Viewpoint

Reflective thoughts on the potential and challenges of wearable technology for healthcare provision and medical education

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ABSTRACT

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 those devices. This article focuses on this development. In doing so, it explores old and recent developments in wearable technology with a focus on their current and potential use in the field of healthcare and medical education. It also highlights the challenges that are likely to face this technology. 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.

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1. Introduction

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 a potential to be used to perform a variety of tasks and enhance the operations of some professions. In this article, the potential and challenges of using wearable technologies in the healthcare domain 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 with relation to healthcare. The theory, developed by Clayton Christensen and his Harvard Business School colleagues (see Christensen, 1997; Christensen, Anthony, & Roth, 2004; Christensen & Raynor, 2003), 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).

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 (see below for details) 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.

2. 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 continue to do) 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 et al., 2004).

The concept of disruptive innovations was first proposed by Christensen and his colleagues and 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

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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 "non-consumers") 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, gaining 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 and 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. Interestingly, wearable technology devices have been around for many years but have been expensive and cumbersome and were mostly used by people engaged in research and development projects (Skiba, 2014). In the last three decades a number of wearable technologies were produced. The 1980s is regarded as the decade when the pioneering wearable computers were introduced. In 1981, a 6502 (8-bit microprocessor)-based multimedia computer was designed to be worn as a backpack by Steve Mann, a researcher and inventor, and in the latter part of the decade, a head-mounted display called Private Eye was developed and marketed by Reflection Technology (a company that is now out of business). The device had a red monochrome display with a resolution of 720×280 pixels and a 1.25 in. screen size that appeared like a 15-inch display when viewed from an 18 in. distance.

The 1990s also saw a few wearable developments. In 1993, a wearable computer system (see Fig. 1) was developed using a kit made by Park Enterprises (an American sports software developer), a Private Eye display, and the Twiddler (a one-handed keyboard and mouse) produced by Handykey Corporation (a US-based company). The system has since evolved into what is now known as the MIT Tin Lizzy wearable computer design.

In the same year, BBN Technologies (an American high technology company) completed the Pathfinder system, a wearable computer that features a radiation detection system and GPS (global positioning system). The following year, a wearable
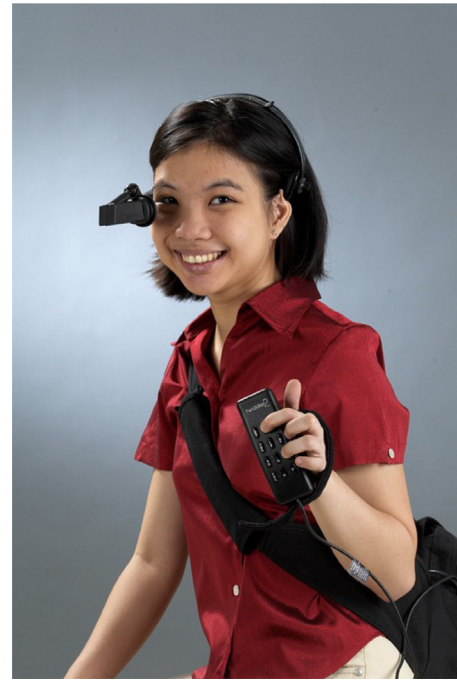

Fig. 1. A wearable computer system from 1993.
Source: Racoma (2013).

computer called "Forget-Me-Not" was developed that was capable of continuously recording interactions with people and devices. In the same year, a "wrist computer" featuring a half-QWERTY keyboard was invented and introduced during the 1994 Conference on Human Factors in Computing Systems in Boston (see Fig. 2).

In 1998, Rockwell International (a defunct American company) produced the Trekker (see Fig. 3), a rugged wearable computer, based on a 120 MHz Pentium, with built-in DSP (digital signal processing) support for speech interface and a monocular head-worn display. It was the first start of commercially available wearable computing hardware to be developed with a price tag of US$10,000.

Fig. 2. Wrist computer.
Source: Atmel (2014).