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Evolution and Impact of Smart Wearable Devices: A Comprehensive Analysis

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ABSTRACT

The popularity of wearable technologies has increased day by day. In the near future, wearable technologies are expected to become an indispensable part of our daily lives. The aim of this study is twofold. The first is the classification of wearable technologies based on their specifications and applications, such as wearable health technologies, wearable textile technologies, and wearable consumer electronics. The second aim of the study is to point out how wearable technologies will be a milestone for both the daily lives of people and the way companies do business in the future. The potential applications indicate that the future will be safer, easier, healthier, quicker, and more entertaining with wearable technologies.

Introduction:

The rapid evolution of the Internet of Things (IoT) has enabled the emergence of compact electronic and computing devices that could be embedded in individuals' bodies. These devices are known as smart wearables, wearable technology, or wearable devices. Accessing information at any time and from any location has become possible with the rise of these technologies. The wide market penetration of smart wearables has empowered individuals to monitor, store, and transfer personal information about health, physical activity, and surroundings such as body temperature, blood pressure, heart rate, calorie intake, calories burned, steps counters, sleep pattern, location, and so forth [2]. Because researchers think that people's behaviour can be changed, there has been an increase in interest in studying ways to increase physical activity levels in older adults and people with disabilities by utilising smart wearables. The ultimate goal is to reduce the prevalence of chronic illnesses and lessen the impact of disabilities. Thus, smart medical and wellness wearables have drawn academic researchers and practitioners' attention as a motivational solution for enhancing individuals' health and well-being.

The market has recently shown a great deal of interest in smart wearables like smartwatches and wristbands. The number of smart wearables shipped globally is expected to reach 302.3 million in 2023, up from 222.9 million in 2019 according to IDC. In addition, the IDC (2019) projects that the number of smartwatch shipments will rise from 91.8 million in 2019 to 131.6 million in 2023. Furthermore, according to IDC's 2019 prediction, there will be 105.3 million earwear devices by 2023, up from 72 million in 2019. According to IDC (2019), the market for smart wearables will likely continue to be supported in the future by the growing popularity of smartwatches and smart earwear devices. Thus, it is reasonable to draw the conclusion that people's willingness to use earbuds and smartwatches will rise dramatically over the next several years.

Although there are many reports claiming that smart wearables are the next big thing, the uptake and adoption of these technologies is still relatively low. Users may not get the benefits that smart wearables claim to offer. In fact, almost 50% of users would abandon their devices within the first half year of use. Therefore, it is essential for the IS and business community to gain a better understanding of smart wearables challenges and opportunities [3].

Historical Background and Evolution of Wearable Technology:

The roots of wearable technology trace back centuries, with early examples such as the abacus rings used by the ancient Chinese and navigational wristwatches worn by World War I aviators. However, the modern era of wearables began to take shape in the late 20th century with the advent of devices like the calculator watch and the Bluetooth headset. These early innovations laid the groundwork for more sophisticated wearables that would follow in subsequent decades. The turning point for wearable technology came with the introduction of the Fitbit Tracker in 2009, which popularized the concept of activity tracking and spurred the growth of the wearable fitness device market. Concurrently, the launch of the Apple Watch in 2015 marked a significant milestone, heralding the convergence of health monitoring, communication, and personal assistance functionalities in a single wearable device. In recent years, smart wearable devices have continued to evolve rapidly, driven by advancements in miniaturization, sensor technology, and data analytics. Wearables now encompass a diverse spectrum of form factors, from discreet fitness bands to immersive virtual reality headsets, catering to a

wide range of user preferences and lifestyle needs. As smart wearables have become more sophisticated and ubiquitous, their impact on society has grown exponentially. Beyond serving as mere gadgets, these devices have become integral components of modern lifestyles, empowering users to track their fitness goals, stay connected with others, and access information in novel ways.

Types of wearable technologies:

Wearable Health Technologies:

Nowadays, probably the most extensive use of wearable technologies has been carried out in the health sector. Moreover, in the literature, most of the studies related to wearable technologies are about health applications. The developments in wearable technologies are expected to lead to a paradigm shift in the health sector. In this context, academics and industry professionals have exerted a great deal of effort to design and develop wearable systems for health-related issues. The most important contribution of wearable technologies in the health sector is enabling continuous monitoring of a patient's health status and gathering real-world information about the patient. Thus, the doctors may monitor the heart rate, blood pressure, fever, and other health indicators ubiquitously and independently while the patients perform their daily routine activities. Wearable technologies can be used for the diagnosis and treatment of several diseases. Researcher claimed that wearable technologies can be used for "'telehealth,' 'telehealth are', 'telemedicine', 'telecare', 'tele homecare', 'e-health', 'p-health','mhealth', 'assistive technology', or 'geron technology'". In addition, esearcher stated that for the treatment of "congestive heart failure, prevention of chronic conditions such as diabetes, improved clinical management of neurodegenerative conditions such as Parkinson's disease, and the ability to promptly respond to emergency situations such as seizures in patients with epilepsy and cardiac arrest in subjects undergoing cardiovascular monitoring," wearable technologies can be used. Other applications of wearable technologies in the health sector are cardiovascular disease, rehabilitation, applications in Parkinson's disease, and functional assessment after stroke [4]. However, today, wearable technologies in the health sector are mostly focused on data gathering, monitoring, and the diagnosis of health problems.

Wearable Textile Technologies:

Integrating the technologies into textile products is a recent concept that enables the development of wearable electro-textiles for sensing and monitoring body functions, delivering communication facilities, data transfer, control of the environment, and many other applications. Especially, the emergence of nanofibers and nanocoatings provides unusual characteristics and leads to breakthrough changes in the textile industry. One of the most significant applications of wearable technologies in the textile industry is clothes, which can change their colors on demand or based on the biological indicators of the wearer. For instance, the researchers at Philips Company created the Bubelle Dress, which changes its color according to the wearer's emotions. In order to enhance the popularity and social acceptance of wearable textile technologies, designers should take some key attributes into consideration. These attributes are thermal management, moisture management, mobility, durability, flexibility, and sizing and fit, as well as the psychological areas of cognitive load and attention. In addition, fashion and aesthetics are the key issues that designers should focus on while designing wearable textile technologies [5].

Wearable consumer electronics:

In the literature, there are hardly any studies related to wearable consumer electronics. Consumer electronics include electronic equipment intended for everyday use. Consumer electronics are most often used in entertainment, communications, and office productivity. Major consumer electronics products are TV's, mobile phones, cameras, camcorders, music, and video players . In this context, wearable consumer electronics can be defined as electronic devices that are worn on a user's body to catalyze their daily activities. Today, big electronic companies such as Google, Apple, Samsung, Nike, Qualcomm, and Microsoft make strategic investments in wearable consumer electronics. Although there are several types of wearable consumer electronics, such as wristbands, headbands, rings, etc., the most promising products are smart glasses and watches.

The future of smart wearable devices:

Looking into the near future, wearable technologies are poised to offer numerous benefits and applications across various domains:

1. Public and Personal Safety: Wearable devices equipped with bio-sensors are anticipated to monitor brain activities, potentially aiding in crime prevention by alerting authorities to suspicious behavior. Smart glasses with specialized applications could enhance safety for drivers, firefighters, and law enforcement officers through features such as GPS-based navigation, real-time information access, and facial recognition capabilities.

2. Business: Wearable technologies are expected to revolutionize business operations, enabling virtual meetings, personalized virtual assistants, and enhanced productivity across various functions such as research, production, sales, and services.

3. Research: Wearable technologies offer researchers valuable insights by collecting real-life data through eye-tracking software, GPS-based tracking, and crowd-sourced information gathering. These technologies have the potential to inform market research, retail strategies, and production processes.

4. Production: Smart glasses can streamline production processes by providing workers with real-time access to inventory lists, navigation assistance, and optimized routes, leading to improved efficiency and cost savings.

5. Sales: Retailers can leverage wearable technologies to enhance the shopping experience through features such as virtual try-on capabilities, personalized recommendations, and indoor navigation assistance.

6. Service: Wearable devices integrated with augmented reality and data management systems can enhance customer service experiences by providing personalized information, remote assistance, and real-time troubleshooting support.

7. Tourism: Augmented reality-enabled wearable technologies offer virtual tourism experiences, allowing users to explore cities and tourist attractions remotely. Tourism agencies may utilize virtual reality tours and 3D hotel previews to aid customers in decision-making.

8. People with Impairments: Wearable technologies hold immense potential for assisting individuals with disabilities, offering features such as indoor/outdoor navigation, facial recognition, speech-to-text conversion, and remote assistance.

9. Health: Wearable devices equipped with health monitoring capabilities can continuously track vital signs and automatically alert emergency services in case of medical emergencies. Advanced wearable technologies may even administer treatment autonomously based on real-time health data.

10. Entertainment: Virtual reality head-mounted displays and motion-sensing input devices are poised to revolutionise the gaming industry, offering immersive gaming experiences and virtual amusement parks [6].

Challenges and Limitations of Wearable Technologies:

Privacy and security concerns: Wearable devices often collect and transmit sensitive personal data, raising concerns about privacy breaches and unauthorized access. Users may be apprehensive about the security of their data, especially if wearable devices are connected to external networks or cloud services. Unauthorized access to wearable devices could lead to identity theft, location tracking, or the exposure of personal health information.

Data Accuracy and Reliability:

The accuracy and reliability of data collected by wearable devices can vary significantly based on factors such as sensor quality, calibration, and user behaviour. Inaccurate data could lead to incorrect health or fitness insights, undermining the trust and utility of wearable technologies. Environmental factors and user variability may further affect the reliability of data collected by wearables, posing challenges for accurate analysis and interpretation.

Interoperability and Compatibility Issues:

Interoperability issues arise because wearable devices frequently function inside heterogeneous ecosystems of hardware, software, and networking protocols. Seamless user experiences may be hampered by compatibility problems that may occur when integrating wearable devices with other platforms, devices, or applications. Interoperability attempts are further complicated by the lack of standardised communication protocols and data formats, which limits the compatibility and interoperability of wearable devices.

Battery Life and Charging Constraints:

Battery life remains a significant limitation for many wearable devices, especially those with high power requirements, such as smartwatches and augmented reality glasses. Limited battery life necessitates frequent charging, which can disrupt user experiences and lead to inconvenience. Advances in battery technology, power management techniques, and energy-efficient designs are necessary to address the battery life and charging constraints of wearable devices effectively. Figure 1 depicts the smart wearable devices [7-8].

Figure 1 Smart Wearable Devices

Conclusion:

In conclusion, wearable technologies have undergone gradual evolution alongside advancements in electronic chips, GPS systems, Wi-Fi connectivity, the internet, computers, and sensors. These technologies find major applications in the health industry, textile industry, and consumer electronics sector. Currently, the diffusion of wearable technologies is at an early adopter stage for both society and companies. However, soon, the evolution of wearable technologies, particularly smart glasses, and smartwatches, will reach completion, and these devices will be widely adopted by societies and businesses. The objective of this study has been to highlight how wearable technologies will serve as a milestone for both the daily lives of individuals and the operational strategies of companies in the future. Wearable technologies are poised to: Ease the lives of people with impairments by helping and enhancing accessibility. Enable companies to interact more efficiently with business partners, conduct market research effectively, and implement sales and service strategies with greater precision. Enhance public and personal safety by equipping professionals like policemen, firefighters, and military members with advanced tools. Revolutionize virtual reality experiences in gaming and entertainment. Enable continuous health monitoring by healthcare professionals, leading to improved healthcare outcomes. In summary, the future holds promise for a safer, easier, healthier, quicker, and more entertaining world with the integration of wearable technologies. As these technologies continue to advance and become more pervasive, they will play an increasingly integral role in shaping various aspects of human life and business operations. The transformative potential of wearable technologies is poised to enhance convenience, efficiency, and quality of life for individuals and communities worldwide.

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