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WEARABLE DEVICES IN HEALTH MONITORING

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ABSTRACT

Wearable gadgets have evolved quickly, becoming essential components in the field of health monitoring. This abstract investigates the changing landscape of wearable technology, focusing on its transformative impact on personal health and well-being. As these devices grow more common, both consumers and healthcare providers must grasp their different types, benefits, and limitations. This study classifies wearable devices into three types: wearable spirometers, smartwatches, and medical-grade wearables. Each type is examined for its distinct features and functionalities, offering a thorough review of the many tools available for health monitoring. The taxonomy offered explains the rising span of wearable technology, ranging from lifestyle wearables to those built for specialized medical uses. The advantages of wearable health monitoring are numerous and go beyond basic data collection. Real-time monitoring, tailored information, and the promotion of preventative health practices are some of the primary benefits. This abstract dives into the positive effects of wearables, proving their ability to raise health awareness, promote physical activity, and aid in the early diagnosis and management of health conditions. Wearable gadgets have significant promise, but they also present issues that must be carefully considered. Concerns about privacy, data security, and the trustworthiness of health data collected by wearables are addressed. Furthermore, difficulties such as user adherence, technological limits, and the possibility of information overload are investigated. Recognizing these limitations is critical for developing a balanced perspective on the use of wearables in health monitoring. This abstract provides a thorough overview of wearable technologies, including their various varieties, benefits, and problems.

KEYWORDS: Wearable gadgets, Spirometer, Smartwatch, Data monitoring, ECG patch.

INTRODUCTION

Professor of mathematics at the Massachusetts Institute of Technology in the United States, Edward O. Thorp, initially presented the idea of wearable technology in the 1960s. Since then, scholars from all around the world have given wearable technology a great deal of attention. Wearable technology has expanded quickly in a number of industries, including health care, education and culture, social networking, and the military, in recent years due to the advent of the internet, intelligent hardware, and big data. In the shape of accessories like smart watches, smart wristbands, armbands, and spectacles, some of these technologies are finding their way into people's daily lives.[1]

With a variety of features and a quick rise in popularity, wearable technology aims to lower healthcare costs while increasing healthcare efficiency. Popular fitness trackers like Garmin, AppleWatch, and MI Band are examples of wearable medical technology. More complex wearables include smart clothing.[2]

Usually, wearable technology is positioned on the wearer's body directly, inside garments, or inside semi-rigid objects like smartwatches, gloves, insoles, and headgear. They can exchange information by using the human body as a transmission channel or by using a suitable transmission medium like Wi-Fi, BLE, or Zigbee. Wearable technology records the wearer's long-term physiological and activity data, filters it, and stores it. Wearables might not be able to process data locally because of their constrained computation and storage capacity. They therefore send the obtained data to a potent remote computer or cloud implementation, where the sensor data is analysed and dissected to provide results that are generated, interpreted, and presented in a way that makes sense to the user.[3]

Intercommunication between sensors and control systems is made easier by communication networks. In order to meet stringent needs, like always-available transmission services, low end-to-end latency, and a notable increase in data rate over fourth generation (4G) communication technologies, fifth generation (5G) communication technology enhances broadband networks. This faster data transfer speed is used by digital healthcare to improve patient care, human health, and eventually population wellbeing. It is common practice to utilise wearable sensors to help patients transition from in-clinic care to out-of-office care. Their capacity to analyse patients' prescribed physical activity regimens for ongoing improvement or decline can provide continual quantification of progress made possible by therapy regimens.

Wearable technologies offer the benefit of delivering objective data regarding mobility and summing it in a way that physicians can understand. They can also be utilised in distant areas when access to health care is limited (for example, on an oil rig) or when the patient is too sick or unable to get to a clinic or hospital. Furthermore, wearable data obtained in an ambulatory setting is expected to give a more accurate and representative estimate of a person's physical state than a snapshot of data acquired during a normal hospital visit.[3]

Wearable spirometer

Tracking vital signs, such as respiration and heart rate, can disclose information about a person's overall health and is an important part of healthcare. Breathing is a unique physiological phenomenon that occurs in both healthy persons and those with respiratory problems. Unlike heart rate, breathing patterns are influenced by both voluntary and involuntary input. According to the World Health Organization (WHO), chronic obstructive pulmonary disease (COPD) kills about 3 million people each year, accounting for 6% of all fatalities globally.[4]

The most frequent way to measure lung function is with a spirometer. Flow-oriented spirometers measure the amount of air going through a tube over a set period. Liters per second are commonly used units of measurement. Volume-oriented spirometers measure displacement in litres.

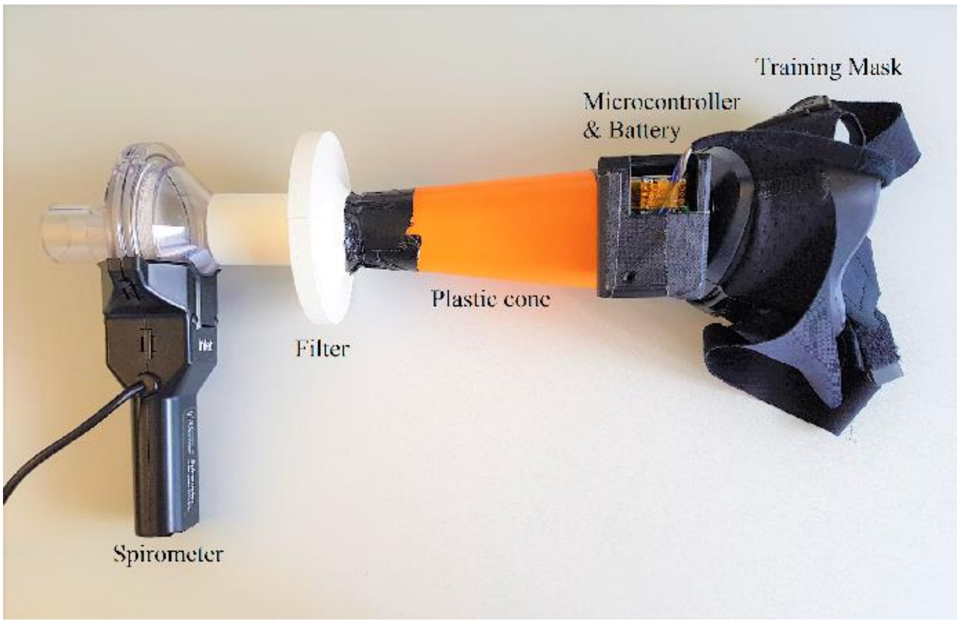

Figure 1: Parts of spirometer.

Spirometry is a well-established medical method that measures lung capacity and oxygen consumption. Studies have demonstrated that oxygen consumption is directly related to body composition and physical conditioning, such as cardiorespiratory performance. Spirometry is useful not only in physical fitness activities but also in one's professional life.[5]

Key respiratory characteristics, such as respiratory rate, tidal volume, respiratory minute volume, and exhalation peak flow rate, may be precisely measured by the wearing mask device, which can also identify the breathing pattern. The disposable mask and head strap are the two accessories for respiratory monitoring that are intended to be used in conjunction with the mask device. The device is fixed to the user's head by the head strap. The mask device for breath collection can be built with a disposable mask.[6]

Characteristics of a disposable mask. To prevent user cross-contamination, it is intended for single use only. Through check valves, it divides inhalation and exhalation. It prevents gas leaks during breathing by using flexible silicone materials and an ergonomic form design.[6]

Smart cloth

The Learn Inspire Free Entertain (L.I.F.E.) gadget is designed to record respiratory movement and ECG simultaneously using various sensor elements woven into the fabric of a compressible, self-wearing, and machine-washable garment that can even be used in a home laundry machine. The simultaneous registration of polysomnography and ECG Holter data with a single recording has several benefits. In particular, arrhythmias generated by apnea/hypopnea are identifiable. The medical compression garment used by L.I.F.E. was made up of one accelerometer, five breathing strain sensors, and twelve dry electrodes based on ink that allowed for ECG monitoring.[7]

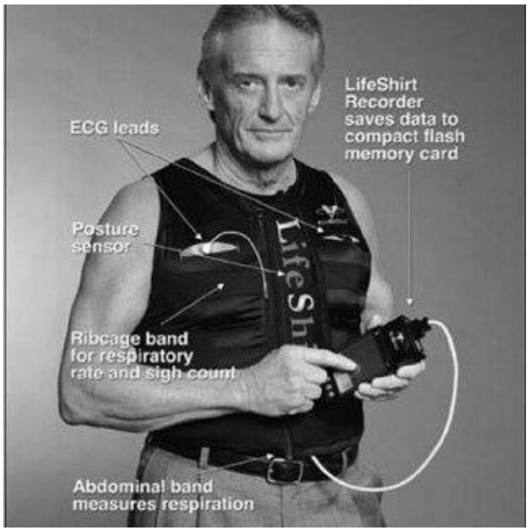

Figure 2: LIFE shirt used in monitoring ECG and respiration.

Glucose monitor

There has been a surge in research efforts to build non-invasive glucose monitoring platforms due to the growing interest in wearable and mobile technologies. The drawbacks of finger-stick blood testing are addressed by continuous glucose monitoring, which also offers the chance for the best possible therapeutic interventions. Studies on non-invasive epidermal electrochemical monitoring have used two easily accessible bio-fluids: sweat and skin interstitial fluid (ISF). Through the endothelium or sweat glands, glucose diffuses from blood arteries into various biofluids, reflecting blood glucose levels. The realization of epidermal non-invasive glucose sensing (by sweat, ISF) can be achieved through the creation of body-compliant wearable platforms, including patches or temporary tattoos on the wristbands, and the integration of wireless electronics for practical wearable applications.[8]

2–40 × 10−3m in blood, 1.99–22.2 × 10−3min ISF, 0.008–1.77 × 10−3m in saliva, 0.01–1.11 × 10−3m in sweat, and 0.05–5 × 10−3m in tears are the ranges of glucose concentrations. The process of collecting target biofluids in noninvasive monitoring is painless, but because of the strong skin barrier, obtaining interior body fluids might be challenging.

Figure 3: Non-invasive glucose sensor.

Glucose in the ISF can be extracted iontophoretically or reverse-iontophoretically and monitored by applying electric fields. Wearable and disposable devices can be used to passively gather the target biofluids, such as saliva, tears, and perspiration. Since the glucose concentrations in these biofluids are typically lower than those in the blood, the devices must be able to detect them. As a result, excellent sensitivity and selectivity of integrated sensors with nanostructured electrodes are typically required.[9]

Smart gloves

Some businesses manufacture smart gloves all over the world, primarily in the USA and Europe but also in China, Russia, Israel, and New Zealand. Many firms, including 5DT, Dexmo, Synertial, Manus, Nansense, Noitom, SenseGlove, and VMG, have several active versions of their gloves. Many times, such as with 5DT, Cobra Glove, Dexmo, Nansense, and VMG, they offer the same glove with a varied number of sensors to allow the tracking of additional DoF. In other instances, manufacturers provide gloves with varying features. For example, Manus and VMG provide gloves that just support tracking and positioning, whereas another model provides kinesthetic feedback.[10]

The following are some common uses for smart gloves that are widely acknowledged. Pose estimation and motion tracking for hands and fingers. This entails having the capacity to gauge the location and motion of each finger as well as the entire hand. To control the mobility of a hand avatar in virtual environments and to recognize human manipulation motions, motion tracking is required tactile response. This relates to the human perception system, which is made up of several cutaneous and kinesthetic sensors found in our muscles, tendons, and skin. In computing, haptic technology replicates the feeling of touch.[10]

Figure 4: Commercial smart gloves.

Thermal sensors

As a basic physical metric, temperature fluctuates across time and space to track physiological activity, especially heat transmission from biological tissues to the surrounding environment. Understanding the thermal principle of homeostasis requires the precise and continuous detection of localized temperature changes in biological tissues, independent of large-scale deformation. Real-time temperature mapping opens up a wide range of additional potential applications, including artificially electronic skins and the reflection of emotional changes.[11]

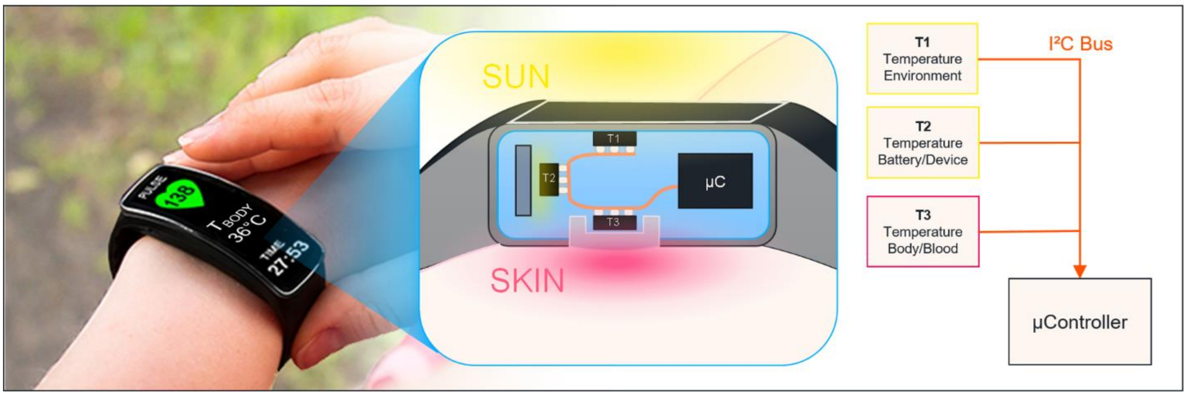

Figure 5: Wearable temperature detector.

Large sensitivity, high accuracy, quick response, good repeatability, a broad operating temperature range of 25 to 40 °C, long-term stability against environmental influences, softness, biocompatibility, extreme flexibility, long fatigue life, and lightweight are all important features of temperature sensors.

ECG patches

An technique that is non-invasive for monitoring and documenting variations in heart potential is the electrocardiogram (ECG). For decades, doctors have utilized this as the most popular and reliable diagnostic method to find heart-related issues, such as various types of arrhythmias.[12]

While many arrhythmias may not pose a threat to life, some, including myocardial infarction (MI), are caused by weakened or damaged hearts and, if left untreated, can result in cardiac arrest. Patients who have a heart attack must get medical help right away because waiting could be fatal. If heart activity irregularities are identified and addressed early enough to necessitate outpatient ambulatory ECG monitoring, these consequences can be prevented. Long QT syndrome, hypertrophic cardiomyopathy, Brugada syndrome, and arrhythmogenic right ventricular cardiomyopathy are a few examples of rare, dangerous arrhythmias that are uncommon and can only be identified by extended surveillance.[12]

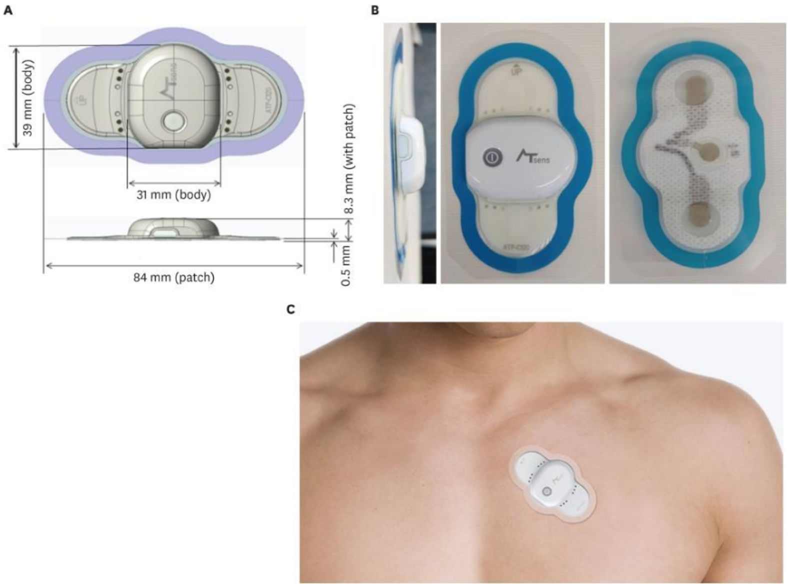

Figure 6: ECG patch.

A set of low-power applications-oriented feature extraction and rhythm analysis software programs are included in the patch. The gateway device continually monitors and updates heart-to-heart rate, respiratory rate, heart-rate variability, and cardiac rhythm-based arrhythmias. The device additionally saves the raw data locally for processing at a later time.[13]

Data obtained from a single lead ECG patch worn across the heart to probe lead I (in women) or lead II (in men) contains a variety of characteristics, including heart rhythms, P waves, R-R intervals, QRS complexes, PR intervals, and breathing-induced artifacts, which can be extracted using feature extraction techniques. ECG characteristics acquired from leads I and II are analyzed using advanced yet lightweight proprietary algorithms to detect the start of rhythm-based heart diseases.[13]

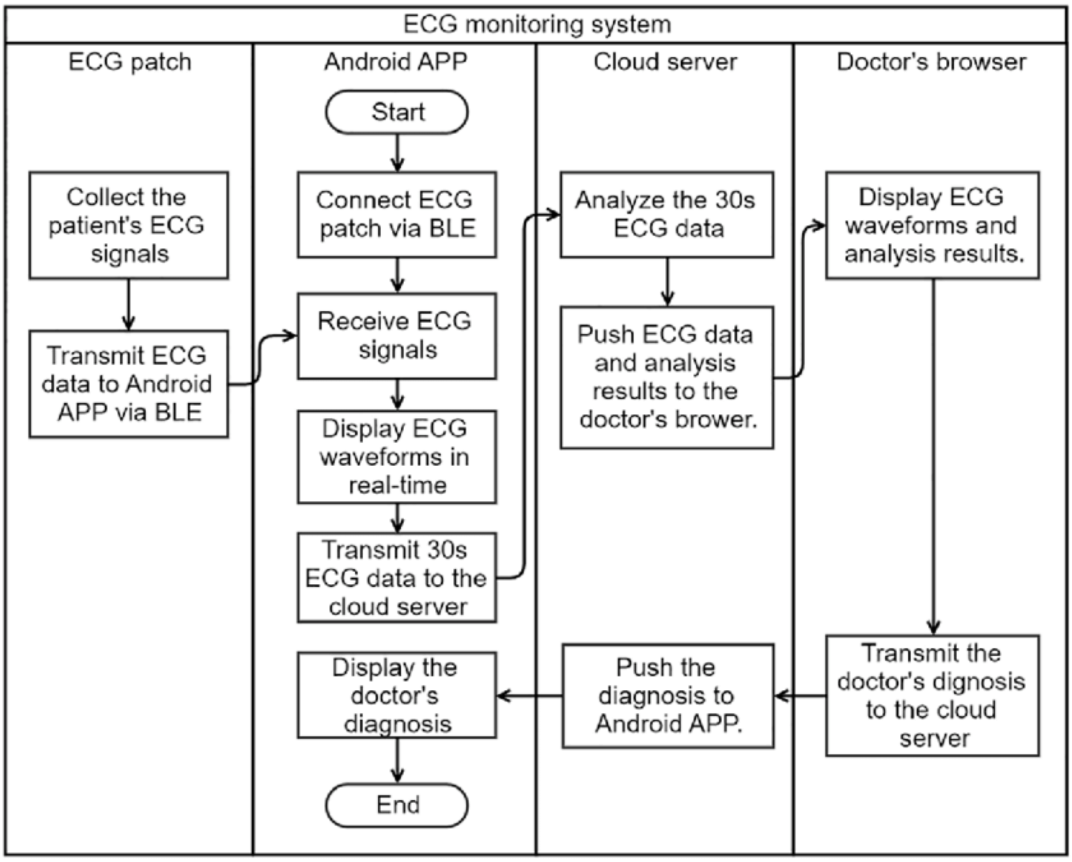

Figure 7: ECG monitoring system.

Smartwatch

Smartwatches, which are small computers, have several tasks other than indicating the time; they are one of the most recent advancements in the growth of information technology. Smartwatches are pieces of technology that a person wears on his or her wrist, allowing others to recognize them. The term 'visibility' refers to a person's perception of how much attention smartwatches receive from others.[14]

Smartwatches have the potential to transform health care by supporting and evaluating health in everyday life because they: (1) are familiar to most people; (2) are increasingly available as a consumer device; (3) enable near-real-time continuous monitoring of physical activity and physiological measures; (4) support tailored messaging and reminders;

(5) enable communication between patients, family members, and health care providers; and (6) allow for in situ, mini-survey.[15]

Insulin pump

Insulin is usually administered subcutaneously in the adipose tissue of the belly, thighs, buttocks, and upper arms. Pain and cosmetics are the most important variables for patients; however vascularization and unpleasant skin responses must also be addressed. Because of the greater vascularity in the arm or belly, insulin is absorbed faster than in the thighs and buttocks. Alternating injection sites are also strongly advised to minimize skin-related adverse effects.[16]

Figure 8: Omni pod insulin pump.

Patch pumps are wearable devices that have smaller dimensions than regular pumps but are just as effective. They are linked to the skin and give bolus or basal insulin by direct touch, eliminating the inconvenience of typical pumps' lengthy infusion tubes and reducing the danger of kinking and tube disconnections. Insulin patches can provide up to 200 U for each infusion and last for three days. However, the primary issues limiting their lifetime are power consumption, insulin capability owing to their reduced size, and skin responses.[16]

Challenges of wearable devices

There are several problems with wearable technology. Price is one of them. Despite the enthusiasm around some of the newly created wearable technologies, they remain quite expensive. If wearables are to become as popular as smartphones, they must be cheap to consumers.[17]

Furthermore, there is a risk that wearable technology for healthcare may have an influence on healthcare providers' capacity to meet demand. UK family doctors have previously expressed major worries about the impact of technologies such as smartphone health applications and their potential to flood offices with concerned patients who misinterpret data supplied by such programs.[17]

Wearable health devices may capture a wide range of user data using sensor technologies, including health information, geographical location, and lifestyle behaviors. The many forms, enormous volume, and multiple mobile linkages of these data may enhance the danger of leakage and manipulation. Strategies for data security and public trust are necessary.[1]

CONCLUSION

Wearable technology has advanced swiftly in many domains, including healthcare, education and culture, social networking, and the military. Wearable gadgets are often worn directly on the body, embedded in clothes, or housed in semi-rigid frames. They may communicate with one another via the human body or another suitable communication medium.

The article talks about wearable technology that monitors heart rate and respiration to give general health information. Spirometry is a crucial medical test used to assess oxygen intake and lung capacity. Key respiratory characteristics, such as respiratory rate, tidal volume, respiratory minute volume, and exhalation peak flow rate, can be precisely measured with a wearable mask device.

Compressible, self-wearing, and washable clothing can have many sensor units woven into its fabric to record respiratory movement and ECG concurrently. This is known as a smart cloth. Studies on non-invasive epidermal electrochemical monitoring have used two easily accessible bio-fluids: sweat and skin interstitial fluid (ISF).

By creating body-compliant wearable platforms and incorporating wireless electronics for useful wearable applications, continuous glucose monitoring systems can be realized. The range of glucose concentrations in blood is 2.5–40%; in perspiration, it is 1.99–22.2%; in saliva, it is 0.008–1.77; and in tears, it is 0.05–5%. While the target fluid collection process in noninvasive monitoring is painless, obtaining the interior fluids is a challenging task.

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