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SIXTH SENSE TECHNOLOGY

Thesis

CENTRIA UNIVERSITY OF APPLIED SCIENCES

Degree Programme in Information Technology

May 2014

ABSTRACT

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Kokkola - Pietarsaari	May 2014	Kedar Kanel

Degree Programme	
Information Technology	

Name of thesis	
SIXTH SENSE TECHNOLOGY	

Instructor	Pages
Kauko Kolehmainen	40

Supervisor	
Kauko Kolehmainen	

The aim of this thesis was to explain the development of the technology by describing current hot concept in its field.

The thesis describes the trend of development and current phase of the technology. The trend was described by explaining the concept of sixth sense technology and the effort that have been applied for this technology. As the concept is new, finding the suitable material related to the subject matter was the challenge for this project. The objective was completed by conducting research in different fields related to the subject matter

The concept of sixth sense technology and the devices, telepointer and sixthsense (also known as Wear Ur World) were also explained in the thesis. The thesis concluded that the progress rate of the technology is rapid and successfulness on the completion of the sixth sense technology concept will surely lead to the bright and brand new future.

ABSTRACT
TABLE OF CONTENTS

GRAPHS

Abbreviations

AI   Artificial Intelligence

AIDC   Automatic Identification Data Collection

AR   Augmented Reality

CV   Computer Vision

MIT   Massachusetts Institute of Technology

RFID   Radio Frequency Identification

TED   Technology Entertainment

Ubicomp   Ubiquitous Computing

V2V   Vehicle to Vehicle

WUW   Wear Ur World

1   INTRODUCTION

Technology is the process by which humans modify nature to meet their needs and wants. Increase in the needs leads to the increase in the technology and vice versa. When it comes to the topic of technology it is not wise to use the word impossible in anything. Because every impossible of past has become possible in the present and day by day the proof has been stronger. The development of technology has made people amazed each day and thus it has been a difficult task for people to recognize or to see what is coming next. There is not a single field or sector that the technology has not touched.

As technology is a vast topic, entering every sector and explaining everything is a difficult task with limitation of words, sources and time. This paper will discuss Sixth Sense Technology, one of the strong topics of now, which has challenged the people with the word impossible on their lips and created another revolution in its own field. As the topic itself is interesting, revealing the real meaning of sixth sense technology and the implementation of this topic in the field of technology is the main aim of this thesis paper. But since the topic is a new concept, finding suitable content materials for research was a very challenging task.

How is the technology progressing and how is it coming in contact with people and the environment in the present time was the question that came into highlight before starting this thesis. As the research was started to find the answer, the concept of sixth sense device was found which created more questions and curiosity. So topic, sixth sense technology was chosen to the answer questions that appeared.

The thesis is based on the basic research. The information that has used to prepare the thesis was collected from different websites from the internet, eBooks and

articles. Materials from library like books written by experts, engineers, lecturers and professors have also been used as research materials for this thesis. Signing up in github (site for developers' tools) and following up the project that was being conducted, related to the topic, or in other word becoming a member of the research team, the subject matter was understood in the clear way. The thesis is prepared by discussing with supervisor about the subject matter and implementing his suggestions. Information collected from different resources was presented after mixing some of own views and thoughts.

After introduction, chapter two of the thesis with topic technology and sixth sense will start. The brief definition of technology and sixth sense and the background of the sixth sense device mentioning the inventor, developer and the working of the device will be mentioned in that chapter. In chapter three, prototypes of sixth sense devices, working prototypes available (from past) and the current prototype which is called Wear Ur World (WUW) or sixthsense, of sixth sense device will be explained. The entire software and hardware requirement for the current prototype of WUW is going to be explained in detail in chapter four. The workings of those components are also briefly explained in that chapter.

Chapter four will be followed by chapter five on the topic, concepts and technologies behind WUW. The concept like ubiquitous computing and technologies like augmented reality, gesture recognition computer vision, and radio frequency identification which are implemented by WUW are going to be discussed. The applications of sixth sense devices and its uses will be discussed in chapter six. The applications will be explained with graphs. Developing the concept is one thing but making it working is another difficult part. The possibility of this concept and the ongoing process will be discussed in chapter seven. In order to find the development progress at present times, the thesis will also explain the technologies based on sixth sense. Chapter eight will be composed of advantages and challenges where the concept prototype will also be presented. And finally the thesis will present the conclusion and future development.

2   TECHNOLOGY AND SIXTH SENSE

People are aware of the senses that they have. Those senses when encounter a new experience tries to analyze that. The analyzed experience is then used to modify the interaction with the environment. There are many small-sized computers or computing devices which are helping people to connect to the digital world in different situations from different parts of the world. But now rather than being connected to the digital world, the demand of people is the use the technology as their sixth sense which in other word is to bridge the gap between two worlds namely digital and real. (Udayakumar & Khanaa 2013.)

2.1   Technology

The term technology itself is the fusion of two Greek words techne and logia which gives the meaning of making of tools, machines, crafts, systems or methods to solve a problem. In other word, the use of science in any field to invent feasible device for doing different tasks or to solve any problem is called technology. According to Encyclopedia Britannica, the application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment is called technology (Encyclopedia Britannica 2014.) The broad meaning of technology implies the meaning of practical art and mining to means of communication, medicine, and military technology. (Merrill 1968.)

The word when appeared in English in 17th century had a definite meaning but in the today's world, it is not easy to confine the meaning of technology into few words as it covers wide range of area and the range extends from computers and software to the totality of all tools devised by or for humankind (Encyclopedia Britannica 2014.) Now, almost each and every human activity is covered with the

technologies. The progress and the changes in the technological field not only has helped the people but also has created a new hope every day with better future. And since progress is being every day the hope of better future is also becoming stronger. Compared to the past the progress rate of technological development has been increasing each day and every second. This progress has been making the world digital every day. The developments have made peoples life easier and convenient but now the time has come to pause and think. There are many digital devices which have surrounded people and have helped them in their daily work. But somehow those devices have been holding people with themselves inside the virtual world and have taken the people away from the real nature or environment. From this perspective it is essential for people to modify the technology in such a way that the devices will adapt according to peoples' surrounding and situations. (Weiser 1991.)

2.2   Sixth Sense

The scientific definition of sixth sense is power of perception seemingly independent of the five senses which are hear, touch, smell, sight and taste. That is to say the reception of information apart from the five senses. This also means Extra Sensory Perception (ESP). Challenge is what people like and change is what they want. To make a device which has power of perception will be the new change in technology and being successful in such task will be a great challenge. Using this definition engineers tried to develop an interface to receive the information from the surroundings and interact with people. Since the objective of the device was to receive the human interaction and use the device's own sense (according to the embedded program) to analyze the interaction and give the results, it was named as sixth sense device. The reason for development of this kind of device is to compel the technology to adapt peoples' environment. People would then be able to stand up from the chair in front of the computer monitor and would enjoy the real world at the same time interacting with the digital device using it as their extra

sense, sixth sense. (Merriam-Webster.com 2014; theFreeDictionary 2014; Mistry 2009.)

2.3   Inventors and developers

The first one to make a device with sixth sense was Steve Mann. By developing the concept and making the wearable computer in 90's when he was Media Lab student, Steve Mann became the father of Sixth Sense Technology. He implemented the concept as the neck worn projector with the camera system. Currently he is the professor at University of Toronto. He is also a director of EyeTap Personal Imaging (ePi) Lab and FL_UI_D laboratory. Apart from this, Mann has contributed in many different projects and published many articles and books. After Mann, the concept was developed further by Pranav Mistry, the Head of Think Tank Team and Director of Research of Samsung Research America, when he was a Research Assistant and PhD candidate at the MIT (Massachusetts Institute of Technology) Media Lab. (Mann 1990; Mistry 2013; Arora 2012.)

2.4   Working mechanism of sixth sense device

The working mechanism of the device is very simple. It gathers data from the users' surroundings, makes query using the internet as a data store, processes the query and presents information back to user via a display. Simple computer vision algorithm and gesture recognition technology are used to understand the input fed by the user as the input is received by the device as the image or the gesture produced by the hand or face. Working field of the device, which can cover every sector as it receives input from the real world, simply depends on the type and amount of applications programmed for the device. (Mann 1990; Mistry 2009; Rao 2010, 336-339; Kumar & Pandithurai 2013, 947-953; Arora 2012)

3   PROTOTYPES OF SIXTH SENSE DEVICES

Prototype is a sample model designed to test a new design of a system. It is a working demonstration of systems or devices. Traditionally it was associated with innovative hardware constructions but today it is also associated with software. To test and demonstrate the technical features it is essential for every products ranging from mobile phones to automobiles to go through prototyping. Prototyping is the best way of finding bugs and fixing it. It not only saves budget of project but also helps developers to understand the problem in whole new perspective. (Sousa,Tanase, Hannig, & Teich 2013; Mullen 2011.)

3.1   Telepointer

The first prototype of Sixth Sense technology was developed by Steve Mann. The name of this device is Telepointer. It is hands-free, headwear-free-device that allows the wearer to experience a visual collaborative telepresence, with text, graphics, and a shared cursor, displayed directly on real world objects (Mann 2000, 177-178). Mann has referred this device as "Synthetic Synesthesia of Sixth Sense". It is a real-time groupware interface feature for indicating where other users are pointing which can also act as a communication channel by conveying gestural messages. (Xia, Sun, and Chen 2005.) It has been tested in telemedicine, and has potential to become a great influence in improving quality of health care. The other reason of its great possibility is its capability of effective communication, precise diagnosis which helps to take a better decision by means of discussion and consultation between the expert and the junior doctors. Since it has large potential for wider acceptance in real life applications, more improvement in real time positioning accuracy is needed.

3.1.1 The working mechanism of Telepointer

According to Steve Mann (Mann 2000, 177.), Telepointer operates through a Reality User Interface (RUI) which allows direct interaction with the real world, establishing a kind of computing that is completely free of metaphors. Graph 1 shows how the device works. The device was proposed as a Direct User Interface (DUI) to fulfill the desire of the augmented reality. It works was the pointing device. The question may arise, if it is a pointing device then what makes it different than other devices with same functionality. In order to get the answer, it is first essential to know the working mechanism of the device in detail.
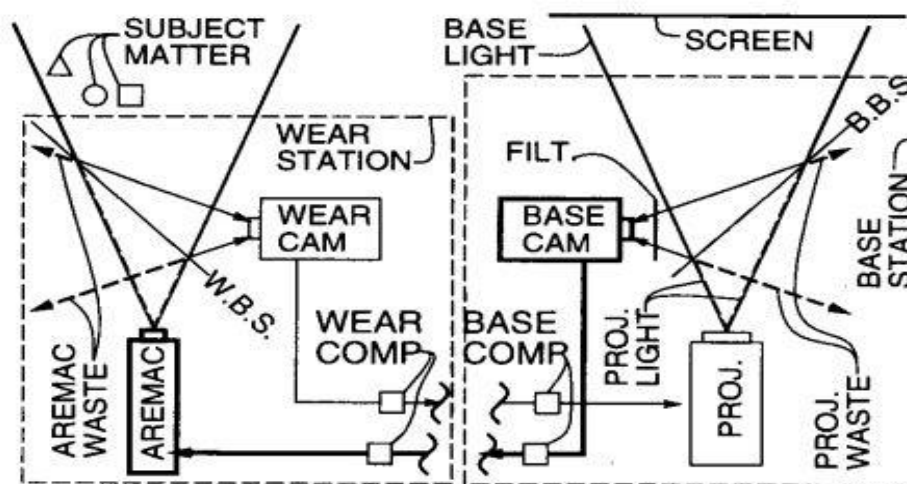
GRAPH 1. Working of Telepointer (Adapted from Mann 2000, 177)

This device establishes the connection between the long distance objects. If somebody is in Helsinki and wants to buy some cloths from a shop in Kokkola, the person in Kokkola wears Telepointer device, and the video is projected on the screen of person who is in Helsinki. The person does not have to produce the sound or to choose the object; all he needs to do is to point a object on his projected screen with laser pointer. The laser point is pointed exactly on the same object in a shop in Kokkola as of the screen in Helsinki. At the same time both, person in Helsinki and in Kokkola see the point on the same object. If he scribbles any image in the projected screen the one wearing the device sees the same

scribbled image in the real object. Graph 2 shows how Telepointer looks. It has also become a powerful tool in the field of medicine as it enhances the effectiveness of long distance communication. (Karim, Zakaria, Zulkifley, Mustafa, Sagap & Latar 2013.)

GRAPH 2. Telepointer Device (Adapted from Mann 2000, 178.)

3.2   Wristband and Ring

 After Steve Mann, seven students of MIT started to think about integrating the world around them to access information without taking out any devices from their pocket. They were successful to develop a wristband which read radio frequency identification tag for recognizing different things, for example which book a user is holding in a store. They had also made a ring using infrared to communicate by beacon. The ring was used in supermarket smart shelves to find information about the products. According to criteria of the program inside the system, the ring would blink in different LED lights to determine if the product was organic or not. (Kohil 2013; Sharma, Agarwal, Sharma, & Gupta 2013, 277-282.)

3.3 Wear Ur World (WuW)

Later Pranav Mistry came up with a prototype consisting of a computing device, camera, projector, color markers, microphone and a mirror. Using wired or wireless connection, projector and camera both are connected to a computing device which uses internet via 3G, 4G or wireless Wi-Fi. The whole system then is made wearable using some short of string in a way that the projector's end is tilted downward to the ground. The mirror is then attached to the front of a projector. The mirror reflects the projection of a visual information to any surface. The cost of the total system is less than $350. (Mistry 2009; Arora 2012; Bhartia, Bhatia, Bhatia & Rani 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

Since the device is wearable and we can interact with the real world it was given a name Wear Ur World (WUW). Gesture recognition is used to understand the gestures by webcam; computer vision algorithms are used to identify the objects through camera. Graph 3 describes the prototype or connection of the WUW. (Mistry 2013.)
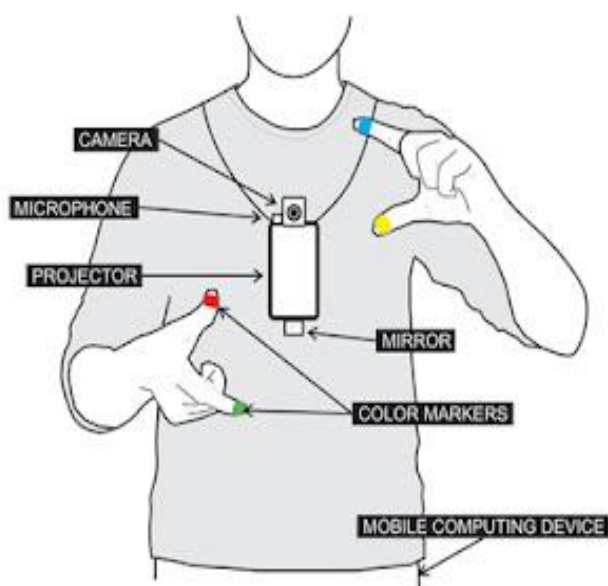
**GRAPH 3. Prototype of WUW (Adapted from Grznar 2013.)**

Now a days WUW is widely called as "SixthSense". The Mistry has published the beta software version of this device written in C++ and C# in the Google Code project and he also has given the name of the project WUW. This prototype also won an Invention Award in 2009 from Popular Science. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

According to Mistry, 'SixthSense' is a wearable gestural interface that augments the physical world around user with digital information and lets user use natural hand gestures to interact with that information. By using a camera and a tiny projector mounted in a pendant like wearable device, 'SixthSense' sees what users see and visually augments any surfaces or objects users are interacting with. It projects information onto surfaces, walls, and physical objects around them, and lets them interact with the projected information through natural hand gestures, arm movements, or their interaction with the object itself. 'SixthSense' attempts to free information from its confines by seamlessly integrating it with reality, and thus making the entire world their computer. (Mistry, 2009.)

3.3.1 The Working mechanism of WUW

The camera streams the video and the gestures made by the user's hand. The user's fingers' tips are covered with different distinct colors which helps the camera to recognize the gesture. The camera has a sensor to understand the gesture. These streaming images of objects and gestures are taken as instructions by the computing device. After which the device works as the instruction and also performs query to the internet if needed and passes the information back. That information is projected out through the projector and mirror reflects it to the desired surface or object. The user can then interact with the projected image to give another instruction. The working is illustrated in Graph 4. (Mistry 2009; Arora 2012;

Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

The Working Of The Sixth Sense Device
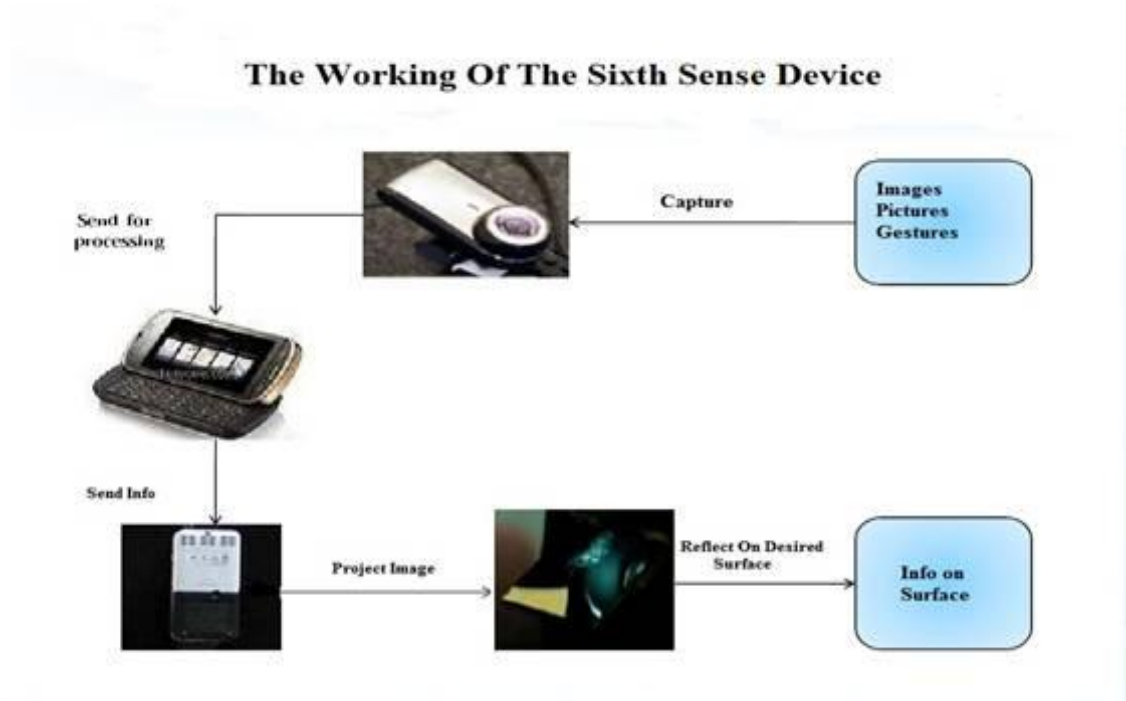
GRAPH 4. Working of the sixth sense device. (Adapted from Sharma et al. 2013.)

4   REQUIREMENTS OF WUW

Requirements can be defined as a careful assessment of the needs for the system. Any system is designed to fulfill a certain function or task. The components or functions needed to fulfill such task are known as requirements. (Mylopoulos 2004.) The technical device is a composition of hardware and software. As one does not work in the absence of other, both are essential components. To make WUW work, certain hardware and software are required. Mistry made the requirement list available in the Google Code. The required things are explained below.

4.1   Software

The set of instructions that tells computer or computing device about the task to be performed is called software. According to the definition of West's Encyclopedia of American Law, software is intangible personal property consisting of mathematical codes, programs, routines, and other functions that controls the functioning and operation of a computer's hardware. (West's Encyclopedia of American Law 2005.) The instructions are written using the language like C, C++, C# and JAVA. It is not a physical component.

The SixthSense technology software is an open source. Mistry has already supplied the beta version of the software. As for now, the prototype system runs on Windows platform. The code has been written in C++ and C# using Visual Studio. To develop more or to test in the real device, Microsoft DirectX, Adobe Flash Player and MS Outlook are essential software. Once the program starts, it uses Outlook to search for the email using internet. (Mistry 2012; McManus 2009.)

4.2 Hardware

Hardware is a physical component of a computer system or a computing device. All the equipment like circuit boards, peripheral devices, cables and connectors falls inside this category. It is not that difficult to make a sixth sense device because of cost efficiency. Also the components that are required are easily available. The essential components to make the sixth sense device are color markers, camera, computing device, projector, mirror and microphone. The requirement of those components for making the sixth sense hardware device is explained in detail below. (Mistry 2012.)

4.2.1 Color Markers

It is necessary to have color markers in order to make camera understand the position of the finger. Users' fingers are marked with red, yellow, green and blue colored tape which helps the camera to recognize the hand gestures that act as an interaction instruction for the projected application interfaces. This is essential to pass input to the device. Any distinct color can be used to mark the finger. Even nail polish with different colors can work sometimes, or multicolor tape, paper, or paint can be used as a marker. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

4.2.2 Camera

The work of camera is to capture images or videos. In sixth sense also, it performs the same task acting as an input device. Acting as user's third eye, it captures the

image, streams video of objects and tracks the gestures. After recognizing all the input, it sends the data to a computing device for processing. The camera used in this device should have the sensor to track the gesture created by the users. For the program written by Mistry, he has suggested to use Logitech QuickCam Pro for notebooks. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

4.2.3 Computing Device

It is the main processing device of the system. It may be any portable device with internet access. The most feasible way is to use a smartphone or any smaller device. All the required software programs and applications are installed in it. The software uses different technological algorithms to process the data and to run the applications. The installed software recognizes the gesture and performs the task. While processing it searches the internet and interprets the streamed image. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

4.2.4 Projector

Projector projects the visual information enabling surface and physical objects to be used as interfaces. In the device made by Mistry, the projector has inbuilt three hour battery. But since it the device can be made by user himself, it depends upon the choice and wish of user to modify it. It acts as the output device. The content, digital information and a graphical user interface are provided by computing device. As for now the developers suggested users to use ser (AAXA, Microvision) or L.E.D (3M MPro110) projectors. (Mistry 2009; Arora

2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

4.2.5 Mirror

The mirror performs special task in this prototype. Since the projector is pointed downward, the mirror helps to reflect the image on to a desired surface such that the digital image is freed from the confined screen and placed in the physical world. It is attached in a way that it can be tilted anywhere as per user's desire of location to project the image. It provides the ability for user to choose the size and place of projecting the result. Varying the angle of reflection the size of the projection can also be varied. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

4.2.6 Microphone

Microphone is an optional component. It is required when using paper as an interactive surface by capturing sound across the paper medium. When the user wants to use a sheet of paper as an interactive surface, he or she clips the microphone to the paper so that it captures the sound signals of user's finger touching the paper. The sound signal captured by it provides time information which combines with the tracking performed by camera to help the system for identifying precise touch event on the paper. It can also be used as the input device by disabled people. By enhancing the device and programming it accordingly, microphone can be used to provide input to the device. The enhanced device is useful for users who do not have hands. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta &

Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

5 CONCEPTS AND TECHNOLOGIES BEHIND WUW

Though the concept of sixthsense or WUW is quite similar as Telepointer, there are some factors that make sixthsense different and somehow complex also. (Mann 2000; Mistry 2009.) One of those factors is the technology that is behind it. Different technological concepts behind WUW are ubiquitous computing, augmented reality, gesture recognition, computer vision and radio frequency identification. (Kumar & Pandithurai 2013, 947-953.) The detailed information of what these terms and terminologies are described in the following topics.

5.1 Ubiquitous Computing

The term ubiquitous computing (Ubicomp) was coined by late Mark Weiser (1952-1999). As the verbal meaning of ubiquitous is to be present, appear or found everywhere it can be said that ubiquitous computing is the concept of making computer available everywhere. According to the Oxford Dictionary of the Internet, this term is used to describe a future where computers are so numerous that they affect every action people take. This includes computers that are part of people's clothing and which monitor their vital functions, computers which control traffic, computers which are integrated with television sets and computers that control people's homes. (Oxford Reference 2009.)

The term became popular and caught attention of other researchers when Weiser introduced the vision of Ubiquitous Computing in an article titled "The Computer for the 21st Century", written in 1988 but published during 1991 in Scientific American, while he was at Xerox PARC. According to him, it is a method of enhancing computing use not only by making many devices available throughout the physical environment but making them effectively invisible to the user. (Weiser 1991.)

Weiser also mentioned in his article that these computers reside in the human world and pose no barrier to personal interaction. Today, Ubicomp has become the inspiration through the development of the new paradigm of computation (off the desktop), where the interaction between humankind and the computer was natural and it has slowly left the paradigm keyboard/mouse/display through the PC generation. (Agushinta, Kusuma, Junatas & Trihasta 2009.)

Allowing people with physical disability and people without computing skills use the computer for all their needs is the greatest asset of Ubicomp. The limiting factor for the development of Ubicomp is the privacy concern. In order to obtain ubiquity, more information about the user, his activities and surrounding environment has to be gathered and once that information are carried out by different applications, there is threat to the privacy of a user. To develop the ubiquitous computing framework by ensuring the privacy of user is indeed a significant challenge to the software engineer of today's world. The WUW clearly fulfills this concept as the device provides seamless information about anything from anywhere. (Weiser 1991.)

5.2 Augmented reality

Augmented reality (AR) is the term that describes a combination of technologies that enable real time mixing of computer-generated content with live video displays. (Mullen, 2011.) This in other word means to integrate the artificially produced information into the real world. Running interactively and in real time, it combines real and virtual objects in a real environment and aligns both objects with each other. (Azuma, Baillot, Behringer, Feiner, Julier, MacIntyre, 2001.) It is a real-time device-mediated perception of a real-world environment that is closely or seamlessly integrated with computer generated sensory objects. (Geroimenko, 2012.)

The name, AR, was first coined in 1990 by a researcher named Tom Caudell at The Boeing Company and the major development in this technology occured at the end of 90's when Hirokazu created ARToolKit, a powerful library of tools for creating AR applications. (Mullen, 31, 2011.) Its endless possibilities in different fields are one of the reasons of its growing popularity. (Geroimenko, 2012.) And now there are already a handful of applications available on smartphones or portable devices.

AR is related to all five senses of the human body i.e. sight, hearing, feeling, taste and smell and the one related to these are respectively called Visual AR, Audio AR, Haptic AR, Gustatory AR and Olfactory AR. Graph 5 provides clear explanation of this classification. Visual AR is a field of computer vision (CV) concerning of the techniques for projecting virtual contents in a scene with real objects creating the illusion of unique environment. In order to achieve an adequate level of realism in AR applications, it is important to have a real-time computation of the relative position between the user and the scene and previse collimation and registration between real and virtual objects. The augmented scene is then projected back to the user by means of head mounted display. In other word AR is a visualization technology that allows the user to experience the virtual experience added over real world in real time. (Geroimenko, 2012.)
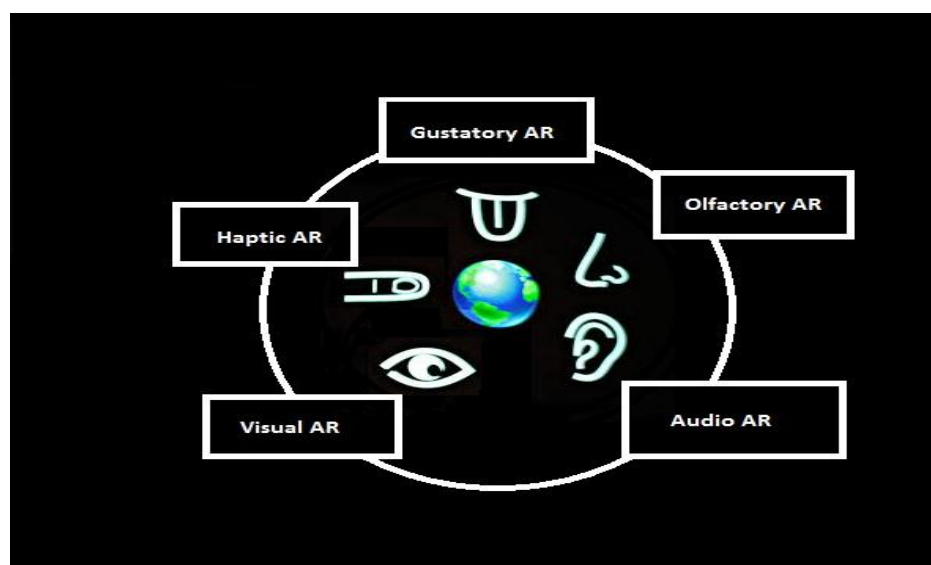
GRAPH 5. Classification of AR based on human Senses. (Adapted from Archakam 2010.)

Audio AR embeds the digital sound in the physical world where as Haptic AR allows the user to touch and feel AR objects placed into a real-world environment. AR adds graphics, sounds, hepatic feedback and smell to the natural world as it exists. Apart from other, Gustatory AR and Olfactory AR are only possible in principle as they are hard to implement. But the research in smell enhanced AR is being conducted at different labs. (Geroimenko, 2012.)

5.3 Gesture recognition

The process of recognizing the gesture (hand movements, facial expressions, body movement etc.) is called gesture recognition and the computer interface using this method is called gesture recognition technology. It is a topic in technology language which interprets human gestures via mathematical algorithms. This technology is a better alternative to the text and graphical user interface since it does not require any mouse, track pad, joysticks or keyboard. There are more possibilities that all such devices will be replaced by sixth sense technology just like touch screen replacing the keypad of phones. (Patch 2003, 1.)

The Magic Cube, evoMouse, Kinect, The Leap are some of the recent technologies which implement gesture recognition. There are numbers of companies working on it and creating or developing technologies based on gesture recognition every day. Sixth sense implements this technology to feed input. As for now, the webcam recognizes the gestures made by the colored marked fingers of users. (Celluon 2012; Microsoft 2013; LeapMotion 2013.)

5.4   Computer vision

It is commonly accepted that the father of computer vision is Larry Roberts, who in his Ph.D. thesis in MIT discussed the possibilities of extracting 3D geometrical information from 2D perspective views of blocks. (Aloimonos, 1992) Computer vision is a field that includes methods for acquiring, processing, analyzing, and understanding images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information. This technology includes the aspect of Artificial Intelligence (AI) techniques like pattern recognition. Image sensors are the essential factors of this device since it has to detect electromagnetic radiation which is in the form of light rays. Computer vision algorithm is used to obtain important information about the spatial position of objects in a scene. But the efficient exploration of these algorithms' capability to adapt in different environmental situations in real time has always been a challenge. (Sousa, Tanase, Hannig and Teich 2013.) This technique is implemented in sixthsense to recognize the gestures and physical object through the camera.

5.5   Radio Frequency Identification

Radio Frequency Identification (RFID) is a means of identifying objects by interrogation a unique characteristic of the object using radio wave. (National Academies Press, 2004.) It is a rapidly growing segment of automatic identification data collection (AIDC). According to AIDC researchers, the first implementation of RFID was completed during the World War II to identify and authenticate the allied planes. Even though it is currently being used in numerous applications throughout the world, the ratio of its uses has not been in the way as it should. It transmits the identity of an object wirelessly, using radio magnetic waves. The main purpose of this technology is to enable the transfer of a data via a portable device. RFID has an ability to identify objects without the requirement of a line of sight meaning that the objects can be identified even when they are tightly packed together or their

surface markings are removed, marred, or obscured.(National Academies Press, 2004.)

6   APPLICATIONS AND USES OF WUW

It is normal that people search for the application and its uses before they buy it. WUW has wide range of applications and uses. Many different applications of this device demonstrate the usefulness, viability and flexibility of the system. (Mistry 2009.) It has applications which perform the task of multiple devices that people are using nowadays. Due to those applications, it offers us freedom from many different devices. Among many of its applications and uses, some of them which can be used in daily basis are going to be described below.
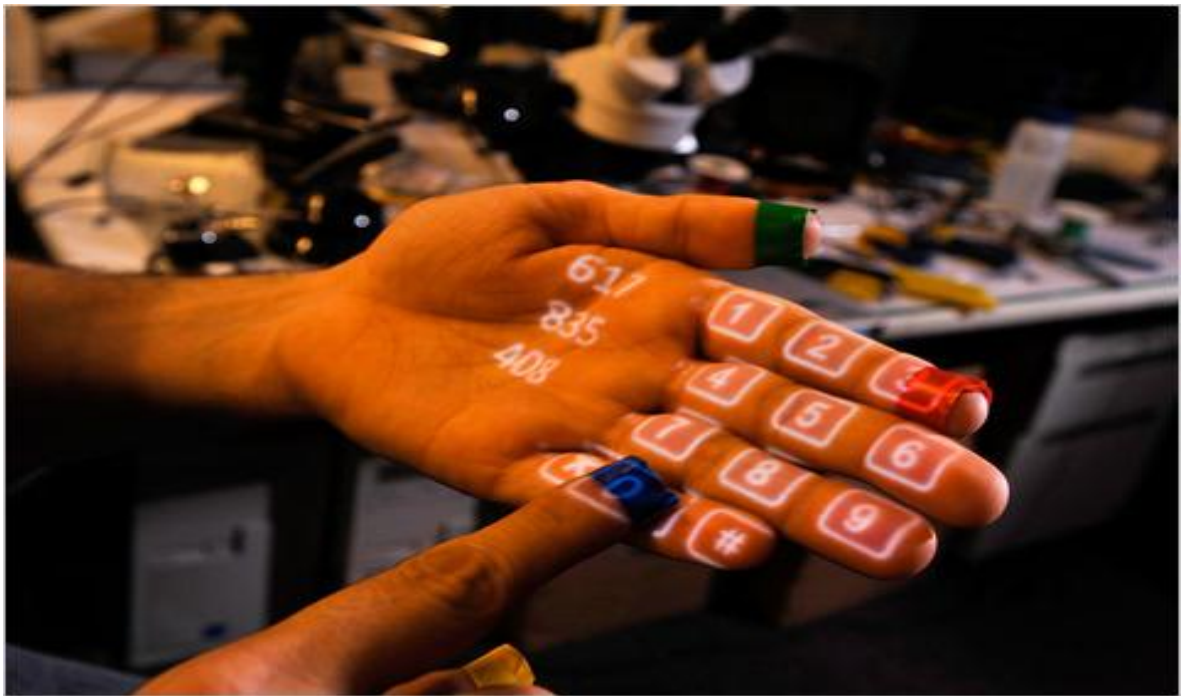
6.1   Applications

WUW implements wide range of applications which are not only useful in daily life but are also very different from applications that people have been experiencing before. For example a newspaper can show live video related to the subject matter. The computing device accesses internet for searching out the related subject and passes the information in the form of video through projector over the newspaper. Thus the user can read the news in the paper as well as see the video. Apart from this, some of the applications are described below. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

6.1.1   Make a call

It is not necessary to take out the phone every time when user wants to call. Using Sixthsense, one can call up the other person. When this application is called the number pad is projected on any surface a user wants, on a palm or on a wall or on a table. When the user positions his colored fingertip on the number, using com-

puter vision algorithm and gesture recognition technology, the device understands which number the user is pointing. And thus the user can give a call. Graph 6 shows how the projected number pad looks in a user's palm and explains how they can give a call. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

GRAPH 6. Projected number pad in palm. (Adapted from Arora 2012.)

6.1.2 Search the map

This application has wide range of uses. It can be used to navigate, to find places, to find the shortest path and many more things. This application starts when the user forms the sign of magnifying glass. The gesture recognition technology helps to understand this. When the application starts, a user can zoom in and zoom out using two fingers' gesture just like in Graph 7. The device is developed on multi-touch based system. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta &

Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

GRAPH 7. Search the map application. (Adapted from Sharma et al. 2013.)

6.1.3 Drawing application

Now, color pens and papers or any wide device is not necessary for drawing picture. Using this small portable device one can let out his artistic talent anywhere on any surface. Understanding the gesture of the colored fingertip of the user, this application draws the image and projects it on the surface. The drawing is saved in the computing device and it can be retrieved anytime wherever the user wants. Graph 8 shows the user drawing on a wall using the gesture of a hand through drawing application. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta &

Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

GRAPH 8. Drawing Application. (Adapted from Aharma et al. 2013.)

6.1.4 Take a Picture

The gestural camera understands the framing gesture made by the user and it captures the image of the scene the user is looking at. The framing gesture is shown in Graph 9. When four fingertips are combined to form a rectangular frame, the camera understands it as a framing gesture and captures the image inside that frame. The user can flick and edit those images on any surfaces. The images can be shared or sent to anyone a user wants through an internet access. Since the application is also in the development stage, wide range of settings like zooming the camera are not available in this application. Yet it is possible to zoom in and zoom out the picture already taken or after taking it. Users only have to use the colored forefinger and thumb to make the gesture of zooming in and out as they do in the touchscreen. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta &

Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

GRAPH 9. Take a picture gesture (Framing gesture). (Adapted from Sharma et al. 2013.)

6.1.5 Clock

It is not necessary to buy watches anymore to see the time. Users do not have to take their phone out from the pocket either. Using clock application of sixth sense device, in order to check the time, all that the users need to do is show their wrist in front of the camera and just draw a circle on it. This will display the clock in the hand of a user. To exit the application, the user can slide his fingertip from left to right. Graph 10 shows how easily the clock can be projected on the wrist of a user. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

GRAPH 10. Sixth Sense Clock. (Adapted from Arora 2012.)

6.1.6 Check mail

This application helps a user to check his mail. All that a user needs to do to open this application is to draw '@' in the air. The device will understand the gesture and opens the application. The mails can be synchronized with the device in a way that a user can view the old mails even in the offline mode. This application uses internet to search the new mail the user received and to send the new mail. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

6.2 Uses

Sixthsense is a technology that can be used to carry the real world objects in to digital world with a minimum effort and a higher accuracy. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar

2010Kohil 2013; Sharma et al. 2013.) Everyone will have the capability and right to develop the applications and use them as per their wish. Sixthsense can be used as phone, as a camera, as a projector or even as a computer. Among the variety of uses the key use of this device is as fifth sense and in industries.

6.2.1 Fifth Sense

Simple modification in this device can help disabled people to use this device as their fifth sense. For example just adding the speaker can help people who cannot speak as they can use a gesture to explain their opinions or instruction which the computing device will understand and will transfer the information in the form of sound waves. And the other people can hear that information through speakers. Tt will not be necessary for everyone to learn sign language to understand them. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

6.2.2 Use in industries

There are different industries like metal, chemical or plastic. Works in those industries are sensitive and difficult as everyone might not know how to handle the different machines or objects. This device can be used to provide information about those objects. The device also provides easy control over the machineries in different industries. (Mistry 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; McManus 2009; Venukumar 2010Kohil 2013; Sharma et al. 2013.)

7   THE DEVELOPMENT STAGE

Creating the concept is one thing and developing it or making it real is another. In 2011, Seema Dahlya mentioned in The Viewspaper that the advent of the SixthSense will undoubtedly lead to a technology addiction, and it will be easier for users to be technologically awake all the time and to connect to the world via this newest invention. (The Views Paper 2011.) It has been more than 2 years what Dahlya mentioned and more than 4 years since the concept was developed. Still there is no exact device available in the market. In order to find out how this concept is developing the research was done on the device's developmental stage and was seen, the progress was going on.

7.1   Technologies based on sixth sense

As the development of the technology has reached its peak stage the question that appears is what to develop next or what to do next. In such context, the concept of implementing sixth sense in the technological devices became the answer of all the questions. The concept has been taken into consideration by different companies. And now, there are different products that can be seen in market place which are related to the sixth sense. Several technological companies have already started to implement the sixth sense in their devices or products.

Whirlpool has launched its washing machine model AWOE 8758 which uses the sixth sense technology to monitor and to control the washing cycle. This helps to obtain the perfect result in the most efficient way. The inbuilt sensor of the device adjusts water, temperature and time levels to save energy and natural resources. Today, there are many washing machines found of this type. These devices really

help to preserve the environment and implements green technology. (Whirlpool 2014.)

There are different distractions in the environment. These distractions limit the ability of people to use all of their senses to find out the things happening around them. While driving, there might be other vehicles in the blind spot or stopped in the area that is difficult or impossible to see, or is about to enter the same intersections same as us. For this, there is General Motors V2V (vehicle-to-vehicle) communication system which communicates with other similar devices and warns the driver about the possible danger. (RITA 2014.)

7.2 Progress of sixthsense device

After Mistry revealed the concept of SixthSense device in TED (Technology, Entertainment, Design) talks in 2009, it took time for everyone to view if the concept in real is possible or not. Everyone was waiting for the open source promised by Mistry. Finally in year 2011, he made beta version, WUW_v0.1, of device code available for everyone in Google Code with the title sixthsense and project name WUW. This work created hope in people and proved that the concept is possible and it works. The code is written in C# with OpenCV (for .NET) and it is tested of Windows. (Mistry 2009; McManus 2009; Mistry 2012.)

Since 2012 there has not been any update in WUW project in Google Code. Neither Mistry nor his project members has updated it. Other users also have not uploaded the new modified version of the code. Looking through the comments posted on different pages of the site, it seems like everyone is busy developing the beta version of WUW in their home and school project only. Yet in GitHub, the work to port the code in JAVA is on progress. The members have mentioned that they are working on an Android port. There is no change in the codes of the C# since a year but the work in JAVA has been updated 8 month ago i.e. during July 2013. And PointR, SizeR, REctangleR, Category, NBestList, NBestResult and Ge-

ometricRecognizer have already been successfully ported. (Google Code 2012, GitHub 2013.)

Even though there are many users being associated with the project and following the work, only four of the members seem to be working actively on this. But looking at the activity log or the trend of users being associated with the project, there is a hope that someday somebody will bring a change. It can also be predicted that the users are working on the codes behind the scenes. It is just the matter of time to find the good solution and post it on the site. (GitHub 2013.)

Even though the new development of the project WUW is not clearly visible at the moment outside the Media lab or in any news or articles, and one that is visible is slow, the development of the sixth sense technology on progress implemented by different companies in their own way. There are different products like Google Goggles and Eye Tap which are based on the concept of sixth sense. Apart from the developmental process, devices like Kinect, The Magic Cube and The Leap have generated more hope. They have shown that the day when people can view the device with the components as mentioned by Mistry or in the modified way with full functionalities is not far. The one which is going to be included in this thesis is The Leap as it has appeared as the device which can interact with the computing device. It has also given more options as before it was only possible to interact with four fingers but now users can use all ten fingers. (Google 2013; Mann 2013; LeapMotion 2013; Kinect 2012; Cellulon 2012.)

8   ADVANTAGES AND CHALLENGES

After Mistry presented his concept about the device, in TED talks in 2009, in the short period of time the concept gained many awards. And the reason behind it is the variety of advantages that it consists. Creating or developing a concept and fulfilling it are two different things. Different challenges and limitations cause many concepts to be stopped or to progress slowly before reaching the final point. However observing at the limitations if the suitable enhancement is done, then the result is will be the good one. (McManus 2009.)

8.1   Advantages

As the device is small in size it is portable. (Sharma et al. 2013; Gupta & Mohammad 2011) It supports multi-touch and multi-user interactions. (Kohil 2013.) It connects a digital world and physical world as user do not have to take their device out from their pocket and press words to search the information. The task can be performed through a user's movements and gestures. (Mistry 2009; McManus 2009; Arora 2012; Bhartia et al. 2012; Gupta & Mohammad 2011; Kohil 2013; Sharma et al. 2013; Venukumar 2010.)This in an extent also saves user's time, the time taken by user take the device out and compute the search query. Data can be accessed directly from the machine in real time wherever users are and the ideas can be mapped anywhere users want. (Mistry 2009; Kohil 2013..) It can have different applications for different developers depending on how user imagines and wants. The project is an open source which enables individuals to develop their own application depending on their needs and imagination. (Mistry 2009; Kohil 2013.) It can perform task of different devices by itself so it saves the money that users use to buy the devices like camera, phone, laptop or watch. (Kohil 2013.)Even after all these the cost of this setup is not expensive so it helps to make the quality of living better. (Bhartia et al. 2012.)

8.2 Challenges and limitations

Finding the good vision based algorithm has been always the main challenging part. There are many challenges associated with the accuracy and usefulness of gesture recognition software. There are limitations on the equipment used and image noise for image-based gesture recognition. Images or video may not be under consistent lighting, or in the same location. Items in the background or distinct features of the users may make recognition more difficult. The variety of implementations for image-based gesture recognition may also cause issue for viability of the technology to general usage. For example, an algorithm calibrated for one camera may not work for a different camera. The amount of background noise also causes tracking and recognition difficulties, especially when occlusions (partial and full) occur. Furthermore, the distance from the camera, and the camera's resolution and quality also cause variations in recognition accuracy. (Sousaet al. 2013.)

8.3 Enhancements

In past, there used to be the gloves for the recognition of hand gesture. They have been replaced by the use of color markers in this device. Searching the alternative for the color markers would be another asset of this device. Kinect and The Leap have shown that it is possible. Enhancing the device to be practiced in various fields like gaming, education systems, entertainment fields will generate wide range of costumer. Extra speaker can be added or mobile computing device with inbuilt speaker can be used to prepare this device. This allows developers to develop and application that can translate the gesture into sound. Device with the gesture to sound converter application helps the people with disabilities to communicate with others and to be stronger. Integrating camera and projector in the mobile computing device would be the perfect idea. As the devices like The Leap,

Kinect have inbuilt sensors to recognize the gesture, replacing camera with one of these devices would be nice idea to solve the limitation of camera algorithm. (Patch 2003; Celluon 2012; LeapMotion 2013.)

The suggestion for the enhancement of the device would be first to finish porting the code in JAVA and to adjust it for Android also. Eventually, phones with projector can be used with little modifications like adding The Leap just below the camera section and adding the mirror just below the projector. After the modification, shaping the device as wearable is not a problem. This modification provides multiple options to the users. They can use the phone by touching in the front screen or just turn the device to back and use it by gestures and images. By adding speech integrated circuit, the device can be built useful for the users with disabilities. The devices like Samsung i7410 for the Android version, LG EXPO (GW820) for the Windows version or components like monolith for iPhone version codes are benefit for the enhancements. (Samsung 2009; LG 2009.) The prototype of this proposal is shown in Graph 11.
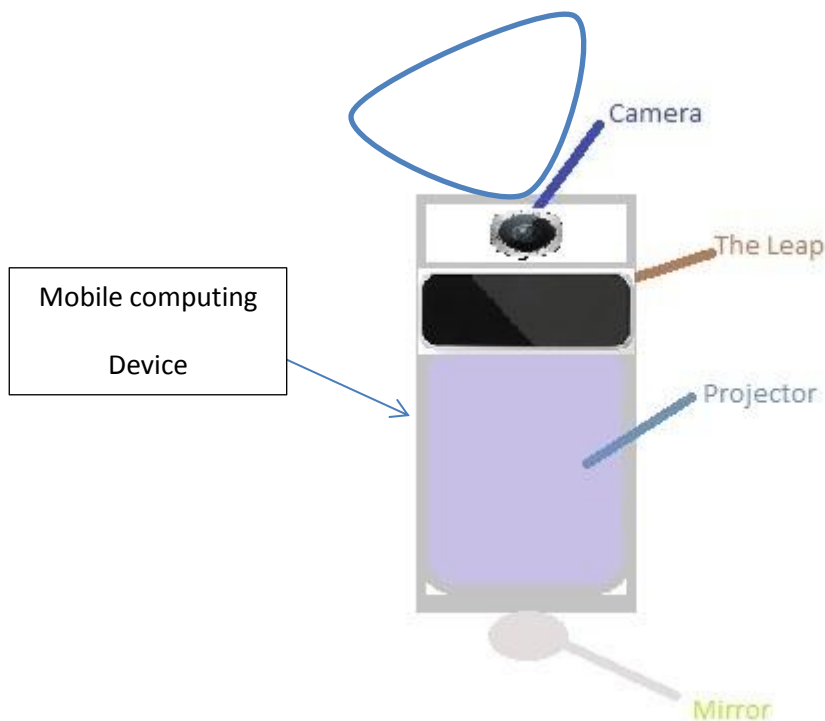
GRAPH 11. Suggested Enhancement.

In the given concept, the mobile computing device has inbuilt microphone and speakers. Also the device has port to insert microphone and speakers if the user wants the external devices. All the other components of the device are similar except the added component, The Leap. The Leap is a device that tracks movement of both hands and all 10 fingers through the open space between a user and users computing device. It operates using LED lights and camera sensors. The software detects user's hands and fingers and translates the data into information for the device (LeapMotion 2013.)

9 CONCLUSION

Sixth sense is the science of tomorrow with the aim of connecting the digital world with the physical world seamlessly, eliminating hardware devices. Even though the sixth sense devices are in development stage and have not been used in widely, it is predictable that this technology will revolutionize the way people interact with the digital world. Sixthsense has potential to become the extreme transparent user interface for accessing information about everything around it. And as different devices have already started to come out with the implementation of this concept, it can be predicted that in near future everyone will have this device in the way they are having cellphones now. Diminishing the mouse and keyboard from everywhere is a challenge. Regardless of that challenge it will for-sure reduce the number of users who uses devices like keyboard and mouse.

There is no doubt that the future of Sixth Sense technology will continue. Once this device is developed, there is no need of printing all the details of components available in the supermarket. Because this device can scan the object and show all the information, details, compositions, and even the costumers' review. All the details can be stored in the cloud and this device can retrieve that information just like the QR code and project it in the real environment in real time. Finding the suitable algorithm for the feasible working of the device, implementing the security system for the personal informations, are however, the biggest general problems of this concept. If the challenges and limitations are overcome with the enhancements of the device, no doubt the device will be a benefit to everyone in the entire world.

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