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IoT Framework for Health Monitoring Using Fog Computing for Improved Outcomes

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KEYWORD

Fog Computing, Real-time based Data Processing, Wearable Sensors, Health Data Analytics

ABSTRACT

Healthcare systems face major issues as the population ages, especially when it comes to managing and monitoring the health of the elderly. With the potential to enhance patient outcomes and lessen healthcare costs, Internet of Things (IoT) technology has emerged as a promising solution for ongoing, real-time health monitoring of senior citizens. In order to monitor the health of the elderly, this research proposes a comprehensive IoT framework that recognizes important physiological and environmental factors. Heart rate, blood pressure, body temperature, mobility, and ambient environmental conditions are some of these parameters. To continuously monitor these characteristics, the framework makes use of cutting-edge IoT sensors, data gathering, and transmission technologies. It also incorporates fog computing to improve the system's real-time processing, analysis, and decision-making capabilities. Fog computing reduces latency, maximizes bandwidth utilization, and guarantees quicker response times by processing data closer to the edge—all of which are essential for senior care. In order to provide better health outcomes for the elderly by guaranteeing prompt treatments, early detection of health abnormalities, and individualized care management, this study investigates the synergistic coupling of IoT and fog computing. The scalability, adaptability, and efficacy of the suggested framework in providing useful insights are assessed. Overall, this study offers a comprehensive strategy to monitoring the health of the elderly, highlighting the necessity of an integrated, real-time, and effective system to handle the particular healthcare issues raised by the aging population.

1. Introduction

The population of India is expected to continue growing over the coming decades, according to the United Nations research. By 2050, India is expected to have a sizable population of 1.66 billion people, according to the UN's World Population Prospects [1]. In order to maintain sustainable development in the upcoming years, this prediction underscores the nation's ongoing population increase and stresses the significance of tackling the opportunities and problems that come with it, notably in areas like infrastructure, healthcare, and education. India is the country with the greatest population in the world, only surpassed by China.

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India's population is estimated to be around 1.3 billion as of the most recent data available [2]. It is difficult to manage and provide for the requirements of such a large population; good policies and strategic planning are necessary.

The demographics of India's population show a clear distribution: 31% of people are between the ages of 0 and 14, 62% are in the critical working age range of 15 to 60, and 7% are old people above the age of 60. The enormous presence of children and adolescents is highlighted by this breakdown, underscoring the urgent need for large investments in social infrastructure, healthcare, and education to promote their growth. The majority of people in the 15–60 age range demonstrate a strong workforce, which is essential for economic output, while the 7% of people over 60 indicate the existence of an aging population, which calls for a greater emphasis on healthcare and strong support networks. It is clear from examining India's health records that a sizable section of the populace deals with a variety of health issues. In particular, 26% of people have heart problems, 2% have diabetes, 13% have respiratory problems, 7% have cancer, 28% have external and communicable diseases, 12% have non-communicable diseases (NCDs), and another 12% have injuries. In order to successfully address the common health conditions, our findings highlight the variety of health issues that the community faces and the necessity of focused healthcare interventions and public health initiatives [3]. Over the past few decades, India's healthcare sector has advanced significantly, increasing life expectancy and lowering infant mortality. These accomplishments represent significant advancements in the population's general health and well-being [4]. Longer life spans and lower infant mortality rates are results of improvements in healthcare services, interventions, and awareness, demonstrating the beneficial effects of healthcare initiatives in the nation. Maintaining and improving these favorable health outcomes for Indians will need ongoing efforts in this area.

However, India has difficulties with emergency medical care. Urgent medical services might not be as readily available and accessible as one would like. This emergency healthcare infrastructure gap highlights a need for improvement. Millions of lives have been lost in India as a result of the absence of a strong emergency response system. The lack of a prompt and well-coordinated emergency response infrastructure has made it more difficult to provide life-saving medical care during emergencies. Tragic outcomes from this systemic flaw highlight the pressing need for major improvements in India's emergency medical services. In order to ensure a more resilient healthcare system going forward and to prevent needless deaths during medical emergencies, emergency response systems should be strengthened and expanded. The critical first sixty minutes following a catastrophic accident or medical emergency are known as the "golden hour," during which prompt and efficient medical intervention greatly increases the likelihood of a successful result. Infrastructure, accessibility, and response time constraints frequently make it difficult for EMS to provide timely care during this crucial time [5]. In order to improve emergency medical care and guarantee that life-saving interventions can be given quickly, particularly in the critical early stages of an emergency, it is imperative to identify and address these issues.

Table1: Important reasons of death in India [6]

Cause of death in India over time					
Year	**Cause Of Death**	**Deaths(%)**	**Year**	**Cause Of Death**	**Deaths(%)**
2005	Communicable, maternal, perinatal and nutritional conditions	36.5	2017	Non-communicable diseases	54.5
2005	Injuries	10.4	2017	Symptoms, signs and Ill-defined conditions	13.0
2005	Non-communicable diseases	45.3	2018	Communicable, maternal, perinatal and nutritional conditions	21.5
2005	Symptoms, signs and Ill-defined conditions	7.6	2018	Injuries	10.4
2008	Communicable, maternal, perinatal and nutritional conditions	32.8	2018	Non-communicable diseases	56.0
2008	Injuries	10.3	2018	Symptoms, signs and Ill-defined conditions	12.2
2008	Non-communicable diseases	48.1	2019	Communicable, maternal, perinatal and nutritional conditions	21.2
2008	Symptoms, signs and Ill-defined conditions	8.4	2019	Injuries	9.8
2012	Communicable, maternal, perinatal and nutritional conditions	27.3	2019	Non-communicable diseases	57.1
2012	Injuries	10.6	2019	Symptoms, signs and Ill-defined conditions	12.0
2012	Non-communicable diseases	49.1	2020	Communicable, maternal, perinatal and nutritional conditions	23.9
2012	Symptoms, signs and Ill-defined conditions	12.4	2020	Injuries	8.7
2015	Communicable, maternal, perinatal and nutritional conditions	22.2	2020	Non-communicable diseases	54.9
2015	Injuries	11.0	2020	Symptoms, signs and Ill-defined conditions	12.5
2015	Non-communicable diseases	52.4	2021	Communicable, maternal, perinatal and nutritional conditions	24.0
2015	Symptoms, signs and Ill-defined conditions	14.4	2021	Injuries	8.8
2016	Communicable, maternal, perinatal and nutritional conditions	22.0	2021	Non-communicable diseases	55.7
2016	Injuries	10.9	2021	Symptoms, signs and Ill-defined conditions	11.6
2016	Non-communicable diseases	52.8	2022	Communicable, maternal, perinatal and nutritional conditions	23.4
2016	Symptoms, signs and Ill-defined conditions	14.4	2022	Injuries	9.4
2017	Communicable, maternal, perinatal and nutritional conditions	22.0	2022	Non-communicable diseases	56.7
2017	Injuries	10.5	2022	Symptoms, signs and Ill-defined conditions	10.5

According to the World Health Organization (WHO) [7], heart and circulatory illnesses are the leading causes of death worldwide, claiming the lives of over 17.9 million people annually. An examination of the factors influencing mortality in India was conducted through a survey. The substantial impact of cardiovascular illnesses on public health is highlighted by this startling number. A significant figure from the Indian Heart Healthcare Association states that those under 50 account for half of all heart attacks in India. This worrying pattern suggests that heart-related problems are prevalent in a comparatively younger population. Developing successful preventative measures and healthcare strategies requires an understanding of and attention to the factors that contribute to heart attacks in this age range. This tendency may be significantly influenced by lifestyle factors, stress, and genetic predispositions, underscoring the significance of encouraging heart-healthy practices and early screenings to reduce the incidence of heart attacks among India's younger population.

In fact, an essential diagnostic tool for identifying a variety of cardiac issues is the electrocardiogram (ECG). It creates a visual depiction of the heart's rhythm and function by recording the electrical activity of the heart over time. Heart attacks, arrhythmias, and other cardiac-related problems can be indicated by abnormalities in the ECG waveform. ECGs are frequently used in clinical settings for both normal examinations and emergency scenarios. They offer useful data that helps medical personnel identify and diagnose heart-related issues. This popular, non-invasive method is essential for the early identification and tracking of cardiac disorders, which leads to successful medical treatments and better patient outcomes. Because ECG is a widely recognized and standardized medical diagnostic, it can be used consistently and reliably in a variety of healthcare settings. Additionally, with advancements in technology, ECG sensors can now be seamlessly integrated into wearable devices, facilitating unobtrusive and convenient health monitoring in real-world settings.

Table2: Literature review

Author	**Summary of Contribution**
Hossain et al. (2015)	An IoT-based healthcare system for ongoing health monitoring was suggested by the author. They underlined the need of wearable sensors for monitoring critical metrics, such as blood pressure and heart rate, which are essential for managing the health of the elderly. The foundation for sensor-driven health monitoring systems was established by their work [8].
Zhang et al. (2016)	A thorough survey on the use of IoT in senior healthcare was presented by researchers. They emphasized the need for real-time data collection and processing while showcasing a variety of sensor technology used to track the health of the elderly. The study highlighted how IoT can revolutionize senior care by enhancing monitoring and results [9].
Kim et al. (2017)	An IoT-based smart health monitoring system specifically designed for senior care was created by the author. Their system included a number of sensors to monitor important health indicators, such as heart rate and body temperature. They emphasized the necessity for effective data management solutions by highlighting the difficulty of processing data in real-time for senior health systems [10].
Ahmad et al. (2018)	Author presented a thorough framework for monitoring the health of the elderly that combines fog computing and IoT. They emphasized that by processing data closer to the data source, fog computing can reduce latency and bandwidth problems commonly associated with cloud computing. Fog computing integration allowed for more effective health interventions for the elderly and faster decision-making [11].
Yang et al. (2019)	The author of this research examined fog computing's use in healthcare, namely in monitoring the health of the elderly. They investigated fog computing's benefits, including reduced latency, faster data processing, and the capacity to manage real-time health data. According to their poll, fog computing is crucial to the creation of responsive and scalable healthcare systems for the elderly[12].
Gubbi et al. (2020)	The integration of IoT with strong security measures was the main emphasis of the author's framework for monitoring the health of the elderly. They emphasized how crucial it is to protect data integrity and privacy, particularly in healthcare systems that depend on wearable devices' constant data transfer. The importance of putting secure communication mechanisms in place to safeguard private health information was highlighted by their study[13].
Sharma et al. (2021)	Researcher highlighted a novel way to track the health of the elderly by combining fog computing with IoT. With fog computing enabling local data processing, their approach focused on gathering important health metrics like heart rate and oxygen saturation. This method lessened the strain on centralized cloud systems and allowed for quicker decision-making[14].
Hussain et al. (2022)	Author examined how edge and fog computing can help with elderly people's real-time health monitoring. Their research showed how data processing at the edge/fog layer might drastically cut down on the amount of time needed for data transmission and analysis, leading to faster responses to health problems. They also tackled issues with energy efficiency and system scalability[15].
Singh et al. (2023)	Contributors created an all-encompassing Internet of Things architecture for monitoring the health of the elderly that processed health data in real time using fog computing. They identified several key health parameters such as glucose levels, activity tracking, and vital signs that are essential for elderly care. Their study emphasized how fog computing enhances the monitoring process by enabling immediate action based on real-time health data[16].

Li et al. (2024)	Researchers looked explored the possibility of enhancing senior health outcomes by incorporating fog computing into IoT-based health monitoring systems. Their study concentrated on utilizing fog computing to improve healthcare responses and minimize data transmission delays. They came to the conclusion that fog computing enables quicker, more localized decision-making, which improves health interventions and results for senior citizens[17].

2. Literature review

The cloud is the only technology that can analyze, store, and access the IoT, depending on the deployment model. In recent years, IoT technology has gained significant interest for embedded applications [18]. IoT is a technological innovation capable of changing applications in various fields and achieving effective results. IoT devices have limited memory and processing capacities that lead to problems with performance, reliability, and security. Thus, integrating IoT with the cloud with huge storage and processing capacity will lead to better performance of real-time systems. The emergence of IoT has trans- formed many applications that include applications in manufacturing, gas and oil plantation, utilities, transportation, public safety, local governance, and health care. IoT technology has gained significant interest in healthcare applications because of its capability to handle the issues in healthcare systems due to the increase in the aging population and chronic diseases. Considering the extensive use of cloud computing, certain IoT applications and healthcare services seem unable to benefit from this popular computing technique due to inherent cloud computing challenges such as latency, location awareness, and flexibility. As a result, edge/fog computing has emerged as a promising technology at the edge of the network to provide elastic services [19]. Edge and fog computing collectively enhance distributed computing by bringing processing closer to data sources, im- proving latency and real-time capabilities, while the key distinction lies in their scope edge computing typically involves local devices, while fog computing ex-tends its reach to cover a broader, intermediate layer of the network infrastructure. Edge/Fog computing techniques include connecting things to analyze and respond to big data they produce in a fraction of a few seconds and sending only the re- quired data alone to the cloud for big-data analytics and storage [20]. Latency reduction is the main advantage of edge/fog computing, and hence, it can be used in IoT healthcare applications as they expect the system to be latency-sensitive. Harshit et al. carries out a case study on iFogSim simulation, a latency- sensitive online game and intelligent surveillance distributed camera networks [21]. An EEG sensor provides EEG signals to the online game application that is sen- sitive to latency and a DISPLAY actuator shows the user the current game scene. Application Model of EEG Game. The cloud-only place- ment (cloud computing only) and edge ward placement (fog computing and cloud computing) efficiencies were assessed by taking into account parameters such as latency, network use, and energy consumption. Another researcher introduce an E-health and wellness monitoring application designed to promote a healthier lifestyle. This research gathers and analyzes user behaviors to make predictions and offer personalized recommendations [22]. How- ever, there is an issue with data processing delay, particularly in critical emergency situations. A real- world cloud-based smart medical system that utilizes communication networking, allowing doctors to provide online treatment to their patients. This application employs mobile devices and wireless body area networks, potentially extending to fog technology.

3. Proposed Framework

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In order to react to major health events, the health monitoring systems need to be reliable almost instantly. Geographical distances between IoT devices and the cloud cause delays in existing cloud-intensive models that send data to clouds for analysis. Milliseconds play a critical role in both treatment and emergency situations where the lives of patients depend on the decision-makers' actions. As additional devices are linked, the network's data restrictions and throughput capabilities become too much for the system to handle and react to.

In the projected framework, the data is gathered from smart health device that is wear by patient. Vital indicators, including blood pressure, are continuously monitored by the device. Abnormal readings are detected by the device. The device prepares data for transmission and signals the occurrence. Heart rate, blood pressure, timestamp, and patient ID information were gathered. Temporary caching on the linked smartphone or device. Data is then securely transmitted to a fog-based health platform via Wi-Fi and router. Real-time data is sent to the hospital via the Remote Monitoring Dashboard. The medical personnel starts the follow-up after reviewing the notifications. The patient is informed of the following stages by a device or app. The hospital may get in touch with the patient or send assistance based on the severity. For Future reference result send on the cloud.

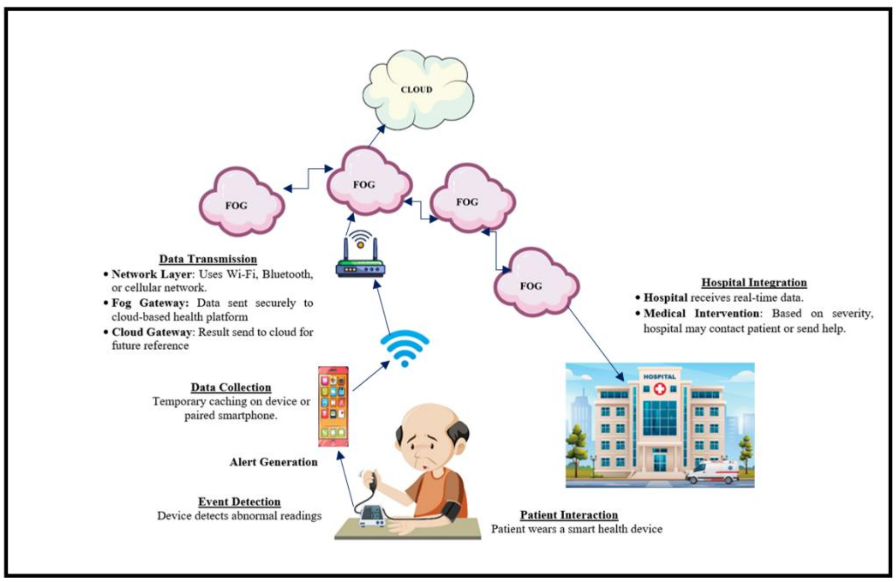

Fig1: Framework presented working of IoT with Fog Computing

4. Conclusion

In conclusion, the integration of **IoT technologies** for elderly health monitoring presents a significant opportunity to enhance the quality of care and support aging populations. The identified key health parameters such as **heart rate, oxygen saturation, glucose levels, and physical activity** serve as critical indicators for continuous health monitoring. By utilizing a combination of **wearable sensors** and **environmental monitoring devices**, IoT frameworks can provide real-time insights into the health status of elderly individuals, ensuring timely interventions and better disease management. Moreover, the incorporation of **fog computing** into this framework enhances their overall efficiency. Fog computing offers several advantages over traditional cloud-based systems, such as reduced **latency**, **improved real-**

time data processing, and alleviating bandwidth constraints. By processing health data closer to the patient or local devices, fog computing ensures faster response times, which is crucial for addressing health emergencies and providing immediate care. This localized data processing also ensures that only necessary data is transmitted to the cloud, reducing communication costs and enhancing privacy. The **synergy between IoT and fog computing** is key to the future success of elderly health monitoring systems. The ability to perform complex data analysis at the edge, combined with real-time decision-making capabilities, leads to more personalized, adaptive, and timely healthcare interventions. Furthermore, this approach supports the **scalability** of monitoring systems, enabling them to accommodate a large number of elderly individuals without compromising performance.

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