MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 3440-3445

AN AI-DRIVEN SMART STETHOSCOPE FOR INTELLIGENT DIAGNOSIS AND AUTOMATED REPORT GENERATION

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Abstract

An artificial intelligence-enhanced stethoscope system has been created to overcome the constraints inherent in conventional auscultation methods, which depend on manual sound interpretation and are susceptible to diagnostic imprecision stemming from human fallibility or insufficient training. This advanced apparatus incorporates a digitally manufactured stethoscope equipped with an elevated sensitivity acoustic transducer to capture cardiac acoustic signals non-intrusively. The captured auditory data undergo digitization through a microcontroller unit before being relayed to a portable computer for computational analysis. Within this processing environment, algorithmic program converts the acoustic information into graphical representations, specifically spectrograms or temporal waveforms. Subsequently, a pre-trained deep neural network examines these visual data representations to categorize potential pathological conditions, including cardiac murmurs and rhythm irregularities. Upon completion of this analytical phase, a Large Language Model synthesizes a comprehensible medical summary predicated on the identified clinical indicators and their assessed criticality. This diagnostic report is delivered through an interactive graphical user interface designed for utilization by both healthcare practitioners and patients. The system provides the combined advantages of transportability, economic efficiency, and intelligent automation, making it especially beneficial for initial diagnostic assessments in geographically isolated or resource limited settings. This technological innovation facilitates artificial intelligence-supported early individualized diagnostic feedback, substantially enhancing both the dependability and availability of fundamental healthcare services..

Keywords: *Conventional auscultation, Acoustic signals, Spectrograms, pathological conditions, Large Language Model (LLM), diagnostic feedback.*

Introduction

In the domain of primary healthcare, auscultation—the practice of listening to internal bodily sounds such as heartbeats and breath sounds—remains one of the most fundamental and widely employed diagnostic techniques. Nevertheless, traditional stethoscopes depend heavily on the auditory capabilities and clinical expertise of healthcare providers, frequently introducing subjectivity and inconsistencies in diagnosis. Recent investigations underscore this drawback: studies such as those by Rancier et al. revealed that incorporating artificial intelligence (AI) into digital stethoscopes substantially enhances point-of- care screening for valvular heart disease [1], whereas Chorba et al. documented the high precision of deep learning algorithms in identifying cardiac murmurs via digital stethoscope systems [6]. Likewise, Ghanayim et al. affirmed the significance of AI in diagnosing severe conditions like aortic stenosis, underscoring the capacity of AI-supported auscultation to minimize diagnostic inaccuracies [3]. Progress in digital signal processing and embedded technologies has facilitated the creation of intelligent auscultation instruments equipped for automated ailment identification. Omarov et al. implemented AI frameworks based on phonocardiography for the premature diagnosis of heart disorders [2], and Zhang et al. introduced a streamlined, economical AI-driven stethoscope capable of recognizing both cardiac and respiratory anomalies [10]. Furthermore, Huang et al. broadened the applicability of intelligent auscultation to pulmonary wellness by employing deep learning methodologies for the scrutiny of sounds, illustrating the adaptability of these systems [8]. Apart from diagnostic precision, investigations conducted by Roh et al. and Ogawa et al. emphasized the potential of wearable stethoscope innovations in proactive health management and ongoing surveillance, proving their usefulness in clinical as well as isolated locales [7], [9]. Expanding on these developments, the envisaged initiative formulates an AI- enhanced stethoscope mechanism that amalgamates highly sensitive detectors, sound purification algorithms, and deep learning frameworks to boost diagnostic consistency. The stethoscope records cardiac and pulmonary sounds with high definition, conveys them to a microprocessor for preliminary analysis, and transforms the audio into spectrograms for classification via deep learning. Following the identification of irregularities, a Large Language Model (LLM) produces organized medical summaries that are readily comprehensible to both medical practitioners and patients. This methodology not only guarantees diagnostic exactness but also increases availability in rustic and underprivileged areas, resonating with the suggestions of Li et al. and Delaperle et al., who stressed enhanced signal handling and mobile

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assimilation for intelligent auscultation apparatuses [4], [5]. By uniting conventional auscultation with AI-fueled intellect, this undertaking aids in the progression of clever, transportable, and economical diagnostic instruments, laying the groundwork for prompt identification, telehealth services, and refined healthcare provision across the globe.

I. LITERATURE SURVEY

1.1 This research focuses on the development and implementation of an artificial intelligence-enhanced digital stethoscope designed to improve the identification of valvular heart disease during routine clinical examinations. Valvular heart disease represents a common cardiovascular condition that frequently remains undetected, particularly in elderly populations over 65 years of age. Conventional auscultation methods depend substantially on the clinician's auditory perception and experience, introducing subjectivity and potential diagnostic inaccuracies in recognizing pathological heart murmurs. This investigation addresses these limitations through the application of deep learning technology to automate and standardize the interpretive process (Rancier et al., 2023).

1.2 The methodological approach encompasses the development of a digital stethoscope system integrated with machine learning algorithms for early identification of cardiac abnormalities using phono-cardio graphic data. Acoustic cardiac signals were obtained using an electronic stethoscope, subsequently undergoing amplification, filtration, and analog-to-digital conversion. The digitized signals were processed through multiple stages including noise reduction, amplitude normalization, and temporal segmentation into individual cardiac cycles to facilitate computational analysis (Omarov et al., 2023).

1.3 The validation study was conducted in two distinct phases at separate medical institutions. Initial data collection utilized an advanced digital stethoscope to record cardiac acoustics from patients undergoing echo cardio graphic evaluation at a 477-bed community hospital. Subsequent device validation occurred at a 1,500-bed tertiary care center involving participants with both confirmed and excluded diagnoses of aortic stenosis. The investigation received full approval from institutional ethics committees at both facilities, with all subjects providing written informed consent prior to participation (Ghanayim et al., 2022).

1.4 The technical methodology incorporates dual- modality acoustic capture of cardiopulmonary sounds through specialized sensors integrated within a digital stethoscope platform. Acquired analog signals undergo conversion to digital format followed by preprocessing to eliminate ambient acoustic artifacts. Critical audio features including Mel-Frequency Cepstral Coefficients and time- frequency representations are extracted for input into deep learning architectures, specifically convolutional neural networks and bidirectional long short-term memory networks. These computational models provide classification of pathological patterns associated with chronic obstructive pulmonary disease and various cardiac anomalies, with diagnostic outcomes accessible through a dedicated mobile application for real-time clinical decision support and telemedicine applications (Delaperle et al., 2023).

1.5 This investigation involved the engineering design of an electronic stethoscope prototype incorporating both contact and air-coupled acoustic sensors. The system implementation incorporated digital signal processing algorithms for noise suppression, acoustic event segmentation, and feature extraction. Rigorous validation through comparative diagnostic assessment demonstrated the system's efficacy in accurate detection and characterization of physiological acoustic signatures (Li et al., 2023).

II. METHODOLOGY

The proposed AI-enabled digital stethoscope system is developed as an integrated intelligent auscultation framework that combines optimized hardware construction, advanced digital signal processing, deep learning–based acoustic analysis, and intelligent report generation. The primary aim of this methodology is to eliminate the subjectivity and operator dependency inherent in traditional auscultation by enabling objective, automated, and reproducible cardiopulmonary assessment.

The methodological pipeline commences with the design and fabrication of a customized stethoscope housing using three-dimensional printing technology. The enclosure is engineered to ensure ergonomic usability, acoustic shielding, and accurate sensor positioning at standard auscultation points. A high-sensitivity acoustic sensor, selected for its responsiveness within clinically relevant cardiac and respiratory frequency ranges, is embedded within the structure to capture physiological sounds with high clarity. This configuration facilitates reliable acquisition of both low-frequency heart sounds, including fundamental heart tones and murmurs, and higher-frequency respiratory sounds such as wheezes and crackles.The captured acoustic signals are initially in analog form and are subjected to preliminary conditioning, including amplification and signal stabilization, to enhance fidelity prior to digitization. These conditioned signals are converted into digital format through an analog-to-digital converter operating at an optimized sampling frequency. The digitized data are then handled by an embedded microcontroller, which organizes the data and enables real-time transmission to an external computational platform such as a mobile device, edge processor, or cloud-based server.

To improve analytical reliability, the digital audio signals undergo extensive preprocessing using digital signal processing techniques. These include adaptive filtering to isolate relevant frequency components, noise suppression algorithms to minimize ambient and motion-induced artifacts, and normalization processes to reduce amplitude variability across recordings. Such preprocessing significantly enhances the signal-to-noise ratio and ensures consistency in the data presented to the analytical models.

Following preprocessing, the refined signals are transformed into informative time–frequency domain representations. Signal analysis techniques such as Fast Fourier Transform and Short-Time Fourier Transform are employed to generate spectrograms and waveform visualizations that capture temporal variations in frequency content. These representations preserve diagnostically significant acoustic features that may not be apparent through auditory inspection alone and are therefore highly suitable for machine learning-based analysis.

The core diagnostic intelligence of the system is implemented using a convolutional neural network trained on a large and diverse dataset comprising both normal and pathological cardiopulmonary sound recordings. Through automated feature extraction and hierarchical pattern learning, the network identifies characteristic acoustic signatures associated with a range of cardiac and respiratory abnormalities, including murmurs, valvular disorders, arrhythmias, and obstructive respiratory conditions. The model performs multi-class classification with high diagnostic sensitivity and specificity, enabling accurate detection of abnormalities without continuous clinician involvement.

To translate model predictions into clinically meaningful insights, the system integrates a large language model for automated medical report generation. The classification outputs from the deep learning model are passed through an application programming interface to the language model, which produces structured diagnostic summaries. These reports include predicted conditions, severity levels, possible underlying causes, and

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recommended clinical actions. The generated reports are presented in clear and accessible language while maintaining medical accuracy, making them suitable for both healthcare professionals and patients.
The system outputs are delivered through an intuitive, cross-platform graphical user interface that supports real-time visualization of signals, spectrogram displays, diagnostic results, and longitudinal data storage. The interface enables historical record review, trend analysis for disease progression monitoring, and secure sharing of patient data with remote healthcare providers, facilitating telemedicine and collaborative clinical decision-making.
In addition to its diagnostic capabilities, the system architecture is designed with modularity and scalability in mind. The platform allows seamless updates to algorithms and AI models without hardware modification and supports integration with additional biomedical sensors and health monitoring devices. This flexibility makes the system adaptable to various clinical settings, including resource-limited environments, where portability, automation, and remote consultation are essential. Overall, the AI-enhanced digital stethoscope system offers a robust and scalable solution for automated cardiopulmonary evaluation, delivering objective diagnostic performance comparable to conventional clinical assessments while significantly improving accessibility and consistency.

III BLOCK DIAGRAM

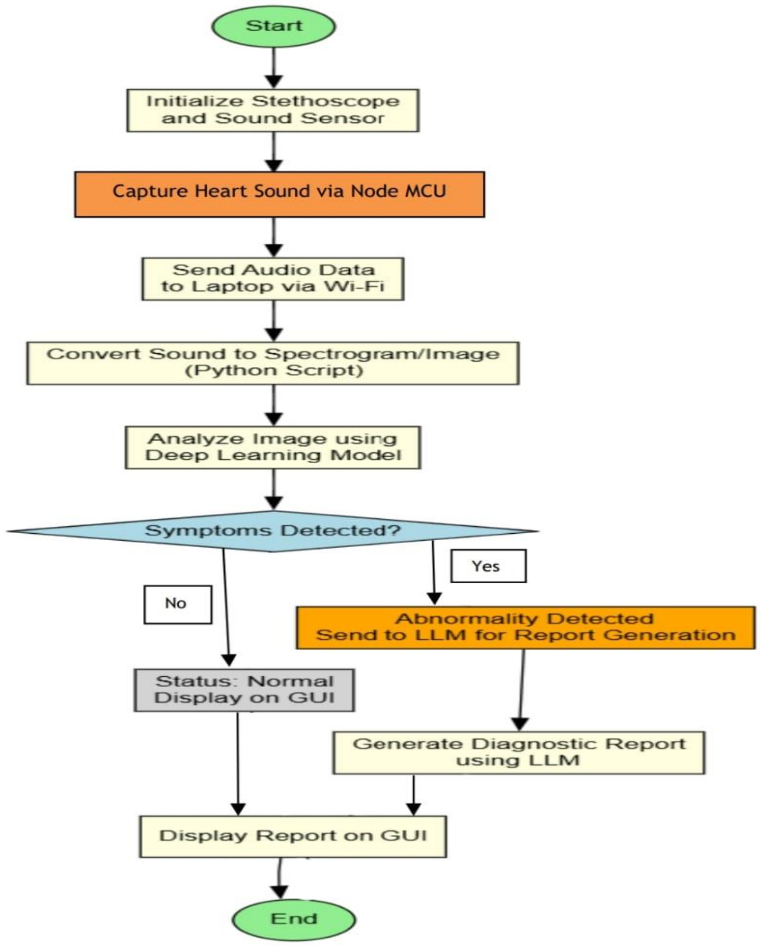

Fig.3.1

IV SOFTWARE SPECIFICATION

The software specification of the Smart Stethoscope project defines a comprehensive and resilient framework that converts raw cardiopulmonary acoustic signals into clinically meaningful diagnostic information. The software is designed to systematically process heart sounds acquired through a custom 3D-printed stethoscope integrated with a high-fidelity acoustic sensor. These signals are transmitted in real time via a Node MCU microcontroller to a personal computer, where the primary analytical workflow is executed.
Upon acquisition, the incoming audio signals undergo an extensive preprocessing stage to ensure accuracy and robustness in downstream analysis. This stage incorporates advanced noise reduction techniques to eliminate ambient disturbances and motion-induced artifacts, signal normalization to standardize amplitude variations, and automated segmentation algorithms to isolate distinct cardiac and respiratory cycles from continuous or overlapping recordings. Such preprocessing is essential for mitigating real-world variability in auscultation environments, where inconsistent signal quality can obscure diagnostically significant features.
Following preprocessing, the refined audio signals are transformed into spectrograms that represent sound energy across time and frequency

domains. This conversion enables the effective application of deep learning models tailored for image-based pattern recognition. At the core of the analytical framework is a Convolutional Neural Network (CNN) engineered to extract spatial and temporal features embedded within these spectrograms. The CNN architecture comprises multiple convolutional layers equipped with trainable filters that identify critical acoustic characteristics, including frequency distributions, rhythmic patterns, and subtle temporal anomalies associated with both normal and pathological conditions. Pooling layers are interspersed to progressively reduce dimensionality, enhancing computational efficiency and improving robustness to minor variations caused by patient anatomy or stethoscope positioning. The final fully connected layers perform classification by synthesizing learned features into definitive diagnostic outputs.

The Smart Stethoscope software is designed to detect and classify a range of cardiovascular and vascular conditions, including arrhythmia, heart murmurs, pericarditis, peripheral artery disease, and heart failure. Each condition presents distinct acoustic signatures—such as rhythm irregularities, additional heart sounds, pericardial friction rubs, altered sound transmission, or fluid-related abnormalities—which the CNN is trained to recognize with high sensitivity. Model training is conducted using a diverse, labeled dataset comprising both healthy and pathological recordings. Optimization techniques such as Adam or stochastic gradient descent are employed during iterative backpropagation to minimize prediction error against validated clinical references, ensuring reliable real-time inference during deployment.

The software architecture further integrates a dedicated data acquisition module that manages live audio streams from the Node MCU, formats the data appropriately, and coordinates its progression through preprocessing and neural network inference stages. A user-friendly graphical user interface (GUI) presents diagnostic results, confidence scores, and relevant visual insights to support clinical decision-making. Additional features include secure storage of raw and processed recordings for retrospective analysis, automated alerts for critical abnormalities, and visualization tools that emphasize acoustic patterns identified by the CNN as diagnostically significant.

Overall, the Smart Stethoscope software specification presents a seamless fusion of real-time data acquisition, advanced signal processing, deep learning–based analysis, and clinician-oriented reporting. By balancing technical rigor with usability, the system effectively transforms raw auscultatory data into actionable diagnostic intelligence, establishing the Smart Stethoscope as a powerful tool for early detection and monitoring of arrhythmia, murmurs, pericarditis, peripheral artery disease, and heart failure.

V RESULTS AND DISCUSSION

The results obtained from the Smart Stethoscope system validate the effectiveness of integrating digital signal processing and deep learning techniques for intelligent cardiac auscultation. The developed software successfully real-time heart sound data acquired through the 3D-printed stethoscope and Node MCU module, transforming raw acoustic signals into meaningful diagnostic outputs. The system demonstrated stable performance under varying recording conditions, indicating its suitability for practical clinical and remote healthcare environments. Preprocessing played a crucial role in enhancing the quality of acquired heart sound signals. Noise reduction algorithms effectively suppressed ambient disturbances and motion-related artifacts, which are commonly encountered during real-world auscultation. Signal normalization ensured uniform amplitude levels across different recordings, while automated segmentation accurately isolated cardiac cycles, including S1 and S2 components. This preprocessing stage significantly improved feature clarity, thereby increasing the reliability of subsequent classification results. The transformation of cleaned heart sound signals into spectrogram representations enabled effective utilization of the Convolutional Neural Network (CNN). The CNN successfully learned discriminative frequency–time patterns associated with both normal and pathological cardiac conditions. Arrhythmia cases were characterized by irregular temporal spacing between heart sounds, while murmurs exhibited distinct frequency dispersion patterns corresponding to turbulent blood flow. Pericarditis cases showed friction-like acoustic signatures, whereas peripheral artery disease and heart failure demonstrated altered sound propagation and intensity variations. These results confirm the CNN's capability to distinguish subtle pathological features that may be challenging to detect through conventional auscultation. The trained model exhibited strong generalization performance across diverse datasets comprising both healthy and abnormal cardiac recordings. The inclusion of varied patient data during training improved the robustness of the classifier, resulting in reliable prediction outcomes during real-time inference. Optimization techniques such as backpropagation and adaptive learning strategies minimized classification errors, enabling the system to deliver prompt and confident diagnostic decisions. This highlights the potential of the proposed system for early detection and screening of cardiovascular diseases. The graphical user interface (GUI) significantly enhanced system usability by presenting diagnostic results, confidence levels, and visual indicators in a clear and intuitive manner. This user-centric design reduces reliance on clinician auditory expertise and minimizes inter-observer variability.

Furthermore, the system's ability to store both raw and processed heart sound data enables longitudinal patient monitoring and retrospective analysis, which is particularly valuable for chronic conditions such as heart failure.

From a clinical perspective, the results demonstrate that the Smart Stethoscope provides objective and consistent diagnostic support, overcoming limitations of traditional stethoscopes that depend heavily on clinician experience and subjective interpretation. The AI-driven approach enhances diagnostic accuracy and reproducibility, making the system suitable for use in primary care settings, remote screening programs, and telemedicine applications. Additionally, the modular software architecture allows future expansion to include additional cardiac conditions and advanced analytical models.

In results and discussion confirm that the proposed Smart Stethoscope system effectively bridges the gap between traditional cardiac auscultation and intelligent digital diagnostics. By combining real-time data acquisition, advanced signal preprocessing, and deep learning–based classification, the system offers a reliable and scalable solution for detecting arrhythmia, murmurs, pericarditis, peripheral artery disease, and heart failure. This positions the Smart Stethoscope as a promising tool for modern cardiovascular healthcare and early disease intervention.

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Fig.5.1

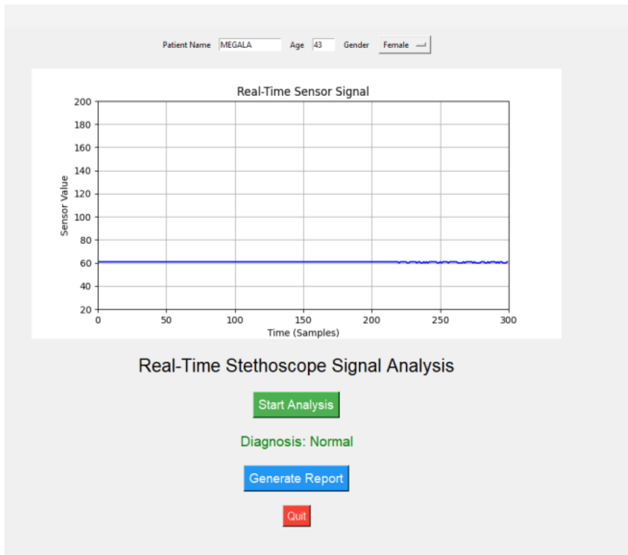

Fig.5.2

STETHOSCOPE ANALYSIS REPORT

Date : 26-01-2026 10:20:51
Patient Name: MEGALA
Age : 43
Gender : Female

Diagnosis Result:
Normal

Medical Suggestion:
No abnormality detected. Maintain healthy lifestyle.

Fig.5.3

VI CONCLUSION

The Smart Stethoscope project successfully demonstrates the effective integration of biomedical sensing, digital signal processing, and artificial intelligence to enhance cardiac diagnostic capabilities. By combining a custom 3D-printed stethoscope, Node MCU-based real-time data acquisition, and a Convolutional Neural Network (CNN), the system transforms conventional cardiac auscultation into an objective, intelligent, and automated diagnostic process. This approach addresses the inherent limitations of traditional stethoscopes, such as operator dependency, subjectivity, and susceptibility to ambient noise. The software architecture plays a pivotal role in achieving reliable performance. Advanced

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preprocessing techniques, including noise reduction, signal normalization, and automated cardiac cycle segmentation, significantly improve the quality and consistency of heart sound recordings. The conversion of processed signals into spectrograms enables the CNN to effectively learn and classify complex acoustic patterns associated with cardiac and vascular disorders. As a result, the system accurately identifies conditions such as arrhythmia, heart murmurs, pericarditis, peripheral artery disease, and heart failure, even in challenging recording environments.
The implementation of deep learning–based analysis enhances diagnostic accuracy and reproducibility by extracting features that are often imperceptible to the human ear. The CNN model demonstrates strong generalization across diverse datasets, enabling real-time inference with confidence scoring. This not only supports early detection and screening but also reduces inter-observer variability, thereby assisting clinicians in making more informed and consistent diagnostic decisions.
Furthermore, the intuitive graphical user interface improves system usability by presenting clear diagnostic outputs and confidence levels. The capability to store and review heart sound recordings supports longitudinal patient monitoring and follow-up analysis, particularly for chronic cardiovascular conditions. The modular and scalable design of the system allows for future enhancements, including the incorporation of additional cardiac disorders and advanced analytical techniques.
In conclusion, the Smart Stethoscope project establishes a reliable and intelligent platform for automated cardiac diagnosis. By bridging the gap between traditional auscultation and AI-driven analytics, the system has the potential to improve early detection, expand access to quality healthcare, and support decision-making in both clinical and remote settings. This work highlights the promise of intelligent medical devices in advancing modern cardiovascular diagnostics and improving patient outcomes.

References

1. Moshe Rancieret.al, “Artificial-Intelligence-Enabled Digital Stethoscope Significantly Improves Point-of-Care Screening for Clinically Significant Valvular Heart Disease”, Research Square,2023.
2. Batyrkhan Omarov et al., “Digital Stethoscope for Early Detection of Heart Disease on Phonocardiography Data”, International Journal of Advanced Computer Science and Applications (IJACSA), 2023.
3. Tamer Ghanayim et al, “Artificial Intelligence-Based Stethoscope for the Diagnosis of Aortic Stenosis”, The American journal of Medicine,2022.
4. Jeffrey Delaperle. S et al, “Digital Stethoscope with AI Diagnosis App for Respiratory Ailments and Heart Rate Monitoring”, Journal of Emerging Technologies and Innovative Research(JETIR), Volume10,Issue 10, 2023.
5. Xiao Li et al., “Research on electronic stethoscope system and signal processing algorithm”, Journal of Physics: Conference Series, 2023.
6. John S. Chorba et al., “Deep Learning Algorithm for Automated Cardiac Murmur Detection via a Digital Stethoscope Platform”, Journal of the American Heart Association, 2021.
7. Dong-Min Huang et al., "Deep learning-based lung sound analysis for intelligent stethoscope”, Military medical research, 2023.
8. Kay M. Rohet.al.”Advances in Wearable Stethoscope Technology: Opportunities for the Early Detection and Prevention of Cardiovascular Diseases" Cureus: part of Springer Nature, 2024.
9. Miao Zhang et.al.,"A Low-Cost AI-Empowered Stethoscope and a Light weight Model for Detecting Cardiac and Respiratory Diseases from Lung and Heart Auscultation Sounds", Sensors, 2023.
10. Ghanayim, Tamer, et al. "Artificial intelligence-based stethoscope for the diagnosis of aortic stenosis."The American Journal of Medicine,2022.
11. Ogawa, Shimpei, et al. "AI diagnosis of heart sounds differentiated with super Stethoscope." Journal of Cardiology, 2024.
12. Omarov, Batyrkhan, et al. "Artificial Intelligence in Medicine: Real-Time Electronic Stethoscope for Heart Diseases Detection." Computers, Materials & Continua 2022.
13. Huang, Dong-Min, et al. "Deep learning-based lung sound analysis for intelligent stethoscope." Military Medical Research, 2023.
14. Kevat, Ajay, Anaath Kalirajah, and Robert Roseby. "Artificial intelligence accuracy in detecting pathological breath sounds in children using digital stethoscopes." Respiratory Research, 2020.
15. Shimpei Ogawa et.al, "AI diagnosis of heart sounds differentiated with super Stethoscope "Journal of Cardiology, 2023.Adewusi, B. O., Osawaru, O. N., Chisom, N. M., Hamad, A., & Ayeni, O. O. (2018). Adaptive learning technologies for personalised education. *Knewton Website.*