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Healthcare Equipment-Monitoring System With Iot And Sensors: Improving Quality Of Life

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Abstract: The Internet of Things (IoT) is essential in innovative applications such as smart cities, smart homes, education, healthcare, and defense operations. IoT applications are particularly beneficial for providing healthcare because they enable secure and real-time remote patient monitoring to improve the quality of people's lives. This review paper explores the latest trends in healthcare-monitoring systems by implementing the role of the IoT. The work discusses the benefits of IoT-based healthcare systems with regard to their significance, and the benefits of IoT healthcare. We provide a systematic review on recent studies of IoT-based healthcare-monitoring systems through literature review. The literature review compares various systems' effectiveness, efficiency, data protection, privacy, security, and monitoring. The paper also explores wireless- and wearable-sensor-based IoT monitoring systems and provides a classification of healthcare-monitoring sensors. We also elaborate, in detail, on the challenges and open issues regarding healthcare security and privacy. Finally, suggestions and recommendations for IoT healthcare applications are laid down at the end of the study along with future directions related to various recent technology trends.

Keywords- **IoT, IoWT, healthcare, monitoring, remote, sensors**

I. INTRODUCTION

The term Internet of Things (IoT) was invented by Kevin Ashton in 1999 and refers to data on the Internet that are connected to evolving global service architecture. IoT is the product of advanced research on information and communications technology. It can potentially enhance urban residents' quality of life. Since the global population is increasing at an astonishing rate, and the prevalence of chronic diseases is also on the rise, there is growing demand for designing cost-effective healthcare systems that can efficiently manage and provide a wide range of medical services while reducing overall expenses. The IoT has become a key development area recently, enabling healthcare-monitoring system advancement. The IoT healthcare-monitoring system aims to accurately track people and connect various services and things in the world through the Internet to collect, share, monitor, store, and analyze the data generated by these things. However, the IoT is a new paradigm where all connected physical objects in any intelligent application, such as smart city, smart home, and smart healthcare, are addressed and controlled remotely. Diagnosing disorders and monitoring patients is essential to providing medical care, and applying sensor networks to the human body will significantly assist in this endeavor. In addition, the information is readily accessible from any location in the world at any given time.

Patients with severe injuries or from certain areas may have difficulty reaching the hospital. Therefore, they can use video conferencing to communicate with their doctors to improve their health while saving money and time. Patients can use this technology to record their health conditions on their phones. It is anticipated that the benefits of the IoT will be improved and result in individualized treatment, improving patient outcomes while saving healthcare management costs. IoT systems allow physicians to keep an eye on their patients remotely and schedule their appointments more efficiently. Patients also can improve their home healthcare to reduce their need for doctor visits and the likelihood of receiving unnecessary or inappropriate medical treatments in hospitals or clinics. For this reason, the quality of medical care and the overall safety of patients may improve, while the overall cost of care may decrease. The IoT holds significant potential in healthcare. It will not be long before we have access to a health-monitoring system that can be used from the comfort of our homes and streamline hospital processes. IoT sensors should be densely deployed to monitor the body and environment continuously. This effort will enable the tracking of chronic-disease management and rehabilitation progress. In the future of virtual consultations for remote medical care, the IoT will be able to provide efficient data connections from multiple locations.

Most of the current implementations of the IoT and research on it are undeveloped and focus on deploying and configuring technology in various contexts and conditions. However, these practices are not widely used today. Therefore, this paper aims to evaluate related research on designing and implementing an IoT-based healthcare-monitoring system that improves quality of life. These systems rely heavily on IoT devices and sensors to connect patients with the healthcare provider's best suited for their care.

II. IOT-BASED HEALTHCARE SYSTEMS AND THEIR APPLICATIONS

IoT-based healthcare systems and their applications:

Remote healthcare: Wireless IoT-driven solutions bring healthcare to patients rather than the patient to healthcare. Data are collected securely through IoT-based sensors, and the data are analyzed by a small algorithm before being shared with health professionals for appropriate recommendations.
Real-time monitoring: IoT-driven non-invasive-monitoring sensors collect comprehensive psychological information. Gateways and cloud-based analysis manage the storage of data.
Preventive care: IoT healthcare systems use sensor data, which help with the early detection of emergencies and alerts family members. Machine learning for health-trend tracking and early anomaly detection is achieved through the IoT approach.

III. INTERNET OF WEARABLE THINGS

The Internet of Wearable Things (IoWT) aims to improve people's quality of daily life. It involves sensors fitted into wearable devices, monitoring the individual's activity, health factors, and other things. The data collected from the IoWT can be fed into medical infrastructure, giving clinician's remote access to their patients' data as they go about their daily lives. Building on the IoT architecture, a novel integrative framework for IoWT is currently being developed. The IoWT is a revolutionary technology that has the potential to change the healthcare industry by creating an ecosystem for automated telehealth treatments.

As shown in Figure1, the architecture of the IoWT and its connections consists of three elements: the WBAN, the gateway connected to the Internet, and the cloud. The WBAN is a front-end component of IoWT that wraps around the body to collect health-related data unnoticed. The WBAN collects data from sensors in direct contact with the body or from sensors in the environment that can collect indirect data about a person's behavior. The WBAN can either analyze the data or transmit them for remote analysis. In addition, mobile computing devices such as smartphones, tablets, and laptops must be connected to the Internet to send data to powerful computing resources.

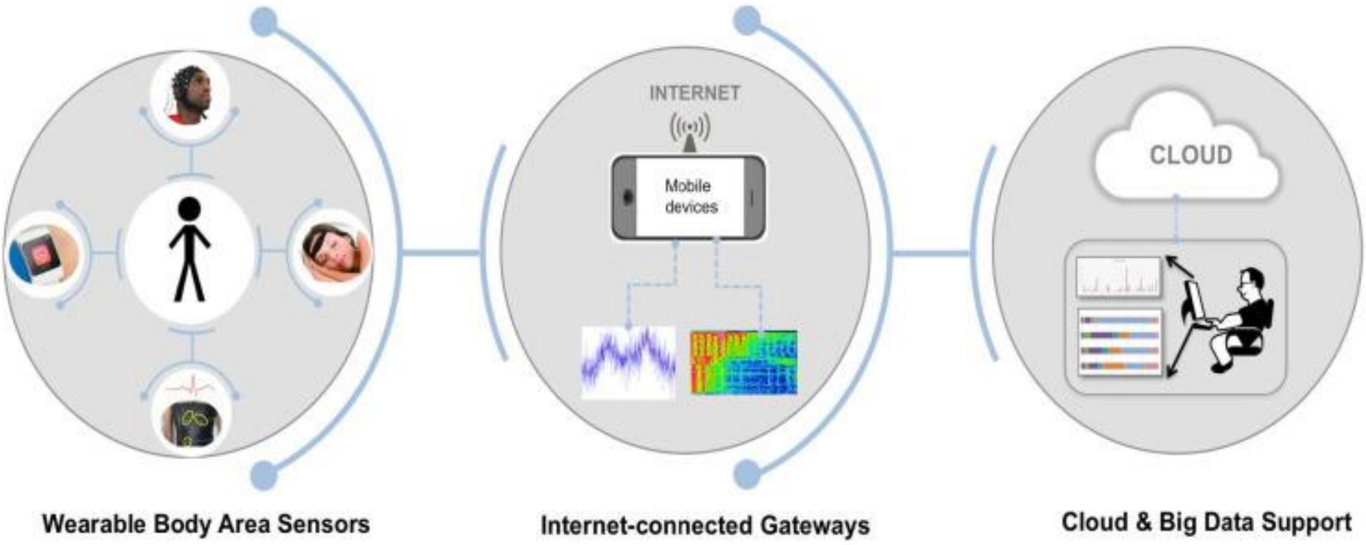

Figure 1. *Architectural elements of IoWT*

IV. WIRELESS NETWORK TECHNOLOGIES FOR IOT HEALTHCARE

Healthcare systems can be monitored remotely using various wireless network technologies. The existence and operation of IoT emerging technologies, such as RFID, wireless network technologies (BLE, Wi-Fi, Zigbee), and low-power wireless area network (LPWAN) technologies (such as LoRa and SigFox) are engaging in terms of the IoT's long-term development and deployment. They enhance device connectivity to the Internet, and the efficiency of IoT application operation.

An essential component of the IoT is the WSN. The IoT, which has already been established, can connect things to the Internet, allowing humans to interact with computers and for computers to interact with other computers. Thus, the combination of the IoT and WSN facilitates machine-to-machine communication.

Figure 2 illustrates the architecture of IoT with the WSN. It shows sensor nodes communicating with a gateway in a separate network. Many devices are linked to the gateway via Wi-Fi or the Internet, ensuring interoperability.

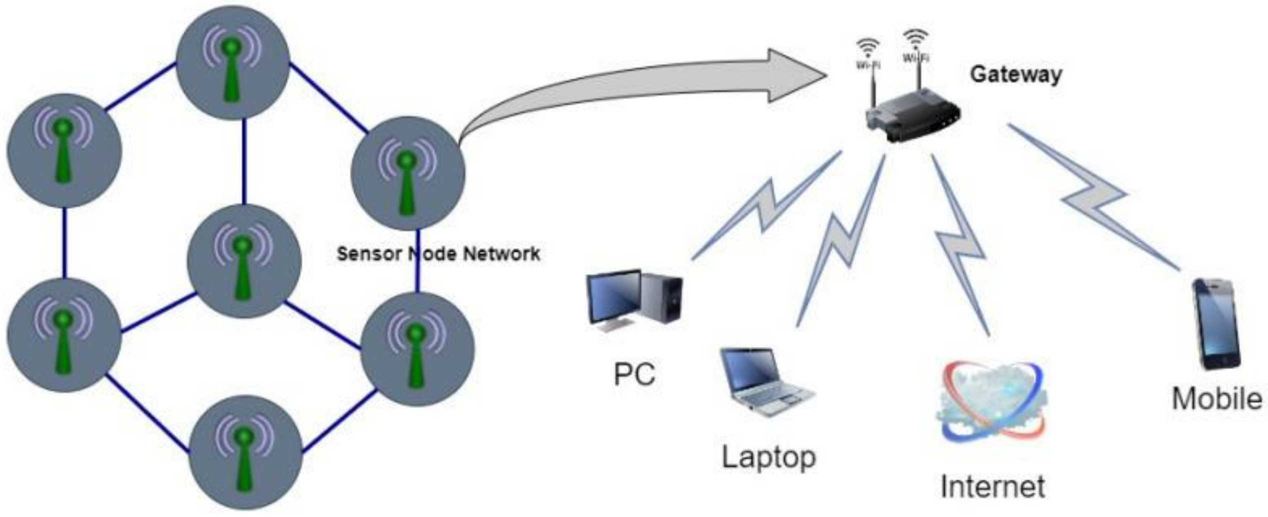

Figure2. *Relationship of WSN to IoT*

V. WEARABLE SENSORS IN HEALTHCARE-MONITORING SYSTEMS

In real-time, the healthcare sector may use wearable devices to monitor and save patients' activity and physiological functions. Such devices have one or more sensor nodes, but each sensor node typically has a radio transceiver, a low-speed processing unit, and small memory. The sensors can measure various physiological parameters and activity, including SpO2, BP and temperature, electro dermal activity (EDA), ECG, electromyography, HR, and RR.

Bluetooth, infrared, near-field communication (NFC), RFID, Wi-Fi, and Zigbee wireless transceiver technologies can support wearable devices communicating with smartphones and other devices. The technology promotes care by facilitating remote diagnosis and monitoring. An important issue of discussion in this period revolves around the IoT in healthcare. One of the essential parts of healthcare is identifying and treating illness. In order to achieve this, the body sensor network will be valuable. Additionally, the data may be accessible from any location in the world.

A wearable sensor gadget created by Veda can monitor and analyze the actions of patients. An IoT technology that measures social distance might help prevent a COVID-19 sufferer from becoming sick. Three layers of IoT sensors, machine learning algorithms, and smartphone apps are used to monitor BP, SpO2, cough rate, and temperature daily. The frameworks outlined by the authors helped the users keep a safe distance between themselves and the transmission of the virus and update their information often. A distance-monitoring system based on Radio Frequency (RF) was also presented in the research, which may be used in both indoor and outdoor contexts. In order to compare the findings under environmental restrictions, the authors looked at two alternative situations. Those who wrote the article claim to have helped expose COVID-19.

Another study demonstrated an IoT-connected wearable sensor network system for industrial outdoor workplace health and safety applications. Wearable sensors worn by the worker collect physiological and environmental data, which are transferred to the system operator and employees for monitoring and analysis. Data harvested from multiple workers wearing wearable sensors can be transferred through a LoRa network to a gateway. The LoRa network combines a Bluetooth-based medical signal-detecting network with a heterogeneous IoT platform. The authors describe the sensor node hardware and design, the gateway, and the cloud application. A heterogeneous wearable IoT device sensor network system for health and safety usage is shown in Figure 3.

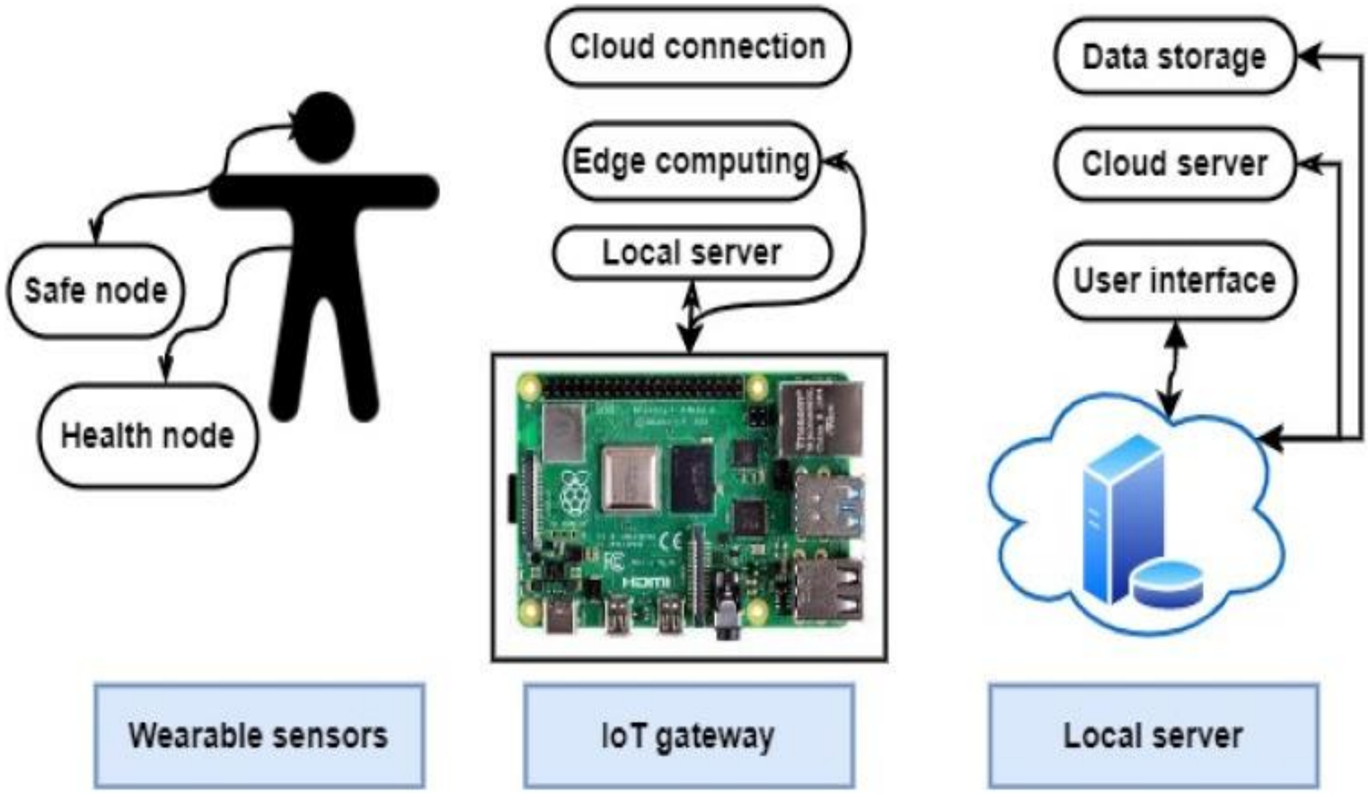

Figure3. *Healthcare-monitoring system using wearable sensor*

VI. BENEFITS OF USING IOT IN HEALTHCARE

The IoT will reshape healthcare as we know it, with profound implications. In terms of how apps, devices, and people communicate with each other to deliver healthcare solutions, we have reached a whole new level of evolution. The IoT has given us a new perspective and tools for an integrated healthcare network, greatly improving healthcare quality.

The IoT has made it possible to automate healthcare procedures that previously required a significant amount of time and left room for error due to human involvement. For example, to control airflow and temperature in operating rooms, many hospitals now use networked devices.

There are almost endless ways the IoT can improve medical care; however, the following are some of the key benefits:

- Reduced cost of care.
- Human errors are reduced.
- Elimination of the limitations of distance.
- Reduced amounts of paperwork and record keeping.
- Chronic diseases are detected early.
- Improvements in medication management.
- The need for prompt medical care.
- Better treatment outcomes.

VII. SECURITY AND PROTOCOLS FOR IOT HEALTHCARE-MONITORING SYSTEMS

Along with the utilization of the IoT, there has also been an increase in the risk of new security assaults and weaknesses in healthcare systems. Healthcare data are highly sensitive and contain personal identifying information such as social security numbers. This is because many medical devices collect and share critical and sensitive patient-related data on the Internet via various connected devices for further evaluations and decisions. IoT technology’s nature presents complexity and incompatibility difficulties in medical-related IoT devices. As a result, security issues such as a lack of availability, confidentiality, and integrity arise. Some of the IoT healthcare solutions include software and hardware that monitor and regulate patients’ vital signs in the form of monitoring services, which are connected to the IoT for data processing. However, these solutions are always at a high risk of security threats such as authorization, privacy, and authentication breaches. Cybersecurity in healthcare has emerged as a big problem. Device flaws could be exploited by hackers, resulting in IoT system operational disruption. More importantly, due to the limitations of medical equipment, such as their scalability, power consumption, and interoperability, standard security criteria for countermeasures for attacks are not relevant. Moreover, when it comes to criteria for security, privacy, and dependability, the medical IoT technology should be trusted too. Additionally, some physical and technical protections to prevent data leakage are available on the market. However, these measures have fallen short of what is needed; stronger and more modern security standards should be implemented, and a resilient strategy should be implemented to save the crucial data. Therefore, to better understand and develop a secure IoT-based healthcare infrastructure, it is necessary to also determine security requirements.

The available solutions could include more secure overlay networks such as the Onion Router (TOR) network, which might be used to transfer confidential data. Moreover, authentication and identity-verification methods such as signatures, voice patterns, finger-print scanning, passwords, and smart cards could be employed in application protocols. Existing security solutions, such as RSA, seed phrases, and DSS, may also be used at all connection endpoints. Technologies such as SDN, blockchain, and NFT tickets could be used to provide authentic and customized service. Last but not the least; artificial intelligence-based approaches that can be used to detect anomalies in IoT networks could be implemented to overcome the issues and challenges of security in IoT-based healthcare-monitoring systems.

Eventually, with the advancements in the IoT’s common standards, many protocols have been created to evaluate the services that are used for IoT solutions, and their relevance, to connect a variety of devices to the Internet and various architectures. IoT protocols for a particular application are selected considering the application’s requirements. Wearable technology, smart medical equipment, smart homes, and remote monitoring are some of the IoT’s most exciting healthcare applications. Some recent studies emphasized IoT interoperability, which includes the healthcare-domain aspects of the IoT, which should compulsorily include the standardization of dependable communication protocols for improved and enhanced mobile and wearable technology. In addition, low-cost, low-power embedded processors are useful solutions. The most popular emerging IoT communication protocols that are extensively used to develop smart IoT applications include CoAP, MQTT, XMPP, AMQP, DDS, LoWPAN, BLE, and Zigbee. The most promising IoT-based healthcare apps for patient monitoring, therapy, and diagnosis are dependent on these protocols. The main uses of these protocols are to enhance the performance of telehealth, medication management, chronic-disease detection, bio-physical parameter monitoring, home and eldercare, and chronic-disease monitoring.

VIII. USE CASES OF HEALTH-MONITORING SENSORS

Medical science research is currently dominated by medical healthcare, which mostly relies on how it integrates with the IoT. This integration is receiving a lot of attention due to its crucial role in utilizing technological paradigms to save human lives. These integrated systems contain three crucial phases, namely, the modules for data collection, data processing, and data evaluation. Healthcare monitoring plays a significant role in the data collection module due to its active involvement in gathering data from various sources and specimens. Most healthcare-monitoring systems use sensors to obtain the necessary input data. The more concise and timely the data, the more accurate the results.

Sensors are employed for more than just data collection; they can also be used for various ongoing and post-monitoring tasks in IoT-based healthcare systems. Blood pressure, body temperature, pulse oximetry, and blood glucose are a few examples of heterogeneous wearable sensing devices developed to collect patients' biomedical data in the era of fast-growing IoT. The proper quality and development of these IoT-based healthcare-monitoring systems are directly related to reliable data from sensors or sensor networks, which necessitate using advanced signal-processing techniques, sensor data fusion, and data analytics. In medical science, sensors that measure heart rate, body temperature, and other things are used to find and diagnose diseases at the earliest stage.

It has been observed that health-monitoring sensors are utilized in various use cases of medical science for healthcare purposes, such as the monitoring of hemoglobin concentration, molecular diagnostics, and clinical diagnosis of albumin-related diseases, heart-rate detection, blood-oxygen-saturation detection, respiratory-rate detection, anemia detection, Alzheimer's disease, and many more.

There are many applications for wearable sensors. IoT-assisted wearables are widely used these days. The friendliness of such devices has created a boom in their application in all fields. With the healthcare field being no exception, the IoT's exploits in healthcare are enormous. Various technologies are linked to existing technology that helps generate data for monitoring and analysis.

IX. USE CASES/APPLICATIONS

1. *Heart-rate detection/Cardiac monitoring systems/Stroke*

The first application of health-monitoring sensors was through IoT-based healthcare-monitoring systems; these can gather and measure the necessary data, transmit these data through various stages reliably to the gateway and the cloud server, and perform some edge tasks to provide low-latency decision-making for cardiac-related diseases and prediction. Some of the pieces utilize sensors to determine heart rate. Several projects involve using WSN technology to continuously monitor heart patients who need a real-time monitoring system. This WSN has several medical-grade sensors and devices that can track blood pressure, body temperature, heart rate, and pulse. A critical patient's real-time ECG is also preserved so that the patient is continuously watched.

2. *Body-temperature measuring*

During the pandemic, IoT-based smart health-monitoring devices with sensors for COVID-19 patients based on body temperature, pulse, and SpO2 were beneficial. Through a mobile application, these systems can measure a human's body temperature, oxygen saturation, and pulse rate.

3. *Activity recognition*

One of the many uses for medical wearables now being used is activity recognition. Almost all fitness trackers perform this kind of recognition. Fitness trackers are now the most popular wearables for tracking a person's activity. A lot of guesswork is being carried out in the background, but most of them include a highly sensitive 3D accelerometer that allows the sensor to determine the acceleration.

4. *Blood-glucose monitoring and hemoglobin concentration*

Heart-rate sensors, blood-glucose monitors, endoscopic capsules, and other devices make up the Internet of Medical Things (IoMT), which together, creates the IoMT diabetic-based WBSN monitoring system.

5. *Respiration-rate detection and monitoring*

We can keep an eye on the human body's respiratory system in several ways. Some writers employed sophisticated sensors that keep track of breathing patterns. A bio-impedance sensor can be useful.

6. *Sleep monitoring*

This sleep-tracking app assists the user in adjusting their sleep patterns and maintaining a healthy life cycle. For this, various sensors are utilized. Wearable often track heart rate, pulse rate, SpO2 levels, and breathing patterns, and by taking these measurements into account, they may make an educated decision regarding the quality of sleep.

7. *Alzheimer's disease monitoring and Anemia detection*

Monitoring for Alzheimer's disease has several issues and needs to be handled carefully. When a patient is alone, diagnosing them with Alzheimer's is impossible.

8. *Molecular diagnostics and Clinical diagnosis*

Due to quick and affordable healthcare applications with reduced risk of infection, recent developments in biosensors for patient-friendly diagnosis and implantable devices for patient-friendly therapy have attracted a lot of attention. The rapid development of point-of-care (POC) sensor platforms and implantable devices with specialized functionality has been made possible by incorporating recently created materials into medical equipment. A lot of work has been conducted on the clinical diagnosis of albumin-related diseases.

9. *Blood-oxygen-saturation detection*

Along with precise, ongoing monitoring of intravascular oxygen levels, it is crucial to monitor patients' cardiovascular health following cardiothoracic surgery. There are new types of data, such as oxygen saturation, which are continuously collected using oxygen-saturation (SpO2) sensors and represent the percentage of oxygen-saturated hemoglobin compared to the total amount of hemoglobin in the blood; these are becoming available for market wearable. Other behavioral and physiological biometric types are already available in many markets wearable.

Thus, it has been shown that health-monitoring sensors are used in various applications and can be used in the future for various diseases, particularly those that focus more on sample or data collection, monitoring, or evaluation. We may assert that whenever a sensor is employed, there is a possibility to collect the necessary data and deliver the desired outcomes, depending on precision and accuracy. Additionally, incorporating the cloud, geographic information systems, and mobile devices has improved the process of sensor-based data gathering and monitoring while allowing for flexible remote sharing and communication.

Numerous case studies and applications are possible for health-monitoring sensors. They can be used to measure hemoglobin concentration; for molecular diagnostics; to provide clinical diagnoses of disorders associated with albumin; to measure heart rate, blood-oxygen saturation, respiration rate, and anemia; to diagnose Alzheimer's; and for many other things.

X. CLASSIFICATION OF HEALTH-MONITORING SENSORS

With advancements in wireless communications, medical sensor technology, and data-collection methods, it is now possible to remotely monitor a person's health by putting wearable technology on them and analyzing the data collected. These sensors and wearable devices can be integrated into various accessories such as clothing, wristbands, glasses, socks, hats, and shoes, as well as other devices such as smartphones, headphones, and wristwatches.

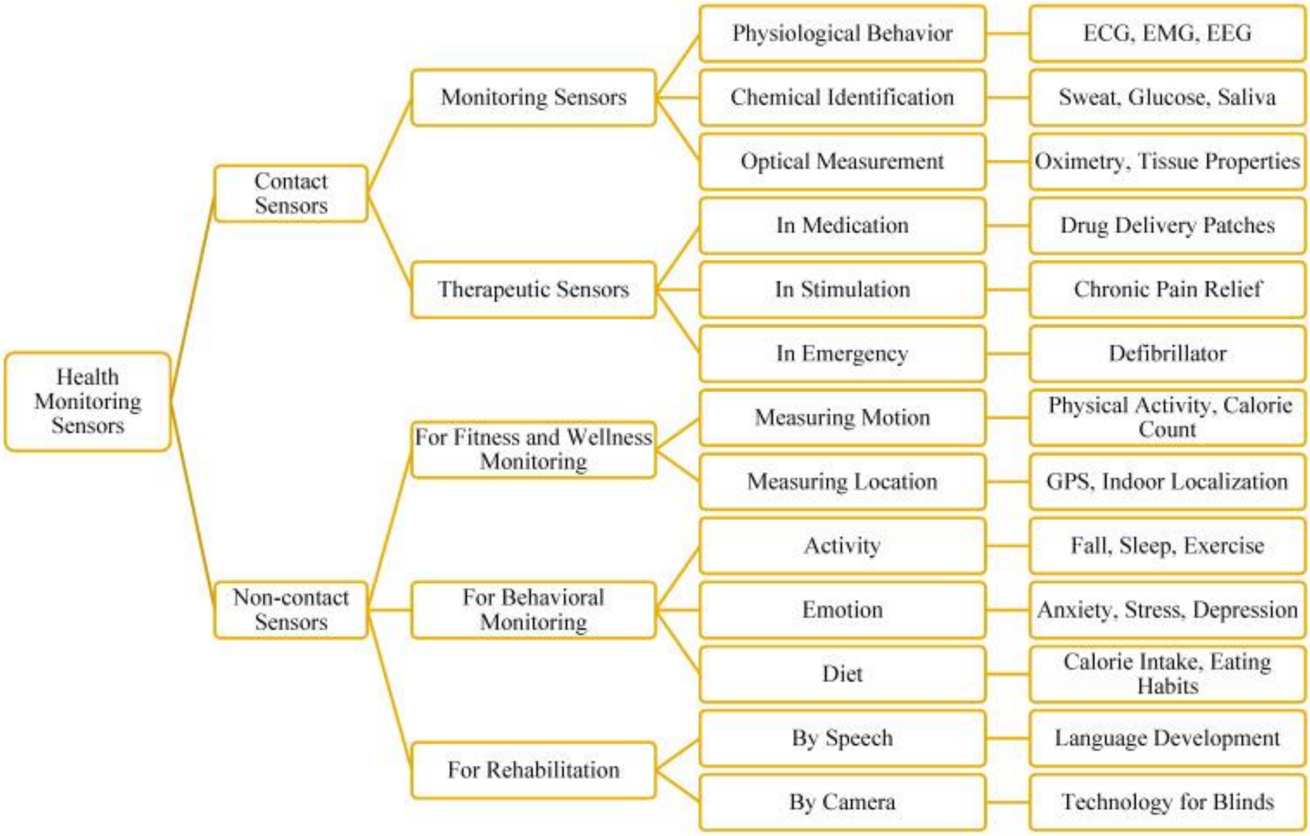

Figure 4. *Classification of health-monitoring sensors.*

The following are some of the medical applications that could benefit from the use of medical sensors and wearable devices:

- Monitoring any signs in hospitals.
- Aging in place and in motion.
- Assistance with motor and sensor devices and batteries.
- Large-scale medical and behavioral research in the field.

These sensors can be divided into many categories, which are covered in the subsections.

Figure 5 is a collection of several wearable sensors applied in various research projects and employed in IoT systems in healthcare.

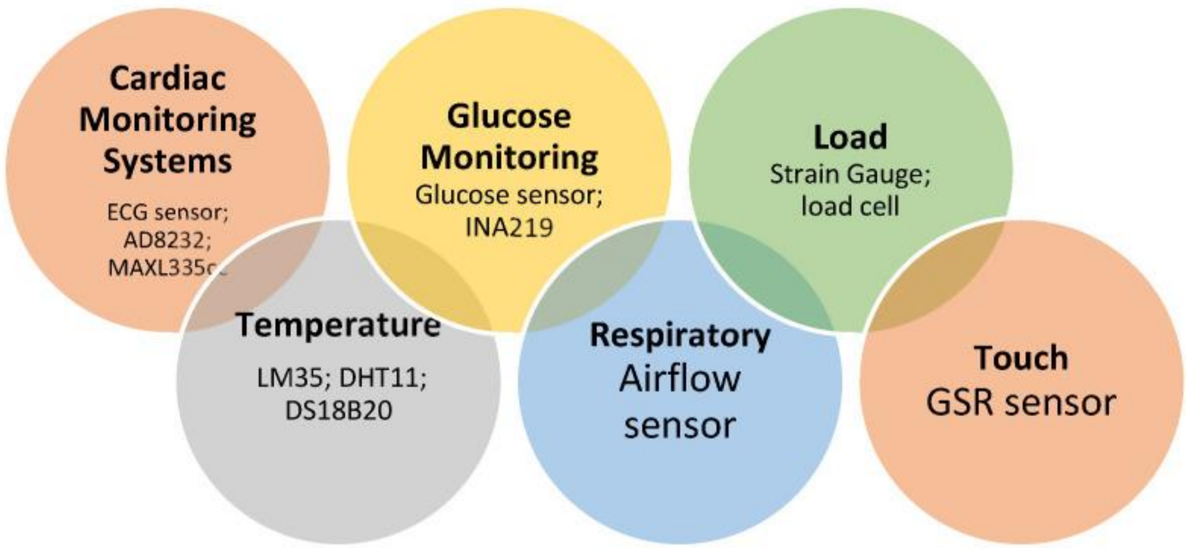

Figure5. *Various applications of use cases and IoT sensors for healthcare monitoring*

XI. SUGGESTIONS AND RECOMMENDATIONS

Based on existing studies and their limitations, there is a need to enhance and integrate wearable healthcare devices to connect with other future technology trends, to solve the communication problems and drawbacks of previous studies. Researchers need to ensure that any proposed systems are user-friendly, adaptable, and secure if they want to retain satisfied customers. Disease management and healthcare can benefit from the new opportunities presented by integrating wearable sensors into healthcare systems. The IoT can provide a solution by connecting health-monitoring devices and sensors to the cloud for 24/7 monitoring. Health records are secured on the server and are available instantly.

In the future, a system could be created to diagnose patients' conditions for chronic diseases and COVID-19; this could help doctors to make the right decision and optimize health conditions, which could improve the functionality of healthcare systems based on the IoT by combining different technological approaches.

Such integration approaches include artificial intelligence (AI), fog computing, Big Data and Nano-Things (IoNT), software-defined networks (SDNs), and the tactile Internet (TI). AI, when integrated with IoT-based healthcare-monitoring systems, can help to generate meaningful and accurate results from sensor data. The fog/edge paradigm can be used to bring computing power closer to where it is needed. Big Data computing can also be utilized in IoT healthcare-monitoring systems because Big Data can make it possible to manage extremely large amounts of data efficiently. In addition, the other most recent technologies of the future, such as the IoNT, software-defined networks (SDNs), and the tactile Internet (TI), have the potential to further enhance the functionality of IoT-based healthcare systems and expand their capabilities in the future.

XII. OBJECTIVE

- To design and implement an IoT-based system for real-time monitoring of critical healthcare equipment conditions.
- 2. To integrate suitable sensors (e.g., temperature, vibration, current, humidity) for detecting operational status, usage patterns, and anomalies in medical devices.
- 3. To develop a communication and data management framework for transmitting, storing, and visualizing sensor data in a secure and efficient manner.
- 4. To enable predictive maintenance by analyzing sensor data to identify patterns and forecast potential equipment failures.
- 5. To evaluate the accuracy, responsiveness, and reliability of the IoT monitoring system in a clinical or simulated healthcare environment.
- 6. To assess the usability and acceptability of the system by healthcare professionals through user feedback and performance metrics.
- 7. To ensure compliance with healthcare data privacy and security standards in the design and implementation of the monitoring system.

XIII. RESEARCH METHODOLOGY

1. Problem Definition

The problem your research addresses, such as:

- Inefficient monitoring of critical medical devices (e.g., ventilators, infusion pumps)
- Manual logging of operational status leading to delays or errors
- Lack of predictive maintenance insights

2. System Architectures

Typical system architectures involve sensors connected to microcontrollers (e.g., Arduino, ESP32), which transmit data to cloud platforms via Wi-Fi, Bluetooth, or LPWAN (e.g., LoRa). Data is then visualized using dashboards for real-time insights. MQTT is commonly used for lightweight data transmission due to its low power consumption and efficiency in healthcare settings (Kumar & Lee, 2019).

3. *Predictive Maintenance and Data Analytics*

Using IoT-collected data, machine learning models can predict equipment failures This predictive approach helps in proactive maintenance and resource optimization.

4. *Experimental Setup*

- Simulated hospital lab or partner healthcare facility
- Equipment: 2 or 3 medical devices to monitor (e.g., suction machines, infusion pumps)
- Continuous monitoring for 4–8 weeks

5. *Data Analysis*

- Using AI tool like powerBi for statistical methods and visualizations
- Apply ML algorithms (e.g., decision trees, anomaly detection) if applicable
- Apply Many Liabraries in python for Graphical Presentation

6. *System Evaluation*

- Accuracy of sensor readings
- Latency in data transmission
- Usability and acceptance by healthcare staff (via surveys/interviews)

7. *Sensor Integration*

- Equipment status (ON/OFF)
- Temperature, humidity (for environment-sensitive devices)
- Vibration (for mechanical devices)
- Power consumption

XIV. LIMITATIONS

- In low-resource or rural healthcare settings, unstable connectivity can lead to data transmission delays or losses.
- The setup of IoT infrastructure, including sensors, gateways, and cloud services, may involve significant upfront investment, which can be a barrier for smaller hospitals or clinics
- IoT devices and sensors often rely on batteries. Ensuring long battery life and regular maintenance of these devices is a challenge, especially in 24/7 monitoring setups.
- Some healthcare institutions may lack IT or engineering personnel capable of managing IoT systems, leading to operational challenges and underutilization of the technology.
- Sensor performance can be affected by electromagnetic interference, temperature fluctuations, or humidity—especially in older hospital buildings.

XV. FUTURE WORK

- Integration with EHR/EMR systems
- Use of AI for automated diagnostics
- Blockchain for secure equipment data logs

XVI. LITERATURE REVIEW: HEALTHCARE EQUIPMENT MONITORING USING IOT AND SENSORS

The literature reveals that IoT and sensor technologies hold significant promise for transforming healthcare equipment monitoring. However, this research is needed to develop scalable, secure, and interoperable systems that meet clinical needs and regulatory standards.

1. *IoT in Healthcare*

   IoT is widely adopted in healthcare for remote patient monitoring, smart diagnostics, and asset tracking. IoT enables continuous data collection from devices, reducing the need for manual supervision and supporting automated decision-making.

2. *Sensor Technologies for Equipment Monitoring*

   - Temperature and humidity sensors: Monitor ambient and internal conditions (e.g., for vaccine refrigerators).
   - Vibration and sound sensors: Detect mechanical faults in equipment such as ventilators or suction pumps.
   - Current and voltage sensors: Track power usage and detect anomalies in electrical performance.
   - Pressure sensors: Useful for devices like infusion pumps or oxygen delivery systems.

XVII. CONCLUSIONS

There are innovative ways in which the IoT can improve medical care. These include reduced cost, and increased efficiency, accuracy, and performance. The benefits of using the IoT have made it possible to automate healthcare systems in the best way. This work aims to be an introductory guide for those who will work in this field in the future, providing them with a detailed reference document related to the IoT and healthcare-monitoring systems. In this work, recent research on IoT-based health-monitoring systems have been reviewed and analyzed in a systematic way. The paper provides in-depth information on their benefits and significance, and a literature review. We also discuss IoT wearable things in healthcare systems and provide a classification of health-monitoring sensors, including the challenges and open issues regarding security and privacy and Quality of Service (QoS). Suggestions for future work have also been included.

In the future, we plan to analyze and evaluate various types of disease-based classification and IoT-based healthcare-monitoring systems. We also plan, in our next phase, to stress the integration of various recent technology trends, such as SDN and AI, with IoT-based healthcare-monitoring systems.

XVIII. ACKNOWLEDGMENTS

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