ISSN No:-2456-2165

A Review of Wearable Sensors In Medical Electronics

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Abstract:- **Wearable devices plays a major role in uplifting the life quality of bed ridden patients. It is becoming a favorite comrade of health conscious people also. Several sensors are used for monitoring the various biological signals of patients suffering from illness like neurological disorders, physiological limitations etc. In this paper sensors, which forms the heart of wearable devices are reviewed. It also discusses the challenges in wearable technology.**

Keywords:- *Wearable Devices,Sensors,Smart Clothing.*

I. INTRODUCTION

Increasing user demands and developing services has pushed Information and communication Technology (ICT) to grow seamlessly .Internet of Things or simply IOT is a network of Physical objects. These physical objects are embedded with softwares sensors and other technologies. The Purpose of IOT is to exchange data between devices through internet. Availability of Consumer and Medical devices equipped with wearable sensor technology has grown over the years. These devices can provide real-time feeds about an individual's health status. These devices find it's use in manage/monitor chronic disease progression (elderly, within rehabilitation, and for those with various disabilities)[2]. Wearable electronics can be defined as the "Devices that can be worn or mated with human skin to continuously and closely monitor an individual's activities, without interrupting or limiting the user's motions [3].

Wearable device are used mostly in construction/building, logistics and healthcare industries. Health condition of elderly people and patients with chronic illness can be easily monitored using wearable devices. Safety of workers like heatstroke prevention while working outside under the sun and sleep monitoring to alert drivers are some of the use cases in constriction/building and logistics industries. According to IDTechEx research (In July 2016) the market of wearable technology will reach over $30bn.

Then continue to grow in three stages:

1st Stage - A limited but two-digit growth of 10% growth until 2018 when the market would be worth over $40bn
2nd Stage - An accelerated growth with a yearly growth of 23% through to over $100bn by 2023
3rd Stage - Slower growth (11 %) to reach over $150bn by 2026 [4].

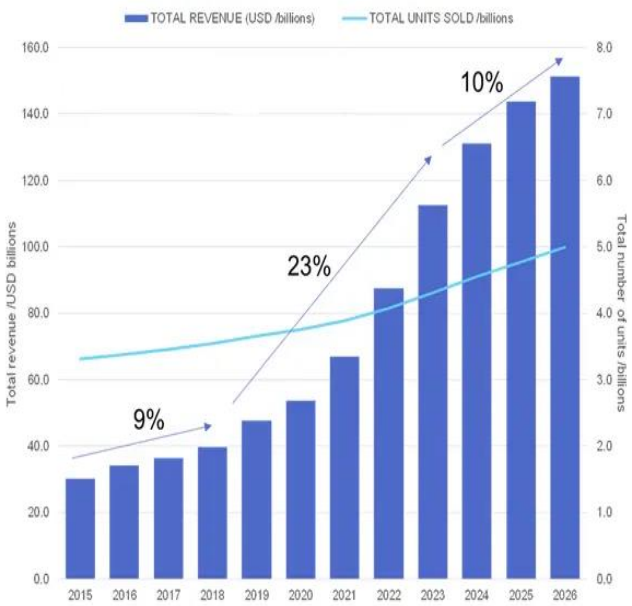

Fig 1.1 Wearable devices Forecast [4]

From sports and recreation to biomedical verity of applications uses human motion detection. Recent times, consumer electronics has used different semiconductor-based tracking tools to allow customers to access various kinds of interface control that use body motions and gestures. But , due to need for high accuracy in the biomedical field, these devices are not typically designed only for medical application. Veltink and Boom introduced an initial concept of using uniaxial accelerometer sensors in motion tracking 1996[5]. Different clinical studies have been conducted on posture estimation using accelerometers for introducing the concept of motion tracking.[6]. To improve precision of motion tracking , researchers incorporated the concept of semiconductor based gyroscopes with accelerometers which results in easier biomechanical assessments. Once the trackers are more reliable by using an integrated gyroscope , the main focus for clinical application using inertial motion tracking was gait analysis. For using this device for clinical needs , and for gait motion, gravity sensitive accelerometers are used to estimate the tilt angles between gravity vector and sensor's axes. Rotenberg proposed the initial version of the integrated sensors (accelerometer, gyroscope and magnetometer) which provide very accurate data with 9 DoE in 2006. Rotenberg proposed by using a set of tri-axial accelerometers, tri-axial gyroscopes, and a magnetometer to estimate and monitor human motion [3].

ISSN No:-2456-2165

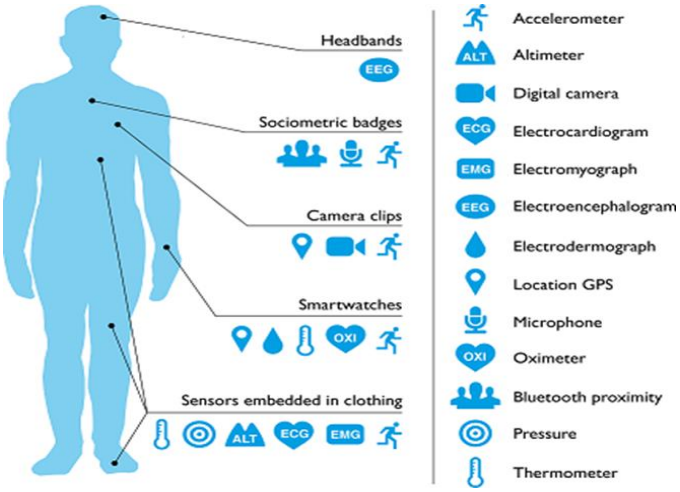

Fig 1.2: a human body with location of multiple wearable devices.

The figure shows a human body with location of multiple wearable devices. Head bands usually embed EEG which provides details of brain waves of patient. Devices like smart watches are fused with Accelerometers, Location GPS, Oximeters, Thermometers etc. .These type of wearable devices closely correlates with modern man's life style.

II. SENSORS USED IN WEARABLE TECHNOLOGY

➢ *Accelerometers*

Accelerometers are sensors used in wearables. Their brand of acceleration, such as gravity and linear, demonstrates their sensing capabilities. The measuring capability of the accelerometers helps the programming of measured data for multiple use cases. For instance, a user who runs can access their maximum speed output along with acceleration. Further, they can track sleep patterns.

➢ *Gyroscopes*

Gyroscopes are also a common wearable sensor. They differ from accelerometers by recording only angular accelerations. In some implementations, the accelerometer is used to measure rotational acceleration, while some systems would like to incorporate both for filtering errors. Precision of the data tracked can be increased by using gyroscope. Different types of gyroscopes are available like gas bearing , mechanical and optical.

➢ *Magnetometers*

Magnetometers can be integrated to create an inertial measurement unit (IMU) with accelerometers and gyroscopes. All of these sensors can feature three axes each, are very similar to a compass and can improve balance. Magnetometers are used for filtering the motion orientation.

➢ *Heart rate sensors*

Various techniques and sensors are available for measuring heart rate. One method uses capacitive sensing to idealize the electrode (sensor) and the skin as two parts of a conventional capacitor. A technology used with light to track blood flow volume changes is Photoplethysmography. Fitness trackers like Fitbit rely on this approach using a photodiode. There is a continuous green light transmitted to the skin of the wearer, which measures the light absorption by the photodiode. This information is transferred so that pulse can be calculated. If there is an increase in the blood passing through the user's bloodstream , then the diode will absorb more light.

➢ *Pressure Sensors*

Usually, pressure sensors operate from strain gauges. When pressure is applied to sensors, the circuit causes a change in resistance. Mechanical quantities like force are observed in many ways and are transformed into resistance-dependent electronic measurements. This method of measuring pressure is achieved through the construction of a Wheatstone Bridge, which can track static or dynamic resistance changes. The sensing device will comprise one, two or four arms in the configuration of the Wheatstone Bridge. The number depends on the use of the device (how many in tension and compression). The sensor mechanism allows them to be integrated into external factors such as ball contact monitoring equipment.

Table 2.1

Types	Location	Application	Accuracy	Available devices
Motion Sensors 1) Accelerometers 2) Gyroscopes 3) Magnetometers	Arm, Leg	Fall risk assessment, Sports Field, Monitoring the elderly.	99% [3]	Activity Monitors , Smart Clothing, Fitness Bands , Sports Gear, Smart Watches
Temperature Sensors	Skin	Monitoring of Blood Sugar , Delivery of Drug and absorption, wound or malignant tumor changes.	94% [3]	Smart watches Bio Stickers
Heart Rate Sensors	Wrist, Finger tip	Cardiovascular Care,Body Fitness	94% [3]	Smart Watches, Fitness Bands
Pressure Sensors	Skin	Fall Risk Assessment, Assessing Altitude Change.	94% [3]	Smart Watches, Smart Band, Smart Phones
Pulse Oxygenation Sensor	Wrist, Finger tip	Detecting Sleep Apnea, Monitoring oxygen saturation in blood	94% [3]	Fingertip Oximeters , Ring type Oximeters

III. SMART CLOTHING

Smart clothing is one of the booming areas of wearable technology which includes garments and footwear with integrated sensors that transmit biometric signals. According to Global Data forecast, smart clothing market is expected to expand to over $4bn by 2030. Smart clothes incorporates interwoven circuitry which captures the bio signals like heart beat, blood pressure etc and they can interact with mobile apps. They can also connect using WiFi or blue tooth to laptops.

Some of the of Use cases of modern world smart clothing includes.

Smart shoes: Limited-edition tech sneakers were introduced by Pizza Hut that can order pizza.

Smart work clothes: Some of the successful companies that makes smart clothing are Clim8,Under Armour , Athos, Jabil etc . Clim8 ‘s technology provides thermoregulation to its customers by means of digital automation in smart clothing. By wearing the smart apparels users can track their thermal needs and system can keep the user in optimal thermal comfort level.

A smart business suit designed by Samsung can exchange digital business cards. Another smart apparel company Under Armour operates a digital fitness app called ‘Map MyFitness’. Smart apparels of Athos read the body's vital signs and transmits that information to a software application. This enables athletes and coaches to get actionable insights regarding athletic training and movement quality using personalized, muscle activity data. Thus this smart apparel is ideal for work out sessions.

Smart sleepwear: An athlete recovery smart sleepwear produced by ‘Under Armour’ absorbs heat from the individuals body while releasing infrared light to increase gradually sleep quality and improve faster muscle recovery.

Smart activewear: A PoloTech T-Shirt from Ralph Lauren interact with an app to record fitness related activities and suggest new workouts to the users.

IV. CHALLENGES IN WEARABLE DEVICES INDUSTRY

New developments in the fields of semiconductor technology and electronics has triggered the growth of wearable devices. A wearable device has sensors, power source, data processing units, actuators and displays and a communication interface packaged together in a small and lightweight device that is worn on human body or it can be integrated with everyday wearable items (clothing, footwear, accessories). Wearable device should be designed to provide the user with highest performance , for less power , small space and most challenging environment. The various challenges that encounter in wearable devices industries may be

- *Battery technology*

Existing types of wearable batteries include Alkaline Batteries, Lithium-Ion (Li-Ion) Batteries, Nickel-Metal-Hybrid (Ni-MH) Batteries, Lithium-Ion Polymer (Li-poly) Batteries, TENGs or triboelectric nanogenerators etc. The energy-harvesting technology or power harvesting technology is an emerging area in battery technology. Here energy from external sources such as heat, light, vibrations, radio waves etc are harvested using appropriate techniques and suitable transducers are used to convert the collected energy into electrical energy.

- *Data Collection &Processing Issues*

Wearable industry involves collection and analysis of big data. A smooth interoperability of data is required without compromising the data privacy and accessibility of patient’s data. Since there is no control over the devices and data permissions, users cannot shutdown a sensor individually or stop data collection. This makes it difficult to authorize viewing and use of data. While transmitting data, the MAC address of the devices is fixed and a simple data format such as JSON is used to transfer data or images and this process lacks multiple encrypted data blurring measures. Careful attention is required while storing big data and provenance, specifically when terabytes of health data are expected to be generated over a patient’s lifetime.

- *Potential Health Problems*

Continuous wearing of these wearable devices especially in case of bedridden/elderly people can cause health issues as these devices completely rely on Wi-Fi networks or similar technologies. As these devices passes the user’s bio signals over a network to a monitoring console ,certain radiations would be emitted .These radiations may adversely affect the user and thereby the wearable devices industry itself.

- *Data Security*

Data security is a key factor that should be considered while dealing with wearable devices. Unfortunately a lot of issues like eavesdropping attack and spyware, Wi-Fi hijacking , Phishing etc poses roadblock in transparency of wearable networks. As an example , BTLE (Bluetooth Low Energy) technology leaks happened in ‘Fitbit’ Devices which compromised user security.

- *Fashion*

Some sections of the society, particularly youth are treating wearable devices as fashion accessories. Smart watches and googles are todays trend. As the interests of the people constantly changes ,the wearable devices industry should cope up with their changing needs.

V. CONCLUSION

Wearable devices has evolved a lot in upgrading the life quality of various sections of people. Various sensors ,its location of placement ,applications and currently available wearable devices in which sensors are integrated are summarized in a tabular format.. The paper also encloses the possibilities of smart clothing technology ,which is one of the booming areas of wearable sensor Technology. It also

discusses the various challenges encountered in wearable devices industry.

REFERENCES

[1]. A Ometov, Viktoriia Shubina, "A Survey on Wearable Technology: History, State-of-the-Art and Current Challenges", Computer Networks Volume 193, 5 July 2021.
[2]. Vini Vijayan,1,* James P. Connolly,1,* Joan Condell,2 Nigel McKelvey,1 and Philip Gardiner3 Carlo Massaroni, Academic Editor"Review of Wearable Devices and Data Collection considerations for Connected Health", MDPI Journal, Published online 2021 August 19.
[3]. Mostafa Haghi, MSc1 , Kerstin Thurow, Dr. Ing. Habil1 , Regina Stoll, Dr. Med. Habil ,"Wearable Devices in Medical Internet of Things: Scientific Research and Commercially Available Devices",Pubmed Central ,Published online 2017 Jan 31.
[4]. I-SCOOP, Wearables Market Outlook 2020: Drivers and New Markets, 2016,[Online] https://www.i-scoop.eu/wearables-market-outlook-2020-drivers-newmarkets/.
[5]. Veltink PH, Boom HB. 3D movement analysis using accelerometry theoretical concepts. In: Pedotti A, Ferrarin M, Quintern J, Reiner R, wearable devices industryeditors. Neuroprosthetics: from basic research to clinical applications. Berlin: Springer; 1996. pp. 317–326
[6]. Foerster F, Smeja M, Fahrenberg J. Detection of posture and motion by accelerometry: a validation study in ambulatory monitoring. Comput Human Behav. 1999;15(5):571–583.
[7]. Smart Clothing (Wearable Tech) – Thematic Research, March 31, 2021 Report Code: GDTMT-TR-S301.
[8]. Dawei Jiang and Guoquan Shi "Research on Data Security and Privacy Protection of Wearable Equipment in Healthcare", Journal of Health care Engineering"Published online 2021 Feb 5.