AI-BASED CONGENITAL HEART DISEASE DETECTION SYSTEM

A Synopsis for

Project Work-II

**BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE & ENGINEERING**

BY

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# Abstract

# This paper aims to implement an AI-based support system to analyze and diagnose congenital heart diseases (CHD) in infants to reduce the risk of infant mortality. The system will analyze various imaging data such as Echocardiograms (ECGs) and Ultrasound (US) and past patient history to provide a preliminary diagnosis.

# The medical professional can utilize this preliminary diagnosis and provide an even accurate diagnosis for early treatment. This project will help in reducing human errors as well as diagnosis delays which will help in accurate diagnosis and early treatment of CHD patients.

# This project will improve the existing CHD detection models and work over them to improve efficiency, accuracy and speed result.

# Introduction

# Congenital Heart Disease (CHD) is a major cause of infant and child mortality worldwide. Hence, it is crucial to identify congenital heart diseases in infants as early as possible. Traditional methods such as ECG and Ultrasound interpretation by medical experts are prone to possible delay and slight human errors or misdiagnosis. Integrating AI in medical diagnosis has shown improvements in the diagnosis of various diseases and integration of AI in CHD detection has various benefits in improving the accuracy of results and will help in early detection of CHD, “Artificial Intelligence has significantly improved CHD diagnosis by automating image and signal analysis, reducing human errors, and enabling faster decision-making (Li et al., 2023).” [1]. This study aims to implement an AI-based support system that will provide early and preliminary detection of Congenital Heart Disease (CHD) in infants and help medical professionals provide an even more accurate diagnosis and early treatment of CHD patients.

# Literature Review

Several research studies have been conducted that have demonstrated the potential of AI in the field of medical diagnosis. For analyses based on images, deep learning models such as Convolutional Neural Networks (CNNs) have been employed extensively, “Deep learning-based CNNs have demonstrated remarkable accuracy in classifying echocardiographic images for CHD detection (Madani et al., 2018).” [2], at the same time, models such as Transformers and Recurrent Neural Networks (RNNs) have also shown considerable promise for sequential data including ECG signals, “RNNs and Transformers have been successfully employed for ECG signal classification, achieving cardiologist-level accuracy in arrhythmia detection (Rajpurkar et al., 2017).” [3].

While existing AI-based CHD detection models have reported high accuracy, there are still issues with model generalization, real-time deployment, and integration with clinical workflows. In addition, there are issues with a lack of standardized datasets, the availability of annotated medical images, and the variations in heart disease presentations among different demographics. The proposed system is intended to fill these gaps by utilizing a multimodal AI approach that combines imaging, signals, and patient history data for better diagnostic precision.

# Problem Definition

# The challenges faced traditionally include:

# There are time delays in treatment because manual diagnosis is time-consuming and experienced professional are needed for accurate diagnosis.

# Advanced scanning tools may not be present in rural areas, leading to an increase in mortality rate.

# Presence of inconsistent and imbalanced datasets impacts the existing models' performance and reliability.

# Need of improvement in efficiency for fast and real-time analysis to be applicable in critical conditions, “Despite advancements in AI-based CHD detection, challenges such as dataset imbalance, model generalization, and real-time clinical integration remain critical hurdles (Yang et al., 2021).” [4].

# Objectives

After completing this study, we should be able to:

1. Developing an AI model to diagnose congenital heart disease based on patient history and ECGs.
2. Developing a model that, even in emergency settings, provides quick and effective diagnosis.
3. Developing an easy-to-understand paradigm in which the patient and the physician can both understand the reasoning behind the findings, “The integration of Explainable AI (XAI) techniques, such as SHAP and LIME, enhances transparency in AI-driven CHD diagnosis, increasing clinical trust (Holzinger et al., 2019)” [5].
4. Develop a model that may be used to facilitate remote access on edge devices.
5. Develop a model that complies with laws such as GDPR and HIPAA to protect patient privacy and respect moral principles.

# Methodology

1. Data Collection & Preprocessing:

* Gather echocardiograms, ECG signals, and patient records from open-access medical datasets such as PhysioNet and Kaggle.
* Apply data augmentation techniques like rotation, flipping, and contrast adjustments to enhance dataset quality.
* Normalize and preprocess ECG signals using filtering techniques to remove noise and artifacts for improved model accuracy.

1. Model Development:

* Use CNNs for echocardiogram analysis to detect structural heart abnormalities.
* Implement RNNs/Transformers for ECG signal processing to analyze cardiac rhythms and detect potential anomalies.
* Integrate a multimodal AI framework that combines medical imaging, ECG signals, and patient history for a comprehensive diagnostic approach, “Multimodal AI frameworks that integrate imaging, signals, and clinical history have been found to improve diagnostic precision in cardiac diseases (Esteva et al., 2019)” [6].

1. Training & Evaluation:

* Train models on labeled CHD datasets with extensive cross-validation to prevent overfitting.
* Evaluate performance using metrics like accuracy, sensitivity, specificity, precision, recall, and ROC-AUC.
* Conduct comparative analysis with existing AI-based CHD detection methods to measure improvement.

1. Deployment & Integration:
   * Develop a Django-based web application for user-friendly interaction, allowing medical professionals to upload patient data and receive AI-based diagnostic feedback.
   * Deploy the AI model using TensorFlow Serving or FastAPI for real-time inference, ensuring seamless interaction with frontend applications.
   * Integrate with hospital systems and electronic health records (EHR) for real-world testing and validation.
   * Implement real-time monitoring capabilities for continuous patient health assessment, potentially integrating IoT-enabled sensors for live data collection, “The deployment of lightweight AI models on edge devices enables real-time CHD screening in remote areas, reducing dependency on centralized computing resources (Lee et al., 2023).” [7].

**Future Scope**

This can further be improved by:

1. Using IOT devices to further enhance the accuracy while diagnosis.
2. Testing the model in real-time environment using the available patient data.
3. Integrating other advanced deep learning models to employ this model to detect a specific disease instead of all the possible diseases, “Recent studies show that AI-powered auscultation and echocardiogram screening tools can detect CHD in neonates with high sensitivity and specificity (Zhang et al., 2022)” [8].

**Conclusion**

We aim to develop an AI model which uses Echocardiograms and patient history to determine the likelihood of having congenital heart diseases. Based on the already existing findings in this field, we aim to develop a faster, efficient and easy-to-understand model which can be further deployed on edge for remote access. With the use of Recurrent Neural Networks for data processing and Convolutional Neural Networks for image analysis, we aim to implement this model for real-time use in both urban and rural areas.

# References

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