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Analysis on Smart Healthcare Monitoring Based on Compound Dimension

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Abstract

INTRODUCTION: Life expectancy has steadily increased in the majority of countries over the last few decades as a result of vast improvements in medical care, public health initiatives, and individual, community hygiene practices as well.
OBJECTIVES: An effective and inexpensive alternative to institutional care was remote health surveillance, which relies on non-invasive and wearable sensors, actuators, and modern statement and information technology to allow the elderly to remain in their familiar homes.
METHODS: With the use of open-source software, widely accessible minimal chipsets, and remote data warehouses for storing, this study details the design and construction of e-health apparel for health monitoring.
RESULTS: By utilizing these devices, medical professionals will be able to track vital signs in real-time, evaluate patients' status, and provide feedback even when they are physically located in a different facility. The next step included creating a wearable system and the garment platform it would be used on.
CONCLUSION: More features were implemented in the form of a smartphone application. This research has potential application in broadening the scope of wearable healthcare systems by investigating the role of apparel in this area.

Keywords: Health jacket, e-Health Apparel, Wearable sensors, Remote health monitoring, vital signs, Smart fashion

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1. Introduction

The healthcare sector has seen substantial changes as a result of the development of information technology, most notably in the field of remote monitoring. [1]. Consistent post-discharge supervision of a people's physiological parameters at the workplace, at home, during sports matches, and so on, or in a medical setting was now possible thanks to wearable medical equipment (WHEs), a new tech that has the obvious benefit of abating embarrassment and prying with regular human pursuits [2]. In the late 1990s, the notion of personal medical systems emerged with the aim of engaging the distinct member at the center of the provision of nursing care, governing one's own wellbeing, and interacting with healthcare professionals; this idea was colloquially known as "patient empowerment." Wearable Healthcare Devices (WHDs) are a part of this system. The objective was to get individuals thinking about their health conditions in order to improve care and make better use of technological advances. These tools encourage cooperation between many branches of science [3,4]. This includes biomedical engineering, micro and nanostructures, materials research, electrical engineering, and computer science. Nowadays, there has been a considerable increase in the number of intelligent systems and newly produced tools that are used for quick monitoring among patients and for controlling their diseases [5].

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In many areas of healthcare, including telemedicine, the ability of such smart devices to store and convey data is crucial [6]. The necessity to observe a patient's well-being even though they are outside of the clinic in their own surroundings has arisen as a consequence of the rising costs of medical care and the fact that the population of the globe as a whole is becoming larger [7]. In response to the growing need for real-time information, numerous system designs and marketable applications have been developed over the course of the past few years. These systems and products are designed to deliver real-time information. The ability to provide feedback on one's health status to the user, a medical facility, or a supervising professional physician; this input can also include alerting the user if there is a health risk. Furthermore, Wearable Healthcare Monitoring Systems (WHMS) offer a novel approach to the management and monitoring challenges posed by chronic diseases, the ageing population, postoperative rehabilitative patients, and people with special abilities [8, 9].

Wearable health monitoring systems may include a variety of wearable or implanted tiny sensors of varying types. These biosensors have the capability of measuring important physiological characteristics such as breathing rate, hypertension, body and body temperature, oxygen levels, breathing rate, Electrocardiogram (ECG), and a host of others [10, 11]. Either a wireless or a wired connection is used to transmit the obtained metrics to a centralized server, such as a Personal Digital Assistant (PDA) or a microcontroller board. This can take place either wirelessly or weirdly. The appropriate information can subsequently be displayed on a graphic user interface by the central node, or the aggregated health status can be sent to a medical facility by the central node. The aforementioned highlights the fact that a wearable health sector may be composed of a broad variety of components, such as sensors, wearable equipment, e-textiles, electric vehicles, units for power supply and wireless connectivity modules and interconnection, governance and data processing units, a functionality for the user, apps, and intelligent systems for the process of data extraction and judgment.

Typically, patient monitoring systems include physiologic data input for the absolute authority of toolkits [12, 13], alerting caregivers to potentially dangerous situations. In any event, intelligent wearable technologies for the observation of victims have the ability and potential to be a significant improvement in efforts to control epidemics, particularly in the context of the current conditions that prevail around the globe. Numerous pandemics of infectious illnesses have emerged over time. The data collected from wearable devices could shed new light on public health surveillance, as suggested above. When it comes to controlling and monitoring epidemics in real time, patient monitoring might be seen as a crucial aspect [14]. The primary goals of prevention and management, trying to regulate, and prevent diseases are made possible by a wealth of innovative technological breakthroughs that are taking the shape of wearable smart technologies. These technology solutions are achieving greater precision on a global scale and becoming more cost-effective for these specific purposes. This is a very exciting development. The goal of this systematic examination is to provide a complete analysis of the deployment of smart wearable sensors for the prevention of disease and the monitoring of physiological parameters throughout infectious epidemic outbreaks.

2. Related Works

The article by *Mohammad Golam Mortuza et al.* [15] describes an automatic and intuitive method of monitoring a patient's vital signs. The LM35 and piezo sensor data is retrieved by an Arduino UNO microcontroller in the wearable sensors and then communicated to a SIM900D GSM module, which subsequently sends the information to the server every 10 minutes. When an emergency occurs, the microcontroller uses the GSM module to send a text message to the designated contact. The server is built with a Python-based microweb application framework using a flask connected with an SQLite database to stock and displays the patient's physiological parameters. Each doctor and patient receives a separate identifier generated by the website's server. A table format allows clinicians to easily view patient information.

In the study of *Vaishnavi Patil et al.* [16], the health monitoring system makes use of a biological sensor that does not provide any instructional data. It has a temperature sensor that was designated as DS18B20, a pulse sensor that was designated as SEN11574, a respiration sensor that was designated as SA9311M, and an ECG sensor that was designated as AD8232. In order to collect signals from the various sensors that are linked to it, an Arduino MEGA 2560 Controller was utilized. An electrocardiogram signal was displayed on an LCD (16x2), and data were transmitted to the server via the Wi-Fi module (ESP8266). The Thing Speak application gives medical professionals the ability to view the physiological parameters, and the data may be saved to an SD card for later examination and analysis.

Data on diabetes were obtained from the Kaggle data center for the purposes of this study by *Sangeetha Vishwanadham et al.* [17], and EHMS was utilized to analyze the data (e-health care monitoring system). The EHMS program makes use of a brand-new machine learning technique known as the SVM (support vector machine) algorithm, which was coupled with the IoT (internet of things), in order to extract the irregularities from the physiological parameters that have been observed. The SVM algorithm has the potential to achieve an accuracy of up to 80.5%.

In this article [18], *Munam Ali Shah et al*. propose an effective paradigm for healthcare that would allow for the regular inspection of a patient even when they are traveling. For the purpose of collecting the patient's physiological parameters, sensors are utilized. When the patient was on the road, a 3G or 4G network was utilized to access the internet, and the data that was captured was sent to the server from the body area network. The server will be responsible for data storage as well as analysis of a crucial nature. Certain individuals have received an urgent communication providing information on the current status of the patient as well as their location.

The World Health Organization (WHO) recognizes that people's health, well-being, and quality of life are influenced by their surroundings. Environmental domains interact significantly. Wearables are vital for persistent healthcare monitoring in pre-emptive and personalized medicine and IoMT. In this paper, *Saeed Danyali et al.* [19] categorize wearables in healthcare according to four innovation categories. Wear ability, expenses, and prolonged monitoring are also considered. Researchers study wearable devices' sampling proportion, resolution, data utilization (propagation), and data transfer. They study wearable device applications.

It was important to avoid this situation because the resources for conventional forms of energy are dwindling as a result of the high demand for electrical energy. The solution to the energy crisis was the primary objective of the system that has been developed. *Ananthajothi et al* [20], discuss the generation of electricity through footfall by using piezo sensors to convert the mechanical stress that was imparted to the floor by footsteps into electrical power. Simply by walking or jogging over the piezo plates, which are covered in this paper, authors were able to generate electrical power in an unconventional manner.

3. System Design of Health Monitoring Devices

A WHMS that was reliant on wearable sensors was designed to facilitate the transmission of patient records through a Central Station. The transmission of the data was carried out through services that are built on top of previously developed wireless technologies and protocols. The suggested jacket utilizes reduced, commercially-available sensors, computational methods, and transmitted components to offer a low-cost solution to issues in individualized healthcare tracking without sacrificing any of the capability or variety of much more expensive systems. The working principles of health monitoring devices are illustrated in Figure 1. The essential fundamental elements will be included in the healthcare monitoring jacket:

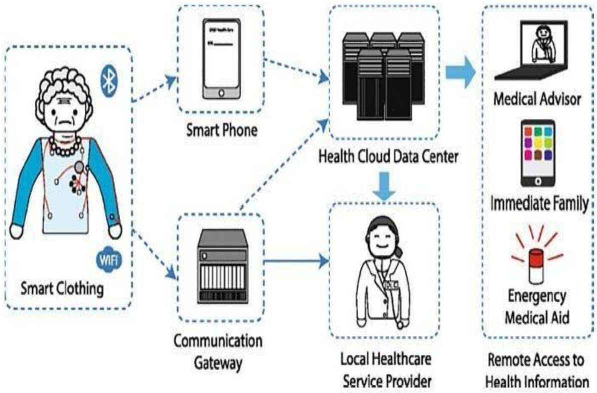

Figure 1. Framework of Smart Jacket

- The jacket contains the various interface plugs as well as the interface sensors. It will be easy to select the appropriate sensors among these, and the controller for the vest will automatically detect which ones are being utilized or interconnected at any given time.
- The controller's wired/wireless transmitter and receiver system are found in the jacket.
- The method for providing electricity to the controller was via the battery-charging system.The data storage and processing infrastructure that receives and processes information from the jacket. This component will be housed on-site at the institution and may be linked to the patients' complete medical records.

The primary objective of the system that was being presented to collect medical and tactile data from patients through the utilization of biomedical and tactile sensors and then transmit this information through the infrastructure of wireless network technology. Data collection also includes historical archiving and statistical analysis of the data obtained and kept on a remote server. This system can be used to examine the medical information of the patients in real-time or with post-processing, depending on the situation:

- Within the clinic as well as the hospital in general, this was where the patients would be admitted to stay.
- During the process of transport via ambulance to the hospital.
- At the domicile of the patient.
- Irrespective of the location of the patient

As a result, the healthcare monitoring jacket design must meet some critical requirements regarding sensors and data transfer. The system was made up of the suggested healthcare monitoring jacket and an information-gathering system that informs doctors and healthcare providers about their health conditions. The following criteria were considered by specialists for the patient's health during the design process:

- **Mobility-** The jacket ought to be hassle-free to wear and should not hinder the patient's ability to work or move around. Signal drops and battery life are only two examples of potential issues that need to be considered.
- **Quality of service-** The exact readings are crucial and must be sent to the server in the right format. Data precision, latency, jitter, maximum throughput, etc., must all be considered.
- **Data sensitivity-** Acquired health information was private and must not be shared with directly with the patient or the supervising physician. Therefore, the information system's user rights module must be used in conjunction with suitable network safety mechanisms.
- **Cost-** Providing a cost-effective solution that represents a sound investment for healthcare facilities was a primary focus of ours.

4. Hardware Configuration

The Intel Curie module was the heart of the hardware setup, as it processes data from sensors and converts it into input for PME. In order to use PME for moment classification, Curie processes raw data from accelerometers and gyroscopes, transforming it into a three-element vector. SPI FLASH will be used to pre-train the PME's expertise. In order to categorize your body's movements, the wristband will periodically access the information stored in its SPI FLASH upon resuming operation. Curie will also receive the raw data from the heart rate sensor and use it for analysis. After being processed, the value will be shown on the TFT screen or sent over to BLE for additional examination.

Metrics such as power consumption, size, and reliability must be thought through when selecting all parts to accomplish the goal of wearability. The authors have decided to equip a DFRobot Curie Nano with an MCU, an accelerometer, and Bluetooth Low Energy. The Intel® CurieTM module was a compact development tool with built-in Bluetooth 4.0 and 6-axis attitude sensors. This module makes use of the LED reflective solution, and it also has the capacity to output data quickly.

5. Materials and Methods

In this study, researchers searched the academic repositories WoS, Scopus, PubMed, IEEE Xplore, and the ACM repository to find examples of wearable tech that are used for healthcare applications in the academic setting. The International Data Company (IDC) classifies wearables into the following five categories: watches, wristbands, clothes, and earwear, as well as other categories [21]. The authors were focusing on the environmental domain, specifically air pollutants, because of the direct and indirect effects it has on the other domains. As a result, the following gadgets are considered and disregarded:

- Used on several body parts such as the wrist, waist, arm, foot, and chest.
- Observing zero or even more metrics originating from either the behavioral, physiologic, or cognitive areas.
- Outfits, booties, gloves, and helmets, along with numerous transportation methods (for instance, adapters for bikes, backpacks, and so forth.), in addition to the wearability of the items.
- Assessment of human or animal behavior and physiology or psychology, but not of environmental factors.

In accordance with the standards defined by the WHO, authors differentiate and classify the following four kinds of wearable technology and the related reviews are represented below:

- Eco-friendly: The equipment must monitor at least one hazardous or poisonous air pollutant to qualify for this category. The number of factors that can be measured by equipment was not limited and may include both air conditions and physical measurements.
- Environmental and behavioral: equipment that assesses in both the ecological and lifestyle domains at the same time: In addition to meeting the standards for G1, a record must be kept of at least one single behavioral characteristic, such as the amount of time spent engaging in physical activity. Movement, gait, step measuring, elevation, and body language are some of the criteria that are included in this domain.
- Environmental, behavioral, and physiological: devices must monitor at least one physiological parameter in addition to complying with the standards for environmental and behavioral data. The physiological domain consists of measures such as vital indicators (like pulse rate and breathing rate, blood volume, and skin conductance) and non-vital measures like blood pressure and skin temperature.

6. Principle of Wearable Devices

In our earlier research [22], authors developed a set of criteria for assessing the effectiveness of wearable technology that included comprehensive monitoring that was also continuous, cost-effective, and convenient. In this section, the authors put these concepts into practice by specifying each wearable and providing technical specifics wherever they are accessible. These are the guiding principles:

- Completeness: indicates the number of domains that are recognized in accordance with the WHO criteria. Because the psychological aspect has not yet been integrated, neither of the gadgets was considered finished at this point.
- Continuity: It achieves a transition from patient monitoring that was merely partial to monitoring that was ongoing. The amount of time monitored was given in either hours or days, and data on the amount of power and current consumed helps to sustain an evaluation of the amount of interval the battery will remain operational.
- Preventive healthcare has a high return on investment, which is why it is so popular. The price of a prototype was heavily affected by the embedded system's design. In the event that information was available, authors compare prices and bills of materials for popular products on the market (BoM).
- Convenience: discusses the issue of wearability in its various forms. The considerations of measurement, solidity, and weightiness were quite significant. In most cases, the convenience of wrist-worn devices was superior to that of other types.

7. Wearable Health Devices Market Trends

In order to carry out an exhaustive market survey of WHDs, it was essential to first have an understanding of the many market categories that are associated with these kinds of devices, and then follow market lines in order to analyze particular markets. By taking this strategy, the authors will be able to gain an understanding of the market standards and developments in the neighboring areas, which may also become potential board areas in the not-too-distant future. The value of the market for wearable gadgets was continuously expanding, and it was anticipated that it would reach around $12 billion in value this year.

If the authors consider that the economy was only $6.3 million in 2010, it is possible to comprehend that in these most recent years, it has increased significantly [23]. Since it was a market that was continually expanding, it was feasible to recognize that in recent years it has risen dramatically. As you can see in Figure 2 [24], according to IDTechEx, the trend for the next five years in terms of global revenue was expected to expand at a higher rate than it did in the previous year.

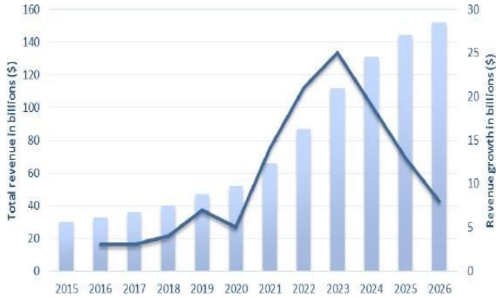

Figure 2. Growth Rate of Wearable Devices.

The market for wearable gadgets can be divided up into the many categories depicted in Figure 3. According to the findings of a study conducted by ABI Research [25], From 2017 to 2019, the usage of wearable technology in healthcare will increase and might eventually surpass the market value of wearables used for sport or exercise. Given that it demonstrates that these businesses have this objective in mind, this fact was a valuable signal for WHDs organizations that aim to create products for use in healthcare applications [26]. The market for smart clothing was still rather modest, but it was predicted to develop significantly in the next few years. It was expected to reach approximately $8.1 million in 2019 and approximately $25 million in 2022 [27].

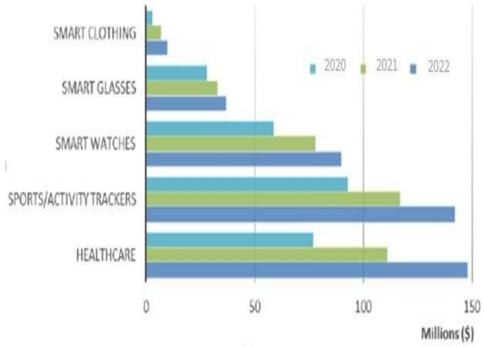

Figure 3. Graphical Trend of World-wide Market Value of Wearable Equipment's

This study's findings suggest that mobile healthcare technology will become the de facto norm for remote health monitoring, opening up new opportunities for WHDs to expand their market share. Interestingly, the global market for mobile health technology was roughly $1.2 billion in 2011, and it was predicted to reach an astonishing $11.8 billion value this year, which was said to support the usage of WHDs in conjunction with mobile technology. The global market for mobile health technology in 2011 was approximately $1.2 billion, and this figure should be taken into account in the analysis of this market.

7. Conclusion

Wearable health devices are a relatively new phenomenon in healthcare, and research and development efforts were ongoing with the ultimate goal of integrating them into existing medical health systems. Some of the personal monitoring gadgets available today may perform instantaneous evaluation and transmission of a single parameter. WHDs' greatest promise, however, lies in their capacity to connect with healthcare practitioners and combine a number of biosensors, cognitive processing, and alarms in order to support medical applications; some of this technology was currently just in development and has not yet made it to market. The mutual connections between the environmental, behavioral, physiological, and psychological domains and their characteristics highlight the importance of simultaneous monitoring across all four domains. The authors have thought of the environment as a key factor that affects the other categories on its own. The authors have divided wearables into classes based on how these various fields interact with one another. Current wearables demonstrate the important role that G3 devices play in the management of diseases such as COPD and asthma and, by extension, preventative healthcare. Wearables could be integrated into our health systems for real-time assessment of user health and quick care delivery if smartphone usage as a tailored gateway increases. The authors advocate for the incorporation of psychological domain elements into future wearables. It was anticipated that WHDs would be capable of overcoming their difficulties and entering the domestic market with a stronger effect in the coming years as a result of recent advancements in novel materials, telecommunications equipment, and information and communications technologies, as well as the entry of multinational corporations, such as Search engine, as well as simple entrepreneurs.

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