INTERNET OF THINGS BASED SECURED HEALTH MANAGEMENT SYSTEM WITH LARGE LANGUAGE MODEL

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Abstract

The increasing prevalence of chronic diseases and rising healthcare costs highlight the urgent need for a more efficient and user-friendly health management system. This study focuses on addressing the challenges faced by individuals, especially those in underserved communities, who lack access to reliable and personalized health management tools. By developing a system that integrates real-time data tracking, predictive analytics, and customized recommendations, this research aims to empower users to take a more proactive role in managing their health and improving their overall well-being.

This study contributes to the field of personal health management by presenting a scalable model that adapts to various user needs and environments. Its focus on accessibility ensures that individuals from diverse economic and cultural backgrounds can benefit from the system. The personalized approach not only enhances user engagement but also makes health management more intuitive and effective, bridging gaps that exist in traditional methods.

Beyond its technical contributions, the study highlights the broader potential of personalized health tools in everyday life. By simplifying complex health data into actionable insights, users are better equipped to make informed decisions about their routines, diet, and exercise. This system demonstrates how digital tools can be integrated into daily life to encourage sustainable, healthier habits, ultimately leading to improved quality of life for individuals across different demographics.

1.0 INTRODUCTION

According to the World Health Organization (WHO), non communicable diseases cause 41 million deaths annually, equivalent to 74% of all global deaths(Noncommunicable diseases, 2023). In the face of this terrifying data, there is an urgent need for health management systems to help people monitor and manage their health status. With the rapid development of the Internet of Things(IoT), health management systems have become an important area of development. Real time monitoring of human body signs such as heart rate, blood oxygen, and body temperature can be achieved through wearable devices. These technologies can not only monitor this data in real-time, but also perform health analysis, prediction, and warning on the human body.

Nowadays, IoT technology provides a lot of help for health monitoring. The IoTconnects sensors, devices, and networks to achieve real-time monitoring of human body signs, enabling real-time monitoring of human health. The global loT Market is expected to grow from UsD 648 billion in 2024 to UsD 153.2 billion by 2029 at a Compound Annual Growth Rate (CAGR) of 18.8% during the forecast period(Internet of Things(loT) Market Size, Statistics & Trends, Growth Analysis and Forecast, 2024). Their applications are not limited to industry, but are gradually expanding to healthcare. The dependence on IoT technology in the medical field will continue to deepen, especially in areas such as remote healthcare and intelligent health monitoring.

Therefore, the Internet of Things plays a very important role in the future development of healthcare.

2.0 LITERATURE REVIEW

Due to rising global diseases and health awareness, health management systems (HMS) are increasingly vital. Real-time data collection enables better personal health management. However, traditional HMS lack real-time monitoring and intelligent suggestions. IoT addresses this by enabling real-time data collection and analysis for personalized advice and disease prevention.

Large Language Models (LLMs) overcome traditional HMS shortcomings in data analysis and intelligence. LLMs possess powerful NLP and data analysis capabilities, understanding user health input and providing predictive, personalized recommendations using large-scale health data. This study aims to develop an intelligent HMS based on IoT and LLM for personalized, comprehensive services via real-time data and intelligent analysis.

Increasing chronic and lifestyle-related diseases highlight the HMS role in daily health and preventive medicine. Traditional HMS rely on periodic check-ups, manual entry, and fragmented records, lacking continuity and real-time capability. This leads to inefficiency and difficulty in early health issue identification. Modern HMS thus evolve towards personalization, data-driven approaches, and real-time monitoring.

IoT development provides a new direction. IoT systems collect user health data (e.g., heart rate, blood oxygen, temperature) in real-time via sensors. This enables continuous monitoring, reducing reliance on user input and periodic checks, improving convenience, efficiency, data accuracy, and completeness.

Analyzing this sensor data is now crucial. The PHIA system (Merrill et al., 2024) demonstrates LLMs processing health data (e.g., heart rate, blood oxygen, steps) for personalized recommendations via multi-step iterative reasoning, enhancing analysis personalization and accuracy.

(Nazi, Z.A., & Peng, W., 2024) found LLMs efficiently analyze/summarize medical literature, aiding faster, more accurate doctor decision-making. (Ho et al., 2024) found integrating multimodal data (e.g., heart rate, temperature, activity) allows the REMONI system to efficiently analyze patient health changes and provide personalized recommendations.

Combining IoT and LLM enhances HMS intelligence and data processing. (Raiaan et al., 2024) proposed LLMs' significant potential in data processing and natural language generation for healthcare, effectively handling health records/feedback for targeted recommendations. (Rezgui, K., 2024) noted LLMs quickly process unstructured text (e.g., EHRs, patient feedback). Guevara et al. (2024) trained an LLM using generated data to better understand/extract complex Social Determinants of Health (SDoH) information. This method improves model generalization for wider patient samples, ensuring complete SDoH recording in EHRs, significantly boosting system intelligence/automation.

IoT-collected real-time health data uploaded to the cloud is analyzed by LLM to generate precise personalized recommendations. For instance, upon detecting abnormal heart rate, the LLM analyzes user history, habits, and other sensor data to infer causes and provide suggestions, greatly enhancing HMS real-time performance and responsiveness.

3.0 METHODOLOGY

This system use an agile development model for this project. Firstly, Through short iterations, new features can be frequently released and user feedback can be collected. This mechanism helps to continuously improve the system.And because agile methods can identify and solve problems in each iteration, they can more effectively manage project risks.

3.1 Needs Analysis

With the popularity of health tracking devices, individual users' health management systems need to handle multiple data sources, such as heart rate,blood oxygen, body temperature, etc. The development of LLM enables the system to integrate and analyze this data, providing users with more comprehensive health reports and personalized recommendations. This type of data analysis can help users better understand their health status, avoid unnecessary diseases, and develop reasonable health plans.

3.2 Conceptual Design and Architecture

According to Figure 1， the architecture of the health management system adopts a layered architecture and a model view controller (MVC) design pattern, combined with a client server architecture to achieve distributed processing of data and services. This design ensures the modularity, scalability, and efficient user interaction of the system.

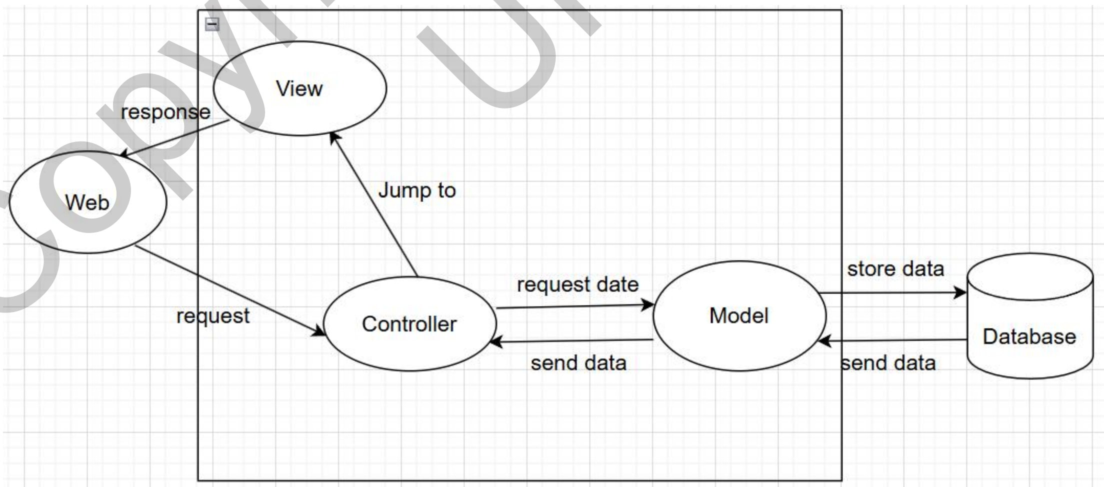

Figure 1: Model-View-Controller (MVC) type design architecture of Healthy management system

3.3 System Modeling

The Figure 2 Use Case Diagram illustrates the primary actors involved in the system, including Users and Administrators, and their interactions with the system's core functionalities. Key use cases such as Sign-Up, Sending Health Reminders, and Managing User Information are highlighted, showcasing the system's ability to address user needs for personalized health management and administrative control.

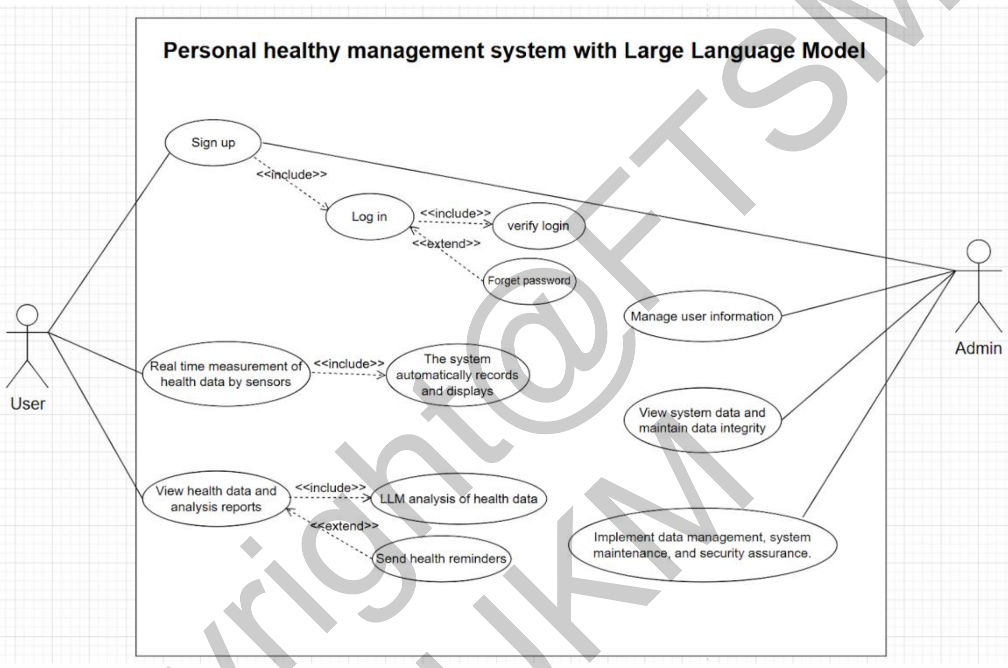

Figure 2 : Use case diagram

3.4 Implementation Tools

The platform was developed using Unity and C# in Visual Studio. Firebase handles cloud storage and user authentication. Minimum development requirements include an Intel i3 processor and 8GB RAM, with user-side operation requiring a dual-core processor and at least 6GB RAM.

3.5 Database and Algorithm Design

Figure 3 for health management systems, using class diagrams provides a solid foundation for database design. By identifying the core entities in the system and understanding their relationships, database tables are organized reasonably, forming a clear and effective structure. The attributes of each entity are carefully mapped to ensure accurate representation of relationships and dependencies.

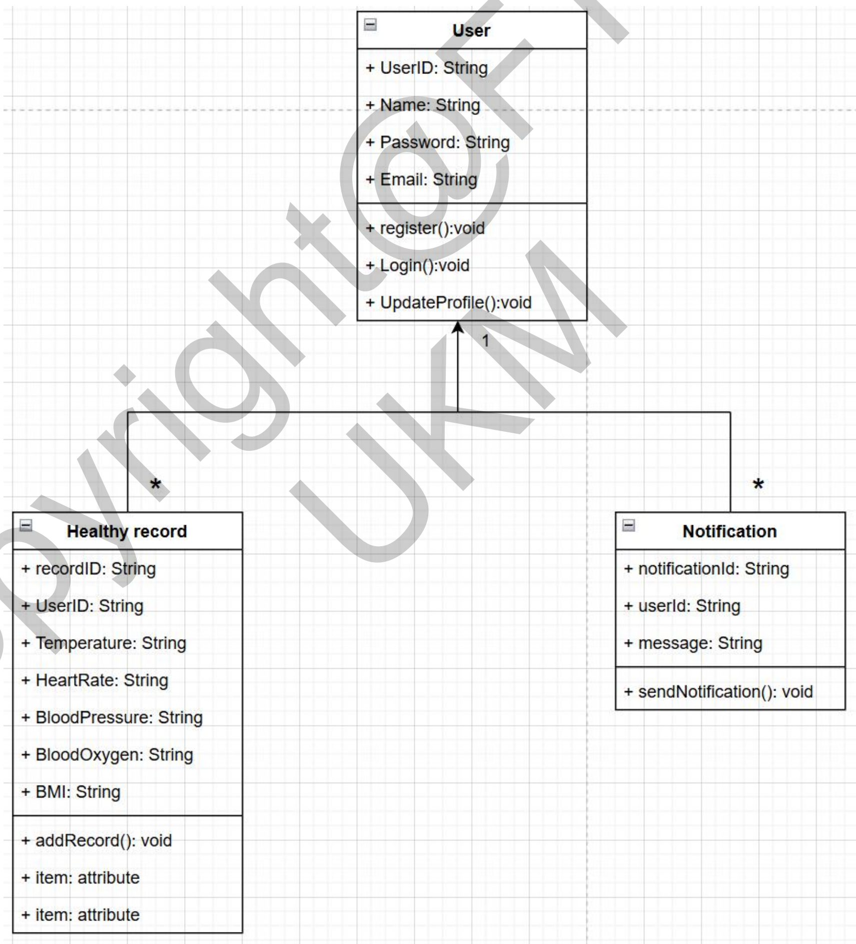

Figure 3 : Class Chart design of the Word Adventure gamification learning platform

4.0 RESULTS

4.1 Application Development

Developing a real-time health monitoring system using Raspberry Pi and Django involves several structured phases, ranging from requirements analysis to deployment and testing. This helped identify core functional needs, such as real-time physiological data acquisition, user-friendly data visualization, and secure user management.

After clarifying the objectives, a detailed requirements specification was prepared. It outlined the functional features like heart rate and blood oxygen tracking, user registration and login, data history browsing. It also included non-functional requirements such as data privacy,responsiveness, and cross-device compatibility.

The frontend was developed using Django’s built-in templating engine, combined with HTML and CSS for structure and styling. The HTML templates are rendered directly by Django views, and dynamic content is passed via context variables. while the backend was built with Python and Django, and the database used was Django's default SQLite3, suitable for lightweight embedded systems like Raspberry Pi.

The database design included models such as User, HHealth, HBloodOxygen, HRecord, each responsible for storing biometric or behavioral health data. Foreign keys were used to associate records with specific users, and the models were migrated using Django’s ORM.

Maintenance tasks include monitoring device connectivity, log collection for API usage and errors, regular code updates for new features or bug fixes, and user support through email or integrated feedback forms. Security patches are applied promptly, and access control is enforced through Django’s permission system.

Through these stages, the system was developed into a robust health monitoring platform capable of capturing and analyzing key health indicators in real time, enhancing personal health awareness and proactive care.

4.2 Key Modules

Several core modules were developed and integrated to complete the system:

- Login and Registration System: Enables users to create and access accounts. Simulated locally with clear feedback for error handling (e.g., duplicate account, password restrictions).
- Health data visualization interface: allows users to intuitively view their own health data
- User Health Report Interface: It allows users to view all their health data in this report, and they can also print itBoss Battle Mode: Timed vocabulary challenges where correct answers damage the boss, incorrect answers trigger penalties. Players level up upon reaching the score threshold.
- Large language model analysis interface: Users can utilize this model to analyze health data.

4.3 Application Testing

The specific testing plan is shown in Table 1. This table outlines the various stages of testing, including their respective start and end dates, as well as the main testing content for each stage. Each stage is assigned to the corresponding testing team members to ensure completion as planned and to collect necessary testing data and feedback.

Testing phase	Start date	End date	Testing content
Test Case Design	2025-06-01	2025-06-07	Write functional test cases, including registration, login, data upload, and viewing analysis reports.
Functional Testing	2025-06-08	2025-06-14	Perform functional testing to cover all functional modules.
Performance Testing	2025-06-15	2025-06-18	Conduct performance testing, including website response time and data processing load capacity.
Security Testing	2025-06-19	2025-06-22	Conduct security testing, including data encryption verification and common vulnerability scanning.
Compatibility Testing	2025-06-23	2025-06-25	Perform compatibility testing and test performance on different browsers and devices.
User Experience Testing	2025-06-26	2025-06-30	Conduct user experience testing, collect user feedback, and evaluate user experience.

Table 1 Test plan

4.5 Test Results

Table 2 below shows that all 17 test cases have been successfully executed, and the actual results are consistent with expectations. No serious functional errors were found during the testing process. All functional modules of the system operate smoothly and meet the project requirements.

Table 2 summarizes the testing outcomes by module

Test Area	Number of Cases	All Passed
Registration & Login	13	Yes
Data upload	4	Yes

5.0 CONCLUSION

The Health Management System was developed in response to the growing demand for accessible and affordable health monitoring tools. It enables real-time tracking of vital signs such as heart rate and blood oxygen levels using Raspberry Pi and sensor modules. Data is continuously collected, processed, and transmitted to a Django-based web server, where users can log in to view their health records, monitor trends, and manage their profiles.

The development process began with defining user requirements and selecting a suitable technology stack. Django was chosen for its rapid development capabilities and clean architecture, while sqlite provided a reliable backend database. The front end was built with HTML and CSS to ensure a responsive user interface.

The system architecture includes sensor input, server-side data handling, database storage, and data visualization components. Features such as user registration and login, sensor data upload, history tracking, and data charts were implemented and tested in stages to ensure functionality and stability. The final product is a web-based system that allows users to interact with their health data in a secure and intuitive environment.

6.0 REFERENCES

Rezgui, K. (2024, July). Large Language Models for Healthcare: Applications, Models, Datasets, and Challenges. In *2024 10th International Conference on Control, Decision and Information Technologies (CoDIT)* (pp. 2366-2371). IEEE.

Park, S. G., Kim, A., Yoon, T., Kamyod, C., & Kim, C. G. (2023, November). A Study of Generative Large Language Model for Healthcare. In *2023 7th International Conference on Information Technology (InCIT)* (pp. 397-400). IEEE.

Rahman, T., & Zhu, Y. (2024). Automated User Story Generation with Test Case Specification Using Large Language Model. *arXiv preprint arXiv:2404.01558*.

Ferrag, M. A., Ndhlovu, M., Tihanyi, N., Cordeiro, L. C., Debbah, M., Lestable, T., & Thandi, N. S. (2024). Revolutionizing cyber threat detection with large language models: A privacy-preserving bert-based lightweight model for iot/iiot devices. *IEEE Access*.

Raiaan, M. A. K., Mukta, M. S. H., Fatema, K., Fahad, N. M., Sakib, S., Mim, M. M. J., ... & Azam, S. (2024). A review on large Language Models: Architectures, applications, taxonomies, open issues and challenges. *IEEE Access*.

Yao, Y., Duan, J., Xu, K., Cai, Y., Sun, Z., & Zhang, Y. (2024). A survey on large language model (llm) security and privacy: The good, the bad, and the ugly. *High-Confidence Computing*, 100211.

Fang, C. M., Danry, V., Whitmore, N., Bao, A., Hutchison, A., Pierce, C., & Maes, P. (2024). Physiollm: Supporting personalized health insights with wearables and large language models. *arXiv preprint arXiv:2406.19283*.

Yang, B., Jiang, S., Xu, L., Liu, K., Li, H., Xing, G., ... & Yan, Z. (2024). DrHouse: An LLM-empowered Diagnostic Reasoning System through Harnessing Outcomes from Sensor Data and Expert Knowledge. *arXiv preprint arXiv:2405.12541*.

Merrill, M. A., Paruchuri, A., Rezaei, N., Kovacs, G., Perez, J., Liu, Y., ... & Liu, X. (2024). Transforming wearable data into health insights using large language model agents. *arXiv preprint arXiv:2406.06464*.

Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., ... & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and vascular neurology*, *2*(4).

Kankanamge, M. W., Hasan, S. M., Shahid, A. R., & Yang, N. (2024, July). Large Language Model Integrated Healthcare Cyber-Physical Systems Architecture. In *2024 IEEE 48th Annual Computers, Software, and Applications Conference (COMPSAC)* (pp. 1540-1541). IEEE.

Wan, J., AAH Al-awlaqi, M., Li, M., O'Grady, M., Gu, X., Wang, J., & Cao, N. (2018). Wearable IoT enabled real-time health monitoring system. *EURASIP Journal on Wireless Communications and Networking*, *2018*(1), 1-10.

Abatal, A., Mzili, M., Mzili, T., Cherrat, K., Yassine, A., & Abualigah, L. (2024). Intelligent Interconnected Healthcare System: Integrating IoT and Big Data for Personalized Patient Care. *International Journal of Online & Biomedical Engineering*, *20*(11).

Dian, F. J., Vahidnia, R., & Rahmati, A. (2020). Wearables and the Internet of Things (IoT), applications, opportunities, and challenges: A Survey. *IEEE access*, *8*, 69200-69211.

Kumar, M., Kumar, A., Verma, S., Bhattacharya, P., Ghimire, D., Kim, S. H., & Hosen, A. S. (2023). Healthcare Internet of Things (H-IoT): Current trends, future prospects, applications, challenges, and security issues. *Electronics*, *12*(9), 2050.

Rezaeibagha, F., Mu, Y., Huang, K., & Chen, L. (2020). Secure and efficient data aggregation for IoT monitoring systems. *IEEE Internet of Things Journal*, *8*(10), 8056-8063.

Liao, Y., Thompson, C., Peterson, S., Mandrola, J., & Beg, M. S. (2019, January). The future of wearable technologies and remote monitoring in health care. In *American Society of Clinical Oncology educational book. American Society of Clinical Oncology. Annual Meeting* (Vol. 39, p. 115). NIH Public Access.

Arora, J., & Yomsi, P. M. (2019). Wearable sensors based remote patient monitoring using IoT and data analytics. *U. Porto Journal of Engineering*, *5*(1), 34-45.

Mamdiwar, S. D., Shakruwala, Z., Chadha, U., Srinivasan, K., & Chang, C. Y. (2021). Recent advances on IoT-assisted wearable sensor systems for healthcare monitoring. *Biosensors*, *11*(10), 372.

Lu, L., Zhang, J., Xie, Y., Gao, F., Xu, S., Wu, X., & Ye, Z. (2020). Wearable health devices in health care: narrative systematic review. *JMIR mHealth and uHealth*, *8*(11), e18907.

Manasa, K., & Venkateswarlu, S. C. (2021, December). A wearable health monitoring system using Arduino and IoT. In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 783-788). IEEE.

Vonteddu, S. N. R., Nunna, P., Jain, S., Nitya, S., & Diwakar, G. (2022, December). Smart Wearable Wristband for Patients' Health Monitoring System through IoT. In *2022 International Conference on Power, Energy, Control and Transmission Systems (ICPECTS)* (pp. 1-6). IEEE.

Ferrara, E. (2024). Large Language Models for Wearable Sensor-Based Human Activity Recognition, Health Monitoring, and Behavioral Modeling: A Survey of Early Trends, Datasets, and Challenges. *Sensors*, *24*(15), 5045.

Ho, T. C., Kharrat, F., Abid, A., Karray, F., & Koubaa, A. (2024, June). REMONI: An Autonomous System Integrating Wearables and Multimodal Large Language Models for Enhanced Remote Health Monitoring. In *2024 IEEE International Symposium on Medical Measurements and Applications (MeMeA)* (pp. 1-6). IEEE.

Nazi, Z. A., & Peng, W. (2024, August). Large language models in healthcare and medical domain: A review. In *Informatics* (Vol. 11, No. 3, p. 57). MDPI.

Hadi, M. U., Al Tashi, Q., Shah, A., Qureshi, R., Muneer, A., Irfan, M., ... & Shah, M. (2024). Large language models: a comprehensive survey of its applications, challenges, limitations, and future prospects. *Authorea Preprints*.

Pool, J., Indulska, M., & Sadiq, S. (2024). Large language models and generative AI in telehealth: a responsible use lens. *Journal of the American Medical Informatics Association*, ocae035.

Guevara, M., Chen, S., Thomas, S., Chaunzwa, T. L., Franco, I., Kann, B. H., ... & Bitterman, D. S. (2024). Large language models to identify social determinants of health in electronic health records. *NPJ digital medicine*, *7*(1), 6.

Kim, Y., Xu, X., McDuff, D., Breazeal, C., & Park, H. W. (2024). Health-llm: Large language models for health prediction via wearable sensor data. *arXiv preprint arXiv:2401.06866*.

Gao, Y., Ye, Z., Xiao, M., Xiao, Y., & Kim, D. I. (2024). Guiding IoT-Based Healthcare Alert Systems with Large Language Models. *arXiv preprint arXiv:2408.13071*.

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