the depth of the map is taken to compute the derivative of the X and Y axis with a 5x5 pixel window. The computer will look for vertical slices of cylinder-like objects. For a slice of pixels to be a candidate, it must show a steep positive derivate, followed by a region of relative smoothness, and finally closed by a steep negative derivative. If this order above is not followed, shapes such as the space between fingers, will be recognized by the computer as well. In order to isolate the finger touches the slices must be between 5 to 25 mm, the typical finger diameter size. Using the derivative of the depth map allows for the computer to process the information as if it was a 2-D screen. The 3-D scenery is converted into a 2-D image for a typical computer to recognize its functions. (Harrison)

There were 12 participants that helped with trial runs to test the effectiveness of the finger sensing. They produced 3456 click trials on our four surfaces, a further 2592 in our distance experiment, and 288 drawn shapes. There were no significant performance differences between participants. The only suggestion to the results was the improvement on the depth perception of the camera. Out of the 6848 trials 96.5%correctly received exactly one finger click event., 0.8% had no click event, meaning the system missed the finger input, 2.5% had two click events, meaning the system thought that there were two fingers or two clicks, and 0.1% had three click events. These percentages are positive, but are not good enough for the system to be sold by the company. (Harrison)

A confined space to work with does not give the user much freedom to operate. The user seeks for the system that will provide them the most advantages. Compared to the current touchscreen software, a multitouch interaction would offer the freedom to execute any function of the system anywhere where there is a flat surface or where the camera is available. The production of the Kinect shows how a simple camera is enough to have a multitouch interaction

without being limited to a single screen. The Omnitouch offerings of being able to have any flat surfaced object be the screen where the system can operate also shows the freedom multitouch interaction offers versus that of a touchscreen. As explored by both this systems, the popularity and effectiveness of such interaction is greater than that offered by a touchscreen. The replacement of the current touchscreens with this multitouch software is a progress when it comes to human interaction with technology.

Results

In a conversation over email I asked Chris Harrison a few questions about the impacts that Omnitouch will bring and its limitations:

> What makes this Omnitouch software unique?

It is one of the first systems to allow multitouch input with a graphical user interfaces to be rendered onto almost every surface in the world around us. This includes surfaces that are not fixed (like a table), including one's own body. Also, OmniTouch is not only software, there is a unique hardware component as well.

> How do you personally think this software will impact society?

OmniTouch shows us that we can escape the small confines of touch screens, and move touch interaction out onto the world (which is much larger and more comfortable). With the gained space, we can perform more significant and complex operations that would never be possible on smartphones in isolation.

> Will the software be economically affordable for any average person or is it targeted for important corporations?

While I can't comment on any details, the raw components of OmniTouch are roughly equivalent in cost to a smartphone.

> What is the hardest challenge when developing this software and making it available for the

public?

Before it can be released to the public, we have to make the touch interaction even more accurate. 99% accuracy is not enough -- that would be like 1 in every 100 presses of your mouse, it would click somewhere else -- not acceptable. It needs to be 99.99% accurate before consumers will accept it.

> How significant is this technological advancement for humanity in our current era?

I'm sure opinions on this would vary considerably. My personal take is that OmniTouch is an early peek of what is coming next. Where digital information and interactions aren't confined to the conventional computers of today. When computation reached out into the world around us, there are some very profound implications.

As seen by the responses of Mr. Harrison, the world will not allow a product to be out on the market unless it almost perfect. In the technology world, society is demanding more perfection from the producers and therefore the OmniTouch has yet to be released. As also stated by Mr. Harrison, this multitouch interaction is the opening of an era where digital information is not confined in a determined space. In future work mentioned by Mr. Harrison, he mentions the idea of using body movements as inputs to the computer. Where if a hand is raised in the form of a telephone, the computer knows that the user wants to make a call, or if a hand is raised and turned around the user wants to know the time. Also, the projector being mounted in a person's shoulder could be a limitation for old people or even children. The next step of this multitouch evolution is to create the body to be the platform of recognition for the computer. The idea to minimize the size problem of the projector was to create a prototype of a projector the size of a box of matches or a watch that you were around your neck. These are all possibilities that will aid the creation of multitouch software to the public, and like Mr. Harrison stated, it will be about the same cost as a Smartphone.

Conclusion

People crave constant change in technology. Apple's success is based on the acquisition of human interaction with new technological instruments. Asides from the fact that touch screens are the most popular between their products, the next step in the technology sequence is called multi touch interaction. People do not like to be limited to confined spaces when interacting with technology and multi touch attempts to break that barrier. The multi touch software is not yet a perfect product, but when its main problems are solved it will be able to provide better user interaction than normal touch screens offer. It can enhance child learning because it offers more hands one experience that children seem to have an appeal for. It initiates their imaginative senses and makes them interact with technology earlier than present generations. The fact that the world is seeking for ideas to be able to be connected to the internet in any part of the world can relate to multitouch interaction because it will enable the user to not worry about a specific device, but only a flat surface where the program can function. Expanding on the idea of touchscreen into something more accessible and available for more people is the next step in the evolution of technology.

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