ANALYSIS OF WEARABLE SENSORS TECHNOLOGY FOR HEALTHCARE MONITORING SYSTEM TO OVERCOME TRADITIONAL PRACTICE

Abstract

Health care is one of the primaries required for an individual to stay fit in this world. To have the pleasures of life one needs to ensure a healthy body. Every individual needs health care at some point of its life accidentally. Health care eventually has its importance. Recent study shows that the expenditure on health care through traditional ways is beyond the reach of a common man. People who cannot afford medical care either have to bear the illness/ injuries or opt for some cheaper treatments making a compromise with their health. With the invention of wearable sensors and their application in the health care sector one may overcome the financial difficulties and hassle free monitoring the health. This article portrays a transition from traditional practice of observing various parameters crucial in healthcare to wearable sensors adoption. With the advancements in technologies, wearable sensors are trying to lay down promising outcomes in medical sector.

Keywords: Traditional ways, temperature, heart rate, glucose level, oxygen saturation, blood pressure, respiratory rate, wearable sensors, wrist bands, smart watch, Fitbit, chest strap, FBG, EPW, pulse oximeter, skin-worn glucose biosensors.

Author

Dr. Shaikh Adiba
Assistant Professor
Dr. G.Y. Pathrikar College of Computer Science and Information Technology
MGM University
Aurangabad, India

Dr. Naziya Haider Pathan
Assistant Professor
Maulana Azad College of Arts, Science & Commerce, Aurangabad
nazi.pathan@yahoo.com

Dr. Almas M. N. Siddiqui
Assistant Professor
Vivekanand Arts Sardar Dalipsingh Commerce and Science College,
Aurangabad
siddiqui.almas29@gmail.com

Tashfin R. Ansari
Student,
Dept. of Computer Science
University of New Heaven
CT, USA
tashhu24@gmail.com

I. INTRODUCTION

Health care is one of the primaries required for a person to live fit on this World. To have the pleasures of a lifestyle one wishes to ensure a healthy frame. This can be completed through everyday checkups, simpler get entry to hospital therapy if unwell or injured in an effort to prevent further extreme illness, and, routinely imaginative and prescient dental examinations.

Every individual needs health care at some point in their life accidentally. Health care eventually has its importance. A recent study shows that the expenditure on health care through traditional ways is beyond the reach of a common man. People who cannot afford medical care either have to bear the illness/ injuries or opt for some cheaper treatment making a compromise with their health. Thus, the escalating health care cost is becoming a major concern. With the invention of wearable sensors and their application in the health care sector, one may overcome financial difficulties and hassle-free monitoring the health. In this article, we first discuss traditional ways of health monitoring and wearable sensor application in the medical field. We also try to forecast the shortcomings of traditional methods over wearable sensors in the health care sector and the appropriate usage of wearable sensors to get an accurate result.

II. KEY PARAMETERS TO MONITORING HEALTH CONDITIONS AND TRADITIONAL PRACTICES

The following are the crucial parameter which requires regular monitoring. These key factors indicate variations in patient's health condition and give an alarm to immediate medical attention in case drastic change crossing the acceptable range is observed.

Heart rate
Blood pressure
Glucose level
Oxygen Saturation
Temperature

1. **Heart rate:** Associate in nursing individual's vital sign helps to see the extent of their fitness. The timely observation vital sign will avoid life threatening unhealthiness. The yank Heart Association describes the traditional sinus 60 minutes as between sixty and a hundred mm. [1]. The relaxed state of heartbeat is remarked resting vital sign. Lower the resting vital sign bigger the fitness and health. A standard resting vital sign of a trained contestant is around forty beats per minute. The low reading of a resting heart signify a healthy heart functioning. The growing increasing proof suggests that vital sign doesn't just predict outcome however that accrued vital sign is also a real vas risk factor; that's, it should be a causative determinant of upset. In fact, cardiovascular disease meets several of issues projected by Sir pressman Hill in 1965 for outlining a real risk factor [2]. To assuredly signify vital sign as a vas risk issue, proof that lowering vital sign reduces vas risk is needed. Such proof is out there looking back from studies of beta-blocker use once myocardial infarct [3, 4]. Therefore, uncommon variations of the heartbeat decision upon immediate doctor's attention.

2. **Blood pressure:** Raised vital sign may be a leading danger issue for acute heart condition, stroke, and coronary heart condition. Elevated BP is absolutely correlated to the chance of movement and anatomical structure of heart condition. Aside from coronary heart condition and stroke, its abide by embrace cardiopathy, marginal tube unwellness, nephritic harm, tissue layer hemorrhage, and damage[5]. Associate in nursing elevated vital sign is commonly remarked as cardiovascular disease. Through medical specialty studies in several countries it's been legendary that cardiovascular disease ends up in higher risk of heart attacks, strokes, uropathy and pre-eclampsia (a dangerous condition associated with most powerfully with high blood pressure) in pregnant ladies. Close to 7.Five million deaths or 12.8% of the whole of all annual deaths global occur way to excessive important sign [5]. Generally men are at additional risk of being hypertensive than female. Increasing age is verified to be associated in nursing freelance risk issue for cardiovascular disease [6]. Arnold et al found that Essential signal varies with time of day, emotion, strain, and exercise, and perhaps a straightforward part of every vas medical examination. The accrued weight of proof linking elevated critical signs and symptoms to vas and all-cause mortality, even in seemingly wholesome people, makes a sturdy case for it to be concept approximately within the evaluation of vas danger[7]. Conformist to World Health Organization (2015), the general presence of cardiovascular disorder in Asian u . S . Become 23.Five% and gender-specific incidence changed into 24.2% and 22.7% a few of the boys and women, severally[8]. It's thus essential to accurately activity vital sign to the hindrance and treatment of blood-pressure–related diseases. The worldwide customary approach to measure vital sign in clinical apply and medical analysis is by diagnostic technique victimization the mercury pressure gage. This can be done by wrapping associate in nursing expansive bladder cased in a very non expansive cuff, round the arm or leg and inflating it till the pressure on the cuff is bigger than the vital sign within the artery, and therefore the artery is occluded. There are 2 blood pressures pulsation and beat that has got to be ascertained whereas observation. The pulsation vital sign is that the peak pressure at every heartbeat whereas the beat vital sign is that the fugitive rest between every heartbeat. A typical reading could be 120/80 mmHg. Cardiovascular disease measurements through mercury pressure gage would like correct activity of the device by the Doctor Patients are possible to visualize their vital sign by visiting their clinic that isn't continuously attainable.

Glucose level: Glucose (sugar) is the primary source of energy to the body to do physical and mental activities. The food we eat is broken down into glucose and is released into bloodstream to supply energy to the body. This is actually known as blood glucose or blood sugar. While the blood sugar rises up, it is signaled to the pancreas to release insulin. Now insulin acts as a key to release the blood sugar into the body's cells for use as energy. As it is very important to have an abundance of energy from blood glucose, it is also essential to maintain blood glucose level within the specified range in order to stay healthy. When blood glucose persistently remains high, it leads to a health condition called as diabetes mellitus. Diabetes is a long lasting condition that affects how your body turns food into energy. It is an inability of our body to either to produce enough insulin or make proper use of insulin produced as a consequence much blood sugar stays in the bloodstream. The body behaves abnormally when blood glucose level goes either very high or very low. Hyperglycemia is high blood glucose while hypoglycemia is low blood glucose. Diabetes mellitus is a profound disorder of metabolic diseases, characterized by recurrent or persistent hyperglycemia [9]. In accordance with [9, 10], in

2013, nearly 382 million human beings were found with diabetes mellitus around the world and type 2 accounted for maximum of the cases, which is approximately eighty three percent of the adult population with equal rates in both women and men. It is usually believed that the principal chance factors for growing diabetes mellitus are encapsulated in the complex interactions between genetic, mental, and social environments inclusive of certain human leukocyte antigen genotypes, and weight problems originating from immoderate eating and reduced physical interest [11, 12]. The classical signs of DM are frequent urination, improved thirst, elevated starvation, and weight reduction, and it's far frequently accompanied via corresponding headaches, together with diabetic ketoacidosis and nonketotic hyperosmolar coma, coronary heart sickness, ischemic stroke, kidney failure, foot ulcers, and damage to the eyes [13, 14]. Ischemic stroke, additionally known as cerebral infarction, is a consequence of a blockage inside the blood vessels supplying blood to the brain [15]. During Pregnancy, changes in blood sugar levels result in delivery defects inside the fetus, an increase in the rate of miscarriages, overgrowth of the fetus leading to obstructed delivery, the low blood sugar stage within the introduced infant, and volatile deliveries [16]. Hence regularly watching blood glucose stages can prevent diabetes complications together with heart assault, stroke, kidney disease, blindness, and amputation. But this requires touring hospitals regularly.

Oxygen saturation: An oxygen saturation proportion larger than ninety fifth is taken into account to be a traditional reading. If you see a score of ninety two or less, then it may well be time to additional investigate, associated resolve whether or not it's associated with an heretofore undetected health issue. John Hopkins drugs explain how measure oxygen levels through pulse oximetry offers insights into a variety of health connected problems. It is accustomed check whether or not somebody desires help with their respiratory via a ventilator, live an individual's ability to handle intensive physical activities, and it may also check whether or not one is experiencing respiratory problems while sleeping. COVID-19 has place the main focus on blood oxygen on the map, however really, there are several less extreme reasons to stay a watch on blood oxygen levels. Athletes or individuals outlay time at altitude can wish to observe blood oxygen levels. However, it's sleep disorder that actually makes SpO2 a worthy sensing element. it is a disorder that if left untreated or undetected could lead on to a rise within the risk of high pressure, fatness and might even cause a heart failure. With the widespread use of pulse oximeters in operational rooms, perioperative hypoxemia became discovered to be an alternative greater common than antecedently suspected[17] And, despite the dearth of precise evidence, the generalized use of pulse oximetry (SpO2) has in all probability decreased perioperative morbidity and mortality. Pulse oximetry may be a standard reveal in scientific useful resource gadgets (ICUs) presently used for manual therapeutic interventions [18]. Hewlett Packard was the primary company to create an ear measuring device that was mostly used inside clinical sleep labs because of its large size. Japanese bioengineer Takuo Aoyagi, within the early 1970s, WHO (World Health Organization) 1st developed a noninvasive manner of victimization the light transmitted through the ear and went on to develop a pulse measuring device. From then up till nowadays, the scale of the tech has become smaller and – crucially – cheaper to make, thus additional individuals were able to get their hands on that.

Temperature: Fine and round-the-clock catchingof vital sign is additionally critical to observance a large vary of alternative health status, together with vessel diseases, pneu-

monic medication, and alternate symptom [19- 22]. The traditional vital sign of an individual varies counting on gender, recent activity, food and fluid consumption, time of day, and, in women, the stage of the cycle. The traditional vital signs will vary from ninety-seven.8° F (36.5°C) to 99°F (37.2°C) for a healthy adult. Somebody's vital signs are often taken orally, rectally, in the cavity by a digital measuring instrument, by ear and skin exploitation special thermometer that may quickly live the temperature and internally that is a common technique in those that are critically sick in a medical aid unit. The temperature is often measured by probes that are placed within the esophagus, heart, or bladder. Usage of glass thermometers with mercury isn't suggested as they'll break.

III. ROLE OF WEARABLE SENSORS/ DEVICES IN MONITORING KEY PARAMETERS

Wearable gadgets are boosting as exceptional fitness tracking gadgets for hospital therapy services, mainly with developing diligence closer to well-being, health, fitness, and sickness prevention. Day-to-day amelioration in huge information, artificial intelligence, robots, smart sensors, radar technologies, and digital wearable can manipulate and prevent illnesses. The primary factor that needs monitoring for maintaining health and problems faced by the people in visiting hospitals and clinics. Consumer wearable promoting healthier lifestyle, medical wearable clinching patient's vital signs, and sensing components uplift the wearable technologies offering person awareness of safety, productivity and health incentives. More than eighty percent of the clients are inclined to display their health and music their crucial signs are keen to put on wearable outfits. Wearable sensors/ gadgets can determine blood strain, body temperature, coronary heart, rate, and respiration of the situation carrying it and may indicate dangers together with declining fitness, worsening illnesses, and other warnings like- hypertension or problem with respiratory, and many others. In the healthcare quarter, wearable tool accommodates electronic gadgets that humans can put on. Wearable devices also permit customers to transfer fitness statistics to healthcare specialists and doctors in real-time.

Table 1[23] shows illustration of user, Scientific and research-grade wearable sensors. A schematic illustration of a frame sensing detail network is shown in Figure 1. Within the figure, a SHIMMER unit [24] is show as an illustration of a sensing element link. A test subject is delineated with sensing element link up to wrists and ankles, a way appropriate to watch major activities. A chest strap is hired to watch pulse and fee of respiratory, to seize physiological responses to motor sports and ability cardiovascular troubles that can be detected, for instance, through analysis of the coronary heart price and its variability. The nodes talk with a base station that might be both a statistics logger worn by using the situation or a pc settled inside the environment near the subject

Manufacturer	Model	Market	Cost (USD)	Form factor	Sensors	US FDA status
Abbott	Libre	Ambulatory diabetes monitoring	149.98 (cost for reader and 10-day sensor)	Semi-invasive	CGM	Approved
AliveCor	Kardia Band	Consumer	199	Wristband	ECG	Cleared
Apple	Watch Series 3	Consumer	329	Watch	Accel, ambient light sensor, BALT, Gyro, PPG HR, GPS	Precertified
Ava Science, Inc.	Ava Wristband	Consumer	249	Wristband	Accel, EDA, PPG HR, temperature sensors	Approved
BACtrack	Skyn	Pre-Market	–	Wristband or watch	Transdermal	–
Bloomlife	Smart Pregnancy Tracker	Consumer (rental)	20/week	Abdominal patch	Accel, 3-channel AFE	–
Dexcom	G5 Mobile	Ambulatory diabetes monitoring	1016 (cost for transmitter, receiver, 4-pack of replaceable sensors)	Semi-invasive	CGM	Approved
Empatica	Embrace	Consumer	249	Watch	Accel, EDA, Gyro, peripheral temperature sensor	Approved
Fitbit	Charge	Consumer	149.95	Watch	Accel, PPG HR	Precertified
GI Logic	AbStats	Premarket	–	Abdominal device	Vibration, acoustic	–
G-Tech Medical	G-Tech Medical	Premarket	–	Abdominal patch	EMG	–
Health Care Originals	ADAMM-RSM	Premarket	–	Chest patch	Acoustic, HR, temperature	–
iRhythm	Ziopatch	Ambulatory cardiac monitoring	Ordered through physician, billed directly to insurance	Chest patch	ECG	Cleared
Med Wise	Gluco Wise	Premarket	–	Clip (thumb, forefinger or earlobe)	CGM Radio wave sensor	–
Medtronic	Enlite	Ambulatory diabetes monitoring	–	Semi-invasive	CGM	Approved
Motiv	Motiv Ring	Consumer	199	Ring	Accel, PPG HR	–
Omron	Heart Guide	Premarket	–	Watch	Accel, PPG HR, oscillometric blood pressure	–

Figure 1: Schematic representation of a wearable system that allows one to collect movement and physiological data (i.e., heart rate and rate of respiration). Physiological data are collected via a chest strap [24].

Table 1: Examples of consumer, clinical and research grade wearable sensors.

Manufacturer	Model	Market	Cost (USD)	Form factor	Sensors	US FDA status
Orpyx	Surro Gait Rx	Ambulatory gait monitoring	Ordered through physician	Watch, shoe insert, shoe pod	Pressure	-
]Orpyx	Surro Sense Rx	Ambulatory gait monitoring	Ordered through physician	Watch, shoe insert, shoe pod	Pressure	Cleared
Oura	Oura Ring	Consumer	299–999	Ring	Accel, Gyro, PPG HR, skin temperature	-
Preventice	Bodyguardian Heart	Ambulatory cardiac monitoring	Ordered through physician billed directly to insurance	Chest patch	Accel, ECG	Cleared
Sentio Solutions	Feel	Premarket	149	Wristband	EDA, PPG HR, skin temperature	-
Tempdrop	Tempdrop	Consumer	150	Underarm armband	Thermometer	-
Verily	Alcon	Premarket	-	Smart lens	CGM	-
VitalConnect	Vital Patch	Premarket	-	Chest patch	Accel, ECG, thermistor	Cleared
Yono	Earbud	Consumer	149.99	Earbud	Thermometer	-
Zoll	Lifevest	Ambulatory cardiac monitoring/intervention (rental)	3–4k	Vest	ECG	Approved

Abbreviations in the table: Accel: Accelerometer; AFE: Analog front end; BALT: Barometric altimeter; CGM: Continuous glucose monitor; ECG: Electrocardiography: EDA: Electrodermal Activity; EMG: Electromyography; GPS: Global positioning system; Gyro: Gyroscope; HR: Heart rate; PPG: Photoplethysmography; Therm: Thermometer.

Catia Tavares, et al [25] Designed a three-D-printed sensor based totally on fiber Bragg grating (FBG) technology for respiration fee (RR) and coronary heart charge (HR) monitoring. Their experiment showed that the 3-d-published sensor based totally on fiber Bragg grating (FBG) era is a wearable solution, and is able to estimate the users' RR and HR at some stage in everyday respiration and apnea. Jang-Ho Park et al [26] conferred a scissor-shaped apparatus equipt with a piezoelectric film sensor and a hardware circuit compartment to monitor heart rate through with in-ear pulse wave (EPW) and found extremely accurate heart rate from in-ear pressure variant Aileni Raluca Maria et al [27] Propose integration of pulse sensors, microcontrollers, and verbal exchange gadgets in a bendy structure that provides a non-invasive wearable device to be worn by using sufferers for offering continuous pulse price tracking in hospitals or at home. Michael Chu, Thao Nguyen et al delivered a wearable sensor capable of concurrently measuring both breathing fee and extent with excessive constancy. The disposable measures the local strain of the ribcage and abdomen at some point of breathing. They used low-powered piezo-resistive sensors integrated with wireless Bluetooth gadgets, as a consequence can be useful in monitoring patients with continual respiration illnesses in everyday settings [28].

Viswam Nathan and Roozbeh Jafari Proposed a method that is able to help multiple simultaneous and heterogeneous sensors for non-stop monitoring of the physiological popu-

larity of the user and fusing them efficaciously for greater correct estimates [29]. Wrist watch kind monitoring device, much as the MediWatch [30], Had been basically advanced through leveraging the miniaturization of sensors based on conventional procedures to measure blood strain (i.E., thru blood, drift brief obstruction). Konstantinidis, D., Iliakis, P., Tatakis, F., et al [31] claim that the availability of easy and affordable gadgets for reliable cuffless blood stress (BP) dimension lets in the prognosis of Hypertension at an early stage, improves BP manage, additionally considerably increases using faraway monitoring within the control of Hypertension. Sokwoo Rhee et al [32] advised the ring sensor for twenty-4-hour affected person tracking. The ring is loaded with LEDs and photograph detectors in which the generation of pulse oximetry is enforced for blood oxygen saturation observance. The ring detector is worn by way of the affected person as a minimum instance, therefore the health status is monitored twenty-four hours on a daily foundation. Considerable study efforts throughout the Eighties caused the advent of self-testing blood glucose meters [33]. CGM (continuous glucose monitor) could be a little wearable device that tracks user's glucose levels in period throughout the day and night. At any moment, while not puncture the finger, unlike self testing glucose meters, one see not solely what your glucose level is however conjointly what direction it's headed in. With personalized settings, CGMs will provide one with a warning to high or low levels whereas conjointly charting your glucose regarding each five minutes on a graph on your Smartphone or separate receiver device. Jayoung Kim, Alan S, et al [34], put forward the recent advances in developing skin-worn non-invasive electrochemical glucose biosensors and discusses their prospects and limitations toward advanced glycemic control. The development of wearable sensors has received tremendous attention over the past decade such devices are composed of flexible materials that comply with the curvilinear geometry of human skin to enable convenient, pain-less non-invasive monitoring. While skin-worn glucose biosensors provide wide promise toward the management of hyperglycemia and improved patient outcomes, these systems nonetheless need more development, crucial analysis, and in-depth validation for widespread implementation. Although, large-scale studies are required to critically assess the accuracy and reliability of these devices in improving glycemic control in individuals with diabetes.

Plenty of flexible/stretchable devices have been reported to detect temperature-oriented electric signal variations, including resistive [35-40]. These resistive temperature sensors provide several advantages, such as 1.simple sensing mechanism, allowing direct measurements with high sensitivity, 2.high stretchability and flexibility, bestowed by the elastomer substrates, 3.low-cost fabrication and industrial scaling up. And lastly, zeng et al [41], summarizes various working mechanisms (resistive, capacitive, triboelectric, piezoelectric, thermo-electric, pyroelectric) and hybrid mechanisms that are incorporated into wearable sensors. They advise combining flexible power units and wearable sensors to make wearable sensors work persistently and form a self-powered system.

IV. DISCUSSION AND CONCLUSION

Although wearable sensors have an awesome style of making use of regions to the restricted field of medication, growing facilitating the looking of acute and continual situations and preserving the fitness each in and exterior the clinics. A new taste that wearable sensors will admit is their relevance in environments anyplace rapid medical resource is crucial but usually not inaccessible at an instantaneous, for example, at the scene of injuries, in military settings, athletics, and in useful resource-limited environments.

Wearable and environmental sensors guarantee advanced know-how assortment and rapid transmission of understanding to off-web site professionals and particularly designed algorithms exchange Automatic and time period clinical call support in time- and useful resource-limited environments.

In this paper, we tend to try to function findings and help the employment of wearable sensors to find strange heart conditions, diabetes, cardiovascular disease, and varied modifications at some stage in gestation. We generally tend to moreover sell the employment of wearable gear and gadgets in specific settings to beat the underlying care prices for instance, by decreasing ER visits and medical institution admission fees, up post surgical and rehabilitation outcomes, helping with aging in-domestic and stopping critical, preventable, and pricey scientific activities. As the wearable alternate continues to strengthen, the need for extra accurate, compact, and reliable sensing technology becomes important for proper lengthy-run practicality in wearable. Knowing the demanding situations associated and therefore the evaluation in improvisation on wearable sensors and devices in a scientific useful resource that location unit energy teaches up, we have a tendency to area unit desire full that those studies can uncover new ways in which at some stage in which we can use wearable tool information to reinforce care.

The outcome of this newsletter is to offer initial know-how of the potential advantage wearable gadgets may have regarding health recognition. The findings urge that folks that put on a physical tracker are extra health aware and energetic, indicating an effective impact that wearing a bodily activity tracker has with regards to activity levels and cognizance**.**

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