The New Disruptive Phase of Mobile Technology

The Case of Wearables

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Abstract

Digital and communication technology is entering a new phase of its development. Tiny mobile gadgets that can be carried or stored in our bags or pockets are destined to be replaced by tiny mobile gadgets that can be worn. Wearing digital gadgets or computers as items of clothing, eye glasses or watches is likely to reduce their propensity to get lost or stolen; but their conspicuous nature could present some consumers with problems as will be demonstrated in this article. However, the great benefit of such devices is their ability to overcome our limitations as human beings. We only have two hands to do most of what we need to do. Wearable technology overcomes this limitation by making use of some of our other senses and attributes such as eyes, skin and voice. Such qualities make wearable computers useful for many tasks and in many situations. This article explores the current and possible uses of wearable technology for healthcare, education, knowledge management and public safety. Moreover, it attempts to provide some insights into the prospects of this technology from the theoretical perspective of the theory of disruptive innovations as proposed by Clayton Christensen and his colleagues from Harvard Business School.

Keywords: Disruptive Innovations; Education; e-Health; Healthcare; Knowledge Management; Public Safety; Police; Firefighting; Ambulance.

Introduction and methodology

Wearable technology is not a new phenomenon. There were many attempts during the last decades to design and develop a series of wearable devices that served many purposes. Most of the wearable technology devices that were developed during the 2010s focused on fitness. However, interest in wearable technology surged during the last few years. The new devices that emerged were more sophisticated than the previous ones with the potential to be used to perform a variety of tasks and enhance the operations of some professions. In this article, four of those professions are highlighted, notably healthcare, education, knowledge management and public safety. To explore this phenomenon, wearable technology is examined within the framework of the theory of disruptive innovations. This approach is helpful as it will shed some light on the process, implications and future direction of this technology. The theory, developed by Clayton Christensen and his Harvard Business School colleagues, is the product of many years of research into the failures and successes of many innovations and organizations and its insightful

and convincing interpretations of historical events are widely acknowledged by many executives and directors throughout the world (McGregor, 2007).

Wearable Technology: Definition

The word "wearable" is often used with other words such as technology (wearable technology), devices (wearable devices) and sometimes the word "wearables", in plural terms, is used (colloquially) instead. However, they all refer to electronic technologies or computers that are incorporated into items of clothing and accessories which can be worn comfortably on the body (Tehrani & Michael, 2014). However, unlike traditional wearable products the new wearable devices (thanks to advancements in technology) are more sophisticated and can perform a variety of functions. Interestingly, the new wearable devices are not being developed by manufacturers of traditional wearable products but, mainly, by computer and software companies.

Disrupting What We Wear

Some past innovations have had a great impact on our lives. They have changed (among other things) how we communicate as individuals and businesses, indulge in leisure, and produce printed material. It is probably safe to claim that the Web is one of the recent innovations to have (and to continue to have) a great impact on our lives by changing some aspects of the way we do business, interact with people, learn and leisure. Such innovations, according to Christensen and colleagues, have disruptive powers (see Christensen, 1997; Christensen & Raynor, 2003; Christensen, Anthony, & Roth, 2004).

The concept of disruptive innovations was first proposed by Christensen and his colleagues and was developed into a theory known as the "theory of disruptive innovations". According to this theory, there are two types of innovations: sustaining innovations and disruptive innovations. Sustaining innovations, according to these authors, are often innovations that occur frequently and are implemented by established, large incumbent companies in order to improve the performance of some of their existing products or services that have strong market shares. Disruptive innovations, on the other hand, occur less frequently and tend initially to have performance problems. Furthermore, there are two main disruptive innovations: new market and low-end disruptions. Disruptive innovations that create new markets, according to this theory, can occur when characteristics of existing products and services limit the number of potential consumers (defined in the theory as "nonconsumers") or force consumption to take place in inconvenient or centralized settings. Moreover, such innovations tend to be of lower quality than the well-established ones and often take a long time before they overcome such limitations. Think of personal computers (PCs) as one example. Prior to using PCs, access to software and hardware for business and personal tasks could only be provided by gaining access to a minicomputer or a terminal connected to a mainframe computer. Minicomputers and mainframe computers were very expensive to buy and rent, and using their services often required a great deal of effort and expertise (e.g., requiring authorization, travel to gain access to a building that houses the terminal, technical skills). Moreover, when the PCs emerged they had many limitations (e.g., limited memory, storage and processing power, and limited screen resolution) but were able eventually to overcome those limitations and disrupt the mainframe computers and minicomputers to create a new PC market.

Low-end disruptions affect the low-end of the original business or mainstream value network by attracting customers (who are often over served) at this level of the business. One example of this type of disruption was the Korean automakers' entry into the US market. The Korean automakers did not create a new market; they simply attracted the "least attractive" customers (those who cannot afford the big cars) of the targeted businesses. A hybrid of the two types (new market and low-end) of disruption can also be found. The American low cost Southwest Airlines is one example of a hybrid disruption. It initially targeted people who were not flying (those who used cars or buses) but later pulled customers out of the low-end of the major airlines' value network as well.

The authors of the "original" theory of disruptive innovations argued that new market disruptive innovations often disrupted well-established products produced by well-established incumbent companies and that the new innovations were often not as good as the well-established ones. However, in a recent Web article, Michael Raynor (one of the colleagues of Clayton Christensen) argues that the disruption theory, like any good theory, has remained a work in progress and that it has matured into a core set of concepts without slipping into an ossified orthodoxy. As such, disruptive innovations need not start with cheap and poor quality products which less resourceful (and unattractive) customers can afford. Rather, disruptive innovations can also get their start in entirely new markets, quite independent of the characteristics of the customers or markets in question. All that is required, according to Raynor, is that the disruptor's foothold market be relatively unattractive to incumbents either because they are more uncertain or simply smaller in absolute terms (Raynor, 2014).

Interestingly, wearable technology has been around for many years but has been expensive and cumbersome and was mostly used by people engaged in research and development projects (Skiba, 2014). Products such as Private Eye (a head-mounted display), Pathfinder (a wearable computer that features a radiation detection system and GPS (global positioning system), Forget-Me-Not (a wearable computer), and Trekker (a rugged wearable computer) are examples.

Some of the aforementioned devices were used to perform certain jobs; others were used for experimental and research purposes. In some situations (as is the case with the Trekker device) they were expensive. Most importantly, for wearable purposes, many of these devices were bulky and lacked an aesthetic sense. If the electronic wearable devices of the 2010s are to establish a new and indeed a mass market for themselves then they need to overcome some of the limitations of the old devices (e.g., expense, complexity, inconvenience and "looks") that afflicted the old wearable electronic devices. Most importantly again, for the new devices to succeed, according to the theory of disruptive innovation, their developers need to target the nonconsumers, those who were unable to use those devices for the reasons highlighted above. The authors of the "original" theory of disruptive innovations argued that new market disruptive innovations often disrupted well-established products produced by well-established incumbent companies and that the new innovations were often not as good as the well-established ones.

In the case of wearable technologies this factor might not be applicable. That is to say there are not many incumbent companies to be disrupted and any new wearable electronic devices will need to be better than the old ones due to the advanced technologies that exists today and also due to the conspicuous nature of wearable devices. Indeed, as mentioned above, Michael Raynor (one of the authors of the disruptive innovation theory) made it clear – in an interesting revision of the theory – that disruptive innovations need not start by being cheap and of poor quality (compared with the well-established ones) but they can also get their start in

entirely new markets, quite independent of the characteristics of the customers or markets in question.

Raynor (2014) provides mobile telephony as an example. When mobile phones were first introduced, according to him, they were much more expensive than landline phones, but they provided the ability to make calls in circumstances that landline phones were unavailable. Moreover, mobile phones were not of poor quality when they first emerged; they were just very different. The mobile phone business was not less profitable, but it was much smaller than the landline business. The companies that were able to most fully realize the disruptive potential of mobile telephony separated the mobile division from the landline division, rode the declining cost curve and, by improving the technology, created profitable, growing businesses, while at the same time absorbing the smaller and less successful companies that had remained focused on relatively high-end niches (ibid.).

It has to be noted here that some wearable fitness devices, particularly during the mid 2010s, did also emerge and are now being used by many sports and fitness enthusiasts. These devices were mainly developed by companies with interest in the sports industry. Devices such as Fitbit (from Fitbit), UP (from Jawbone) and FuelBand (from Nike) are examples. Examining this industry, however, is beyond the scope of this article.

The Potential of Wearable Technology

Wearable and state-of-the-art technology no longer belongs to science fiction. The evolution of digital and mobile technology has transformed many aspects of our lives. Connectivity has become easy and increasingly important for many of us and access to data and knowledge has been made affordable, manageable and convenient. Such technological developments are now preparing the ground for the next stage of the digital revolution where we not only use and carry technology but we also wear it. The following examples demonstrate the current and potential uses of wearable technology in the fields of healthcare, education and knowledge management.

Healthcare management

Healthcare and fitness are a major world-wide market. The US alone spends over three trillion dollars on healthcare (Munro, 2014). A large proportion of countries' income also goes towards meeting the costs of education, and companies continue to devote large resources to meet the increasing costs of managing data and knowledge. It is quite possible that developments in state-of-the-art wearable technology devices have been motivated by the huge rewards that can be gained by tapping into such markets. The built-in infrastructure of some of these devices such as the Apple Watch and Google Glass provides an early indication of the potential of such products to cater to the aforementioned markets. For example, Google Glass (which was in prototype when it was released in 2013) is packed with Bluetooth, Wi-Fi, GPS (global positioning system), speakers, a camera, a tiny screen, microphone, touchpad, a gyroscope and a number of sensors for detecting other human functions. Future versions are likely to contain more tiny hardware for more functions. With relation to healthcare, researchers from MIT's Media Lab and Georgia Institute of Technology's School of Interactive Computing developed an application for Google Glass and were able to demonstrate how the device's built-in sensors can be used to calculate heart and respiratory rates (Husain, 2014). Other wearable devices

(developed by other companies) are also being used for heart-related and brain-related tasks such as monitoring the central aortic pressure to aid antihypertensive therapy and the non-invasive recording of the brain's electrical activity (Krivoshei et al., 2013; Balanou, Van Giles, & Vanhala, 2013).

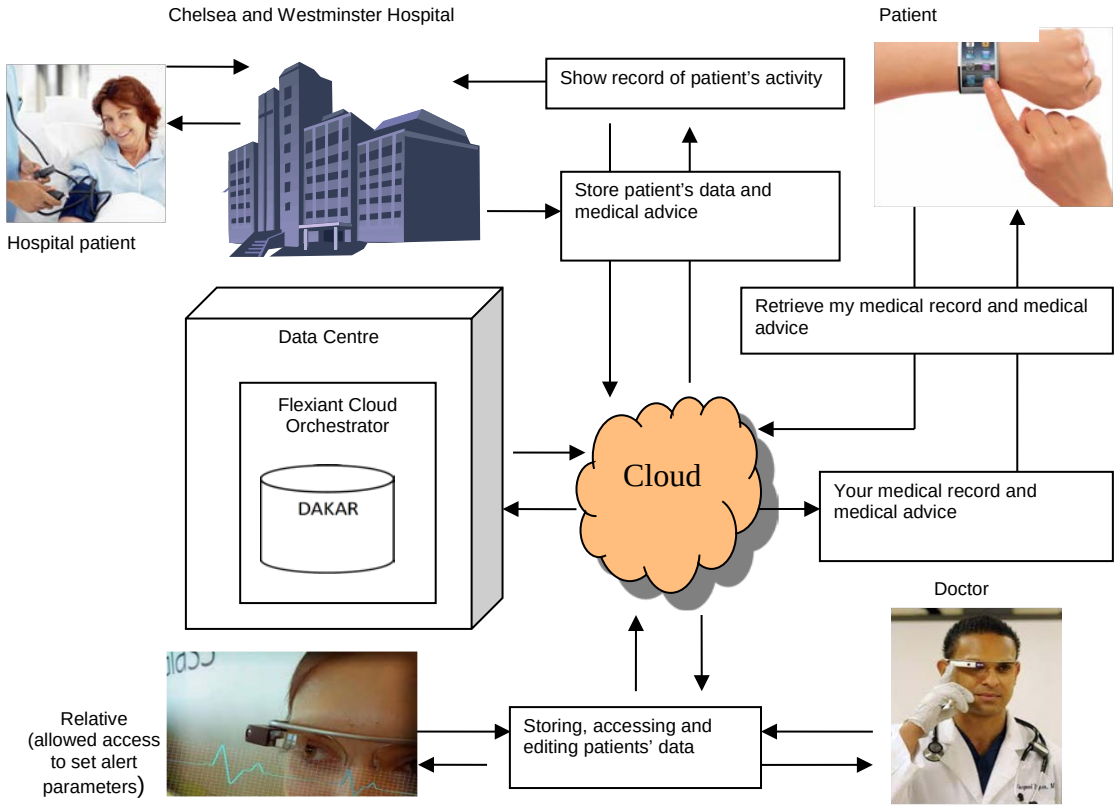
The clinical potential of using devices such as Google Glass to save lives came into focus following a story from a Boston hospital in the USA. In 2013 Beth Israel Deaconess Medical Center in Boston was piloting a Google Glass program with the hope of using it to save lives. The doctors were able to immediately access the records of a man with a severe bleeding in the brain.

Using Google Glass, the physicians at the medical centre were able to discover that the patient had given them an incomplete account of his medical history due to his serious condition. For example, he managed to tell the doctors that he was allergic to some blood pressure drugs - which the doctors needed to slow the bleeding. However, the man did not remember to tell them that he was also taking blood-thinning drugs, which, if applied in combination with the blood pressure drugs, could have been fatal. But, rather than wasting time searching paper records or a computer screen, the doctors relied on Google Glass to access the patient's correct medical information and then provide him with the correct dose of medication which saved his life. Following this event, Beth Israel Deaconess expanded the use of Google Glass to its entire emergency department, making it the first hospital in the US to employ the device for everyday medical care. Emergency doctors at this hospital now begin their shifts by wearing pairs of the high-tech glasses as routinely as they put on their "scrubs" (Borchers, 2014). Many other wearable healthcare-centric electronic devices have been developed for various functions. Electronic fabrics (e-fabrics) are now being developed to help design clothes that can be worn for phototherapy treatments and other diagnostic purposes for the treatment of epilepsy, cardiac, and other illnesses (Os & Cherenack, 2013; Graham, 2014; Berglin, 2013).

In July 2014 Google signed a deal with Novartis (the global European pharmaceutical to develop a smart contact lens with the potential to monitor the wearer's blood sugar levels. Information about blood sugar levels, particularly useful for people with diabetes, could be uploaded to smart phone devices and used by doctors and patients to monitor the data almost in real time, according to a statement from Google issued when the company released its prototype in January of the same year (Scott, 2014). Glucose monitoring is regarded as the "Holy Grail" by some people due to its importance for people with diabetes and for health insurance companies (Olson, 2014).

From 2009 to 2011, London's Chelsea and Westminster Hospital embarked on an e-Health project to pilot the remote delivery, storage and access of patients' electronic records using a Platform as a Service (PaaS) software system known as DAKAR (Data Capture and Auto Identification Reference) underpinned by a Platform as a Service (PaaS) known as Flexiant Cloud Orchestrator developed by Flexiant (an SME British company based in Scotland) (Sultan, 2014). The system allows close and trusted circles of friends or relatives access to patients' data buckets (i.e., physical memory storage locations) where they can set certain thresholds for things such as heart rate or blood pressure. If that data goes beyond a certain threshold the person's family can be alerted and this will allow them to check their physical conditions. With the arrival of wearable technology, such operations (as depicted in Figure 1) can be performed by wrist and/or eye-based devices such as Google Glass or Apple Watch.

Figure 1. The pilot e-Health system at Chelsea and Westminster hospital (London).



Source: Sultan, 2014.

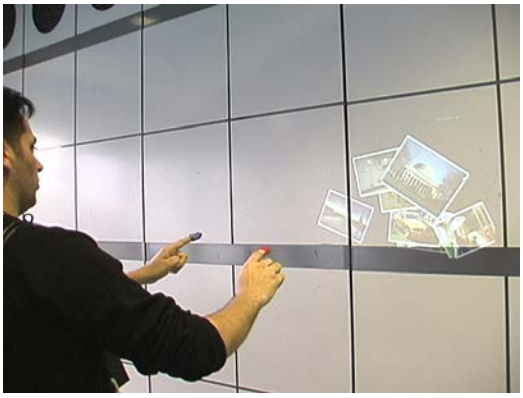
Education

Given the apparent interest in using wearable technology for healthcare management it should not be surprising to see wearable devices used in medical education. Medical schools in some parts of the world have embraced them (Pelletier, 2014). For example, the School of Medicine at the University of California, Irvine, has issued Google Glasses to all of their students to use during anatomy and clinical skill classes while final year students wear them during their hospital rotations (Bartlett-Bragg, 2014). According to Bartlett-Bragg, this is more than another tool to use as performance support, as they have the potential to completely re-design the relationship between work and learning.

An experiment to enhance the medical education of cardiovascular diseases, using Google Glass, was carried out in 2013 by a team of medical instructors at the University of Arkansas for Medical Sciences (Vallurupalli, Paydak, Agarwal, Agarwal, & Assad-Kottner, 2013). In this experiment, different scenarios were used in cardiovascular practice where a mock trainee wearing Google Glass would transmit live video streams from the glass via Wi-Fi or Bluetooth which could be received by a smart phone, tablet or personal computer. According to these authors there are many other uses for this technology, such as seeking help from experts (anywhere in the world) during a complex procedure without breaking sterile precautions.

Early indicators suggest that devices such as Google Glass could transform medical education. However, there are very few examples exploring the use of this technology in the education of other disciplines. This is not surprising given the novelty of sophisticated wearable electronic devices. Nevertheless, there are many views as to how this technology can be harnessed for educational purposes. One particular device (SixthSense) that was developed by Pranav (an MIT graduate and now director of research at Samsung Research America) is quite interesting and could solve many of the problems that are often experienced during classroom sessions. The device (currently in prototype phase) – see Figure 2 – is comprised of a pocket projector, mirror, and camera that can be put around the neck (like a necklace). Both the projector and the camera are connected to a mobile computing device in that can be housed in the user's pocket. The system can project information onto surfaces and physical objects, thus making any surface into a digital screen. SixthSense uses simple computer-vision techniques to process the video-stream data captured by the camera and follows the locations of colored markers on the user's fingertips (which are used for visual tracking). Furthermore, the software interprets the data into gestures to use for interacting with the projected information. The use of such devices in classrooms or lecture theatres that are not fitted with expensive (and often problematic) overhead projectors is obvious. Such devices could be hugely popular in developing countries that lack the necessary resources to equip (and maintain) their classrooms with expensive overhead projectors.

Figure 2. SixthSense.



Source: http://www.pranavmistry.com

Devices such as Google Glass (see Figure 3) can also solve problems in classrooms or lecture theatres (e.g., used for Arts and Humanities and Social Sciences lectures) that are not fitted with computers. Imagine a lecture that requires students to conduct a Web search for some questions that a lecturer might propose after as part of an exercise or seminar. In such situations using Google Glass is much quicker and easier than using a smart phone, a netbook or a laptop. There are many scenarios for the potential use of wearable technology in education (Delgado, 2014; Skiba, 2014).

Figure 3. Google Glass.

Source: www.mashable.com

The following scenarios are selected as simple examples of the potential use of smart wearable devices by students and teachers:

> "Stephen is an extremely busy college student with a full schedule and two part-time jobs. As he's walking around campus, his Galaxy Gear smartwatch receives an alert. Looking down, he sees one of his professors has sent out a class-wide message saying tomorrow's assignment has been postponed until the following week. Moments later, Stephen receives another alert, this one a voice recording sent from another professor's smartwatch telling him Thursday's class is canceled.
>
> Alice sits in a big lecture hall for her biology class. She enjoys the material, but she finds it difficult to take good notes. This time, she pulls out Google Glass and hits the record button. The wearable tech is able to record the professor's lecture. She can then play the recording back at a later date so she can review the material directly from the professor's mouth.
>
> Professor Davis teaches an introductory physics class in college. This class is filled with hundreds of students. Using a pair of smart glasses with facial recognition technology, Professor Davis is able to answer questions from students by calling on them by name. At the same time, he is able to use similar technology to instantly take attendance for the entire class" (Delgado, 2014).

Bartlett-Bragg (2014) contends that we are at an exciting stage in the development of new devices. This situation, according to her, will drive us to re-think our relationship with content-based teaching to a more situation-oriented capability that will enable us to engage and interact with others and their environment. The way we use those devices, she argues, will be up to our creative learning design.

Knowledge Management

Making the most of their knowledge has always been organizations' Holy Grails. Some of these organizations design their methods to achieve this objective and others resort to experts who possess the tools (often technological) in order to take advantage of developments in digital

technology. The latter option often commands a great deal of commitment and tends to be employed by large organizations that have the economic means to cope with the resource implications of adopting advanced technologies. Hence, many of the current enterprise Knowledge Management Systems (KMS) were developed for large organizations that can afford to buy them and cope with their maintenance and operations. The amount of effort required for performing activities core to KMS, such as designing taxonomies, classifying information, and monitoring functionality, according to Nunes, Annansingh, Eaglestone and Wakefield (2006) is often disproportionate to the resource capacity of most Small to Medium Enterprises (SMEs). Moreover, typical KMS places emphasis on predetermined workflows and rigid "information-push" approaches (Malhotra, 2005) that reflect the philosophy behind working practices in large enterprises. In contrast, SMEs rely mostly on informal person-to-person communications and people-centric operations for KM (Desouza & Awazu, 2006) that often take place in largely ad-hoc and non-standardized ways (Nunes, Annansingh, Eaglestone, & Wakefield, 2006).

This view is further echoed by Reichental (2011) who also adds a behavioural dimension to the challenges of enterprise KMS. He argues that it is remarkably difficult to organize information in the right manner, make it searchable, and then present it so that the most relevant responses are placed at the top of the search results (as is the case with public search engines). Internal systems, according to this author, have no such equivalent and organizational information is hardly the example of pristine structure. While unstructured content is the king of the public Web, it is often the bane of the enterprise. Such systems can also be inflexible in meeting the fluctuating needs of corporate end users and executives (Kaplan, 2010).

The situation is also compounded when employees are disillusioned by the effectiveness and effort required to use KMS and may resort to old habits such as asking colleagues or improvising in the absence of guidance (thus repeating mistakes or missing best practices). In such situations, the system often fails to be adopted — or at best is used by a small proportion of the organization — and no amount of resuscitation will be enough to bring it back to life (Reichental, 2011). This view is further shared by Kaplan (2010) who also adds that many organizations were realizing that their employees were either not prepared to share information in order to protect their jobs or too busy to funnel information into such systems.

However, wearable technology is likely to overcome many of the drawbacks of current KMS. Speaking to a computer to store and retrieve information is much easier than using a keyboard to do such chores. Moreover, sharing written, audio and video data in real-time is likely to be convenient for many professions such as healthcare (as demonstrated above), maintenance, production, and emergency response (Pasher, Levin-Sagi, Dvir, & Goldberg, 2006). Most importantly, the mobility, or to be precise, the wearability, of electronic devices and computers bring an interesting dimension to the field of KM.

Public Safety

Wearable technology is likely to make an impact in professions where both hands and mobility are needed to carry out most roles (Luchetti, 2015). Apart from healthcare and manufacturing professions, industries such law and order, firefighting, emergency services, and those where personal safety is of paramount importance, are likely to benefit from wearable technology. Motorola Solutions is already developing wearable devices for police forces that will increase the safety of their officers and improve their efficiency. One such device is the HC1 Headset Computer (released in 2012). HC1 (see Figure 4) is a helmet with a clear screen that covers the face, a camera attachment and an arm on the side. It is controlled via head movements

and voice activation and allows officers to be in constant communication with their superiors while receiving real time data that will aid their work, such as information on potential suspects and the surrounding area.

Figure 4. Motorola's Headset Computer

Source: http://www.motorolasolutions.com

Dr Andrew Cook, Senior Vice President of Operational Excellence and Innovation at AREVA (the nuclear and renewable energy French multinational) was complimentary of this innovation from a safety perspective. He commented:

> In the highly demanding and regulated nuclear energy industry, innovation is essential in meeting ever-increasing standards for safety and operational performance for our utility customers. With the Entervise Remote Expert application running on Motorola's HC1 headset computer, we can perform independent quality oversight at nuclear power plants without requiring a second person to enter restricted areas (Smolaks, 2012).

In Britain, Samsung Electronics has partnered with West Yorkshire Police to help the force lead the way in one of the biggest technological advancements in modern policing (Samsung, 2014). This project is expected to maximise the capability and effectiveness of policing at the front-line and has the potential to lead to 7,000 front line officers and staff using the wearable devices. Police officers will be able to enter electronic witness statements and complete missing person forms without having to put pen to paper back at base. Moreover, the devices will allow them to view and update incidents whilst on the beat, thus increasing their visibility, responsiveness and presence on the streets and saving the police force some money. West Yorkshire Police and Crime Commissioner, Mark Burns-Williamson, commented: "Providing the best possible service to our communities through modern mobile technology and innovation is at the heart of my Police and Crime Plan." (ibid.).

The life-saving potential of wearable technology for paramedics in emergency services is huge. MedEx, a Chicagoland provider of ambulance and telemedicine services, is behind the first line of ambulances in the U.S to use Google Glass to visually connect paramedics in the field (see Figure 5). In early 2015, the company rolled out ten ambulances with Google Glass devices with software that enables paramedics to transmit live audio and video to hospitals. Prior to this development, paramedics would have to communicate with doctors via a two-way radio or a cell

phone. With the wearable device, the paramedics can now send real-time footage of the patient directly to a hospital tablet or desktop while the ambulance is on-route, thus providing doctors with critical visual information even before the patient arrives (Flanagan, 2015).

Figure 5. MedEx using Google Glass for Paramedics

Source: Flanagan, 2015.

Wearable technology could prove to be a welcome innovation for firefighting services. In 2012, the U.S. Fire Administration reported that nearly 50 percent of U.S. firefighter deaths were caused by heart attacks. Wearable health-monitoring devices could help prevent some of these attacks (Chong, 2014). There are plans to use wearable products for firefighting. Globe Manufacturing's Wearable Advanced Sensor Platform or WASP is one. WASP is a flame-resistant T-shirt with an embedded adjustable strap that has a removable physiological sensor. Secured to a waist belt is a device (made by TRX Systems) that uses accelerometers, a compass, and other sensors to locate firefighters relative to a fixed point, even inside buildings.

Motorola is also active in this field through developing a high-tech firefighter suit (see Figure 6), which is part of a prototype concept called Next Generation Fireground Communications which incorporates a host of wearable technologies, including a helmet-mounted camera, a head-up display on the breathing mask, an environmental sensor, a strap that monitors vital signs, indoor location tracking, and a rugged radio.

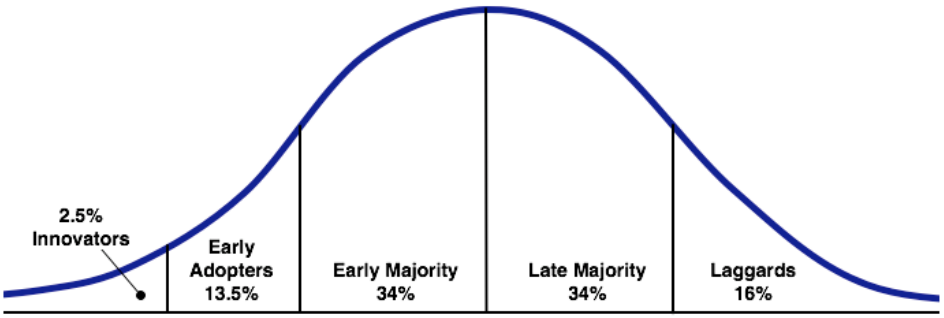
Figure 6. Motorola's Firefighting Suit

Source: Chong, 2014

Reflective Thoughts

As can be gleaned from the aforementioned introduction and information there is promising potential for the successful use of wearable technology in fields such as healthcare, education, knowledge management and public safety. However, the market for wearable technology is still at the stage of "early adoption" of Everett Rogers's diffusion of innovation trajectory. Rogers defines this diffusion as a process by which an innovation is communicated through certain channels over time among members of a social system (Rogers, 1983). Such channels are often a two-way communication media between individuals based on interpersonal relationships. Figure 7 depicts the stages through which innovations progress. An innovation is first adopted by the people or organizations that developed it. It then goes through a higher cycle of adoption reaching a peak and finally adoption begins to decrease gradually as the innovation becomes standardized and mainstream.

Figure 7. Rogers's Technology Diffusion Trajectory.



Source: Rogers, 1983.

However, there are estimates that predict significant increases in the adoption rate of wearable technology. Analysts at Morgan Stanley believe that despite its infancy the technology will be worth US$ 1.6 trillion in the future and argue that wearable devices will have far-reaching impacts by disrupting or even accelerating change within industries outside of technology (Derrick, 2014). Much of the optimism for the future of wearable technology is based on the belief that wearable devices will become ubiquitous in the future due to enhanced connectivity, improved usability, reduced cost, increased reliability and long battery life. Indeed, some analysts even suggest that the wearable revolution could take shape much faster than the mobile revolution that preceded it thanks, interestingly, to the smart mobile wars which rendered such hardware components as sensors and chip sets cheaper than ever before, thus making it possible for small companies to incorporate those components into wearable devices and compete with big companies (Wasik, 2013).

Regardless of such optimism, there are many challenges facing wearable technology. Price is one of those. Despite the excitement that greeted some of the newly developed wearable devices, they remain highly priced. The Google Glass prototype for example had a price tag of US$ 1,500. If wearable devices are to become as widely popular as smart phones then they need to be affordable for consumers. More and clever applications will need to be developed for the various purposes that this technology will be used for. Furthermore, given the conspicuous nature of wearable devices, factors such as design, aesthetics and acceptability will become increasingly important. Technology companies that mastered design in the past will now need to

conquer the entirely different realm of fashion, which could require them to unlearn a great deal of what they think they know (Wasik, 2013). Some analysts contend, however, that such looks will not matter for enterprise (i.e., workplace) applications where they believe wearable technology will have its growth in the early stages of its development (Sacco, 2014).

Future wearable devices will be expected to perform many tasks that have implications for our health, education and data. As such, issues of privacy and security (particularly for healthcare purposes) will become increasingly important. Wearing devices such as glasses with embedded cameras could also have cultural and social implications. Public acceptability of this phenomenon will be needed if these wearable devices are to become as widely popular as, for example, smart phones. There is also debate on whether devices such as Google Glass will empower or detach users from reality (Sapargaliyev, 2014). Moreover, convenience and accessibility are also important factors for wearable devices. Battery life will need to be longer than what is currently available. Google Glass currently has a battery life of about eight hours of intermittent use (Gibbs, 2014). We are inclined (according to some psychological research) to give up the use of technology devices if they take more than two seconds to respond to an instruction (often referred to this phenomenon as the "magic two-second rule"). For example, if one cannot reach for a device within two seconds the use of this device goes down exponentially (Wasik, 2013). Furthermore, research suggests that the digital technology is also taking its toll on people. A British study, carried out by psychologists from the University of Surrey, analyzed 65 previous surveys involving 50,000 employees to determine the consequences of having constant access to work. They found that those who 'switched on' long after the office was shut (through devices such mobile phones and laptops) were more likely to have problems with their health and private lives. These devices, according to this study, are increasingly blurring the boundaries between work and home life and causing work-family conflict (Knapton, 2015). If this is what happens to people when they carry the technology the implications for wearing it could be even worse. Technologists will need to give this issue more thought and consideration.

Conclusion

Developments in digital and communication technology are now reaching the realms that border on science fiction. Computing devices are no longer items that we use in our homes and places of work and carry in our bags and pockets. We can now wear them. In this article, old and recent developments in wearable technology have been explored with a focus on their current and potential use in the fields of healthcare, education, knowledge management and public safety. In doing so, an attempt was made to provide some insights into the prospects of this technology from the perspective of the theory of disruptive innovations as proposed by Clayton Christensen and his colleagues from Harvard Business School.

Wearable technology has disruptive characteristics and the potential to create a new market in wearable devices. As is the case with many disruptive innovations, the technology is still in its infancy and there are many challenges before wearable devices become widely popular and affordable. However, early indications suggest that there is great potential for this technology to develop further and create a multibillion dollar industry. Current practical and potential uses of this technology in healthcare, education, knowledge management and public safety indicate, as explained in this article, that a new era of interaction between people and technology is about to begin. However, for this to take place there are a number of technological, personal, social and cultural issues that this technology needs to address.

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The New Disruptive Phase of Mobile Technology

The Case of Wearables

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Abstract

Digital and communication technology is entering a new phase of its development. Tiny mobile gadgets that can be carried or stored in our bags or pockets are destined to be replaced by tiny mobile gadgets that can be worn. Wearing digital gadgets or computers as items of clothing, eye glasses or watches is likely to reduce their propensity to get lost or stolen; but their conspicuous nature could present some consumers with problems as will be demonstrated in this article. However, the great benefit of such devices is their ability to overcome our limitations as human beings. We only have two hands to do most of what we need to do. Wearable technology overcomes this limitation by making use of some of our other senses and attributes such as eyes, skin and voice. Such qualities make wearable computers useful for many tasks and in many situations. This article explores the current and possible uses of wearable technology for healthcare, education, knowledge management and public safety. Moreover, it attempts to provide some insights into the prospects of this technology from the theoretical perspective of the theory of disruptive innovations as proposed by Clayton Christensen and his colleagues from Harvard Business School.

Keywords: Disruptive Innovations; Education; e-Health; Healthcare; Knowledge Management; Public Safety

French abstract*
The New Disruptive Phase of Mobile Technology
The Case of Wearables

La nouvelle phase disruptive de technologie mobile

Le cas de la technologie digitale portée

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Résumé

La technologie de communication digitale entre dans une nouvelle phase de son développement. Des petits gadgets mobiles, qui peuvent être transportés et stockés dans nos sacs ou poches, seront remplacés par de minuscules gadgets mobiles qui peuvent être portés. Le port de gadgets ou d'ordinateurs numériques, sous forme de vêtements, lunettes ou montres, est susceptible de réduire leur propension à se perdre ou faire voler. Mais leur nature ostentatoire pourrait présenter pour des consommateurs des problèmes comme ce sera démontré dans cet article. Cependant, le grand avantage de ces dispositifs est leur capacité à surmonter nos limites humaines. Nous avons seulement deux mains pour faire ce que nous avons à faire. La technologie portée surmonte cette limitation en faisant usage de certains de nos autres sens tels que la peau, les yeux et la voix. Ces qualités font que les ordinateurs portés peuvent être utiles pour de nombreuses tâches et dans de nombreuses situations. Cet article explore les utilisations actuelles et possibles de la technologie portée dans les domaines de la santé, l'éducation, la gestion des connaissances et la sécurité publique. En outre, il tente de fournir quelques perspectives de cette technologie portée dans le cadre théorique des innovations de rupture, proposée par Clayton Christensen et ses collègues de la Harvard Business School.

Mots-clés: Innovations disruptive; Education; e-santé; Soins; Gestion de connaissances; La sécurité publique; Police; Lutte contre l'incendie; Ambulance.

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German abstract*
The New Disruptive Phase of Mobile Technology
The Case of Wearables

Die Neue Disruptive Phase der Mobilen Technologie

Der Fall der "Wearables"

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Zusammenfassung

Digitale und Kommunikationstechnologie beginnen eine neue Phase ihrer Entwicklung. Winzige mobile Geräte die in unseren Taschen getragen und verstaut werden können sind dazu bestimmt, durch winzigen mobilen Geräten die am Körper getragen werden, ersetzt zu werden. Digitale Geräte oder Computer ähnlich wie Kleidungsstücke, Brillen oder Armbanduhren am Körper zu tragen reduziert die Tendenz sie zu verlieren oder die Wahrscheinlichkeit bestohlen zu werden; allerdings könnte ihre Auffälligkeit für einige Kunden zu Problemen führen, wie in diesem Artikel gezeigt wird. Der große Vorteil solcher Geräte ist ihre Fähigkeit uns dabei zu helfen unsere menschlichen Limitationen zu überwinden. Wir haben nur zwei Hände um zu tun was wir tun müssen. Tragbare Technologien überwinden diese Einschränkung durch die Nutzung anderer Sinne und Eigenschaften wie bspw. durch die Einbeziehung unsere Augen, Haut oder Stimme. Auf Grund solcher Merkmale sind tragbare Computer für viele Aufgaben und in vielen Situationen nützlich. Dieser Artikel untersucht die aktuelle und die mögliche Nutzung von tragbarer Technologie für Gesundheitsfürsorge, Bildung, Wissensmanagement und die öffentliche Sicherheit. Zudem sollen Einblicke in die Zukunftsperspektiven dieser Technologie, im Hinblick auf die theoretische Perspektive der Theorie der disruptiven Innovationen wie sie von Clayton Christensen und seinen Kollegen der Harvard Business School vorgeschlagen wurde, vermittelt werden.

Keywords: Disruptive Innovationen; Bildung; e-Health; Gesundheitsfürsorge; Wissensmanagement; Öffentliche Sicherheit

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Spanish abstract*
The New Disruptive Phase of Mobile Technology
The Case of Wearables

La Nueva Fase disruptiva de la tecnología móvil
El caso de las *Wearables*

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Resumen

La tecnología digital y la comunicación están entrando en una nueva fase de su desarrollo. Dispositivos móviles diminutos, que se pueden llevar o almacenar en nuestros bolsos o, incluso, en nuestros bolsillos, están destinados a ser reemplazados por minúsculos aparatos móviles que pueden ser parte de nuestro propio atuendo. El uso de aparatos digitales u ordenadores como prendas de vestir, gafas o relojes es probable que reduzca su propensión a perderse o a ser robados; pero su naturaleza visible podría presentar problemas a algunos consumidores como se mostrará en este artículo. Sin embargo, la gran ventaja de estos dispositivos es su capacidad para superar nuestras limitaciones como seres humanos. Sólo tenemos dos manos para hacer más de lo que tenemos que hacer. Los *wearables* superan esta limitación mediante el uso de algunos de nuestros otros sentidos y atributos tales como los ojos, la piel y la voz. Estas cualidades hacen que los *wearables* sean útiles para muchas tareas y en muchas situaciones. Este artículo explora los usos actuales y posibles de la tecnología portátil para la asistencia sanitaria, la educación, la gestión del conocimiento y la seguridad pública. Por otra parte, se trata de proporcionar algunas ideas sobre las posibilidades de esta tecnología desde una perspectiva teórica basándonos en la teoría de las innovaciones disruptivas de la forma propuesta por Clayton Christensen y sus colegas de la Harvard Business School.

Palabras clave: Innovaciones disruptivas; educación; e-salud; cuidado de la salud; gestión del conocimiento; seguridad pública.

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Arabic abstract*

The New Disruptive Phase of Mobile Technology
The Case of Wearables

المرحلة التعطيلية الجديدة لتكنولوجيا الهاتف النقال

حالة ما يمكن ارتداؤه

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الملخص

ان التكنولوجيا الرقمية والاتصالات تدخل مرحلة جديدة من مراحل تطورها. حيث أنه سيتم استبدال الأدوات الصغيرة المحمولة التي يمكن حملها أو تخزينها في حقائبنا او جيوبنا بأدوات محمولة صغيرة يمكن ارتداؤها. ارتداء الأدوات الرقمية أو أجهزة الكمبيوتر مثل قطعة من الملابس والنظارات والساعات سيقلل من احتمالية ضياعها أو سرقتها. ولكن طبيعتها الواضحة يمكن أن تعرض بعض المستهلكين لمشاكل كما سيتم طرحه في هذه المقالة. ومع ذلك، فإن الفائدة العظيمة لهذه الأجهزة هي قدرتها على التغلب على أوجه القصور لدينا كبشر. يوجد لدينا يدين اثنتين فقط لتفعلا ما نحن بحاجة لفعله. التكنولوجيا القابلة للارتداء تتغلب على هذا النوع من القصور من خلال الاستفادة من بعض حواسنا وسماتنا مثل العيون والجلد والصوت. هذه الصفات تجعل أجهزة الكمبيوتر القابلة للارتداء مفيدة لكثير من المهام، وفي كثير من الحالات. يكشف هذا المقال الاستخدامات الحالية والمحتملة للتكنولوجيا التي يمكن ارتداؤها كجوانب الرعاية الصحية والتعليم وإدارة المعرفة والسلامة العامة. وعلاوة على ذلك، فإنه يحاول تقديم بعض الأفكار في آفاق هذه التقنية من الناحية النظرية لنظرية الابتكارات التوزيعية على النحو الذي اقترحه كلايتون كريستنسن وزملاؤه من كلية الأعمال في جامعة هارفارد.

الكلمات الدالة :الابتكارات التعطيلية. التعليم؛ الصحة الإلكترونية. الرعاية الصحية؛ إدارة المعرفة؛ السلامة العامة؛ الشرطة؛ رجال الاطفاء. الاسعاف.

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Chinese abstract*

The New Disruptive Phase of Mobile Technology
The Case of Wearables

移动技术的新破坏性阶段

可穿戴技术的案例

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摘要

数字和通信技术正进入一个新的发展阶段。微小移动的可以携带或放在我们的包里或口袋里的小工具注定要被可穿戴的微小移动的工具来代替。像衣服，眼镜或手表，可穿戴数码产品或电脑可能会减少丢失或被盗的机率。但他们的显著特性也给一些消费者带来问题。本文彰显了这些问题。然而，这种装置较大的好处就是其克服我们人类的一些限制。我们只有两只手去做大部分需要做的事情。可穿戴技术通过利用我们的其他感官和属性，如眼睛，皮肤和语音，克服了这一限制。这种特性使穿戴式计算机可用于许多情况下的多种任务。本文探讨了可穿戴技术在当前医疗保健，教育，知识管理和公共安全的潜在用途。此外，本文试图将Clayton Christensen和他在哈佛商学院的同事们提出的破坏性创新理论引用到这项可穿戴技术并为其提供一些理论见解。

关键：破坏性创新；教育；电子健康；卫生保健；知识管理；公共安全]

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