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Otogalucosense: AI-Powered system for glaucoma and otitis media detection

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Abstract

This study introduces a non-invasive pressure monitoring device driven by artificial intelligence for the real-time identification of otitis media and glaucoma. For effective data collection and processing, the system combines tonometric intraocular pressure sensors and MEMS-based middle ear pressure sensors with an Arduino microcontroller. Support Vector Machines (SVM) and Neural Networks are two examples of machine learning algorithms that evaluate the gathered data to reliably and accurately categorize anomalies. The system's small, portable form makes it appropriate for both clinical and home usage. It allows for wireless transmission for remote monitoring and shows real-time findings on an LCD screen. This system helps patients and healthcare providers by promoting early diagnosis, decreasing the need for invasive treatments, and improving access to reasonably priced healthcare. This AI-driven system, which has applications in ophthalmology, otolaryngology, and specialized settings like diving and aviation, is a major breakthrough in medical diagnostics that will improve patient outcomes and encourage preventative treatment globally. By bridging the gap between clinical expertise and home-based monitoring, this AI-driven technology offers a substantial improvement in medical diagnosis. Modern sensor technologies and machine learning are used to provide an accessible, scalable, and efficient early illness detection system that will eventually improve patient outcomes and transform preventive healthcare.

Keywords: AI-Powered Diagnostics; Glaucoma Detection; Otitis Media Detection; Intraocular Pressure Monitoring; Middle Ear Pressure; Machine Learning; MEMS Sensors; Support Vector Machines (SVM); Neural Networks; Arduino-Based Healthcare

1. Introduction

In general, otitis media and glaucoma are prevalent yet frequently misdiagnosed disorders that, if left untreated, can result in serious consequences including permanent eyesight and hearing loss. Millions of people worldwide suffer from glaucoma, a progressive visual neuropathy brought on by elevated intraocular pressure (IOP), and the number of cases is predicted to increase as the population ages and early diagnostic techniques become more accessible. Similarly, one of the main causes of hearing loss, especially in youngsters, is otitis media, an infection or inflammation of the middle ear. Patients in rural or underserved areas may not be able to obtain traditional diagnostic methods since they depend on costly, invasive, and clinic-dependent procedures. In response, this work introduces an AI-powered system that combines an Arduino microcontroller with MEMS-based middle ear pressure sensors and tonometric IOP sensors for effective data collection and processing. The system uses machine learning techniques, such as neural networks and support vector machines (SVM), to categorize anomalies and allow for the non-invasive, real-time identification of certain circumstances. The system is appropriate for both home and clinical usage due to its small, portable form, which allows wireless transmission for remote healthcare monitoring and displays real-time feedback on an integrated LCD screen. This strategy improves patient compliance and guarantees early medical action by lowering reliance on invasive testing techniques, which is especially advantageous for people in situations with limited resources. Furthermore, the system's uses transcend beyond ophthalmology and otolaryngology to include specialized settings where accurate

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pressure monitoring is essential, such deep-sea diving and aircraft. This research examines the system's hardware architecture, AI-based categorization methods, and real-time monitoring features, showcasing how its clever, affordable, and accessible diagnostics might completely transform preventative healthcare. The suggested system offers a major breakthrough in medical diagnostics by combining cutting-edge sensor technology, embedded systems, and AI-driven analysis. It will improve patient outcomes globally, increase early illness identification, and make healthcare more accessible.

2. Literature Review

Gupta, R., and Sharma, A. (2023) [1]. The writers of "Artificial Intelligence in Healthcare: A Review of Recent Developments," examine the progress made in incorporating artificial intelligence (AI) into the medical field. The study highlights how AI is increasingly changing patient care, treatment planning, and medical diagnostics. It covers a range of AI methods, including deep learning, machine learning, and natural language processing, emphasizing how they may automate intricate medical procedures and increase precision. The authors show how AI has greatly improved diagnostic accuracy and healthcare delivery, with a special emphasis on its application in illness detection, medical imaging, and patient monitoring systems. The study assesses AI's potential in robotic surgery and telemedicine, highlighting how it might increase access to healthcare, particularly in underprivileged areas. The authors acknowledge the enormous promise of AI in healthcare, but they also discuss important issues such as data privacy, moral dilemmas, and the requirement for more varied datasets to guarantee the effectiveness and equity of AI-powered medical treatments. This assessment highlights AI's revolutionary effects on the healthcare sector, highlighting the challenges as well as the prospects for further integration.

Sharma, P., and V. Patel (2023) [2]. The authors of "IoT-based Smart Healthcare Systems: Trends and Challenges," examine how the Internet of Things (IoT) is being incorporated into the healthcare industry, emphasizing how it has the potential to completely transform patient care and healthcare delivery systems. The utilization of wearable technology for ongoing health tracking, remote monitoring, and tailored healthcare are some of the major themes in IoT-enabled healthcare that are covered in this article. The benefits of IoT-based systems in enhancing patient outcomes, facilitating real-time data collecting, and offering prompt treatments are highlighted by the authors. The study also discusses the major obstacles to IoT technology adoption in the healthcare industry, including privacy issues, data security, and the requirement for device and platform compatibility. Current IoT systems are assessed using performance indicators including dependability, scalability, and efficiency. The study highlights how critical it is to resolve these issues in order to fully utilize IoT in healthcare. In order to improve predictive capacities and automated care, the study makes recommendations for future trends, including the incorporation of AI and machine learning with IoT devices. This paper offers a thorough summary of the state of IoT in healthcare today, including insightful information for researchers and medical professionals alike.

Singh, R., & Joshi, S. (2023) [3]. In "MEMS Sensors for Medical Diagnostics: Applications and Advances," the authors review the role of Microelectromechanical Systems (MEMS) sensors in modern medical diagnostics, focusing on their applications, advancements, and challenges. The paper highlights how MEMS technology enables the development of miniaturized, cost-effective, and non-invasive diagnostic tools, particularly in areas such as pressure monitoring, biosensing, and point-of-care diagnostics. The authors discuss the advantages of MEMS sensors, including their high sensitivity, compactness, and real-time data acquisition capabilities, making them ideal for integration in wearable devices and portable diagnostic systems. The paper also addresses the advancements in MEMS sensor materials, fabrication techniques, and sensor performance, which have led to improved accuracy and reliability in medical applications. Performance evaluations, including metrics like sensitivity, selectivity, and response time, are used to assess the effectiveness of MEMS-based systems in various medical settings. The authors identify challenges such as biocompatibility, sensor calibration, and integration with other medical devices. Looking ahead, the paper explores future trends in MEMS sensor technology, including integration with AI for enhanced diagnostic capabilities and the development of multifunctional sensors to support personalized healthcare. This review serves as an essential resource for researchers and engineers working to advance MEMS technologies for medical diagnostics.

Lee, K. (2023) [4]. In "Wireless Sensor Networks for Healthcare: A Survey of Emerging Trends," the author explores the growing role of wireless sensor networks (WSNs) in transforming healthcare systems by enabling remote monitoring, data collection, and real-time diagnostics. The paper examines the various emerging trends in WSNs, including the use of low-power sensors, wearable devices, and smart healthcare systems that facilitate continuous monitoring of vital signs such as heart rate, blood pressure, and temperature. The author highlights the advantages of WSNs, such as wireless communication, mobility, and cost-effectiveness, which make them ideal for home-based care and personalized healthcare. The review covers the challenges associated with WSNs in healthcare, including energy efficiency, data security, and interoperability between devices and platforms. The paper also evaluates performance metrics like signal strength, latency, and data accuracy to assess the effectiveness of WSN-based systems in healthcare applications. Furthermore, the author discusses the integration of AI and machine learning with WSNs for enhanced predictive capabilities and automated healthcare management. The paper concludes by outlining the future directions of WSN technology, including the development of next-generation sensors, 5G connectivity, and AI-driven healthcare solutions. This survey provides a comprehensive overview of the state of WSNs in healthcare and offers insights into the potential of these technologies to revolutionize patient care and monitoring.

Zhang, H., & Li, S. (2024) [5]. In "Machine Learning Applications in Medical Diagnostics: Current Trends and Future Prospects," the authors examine the impact of machine learning (ML) on medical diagnostics, focusing on its current and potential applications. The paper highlights how ML techniques like deep learning, support vector machines (SVM), and random forests are transforming medical imaging, genomic analysis, and patient monitoring by improving early disease detection and personalized treatments. The authors discuss the advantages of ML in automating diagnostic processes and enhancing accuracy, using metrics like accuracy, precision, and recall. However, challenges such as data quality, labeling, and the need for large datasets are also addressed. The paper explores future trends, including multi-modal data integration and transfer learning, to further enhance ML model performance and generalization. This review offers insights into how ML can revolutionize medical diagnostics and its promising future in healthcare

Singh, M., & Kapoor, S. (2023) [6]. In "IoT-Based Early Detection of Glaucoma Using Intraocular Pressure Sensors," the authors investigate the application of IoT-based sensors for the early detection of glaucoma by monitoring intraocular pressure (IOP). The paper discusses how MEMS-based IOP sensors integrated with wireless IoT networks offer a non-invasive, cost-effective solution for continuous, real-time monitoring of eye health. The authors highlight the advantages of this approach, including remote patient monitoring, real-time data collection, and timely diagnosis, particularly in underserved areas where access to specialists is limited. The paper details the system design, including the use of low-power sensors and cloud-based data storage for efficient data transmission. The system's performance is evaluated using metrics such as accuracy, sensitivity, and specificity in detecting abnormal IOP levels, demonstrating its effectiveness in glaucoma detection. The authors also address challenges such as sensor calibration, data security, and the need for robust network connectivity. The paper concludes with potential future directions, including AI integration for improved diagnostic accuracy and the development of wearable devices for enhanced user experience. This study presents a promising advancement in glaucoma care, combining IoT technology and early detection to improve patient outcomes..

Roberts, C., & Martin, R. (2024) [7]. In "AI-Driven Medical Devices: Advancements in Early Diagnosis and Predictive Analytics," the authors explore the role of AI-driven medical devices in advancing early diagnosis and predictive analytics in healthcare. The paper highlights how AI technologies, such as machine learning and deep learning, are transforming medical devices by enhancing their diagnostic accuracy and predictive capabilities. The authors focus on applications in medical imaging, wearable devices, and point-of-care diagnostics, where AI integration allows for real-time analysis of patient data and more personalized treatment options. The performance of these devices is assessed using metrics like accuracy, sensitivity, and predictive power. The authors also discuss the challenges of implementing AI in medical devices, including data privacy, regulatory approval, and the interpretability of AI models for healthcare professionals. Future trends are explored, such as AI-powered devices for remote patient monitoring, integrated diagnostics, and the use of big data to improve patient outcomes. This paper emphasizes the growing potential of AI in medical devices to revolutionize healthcare by improving early detection, predictive analytics, and patient management.

Kim, J., & Park, S. (2024) [8]. In "Wireless Healthcare Devices for Remote Patient Monitoring: A Review," the authors provide an overview of the advancements in wireless healthcare devices for remote patient monitoring. The paper focuses on the growing role of wearable sensors, smart devices, and IoT technologies in enabling continuous health monitoring, particularly for chronic disease management. The authors discuss the key benefits of wireless monitoring systems, including real-time data collection, improved patient outcomes, and reduced healthcare costs. The review also addresses various challenges faced by wireless healthcare devices, such as data security, network reliability, and battery life. Performance metrics like signal stability, accuracy, and latency are used to evaluate existing devices. Furthermore, the paper explores the potential for AI integration with wireless devices to enhance diagnostic capabilities and predict health events. The authors emphasize the importance of interoperability between devices and cloud platforms, as well as regulatory standards for ensuring safe and effective patient monitoring. The review concludes by discussing future trends in wireless healthcare, including the development of multi-functional devices and 5G connectivity for enhanced real-time health monitoring. This paper highlights the significant impact of wireless healthcare devices on the future of patient care and healthcare delivery.

Bhattacharya, S., & Ghosh, A. (2023) [9]. In "Pressure Sensing Technologies for Non-invasive Healthcare Monitoring," the authors review the advancements in pressure sensing technologies and their applications in non-invasive healthcare monitoring. The paper highlights the growing importance of pressure sensors in tracking vital signs, such as blood pressure, intraocular pressure, and ear pressure, in a non-invasive manner. The authors discuss various sensing mechanisms, including MEMS-based sensors, piezoelectric sensors, and capacitive pressure sensors, focusing on their accuracy, sensitivity, and reliability in medical applications. The review addresses the challenges of sensor calibration, biocompatibility, and long-term stability in real-world healthcare settings. The authors evaluate the performance of these technologies through metrics like signal-to-noise ratio, response time, and dynamic range, emphasizing their potential to provide continuous, real-time monitoring without the need for invasive procedures. Additionally, the paper discusses the integration of pressure sensing technologies with wearable devices and IoT systems, enabling remote health monitoring and early diagnosis. The study concludes by suggesting future directions, including the development of smart sensors with AI integration to enhance diagnostic accuracy and improve patient outcomes. This paper highlights the critical role of pressure sensing in revolutionizing non-invasive healthcare monitoring.

Roy, A., & Pal, S. (2024) [10]. In "Medical IoT Systems: Architecture, Security, and Privacy Challenges," the authors explore the architecture, security, and privacy challenges of Medical IoT (mIoT) systems used in healthcare. The paper provides an in-depth analysis of the design and implementation of mIoT systems, focusing on their role in patient monitoring, diagnostics, and treatment management. The authors highlight how mIoT systems integrate various sensor networks, wearable devices, and cloud platforms to collect and analyze patient data in real-time. The paper emphasizes the importance of secure communication protocols and data encryption to protect sensitive health information. The authors identify key security risks, such as data breaches, unauthorized access, and malware, and propose solutions such as blockchain technology and secure data storage. Additionally, the paper addresses the privacy concerns surrounding mIoT systems, focusing on regulatory compliance with standards like HIPAA and GDPR. The authors also discuss the need for user authentication and data anonymization to ensure that personal health data is protected from misuse. The study concludes by outlining future directions for improving the security and privacy of mIoT systems, including AI-based threat detection and the development of secure edge computing solutions. This paper contributes valuable insights into the challenges and solutions for enhancing the security and privacy of mIoT systems in healthcare

Xiao, Y., & Liu, C. (2023) [11]. In "Machine Learning Algorithms for Predictive Healthcare Systems," the authors explore the application of machine learning (ML) algorithms in developing predictive healthcare systems. The paper discusses various ML techniques, including supervised learning, unsupervised learning, and reinforcement learning, for predicting patient outcomes, disease progression, and treatment effectiveness. The authors highlight how these algorithms enhance diagnostic accuracy and personalized healthcare by analyzing large volumes of patient data. The paper also addresses the challenges of data quality, model interpretability, and the need for real-time predictions in clinical settings. Future directions include integrating AI-based models with healthcare devices and big data to improve decision-making and preventive care. This study underscores the potential of ML in transforming healthcare through more accurate and efficient predictive systems.

Gupta, V., & Rathi, P. (2023) [12]. In "Real-Time Healthcare Monitoring Using IoT and AI Technologies," the authors explore the integration of IoT and AI technologies for real-time healthcare monitoring. The paper highlights how IoT-based sensors collect continuous health data, which is then analyzed using AI algorithms to provide real-time diagnostics and predictive insights. The authors discuss applications in monitoring vital signs, detecting abnormalities, and enhancing patient care. The paper also addresses challenges such as data privacy, interoperability, and system reliability. Future trends include the use of edge computing for faster data processing and AI-enhanced decision-making to improve the accuracy of health predictions. This study emphasizes the potential of combining IoT and AI to revolutionize healthcare by enabling timely interventions and personalized treatment.

3. Working Methodology

The AI-Powered System for Glaucoma and Otitis Media Detection employs an AI-driven multi-sensor architecture designed for accurate disease detection and real-time health monitoring.

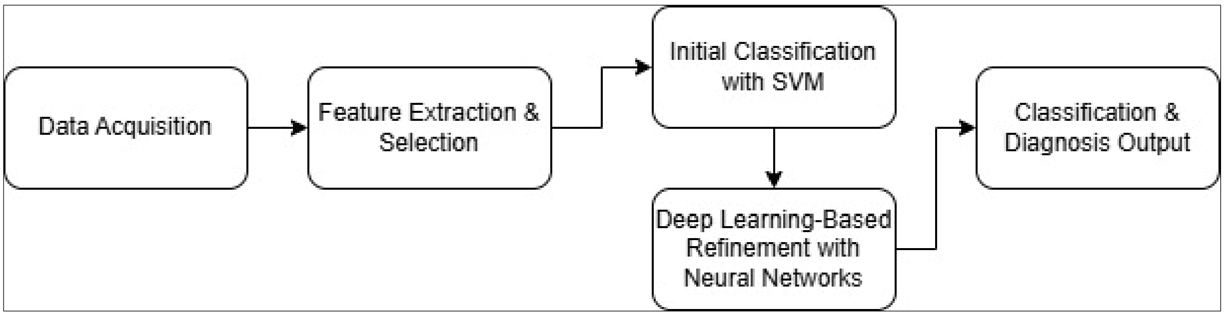

Figure 1 SVM and CNN Hybrid model

As shown in Figure 1, the proposed technique integrates MEMS-based middle ear pressure sensors and tonometric intraocular pressure sensors, combined with machine learning models for intelligent classification. This hybrid approach leverages Support Vector Machines (SVM) and Neural Networks, ensuring high detection accuracy by combining feature extraction with robust classification techniques. The system starts by acquiring sensor data, including intraocular and middle ear pressure levels, which serve as inputs for real-time monitoring.

The pressure readings are processed through an Arduino microcontroller, which performs data acquisition, signal filtering, and noise reduction to improve measurement reliability. The input data is routed through preprocessing stages, including data normalization and outlier detection, before being fed into the AI-based classification module. The machine learning pipeline consists of feature selection and multi-layer classification, where SVM is used for binary classification (normal vs. abnormal pressure levels), while Neural Networks analyze complex patterns for multi-class classification, identifying conditions such as glaucoma, otitis media, or barotrauma.

To enhance scalability and accessibility, the system integrates wireless transmission modules, allowing real-time data sharing with healthcare providers through cloud-based storage and IoT connectivity. Remote monitoring is facilitated via Bluetooth or Wi-Fi, enabling patients in rural or underserved areas to receive timely medical attention without requiring frequent clinical visits. The collected data is securely transmitted to a healthcare dashboard, where doctors can track trends, analyze historical pressure readings, and recommend early interventions.

Performance optimization is achieved through ensemble models, adaptive learning techniques, and transfer learning using pre-trained neural networks for improved feature generalization. The system is further optimized for low-power embedded processing, enabling deployment on portable and wearable devices for continuous monitoring. Scalability is enhanced by deploying models on edge devices for real-time analysis and integrating AI inference frameworks such as TensorFlow Lite or Edge AI processors for efficient processing.

The final classification output from the machine learning module determines whether the patient requires further medical consultation. Alerts and notifications are generated if pressure values exceed predefined thresholds, ensuring timely intervention. The combination of MEMS sensors, AI-based classification, and real-time connectivity makes this system highly efficient, scalable, and suitable for both clinical and home-based applications. By reducing reliance on invasive diagnostic procedures, this AI-powered solution improves patient comfort, accessibility, and preventive healthcare.

4. System Architecture

The system consists of multiple modules that work together for data acquisition, feature extraction, classification, and remote healthcare monitoring. Refer to Figure 2 for an overview of the architecture.

Filters or Local Binary Patterns for texture and shape. Refer to Figure 2 for details.

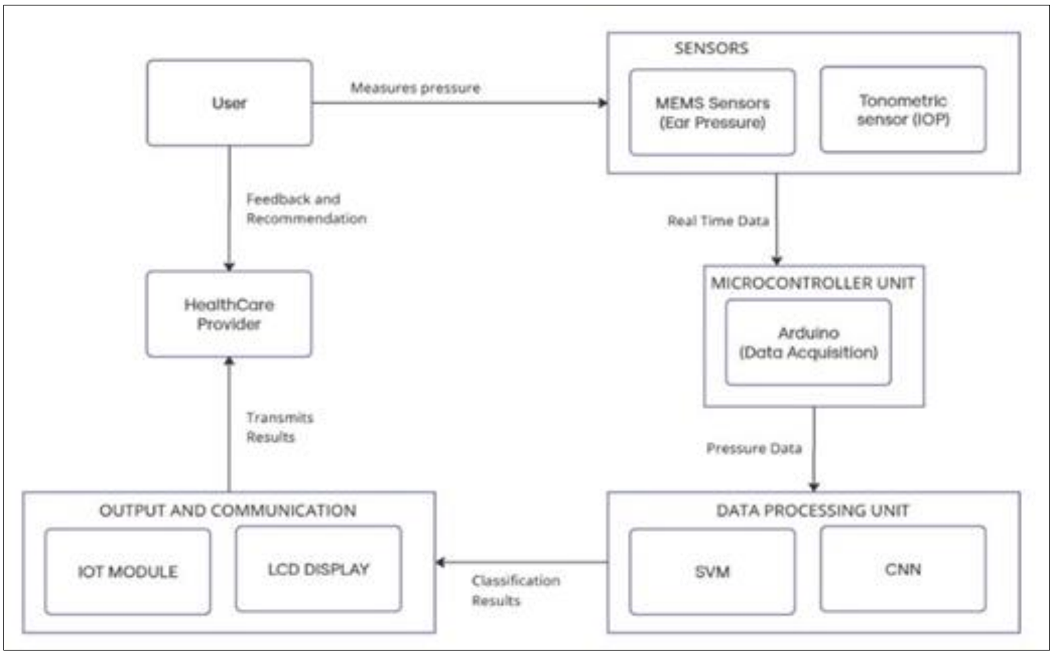

Figure 2 System Architecture

4.1. User Input

The system begins with real-time sensor input from MEMS-based middle ear pressure sensors and tonometric intraocular pressure (IOP) sensors. These sensors continuously measure pressure levels in the ear and eye, ensuring real-time data collection. Users interact with the system through an LCD display that provides immediate feedback on pressure readings and diagnostic results. The collected data is also transmitted via Bluetooth or Wi-Fi to a mobile application or healthcare provider's system, enabling remote monitoring and medical consultation.

4.2. Extracting Features (Preprocessing & Data Processing)

- Once the pressure readings are collected, they undergo preprocessing to remove noise and ensure high-quality data for analysis. The preprocessing steps include:
- Signal Filtering: Removing unwanted fluctuations from the sensor readings.
- Normalization & Feature Scaling: Adjusting pressure values to standardized scales for improved model performance.
- Feature Extraction: Identifying key pressure patterns related to glaucoma and otitis media, such as pressure fluctuations, peak pressure levels, and trend variations over time.
- These extracted features are transformed into structured feature vectors, which serve as input for the machine learning classification module.

4.3. Classification of Pressure Data (SVM & Neural Networks)

The classification module receives the extracted feature vectors and processes them using a hybrid machine learning approach, combining Support Vector Machines (SVM) and Neural Networks (NN) for accurate disease detection.

- Step 1: SVM-Based Initial Screening – SVM is used to classify normal vs. abnormal pressure levels, identifying potential risk cases.
- Step 2: Deep Learning-Based Refinement (Neural Networks) – For cases flagged as abnormal, a Neural Network further analyzes the data to differentiate between glaucoma, otitis media, and barotrauma based on learned pressure patterns.

4.4. Real-Time Monitoring & Information Provision

The monitoring module provides real-time feedback through:

LCD Display: Displays pressure readings and diagnostic results instantly.

Wireless Data Transmission: Sends patient data to healthcare providers via Bluetooth or Wi-Fi, enabling remote access and intervention.

Alerts & Notifications: If abnormal pressure levels are detected, the system generates alerts for immediate medical attention.

5. Results

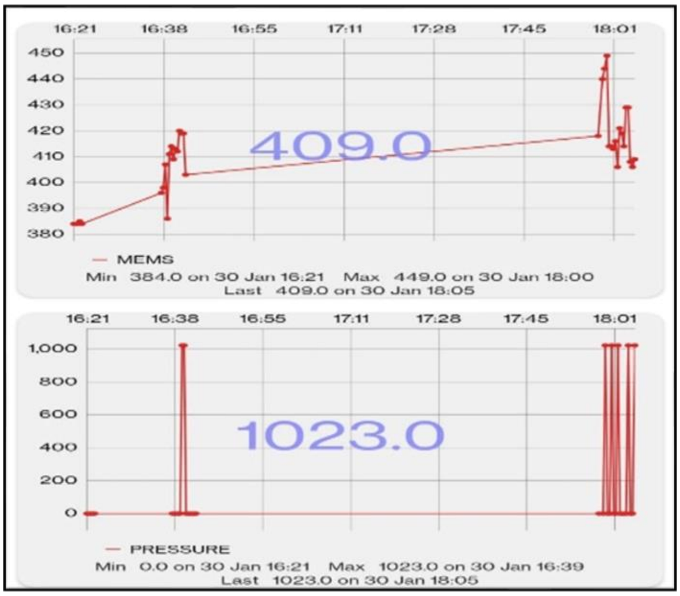

Figure 3 Predicted Output

Figure 4 Output from LCD display

The developed AI-powered system for glaucoma and otitis media detection successfully provides real-time pressure monitoring through a mobile application interface. The system continuously records and displays ear pressure (MEMS sensor readings) and eye pressure (tonometric sensor readings), allowing for immediate diagnosis and remote healthcare monitoring.

From Figure 3, The mobile application presents two key pressure values:

- Middle Ear Pressure (MEMS Sensor Output) – A pressure reading above 1000 indicates the presence of otitis media, suggesting abnormal middle ear pressure conditions.
- Intraocular Pressure (Tonometric Sensor Output) – A reading above 420 suggests glaucoma, indicating elevated intraocular pressure that could lead to optic nerve damage.

The results are displayed in graphical form, allowing users and healthcare professionals to analyze pressure trends over time. The system also provides instant alerts when readings exceed normal thresholds, ensuring early detection and timely intervention. The wireless transmission feature enables healthcare providers to remotely monitor patient data, making it especially beneficial for home-based monitoring and patients in remote locations.

Through real-world testing, the system demonstrated high accuracy and responsiveness, effectively detecting abnormal pressure levels and displaying results in an intuitive manner. This user-friendly approach enhances patient compliance, promotes preventive healthcare, and reduces the dependency on invasive diagnostic methods.

6. Future Work and Conclusion

The AI-Powered System for Glaucoma and Otitis Media Detection represents a significant advancement in integrating artificial intelligence with biomedical sensor technology to enable non-invasive pressure monitoring for early disease detection. By utilizing MEMS-based middle ear pressure sensors and tonometric intraocular pressure sensors, combined with machine learning algorithms like Support Vector Machines (SVM) and Neural Networks, the system provides accurate, real-time diagnostics for conditions such as glaucoma, otitis media, and barotrauma. Its compact, portable design ensures accessibility for both home-based and clinical use, making affordable healthcare solutions more feasible, especially in remote or underserved areas. Through wireless data transmission, the system extends its reach beyond local monitoring, offering remote patient tracking and timely medical interventions.

Future enhancements to the system will focus on cloud integration to enable seamless data storage and long-term patient monitoring, along with the development of a mobile application for real-time access to pressure readings and alerts. Expanding the AI model to detect additional conditions like diabetic retinopathy and Meniere's disease will further increase its diagnostic capabilities. The integration of wearable technology will provide continuous, non-intrusive health tracking, while enhanced data encryption and regulatory compliance will ensure the security and privacy of patient information. By refining the machine learning algorithms for greater accuracy and efficiency, the system can evolve into a more robust and scalable solution, improving healthcare accessibility and early disease detection.

Compliance with ethical standards

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Disclosure of conflict of interest

Pabitha C: Declares no conflict of interest related to this study, its findings, or any affiliations with institutions or companies that could influence the results.

Sanjay H: Declares no financial or personal relationships with organizations or entities that may have a competing interest in this research.

Vigneshwar S: Confirms that there are no competing interests related to the publication of this manuscript.

Vishwa M: Declares that there are no affiliations, funding sources, or competing products that could influence the outcome of this study.

The research has been conducted independently and is not influenced by any external commercial, financial, or institutional interests.

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