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WEARABLE COMPUTERS: STATE OF THE ART AND FUTURE CHALLENGES



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In 2007, the advent of iPhone redefined the smart phone; in 2009, the entire market of smart phone systems was shuffled by the Android; in 2015, the number of the mobile phone users worldwide has jumped to 1.91 billion. The mobile Internet and intelligent terminals are now sweeping around the world, standing at the center of everyone's life, profoundly changing everyone's ways of communicating, shopping, studying, traveling and so on.

As a result, the market of smart phone, tablet and PC has gradually moved into a saturation period and there are many conjectures about when, what, and how the next round of commercial reform is. With the trend of the time, the wearable computers embedded into the world, with its perfect features, combining the mobile Internet, smart homes, humans, the Internet of Things and so on, have become the most ideal internet smart devices of connecting every aspect and with the most potential market.

2014 is said to be the year of the wearable computers by the people inside or outside the industry. This year, with the massive influx of talents and capital, the field of wearable computers has experienced a new round of improvement and change; boom of hardware and frequent mergers and investments showed up frequently. The giants of IT industry, like Google, Microsoft, Apple, Samsung and so on, entered the furious competition from hardware to the ecosystem platform, which indicates a new technology wave.

This thesis gives a brief introduction of the definition and development history of the wearable devices, introduces the categories and functions of different kind of wearable devices in detail, indicates how the wearable computers change our life, points out the develop opportunities in different application areas, and analyzes the challenges the field is now facing.

KEYWORDS:

Wearable computers, smart glasses, smart watch, smart bracelet

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LIST OF ABBREVIATIONS

PC	Personal Computer
OLED	Organic Light Emitting Diode
GPS	Global Position System
VR	Virtual Reality
MIT	Massachusetts Institute of Technology
VC	Venture Capital
AR	Augmented Reality
OHMD	Optical Head-Mounted Display
GB	Gigabyte
UI	User Interface
LED	Light Emitting Diode
NFC	Near Field Communication

1 INTRODUCTION

The famous media theorist Marshall McLuhan said that “media is the extensions of man” (McLuhan 1964). The capacity of human body is limited, but the media can extend its possibility. Every kind of media is a kind of way to extend the capacity of human body: the broadcast extends the hearing capacity, newspaper and magazines extend the vision, and the television extends the capacity of hearing and seeing at the same time. It is not difficult for us, who have already entered the Internet era, to understand the view of McLuhan – the World Wide Web extends our bodies, senses and even spirits. Through the Internet, we are able to connect with anybody around the world at anytime and anywhere, easily hear and read the news from the other side of the world, follow the rich text, photograph, audio and visual materials to visit the world...

Reviewing the history of the media, it is slightly far-fetched to call the devices like television, computer and so on “the extensions of man”, because most of them have the fixed structures and cold design styles, and do not associate with the human directly. Things changed when the iPhone came onto the scene in 2007. As a technical company producing media tool, Apple began to focus on the humanistic design and the direct and natural feeling of the users interacting with the information. With the popularity of the smart phone and tablet, as our intermediary originally, the media is becoming our virtual feeling substitution, we can have the audio and visual experiences with the world through the Internet, and now the media becomes the real “extensions of man”.

With the unceasing progress of science and technology, when people are no strangers to the concepts of wearable and human-interactive, the market demand of smart and mobile devices has been promoted to an extreme. In this kind of background, the wearable computers began to move from concepts to the commercial stage.

In April 2012, with the release of the Google Glass, the wearable computers have become the focus of the market. Some people believe that the wearable

computers will replace the mobile devices like smart phones and tablets in the future, making the work and live experiences much easier and more intelligent. In no time, many technology companies have started to enter the market of the wearable computers, providing a variety of new products.

What are the mainstream products in the market now? What functions do they have? Is the prospect cheerful or not? What problems are there? How to solve them? These questions will be answered or discussed in this thesis. The thesis is structured as follows:

- Chapter 1: introduction of this thesis
- Chapter 2: introduction and development history of the wearable computers
- Chapter 3: descriptions of the mainstream products in the market
- Chapter 4: discussion of how the wearable computers change our life
- Chapter 5: analysis of the opportunities and challenges that the industry of wearable computers are now facing
- Chapter 6: conclusion

2 WEARABLE COMPUTERS

2.1 What is the wearable computer?

Imagine that one day everything that we are wearing on or in our body is having many more capabilities than it used to have. For instance, a pair of shoes, which are just used to keep us warm, can now measure the steps, heart rate, calorie reduction and so on. It may make people surprised, but the history and the developing trends of times tell us that this is not accidental but inevitable. After more than half a century of gestation, the wearable computers are no longer science fiction, but entering a rapid development period and becoming the new wave of the mobile Internet. They are now substituting or assisting the smart phone, tablet, PC and so on, with their unique advantages.

So, what is the wearable computer?

To say it informally, the wearable computers are the smart devices, which can be put on or in the human body. Those smart devices are able to integrate the most cutting-edge technologies like multimedia, wireless communication, micro sensors, flexible OLED, GPS, VR, biometric system and so on. Moreover, those smart devices are able to collect, process, share and feedback every information of the people at anytime and anywhere, through a combination of big data platforms, cloud computing, mobile Internet and so on.

They could be any item which is closely related with our life, like glasses, bracelet, watches, clothes, shoes, socks and so on. Unlike the mobile devices such as smart phones and tablets, which are just adjuncts of our life, the wearable computers tend to be developed as a part of human's life or even body.

Now the most commercially available wearable computers are smart glasses represented by Google Glass, smart watches represented by Apple Watch, SUNSANG and Pebble, smart bracelets represented by Fitbit, Jawbone and Nike. Beside those, there are Virtual Reality (VR) headsets represented by

Oculus Rift, which can provide the users with more real feelings of stepping into the games.

Every part of human's body can be the potential development field of wearable computers. Besides the apparent parts like head, wrist and foot (Picture 1), there are many implanted wireless micro sensors as a new breakthrough, which are bringing changes to the whole health care domain.



Picture 1. Wearable Computers

2.2 Development history

The wearable computer is the newest in technology that comes from science fictions into real life. The secret agent 007, James Bond, could be called as the founder of the wearable computers. In the movie Moonraker in 1979, the watches that worn on the tough guy are able to be used for communicating and turning to bomb, which can be called as the prototypes of the wearable computers.

According to the research of the wearable computers' history, the wearable computers originate from the casinos. In the 1960s, the gamblers in the America casinos put tiny cameras and interphones in their pocket to gain the information from their partners to win the game.

- 1950s and 1960s

Edward O. Throp, the professor of mathematics in MIT, mentioned in his book *Beat the Dealer: A Winning Strategy for the Game of Twenty-One* (Vintage, 1966) that he first came up with the idea of the wearable computers to improve the odds of winning the game in 1955, and developed the devices with another developer during 1960 to 1961. In June 1961, the development was completed, the devices successfully increased 44% the odds of winning the game. (Throp 1966; Melanson 2013)

- 1970s and 1980s

In the end of 1975, Pulsar released the first calculator watch in the world and set a new trend.

In 1981, Steve Mann, "The father of the wearable computers", designed the first backpack-mounted computer to control photographic equipment when he was in high school. After that, Steve Mann achieved many successes in the field of wearable computers.

- 1980s and 1990s

During 1980s and 1990s, there are pretty good explorations and developments in the wearable computers field. Steve Mann, the first cyborg in the world, had started to use wearable computers to help with improving his eyesight since the 1970s. Now he put a display beyond his right eye and connected it to the computer and Internet through that device, which was much earlier than the Google Glass and could be called as the first smart glasses. (Picture 2)



Picture 2. Evolution of Steve Mann's Wearable Computers

- Late 20th century – now

After entering the 21st century, the wearable computer is running into a period of rapid development. In 2006, Apple and Nike jointly launched the Nike+ iPod, a device suite that allowed the users to synchronize their exercise records to the iPod. Later on, Nike launched kind of clothes with a pocket for iPod.

In 2007, James Park and Eric Friedman jointly established the Fitbit. Later in 2009, Fitbit launched its first product – Fitbit Tracker. Within 3 years, this thumb-long device rapidly made the wave of exercise in America, becoming the new favorite of the Venture Capital (VC).

In April 2014, Google launched a smart glass named Google Glass, which has functions of taking pictures using voice action, video chat, orientation, surfing the Internet and sending email and this made the popularity of wearable computers again on the worldwide scale.

In September 2014, Apple announced a smart watch named Apple Watch.

3 PRODUCTS AND EVALUATIONS

In the market of the wearable computers, new ideas and originalities are emerging in an endless stream. There are always surprising new products on the crowd-founding platforms, but most of them can last for only a very short time. There are only some but rare products that can be remembered by the public.

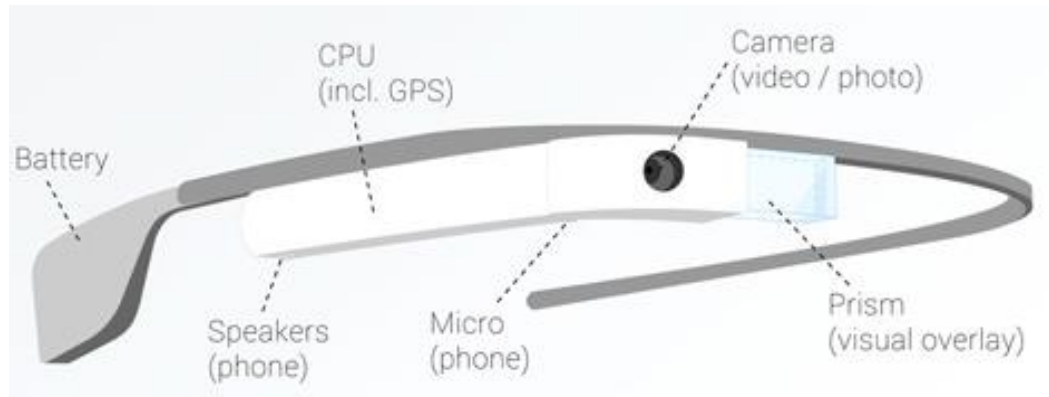
For now in the market of wearable computers, the mainstream products are smart glasses, smart watches and smart bracelets. The following sections introduce the functions and features of some mainstream products in different fields of the wearable computer.

3.1 Smart glasses

3.1.1 Google Glass (AR)

Google Glass is a kind of smart glasses of augmented reality (AR), which was released by Google in April 2012. It is just like wearing a smart phone on the head, and has almost the same functions as the smart phone. (Albanesius 2012) The only difference is that the user can use it to take pictures, video chat, identify directions, and deal with their messages and email just through the voice, which free the users' hands and brings a lot of convenience.

The main structures of the Google Glass are a 5-megapixel camera suspended in front of it and a wide strip of computer processor drives at the right side of the glass (Picture 3). The Google Glass is equipped with an optical head-mounted display (OHMD) in front of it, which can project the data on the screen in front of the users' right eye. The display effect is just like a 25-inch high-resolution screen in 2.4 meters away. There are two adjustable nose pads, which can fit different faces. The sensor that embedded in the nose pads can identify whether the Google Glass is worn. The battery can support one day of typical use. Google Glass weights only 43 g, with 12 GB of usable memory and 16 GB Flash memory total. (Google Glass Help, 2015)



Picture 3. Google Glass

For now the characteristic functions of Google Glass include: analyzing emotions through the facial expressions, live telecasting of the NBA show, assisting education, medical research and so on.

On April 10th, 2014, Google, which is based in San Francisco, announced that the Google Glass would be released on the Internet on April 15th, 2014, at a price of 1500 dollars.

On May 25th, 2014, Google opened the market of Google Glass to everyone who is over 18 years old in USA. The customers just need to login into the Google official website to buy the Google Glass.

On June 23th, 2014, Google launched the Google glass into UK, the first oversea market, at a price of 1000 pounds.

On January 19th, 2015, Google stopped selling the Google Glass to individual customers through its Explorer program. (Luckerson 2015) After that, Google transferred this project to Tony Fadell, the CEO of Nest. (Patel 2015)

3.1.2 Oculus Rift (VR)

On August 1st, 2012, a virtual reality (VR) head-mounted display called Oculus Rift (Picture 4), which seemed like science fiction but is actually scientific, was put on the crowd-founding platform – Kickstarter, waiting for the funds from the investors, with the manifesto of “changing the way people experience video

games forever”. (Kickstarter 2012) Now from the view of its preferences in the video game field, Oculus Rift has not been disappointing yet.



Picture 4. Oculus Rift

Virtual Reality (VR) technology is one of the frontier technologies in the world today. Since the 21st century, there has been some similar devices in the military field, but all facing the problems of high price, massive size, heavy weight and so on. However, the Oculus project can bring the immersing experiences of wide angle and low latency to the public at an acceptable and reasonable price.

Oculus Rift is a kind of virtual reality head-mounted display that is specially designed for the video games. It captured the public’s hearts with its special functions, getting the support from more than 9000 customers in only one month, harvested 2.43 million dollars’ crowd funding, raised 16 million dollars in a Series A funding, which accumulate their first capital for the further development and production. (Oculus VR, 2013)

There are two eyepieces in the Oculus Rift, with the resolution of 6400×800 per eyepiece and 1280×800 for both. The most special feature of this device is providing the perspectives that are controlled by the gyroscope, which significantly increases the immersion in the video games. Oculus Rift can be connected to the computers or consoles with DVI/HDMI and USB. (Oculus VR, 2013)

Considering the reasons of why Oculus Rift is so popular, besides the extraordinary gaming experiences it brings to the users, the other important reason is its acceptable and reasonable price. Before the appearance of Oculus Rift, this kind of peripherals was very expensive, often costing more than ten thousand dollars. However it only takes 350 dollars to buy an Oculus Rift (Development Kit 2), which gives more people the opportunity to have the immersion experience of video games.

On March 26th, 2014, Facebook announced that it would buy the Oculus VR for 20 billion dollars in total and took this opportunity to step into the field of wearable computers.

3.2 Smart watch

3.2.1 Pebble Time

Similarly to Oculus Rift, Pebble is also one of the star projects on the crowd-founding platform Kickstarter, received more than 10 million dollars financing at first, and absorbed 15 million dollars funding from the VC later. In 2012, when the first generation of Pebble raising money from the crowd-founding platform, it not only raised the record of crowd fund, but also made Kickstarter gain fame. (Vancouver Sun 2012)

On February 24th, 2015, Pebble announced their third generation smart watch -- Pebble Time (Picture 5) on KickStarter. (KickStarter 2015) Pebble Time is a smart watch that is compatible with iPhone and Android smart phone, which is designed by a start-up company named Pebble Technology. Users can use the Pebble Time to check many kinds of messages from the smart phone, for instance, it can show the incoming display, immediately remind the users of text message, email, and information from social software.



Picture 5. Pebble Time

Pebble Time only weights 42.5g, and the completely sealed exterior structure makes it water resistant to 50 meters. (Pebble 2015) There are three buttons on the right side of the dial: up, select and down, a back button and a magnetically charge connection on the left. The R&D team declared that once Pebble is fully charged, it could have 7 days of battery life. (Pebble Support 2015) Pebble Time has a color e-paper display with LED backlight, which significantly reduces the electrical consumption and increases the battery life, which brings one of the most competitive advantages for Pebble Time. There are Bluetooth 4.0 radio module, 3D accelerometer, Compass, Ambient light sensor and Microphone in the watch, which creates some interesting functions, for instance, the user can light the screen by shaking the watch. (Pebble 2015) Pebble Time has a very simple and intuitive user interface (UI), users can use the up and down buttons to switch options in the menu, use the select button to choose the option, and the back button to go back to upper menu.

The main reasons of why Pebble is so popular is that it is simple and specific without tedious functions, keeping its own characteristics without blindly imitating. For instance, the e-paper display cannot provide a very good visual experience, but it can save much energy. As one of the most successful projects on KickStarter, Business Insider, one of the most famous technology media in the United States, evaluates Pebble to be one of “The 10 Most Innovative Gadgets

Of 2013". (Kovach 2013) From the view of the market performance since its birth, Pebble deserves this high estimation.

3.2.2 Apple Watch

On September 9th, 2014, the Apple September Event 2014 was held at Cupertino, California, where the headquarters of Apple is located. Tim Cook, the CEO of Apple, announced the release of the Apple Watch (Picture 6) in the event. (Cook 2014)

On March 10th, 2015, the Apple March Event 2015 was held at Moscone Center of San Francisco. During the event, the Apple Watch was officially released with three versions: Apple Watch Sport, Apple Watch, and Apple Watch Edition, and would be available for pre-order on April 10th 2015, and begin shipping on April 24th. (Cook 2015)



Picture 6. Apple Watch

There are two buttons on the right side of the Apple Watch: the Digital Crown and the Power button. Users can use the digital crown to zoom the pictures and scroll the list by pinching it, return to the home screen by pressing it. Apple Watch has two kinds of materials of screen: ion-X glass screen for Apple Watch Sport and sapphire crystal screen for Apple Watch and Apple Watch Edition, which can resist scratching and make Apple Watch more durable. Users can use

Apple Watch to pick up phone, send and receive text messages, play music, check the weather and flight information, surf the Internet and so on. Apple Watch also supports car connection, map navigation, digital touch, heartbeat measurement, step counting, and dozens of functions, which makes it a comprehensive health and exercise tracking wearable device. (Apple 2015)

There are three versions of Apple Watch: Apple Watch Sport, Apple Watch, and Apple Watch Edition. These three versions of Apple Watch have different kinds of screens and cases. (Table 1)

Table 1. Apple Watch

	Apple Watch Sport		Apple Watch		Apple Watch Edition	
Height	38.6mm	42.0mm	38.6mm	42.0mm	38.6mm	42.0mm
Width	33.3mm	35.9mm	33.3mm	35.9mm	33.3mm	35.9mm
Depth	10.5mm					
Weight of Case	25g	30g	40g	50g	54g	67g
Weight of Band	47g	51g	47g	51g	48g	53g
Case	7000 Series Silver Aluminum		316L Stainless Steel		18-Karat Rose Gold	
Screen	Ion-X Glass			Sapphire Crystal		
Back	Composite			Ceramic		
Display	Retina Display					

Apple Watch Sport has lighter weight by using 7000 Series Silver Aluminum for case and Ion-X Glass for screen, which ease the burden for the users while they are exercising. On the other hand, Apple Watch and Apple Watch Edition are

more tasteful with 316L Stainless Steel / 18-Karat Rose Gold case and Sapphire Crystal screen. All of these three versions of Apple Watch can match with different bands.

On the 2014 September Event, Tim Cook said “What we DIDN'T do is shrink down the iPhone interface and put it on your wrist.” which means that Apple Watch has several special functions. (Cook 2014)

- Users can start using it just by raising their wrists.
- There are various personalized dials on Apple Watch, users can change them as they like, for instance, changing the background pictures of the dial, adding information about weather, activities and so on. It can also show the information of the users' heartbeat.
- When receiving notifications, the Tapic Engine will remind the user immediately by a gentle tap.
- Users can send Sketch, Tap and their own heartbeats to the other users through the Digital Touch.
- According to the exercise data of last week, Apple Watch will advice the users with a new exercise target in every Monday.
- Users can use the Apple Watch to turn on and off of their lights of their home, unlock the door and use the Passbook as the boarding pass.
- Apple Pay is also available with the Apple Watch.

(Apple 2015)

3.3 Smart bracelet

3.3.1 Jawbone

Jawbone is known for its three iconic products: Bluetooth earpieces, loudspeaker, and the smart bracelet UP.

In November 2011, Jawbone released their first smart bracelet product – UP. However, because of the battery problem, Jawbone had suffered from a great deal of criticism. After one month of releasing, Jawbone removed the UP and refunded the users for “no questions asked”, users even did not need to return the problematic UP bands. (Smith 2011)

In 2012, after a year’s development and improvement, Jawbone released the UP with the version 2G, at the price of 129.99 dollars. The new generation of UP band has four main functions: activity tracking, sleep tracking, smart coach, and food logging.

In November 2013, Jawbone released the UP24 Band (Picture 7) with the 3.0 software update. The highlight of this new product is the ability to sync wirelessly via Bluetooth to the companion application in the smart phone, tablet, or PC. (Kumparak 2013) Even with the wireless function, the UP24 Band still has the same 7-day battery life as the previous generation.



Picture 7. Jawbone Up 24

According to the gender, age, height, weight and the other information that the users have entered, the companion application can show more accurately the steps, distance, speed, and calorie consumption while the users are exercising. Besides, the Jawbone UP24 Band is also resistant to water and dust.

The Food Logging function really features the Jawbone Band. Users can log their meal and track calories with the UP Band barcode scanner, restaurant menu search and food database that referred by the UP Band users. When the other smart bracelets are still remaining in the cut and dried functions of step counting, calorie tracking, sleep tracking and so on, and the whole field of smart bracelets is becoming assimilated, the Food Logging of Jawbone UP24 can be really meaningful. In a sense, Jawbone UP24 broke the tepid development state of the smart bracelet, first stepped into the real phrase of big data application and platform building.

3.3.2 Fitbit

Fitbit is one of the first companies of researching and developing the smart bracelet. Fitbit Flex (Picture 8 right) is the first product that Fitbit has released. Similar to the Jawbone UP, it is also a smart bracelet designed for exercise. The LED light on the Fitbit Flex can show the progress of the users' exercise, and sync wirelessly via Bluetooth to the companion application in the smart phone, tablet, or PC. Therefore, users can be informed about the data and information of their body and exercise, for instance, step counting, journey recording, calorie consumption counting, active time, sleep time and quality. Fitbit Flex is waterproof and has 5 to 7 days battery life.

In 2013, Fitbit released the new generation of the smart bracelet – Fitbit Force (Picture 8 left), with 130 dollars' price. Fitbit Force has the similar basic design with the Fitbit Flex, but was added a small OLED screen, so that users can check their exercise data more intuitively. It is worth mentioning that Fitbit Band is compatible with both iOS and Android smart phones.



Picture 8. Fitbit Force/ Flex

Fitbit Force is also evaluated to be one of “The 10 Most Innovative Gadgets Of 2013” by the Business Insider. (Kovach 2013)

4 HOW WEARABLE COMPUTERS CHANGE OUR LIFE

4.1 Changes in our life

As early as a dozen years ago, we saw some technology giants exploring in the wearable computer field, including some prototypes. However, because of the high technological level and development costs or lack of attention from the public, the wearable computers used to be far from our life. Nevertheless, with the release of the Google Glass, the wearable computers began to enter the public's awareness. Besides Google, some other technology giants like Apple, Amazon, Facebook, Microsoft and Samsung also began to enter this field and develop their own wearable computers.

When the wearable computers begin to enter everyone's life, it is inevitable that changes will come to our life. With Google Glass for example, this section shows how the wearable computers change our life.

4.1.1 Creating a more convenient life

In terms of hardware, Google Glass is essentially a combination of a mini projector, a camera, a sensor, capable of storage, transmission, and manipulation. It is a smart glass with almost the same functions with a smart phone, operationally controlled through biometric technology. Besides, it is a fully functional life assistant, providing users functions of GPS, receiving and replying text message, taking photos, surfing the Internet and so on.

The working principles of Google Glass are not very complicated, mainly consisting of projection and reflection principles. First the light is projected onto the reflecting screen through the mini projector in the Google Glass, then the light is reflected into the user's eye through a convex lens, so that there will be a screen large enough before the user's eye, showing the relevant information.

When wearing the Google Glass, we are not only able to taking pictures at anytime and anywhere, but obtain the information we want by saying "OK,

glass”, via voice-recognition technology. For example, when the user receive a message and want to reply it, he or she just need to say “Ok glass, reply...” This kind of hand-free functions really make our life much more convenient. (Google 2013)

When using the wearable computers becomes our habit, our life is subtly influenced, shifting towards the continued convergence of wearable computers and human beings. Beyond that, people will keep pursuing a more convenient life, and the wearable computers will be continually improved during this process. Both the wearable computers and our life will be better and better.

4.1.2 Increasing efficiency in working and studying

Besides the convenience that the wearable computers bring to us, there is also a huge market for them in the business environment. They can help people increase their efficiency in working and studying, help the enterprises lower the cost of service. For instance, the engineers engaged in the after-sales service do not need to show up every time to solve the sudden problems of the devices, but using the wearable camera, Google Glass for example, they can remotely mentoring and solve the problems. This not only can lower the cost of travel between the office and the workplace, but also more to the point, increase efficiency.

For example, Sullivan Solar Power, a solar installer company in California, USA, developed an application in the Google Glass to show the technicians the technical information and provide searching and guiding functions. (Clancy 2014) Therefore, the applications of the wearable computers in the enterprises are very likely becoming the potential market that for the practitioners and investors of the wearable computers.

Moreover, Google Glass is also becoming more and more popular in the medical field. Pierre Theodore, a lung surgeon in California USA, used Google Glass during a surgery that needed the surgeon use the instrument according to the image information. By using the Google Glass, Theodore could see the X-rays

and real-time images at the same time during the surgery. Theodore said “To be able to have those X-rays directly in your field of vision without having to leave the operating room or to log on to another system elsewhere, or to turn yourself away from the patient in order to divert your attention, is very helpful in terms of maintaining your attention where it should be, which is on the patient 100 percent of the time.” Now, many surgeons in USA and France are beginning to use the Google Glass into the operating room.

4.2 Changes in the industry

4.2.1 Health care

When the functions of the wearable computers cover our social life, entertainment, fitness, navigation and other aspects, health management could be the most revolutionary function with the most certain demands among them. It helps people to change from passive disease treatment to the initiative health management, saving on medical fees at the same time.

Nowadays, almost everyone is under threats of various diseases. With the further deterioration of the living environment and pressure from increasing competition, most people are in a state of sub-health. People start to be concerned about their health condition more and more frequently, and want to know and control their health condition. This provides the basis of demands for the development of wearable medical devices. The wearable medical devices are soon accepted by people and become their necessities of life.

Wearable computers and big data management platforms of the hospitals are used to diagnose the state of illnesses early. This trend is set to continue as the demand is growing. However, the doctors or the big data platform of the hospital only can diagnose the state of illnesses based on the various measured data of the human's body, and this is just the strength of the wearable computers.

With the combination of the wearable computers and big data platforms, it will be much easier and more effective to use the information and medical resources. For instance, users can use the wearable computers to send the various data, like blood and heart rate that are measured by the wearable computers, to the big data platform of the hospital, then the backend data evaluation system of the hospital will give the feedback to the user rapidly after analyzing the various data, and give them health advice according to the result. This progress can save time, money and space for both the users and doctors, help the users to prevent diseases and develop health life habits at the same time.

4.2.2 Online finance

In 2007, the first iPhone revolutionized the consumers' behavior. Nowadays, on the street or in the subway, there are many people around using the smart phone to receive and send messages, read e-books, watch videos and consume. Apple made the mobile phone be a smart hardware connected with the system platform. Through the development of software applications, the iPhone was made be a fully functional device, with a great dependence on a lot of people. The reason for the popularity of the iPhone is its excellent design and humanized functions that bring unprecedented experiences to the users. The wearable computers have the similar fascination, and are better than the smart phone in some aspects, for instance, the convenience of recognition only based on the human's body.

In the field of online finance, many enterprises are trying to do something in the field of mobile payment. As regards its development trend, compared with the wearable computers, the existing payment methods, like PayPal and mobile wallets, are just phased transition products. Now the payment methods based on mobile phones or cards are either lack of convenience or security. But in the future, the online financing mobile payments based on the wearable computers will fulfill both of these two elements, becoming the most ideal payment method.

The wearable computers based on the biometrics technology are very personal and unique. Nowadays, the biometrics technology is widely applied to various

devices. For instance, the Touch ID of iPhone and iPad is the fingerprint identification technology, which is one of the biometrics technologies. However, in the field of mobile payments, the first element that users are concerned about is the security then is the convenience. The wearable computers have both of those two features. In the future, with the continual development of the recognition technology, any features of the human's body could be the recognition feature to pay, for example, the fingerprint and face.

Besides, with the continually development and maturity of the near field communication (NFC) technology, it also can be one of the ideal payment methods. With the NFC technology, the wearable computers will have not only the payment function, but with an integrated approach to bus card, work card, garage key, home key, VIP card and so on. In the future, with the wearable computer, users can do several activities things in a more convenient way.

4.2.3 Smart home

On January 14th, 2014, Google purchased the smart home company Nest for 3.2 billion dollars. (Olson 2014) Nest announced a product named Nest Learning Thermostat, a smart thermostat that can control the heating, ventilation and air conditioner automatically, making the indoor temperature keep at the temperature value that the users are used to.

In the beginning of June 2014, Apple unveiled its smart home program on the WWDC 2014, announced the HomeKit development platform. (Gibbs 2014)

Both the smart home and wearable computers are the products of the intelligence era. When the smart home becomes perfect enough and the wearable computers are fully developed, the integration of these two products is an inevitable trend. As a portal of the Internet, the wearable computers are not only able to connect the human to the hardware, but also a key carrier to make the smart home more effective. With the wearable computers in the smart home, the interaction between the users and the products will be greatly reduced; the

users will have the real convenient experience. The smart home products based on the smart phone or tablet will be completely subverted.

Now the smart home is still in the development stage, as it still needs to be given the commands by the simple operations of the users. So it is significant and meaningful to simplify the carry and operate method of the control site. Most of the control site of the smart home is the control interface based on a smart phone or tablet. If the control site can be changed to the wearable computer, the smart watch for example, will significantly improve the user experience.

4.2.4 Big data

The core position of the wearable computers is the collecting, digging, computing, feedback, using of the data, so that it can influence and change the lives and behavior of people.

In the future, the big data is more and more coming into various fields, the commercial value it creates is limitless. One of the greatest values of the wearable computers is becoming the new portal of the Internet. There are personalized data based on everyone created every time. The platform of big data and cloud computing will directly influence the user by analyzing, digging the data and giving feedback in time. The wearable computer is a data source and an ideal terminal of receiving data analysis and feedback.

The rise of wearable computers and the coming of the big data era are built upon each other. The wearable computer is the portal of the data, and the deep analysis of the big data can make the user reconsider and even further change the uses' life.

4.2.5 Social security

When the wearable computers are coalesced with the unique recognition of people, it will be very accurate on the aspect of personal identification. Especially at the security checkpoints, it will save plenty of time and manpower.

With the development and popularization of the wearable computers and the improvement of the backend system, the wearable computers will be used in various aspects of social life, bringing great changes in how people travel and manage public domains.

4.2.6 Advertisements

The development of advertisements formats is always changing with the development of the information medium. Developing from the words on the newspaper to the voice of the broadcast, and then with the popularization of the television, video advertisements began to be one of the most dominant advertisements formats. But by the end of 20th century, the Internet included all the advantages of the other media, and derived some unprecedented advantages. So the advertisements enterprises began to turn the focus on the Internet with great hope and explore the possibilities of the Internet.

When the Internet began to step into the era of mobile Internet, the advertisements enterprises saw new hope again. On the mobile devices, the advertisements are just text messages at first. Then with the popularization of the smart phone, the advertisers began to choose the mobile application as the new advertising channel.

The greatest difference between the early advertisements and the advertisements based on the wearable computers is that the wearable computers will be much faster and more precise. With the big data, the advertisers can analyze the data from the wearable computer users according to the strong backend data system, and then present the advertisements to the target users.

5 OPPORTUNITIES AND CHALLENGES

5.1 Opportunity

The early wearable computers mainly needed to be wire-connected to the computers, so that they were not very easy to use by the public. In 1981, Polar announced the first wearable heart monitor, making people aware of the developing form of the wearable computers – wireless.

The wearable computers were primarily used to measure the heart rates of the athletes at first. Then with the development of the smart phones, varieties of smart bracelets with built-in software applications have been announced in succession. An increasing number of people who love sports began to use the wearable heart rates measuring devices.

It is obvious that wearable computers have many functions, such as computing, and connecting to the terminal devices. Now the wearable computers are becoming the new Internet portals, making the connection between people and Internet closer, and will replace many functions of the smart phones to a large extent. Several years ago, the wearable computers were more like invented for professionals. However, since 2013, the wearable computers are transforming into mass products. This change and tendency are subtle but also make people see more opportunities.

First of all, the wearable computers make it much easier and safer for people to purchase something. The wearable computers have the function that can recognize features of the human body rapidly, so that users do not need to remember those complicated passwords or make the validation or bind layer upon layer.

Secondly, people do not need to make an appointment in advance to see the doctor. Through the wearable computers, they can communicate with the doctor at anytime and anywhere. The doctors can obtain the health data and feedback

information of the patients via the wearable computers, so that they can make the diagnostic analysis of the patients and give them advise.

The wearable computers will serve as personal assistants, doctors, fitness instructors and so on. In the future, it may be possible to read the users' subconscious; building a living environment they want before they reacting.

5.2 Challenges

Currently, most of the products of wearable computers released by the major enterprises have not generated huge sales. It is not hard to see that the whole industry of wearable computers is still at a growing stage. Simple observation makes clear the shortcomings of the products. The challenges that the industry is facing are becoming greater with the overall progress.

5.2.1 Lack of Independency

Most of the products of wearable computer in the market now still exist as the garnitures of the smart phones. It is hard for the industry of wearable computers to seize the market of the other smart devices, especially the smart phone. Most of the products do not have a native Internet connectivity; they have to be connected to the other devices with more memory, storage and processing power via Bluetooth or some other way. The user cannot use them independently; they are just the extensions of the smart phones.

For instance, the functions that are supported by the smart bracelets like activity tracking, calorie counting and smart alarm, which are mentioned in the third chapter, can be implemented completely only based on the smart phone.

How to disaffiliate the wearable computers from the smart phones and make them record, analyze and feedback information independently is a question that the enterprises in this industry need to think about.

5.2.2 Poor user experiences

User experience is one of the greatest challenges that the industry of wearable computers is facing. Many users gave up the products after using them for some time.

Low battery life, lack of killer applications and unifying platforms are all problems decrease the user viscosity. For instance, the widely anticipated Apple Watch only has an 18-hour battery life, which means that the users have to charge it everyday.

5.2.3 Little esthetic appeal

For now, though, most of the wearable computers in the market are lacking good design taste. For most users, the products are just “wearable” than “making me want to wear it”. Manufacturers are competing to achieve more and more functions, but overlooking the fashion and design of the products.

However, users will not reduce the demands of the product appearance because of its smartness. On the contrary, they have even higher demands of the appearance of the wearable computers than the other smart devices. The wearable computes are just like accessories that only can win the consumer hearts with good design taste.

Early in 2014, in cooperation with the fashion giant Luxottica, the world’s largest manufacturer of glasses, Google launched the Google Glass. For the geeks, Google Glass may indeed be a fine high-tech product with technological aesthetics. However, for normal electronic consumers, Google Glass looks too geeky, not fashionable enough to wear. By appealing to the wider consumers, Google has to admit that their product is not fashionable enough, and do something to improve this problem.

Sonny Vu, the founder and CEO of Misfit Wearables, said that the wearable computers needed to be either “gorgeous or invisible”. (Farr 2013) Only adding

more fashion popular elements into the wearable computer can make it mass-market product.

5.2.4 Low social recognition

Before the official release, Google Glass had already been much criticized. In March 2013, a café in Seattle USA, named The 5 Point, posted a poster with “Google Glasses Banned”. (Picture 9) “The 5 Point is a No Google Glass zone. Respect our customers privacy as we’d expect them to respect yours.” (The 5 Point Café 2013)

MAR 11, 2013



GOOGLE GLASSES BANNED

by the5pointcafe • [Blog](#) • Tags: [5 Point](#), [geeks](#), [google](#), [google glass](#), [public embarrassment](#)

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If you're one of the few who are planning on going out and spending your savings on Google Glasses – what will for sure be a new fad for the fanny-pack wearing never removing your bluetooth headset wearing crowd – plan on removing them before you enter The 5 Point. The 5 Point is a No Google Glass zone. Respect our customers privacy as we'd expect them to respect yours.

Picture 9. Google Glass Banned

Obviously, the privacy issue is the main reason of why many people do not accept some wearable computers like Google Glass. This is a great issue that cannot be ignored in this more and more open Internet era.

On the other hand, sin against propriety is also an aspect of wearing the wearable computers. For instance, try to imagine, if someone wears a smart glasses, recording the things happening in the meeting or party, is there any propriety?

5.2.5 Homogeneity in products

Although there are varieties of wearable computer products launched by various manufacturers, wearable computers are basically still in the homogeneous competitive stage, lacking unique creativity. There are improvements of battery life, display and appeal in smart watches like Pebble, but they are still kind of smart phone companions.

With smart bracelets, for example, the functions of both Jawbone and Fitbit are sleeping tracking, exercise tracking, step counting and so on. After comparing and analyzing, it is not hard to find that most smart watches or bracelets are still as the extended accessories of smart phones, with singular functions, lack of enough and killer application.

In the situation of highly homogeneous competition of hardware and lack of creation of software application, wearable computers only are changed in appearance; they are not really attractive and creative products. Compared with the almost fully developed smart phones, the wearable computers obviously do not have the subversive capability.

5.2.6 Affordability

Now most consumers are taking a wait-and-see attitude for the wearable computers just because of their high price.

Since 2014, many wearable computers including smart watches, smart bracelets, smart glasses, have been vying for our attention. Concerning the

prices, there are smart bracelet for tens of dollars, and smart watches for more than ten thousand dollars. Despite the wide range of products and prices, consumers are not buying them.

The 1500-dollar high price of Google Glass prevents it from being a mass product. The most expensive version of Apple Watch is worth 17,000 dollars, which is defined as a luxury electronic product.

Although there are smart bracelets only costing tens of dollars, the consumers still will not buy them. They think it is not worthy to spend tens of dollars to buy a smart bracelet that only have some more functions than a band. Furthermore, the functions of the smart bracelets seem not to be that useful. After all, most consumers are normal people purchasing goods according to the performance-to-price ratio rather than technology enthusiasts.

6 CONCLUSION

This thesis work is a fundamental review of the state of the art in wearable computers and their future challenges. By studying the development history of wearable computers from 1960 to 2014, it can be seen that the design of wearable computers is driven forward closely by the practical use cases in the ordinary life of human beings. In these use cases, even though their appearance and features vary, wearable computers can be generalized as any smart devices that can be put on or in the human's body. The term "smart" requires the ability of integrating technologies like multimedia, wireless communication, micro sensors etc. and capability of collecting, processing, share and feed-backing every information of the people at anytime and anywhere. Based on this concept, three categories of commercial wearable computers were introduced. The presented commercial products give a clear snapshot of the cutting edge technologies in wearable computers. For instance, the Oculus Rift is using the virtual reality technology to provide the users with spectacular experiences of video games.

In addition, as studied in the thesis, wearable computers already impact and will continue to impact on our lives in terms of both personal living and industry. They offer unprecedented convenience and improvement of efficiency and even affect the way of thinking. From the industry point of view, they bring several opportunities to the enterprises in various fields. The analysis of their influence shows important motivation for the future development of wearable computers.

The positive influence of wearable computers demonstrates that they offer huge opportunities, for example in the industry of health care, online finance, smart home and advertisement. However, challenges also exist and have to be tackled. In the thesis, six key challenges were identified:

1. Lack of Independency
2. Poor user experiences
3. Little esthetic appeal
4. Low social recognition

5. Homogeneity in products
6. Affordability

In summary, the review and analysis of wearable computers provide a practical understanding of their concept, development and usability. The presented opportunities and challenges are of reference value in the future designed of wearable computers. Nevertheless, there are still more topics that need to be considered.

It is imaginable, with the advance of technology, wearable computers will be fully developed and popularized, bringing a lot of convenience to our life.

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