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IOT In Patient Monitoring

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ABSTRACT

The unexpectedly high number of deaths caused by inadequate medical care is, to date, considered as a serious problem. Besides, the ratio of elderly people who require continuous care is rising. Therefore, a patient monitoring system (PMS) also known as remote patient monitoring (RPM) using the latest Internet of Things (IoT) technology becomes a viable solution that can provide efficient healthcare from a remote distance. PMS monitors timely physiological signals of a patient's health and can reduce the healthcare costs of treatment significantly. In PMS, different health and vital signs issues such as body temperature, heart rate, sleep monitoring, fall detection, and blood pressure can be checked effectively in real-time. To this end, this paper provides a clear vision of electronic healthcare assistance based on PMS and explores the applications of IoT that allow efficient medical services in healthcare systems. In particular, the objective of this paper is to provide a review of PMS, current research, and the challenges associated with this area. Besides, the essential services that can be offered by PMS for monitoring human activities are also discussed. Furthermore, the communication networks and protocols that are required to endure efficient healthcare systems are explained. Finally, this paper discusses several research challenges and open issues that can be investigated for further work. Overall, this paper offers valuable insights for both industry professionals and academic researchers, exploring potential avenues for new research directions.

1. INTRODUCTION

The Internet of Things (IoT) is a network of interconnected physical devices that communicate and exchange data autonomously. It can function without human intervention, using network protocols like Wi-Fi, Bluetooth, and cellular connections.

The Internet of Things (IoT) in healthcare refers to the network of physical devices, sensors, and applications that are connected to the internet and used to collect, transmit, and analyze health-related data. These devices and systems enable real-time monitoring, diagnostics, and management of patients to improved healthcare outcomes and efficiency.

PMS (Patient Monitoring System)

Patient Monitoring System also known as Remote Patient Monitoring (RPM) is a healthcare system that allows caregivers to monitor patients remotely using smart body sensors and modern connectivity standards. RPM conducts essential tests on patients, particularly benefiting the elderly and those with chronic conditions. The terms Personalized Medicine System (PMS), Remote Health Monitoring System (RHMS), Mobile Health Monitoring System (MHMS), and Wearable Health Monitoring System (WHMS) are used interchangeably in the literature, all referring to similar systems that provide remote health monitoring with slight variations in naming. These systems are crucial for improving healthcare delivery and patient management.

2. CONCEPTS OF PMS

Terminologies of PMS

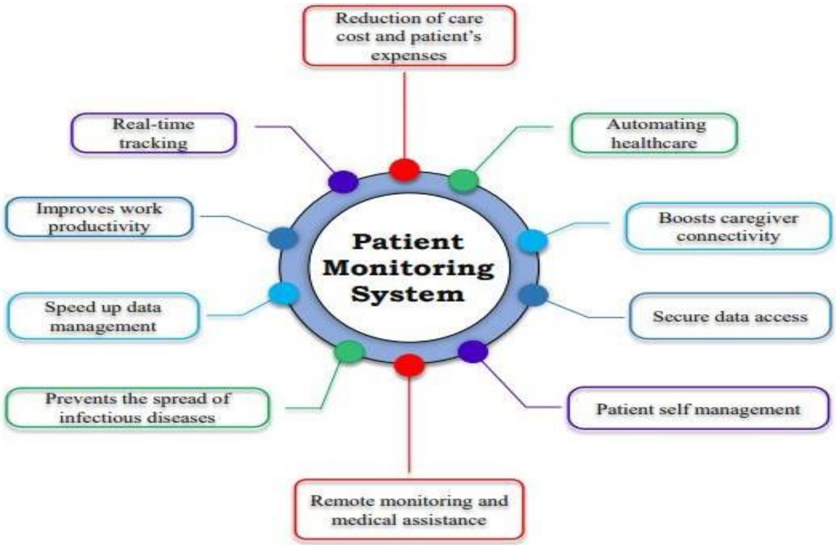
Recent advancements in health technologies, including mobile health, e-health, and IoT, have significantly improved patient care by enabling remote monitoring and quicker diagnosis. Traditional healthcare methods, though cost-effective, face delays, especially for remote patients. Personalized Medicine Systems (PMS) use devices like sensors and microcontrollers to collect patient data, offering real-time monitoring, particularly beneficial for elderly and chronically ill patients. PMS enhances proactive care, ensuring timely interventions and improving overall patient wellbeing and quality of life. The following are some basic terminologies that are used for PMS.

- Conventional Healthcare System: This refers to traditional healthcare practices where doctors physically visit patients and use conventional diagnostic tools, without relying on Information and Communication Technology (ICT).
- Medical emergency: This refers to the manual call to the hospital when needing emergency care. This call should constitute some critical information such as the location, the medical problem nature, and a valid available contact until the ambulance arrives.
- The Internet of Medical Things (IoMT): represents a significant advancement in healthcare, leveraging IoT technologies to enhance patient care and healthcare services connected to the Internet and wearable sensors.
- Remote Patient Monitoring system (RPM): This term is a standard for healthcare delivery that enables caregivers to monitor patients remotely using smart body sensors and built upon modern connectivity standards.

Functions of PMS

The applications of IoT in the medical sector seem to be endless, but the most promising ones are represented by monitoring and tracking patient health using PMS. To this end, PMS is able to perform various functions with an aim to achieve different objectives, which can be listed as follows:

- Reduction of care costs and patient expenses: PMS can play an essential role in lowering healthcare costs. This can be achieved by detecting health issues in an early stage, proactive management, and reduced hospitalization, and hence, beneficial for both providers and patients, resulting in decreased overall expenses.
- Affordability and automating healthcare: Affordability in healthcare can be significantly enhanced by PMS through measures such as reducing hospital readmission and administrative costs, ultimately lowering overall healthcare expenses. Additionally, PMS contributes to automating healthcare processes, optimizing tasks.
- Boosts caregiver connectivity: PMS enhances communication and collaboration among caregivers, enabling seamless coordination of patient care plans, sharing of medical information, and providing support to patients and their families.



3-ARCHITECTURE

The use of five 5 layers PMS architecture which is composed of a sensing layer, wireless communication layer, edge/fog computing layer, cloud computing layer, and application/action layer that involves a user interface and medical server layer. The data is obtained by different types of sensors and wearable devices, then it is transmitted using a short-range communication protocol to the nearest gateway, such as a display, a smartphone, or a computer. After that, the processed signal is transmitted to a remote server that is used by the healthcare specialized person, which is usually placed in a health institution. End users are the one benefit from the PMS, which could be patients, medical staff, hospitals, doctors, government organizations, clinical research institutes, and manufacturing companies

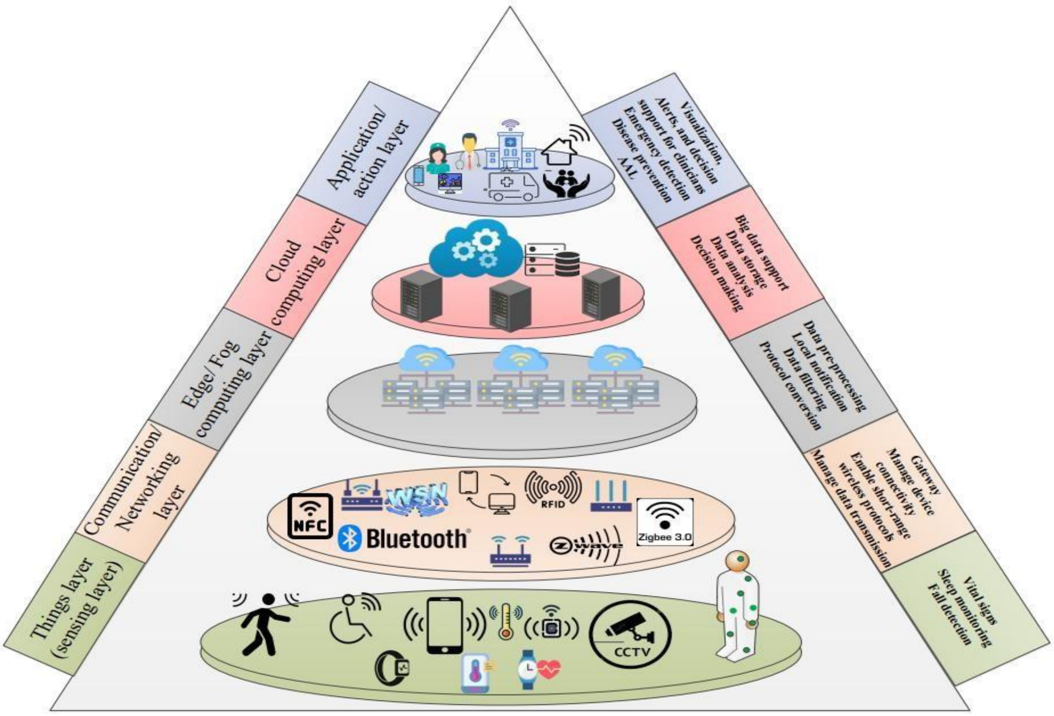


Fig.3.1 The general multi-layer architecture of PMS in healthcare systems

The Role of "IoT in Healthcare Delivery"

The integration of IoT technologies across various layers—such as the sensing layer, communication layer, edge/fog computing layer, cloud computing layer, and application/action layer—has revolutionized the healthcare industry, particularly in personalized medicine systems (PMS). These technologies enable continuous, real-time monitoring of patients' health, improving data collection, analysis, and decision-making processes. With the use of wearable sensors, cloud platforms, and advanced analytics, healthcare providers can remotely monitor patients, detect potential health issues early, and offer timely interventions. Additionally, edge and fog computing enhance system efficiency by processing data closer to the source, reducing latency and conserving bandwidth. The application layer further supports clinical decision-making through visualization, alerts, and decision support tools, while also empowering patients with self-management and disease prevention tools. Overall, this interconnected IoT healthcare ecosystem significantly enhances patient care, making healthcare more proactive, efficient, and accessible, especially for individuals with chronic conditions or those in remote locations.

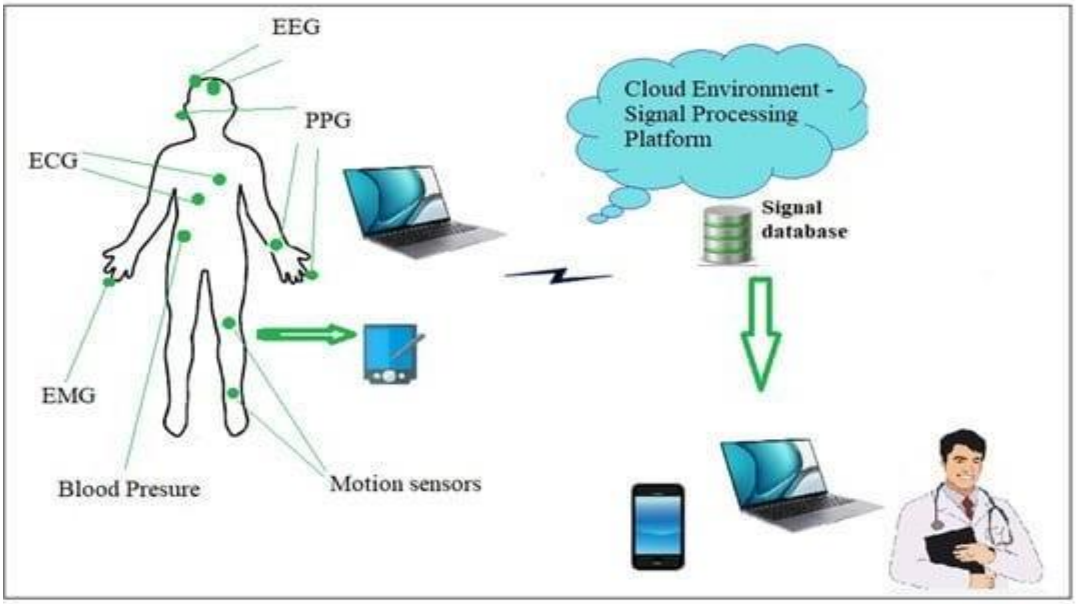


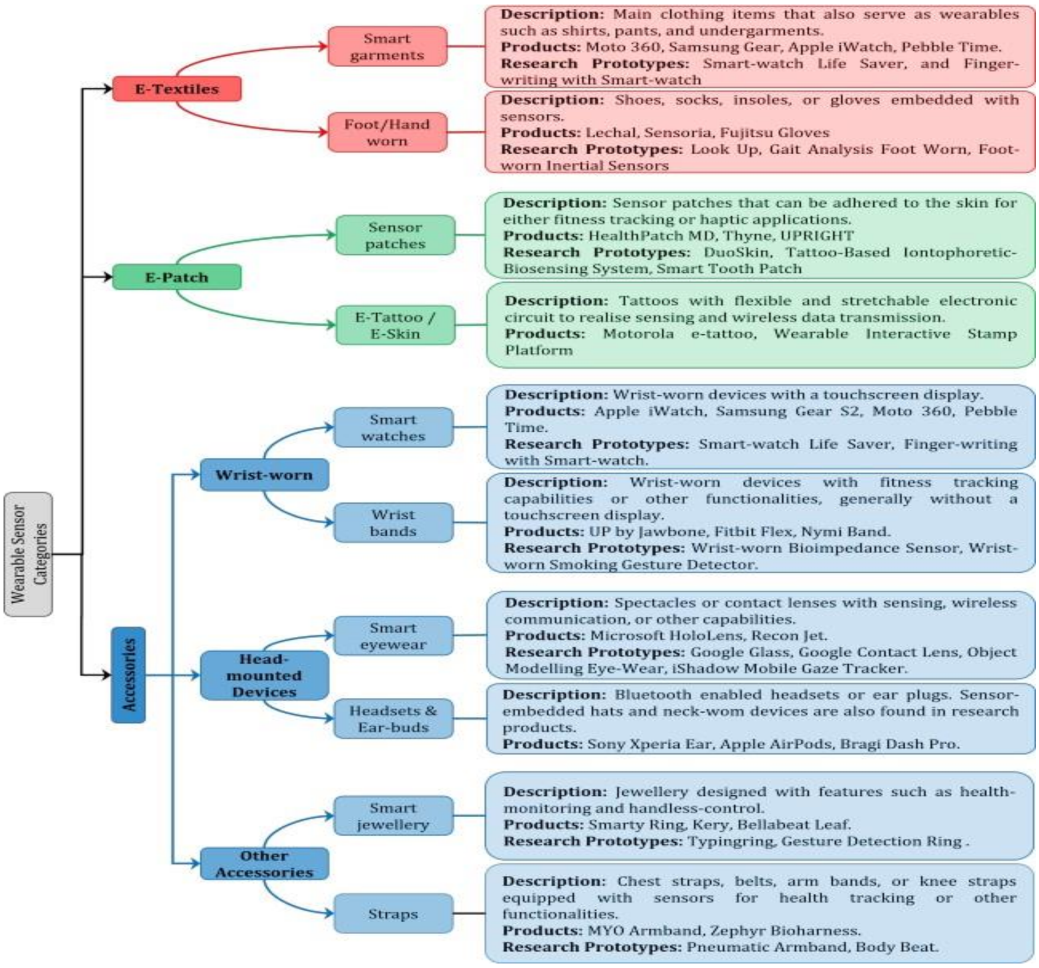
Fig.3.2 The IoT Based Health Monitoring System

4-SENSORS AND WEARABLE DEVICES

A sensor is a device that receives signals and responds to a stimulus. An electrical value is translated from a nonelectrical value via a sensor. Typically, the first layer in PMS healthcare architecture is represented by sensor nodes. In wearable technology for monitoring health parameters or activity levels such as accelerometers, heart rate sensors, temperature sensors, and ECG sensors, are integrated into wearable devices to collect specific data points which is sewn into clothing (wearable), or applied to the human body as tiny patches. Sensors are made to be implanted beneath the skin (in-body). Sensors are the most important part in PMS, which are used to collect information of the patient's condition they are smaller in size, faster in process and gather information, and cost efficient.

Wearable Sensor Devices in Healthcare System

Data acquisition plays a crucial role in PMS by utilizing smart health devices, primarily wireless sensors, and wearable devices, which gather comprehensive patient data. Wearable devices like digital watches, smart clothing, and fitness tracker bands collect a diverse range of health information, enabling continuous PMS and data collection for wearable health monitoring systems) and general health monitoring systems. Specialized devices like smart vests are used for non-invasive physiological monitoring, including ECG, galvanic skin response, body temperature, and blood pressure assessment. Such data acquisition methods not only enhance athlete performance and support disabled individuals but also enable personalized healthcare interventions based on real-time patient data.



Wearable devices in the context of Personalized Medicine Systems (PMS) are on-body biosensors that unobtrusively measure key physiological signals such as blood pressure, heart rate, body movement, skin temperature, and body temperature. These devices are versatile and can be worn directly on the body, concealed in clothing, or integrated into semi-rigid objects like headgear, gloves, insoles, and smartwatches. The primary function of these wearables in healthcare is to continuously observe and record the user's physiological data, enabling real-time health monitoring.

The characteristics of wearable devices in PMS make them particularly valuable in healthcare applications. They are typically easy to use, low-cost, and independent, meaning they don't require the constant involvement of medical professionals for their operation. These devices are designed to empower individuals to monitor their own health and manage conditions without the need for frequent doctor visits, making them ideal for personal, at-home use.

Fig.4.2 The most common types of wearable devices

5-DATA TRANSMISSION AND NETWORKING

Wireless Data Network Infrastructure

Recent advancements have enabled the virtualization and decentralization of networks, creating programmable networks that help reduce delays in IoT applications. By segmenting the network into multiple communication layers, this approach bridges the gap between end-users and the cloud, improving the efficiency of IoT systems. Wearable devices and sensors, such as fitness trackers, collect patient health data like blood pressure, glucose levels, pulse rate, ECG, and cholesterol. Data cleaning techniques, such as noise removal and handling missing values, enhance the accuracy of diagnostic processes. The median studentized residual method can be used to filter out undesirable data, improving detection rates. Additionally, data normalization scales values between 0 and 1, simplifying the diagnostic process and improving the overall system's efficiency.

Wireless Body Area Networks (WBANs)

In Personalized Medicine Systems (PMS), various technologies work together to enable seamless healthcare delivery through real-time data collection, analytics, and device connectivity. Wearable Body Area Networks (WBANs) play a central role in monitoring patient health by collecting physiological data, such as blood pressure, glucose levels, pulse rate, and ECG. These wearable devices can transmit the data wirelessly to nearby processing nodes or directly to the cloud for further analysis. WBANs utilize various wireless technologies, including Bluetooth, Zigbee, WLANs, and mobile networks, to ensure dependable communication with low power consumption and high accuracy. These networks are capable of providing continuous monitoring, offering healthcare providers valuable insights into patients' conditions, which can lead to improved care and reduced healthcare costs.

6-CLOUD AND DISTRIBUTED COMPUTING

Connecting a multitude of physical objects, such as humans, animals, smartphones, and PCs equipped with sensors, and linking them to the Internet generates vast amounts of data known as "big data." Such a big data scale necessitates smart and efficient storage, processing, and retrieval mechanisms. However, traditional hardware and software tools often struggle to handle such immense data volumes within acceptable time slots. In order to accomplish this, the US National Institute of Standards and Technology (NIST) invented cloud computing, which offers a shared programmable network of networks, servers, storage, applications, and services that can be accessed on demand. A longer explanation of cloud computing can be found in the next subsection.

Cloud Computing

Cloud computing has revolutionized healthcare, providing a scalable and cost-effective solution to store, manage, and process large volumes of data generated by IoT devices like sensors and actuators. It eliminates the need for significant capital investments in infrastructure, offering flexibility, rapid elasticity, and on-demand computing resources. Cloud services, such as IaaS, PaaS, DBaaS, and SaaS, allow healthcare providers to efficiently handle vast amounts of patient data, improving service outcomes and enhancing patient care. The use of cloud computing in healthcare also facilitates advanced data analytics, enabling healthcare professionals to extract actionable insights, streamline health information management, and offer personalized treatment strategies. This has led to the concept of Healthcare as a Service (HaaS), which leverages cloud- based technologies to transform health information management and healthcare delivery.

While cloud computing offers significant advantages, it also introduces latency issues due to the need for data transmission over the internet, which can be problematic in emergency healthcare scenarios. To address these challenges, the integration of fog/edge computing with cloud systems is gaining momentum. This hybrid approach optimizes data processing and reduces response times at the network edge, improving real-time decision-making and ensuring timely interventions in healthcare applications. The combination of cloud and edge computing enhances resource utilization, reliability, efficiency, and security, thus optimizing healthcare operations and patient management. These innovations pave the way for advanced healthcare frameworks that prioritize performance, security, and patient outcomes, offering a promising solution for modern healthcare systems.

Distributed Computing

Distributed computing models like fog computing and Multi-Access Edge Computing (MEC) address the limitations of traditional cloud-centric architectures in healthcare applications. As IoT devices generate increasing volumes of data, conventional cloud systems struggle to meet the latency demands of real-time healthcare services. Fog computing and MEC decentralize data processing and storage, bringing computation closer to the data source. This reduces latency, improves scalability, and enhances privacy and security, optimizing network bandwidth and resource utilization. These distributed computing paradigms seamlessly integrate with existing healthcare systems, improving performance and reliability in patient monitoring and healthcare delivery.

7-CONCLUSION

Patient Monitoring Systems (PMS) powered by IoT technologies represent a transformative advancement in healthcare, offering a promising solution to the growing need for efficient, real-time health monitoring and management. By integrating IoT devices into healthcare systems, PMS can provide continuous monitoring of patients, enabling early detection of health issues, timely interventions, and personalized care. This review has outlined the key elements necessary for the development of effective PMS, including their architectural design, communication technologies, and essential protocols required for seamless integration into healthcare environments. Furthermore, the paper has emphasized the importance of addressing ongoing research challenges, such as data management, security, and power consumption, to ensure the successful implementation of PMS in real-world settings.

With the rise in chronic illnesses, aging populations, and the increasing demand for remote healthcare, IoT-based PMS can significantly enhance the quality of care, reduce healthcare costs, and improve patient outcomes by enabling proactive, personalized treatment plans. Additionally, PMS can be crucial in emergency situations and public health crises, providing vital data for healthcare professionals and improving response times. As research continues to evolve, addressing unresolved issues will pave the way for more efficient and scalable PMS solutions, ultimately benefiting both healthcare providers and patients alike. The continued development and implementation of PMS will be critical in shaping the future of healthcare, offering new opportunities for improving patient safety, optimizing resource management, and advancing public health strategies.

8-REFERENCES

[1]M. A. Khan, I. U. Din, B.-S. Kim, and A. Almogren, "Visualization of remote patient monitoring system based on internet of medical things," Sustainability, vol. 15, no. 10, p. 8120, 2023.

[2]H. H. Alshammari, "The internet of things healthcare monitoring system based on mqtt protocol," Alexandria Engineering Journal, vol. 69, pp. 275–287, 2023.

[3]Z. Chen, C. Sivaparthipan, and B. Muthu, "Iot based smart and intelligent smart city energy optimization," Sustainable Energy Technologies and Assessments, vol. 49, p. 101724, 2022.

[4]Z. Mohammadzadeh, H. R. Saeidnia, A. Lotfata, M. Hassanzadeh, and N. Ghiasi, "Smart city healthcare delivery innovations: a systematic review of essential technologies and indicators for developing nations," BMC Health Services Research, vol. 23, no. 1, p. 1180, 2023.