

# Wearable technology - An exploration towards contribution to human life

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#### Abstract

The topic of wearable technology and its adaptation in various industries is growing rapidly worldwide. One of the significant reasons behind the growth is the comfort and dependence such devices bring in a person's lifestyle. Brand value, marketing strategies, context and understanding human interaction with these devices play a crucial role in the growth of wearables. Advancement in technology and its use in products is not the only key factor affecting the product's value, but the time of launch, psychology of people and other factors such as the lifespan of products, health concerns by using the product, environmental impacts from the device, all have an important role to play. This study argues the different marketing strategies, functions, features, contexts of the launch by using different examples of wearable devices over the years. New technologies like haptics and AR are analysed to explore the possibility of its melange with wearables and the effects on people's life. Priority of these factors are then listed to discover patterns and trends of successful stories of products as well as failures.

Keywords: Wearable technology, smart devices, haptic language, user needs, digitization

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### 1. Introduction

In a world where new inventions occur every day, technology is moving even faster<sup>1</sup>. With a market size of USD115.8 Billion in 2021, current technological advances help in tracking workouts, answering queries, connecting you to the entire world, and calculating your nutritional needs and the amount consumed. It can do almost any work at a much faster rate and at the convenience of a click of a button. These developments lead to several overlaps amongst brands, their products, and their uses, making minute details of the products and user's needs play a crucial role in technology preference. Users prioritize purchases through different factors such as brand value, form features, user interface, price point, ease of use, compatibility, available features, and more. Brand value plays a vital role in how a company penetrates the market<sup>2</sup>. Brand value is all about communicating the essence of the business, this not only helps the brand place itself in the market, but also increases sales and awareness.

Wearable technology or wearable devices are objects worn near/on one's body. This could range from wearing on the skin, wrist, over one's clothing, footwear, eyewear or headset<sup>3</sup>. With the advancement in technology and people's preference for comfort, an increased number of individuals prefer wearable devices compared to other commercialized technologies in today's world. Today, more than 15% of the world's population<sup>4</sup> uses connected wearable devices, which has increased from 10% in the year 2019. The exponential rate of growth shows the potential of the field. The field attained its popularity due to its ease of convenience and the ability to cater to the numerous needs of people of all ages. However, it is not just about technology and people's lifestyle anymore; many conversations today revolve around the health of the planet and e-waste management. Due to the increase

<sup>&</sup>lt;sup>1</sup> Facts, and Factors, "Insights on Global Wearable Technology Market Size & Share to Surpass USD 380.5 Billion by 2028, Exhibit a CAGR of 18.5% - Industry Analysis, Trends, Value, Growth, Opportunities, Segmentation, Outlook & Forecast Report by Facts & Factors, "*Facts & Factors*, 2022 <<a href="https://www.globenewswire.com/news-release/2022/04/13/2421597/0/en/Insights-on-Global-Wearable-Technology-Market-Size-Share-to-Surpass-USD-380-5-Billion-by-2028-Exhibit-a-CAGR-of-18-5-Industry-Analysis-Trends-Value-Growth-Opportunities-Segmentatio.html>[accessed 8 June 2022]

<sup>&</sup>lt;sup>2</sup> McManus, Orla, "Importance of Brand Values to Your Business Nettl.Com," Nettl, 2021 <a href="https://www.nettl.com/ie/importance-brand-values/">https://www.nettl.com/ie/importance-brand-values/</a>> [accessed 8 June 2022]

<sup>&</sup>lt;sup>3</sup> "Keeping Wearable Technology Safe at Any Speed," *UL* <https://www.ul.com/insights/keeping-wearable-technology-safe-any-speed?utm\_mktocampaign=medicalsafetytesting-

digitalads&utm\_mktoadid=&campaignid=16184601994&adgroupid=135173033420&matchtype=b&device=c&creative=5873427 37179&keyword=wearable%20technology&gclid=CjwKCAjwkYGVBhArEiwA4sZLuFoCjgm0cO4bYSMqn2ysD4\_Mn8v8ls7fuK5 25Q9pBEDVH3J96AxQBBoCyO0QAvD\_BwE> [accessed 8 June 2022]

<sup>&</sup>lt;sup>4</sup> "Global Connected Wearable Devices 2016-2022." [n.d.]. *Statista* <a href="https://www.statista.com/statistics/487291/global-connected-wearable-devices/">https://www.statista.com/statistics/487291/global-connected-wearable-devices/</a> [accessed 30 March 2022]

in the production of components and other electrical parts/bodies, the energy consumption has increase along with the amount of waste due to the rapid disposal of batteries and parts<sup>5</sup>.

This study focuses on studying the evolution of wearable technology, changes in user preference, product demand and projective value. It looks at two main interest points: Planet health and e-waste management, by studying various devices available in the market. The thesis focuses on their features, catering needs of the users and hypothesizes the future of these devices while investigating how new technological inventions sustain these products, considering the issues like overutilization of resources, global warming and rapid increase in water levels. It also tries to delve deeper into sustainable practices<sup>6</sup> and measures taken by companies to continue these initiatives for the future generation.

The thesis is divided into five main chapters. The first one talks about what wearable technology is and how it has evolved throughout these years. The need of invention, view of the technology and the changes in perception throughout the ages. Additionally, it comments on the idea of embodiment and how these devices are becoming part of one's body. The second chapter discusses market trends and patterns over the past few years, while looking at changes in user needs by analysing secondary research to understand their current usage patterns. The third chapter of this paper is a comparative study of four different industries where wearable devices play a crucial role. It challenges the current boundaries of technology and looks at innovative ways of creating a more significant impact within these fields of study. The fourth chapter is also a comparative study of two multinational globally renowned brands. It focuses on how products are promoted, how companies obtain information about user requirements and what changes are made to cater to those requirements. The last chapter talks about speculative design solutions keeping in mind developing and upcoming technologies. It includes various projects currently hovering in the market and a few original concepts that benefit the society in the future.

<sup>&</sup>lt;sup>5</sup> Gurova, Olga, Timothy Robert Merritt, Eleftherios Papachristos, and Jenna Vaajakari, "Sustainable Solutions for Wearable Technologies: Mapping the Product Development Life Cycle," Sustainability, 12.20 (2020), 8444

<sup>&</sup>lt;https://doi.org/10.3390/su12208444>
<sup>6</sup> "Sustainability Services," Accenture.Com <https://www.accenture.com/gb-en/services/sustainability-</pre>

index?c=acn\_glb\_brandexpressiongoogle\_12817819&n=psgs\_0122&gclid=CjwKCAjwkYGVBhArEiwA4sZLuDjdcgM2z8RfBh9 ncQAS6Nr9mFLUf0H701Rje5vZFMcnMn1Nbc2quhoC\_YcQAvD\_BwE> [accessed 8 June 2022]

#### 1.1 Aim of the study

This study is intended to investigate and understand the perception of wearable technology amongst users. To analyse the factors that affect the choice of people's purchases within the industry and what needs are to be kept in mind while designing a wearable device for a particular context. How these devices contribute in a person's lifestyle, stay connected with the world, and reach maximum potential through this technology are discussed.

The objectives are to understand the theory of wearable technology, concepts and roles. Explore various options/platforms available for the technology and analyse the worldwide trends using market statistics. Lastly, to unveil the future trends and demands of wearable technology, what and how it can contribute for betterment of quality of lifestyle.

### **1.2 Scope and limitation of the study**

The study is focused mainly towards the current technological trends and arguments are based on the studied market trends. Scope of the study is restricted to digital platforms and limited to only wearable devices. Additionally, the arguments are restricted to certain age groups and contexts according to the product/company that is being analysed.

#### **1.3 Methodology**

This study encompasses arguments and insights from various primary sources and secondary source. Information from newspaper articles, research documents and government policies were primary sources referred throughout, at different stage of this thesis. This helped shape the context and build a narrative throughout this study. Secondary resources included academic research papers, websites, journals, books and reviews from the internet to understand the user market for various case studies of products discussed in the paper.

#### 2. Understanding of wearable technology

"Wearable technology, also known as "wearables," is a category of electronic devices that can be worn as accessories<sup>7</sup>, embedded in clothing<sup>8</sup>, implanted in the user's body, or even tattooed on the skin. The devices are hands-free gadgets with practical uses, powered by microprocessors and enhanced with the ability to send and receive data via the Internet."<sup>9</sup>

According to this definition, there are various possibilities of how wearable technology can be interpreted ranging from external accessories to internal embedded sensors. However, if all the features can be performed by some or the other product, what is the need for wearables? What is the need for developing products that are attached to one's body?

Very rightly said "Wearable technology provides us with the ability to monitor our fitness levels, track our location with GPS, and view text messages more quickly. Best of all, most of the devices that allow us to do this are hands free and portable, eliminating the need to take our devices out of our pockets"<sup>10</sup>. In addition to the functions performed by these devices, it is about the convenience and hassle-free attachment that does not require any manual effort to operate it. With people having less time and multiple tasks that need to be performed, automatic collection of data and feedback system is important. Products like Apple Watch Series 7<sup>11</sup> develop models and interfaces after extensive understanding of user behaviours and needs. I will be discussing about the brand and particular products later in chapter 5.

Other wearables include embedded sensors either in cloths or bodies which goes one step further from the hassle of wearing accessories like smart watched but instead just leaving it on once and forgetting about it altogether. According to Microsoft<sup>12</sup>, smart tattoos are the next trend where you are practically wearing your phone. This eliminates the need of developing external bodies of tables or phones, which drastically reduces the use of plastic body cases. The development of these ecological steps will be further discussed in chapter 6. This would

<sup>&</sup>lt;sup>7</sup> "Wearable Technology: The Future of Fashion Accessories?," *PITAKA* <a href="https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-the-future-of-fashion-accessories>">https://www.ipitaka.com/blogs/news/wearable-technology-tech

<sup>&</sup>lt;sup>8</sup> Stephenson, Brad, "The 7 Best Smart Clothes of 2022," *Lifewire*, 2018 <a href="https://www.lifewire.com/best-smart-clothes-4176104">https://www.lifewire.com/best-smart-clothes-4176104</a> [accessed 8 June 2022]

 <sup>&</sup>lt;sup>9</sup>Hayes, Adam. 2021. "Wearable Technology," *Investopedia* <a href="https://www.investopedia.com/terms/w/wearable-technology.asp>">https://www.investopedia.com/terms/w/wearable-technology.asp></a> [accessed 30 March 2022]
 <sup>10</sup> "Wearables: Pros and Cons of Wearable Technology." [n.d.]. *GCFGlobal.Org* <a href="https://edu.gcfglobal.org/en/wearables/pros-">https://edu.gcfglobal.org/en/wearables/pros-</a>

<sup>&</sup>lt;sup>10</sup> "Wearables: Pros and Cons of Wearable Technology." [n.d.]. *GCFGlobal.Org* <a href="https://edu.gcfglobal.org/en/wearables/pros-and-cons-of-wearable-technology/1/> [accessed 30 March 2022]</a>

<sup>&</sup>lt;sup>11</sup> "Apple Watch Series 7." [n.d.]. *Apple (United Kingdom)* <a href="https://www.apple.com/uk/apple-watch-series-7/">https://www.apple.com/uk/apple-watch-series-7/</a> [accessed 30 March 2022]

<sup>&</sup>lt;sup>12</sup> "Smart Tattoos." 2019. *Microsoft Research* <a href="https://www.microsoft.com/en-us/research/project/smart-tattoos/">https://www.microsoft.com/en-us/research/project/smart-tattoos/</a> [accessed 30 March 2022]

provide a clear perspective about where we see the world of technology in the next ten years, where climate crisis is an important issue that would be addressed in any company's production of products.

#### 2.1 Evolution of wearable technology in the consumer market

Wearable products have been in existence since the stone age, where the most secure way of keeping any object was on themselves. This concept, however, has changed over the years, where security of objects is not the only concern anymore. However, the functionality of the device and how it benefits the lifestyle of people is what matters. The first wearable tech device was an eyeglass, invented in the 13<sup>th</sup> century in Italy<sup>13</sup>. Hence, it can be said that the concept of wearables is not new. Later, in 1510, the marine chronometer pocket watch was invented by a German clockmaker which was the first ornament of time worn on one's body. Preceding this, in 1600s, the abacus ring was another set of accessory worn to instantly solve mathematical problems without the worry of any battery draining off.

Jumping to the 1800's, two significant wearables were created; air conditioned top hat that was patented by the Victorians and the project 'Electric girl lighting company'. The model wore a dress fitted with batteries and bulbs. With the advancement of technology, birth of the first wearable camera took place. To my surprise, it was called the Pigeon Camera, and as the name suggests, it was strapped onto homing pigeons for surveillance purpose. Its initial use took place during world war I to capture aerial photographs behind the enemy line<sup>14</sup>. Whilst major inventions were taking place, computers small enough to fit into shoes were being made, called roulette shoe. In 1963, TV glasses were designed, which were the primitive versions of VR glasses.

Later in the 1970's, major products were designed whose bases are still present in products today. The Pulsar calculator watch<sup>15</sup> was the first smart watch that was commercialised with the stainless steel version with gold model. Subsequently, the multinational company Sony<sup>16</sup>

<sup>&</sup>lt;sup>13</sup> "Computer Disposals Ltd: Now Part of Restore Technology for IT Lifecycle Services."

In.d.l. Computerdisposals.Com <a href="https://www.computerdisposals.com/blog/exploring-history-future-wearable-tech/">https://www.computerdisposals.com/blog/exploring-history-future-wearable-tech/</a>> 30 March 2022] <sup>14</sup> Desjardins, Jeff, Niccolo Conte, and Nick Routley. 2015. "The History of Wearable Technology," *Visual* 

Capitalist <a href="https://www.visualcapitalist.com/the-history-of-wearable-technology/">https://www.visualcapitalist.com/the-history-of-wearable-technology/> [accessed 30 March 2022]</a>

<sup>&</sup>quot;Pulsar Calculator Watch," Vintagecalculators.Com <a href="http://www.vintagecalculators.com/html/pulsar\_calculator\_watch.html">http://www.vintagecalculators.com/html/pulsar\_calculator\_watch.html</a> [accessed 8 June 2022]

<sup>&</sup>quot;Sony UK," Sony.Co.Uk < https://www.sony.co.uk> [accessed 8 June 2022]

launched the portable Sony Walkman<sup>17</sup> which was a revolution in the music industry. It was supposed to be wrapped on the waist and with several new features for the time.

The boost of technology led towards the invention of Private Eye<sup>18</sup> in 1980's which was essentially an eye screen that took advantage of microchips that would allow users to record what they saw through their right eye whilst allowing them to see what is happening in real time. It was an attempt to create an early Google Glass by Steve Mann<sup>19</sup>. Additionally, along with this, The Helmet Camera was invented and created a system while producing The Great Mountain Biking Home Video in 1987.

With the commencement of 2000s, various objects were mass produced ranging from Nokia Bluetooth set<sup>20</sup>, Nike+/Apple iPod Nano<sup>21</sup>, Levis ICD+ jacket<sup>22</sup>, Microsoft SPOT smartwatch<sup>23</sup> to Fitbit waistband<sup>24</sup>, Google Glasses<sup>25</sup>, GoPro<sup>26</sup> and solar powered jackets by Tommy Hilfiger<sup>27</sup>. These inventions are designed to wear rather than carrying around another product. However, several products listed above do not have an exact success story, and the reasons for that will be discussed further in the following chapters.

### 2.2 Wearables as an extension of your body

An embodiment of wearables such as mobile phones, watches and jewellery is becoming a prevalent trait amongst young adults. According to a survey, these objects are becoming part

<https://www.iconeye.com/design/features/a-short-history-of-the-sony-walkman> [accessed 8 June 2022]

<sup>&</sup>lt;sup>17</sup> Ray, Debika, "A Short History of the Sony Walkman," *ICON Magazine* (iconeye.com, 2020)

<sup>&</sup>lt;sup>18</sup> "The Wearable Computer Revolution," *Herox.Com* < https://www.herox.com/blog/151-the-wearable-computer-revolution> [accessed 8 June 2022]

Mann, Steve, "Steve Mann: My 'Augmediated' Life," IEEE Spectrum, 2013 < https://spectrum.ieee.org/steve-mann-myaugmediated-life> [accessed 8 June 2022]

Microsoft Devices Blog, "All Ears! A Pictorial History of Bluetooth Headsets. Part 1," Microsoft Devices Blog, 2012 <https://blogs.windows.com/devices/2012/02/03/all-ears-a-pictorial-history-of-bluetooth-headsets-part-1/> [accessed 8 June 20221

<sup>&</sup>lt;sup>21</sup> *Ilounge.Com* <https://www.ilounge.com/index.php/reviews/entry/apple-computer-nike-ipod-sport-kit> [accessed 8 June 2022] <sup>22</sup> "An Expanded History of Levi's ICD+ & Philips' Wearable Electronics Program," *Shellzine.Net* (Shell Zine, 2020)

<sup>&</sup>lt;a href="https://shellzine.net/levis-icd/">https://shellzine.net/levis-icd/</a> [accessed 8 June 2022]</a>
<sup>23</sup> Karella, Ambrose, "Microsoft SPOT and the Beginning of Smartwatches," *Digital Shroud*, 2020

<sup>&</sup>lt;https://medium.com/digitalshroud/microsoft-spot-and-the-beginning-of-smartwatches-e29be21f0d33> [accessed 8 June 2022]
<sup>24</sup> "Shop Fithit Inspire Accessed 7" Fithit Computing of Smartwatches-e29be21f0d33> [accessed 8 June 2022] "Shop Fitbit Inspire Accessories," Fitbit.Com <a href="https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/inspire-clip>">https://www.fitbit.com/global/uk/products/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessories/accessor June 2022] <sup>25</sup> Gvora, Joe, "Google Glass: What Happened to the Futuristic Smart Glasses?," *ScreenRant*, 2020

<sup>&</sup>lt;https://screenrant.com/google-glass-smart-glasses-what-happened-explained/> [accessed 8 June 2022] <sup>26</sup> "Action Cameras: HD Video Cameras for Sports +

Adventure," Gopro. Com <a href="https://gopro.com/en/gb/shop/cameras?gclid=CjwKCAjwkYGVBhArEiwA4sZLuMlfKa1aVL-">https://gopro.com/en/gb/shop/cameras?gclid=CjwKCAjwkYGVBhArEiwA4sZLuMlfKa1aVL-</a> vpoOIJW7Hi057yBPQXVndjrv1lyZUSnAzDgs8qOi2RoCmwEQAvD\_BwE&gclsrc=aw.ds> [accessed 8 June 2022]

Starr, Michelle, "Tommy Hilfiger Launches Solar Power Jackets to Charge Your Phone," CNET, 2014 <https://www.cnet.com/tech/mobile/tommy-hilfiger-launches-solar-power-jackets-to-charge-your-phone/> [accessed 8 June

<sup>2022]</sup> 

of people's body, just like a physical prosthetics<sup>28</sup>. Such prosthetics talk about objects being part of one's body and how phones, watches and such electronics are an extension without which certain functionality would be difficult to perform. For example, a smart tattoo is literally a form of wearable technology engraved on your skin which enables the users to send signals to devices around them via touch. Allowing them to interact with the world around them without moving physically or putting in any efforts<sup>29</sup>.

This is a project done as a collaboration between Microsoft Research and MIT Media Lab, where the material and circuit arrangement patterns are being developed to reach its full efficiency. These type of projects supposedly argue to have developed in terms of technology however multiple other questions are generated that raise concerns about its effects on health. Permanent tattoos that are inked on the body have several health risks like infections and allergic reactions<sup>30</sup>, which triggers concerns about attaching electrical foil papers/circuits on one's body. On the other hand, this technology can be seen as a sustainable, instantaneous and long lasting concept that does not require change of battery like other wearable device and real-time data can be captures that could potentially revolutionize the health industry.<sup>31</sup> All these are examples of people extending themselves physically to perform tasks efficiently, with ease and convenience. It is possible to live without these extensions, however we live in a world where most of the objects that we use are a want rather than a need and this is where products related to wearables come into existence. Additionally, this extension of one's body is not just a want but also a way of experiencing the virtual connection between the physical and digital world. A space in-between where sense of touch would enable several functions, creating a difference in the physical world through a technological interaction.

<sup>&</sup>lt;sup>28</sup> Nelson, Elizabeth C., Anneke M. Sools, Miriam M. R. Vollenbroek-Hutten, Tibert Verhagen, and Matthijs L. Noordzij. 2020. "Embodiment of Wearable Technology: Qualitative Longitudinal Study," JMIR MHealth and UHealth, 8.11: e16973 <a href="https://doi.org/10.2196/16973">https://doi.org/10.2196/16973></a>
<sup>29</sup> Book, Adrien. 2020. "'smart Tattoos': The next Big Thing in Technology?," *The Pourquoi* 

Pas <https://www.thepourquoipas.com/post/smart-tattoos-technology> [accessed 30 March 2022]

<sup>&</sup>lt;sup>30</sup> Hunter, Dan, "Are Tattoos Safe? The Risks of Getting Tattooed," Authority Tattoo, 2021 < https://authoritytattoo.com/aretattoos-safe/> [accessed 4 June 2022]

<sup>&</sup>lt;sup>31</sup> Hunter, Dan, "Are Smart Tattoos the Future?," AuthorityTattoo, 2021 <a href="https://authoritytattoo.com/smart-tattoos/">https://authoritytattoo.com/smart-tattoos/</a> [accessed 4 June 2022]

#### 3. Market trends of wearable technology

Everyone owns a gadget in a world that is becoming techno-savvy day-by-day, from kids to elderly. It may be as basic as a Nokia 109<sup>32</sup> or as modern as iPhone 13 Pro Max<sup>33</sup>. At the end of the day it is a technology that is glued to people, making it a wearable object that performs multiple functions. The market growth in this industry has grown exponentially in the last 10 years and is expected to keep growing in the coming years. Looking at the statistics, figure 1 represents the US market in 2018 and 2019 with segmented electronic growth and the prediction of its growth in the coming years. This clearly shows how humans are merging the virtual with physical.



Figure 1: Trajectory of wearable device market

Wrist wear and eye/head wear are the most popular wearables amongst all and this can also be seen in the growing sales of Apple watch and other smart watch models. Ear plugs and headsets are the initial wearables that helped make music portable. These are objects mainly worn on the face; the ears. Whereas the next significant invention was the smart watch worn on the wrist. This shows the region on a person's body where it is acceptable for them to wear

<sup>&</sup>lt;sup>32</sup> "Nokia 109." [n.d.]. *Vodafone.Co.Uk* <a href="https://deviceguides.vodafone.co.uk/nokia/109/messaging/set-up-your-phone-for-web-based-email/>[accessed 30 March 2022]</a>

<sup>&</sup>lt;sup>33</sup> "IPhone 13 Pro." [n.d.]. Apple (United Kingdom) < https://www.apple.com/uk/iphone-13-pro/?afid=p238%7Cs-

dc\_mtid\_20925ukn39931\_pcrid\_587053610281\_pgrid\_135548529802\_&cid=wwa-uk-kwgo-iphone-slid---productid--Brand-iPhone13ProMax-SpringAnnounce-> [accessed 30 March 2022]

a device and are willing to use the features performed by the object. Looking at figure 1, the US market has shown immense growth in two sectors, i.e., wrist wear and eye/head wear<sup>34</sup>.

This prediction in wearables suggests that people are more open towards adapting devices that would be seen in front of them or felt on their face. Digging deeper into this argument, when compared with products for footwear, neckwear and body wear, wrist and eye wears are dominating the market due to its availability, affordability and functionality.

## 3.1 Importance/significance of wearable technology

Why do people want wearable devices? Why do they require it? Is it just another product that one would show off when they would go out or a piece of intelligence that they would respect and use for its abilities? Because of the advancement in technology and the reliance of people on it, thinking about life without it seems impossible. Some wearables have become part of the body because of the information provided by these devices. Basic information like time and date are somethings that you would always have on you (be it through mobile phone or your smart phone). Additionally, information such as number of steps walked and track the heartbeat rate are functions used in routine life. It enables users to perform effortless tasks such as mounted cameras for recording adventurous footages of your hike or record your daily screen time usage. All this features are taken for granted however, only when you do not get this feedback do you realise the importance of it.

<sup>&</sup>lt;sup>34</sup> "Wearable Technology Market Size Analysis Report

<sup>2028,&</sup>quot; *Grandviewresearch.Com* <a href="https://www.grandviewresearch.com/industry-analysis/wearable-technology-market">https://www.grandviewresearch.com/industry-analysis/wearable-technology-market</a> [accessed 8 June 2022]

#### 4. Market study of wearable technology in different industries

Wearables have made their place in several industries across the globe. Electric consumerism is the biggest market that captures a wide range of audience ranging from kids to elderly. The significance of this has been discussed earlier in the paper with reasons and predictions about its evolving trends. Besides this, wearables are being used in many different contexts to maximise their potential use. It is popular in the sports industry where professional athletes, coaches, novice players and gamers use it to enhance their experience as well as gather information about their activities and moves. Considering the new technologies, it is a field where immense amount of development is possible in the future. Second industry where wearables has created a huge impact is in the field of healthcare. Here, devices have helped in monitoring simple heartrate changes to detecting cancer cells in blood, aiding doctors to make accurate decisions for the patients. Thirdly, the fashion industry has grown vastly since the first light bulb dress was designed. It is not just a piece of clothing as a statement but rather a piece of clothing that fulfils a purpose and performs activities according to the context. This could be the fabric showcasing mood via colour or a jackets with sensors keeping the user warm. Fashion industry has adapted these technologies in such innovative ways that there are n number of innovative uses seen within this field. Lastly, labour work and safety is a crucial space where wearables act as a safety equipment to protect labour workers at construction sites and similar environments. The following subchapters will talk about each of these industries in detail.

#### 4.1 Sports industry

Smart wearables have benefited the sport industry to a great extent. It aids both, amateur players as well as professional athletics track their training, achievements and helps avoid injuries during games. This range of data is possible to collect through various equipment and sensors installed at different places such as game equipment, player's body through clothing or patches and sensors across the playing field for data tracking.

For professionals, live data tracking is crucial and these wearable sensors allow the tracking of vitals and other changes in the body to be sent to the player as well as their coaches and trainees for better insights. This helps the athlete change their practice manner according to their body requirements and helps their coach to help them improve in ways where these insights are extremely beneficial. Especially during the pandemic, professions training remotely, can send live data readings to their coaches elsewhere across the globe, making their job possible and easier<sup>35</sup>.

Talking about an example, few of the NFL<sup>36</sup> teams inserted microchips in the player's shoulder pads to track various factors of their vitals during the game play. In the 2018-2019 NFL season, according to the data collected by these sensors, Ezekiel Elliot ran 21.27 mph for 44-yeards which was his fastest that season<sup>37</sup>. This technology can be utilised by schools and colleges as well; the only advantage professions have is to negotiate contracts using these statistics. However, one of the major limitation is that players do not have access to full information which raises the question of who actually owns this data. There are several policies in place<sup>38</sup> because this data has the power to reveal sensitive information about an individual which is difficult to know from afar.

Cyclist shirt<sup>39</sup>, designed by Byborre<sup>40</sup> is a product that tracks data of the person cycling using actuators and electronics connected to a mobile phone. This helps cyclists monitor heart rates and identify when they need to slow down/speed up.



Figure 2: Cyclist shirt designed by Byborre

Another very famous example that is common amongst common public is the Apple watch Fitness+ that allows to perform and track plenty different activities and gestures. This helps users to evaluate their progress and keep them reminding and motivating to move forward.

<sup>&</sup>lt;sup>35</sup> Zubov, Pavel. [n.d.]. "Wearable Technology in Professional Sports -," *Mbicycle* <a href="https://mbicycle.com/blog/wearable-">https://mbicycle.com/blog/wearable-</a> technology-in-sports/> [accessed 30 March 2022]

<sup>&</sup>lt;sup>6</sup> "NFL.Com." [n.d.]. NFL.Com < https://www.nfl.com/> [accessed 30 March 2022]

<sup>&</sup>lt;sup>37</sup> Lazzarotti, Joseph J. 2019. "As Wearable Technology Booms, Sports and Athletic Organizations at All Levels Face Privacy Concerns," Workplace Privacy, Data Management & Security

Report <a href="https://www.workplaceprivacyreport.com/2019/04/articles/health-information-technology/as-wearable-technology-as-wearable-technologybooms-sports-and-athletic-organizations-at-all-levels-face-privacy-concerns/> [accessed 30 March 2022]

EU's General Data Protection Regulation & California Consumer Privacy Act

<sup>&</sup>lt;sup>39</sup> "Cycling Shirt." 2019. *Elitac Wearables* <a href="https://elitacwearables.com/projects/cyclingshirt/">https://elitacwearables.com/projects/cyclingshirt/</a> [accessed 30 March 2022]

<sup>40 &</sup>quot;Create" "." [n.d.]. *Byborre.Com* <https://byborre.com/> [accessed 30 March 2022]



Figure 3: Apple watch Fitness+

These kind of objects surely help track and save data sets however, to what extent is it motivating people to continue performing the activity. To certain degree, the products become part of the body which keeps giving you alarms and reminders to perform tasks. However, these devices make you dependent on technology to a huge extent that without it, life seems impossible. But is being dependant on technology so bad? All these devices require certain movements that need to be captured through the device, through which it records certain data. This does not guarantee tracking each and every movement which results in an inaccurate dataset. However, these wearables have now created an important place in people's life and the regular reminders and statues updates help people work on themselves and their health.

#### 4.2 Health and Wellness

This is connected to the previous sub-chapter as sports and wellness goes hand-in-hand however, in this chapter, majorly the different diseases that can be tracked with the advancing technologies and the communication between patient and the medical practitioner will be discussed. Quoting back to the example of smart tattoos referred in chapter 2.2, that is a development that concerns the health industry largely due to its ability of capturing real-time data without any efforts or hassle of recharging the device. This technology is still under development however various prototype stages are being developed. DuoSkin<sup>41</sup>, is developing a gold metal leaf that is cheap, skin friendly and robust that can be worn and used as a digital interface which enables users to control their smart phones, display information as well as store information of their skin, on their skin.

<sup>&</sup>lt;sup>41</sup> Lab, Mit Media, "DuoSkin," *Mit.Edu* <a href="https://duoskin.media.mit.edu/>[accessed 4 June 2022]">https://duoskin.media.mit.edu/>[accessed 4 June 2022]</a>



Figure 4: Smart tattoo technology developed by DuoSkin

In the health care industry, non-invasive diagnosis is potent for medical experts as it gives them time to curate a plan of action for the treatment as well as helps experts diagnose the diseases at an early stage through the blood count. Various chronic illnesses<sup>42</sup> such as obesity, panic disorders, asthma, depression and Parkinson's disease can be diagnosed using wearable patches. A new patch developed by a team of engineers at the University of California San Diego (UCSD)<sup>43</sup> is capable of sensing microscale structures like red blood cells deep within the body in real-time. This technology can aid clinicians to identify cardiovascular problems at early stages. These patches eliminate the need for probes or other invasive equipment along with trained technician for operating them. Additionally, it also eliminates the labour involved, risking human errors and reduces any commute time because the of at-home diagnose feature.

As part of these inventions, an interesting source of energy other than batteries or solar energy comes the human body itself. Because these interfaces and discoveries do not require a large amount of energy, the movements and fluctuations in body temperature serve as a source of energy. Energy source today can be harvested using human kinetics or bodily heat exchange that is measured in microwatts which is a small amount of energy that cannot be used to drive larger energy consuming devices such as smart watch or smart glasses. However, if and when this is achieved, a true source of sustainable energy would be discovered<sup>44</sup>.

This however shreds light on many ethical concerns users may have for using one's own self to generate energy. Even though this energy is generated to use for their own self, is it still ethical for users to work in order to source energy for themselves?

<sup>&</sup>lt;sup>42</sup> DelveInsight, "Wearable Devices: Weighing the Potential Benefits and Pitfalls of the Innovative Wearable Products," *DelveInsight Business Research*, 2021 <a href="https://www.delveinsight.com/blog/pros-and-cons-of-wearable-devices-">https://www.delveinsight.com/blog/pros-and-cons-of-wearable-devices-</a> [accessed 4 June 2022]

<sup>&</sup>lt;sup>43</sup> Sutterby, Emily, "Wearable Patch Could Predict Risk of Stroke and Heart Attacks –," *Physics World*, 2021

<sup>&</sup>lt;a href="https://physicsworld.com/a/wearable-patch-could-predict-risk-of-stroke-and-heart-attacks/>[accessed 4 June 2022]</a>

<sup>44</sup> Seymour, Sabine, *Fashionable Technology: The Intersection of Design, Fashion, Science and Technology*, 2009th edn (Vienna, Austria: Springer, 2013) <a href="https://doi.org/10.1007/978-3-211-79592-7">https://doi.org/10.1007/978-3-211-79592-7</a>

#### 4.3 Fashion

Smart clothing or smart apparel can vary from expressive fashion to functionality fashion. This technology has been developing since several years and the major considerations while constructing such garments are body ergonomics, aesthetics, functionality, technology, materials, energy and recyclability<sup>45</sup>. Fashion industry has taken advantage of sensorial technology to its fullest and developments are still going on. Nadi X<sup>46</sup> is a smart yoga wear that uses haptic technology of vibrations as form of feedback. These are a set of yoga pants that allows users to customise their yoga plans and collects data directly to the connected smart phones.



Figure 5: Smart yoga pants by NadiX

This however does not capture the movement of your hand. The data collected is restricted to the leg movement. Even if there are visual and audio aids to help perform a particular yoga posture, it would not provide feedback for the overall body posture. Material of the wearable and the technological components inside it need to be durable and water proof. These factors can guestion to effectiveness of the garment. On the other hand, this garment uses three senses that enriches the experience of the activity performed. It uses the sense of vision through the mobile interface connected with the pants, audio through the option of audio

<sup>&</sup>lt;sup>45</sup> Seymour, Sabine, Fashionable Technology: The Intersection of Design, Fashion, Science and Technology, 2009th edn (Vienna, Austria: Springer, 2013) <a href="https://doi.org/10.1007/978-3-211-79592-7">https://doi.org/10.1007/978-3-211-79592-7</a> <sup>46</sup> "How It Works - Wearable Tech Company," *Wearable X* <a href="https://www.wearablex.com/pages/how-it-works">https://www.wearablex.com/pages/how-it-works</a> [accessed 4 June

<sup>2022]</sup> 

guidance and the sense of touch using haptic technology (vibrations) that gives direct feedback about their posture.

Another example is about 'sensitivity' rather than 'smart' or 'intelligent' and its representations through technology and fashion. This is a design by Phillips Design<sup>47</sup> called the SKIN probe project – Bubelle. It is called the blush dress that behaves differently and adapts to the body type of whoever is wearing it. This garments uses various materials such as Polyester, non-woven fabric, LED projectors and glass fibre rods.

The purpose of this design is to show the 'far-future' of the emerging trends in the apparel industry. This 'soft technology<sup>48</sup>' serves various functions that explores multiple dimensions of the future such as skin being the largest sexual organ, an electrical network, an input device, a chemical and optical sensor, a display, a thermal regulator and a chemical filter. Through this project, Phillips design is exploring different materials and potential functions that would emulate some of these functions mentioned above. It taps into the possibility of the world being a place with decreasing materialization and an increase of virtual functions.



Figure 6: Phillip Design – SKIN probe project (Bubelle)

All these designs look impressive, highly functional and are required in today's world, though clothing and technology have different life cycles. Fusion of these two very different products

<sup>&</sup>lt;sup>47</sup> "Phillips Design," Phillips Design <a href="https://phillips-design.com/?gclid=Cj0KCQjwheyUBhD-ARIsAHJNM-">https://phillips-design.com/?gclid=Cj0KCQjwheyUBhD-ARIsAHJNM-</a>

Ov3hWytbmxJU11UB\_Mv1yunV4dhRrj\_rQdOSgQNXHND-9IOOErypEaAgEeEALw\_wcB> [accessed 4 June 2022]

<sup>&</sup>lt;sup>48</sup> Rohan, Maiya, "Soft Technology: Characteristics, Applications and Examples," *Life Persona*, 2018

<sup>&</sup>lt;a href="https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-and-examples>">https://www.lifepersona.com/soft-technology-characteristics-applications-applications-applications-applications-applications-applications-applications-applications-applications-applications

with different lifespans can harm the environment and not reach its full potential. An average life cycle of an electronic component is somewhere between 3-3.5 years, which falls under non-frequent disposal products where as a garment/piece of clothing is disposed more frequently, say every season or every couple of seasons. These issues make the workings of these integrations difficult and challenging.

Moreover, the large scale manufacturing rate of the two items are significantly different due to its uses, customisation and demand. Garments are generally manufactured in thousands or less quantities because of its need of customisation and change in trends whereas electronic components are produced in significantly larger amounts, for cost efficiency and bulk manufacturing. The R&D phase for these components is also comparatively longer which adds on to the issue of costing and integrating the two significantly different industrial products.

Recycling these smaller components create even bigger threats for the environment as the energy for these smart fashion garments come from batteries which need to be discarded once their lifespan expires and this amplifies the environmental issue of e-waste. Due to several smaller battery outlets and circuits, more amount of waste is supposedly generated than compared to a wearable device such as a smart watch.

Lastly, an important concern that arises within this industry as well as the health and wellness sub-chapter previously, is the health implications of these electronical attachments to one's self. The problem of being around electromagnetic frequency for a long period of time and its effects on different body parts have yet to be discovered. Concerns of battery leakage or battery defect and its effect on the human skin is yet a topic of debate with any wearable device/garment. Also, what about the signals of wireless communication and its effect of the subconscious along with privacy concerns. These are all topics of concern that have yet to be addressed to the users by the scientists and other experts in the respective fields.

#### 4.4 Labour work and safety

Safety while doing labour work is one of the most crucial area where wearable technology has played a significant role. Attaching sensors and other features to enhance the experience of users while performing certain activities can significantly create a huge impact on one's life. This specifically concerns users who are working on construction site, performing laborious work, driving the motorbike or doing water sports/other sports activities. Safety becomes a crucial factor to keep in mind. Some examples are discussed below.

While riding the motorbike, safety is an important factor and hence the helmet. The sole purpose of a helmet is to protect the head if there is an accident that took place. However, this is where there is a difference between enabling and enhancing. What if helmets became smart? This enables users to perform many different functions while driving a motorbike.



Figure 7: Smart helmet by Harley Davidson

This is the Harley Davidson Boom! Audio N02<sup>49</sup> which is a smart helmet that does much more than just protect the rider's head. It would allow them to take hand-free calls, listen to their favourite playlist, have a microphone to talk on calls and some much more advanced features such as heads-up displays, integrated cameras, voice control, navigation system and emergency features<sup>50</sup>.

These features are not just to perform these functions mentioned, rather they enhance the experience of riders. For starters, users enjoy communicating with other riders, especially when riding in a group. This allows them to talk while riding without any interruptions or disturbances. The feature of Bluetooth connectivity with their smart devices further enhances

<sup>&</sup>lt;sup>49</sup> Oops!, O. K., "Boom! Audio N02 Full-Face Helmet - 98365-19VX," *Harley-Davidson* <a href="https://www.harley-live.ic/">https://www.harley-live.ic/</a>

davidson.com/us/en/shop/Boom-Audio-N02-Full-Face-Helmet/p/98365-19VX> [accessed 4 June 2022] <sup>50</sup> Cervantes, Edgar, "The Best Smart Motorcycle Helmets to Smarten up Your Ride," *Android Authority*, 2022

convaries, Edgar, The best offiant motorcycle refinets to offiant up rout hide, Android Authonly, 2 <a href="https://www.androidauthority.com/best-smart-motorcycle-helmets-1014050/>[accessed 4 June 2022]</a>

the experience of listening/changing to their preferred songs. This technology eliminates the hassle of pulling over on the road and stopping the journey. The voice command features make things much safer as the rider can keep their eye on the road while commanding different commands to perform without putting in any effort.

All these advantages come with a price. What about the cost efficiency of this product? As this product is an investment that we all hope we just need once in our life, it still serves the main purpose as protection from any accident. The target group it carters to is relatively small and the sales of this product can get limited due to its pricing point.

Even though it is claimed that due to multiple smart features the chances of safety increases, it can still be debated that due to the many virtual distractions, there can be distractions which would confuse the rider and this itself can generate a bigger distraction. Moreover, it eliminates the presence/awareness of the external environment completely, creating a bubble for the rider in a completely different world. This can cause further barriers with other vehicles and stakeholders around the rider on the road.

Lastly, this product adds up to another device that needs to be charged along with the family of smart devices. How long will one charge last for and would it be enough for one whole journey? And what would the effects of the electromagnetic frequency be on the brain? These questions are yet to be answered by researchers and scientists.

The second example for this category is the head set cameras and AI technologies attached on headsets/handsets for automatic warehouse inventory and/or construction workers to alert them for any danger in the vicinity of their presence.

Rufus Cuffs Pro<sup>51</sup> is an example that is used in the industry recently to enhance the work efficiency and eliminate significant human errors. This device works on RFID technology along with cameras attached to improve work accuracy.

<sup>&</sup>lt;sup>51</sup> "Services -," *Rufus Labs - Wearable Barcode Scanning Technology* <a href="https://www.getrufus.com/wearables>">https://www.getrufus.com/wearables></a> [accessed 4 June 2022]



Figure 8: Rufus Cuffs Pro – industrially used RFID technology

This solution enables users with no knowledge in the field to perform tasks as efficiently as an expert. It allows users to simply scan the barcode and all information related to the product/inserted on the barcode through RFID. This would be captures=d and loaded onto the inventory sheet.

Cooling helmet<sup>52</sup> is another example of enhancing experience of the user while on the construction grounds. This helmet is designed with an air-cooling fan for workers working in warm regions of the globe. This example emphasises the term 'functionality' along with 'wearable technology' and it can be used best to suit the address situation/context.

According to the use and the situation, features and functions of the products are changed. This allows users to complete the desired task efficiently and gain an immersive experience along with it.

<sup>&</sup>lt;sup>52</sup> Seymour, Sabine, *Fashionable Technology: The Intersection of Design, Fashion, Science and Technology*, 2009th edn (Vienna, Austria: Springer, 2013) <u>https://doi.org/10.1007/978-3-211-79592-7</u>

#### 5. Companies that were able to penetrate the market

This chapter discusses some famous examples of wearable technology by big tycoon companies that were either able to penetrate the market or analyse the possible reasons of failing within the market. Discussion about some product launches that instantly took over the market, reasons behind it and analysing the priorities of users in order to buy that particular product. On the other hand, analysing the possible reasons for the down fall of certain technologies will also be analysed.

#### 5.1 Apple

Apple<sup>53</sup> is one of the biggest consumer electronic company across the globe and it is of no shock if one of the best-selling wearable product is from this company. According to reports, in 2021, Apple is the highest selling smart watch company with more than 30% of the market captured<sup>54</sup>. Prior to Apple, in 2017, Fitbit was the best-selling smart watch, with a market close to 40% however, with various advancements and enhanced technologies used by the new Apple watch in recent years, the company was able to capture maximum share in the market.

How does Apple manage to be so different, so superior within such a competitive market amongst companies like Fitbit, Xiaomi, Samsung and Huawei? Primarily, the marketing of this particular product does not just talk about any other smart watch that performs numerous functions, rather, it has focused on the tagline '*It's the ultimate device for a healthy lifestyle*'. It is portrayed as a fitness buddy, a trainer and a record keeper that motivates you to push yourself to be fit. With this they promote other features such as emergency calling, phone calls, reminders, messages, notifications and other such features. Along with this, their advantage is to play with the family of products they have created along with the loyalty of certain customers who already use apple products such as iMac, Air pods or iPhones.

The strategy of tapping into the psychological need for people to be fit in this time and day is a smart move. However, this cannot be the only reason for its success. Apple has created its own world with Apple Home, Apple music and Apple pay<sup>55</sup> which keeps users loyal to their

<sup>&</sup>lt;sup>53</sup> "Apple," Apple (United Kingdom) <https://www.apple.com/uk/> [accessed 5 June 2022]

<sup>&</sup>lt;sup>54</sup> "Global Wearables Market Share 2014-2021," *Statista* <a href="https://www.statista.com/statistics/515640/quarterly-wearables-shipments-worldwide-market-share-by-vendor/>[accessed 5 June 2022]</a>

<sup>&</sup>lt;sup>55</sup> Ritchie, Rene, "Should You Buy an Apple Watch in 2022?," *IMore*, 2021 <a href="https://www.imore.com/should-you-buy-apple-watch">https://www.imore.com/should-you-buy-apple-watch</a>> [accessed 5 June 2022]

purchases as it is convenient to work on the same platform with all devices, i.e. iPhone and Apple watch.

All these benefits are further built using the aesthetics and accessories of the technology offered through the company for Apple watch. Changeable belts and customisable engraving for the watch help users build emotional connection with the product.

Lastly, the interface and user experience of the watch display along with the use of haptic technology for certain functions enhances the experience for the users. Navigating through the watch and understanding its language is comprehensive for anyone regardless of their education. Icons and memojis created for this interface separates its experience from any other smart watch.

Despite its high price point and planned obsolesce, users are still loyal to this brand and product because of these factors. Users prioritize several factors over cost and functionality is one of the main ones. Apple watch has several features which are rarely used by users however, they are still there in the newest model. But this is just to support the most used applications/features which actually create a difference in their life.

## 5.2 Google

In spite of numerous product successes in the market, Google<sup>56</sup> is a company that has suffered one of the greatest failure with its Google Glasses<sup>57</sup> in the year 2014. For the time when these glasses were launched in the market, it was a new invention and a fairly exciting one which makes you question why it failed.

<sup>&</sup>lt;sup>56</sup> "Google," *Google.Co.Uk* <a href="https://www.google.co.uk/>">(accessed 5 June 2022)</a>

<sup>&</sup>lt;sup>57</sup> "Glass -," *Glass* <https://www.google.com/glass/start/> [accessed 5 June 2022]



Figure 9: Google glasses developed in the year 2014

One of the reasons to its failure is the lack of market study and validation<sup>58</sup>. It was assumed that the product and its unique purpose for the-then time would sell itself however without any focused purpose and a clear marketing strategy, the product struggled to survive and thrive in the market. Due to the confusing context in which they were meant to be worn, its story ended at a very early stage. The assumption about 'hype' of wearing a cool pair of glasses was not able to overtake the user's actual need and concerns in the real world.

Furthermore, the cost price of the product did not really help the positioning of the product either. Because the price point was too high and the product lacked a purpose for which it was created, a clear market positioning was not made.

Additionally, they did not consider the psychology of people while wearing/interacting with the product. The situations where they would wear the glasses was assumed to be public spaces, however, they did not anticipate people getting uncomfortable wearing a piece of such technologically advanced eye-wear in front of everyone. Social adaptability played a crucial role within this context<sup>59</sup>.

<sup>&</sup>lt;sup>58</sup> Yoon, Clara, "Assumptions That Led to the Failure of Google Glass," *NYC Design*, 2018 <a href="https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-design/the-assumptions-that-led-to-failures-of-google-glass-8b40a07cfa1e>">https://medium.com/nyc-glass-8b40a

<sup>&</sup>lt;sup>30</sup> Subin, Samantha, "Is 2021 Finally the Year for Smart Glasses? Here's Why Some Experts Still Say No," *CNBC*, 2021 <a href="https://www.cnbc.com/2021/01/23/why-experts-dont-expect-smart-glasses-to-surge-in-2021.html">https://www.cnbc.com/2021/01/23/why-experts-dont-expect-smart-glasses-to-surge-in-2021.html</a>> [accessed 5 June 2022]

Furthermore, the glasses did not reach the basic requirements of any smart device in that time. Namely, the battery life was said to last only 2-3 hours which did not make them a priority for the users in any way. Even though one of the major function these glasses performed were scrolling through pictures and quickly searching pictures from the internet, if the battery life did not support, users preferred to do these function on a normal camera/phone. It particularly did not have any superior function that could not have been performed by any other smart device.

Confusion between glasses being a fashionable product or a functional one questions the existence of the whole product. Moreover, the concern of privacy played a huge role in the product's market value. Searching information on the glass screen looks fancy and futuristic, however, to what expend are people willing to do it without feeling uncomfortable? Simply, it could be said that the concept of smart glasses was ahead of time however the functionality of it was behind its time.

## 5.3 Conclusion of overall success points and reasons for failures

By analysing one of the most successful wearable of all times and analysing one of the biggest failures in the wearable industry, it has helped draw some patterns and connections to understand the priorities of user preferences and how the market can be penetrated with your design.

Firstly, one of the most important factor affecting the success/failure of the product is the story behind the product's existence. The value of the product. Value of the technology. Importance of the wearable. There are 10 different brands that sell the same product with similar feature. Then how does your product stand out? This is where the marketing strategy comes into play and the value of the product. Where does the company want to place the product and in which context do they want users to use their product in? It is essentially, like subconsciously painting a fairy-tale picture in the user's mind and making them want the experience rather than relying on the product to sell itself by the functions its offers.

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The importance of role-play and situational play is important to understand the social dynamics when the product is integrated within the existing market. This is done by placing the product within the market, testing and validating according to the time and advancement of technology in the current period. It cannot be behind of time for sure however, neither can it be ahead of time because that hinders the social dynamics.

Secondly, the costing of the product should be done keeping in mind the target audience and context the product is launched into. This is not just based on the affordance level of the target audience group, rather the competitive companies and devices that offer similar functionalities.

Ethical and privacy issues are equally important in these fast-moving world we live in today. Privacy of data and its secure storage is significant and needs to be addressed while promoting the product features.

Lastly, the user interface and experience plays a crucial role as that is what aids users to navigate and use the device. Without a comprehensive interface, all the functions and features are useless to the user.

### 6. How might wearable technology evolve in the future

Through this thesis, a range of examples were discussed to understand the needs and wants of the users, company and the environment. It touches upon various important factors that need to be addressed while talking about wearable technology and its contribution towards human life. However, these advancements and inventions are just the start. The need and awareness of these wearables have increased scientifically due to the pandemic and now that the trend has boosted, the graph will only go upwards. This mean scientists and researchers doing that much more work into developing more accurate, automated and required technologies.

There are already various technologies being developed that may influence the future of wearable technology to a great extent. These technologies include the haptic technology and the augmented reality. However, along with these advancements, comes the actual reality. The last subpart of this chapter would talk about the environmental impacts all these advancements may have and how we can move towards a sustainable future along with these advancements.

## 6.1 Haptic language

Haptic language,<sup>60</sup> which is essentially the sense of touch, has made its way into wearable technology as one of the significant triggers after visual and audio senses. The sensation of touch on the skin is one of the most powerful sensation one can feel. It could consist of pressure, vibration or stretching of skin.

This technology is relatively new however, it has been used within various devices such as the Apple watch for certain features and other smart watches. WearWorks<sup>61</sup> has developed another interesting example called Wayband. It is a wristband that guides you to your destination, using only vibrations. It is an eye-free, ear free, hand

<sup>60 &</sup>quot;Haptic Communication," Google Arts & Culture < https://artsandculture.google.com/entity/haptic-

communication/m02p3b02?hl=en> [accessed 5 June 2022] <sup>61</sup> "Wayband by WearWorks - Wayband," *Wayband by WearWorks* <a href="https://www.wear.works/> [accessed 5 June 2022]">https://www.wear.works/> [accessed 5 June 2022]</a>

free, intuitive navigation experience. This is a unique approach of using a different sense which users are not acquainted with yet.

This allows visually impaired users interact with objects and their surroundings in a completely different way. This enhances their experience of navigating on the streets without always having to use their hands.



Figure 10: WayBand developed by WearWorks. A device using haptic technology.

This language is relatively new for users which enables designers to tap into an unexplored space to use this technology in various contexts. There are endless future scopes of its uses, primarily it can help people with no visual or audio sense at all in ways that cannot be imagined. This would not just enable them to performs desired activities, rather enhance their experiences throughout because of the feedback system.

It can greatly impact the health industry as one of the advantages of haptic technology is its ability to reduce stress by 74% in 30 seconds if used correctly<sup>62</sup>. Professions like

<sup>&</sup>lt;sup>62</sup> "Haptic Technology: The Future of Engagement?," Masschallenge.Org <https://masschallenge.org/article/haptic-technology> [accessed 5 June 2022]

chiropractors and doctors can correct body postures and improve the ergonomics of sitting, standing or sleeping positions.

This technology is widely used with Virtual Reality experiences where all three senses are used to have an immersive experience. The next sub-chapter will talk about this technology and its future scopes in detail.

## 6.2 Impact of AR/VR on wearable technology

Augmented Reality/Virtual Reality is an experience in the digital world that is enhanced using different senses like audio, visual and touch<sup>63</sup>. This form of design development is widely adapted within the gaming industry to augment the experience between the virtual and physical world. One commonly known example would be PokemonGo<sup>64</sup> where virtual characters have to be spotted within the physical world and captured to gain points. Use of this technology merges the virtual and real world which helps children develop their fine motor skills along with improving reaction timing and reflexes for adults.

AR is commercialised in various creative fields where imaginative spaces have to build and shared with users. Fields such as architecture and interior designing use the means of virtual reality to display their models and aid users to experience being in the space in the digital world.

Augmented reality has created a huge impact on several industries and a lot more potential developments are believed to take place. The combination of augmented reality along with haptic technology can be used within the health industry to effectively stimulate recovery paths of patients suffering from nerve damage. It would help in interacting with situations where precision and stability is required such as pouring a hot cup of tea.

<sup>&</sup>lt;sup>63</sup> Binstock, Yoni, What Is Augmented Reality?: Everything You Wanted to Know Featuring Exclusive Interviews with the Leaders of the AR Industry (Independently Published, 2020)

<sup>&</sup>lt;sup>64</sup> Lee, John Lau, *Pokemon Go: The Ultimate Guide to Hacks, Tricks & Cheats* (North Charleston, SC: Createspace Independent Publishing Platform, 2016)

AR and haptics can help with people's mental health by sending virtual hugs in time of insolation. It would extend beyond vision and tap into the possibility of actually feeling the sensation of hug<sup>65</sup>.

Within the Sports industry, AR and haptics can be developed to understand players vital, send virtual feedbacks and help them interact with situations that would normally be difficult to create. It would not only train the players better, but also prepare them for unexpected situations through a digital platform.

To conclude, haptics and the AR world are technologies that can create a whole new universe of creative scenarios. It could train users for better performance, save users from unexpected accidents, make users experience the unexpected and help develop several skills without leaving their home.

## 6.3 Impact of climate change on wearable technology

With all the technological advancements to improvise the lifestyle of humans, it is often forgotten by designers and scientists to improvise the health of our environment. Wearable technology suggests integrating technological components with another material such as plastic, fabric or on the body. This melange of materials can impact the life cycle of both materials resulting in either one material not being used to its full potential and later, going through the struggle of separating the materials<sup>66</sup>.

Even though designers across the globe are trying to use renewable energy source where possible, the efficiency and ease of using lithium batteries dominates the choice for wearable devices. However, the use of smaller batteries in order to fit into wearables is shorter in lifespan hence, more amount of waste ending in landfills. This

<sup>65 &</sup>quot;Call for More Awareness of the Massive Potential of Haptics Technology," Future Care Capital, 2020

<sup>&</sup>lt;a href="https://futurecarecapital.org.uk/latest/call-for-more-awareness-of-the-massive-potential-of-haptics-">https://futurecarecapital.org.uk/latest/call-for-more-awareness-of-the-massive-potential-of-haptics-</a>

technology/?gclid=Cj0KCQjwqPGUBhDwARIsANNwjV4bACQZih39T5rxlfXQaxK\_K98ooVLgy5cKcbl8d8fVgPYx7SEFoAaAiiTEALw\_wcB> [accessed 5 June 2022] <sup>66</sup> "Environmental Technology," *Edinburgh Sensors*, 2019 <a href="https://edinburghsensors.com/news-and-events/impact-of-">https://edinburghsensors.com/news-and-events/impact-of-</a>

<sup>&</sup>lt;sup>66</sup> "Environmental Technology," *Edinburgh Sensors*, 2019 <a href="https://edinburghsensors.com/news-and-events/impact-of-technology-on-the-environment-and-environmental-technology/> [accessed 5 June 2022]

adds to the e-waste which has been growing exponentially with an estimate of 21% growth since 2014<sup>67</sup>. This concerns every brand and company involved in this industry.

If the growth of this industry takes place as expected in the future, solutions related to this topic need to be considered for a sustainable and regenerative development. Efforts like monitoring the greenhouse gas emissions need to be put in place<sup>68</sup>. These measurements help keep a track of the CO, CO2 and CH4 gases that are harmful for the environment. This would simply give feedback for the companies that are producing the maximum amount of wastage at different stages of manufacturing and disposal of electric components.

Data collected as form of feedback by companies can then be considered by companies to plan strategies in order to cut down greenhouse gas emissions. This process could be incentivised either at a local level or by the government. These steps can be taken at a manufacturing stage, assembly stage, community stage or disposal/end of product life stage. At each stage there is a potential of improvement that can help the world take a step towards a being a better place.

<sup>&</sup>lt;sup>67</sup> Rosane, Olivia, "This Year's e-Waste to Outweigh Great Wall of China," World Economic Forum, 2021

<sup>&</sup>lt;https://www.weforum.org/agenda/2021/10/2021-years-e-waste-outweigh-great-wall-of-china/> [accessed 5 June 2022] <sup>68</sup> "Greenhouse Gas Emissions Measurement," *Edinburgh Sensors*, 2018 <a href="https://edinburghsensors.com/news-and-events/measuring-greenhouse-gas-emissions/> [accessed 5 June 2022]">https://edinburghsensors.com/news-and-events/measuring-greenhouse-gas-emissions/> [accessed 5 June 2022]</a>

## 7. Conclusion

To conclude, wearable technology has had a long history amongst the smart gadget industry and looking at the current growth of demands, it seems like it still has a long way to go. Various innovative technologies are being development which can then be integrated with wearable technologies for different contexts and uses.

By discussing various examples, many points have been highlighted that have helped draw patterns and trends to understand its changes and potential future demands. As the title of the thesis suggests – an exploration towards contribution to human life. These points help analyse the change in human lifestyle and how wearable technology has contributed.

Wearable technology contributes towards a material free world where touch is appreciated more than the feel of objects. Objects are embedded within one's body and functions are set to perform respective jobs for the desired results.

All these innovations and advancements draw patterns that reflect the understanding of a good wearable device that has been launched in the market. An ideal wearable product would have a clear vision about where this product has to be used, context of the device, audience, where exactly is the product place in the market (be it a crowded market or a niche one), how is the product placed financially, how is the product impacting the environment, what are the alternative energy courses that can be offered, user interface and user experience of the device when interacted with it and to what extent is it safe to wear it on one's body.

Out of these points, there are factors which are still under research/study by experts however for products that are to be launched in the near future which are expected to commercialise, all these factors need to be taken into consideration. Without even one factor, the whole device can fail within one of the most competitive market spaces currently.

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