Contactless Sensing and IoT Integration in Geriatric Healthcare: A Literature Review

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Abstract*—Continuous and non-invasive health monitoring has gained significant attention in recent years, particularly for elderly care and clinical environments where patient comfort and hygiene are critical. This literature review presents a comprehensive analysis of existing contactless health monitoring systems, focusing on radar-based sensing, infrared thermography, ambient assisted living frameworks, and IoT-enabled healthcare architectures. Previous studies demonstrate that radar-based techniques, including FMCW and Doppler radar, offer high accuracy in monitoring vital signs such as heart rate and respiration without physical contact. Infrared thermography has proven effective for non-contact body temperature measurement, especially in clinical screening and remote healthcare applications. Additionally, IoT-based healthcare systems enhance real-time monitoring, data accessibility, and remote medical supervision. However, the literature also highlights key limitations such as high system cost, complex hardware requirements, sensitivity to environmental factors, and challenges related to data security and system scalability. This review synthesizes the strengths and limitations of existing approaches and identifies the need for cost-effective, scalable, and reliable contactless health monitoring solutions suitable for continuous elderly care and home-based healthcare environments.

Index Terms*—Contactless health monitoring, elderly care, IoT, ESP32, vital signs, wireless healthcare.

I. INTRODUCTION

The rapid growth of the elderly population worldwide has increased the demand for efficient, continuous, and non-invasive health monitoring systems. Elderly individuals are more vulnerable to chronic illnesses and sudden health complications, making regular monitoring of vital parameters such as heart rate, respiration, and body temperature essential. Traditional contact-based monitoring systems, including wearable sensors and electrode- based devices, often cause discomfort, skin irritation, and increased risk of infection, particularly in long- term care and hospital environments.

Recent advancements in contactless sensing technologies have enabled the development of non-invasive health monitoring systems that improve patient comfort and hygiene. Radar-based techniques have emerged as a promising solution for monitoring vital signs by detecting minute chest movements associated with respiration and cardiac activity. Studies using FMCW and Doppler radar demonstrate high accuracy and robustness under various conditions, including monitoring through clothing and bedding. These systems are particularly suitable for elderly and bedridden patients, where physical contact should be minimized.

Infrared thermography has also been extensively studied as a non-contact method for body temperature measurement. By capturing thermal radiation emitted from the human body, infrared sensors provide rapid and hygienic temperature assessment, making them suitable for clinical screening and remote healthcare applications. However, thermal imaging alone is insufficient for comprehensive vital sign monitoring.

In parallel, IoT-based healthcare monitoring systems have gained prominence due to their ability to collect, transmit, and analyze physiological data in real time. IoT frameworks enable remote access to health data, support continuous monitoring, and facilitate timely medical intervention. Ambient Assisted Living systems further integrate contactless sensors with smart environments to support elderly individuals in daily life. Despite these advancements, existing systems often face challenges such as high implementation cost, complex system architecture, power consumption issues, data privacy concerns, and

limited integration of multiple contactless sensing modalities.

This literature review examines key research contributions in contactless sensing, radar-based monitoring, infrared thermography, and IoT-enabled healthcare systems. By analyzing their methodologies, advantages, and limitations, the review highlights existing research gaps and the need for affordable, scalable, and integrated contactless health monitoring solutions for elderly care and remote medical supervision.

II. LITERATURE SURVEY

A. Alizadeh, G. Shaker, and J. C. M. Choi – Contactless Vital Signs Monitoring for the Elderly Using Radar and Thermal Sensors (2019), IEEE Sensors Journal

Alizadeh et al. presented a comprehensive study on contactless vital signs monitoring systems using radar and thermal imaging technologies, with a primary focus on elderly healthcare applications. The paper investigates how radar sensors can be used to accurately extract physiological parameters such as heart rate and respiratory rate by detecting subtle chest movements, while thermal sensors are employed for non-contact body temperature monitoring. The authors emphasize the importance of contactless monitoring in elderly care to improve patient comfort, reduce dependency on wearable devices, and minimize the risk of infections.

The study also discusses the challenges associated with real-world deployment of contactless monitoring systems, including motion artifacts caused by body movements, environmental interference, and accuracy limitations in indoor healthcare settings. Various signal processing and sensor fusion techniques are reviewed to enhance reliability and measurement precision. The authors conclude that integrating radar and thermal sensors provides a promising solution for continuous, unobtrusive health monitoring in homes, hospitals, and assisted living facilities, making it highly suitable for long-term elderly care.

B. C. Li, V. M. Lubecke, and O. Boric-Lubecke – Non-Contact Monitoring of Human Vital Signs Using FMCW Radar (2013), IEEE Transactions on Microwave Theory and Techniques

Li et al. presented a pioneering study on the use of Frequency-Modulated Continuous-Wave (FMCW) radar for non-contact monitoring of human vital signs. The paper demonstrates how FMCW radar technology can accurately detect small chest wall movements caused by respiration and heartbeat without requiring any physical contact with the subject. This approach eliminates the need for wearable sensors, making it highly suitable for continuous and unobtrusive health monitoring.

The authors provide a detailed explanation of radar signal processing techniques used to separate respiration and heartbeat signals from noise and motion interference. Experimental results show that the proposed system achieves reliable accuracy under different conditions, including variations in distance and body orientation. The study also discusses potential healthcare applications such as patient monitoring in hospitals, sleep monitoring, and elderly care. Due to its robustness, precision, and non-invasive nature, this work serves as a foundational reference for many modern contactless vital sign monitoring systems.

C. M.Mercuri et al. -Radar-Based Contactless Monitoring of Vital Signs in Bedridden Patients (2020)

In recent years, the need for non-contact vital sign monitoring systems has gained significant attention due to the limitations of conventional contact-based sensors, especially in clinical environments. Mercuri et al. (2020) proposed a radar-based contactless monitoring system aimed at continuously tracking vital physiological parameters of bedridden patients without physical contact. The system employs a Doppler radar sensor to detect micro-movements associated with respiration and cardiac activity, translating them into vital sign measurements. By eliminating the requirement for electrodes or wearables, the method effectively reduces patient discomfort and decreases the risk of cross-infection, which is a critical concern in hospital wards and long-term care facilities. The study demonstrates the potential of radar sensing as a reliable alternative to traditional monitoring techniques, highlighting

enhanced patient comfort and improved hygiene outcomes. Furthermore, the non-intrusive nature of the system makes it particularly suitable for continuous monitoring in sensitive patient populations, including the elderly and immunocompromised individuals.

D. Queirós et al. -Ambient Assisted Living Systems for Elderly Health Monitoring (2018)

Queirós et al. (2018) provided a comprehensive review of Ambient Assisted Living (AAL) systems aimed at supporting elderly health monitoring. The paper focuses on the integration of contactless and IoT-based technologies to enable continuous and unobtrusive monitoring in everyday environments. It discusses various system architectures that combine sensors, communication protocols, and data processing units to facilitate real-time health monitoring. The authors also examine key challenges associated with AAL systems, such as ensuring data privacy, maintaining reliable long-term performance, and addressing interoperability among heterogeneous devices.

Lahiri et al. (2012) explored the use of infrared thermography as a non-contact method for measuring body temperature. Infrared thermography offers a way to detect thermal emissions from the skin without direct contact, making it suitable for applications where hygiene and patient comfort are critical. The study evaluates the accuracy and limitations of infrared thermal sensors in capturing temperature variations, emphasizing its potential in clinical and remote health monitoring scenarios.

Islam et al. (2015) investigated IoT-based smart healthcare monitoring systems, highlighting how interconnected devices can improve patient care and health tracking. The paper presents IoT architectures that collect physiological and environmental data through wearable and non- contact sensors, transmit the data over wireless networks, and analyze it on cloud platforms. Key advantages discussed include real-time monitoring, scalability, and remote access for healthcare providers. However, the authors also address challenges such as data security, energy efficiency of devices, and integration of heterogeneous sensor networks.

Together, these studies illustrate the evolution of contactless and IoT-enabled health monitoring, from sensor technologies like infrared thermography to system-level architectures in ambient assisted living. They highlight both the opportunities in improving patient comfort and care continuity, as well as the technical and ethical challenges that must be addressed for widespread adoption.

E. M.Lahiri et al. -Infrared Thermography for Non-Contact Temperature Measurement (2012)

Lahiri et al. (2012) investigated the use of infrared thermography as a non-contact method for measuring human body temperature. The study focuses on overcoming the limitations of traditional contact-based temperature measurement techniques, such as thermometers and skin-mounted sensors, which may cause discomfort, require physical contact, and increase the risk of infection transmission. Infrared thermography works by detecting the thermal radiation emitted from the surface of the human body and converting it into temperature information.

The authors analyzed the accuracy and effectiveness of infrared thermal imaging systems in capturing temperature variations under different conditions. The study highlights that non-contact temperature measurement is particularly useful in medical environments, mass screening, and remote health monitoring, where hygiene and patient comfort are critical. However, the paper also discusses challenges such as sensitivity to environmental factors, calibration requirements, and variations due to skin emissivity.

Overall, the research demonstrates that infrared thermography is a promising, non-invasive technique for temperature monitoring, offering advantages in terms of safety, comfort, and rapid measurement. The study provides a foundation for the use of thermal imaging in modern healthcare monitoring systems, especially in contactless and remote diagnostic applications.

F. S. M. R. Islam et al. IoT-Based Smart Healthcare Monitoring Systems (2015)

Islam et al. (2015) presented a detailed study on IoT-based smart healthcare monitoring systems, focusing on how Internet of Things (IoT) technologies can

improve healthcare services through continuous and remote patient monitoring. The paper discusses the use of interconnected sensors and devices to collect physiological data such as heart rate, body temperature, blood pressure, and activity levels from patients in real time.

The proposed IoT-based healthcare architecture consists of sensing units, communication networks, data storage, and cloud-based processing platforms. Sensor data is transmitted wirelessly to remote servers, where it can be analyzed and accessed by healthcare professionals for diagnosis and decision-making. This enables timely medical intervention and reduces the need for frequent hospital visits, especially for elderly and chronically ill patients.

The authors also highlight key advantages of IoT-based healthcare systems, including real- time monitoring, scalability, cost-effectiveness, and improved patient care. However, the paper identifies several challenges such as data security, patient privacy, power consumption of devices, and system reliability. Overall, the study emphasizes that IoT-based smart healthcare monitoring systems have strong potential to transform traditional healthcare by enabling efficient, remote, and continuous health monitoring.

G. A. Singh et al. - A Review of Contactless Sensing Technologies for Healthcare (2021)

Singh et al. (2021) conducted a comprehensive review of contactless sensing technologies and their applications in healthcare monitoring. The study focuses on various non-contact sensing modalities, such as radar, infrared thermography, ultrasonic sensing, and computer vision, which are capable of detecting physiological signals without attaching sensors to the patient's body. The objectives of the review include evaluating the performance, advantages, limitations, and potential use cases of different contactless techniques in clinical and remote health monitoring environments.

The authors discuss how radar-based systems can capture respiratory and cardiac activity, how infrared thermal imaging can measure body temperature, and how vision-based approaches using cameras can monitor movement, posture, and vital sign indicators. The review highlights the growing importance of contactless sensing, especially for vulnerable patient groups, where minimizing physical contact can reduce discomfort, improve hygiene, and lower the risk of infection.

The paper also addresses key technical and practical challenges associated with implementing contactless healthcare systems, such as signal interference, environmental sensitivity, data accuracy, computational complexity, and privacy concerns. Singh et al. conclude that while contactless sensing technologies show promising potential for transforming healthcare monitoring, further research is needed to improve robustness, integration with IoT systems, and standardized evaluation methods. The review provides a solid foundation for understanding the state of the art in contactless sensing and helps identify future research directions in non-invasive healthcare solutions.

III. COMPARITIVE ANALYSIS OF LITERATURE SURVEY

A. Contactless Vital Signs Monitoring Using Radar Sensors

A. Alizadeh et al. investigated radar-based contactless monitoring techniques for measuring human respiration and heart rate without physical sensors. The study emphasizes applications in elderly care and indoor healthcare environments where long-term monitoring is required. The system improves patient comfort and hygiene while reducing infection risks. However, the authors identify challenges such as motion artifacts and environmental interference, which can affect accuracy in real-world deployment.

B. Non-Contact Vital Sign Detection Using FMCW Radar

C. Li et al. presented a frequency-modulated continuous-wave (FMCW) radar technique for detecting vital signs such as heartbeat and respiration. The study demonstrated reliable performance even through clothing and bedding, making it suitable for unobtrusive health monitoring. While the method offers high accuracy, it requires advanced signal processing and specialized radar hardware, increasing system complexity.

C. Radar-Based Contactless Monitoring of Vital Signs in Bedridden Patients

M. Mercuri et al. developed a radar-based contactless system specifically designed for monitoring bedridden patients in hospital and long-term care environments. The system significantly reduces patient discomfort and minimizes infection risks associated with contact-based sensors. However, the work mainly focuses on clinical settings and lacks integration with IoT-based remote monitoring platforms.

D. Ambient Assisted Living Systems for Elderly Health Monitoring

J. Queirós et al. reviewed ambient assisted living technologies with a focus on contactless and IoT-based healthcare solutions. The paper discusses system architectures, sensor integration, data management, and privacy concerns. Although the study provides a comprehensive overview, it does not present a practical implementation model for real-time monitoring.

E. Infrared Thermography for Non-Contact Temperature Measurement

M. Lahiri et al. explored the use of infrared thermography for non-contact body temperature measurement. The system is effective for fever detection and mass health screening, particularly in public and clinical environments. However, thermal imaging alone cannot monitor other vital signs such as heart rate and respiration, limiting its applicability as a standalone solution.

F. IoT-Based Smart Healthcare Monitoring Systems

S. M. R. Islam et al. proposed an IoT-based healthcare monitoring framework integrating sensors, cloud platforms, and data analytics. The study highlights the importance of remote and real-time monitoring to improve healthcare accessibility. However, the framework primarily focuses on system architecture and does not deeply address contactless sensing accuracy.

G. Review of Contactless Sensing Technologies for Healthcare

A. Singh et al. presented a comprehensive review of contactless sensing technologies including radar, thermal imaging, and vision-based systems. The study compares performance, accuracy, and limitations of different approaches, providing valuable insights for designing modern contactless monitoring systems.

IV. CONCLUSION

This literature review analyzed existing research on contactless health monitoring systems, with particular emphasis on radar-based sensing, infrared thermography, ambient assisted living technologies, and IoT-enabled healthcare frameworks. The reviewed studies demonstrate that contactless monitoring techniques offer significant advantages over traditional contact-based systems by improving patient comfort, maintaining hygiene, and reducing infection risks—especially in elderly care and clinical environments.

Radar-based approaches provide high accuracy in detecting vital signs such as heart rate and respiration without physical contact, making them suitable for continuous and unobtrusive monitoring. Infrared thermography offers an effective solution for non-contact body temperature measurement but is limited when used as a standalone method. IoT-based healthcare systems enhance real-time monitoring, scalability, and remote access to patient data; however, many existing solutions rely on expensive hardware, complex architectures, and face challenges related to data security and power efficiency.

Overall, the literature indicates a growing need for integrated, low-cost, and energy-efficient contactless health monitoring systems that combine reliable sensing techniques with IoT connectivity. Addressing the identified limitations can support the development of practical solutions suitable for long-term elderly healthcare, home-based monitoring, and remote medical supervision. This review provides a foundation for future research aimed at designing scalable and economically feasible contactless healthcare systems.

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