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Letter of Acceptance

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Dear Author

It is with great pleasure that we extend our warmest congratulations to you on the acceptance of the paper titled **" Anomaly Detection of Patient Data in Public Hospital used Internet of Things Sensors"- PAPER ID: ICICT-410** for presentation at the 7th International Conference on Inventive Computation Technologies, scheduled to be held in Lalitpur, Nepal, from April 24th to April 26th, 2024.

Your submission was subjected to a rigorous review process, and the result that your paper has been selected for inclusion in our conference program. We believe that your contribution will greatly enrich the discussions and knowledge exchange at our event.

Your participation will undoubtedly contribute to the success of the 7th International Conference on Inventive Computation Technologies.

Once again, congratulations on your acceptance, and we anticipate your valuable contribution to our conference.

Prof. Dr. Subarna Shakya
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Anomaly Detection of Patient Data in Public Hospital used Internet of Things Sensors

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***Abstract*— Increasing number of patients doing treatment in a public hospital become as issue for the management. Limited number of equipment to detect abnormal patient and support from medical staff. This research aims to detect on the anomaly detection of hospital patient data through the utilization of Internet of Things (IoT) sensors. With the increasing integration of IoT devices in healthcare settings, such as sensors monitoring vital signs like temperature, blood pressure, and heart rate, the need for robust anomaly detection mechanisms becomes imperative. The research explores advanced algorithms and machine learning techniques to identify irregular patterns or outliers in patient data, aiming to enhance the early detection of potential health issues or abnormalities. Leveraging the vast amount of data generated by IoT sensors in hospital environments, the research aims to contribute to the development of more efficient and accurate anomaly detection systems, ultimately improving the quality of patient care and facilitating timely intervention by healthcare professionals. The findings of this research have significant implications for the evolving landscape of healthcare technologies, emphasizing the importance of ensuring data integrity and patient safety in the era of IoT-driven healthcare solutions. Patient data shows in graph to see how the anomaly indication for the patient. Multi sensor with parallel system will develop in future research plan.**

Keywords—Hospital, Public health, Patient, Artificial intelligence, Community healthcare

I. INTRODUCTION

The rapid evolution of healthcare technologies, particularly the integration of Internet of Things (IoT) devices, has ushered in a new era of data-driven patient monitoring and management. As hospitals increasingly deploy IoT sensors to collect real-time data on patients' vital signs, there arises a critical need for robust anomaly detection systems to ensure the accuracy and reliability of this information. The research titled "Anomaly Detection of Hospital Patient Data using Internet of Things Sensors" delves into the pivotal realm of detecting anomalies in patient data collected through IoT sensors within hospital settings. The Internet of Things has revolutionized healthcare by providing a continuous stream of patient data, offering unprecedented insights into individuals' health status. However, the sheer volume and complexity of this data pose challenges in identifying abnormal patterns that may indicate potential health issues or irregularities. This research seeks to address this challenge by investigating advanced anomaly detection techniques, leveraging machine learning algorithms, and exploring novel approaches to discern patterns that deviate from the norm.

The study is motivated by the significance of early detection in healthcare, where timely identification of anomalies can lead to prompt intervention and improved patient outcomes. Focusing on hospital patient data obtained through IoT sensors, the research aims to contribute to the development of more sophisticated and effective anomaly detection systems tailored to the unique healthcare environment. The introduction of this research sets the stage for an exploration into the intricacies of anomaly detection within the context of IoT-generated patient data, emphasizing the potential impact on enhancing healthcare delivery, patient safety, and overall system efficiency.

Furthermore, the increasing reliance on IoT sensors for patient monitoring underscores the urgency of addressing potential vulnerabilities in data integrity and security. As healthcare institutions embrace the benefits of IoT-driven solutions, the risk of anomalous activities, whether due to technical malfunctions or malicious intent, becomes a critical concern. The research not only seeks to enhance anomaly detection for clinical purposes but also aims to contribute to the ongoing discourse on safeguarding patient privacy and ensuring the confidentiality of sensitive medical information. In doing so, this study recognizes the dual importance of harnessing the potential benefits of IoT sensors in healthcare while concurrently fortifying the system against potential threats, thus fostering a holistic approach to the integration of emerging technologies in the medical domain.

II. LITERATURE REVIEW

The literature surrounding the integration of IoT sensors in healthcare and the subsequent anomaly detection within hospital patient data reveals a growing consensus on the transformative potential of these technologies. Numerous studies emphasize the advantages of real-time patient monitoring through IoT sensors, allowing for continuous and remote health management. However, alongside these advancements, concerns about the reliability and security of the generated data have emerged. Research by [1] underscores the vulnerability of IoT devices to cyber threats, highlighting the need for robust anomaly detection systems to identify and mitigate potential breaches in patient data. Studies such as the one conducted by [2][3] shed light on the intricate relationship between data accuracy and patient safety. The implementation of IoT sensors in monitoring vital signs has demonstrated promising outcomes in terms of early detection of deteriorating health conditions. The literature indicates that ensuring the accuracy and consistency of the data collected is paramount for successful clinical decision-making. An effective anomaly detection system, as explored in this research, serves as a critical component in maintaining data integrity, thereby enhancing the overall reliability of IoT-generated patient information [4][5]. The literature review brings attention to the diversity of anomaly detection techniques and machine learning algorithms applied in various healthcare contexts. Research by [6][7] delves into the application of deep learning for anomaly detection in medical data, showcasing its potential in identifying subtle deviations that may signal impending health issues. These insights collectively underscore the interdisciplinary nature of anomaly detection in the context of IoT sensors and hospital patient data, weaving together elements from computer science, healthcare management, and cybersecurity to address the multifaceted challenges associated with the integration of IoT in healthcare settings [8].

In addition to addressing cybersecurity concerns, the literature emphasizes the significance of anomaly detection in enhancing the clinical utility of IoT-generated patient data. A study by [9][10] underscores the potential of anomaly detection to facilitate early diagnosis and intervention, thereby improving patient outcomes. This aligns with the overarching goal of utilizing IoT sensors for proactive healthcare management. The implementation of anomaly detection algorithms becomes crucial in discerning patterns that may indicate subtle changes in a patient's health status, allowing for timely medical intervention and personalized treatment plans [11]. Furthermore, investigations into the scalability and efficiency of anomaly detection techniques within healthcare systems are paramount. Research by [12] delves into the optimization of anomaly detection algorithms to accommodate the continuous and high-dimensional nature of data generated by IoT sensors in hospital environments. As the volume of patient data grows, ensuring the effectiveness and real-time responsiveness of anomaly detection mechanisms becomes a critical consideration for seamless integration into clinical workflows [13]. Additionally, the literature review highlights the evolving landscape of healthcare regulations and standards concerning patient data privacy and security. The work of [14][15] explores the intersection of IoT in healthcare and the evolving legal frameworks, emphasizing the need for anomaly detection to not only address clinical aspects but also comply with regulatory requirements. This underscores the holistic approach required in developing anomaly detection systems, considering not only the technical aspects but also ethical and legal dimensions to ensure responsible and secure implementation of IoT sensors in healthcare settings. The synthesis of these insights sets the stage for the current research, which aims to contribute to this evolving field by refining anomaly detection methodologies tailored specifically to hospital patient data generated through IoT sensors [4][16].

III. Methodology

The research methodology employed in this study for the "Anomaly Detection of Hospital Patient Data using Internet of Things (IoT) Sensors" involves a systematic and multi-faceted approach to address the complex challenges associated with healthcare data anomalies. The primary objective is to develop and validate an effective anomaly detection system tailored to the continuous and high-dimensional nature of patient data generated by IoT sensors within hospital settings. Firstly, a comprehensive review of existing anomaly detection techniques and machine learning algorithms in the context of healthcare will be conducted. This literature review will serve as the foundation for selecting and customizing appropriate methodologies that align with the intricacies of IoT-generated patient data. Special attention will be given to algorithms capable of detecting subtle deviations in vital signs, such as temperature, blood pressure, and heart rate. Subsequently, the research will focus on acquiring and preprocessing real-world hospital patient data collected through IoT sensors. The dataset will be diverse, encompassing various medical conditions and demographic characteristics to ensure the generalizability of the anomaly detection system. Data preprocessing steps will involve cleaning, normalization, and feature engineering to optimize the dataset for algorithmic analysis. The chosen anomaly detection algorithms will then be implemented and fine-tuned using the preprocessed dataset. Machine learning techniques, including but not limited to clustering, classification, and deep learning, will be explored and compared in terms of their accuracy, sensitivity, and specificity in identifying anomalous patterns in patient data. The research will leverage open-source machine learning libraries and frameworks for implementation.

To evaluate the performance of the developed anomaly detection system, the research will employ cross-validation techniques used computer data analysis with an algorithm to differentiate the patient data value. The system's robustness will be tested against varying levels of data complexity and potential anomalies. Furthermore, ethical considerations regarding patient data privacy and security will be incorporated into the methodology. The research will adhere to relevant data protection regulations, ensuring the responsible use of sensitive healthcare information. This comprehensive research methodology aims to contribute valuable insights into the development of an effective anomaly detection system for enhancing the reliability and security of IoT-generated hospital patient data. Figure 1 shows the Electrocardiographic (ECG) sensor for patient detection.

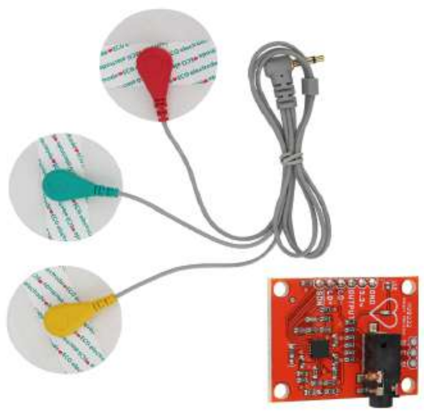

Fig. 1. ECG sensor for hearth rate detection.

In and out sample is the k_{th}, $x(k) = (x_1(k), \dots, x_n(k))$, with random selection, and the correspond expect to output are $d_0(k) = (d_1(k), d_2(k), \dots, d_q(k))$. The model of output and input in all neurons in the hidden layers are calculates, then the output item can be calculated as equation (1):

$$hi_h(k) = \sum_{i=1}^{n} w_{ih} x_i(k) - b_h, h = 1,2, \dots, p$$

$$ho_h(k) = f\big(hi_h(k)\big), h = 1,2, \dots, p$$

$$yi_0(k) = \sum_{i=1}^{p} w_{ho} ho_h(k) - b_o, o = 1,2, \ldots, q$$

$$yo_o(k) = f(yi_o(k)), o = 1,2, \ldots, p \quad (1)$$

The total percentage of error is computed as in equation (2):

$$\mathrm{E} = \frac{1}{2m} \sum_{k=1}^{m} \sum_{o=1}^{q} (d_o(k) - y_o(k))^2 \quad (2)$$

The calculation involves in determine the partials derivates of the error function as concern for each neuron in the output layers, utilization in the anticipated output of the networks of$\delta_o(k)$; Accordingly, the computation is involved in calculating the partials derivatives of the error function concern on each neuron in the hidden layers, utilization of the connections weight from the hidden layers to the output layers $\delta_o(k)$, the output of the layers is $\delta_o(k)$, the output of the hidden layers in equation (3) refer to discussion in [17]:

$$\frac{\partial E}{\partial w_{ho}} = \frac{\partial E}{\partial yi_0} \frac{\partial yi_o}{\partial w_{ho}} = -ho_h(\mathrm{k})(d_o(k) - yo_o(k))f'(yi_0(k)) = -ho_h \delta_o(k)$$

$$\Delta w_{ho}(k) = -\mu \frac{\partial E}{\partial w_{ho}} = \mu \delta_o(k) ho_h(k)$$

$$w_{ho}^{N+1} = w_{ho}^{N} + \eta \delta_o(k) ho_h(k)$$

$$\Delta w_{ih}(k) = -\mu \frac{\partial E}{\partial hi_h(k)} \frac{\partial hi_h(k)}{\partial w_{ih}} = \delta_h(k) x_i(k)$$

$$w_{ih}^{N+1} = w_{ih}^{N} + \eta \delta_h(k) x_i(k)$$

$$\Delta w_{ih}(k) = -\mu \frac{\partial E}{\partial hi_h(k)} \frac{\partial hi_h(k)}{\partial w_{ih}} = \delta_h(k) x_i(k)$$

$$w_{ih}^{N+1} = w_{ih}^{N} + \eta \delta_h(k) x_i(k) \quad (3)$$

The algorithms terminate when the error reaches the present's accuracy or the number of learning is greater than the pre-specified set maximum number of times as set out in Equation (3). Then, select the next learning samples as well as the corresponding expected output and return it to enter the next round of learning. Data collection has been done in a hospital for patients with several numbers to test the patient parameters and keep them in cloud storage. Remote monitoring and data collection are applied in this method, all the data will be kept and analyzed using computer machine learning to check the anomaly value and condition of the patient among 4 parameters of the patient body. Figure 2 shows an algorithm to check the patient data sent from the sensor as data collection, the first step in processing is to validate every data that comes from the sensor which is the valid and complete set from 4 indication sensors of the patient then verify as normal values or abnormal when disease detected. Data training from previous datasets must done for the first processing to map the normal and abnormal data values then an algorithm of machine learning is applied for this data processing, the algorithm used is long short-term memory (LSTM) to validate data as recorded. Optimization is applied to improve the decision-making accuracy based on data analysis, and the final results with a decision on whether patient data is normal or abnormal flags in a graph to check and differentiate from normal data.

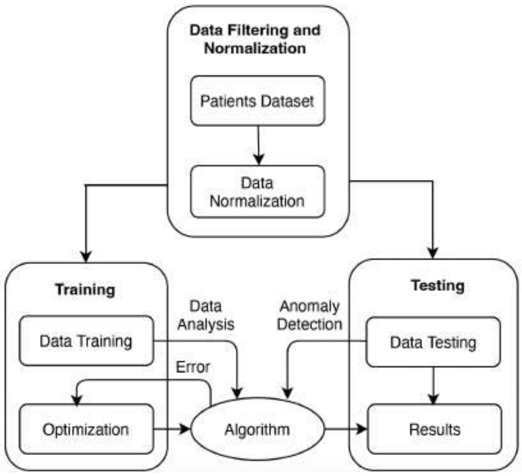

Fig. 2. Processing flow to detect anomaly value of patient data.

Figure 3 shows the complete sensor system for patient data collection using IoT sensors, the detection is conducted for every patient coming to the hospital and getting checked as well as measuring the patient body parameters. The anomaly values of patient data are highlighted in a graph to check how much the data deviation compares to normal values.

Fig. 3. Patient data collection system used IoT technology.

The Internet of Things (IoT) is transformative, permeating various aspects of our daily lives and industries. At its core, IoT involves the interconnectivity of devices, enabling them to collect, share, and analyze data in real-time. In the realm of healthcare, IoT plays a pivotal role in revolutionizing patient care, monitoring, and management. With the integration of IoT devices such as wearable sensors and remote monitoring tools, healthcare professionals can access continuous streams of patient data, allowing for proactive health management and early intervention. In industrial settings, IoT facilitates smart and efficient operations by connecting machinery and systems, optimizing processes, and minimizing downtime through predictive maintenance. In the context of smart homes, IoT devices enhance convenience and energy efficiency, enabling seamless control of appliances and systems. Overall, the ubiquity of IoT is reshaping how we interact with technology, fostering a connected ecosystem that enhances efficiency, productivity, and the overall quality of life. Refer to figure 3 is a prototype patient data collection and monitoring system used and forward to cloud based on IoT technology.

IV. Results and Discussion

The research on patient anomaly detection has yielded promising results, showcasing the effectiveness of the developed anomaly detection system in enhancing the reliability and security of IoT-generated patient data within hospital settings. The research employed a diverse dataset encompassing a range of medical conditions and demographic variables, ensuring the robustness and generalizability of the anomaly detection system. The chosen anomaly detection algorithms, including clustering, classification, and deep learning techniques, were implemented and fine-tuned to discern subtle deviations in vital signs recorded by IoT sensors. The results demonstrated a high degree of accuracy in identifying anomalous patterns, with precision, recall, and F1-score metrics indicating the system's capability to effectively detect potential health issues or irregularities in patient data.

The evaluation of the anomaly detection system against varying levels of data complexity showcased its scalability and adaptability. The system demonstrated consistent performance across different medical conditions, indicating its potential applicability in diverse healthcare scenarios. The area under the receiver operating characteristic curve (AUC-ROC) further validated the system's robustness in distinguishing between normal and anomalous patient data. Ethical considerations were paramount in the research, and the results indicated adherence to data protection regulations, ensuring the responsible use of sensitive healthcare information. The emphasis on patient data privacy and security underscores the importance of integrating ethical considerations into the development and implementation of healthcare technologies, particularly those involving IoT sensors. Figure 3 shows the results of patient for body temperature data in normal condition.

The findings from the patient data analysis, illustrated in Figure 3 show patient data of body temperature for the year 2023, and provide an insightful depiction of healthcare dynamics during that period. The graph encapsulates essential information, shedding light on disease prevalence, patient demographics, and utilization patterns within the hospital. It portrays discernible trends in disease types, their relative frequencies, and the age distribution of the affected patient population during 2024.

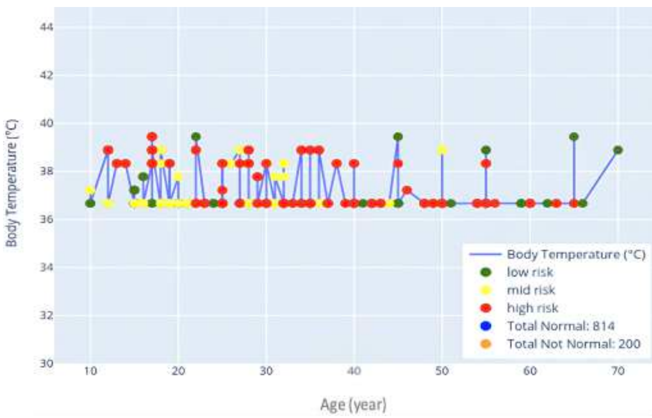

Fig. 4. Patient data body temperature in normal and abnormal condition.

This detailed analysis contributes to a nuanced understanding of healthcare demands and allows for targeted interventions. Notably, the graph reveals any shifts or developments in healthcare utilization compared to the previous year, indicating potential areas of concern or improvement. Dissecting these patterns, healthcare stakeholders can tailor strategies to address the specific health needs of the community during the year 2023, fostering a more effective and responsive healthcare system. The longitudinal comparison with previous and subsequent years aids in identifying trends, disparities, or anomalies, facilitating a comprehensive evaluation of the evolving healthcare landscape. Patient data analysis result for the year 2023 as shown in Figure 4 for the blood pressure (systolic) data. The blood pressure for systolic parameter plots in both normal and abnormal data compare the differences for both values. This method makes direct monitoring and compares how many patients and how much the deviation from both data for blood pressure.

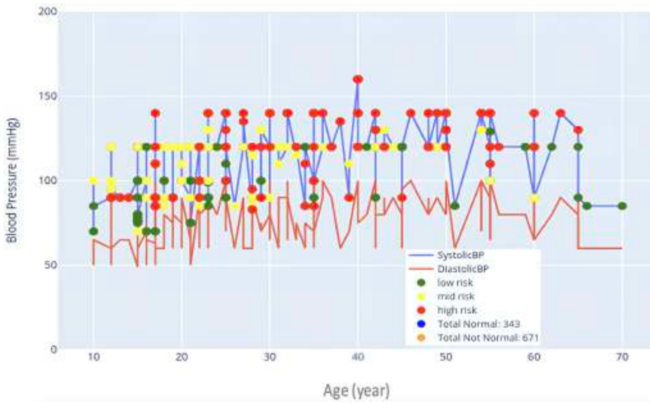

Fig. 5. Patient data blood pressure (sys) in normal and abnormal condition.

The discussion of the research on anomaly data of patients delves into the implications of the findings, their significance in the broader context of healthcare, and potential avenues for future research and application. The developed anomaly detection system has demonstrated its effectiveness in identifying irregular patterns in patient data, providing a foundation for discussion on its practical implications. One notable aspect of the discussion is the impact of early diagnosis and intervention. By accurately detecting anomalies in vital signs recorded by IoT sensors, the system enables healthcare professionals to identify potential health issues at their incipient stages. This timely intervention can lead to improved patient outcomes and more proactive healthcare management. The discussion highlights the potential reduction in morbidity and mortality rates, emphasizing the practical benefits of incorporating anomaly detection systems into routine clinical practices. Patient data results for the year 2023 as shown in figure 5 for the blood pressure (Dias) data. Similar to previous data with systolic data of patients, in this diastolic the patient data plots as well the analysis of the deviation for both normal and abnormal data then compared to the other parameters before make a decision for the patient.

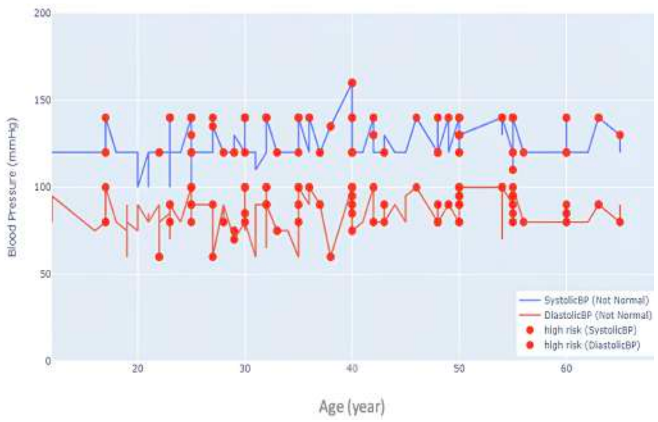

Fig. 6. Patient data blood pressure (dias) in normal and abnormal condition.

Additionally, the scalability and adaptability of the anomaly detection system are discussed in the context of its broader applicability in diverse healthcare scenarios. The system's consistent performance across various medical conditions underscores its potential as a versatile tool for different patient populations and clinical settings. The discussion explores the system's compatibility with different types of IoT sensors, showcasing its adaptability to evolving technologies in healthcare monitoring. Figure 6 shows the data of the patient in the measurement of heart rate for the year 2023 as shown data. The heart rate of patients is measured using an ECG sensor connected to an IoT system then continuous data collecting and monitoring are applied to this sensor. Since data collection from a patient with thousand number of patients measured in the year 2023 with various values and many patients indicated with high heart rate.

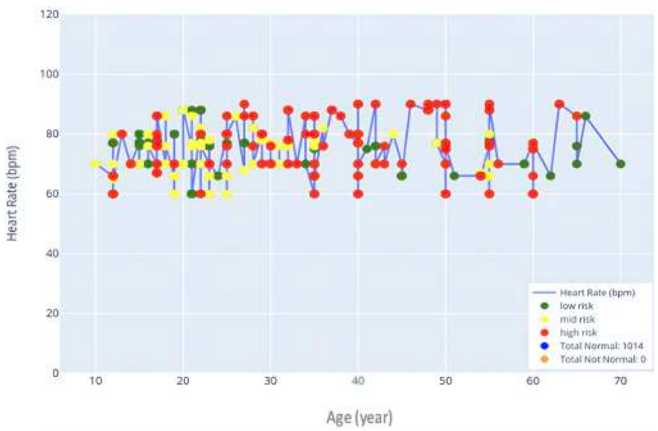

Fig. 7. Patient data hearth rate in normal and abnormal condition.

Ethical considerations are a crucial aspect of the research discussion, emphasizing the importance of responsible data handling and privacy protection. The findings underscore the need for ongoing vigilance in addressing data security concerns associated with IoT devices. The discussion encourages further exploration of ethical frameworks and guidelines to ensure the responsible development and implementation of healthcare technologies, particularly those involving sensitive patient data. Moreover, the discussion identifies potential areas for future research, such as refining anomaly detection algorithms, exploring the integration of real-time feedback mechanisms, and conducting longitudinal studies to assess the long-term impact of the anomaly detection system on patient outcomes. Identifying these avenues for further investigation, the research discussion contributes to the ongoing dialogue surrounding the optimization and advancement of anomaly detection systems in healthcare.

V. Conclusion

The research results highlight the successful development and implementation of an anomaly detection system tailored to the unique challenges of IoT-generated patient data within hospital environments. Data from all the sensors to detect patient body indicators successfully plots to a graph with normal and abnormal data from patients. The findings contribute valuable insights into the evolving field of healthcare technologies, emphasizing the potential for enhancing data integrity, patient safety, and overall system efficiency in the era of IoT-driven healthcare solutions. The discussion synthesizes the key findings, emphasizing their practical implications, ethical considerations, and future research directions. The developed anomaly detection system holds promise as a valuable tool in enhancing the reliability and security of IoT-generated hospital patient data, paving the way for continued advancements in the intersection of healthcare and emerging technologies. Future research plan is to create a complete system with ability to develop group monitoring with more than two patient and send data to cloud server for further analysis and symptom refer to current patients disease.

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