Game, Settings, Match – The Impact and Future of Wearable Technology in Fitness and Healthcare

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Abstract—**The modern day smartphone has become an integrated part of everyday life - barely noticed when there, but missed dearly when not. With the recent introduction of wearable technology that acts as an extension of the smartphone, the industry is growing at an incredibly rapid pace, introducing new opportunities and areas of application. Android Wear, developed by the search engine giant Google, exhibits particular promise in the watches category of wearable devices. We sample the specifications of a collection of watches that run Android Wear and identify the trends in both screen size and sensing capabilities. We proceed by identifying various industries that have been affected by these watches including fashion, television, arts, automobiles as well as fitness and healthcare. With a hands-on experience of the Moto 360 watch, we are able to test the sensors of the device and finally, conclude with suggestions of possible additions that can be made to wearable devices by means of optical fibres.**

Keywords— **Smartphone, Smartphone Applications, Wearable Technology, Wearables, Android Wear, Moto 360**

I. Introduction

Clicking, dragging, copying and pasting are no longer words that are only associated with the jargon of laptop, desktop and notebook users. Mobile phones, but more specifically mobile smartphones, have evolved from being mainly text and phone call capable devices to intricate devices capable of surfing the Internet, downloading and installing new software on the fly, taking photos, editing and sharing them all in one go. The convenience, reliability and ubiquitous nature of these devices have made them an indispensible part of the modern day individual's life – barely noticed when there, but missed dearly when not. The ability of the smartphone to 'disappear' in plain sight is certainly beneficial to the end user, but as with many things in life, too much of a good thing can also be bad.

In Australia for example, younger users (aged between 16 and 24 years) have been observed to display symptoms closely related to that of behavioural addiction [1]. Although the use of smartphones has been thought of as mostly beneficial (informing parents of a child's whereabouts for example), addictive behaviour can have negative effects on not only an individual's state of mind, but also their state of body. With the introduction of wearable devices that act as an extension of the smartphone, there exists a possibility that a user's behavioural addiction could be aggravated even further.

In this paper we will have a look at how wearable devices can be used to encourage users to create new addictive behaviours to the contrary i.e. to the benefit of their own health. We begin by looking at the concept of wearable technology, followed by a brief discussion on the variations of wearables already in existence. By focusing our attention specifically on watches, we identify the trends in size and sensing capabilities that have been observed to date.

We proceed with a discussion on the various industries that have been affected by the wearables revolution focusing specifically on watches that run Android Wear. We conclude by noting possible additions that can be made to wearable devices and their sensing capabilities by making use of optical fibres.

II. The Role of the Smartphone in Society

As mentioned previously, the identification of addictive smartphone usage is one of the bigger concerns that the smartphone industry may be faced with. Despite this concern however, the fact remains that end user behaviour does not affect a smartphone company or any other production stakeholder directly. While health concerns should be taken into consideration, it is the primary responsibility of the end users themselves to choose how to use their devices in both private and public capacity.

One such choice has allowed smartphones to become such an integrated part of society that social behaviours (specifically in public places) have been observed to change as a result [2]. As with behavioural addiction, smartphone companies and other production stakeholders are not affected directly by this occurrence, although it stems directly from the use of their smartphone product.

The study that was performed by Lycett and Dunbar [2] was focused mainly on male smartphone users and how they tend to display their smartphones more often when in the company of mainly other males in a public setting. The increased competition in a predominantly male group was identified to be one of the driving factors for this occurrence and it is concluded that smartphones have ultimately become indicators of status and wealth by which females are able to more accurately assess the modern day male.

With the recent introduction of wearable technology that acts as an extension of a smartphone, the combined importance of these two devices is sure to have an even

bigger impact on society. It thus merits investigating the concept of wearable technology further.

III. WEARABLE TECHNOLOGY

A wearable in itself can be described as something that is fit or suitable to be worn, often an article of clothing or an accessory [3]. A piece of wearable technology takes this concept one step further by incorporating computerised circuitry into an article of clothing or an accessory.

Although the concept of wearable technology is still in its infancy, the search engine giant Google is at the forefront of developing and distributing wearable technologies that are compatible with their smartphone Operating System (OS), Android. Some of the most noteworthy devices that have been introduced thus far include watches, glasses and Virtual Reality (VR) sets. We will now briefly look at each of these starting with watches.

A. Watches

Android Wear makes it possible to connect a supported watch to an Android compatible smartphone through Bluetooth (Low Energy) and Wi-Fi [4]. This allows users to access notifications, music, emails and a variety of supported apps (such as fitness, navigational and weather) directly on their watch.

B. Glasses

Google Glass is a headset that is intended to be worn like a pair of eyeglasses all the while providing a second screen to the user's Android smartphone [5]. Even though Google Glass is not yet available to the general public, the intention is to make these available once the beta testing phase has been successfully completed.

C. Virtual Reality Sets

Google Cardboard for Android is an attempt at creating accessible Virtual Reality (VR) experiences to owners of Android smartphones – this is achieved by placing a smartphone inside a self-assembled cardboard headset. The Cardboard Software Development Kit (SDK) in turn allows developers to build smartphone apps that display 3D scenes with binocular rendering, track and react to head movements and interact with apps through the magnet input of the headset [6].

IV. WEARABLE DEVICE TRENDS

The pace of technological advancement will undoubtedly favour the growth of the wearable market in the future. In these early stages however, Android Wear watches have already proved their worth. At the time of writing this article, numerous major device manufacturers were already capable of producing devices that run Android Wear, some of which include [4]:

- Motorola (Moto 360)
- LG (G watch R)
- Asus (ZenWatch)
- Samsung (Gear Live)
- Sony (SmartWatch 3)

In Table 1 we are presented with a summary of the technical specifications of each of these devices including the particular device's manufacturer, name, screen type, screen size and available sensors. Upon closer inspection, similarities can be identified in both the sizes of the watch screens as well as the type of sensors provided.

TABLE I
SPECIFICATIONS OF VARIOUS ANDROID WEAR WATCHES [7] – [11]

Manufacturer/ Device Name	Screen type/ Screen size	Sensors
Motorola Moto 360	LCD 1.56"	• 9-Axis (Gyroscope, Accelerometer, Compass) • Pedometer • Optical Heart Rate Monitor (PPG) • On-body detection • Dual Microphones
LG G watch R	P-OLED 1.3"	• 9-Axis (Gyroscope, Accelerometer, Compass) • Barometer • PPG (Heart Rate Monitor) • Microphone
Samsung Gear Live	AMOLED 1.63"	• 9-Axis (Gyroscope, Accelerometer, Compass) • Heart Rate Sensor • Microphone
ASUS ZenWatch	AMOLED 1.63"	• 9 Axis (Gyroscope, Accelerometer, Compass) • Bio Sensor (Heart Rate Monitor) • Microphone
SONY SmartWatch 3	Transflective 1.6"	• 9-Axis (Gyroscope, Accelerometer, Compass) • GPS • Microphone

Although the sizes of the watch faces (in diameter) vary from 1.3 inches (± 33 mm) to 1.63 inches (± 41 mm), the majority of device screens are in the range of 1.6 inches (± 40 mm). The most common sensors can in turn be identified as:

- 9-Axis (Gyroscope, Accelerometer, Compass)
- Heart rate monitor/sensor
- Microphone

The Sony SmartWatch 3 is the only exception where a heart rate monitor is not present. At the same time, however, it is the only device that has a GPS. This is a unique feature that allows the watch to track location on its own, i.e. without having to be connected to a smartphone [12]. This makes the SmartWatch 3 a popular choice amongst joggers as they do not have to carry a smartphone with them while running.

Upon return, they are then able to synchronise the data of their run (such as the route, distance etc.) back onto their smartphone for safe keeping.

With a wide variety of devices to choose from, the end user is ultimately faced with making a decision between aesthetics (square or round watch face), customisability (metal, leather, rubber or other type of band) and functionality (types of sensors included/not included).

Of course, there isn't a limit to the number of watches an end user may choose to purchase. Using the Moto 360 during business hours and switching to the Sony SmartWatch 3 for afterhours jogging is a reality that Android Wear has made possible - seamless transitioning between contrasting worlds.

By allowing different manufacturers to produce different types of watches, Android Wear can provide users with a greater variety to choose from than rivals Apple [13] for instance can. The focus can thus be on enhancing the User Experience (UX) of Android Wear, leaving device manufacturers with the daunting task of producing highly sought-after devices.

This indirect method of 'outsourcing' device manufacturing not only alleviates some of the pressure on Google, but also creates an opportunity for other device manufacturers to enter the market of wearable technology. Android Wear watches, in particular, have had an impact on various other industries as we will discuss next.

V. The Impact of Android Wear on Other Industries

As mentioned previously, different manufacturers incorporate different types and combinations of sensors in their devices for different reasons. The most common combination thus far (based on Table 1) being identified as 9-Axis (Gyroscope, Accelerometer and Compass), heart rate monitors/sensors and microphones. Despite their technological roots, wearables that run Android Wear have had an enormous impact on various other industries (that are not necessarily technology oriented) including fashion, television entertainment, arts, automobiles as well as fitness and healthcare. We will briefly discuss each of these next.

A. Fashion (Haute Couture)

Android Wear watches allow users to customise the face of their watch by choosing from numerous designs. BCBGMaxazria [14] and Rebecca Minkoff [15], two world renowned fashion houses, designed their own branded watch faces that end users can download and install on their Android Wear watches. Not only does this provide an opportunity to increase brand awareness and marketing for the fashion houses, but provides a greater selection for Android Wear users to choose from. A win-win-win situation for all parties involved.

B. Television Entertainment

With various television series being broadcast all over the world, end users now have the opportunity to carry a small piece of their favourite show on their wrist. Television series enthusiasts of Hannibal [16] and Doctor Who [17] have already made watch faces available to other avid fans of the shows.

C. Arts

Google promotes a collection of new and emerging artists' work by featuring it as a watch background on Android Wear devices [18]. Alternatively, it is also possible to have historically famous paintings (including works from Van Gogh amongst others) as a watch face by making use of the Muzei app [19].

D. Automobiles

A well-known brand of automobiles, Porsche, has taken initiative to provide Android Wear users with the option of having a Porsche branded watch face on their wrist [20]. As with the fashion houses discussed earlier, this provides an opportunity to increase brand awareness without the need of an expensive marketing campaign, while contributing a greater choice to Android Wear device owners.

E. Fitness and Healthcare

By revisiting the technical specifications of various Android Wear watches as summarised in Table 1, we come to the realisation that the majority of sensors provided in these devices can be used to track the movement, pace and overall well-being of the end user. As such, wearable devices have the potential to make an impact on the fitness and healthcare industries by encouraging users to set a daily workout goal, monitor their progress and also inform users when they have achieved their goal. Proprietary software provided on the wearable device or smartphone is a potential competitor in this realm although, by providing a cross-device compatible alternative, Google Fit [21] allows users to monitor and synchronise their activities across multiple different devices. As the healthcare industry can benefit greatly from technological innovation and research, we decided to investigate this phenomenon further.

VI. Discussion

With numerous industries already being affected by Android Wear watches, it is important to note that smartphones running Android (version 4.3 or later) and wearable devices running Android Wear are already able to communicate with one another, despite the fact that they are produced by different manufacturers. To put this inter-device communication capability to the test, we combined a Motorola Moto 360 wearable running Android Wear v.5.0.2 with a Samsung Galaxy S4 (GTI9500) smartphone running Android v.4.4.2 (Kit-Kat).

With the devices having successfully paired, we evaluated the behaviours of various fitness apps including S Health [22], Google Fit [21] and Moto Body [7]. The main focus was on identifying the level of communication that occurs between the two devices when making use of the pedometers on offer.

We started by looking at S Health [22], an app that is developed specifically for the Samsung brand of smartphones and allows users to track their daily steps taken, caloric intake,

hours slept and many more. The app is developed for use on the Android smartphone itself. Upon closer inspection we came to realise that despite the fact that the app runs on the (Android) smartphone and gathers statistics based on the movement of the smartphone alone, basic notifications were still sent through to the Moto 360 as seen in Figure 1 (right) with the more advanced details available through the app on the smartphone as shown in Figure 1 (left).

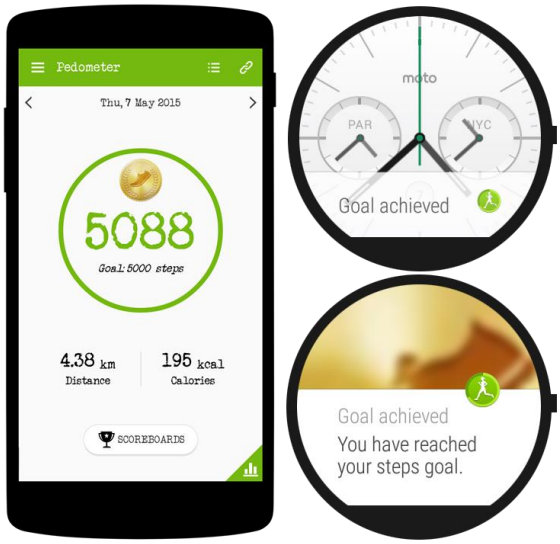

Figure 1: Advanced Android S Health Statistics on Samsung S4 (left) and Basic S Health Notifications on Moto 360 (right)

In the case of Google Fit [21] however, statistics are gathered based on the movement of both the watch and the smartphone as the app runs on Android devices, but supports devices that are Android Wear compatible too.

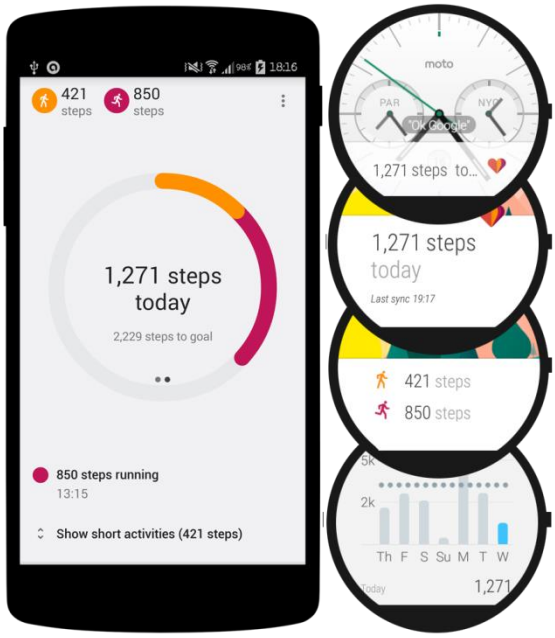

Figure 2: Advanced Android Google Fit Statistics on Samsung S4 (left) and Advanced Android Wear Google Fit Notifications and Statistics on Moto 360 (right)

As a result, detailed information is available on the watch (Figure 2, right) while an even more advanced summary is available on the smartphone (Figure 2, left). This provides a seamless experience between wearable and smartphone by periodically synchronising data between the devices.

Lastly, Moto Body [7] is specifically developed for the Moto 360 and tracks daily steps taken while wearing the watch only. As the application is preinstalled on the watch, reports such as daily steps taken (Figure 3, left) and weekly steps taken (Figure 3, right) are available exclusively on the watch.

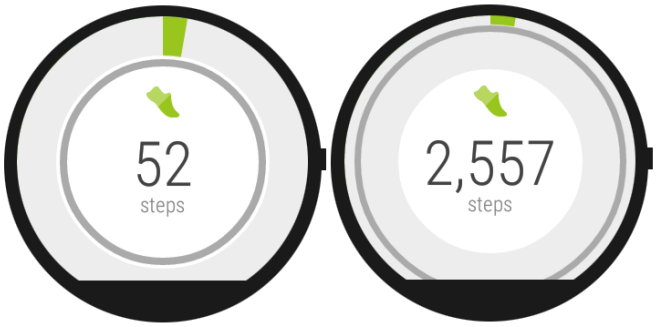

Figure 3: Moto Body (Motorola) Statistics on Moto 360

VII. THE FUTURE OF WEARABLES

In the previous section we evaluated the cross-platform communication capabilities of smartphones and wearable devices that are Android compatible and found that multi-directional (smartphone to watch, and watch back to smartphone) communication is already possible.

A specific industry that can possibly benefit greatly from the rapid evolution of wearable technology in particular, is the healthcare industry. With heart rate monitors and pedometers arriving with the majority of watches (as seen in Table 1) already, encouragement of leading healthier lifestyles could possibly be a result thereof.

The fact of the matter, however, is that these sensors are still of limited use when it comes to more advanced healthcare scenarios. The possibility of building onto the existing capabilities of these devices by making use of optical fibre could possibly address this.

In certain aspects, optical fibre sensors can be regarded as a specialised type of yarn that can be embedded into textile fabrics allowing continuous monitoring of various vital signs [23]. This is done in an endeavour to identify certain life-threatening diseases some of which could include heart failure, heart attacks, high cholesterol, strokes and sleep apnoea. Wearable devices, and in particular watches, offer an ideal opportunity to integrate optical fibre with everyday accessories in a non-invasive manner.

The straps of a watch could be the ideal area for the placement of optical fibre as it is often directly in contact with the body and close to the veins located in the wrist. In the case of the Moto 360 with a black Horween leather strap,

lengths of 73mm and 123mm are available on the short and longs straps of the watch respectively.

Some of the main concerns that still need to be addressed by various methods of optical fibre sensing include high costs, oversized monitoring units, fragile fibres and lack of sensitivity [24]. Despite these concerns however, reporting of fibre sensor results via Bluetooth have already been successfully recorded [23]. As Android Wear devices are connected to Android smartphones by means of Bluetooth (Low Energy) [4], the technology is already made available on the wearable device making the integration of fibre with these devices an attractive prospect.

The possible areas of application (in the healthcare industry) for more advanced wearable devices making use of optical fibres are undoubtedly vast. Home care systems for aging individuals [25], vital sign monitoring for fire fighters [26] and remote health monitoring systems of a preventative and rehabilitative nature [27] are but a drop in the ocean of possibility.

VIII. CONCLUSION

In this paper we investigated the role that smartphones and wearables play in our technological society. In particular, we noted that a very prominent leader in the expansion of the wearable industry is the search engine giant Google with their Android and Android Wear Operating Systems.

These wearable technologies, and in particular the various watches readily available, have proved to be fit for the task of recording, communicating, reporting and possibly also encouraging healthier end user lifestyle habits.

In the future however, integration of additional technologies such as optical fibres could enhance the capabilities and subsequent impact that wearables have on the healthcare industry in particular. Home care systems and remote vital sign monitoring could possibly prevent patients from having to travel to medical facilities unnecessarily by recording and possibly sharing medical information with their physician.

Game, settings, match – the battle for producing the ultimate wearable is on. The question now is: Which manufacturers are fit for accepting the challenge?

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