

# Exploring the Frontier: A Comprehensive Exploration of Wearable Sensor Technologies and Systems

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**Abstract --** The primary objective of this study is to explore the recent advancements and evolutionary trends in wearable sensors and systems. The focus lies on the application of wearable technology for health monitoring and the generation of corresponding reports, benefiting older adults and athletes in tracking their fitness levels. Continuous monitoring of health data facilitates the diagnosis and treatment of various ailments over time. The global adoption of wearable healthcare technology has surged, largely driven by the widespread use of smart-watches and bands. Real-time data capture enables proactive responses to health indicators, firmly embedding wearable sensors into our daily routines. Additionally, wearable assistive robots, also known as wearable robotics, have garnered attention for their role in aiding individuals with physical disabilities in daily activities and movements. The applications outlined in this research encompass health and wellness, remote health monitoring, and sports-related endeavors.

**Keywords :** Wearable sensors, Technology, Health monitoring, Fitness, Robotics.

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## I. INTRODUCTION

In the expanding realm of IT, where technology permeates every aspect of life, the use of wearable sensors has seen significant growth. These sensors are the core components of wearable devices, which are computing gadgets that can be attached to individuals, enabling them to sense, transmit, and provide information. Thanks to advancements and research, wearable sensors have become affordable and user-friendly. This technology has revolutionized many aspects of human health, making it possible to monitor health conditions from home. This field has garnered significant attention as these sensors are worn on the body and exhibit a very low failure rate. However, this adoption requires innovations in miniaturizing sensing technology, ensuring comfort, and achieving precise data measurement. The integration with smart mobile devices has further propelled the development of wearable devices, offering numerous benefits to users. In our daily work routines, wearables could play a crucial role in a connected workplace, allowing individuals to stay connected with one another.



Figure No.1

The primary goal of any healthcare wearable sensor is to develop a system with medical and assistive technology to provide long term care. The data generated by sensor can provide excellent value to healthcare and capable of providing insight into wellbeing of any person. This technology offers an efficient and cost reducing solution that allows everyone to live in their comfortable home instead of expensive healthcare facilities. Now-a-days organizations tracks their employee health with these wearable technology as a part of their health program. Some schools in China also uses wearable technology. Their students wear uniforms with chips that tracks their location which is useful if any student is lost. They use headbands to calculate concentration level and teacher gets information about that on computer. There are multiple types of wearable device available in the market. Everyone has their own features, but the most important thing is that they collect useful data.

**II. PROBLEM DEFINATION**

To analyze the impact of wearable sensors and system on human health and its future. This study is based on reviewing various research papers of different authors, understanding their views and opinions on the subject and conducting survey analysis.

**III. LITERATURE SURVEY**

Table No. 1

Sr. No.	Paper title	Author	Year	Advantages	Limitations
1	<b>A review of wearable sensors and system with applications in rehabilitation</b>	Shyamal Patel	2012	Proper explanation about health monitoring	Rehabilitation technique is not briefly explained

2	<b>Wearable sensors and system</b>	Paolo Bonato	2010	Rehabilitation with robotics explained very well	Lack of information about fabrication technique used to produce flexible material
3	<b>Wearable sensor-based Human Activity Recognition in smart healthcare system</b>	Fatemeh Serpush	2021	Proper examining and analyzing of survey related to HAR	Smart healthcare system is not briefly explained
4	<b>Materials for wearable sensors</b>	Mudassar Abbas	2022	Sensing material, flexible material, electrode substrate explained well	Lack of information regarding 2d materials.
5	<b>Wearable sensors in healthcare and sensor-enhanced health information system: All Our Tomorrows?</b>	Michael Marschollek	2012	Applications of Sensors in healthcare Explained very well	Sensors and technology related to healthcare are not addressed

Table No.1

As shown in Table No. 1, Shyamal Patel in “**A review of wearable sensors and system with application in rehabilitation**” explained about human health monitoring with wearable sensors with key enabling technologies and applications. Techniques of rehabilitation are not explained briefly.

Paolo Bonato in “**Wearable sensors and system**” explained working of wearable sensors with robotics which is called as wearable assistive robots which are designed to help humans with disabilities for rehabilitation. Information regarding fabrication technique used to produce flexible material is not given.

Fatemeh Serpush in “**Wearable sensor-based Human activity recognition in smart healthcare system**” properly explained term of human activity recognition (HAR) with challenges of HAR and tools related to it. Analyzation of survey related to HAR has done properly.

Mudassar Abbas in “**Materials for wearable sensors**” proper information about recent advances in the use of material used in sensing element, flexible substrates and electrodes for wearable sensor is given Importance of metals and good material is addressed. Information regarding 2d materials are not given.

Michael Marschollek in “**Wearable sensors in healthcare and sensor-enhanced health information system: All Our Tomorrows?**” explained applications of sensors in healthcare in well manner. The future need of healthcare with wearables is explained. Although sensor related to healthcare are not explained.

#### IV. TYPES OF WEARABLE SENSORS

The wearable sensors are classified into two categories. flexible and non-flexible sensors.

### 1) Flexible sensors

Flexible sensors are made up of fabric material and can acquire desired shapes. The sensors which are light, comfortable are mostly preferred to wear on body. These sensors are portable as well as inexpensive due to the low production of hardware. They are compact, easier to use, and they often have a much faster response time. There are many fabrication techniques available to produce flexible sensors like screen printing, laser painting, weaving, Photolithography. Due to their higher sensitivity and bendability, flexible sensors are dominant compared to non-flexible sensors.

### 2) Non-flexible sensors.

Non-flexible sensors are rigid, made up of hard, heavy plastic and metal. The non-flexible sensors are most used wearable sensors. Due to their availability in smart bands, the market of non-flexible sensors is more than that of flexible sensors. The non-flexible wearable sensors have some disadvantages like intransparency and stiffness. Due to stiffness, the accurate measuring is difficult.

## V. Applications

### 1) Health and Wellness:

During the period of covid-19, we have seen that our health should be our priority. As the hospitals were full of patients, people who were in doubt about their health started using SpO2 devices. The wearable device used to monitor SpO2 in real time & temperature continuously. The wearable SpO2 monitor provides continuous tracking of patient's oxygen saturation levels without manually starting a reading. As this sensor is now available on many smart bands because everyone is becoming more health-conscious. The remote health monitoring is the biggest usage of wearable technology. As the Internet of Things (IoT) is growing, there are many products, sensors, and equipment's being developed to monitor health at home. Health-related information is collected from movement, which enables patient's health monitoring. This information is collected from body-worn wireless sensors and transmitted to caregivers such as home i.e., family and doctors through the internet. Doctors can monitor this health-related information and generate their reports on its basis. This technology is often useful in case of heart failure. This technology is consisting of three parts:

1) sensing and collection of data through movement 2) The communication system to transfer the data 3) the data analysis technique to generate report.

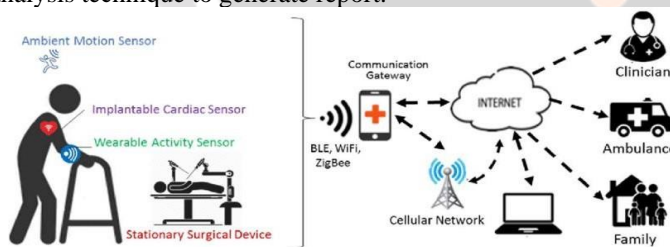
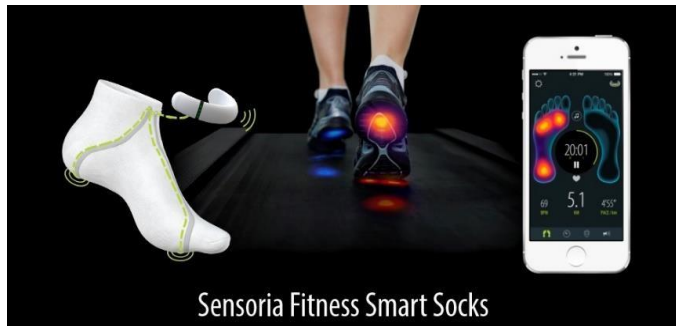


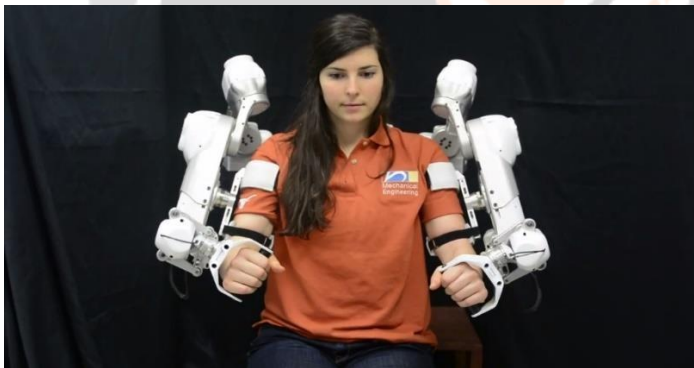
Figure no.2

### 3) Sports

The industry of wearable sensors and technology has grown so much that it has an impact everywhere. Athletes need to monitor their health everywhere as well as performance. A pedometer is the most commonly used sensor. A pedometer is used to count the steps. This sensor is useful as athletes can track their daily activity. An accelerometer is used to measure acceleration and fall detection. The managers of rugby teams use accelerometers for their players' injuries. Swimmers use smart swim goggles which have features like heads-up display to allow them to track their progress by letting them know data like speed, distance. Thus, this technology helps to improve performance for athletes. We can say that the future of sport is smart. The next generation athletes will achieve their fully potential with this smart wearable technology.

**Figure no.2****3) Rehabilitation and robotics**

Wearable assistive robots designed to help humans which are physically disabled to Perform their daily task. This rehabilitation robots help therapist to perform exercise beneficial for their body. Many conditions like stroke, brain injury affects the ability to walk Robot assisted gait training is used in rehabilitation of these conditions, for example due to any condition if any person cannot move their hands, then this robot assistive devices helps him to move that brady part. The research is going to Make perfect, wearable robots that has ability to learn from user and adapt them to perform certain task.

**Figure no.3**

**VI. SURVEY ANALYSIS**

The survey was designed specifically to gather data regarding public opinion about wearable sensors and technology. This survey was conducted using Google form. In google form different questions were asked more than 120 people participated in survey. In this survey following questions were asked: -

Have you ever purchased any wearable sensors ? i.e. smartwatch, fitness band  
123 responses

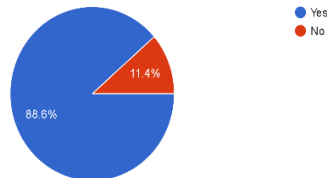


Figure no.4

when this question was asked 88.6 % people have purchased smart wearable devices and 11.4 % people haven't purchased any wearable devices.

Do you think early detection of diseases are possible with wearable technology ?  
123 responses

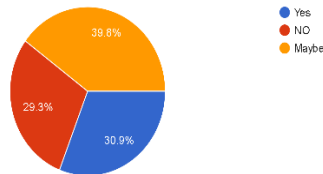


Figure no.5

When this question was asked 39.8% people thinks maybe early detection is possible while 30.9% people thinks it is possible and 29.3% people thinks it is not possible.

How often do you wear your wearable devices ?  
122 responses

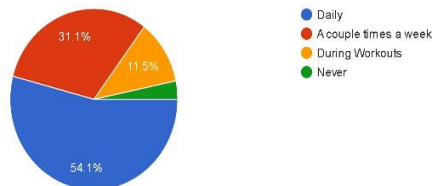


Fig no.6

When this question was asked 54.1% people use it daily 31.1% Couple times a week and 11.5% people during workouts.

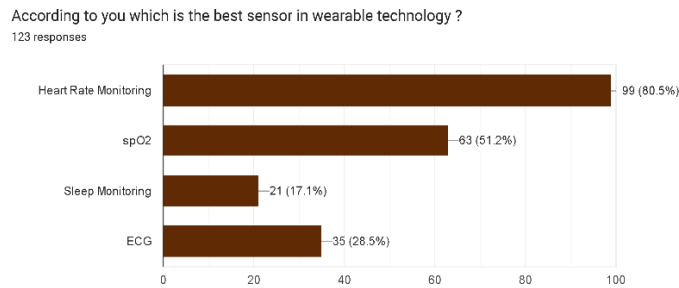


Figure no.7

According to figure 8 most people prefers heart rate monitoring sensor then SP02 followed by ECG and sleep monitoring.

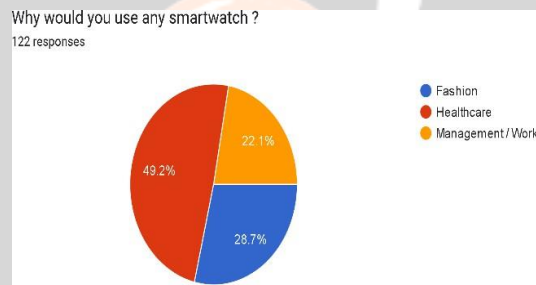
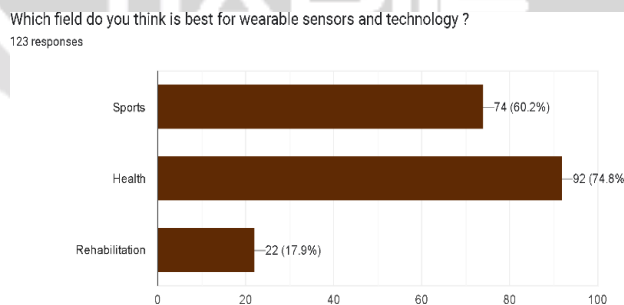


Figure no.8

when this question was asked 49.2% people use wearable devices for healthcare, 28.7% for fashion and 22.1 for work.



As shown in above people thinks best field for wearable sensor is health followed by sports and rehabilitation.

### VII. Conclusion

Due to rapid growth in technology wearable sensors are becoming more common. we must adapt the Functionality of wearable have impact on every field such as sports, health monitoring, rehabilitation. This technology is important to have challenges. Smart band manufacturing companies are going to introduce more Sensors in smart bands. We have witnessed

the growing interest to look smart and fit have massive impact on the market of wearable sensors. wearable sensors are potential to monitor patient's health at home and early diagnosis of various diseases are possible. Rehabilitation with robots is getting more responses as patients are recovering faster. In the metaverse of virtual reality the Sensors in basic VR system such as accelerometer, gyroscope and magnetometer are becoming more advanced.

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