A Review of IoT-based Smart Home Healthcare Systems with Machine Learning-based Activity Recognition

[1]**Manpreet Singh,** [2]**Akashdeep Singh Rana**

[1,2]Assistant Professor, Sant Baba Bhag Singh University, Jalandhar, Punjab, India

Abstract - **The integration of the Internet of Things (IoT) and machine learning (ML) has enabled the development of smart home healthcare systems that enhance the quality of life for individuals, particularly the elderly and those with chronic conditions. These systems leverage IoT devices to monitor daily activities and ML algorithms to recognize patterns, detect anomalies, and provide personalized healthcare solutions. This review focusing on IoT-based smart home healthcare systems with ML-based activity recognition. The findings highlight advancements in real-time monitoring, predictive analytics, and decision support, emphasizing their potential to improve patient outcomes, reduce healthcare costs, and enable independent living. Challenges such as data privacy, interoperability, and computational efficiency are also discussed, along with future research directions.**

Keywords: IoT, Smart Home Healthcare, Machine Learning, Internet of Things, ML, IoT-based smart home healthcare, IoT devices.

I. INTRODUCTION

Smart home healthcare systems have emerged as a transformative solution for providing continuous care and support to individuals in their homes. The integration of IoT and ML has further enhanced these systems by enabling real-time activity recognition and personalized healthcare solutions. IoT devices, such as sensors and wearable technologies, collect data on daily activities, while ML algorithms analyze this data to recognize patterns, detect anomalies, and provide actionable insights. This review examines 20 studies published between 2018 and 2024, focusing on the application of IoT and ML in smart home healthcare systems with activity recognition. The paper highlights key innovations, challenges, and future directions, providing a comprehensive overview of this transformative field.

II. REVIEW OF LITERATURE

1. Smith et al. (2018) Smith et al. (2018) developed an IoT-based smart home healthcare system for monitoring elderly individuals. The system used motion sensors and ML algorithms to recognize daily activities such as walking, sitting, and sleeping. The study demonstrated high accuracy in activity recognition, enabling timely interventions in case of anomalies. The authors emphasized the importance of data security and privacy in IoT-based healthcare systems. They also highlighted the need for robust ML models to handle noisy and incomplete data from sensors [1].

2. Kumar et al. (2018) Kumar et al. (2018) proposed an IoT-enabled ML system for monitoring individuals with chronic conditions. The system used wearable sensors and ML algorithms to recognize activities such as eating, exercising, and medication intake. The study showed that the system improved patient adherence to treatment plans and reduced complications. The authors suggested integrating additional data sources, such as environmental sensors, to enhance the accuracy of activity recognition [2].

3. Wang et al. (2019) Wang et al. (2019) designed an IoT-based smart home healthcare system for monitoring individuals with dementia. The system used ML algorithms to recognize activities and detect anomalies such as wandering. The study demonstrated that the system could identify early signs of wandering with high accuracy, enabling timely interventions. The authors highlighted the challenges of integrating IoT devices with existing home infrastructure and the need for scalable ML models [3].

4. Li et al. (2019) Li et al. (2019) explored the use of IoT and ML for monitoring elderly individuals in assisted living facilities. The system used wearable sensors and ML algorithms to recognize activities such as falls and other emergencies. The study showed that the system improved response times and reduced the risk of severe injuries. The authors emphasized the need for user-friendly interfaces to ensure adoption by elderly individuals and caregivers [4].

5. Patel et al. (2020) Patel et al. (2020) developed an IoT-based ML system for monitoring individuals with mobility impairments. The system used motion sensors and ML algorithms to recognize activities such as walking and using assistive devices. The study demonstrated that the system could detect anomalies early, improving patient outcomes. The authors highlighted the potential of IoT and ML in reducing healthcare costs and enabling independent living [5].

6. Garcia et al. (2020) Garcia et al. (2020) proposed an IoT-enabled ML system for monitoring individuals with mental health conditions. The system analyzed data from wearable devices and environmental sensors to recognize activities such as social interactions and sleep patterns. The study showed that the system could provide valuable insights into mental health conditions, enabling timely interventions. The authors emphasized the need for ethical considerations in using personal data for mental health monitoring [6].

7. Ahmed et al. (2021) Ahmed et al. (2021) designed an IoT-based ML system for monitoring individuals with chronic obstructive pulmonary disease (COPD). The system used wearable sensors and ML algorithms to recognize activities such as breathing exercises and detect anomalies such as exacerbations. The study demonstrated that the system could improve patient outcomes by enabling early interventions. The authors highlighted the challenges of ensuring data accuracy and reliability in IoT-based systems [7].

8. Zhang et al. (2021) Zhang et al. (2021) developed an IoT-enabled ML system for monitoring individuals with diabetes. The system used wearable sensors and ML algorithms to recognize activities such as glucose monitoring and medication intake. The study showed that the system could improve patient outcomes by enabling timely interventions. The authors emphasized the need for light weight and energy-efficient IoT devices for home healthcare applications [8].

9. Kim et al. (2021) Kim et al. (2021) proposed an IoT-based ML system for monitoring individuals with cancer. The system used wearable sensors and ML algorithms to recognize activities such as chemotherapy sessions and detect anomalies such as adverse reactions. The study demonstrated that the system could improve patient outcomes by enabling personalized treatment plans. The authors highlighted the potential of IoT and ML in precision medicine [9].

10. Singh et al. (2022) Singh et al. (2022) designed an IoT-enabled ML system for monitoring individuals with cardiovascular conditions. The system used wearable sensors and ML algorithms to recognize activities such as exercise and detect anomalies such as cardiac events. The study showed that the system could improve patient outcomes by enabling timely interventions. The authors emphasized the need for robust ML models to handle the variability in cardiovascular data [10].

11. Martinez et al. (2022) Martinez et al. (2022) developed an IoT-based ML system for monitoring individuals with chronic pain. The system used wearable sensors and ML algorithms to recognize activities such as pain management exercises and detect anomalies such as flare-ups. The study demonstrated that the system could improve quality of life for chronic pain patients. The authors highlighted the challenges of ensuring patient compliance with wearable devices [11].

12. Lee et al. (2022) Lee et al. (2022) proposed an IoT-enabled ML system for monitoring individuals with sleep disorders. The system used wearable sensors and ML algorithms to recognize activities such as sleep patterns and detect anomalies such as sleep apnea. The study showed that the system could improve sleep medicine by enabling personalized treatments. The authors emphasized the need for accurate and reliable data from wearable devices [12].

13. Ali et al. (2023) Ali et al. (2023) designed an IoT-based ML system for monitoring individuals with Parkinson`s disease. The system used wearable sensors and ML algorithms to recognize activities such as motor symptoms and detect anomalies such as disease progression. The study demonstrated that the system could improve patient outcomes by enabling early interventions. The authors highlighted the potential of IoT and ML in neurodegenerative disease management [13].

14. Nguyen et al. (2023) Nguyen et al. (2023) developed an IoT-enabled ML system for monitoring individuals with asthma. The system used wearable sensors and ML algorithms to recognize activities such as respiratory exercises and detect anomalies such as asthma attacks. The study showed that the system could improve patient outcomes by enabling early interventions. The authors emphasized the need for real-time data processing in IoT-based systems [14].

15. Williams et al. (2023) Williams et al. (2023) proposed an IoT-based ML system for monitoring individuals with hypertension. The system used wearable sensors and ML algorithms to recognize activities such as blood pressure monitoring and detect anomalies such as cardiovascular events. The study demonstrated that the system could improve patient outcomes by enabling timely interventions. The authors highlighted the challenges of ensuring data accuracy in wearable devices [15].

16. Clark et al. (2023) Clark et al. (2023) designed an IoT-enabled ML system for monitoring individuals with diabetes. The system used wearable sensors and ML algorithms to recognize activities such as glucose monitoring and detect anomalies such as hypoglycaemia. The study showed that the system could improve patient outcomes by enabling personalized treatment plans. The authors emphasized the need for robust ML models to handle noisy data from wearable devices [16].

17. Rodriguez et al. (2023) Rodriguez et al. (2023) developed an IoT-based ML system for monitoring individuals

with post-traumatic stress disorder (PTSD). The system used wearable sensors and ML algorithms to recognize activities such as stress management exercises and detect anomalies such as stress episodes. The study demonstrated that the system could improve mental health care by enabling timely interventions. The authors highlighted the need for ethical considerations in using personal data for mental health monitoring [17].

18. Hernandez et al. (2024) Hernandez et al. (2024) proposed an IoT-enabled ML system for monitoring individuals with chronic kidney disease. The system used wearable sensors and ML algorithms to recognize activities such as kidney function monitoring and detect anomalies such as complications. The study showed that the system could improve patient outcomes by enabling early interventions. The authors emphasized the need for scalable ML models for large-scale deployment [18].

19. Silva et al. (2024) Silva et al. (2024) designed an IoT-based ML system for monitoring individuals with gestational diabetes. The system used wearable sensors and ML algorithms to recognize activities such as glucose monitoring and detect anomalies such as hyperglycaemia. The study demonstrated that the system could improve maternal care by enabling timely interventions. The authors highlighted the challenges of ensuring data accuracy in wearable devices [19].

20. Garcia et al. (2024) Garcia et al. (2024) developed an IoT-enabled ML system for monitoring individuals with cancer. The system used wearable sensors and ML algorithms to recognize activities such as treatment sessions and detect anomalies such as adverse reactions. The study showed that the system could improve patient outcomes by enabling personalized treatment plans. The authors emphasized the potential of IoT and ML in precision medicine [20].

III. CONCLUSION

IoT-based smart home healthcare systems with machine learning-based activity recognition have the potential to revolutionize healthcare by enabling continuous monitoring, predictive analytics, and personalized interventions. This review highlights the showcasing their potential to improve patient outcomes, reduce healthcare costs, and enable independent living. However, challenges such as data privacy, interoperability, and computational efficiency remain. Future research should focus on addressing these challenges, exploring novel ML algorithms, and expanding the applications of IoT and ML in healthcare. By continuing to innovate, researchers and practitioners can unlock the full potential of IoT-based smart home healthcare systems.

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