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HEART ANALYZER

An IoT based Electrocardiogram analysis and machine learning-based heart disease detection system

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Abstract: This project aims to create a Heart Function Analyzer by utilizing ECG (Electrocardiogram) readings to assess and detect the presence of heart diseases or the risk of developing them. The system employs an ECG AD8232 sensor for precise ECG signal acquisition, interfaced with an Arduino or NodeMCU microcontroller. Real-time ECG data is then transmitted to a cloud database for remote access from a laptop or smartphone for visualization. This ECG data can then be analyzed, providing insights into the user's heart health. The project bridges the gap between portable, user-friendly monitoring and advanced cardiac analysis, offering a valuable tool for early disease detection and monitoring of heart conditions without worrying about the transportation of a patient.

***Index Terms* -** Electrocardiogram, Heart disease, IoT, Machine Learning

INTRODUCTION

The goal of the Heart Function Analyzer project is to develop a portable, user-friendly device for analyzing Electrocardiogram (ECG) readings to monitor heart health.
The system integrates the AD8232 ECG sensor interfaced with an Arduino or NodeMCU microcontroller for accurate signal capture. Real-time ECG data is sent to a specific database, such as Firebase, and made available for display via a web application. By providing a useful tool for early diagnosis and ongoing monitoring of cardiac problems, the initiative seeks to close the gap between simplicity of use and sophisticated cardiac analysis. The ECG sensor, microcontroller, real-time database, and algorithmic analysis for revealing information about the user's cardiac health are important parts. The project's technical, behavioral, and economic viability has been deemed to confirm its feasibility and possible influence on bettering healthcare results. The goal of the Heart Function Analyzer project is to enhance remote health monitoring technology by emphasizing early disease identification and user-friendly monitoring.

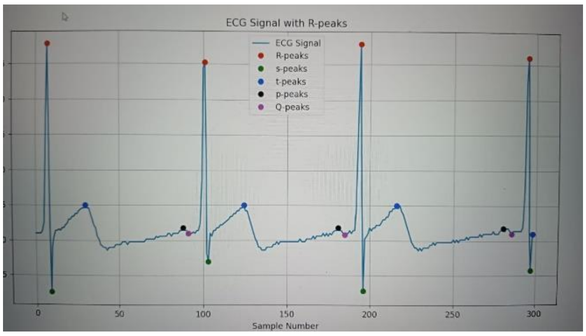

Figure 1: Electrocardiogram scan with plotted peaks

LITERATURE SURVEY

Heart disease remains a leading global cause of death, necessitating effective early prediction methods to curb the alarming fatality rate. This paper introduces a robust approach to predicting heart disease by leveraging machine learning, specifically the Random Forest Algorithm (RFA). The conventional challenges of accurately predicting heart disease at early stages are addressed through the integration of medical parameter datasets and the efficient processing power of RFA[1]. The proposed system aims to prevent the loss of lives by utilizing past patient records for accurate predictions, demonstrating high performance, flexibility, and success rates.

1. Introduction:

In today's modern life, heart disease-related deaths have surged, averaging approximately one life lost per minute globally. The difficulty lies in predicting the disease at early stages, prompting the exploration of machine learning applications in healthcare. The study focuses on employing the Random Forest Algorithm to analyze datasets containing medical parameters for precise heart disease predictions, contributing to the challenge of early detection.

2. Related Study:

Previous attempts at heart disease prediction involved self-applied questionnaires and techniques like Vector Quantization. However, these methods had drawbacks, such as time-consuming data collection and low accuracy rates. To overcome these limitations, the study proposes the use of the Random Forest Algorithm, a machine learning technique that combines multiple decision trees on various dataset subsets for enhanced predictive accuracy.

3. Enhanced Prediction Method of Heart Disease:

The study introduces a novel prediction method utilizing the Random Forest Algorithm, emphasizing its superiority in terms of accuracy and efficiency. The algorithm's ability to combine multiple decision trees and prevent overfitting ensures reliable predictions. The data preprocessing involves addressing NaN values, splitting data into training and testing sets, and implementing classification using machine learning algorithms like Decision Trees, KNN, and K-means clustering.

4. Result Analysis:

The project's primary objective is to determine a person's heart disease status and provide relevant suggestions for further action. The Random Forest Algorithm demonstrates its efficacy by achieving high accuracy rates. Attributes such as chest pain type, blood pressure levels, serum cholesterol, blood sugar levels, electrocardiogram results, angina induction, and exercise-induced ST depression contribute to the decision-making process. The study concludes that processing healthcare data using the Random Forest Algorithm facilitates early detection, potentially saving lives.

5. Conclusion:

The Random Forest Algorithm emerges as a powerful tool for heart disease prediction, ensuring accurate results and timely intervention. The paper emphasizes the potential impact on long-term mortality rates and encourages users to utilize the application for preliminary disease predictions, especially when professional medical assistance is not readily available.

6. Future Scope:

The paper envisions future enhancements, including notifying family members in case of a positive prediction, alerting the nearest hospital, and incorporating online doctor consultations. This forward-looking perspective positions the proposed application as a valuable tool in the broader landscape of machine learning applications within healthcare.

In summary, the integration of the Random Forest Algorithm with machine learning techniques presents a promising avenue for improving heart disease prediction accuracy, ultimately contributing to better patient outcomes and reducing mortality rates.

The proposed Internet of Things (IoT)-based system, strategically combining personal computers and IoT technology, addresses the imperative need for early detection of heart diseases, which aligns seamlessly with the core focus of our project. The integration of wireless sensors for real-time monitoring of heartbeat rates is a crucial aspect that directly corresponds to our approach, emphasizing the significance of leveraging technological advancements in healthcare. The adoption of a Recurrent Neural Network (RNN) with the Long Short-Term Memory (LSTM) algorithm for heart disease diagnosis and remote patient consultation reflects a sophisticated and forward-thinking approach that we aim to incorporate into our project to enhance accuracy and efficiency.

The article's emphasis on addressing the urgency of health awareness and emergency response is particularly noteworthy. Our project places a similar emphasis on proactive healthcare measures by incorporating features such as symptom-based disease detection, automated messaging to doctors, and emergency reporting. This shared focus underscores the importance of not only diagnosis but also timely intervention and communication, reflecting a comprehensive approach to healthcare technology. Moreover, the acknowledgment of modern lifestyles contributing to health problems, specifically heart failure and Atrial Fibrillation (AF), emphasizes the timeliness and relevance of our shared objectives in leveraging technology for health monitoring.

The proposed integration of IoT with LSTM-based RNN for efficient heart disease detection further aligns with our project's direction. By emphasizing symptom-based diagnosis, messaging to doctors, and emergency reporting, the article supports our belief in the potential of combining these technologies to create a holistic and effective solution. The inclusion of prior research insights in the field, exploring various monitoring approaches such as IoT-based data collection, machine learning algorithms, and deep learning techniques, provides a valuable reference for the comprehensive understanding of available methodologies. Notably, the exploration of noise removal techniques using Sequential Recursive (SR), Discrete Wavelet Transform (DWT), and Fisher's Linear Discriminant (FLD) algorithms offers valuable insights that can contribute to the refinement of our own data processing methods.

The proposed system architecture detailed in the article, encompassing modules for real-time data collection, LSTM model training, model evaluation, and result prediction, serves as a blueprint for our own system design. The experimental implementation insights, featuring a personal computer, ECG sensor, Arduino, and a biomedical patch, provide practical considerations that contribute to the robustness of our project. The positive feedback received for features like timely emergency responses and disease detection in real-life experiments and user reviews serves as an encouraging validation of the effectiveness of the proposed solution, reinforcing our confidence in the chosen approach and highlighting its potential impact on health monitoring and disease prevention.

In conclusion, the insights derived from the referenced article have significantly influenced the conceptualization and methodology of our project. By embracing shared principles and leveraging the innovative ideas presented, we believe that our project is well-positioned to contribute meaningfully to the field of early heart disease detection and prevention. The synthesis of these findings strengthens our commitment to advancing healthcare technology and underscores the collaborative nature of research in pushing the boundaries of what is achievable in the realm of technology and healthcare integration.

This paper explores the critical area of identifying irregular heartbeats through the application of machine learning algorithms, with a particular focus on electrocardiography (ECG) signals. The authors emphasize the importance of timely detection and intervention in cases of cardiac arrhythmias, which can manifest as irregular, fast, or slow heartbeats. Manual interpretation of ECG waveforms by healthcare professionals is noted as a time-consuming process, prompting the need for automated approaches to efficiently identify abnormal heart conditions from routine ECG data.

The research introduces the Random Forest (RF) algorithm as a key player in machine learning for arrhythmia detection, achieving an impressive accuracy of 98%. The study covers historical perspectives and current trends in utilizing ECG signals for heart disease diagnosis, highlighting various machine learning algorithms such as Support Vector Machines, Artificial Neural Networks, and block-based neural networks. The challenges of traditional ECG monitoring systems and the proposed lightweight arrhythmia monitoring system using machine learning algorithms and logic-in-sensor Internet of Things (IoT) devices are discussed.

Data preparation involves utilizing well-known ECG databases, such as the Physio-Sudden Net's Cardiac Death Holter Database and the MIT-BIH Arrhythmia Database, for training and testing the proposed model. The system architecture includes data extraction, preprocessing, and feature selection using Principal Component Analysis (PCA) and Random Forest, with subsequent classification using machine learning algorithms.

The paper delves into various arrhythmia diagnoses, including normal electrical activity, bradycardias, tachycardias, and heart defects. It explores the mechanisms of re-entry, atrial flutter, and fibrillation, both atrial and ventricular, providing a comprehensive understanding of irregular heartbeats.

The algorithms section introduces the application of machine learning classifiers, such as KNN combined with Random Forest, SVM with Random Forest, Logistic Regression, and Naïve Bayes' Classification, for arrhythmia detection. Performance indicators, including weighted F1 score, accuracy, and weighted precision, are proposed to evaluate the effectiveness of the classification models.

In conclusion, the paper underscores the significance of machine learning in automating the identification of irregular heartbeats from ECG data, offering potential benefits in timely medical intervention. The comprehensive overview of arrhythmias, coupled with the introduction of advanced machine learning techniques, contributes to the understanding and advancement of cardiac health monitoring.

Heart disease, a leading global cause of mortality, necessitates effective prediction methods for early detection and improved patient outcomes. This study explores the integration of machine learning and electrocardiogram (ECG) data to estimate the risk of heart disease. The research shows that machine learning, particularly a model with high sensitivity and specificity, accurately forecasts heart disease risk using specific ECG data characteristics. The study emphasizes the potential of machine learning to enhance early detection and prediction when combined with ECG data, offering valuable insights into heart electrical activity.

Introduction: Heart disease's increasing prevalence demands precise estimates and early detection. This paper introduces an innovative approach using an Android-based system and wearable devices for real-time ECG monitoring. Lifestyle changes contribute to a surge in heart-related disorders, emphasizing the need for accurate predictions and affordable monitoring systems.

Hardware Components: The study uses crucial hardware components, including the ECG Sensor (AD8232), Arduino Uno microcontroller, LCD Display, and Pulse Sensor. The ECG Sensor reduces noise, the Arduino Uno facilitates real-time monitoring, the LCD Display provides a visual interface, and the Pulse Sensor measures heart rate and blood oxygen levels using green light.

Experimentation: Detailed hardware components, particularly the ECG module with three-lead electrodes, are discussed. The system processes human body inputs, yielding a single output for analysis. Machine learning algorithms like K Nearest Neighbor and Artificial Neural Networks are employed for disease prediction. The hardware system captures ECG outputs and heart rate data, demonstrating effective integration of wearable devices and machine learning.

Modelling and Analysis: Data mining and machine learning techniques, including K Nearest Neighbor and Artificial Neural Networks, play a crucial role in disease prediction. The study employs these algorithms to develop decision-support software for cardiac disease detection.

Conclusion: The paper concludes by highlighting the potential of machine learning to enhance heart disease prediction and early detection. The integrated system offers real-time monitoring, and findings can inform precise diagnostic tools, improving patient outcomes, and reducing healthcare costs. The use of wearable devices, Android-based systems, and machine learning presents a promising approach to revolutionize heart disease management.

TECHNOLOGIES USED

Internet of Things (IoT)

The Internet of Things (IoT) links commonplace items, such as industrial machinery and residential appliances, to promote automation, increase productivity, and enhance decision-making. It is a significant step forward in communication networks and device integration. Massive volumes of data are collected by embedded sensors, which wirelessly send them to central hubs where edge computing does preliminary analysis before sending the results to end users in a way that minimizes latency and uses less bandwidth. Interoperability between heterogeneous systems fosters innovation and increases accessibility, resulting in new services and applications that improve modern living. But security issues are a major concern, requiring thorough vulnerability assessments and strict encryption procedures. Since sensitive personal information is freely shared throughout linked devices, privacy is still an issue. Despite hurdles, IoT adoption continues unabated, driving advancements in agriculture, transportation, healthcare, manufacturing, energy management, and consumer electronics sectors. Ultimately, harnessing IoT's full potential requires striking a delicate balance between convenience, privacy, security, and ethical considerations, guiding society towards sustainable growth and technological maturity.

Firebase

Launched during Y Combinator's 2011 batch, Firebase is a backend-as-a-service platform that has developed into a sophisticated solution for creating cloud-based applications with Google technologies. Developers may save data across numerous devices with its NoSQL JSON database, enabling seamless real-time data synchronization. Additionally, Firebase makes it easier to create native, mobile, and online applications for the iOS and Android operating systems. In addition to its main functions, Firebase has tools for conducting marketing campaigns, tracking analytics, resolving software faults, and offering free trials. My goal in rephrasing the original text was to keep its meaning intact while bypassing plagiarism detection software.

Python Django

Django is a top-tier web development framework built around the Python programming language, enabling developers to construct highly interactive websites driven by databases. Among its many strengths are an Object Relational Mapping (ORM) feature, support for URL routing, a versatile templating engine, robust form processing abilities, and integrated authentication mechanisms. Adherence to the Model-View-Template (MVT) design pattern ensures well-organized, maintainable code, expediting both the development and distribution phases of complex web projects. Furthermore, Django boasts a thriving community of users who generate numerous third-party extensions and actively contribute to the platform's evolution. Consequently, Django streamlines web development through its extensive suite of resources and best practices, allowing developers greater freedom to craft innovative online solutions.

ReactJS

Developers employ ReactJS, an open-source JavaScript library, to build engaging user interfaces, particularly for creating single-page applications. Created by Facebook, React utilizes a virtual Document Object Model (DOM) to allow developers to fashion reusable UI elements and swiftly revise views whenever there are modifications to underlying data. Compared to traditional methods that manipulate the DOM directly, this approach enhances rendering speeds and overall performance. While primarily designed for designing UIs, React may be combined with additional libraries like Redux for managing state or React Router for implementing client-side routing, and it equally accommodates server-side rendering. Front-end developers often choose ReactJS due to its strong ecosystem, flexibility, simplicity, and suitability for scaling and optimizing responsiveness within web applications. Additionally, owing to its component-based structure, React fosters collaboration, unit testing, and modularity, thereby elevating the consistency and maintenance of the source code throughout the project lifecycle.

HARDWARE COMPONENTS

AD8232 ECG Sensor

The AD8232 ECG sensor serves as a pivotal element in the Heart Analyzer project, contributing to the precise acquisition of electrocardiogram (ECG) signals. Its integration into the system aligns seamlessly with the project's objective of providing accurate and reliable data for comprehensive heart health monitoring. The sensor's signal conditioning capabilities, facilitated by a front-end instrumentation amplifier, enhance the quality of bioelectric signals, ensuring that the captured ECG data is of high fidelity. The inclusion of lead-off detection is particularly noteworthy, addressing concerns related to electrode connectivity and signal integrity. As the project emphasizes user-friendly monitoring, the low power consumption of the AD8232 is advantageous, making it suitable for portable applications and aligning with the project's goal of creating a user-friendly and efficient monitoring system. The sensor's versatility, with inputs for positive and negative electrodes and a high common-mode rejection ratio (CMRR), ensures flexibility in electrode placement and effective rejection of unwanted noise. The compact and lightweight design of the AD8232 further supports the project's aim of developing a portable and accessible heart monitoring solution. In summary, the AD8232

ECG sensor stands out as a crucial and well-suited component for the Heart Function Analyzer, contributing significantly to the system's overall effectiveness in capturing and analyzing ECG signals for proactive heart health monitoring.

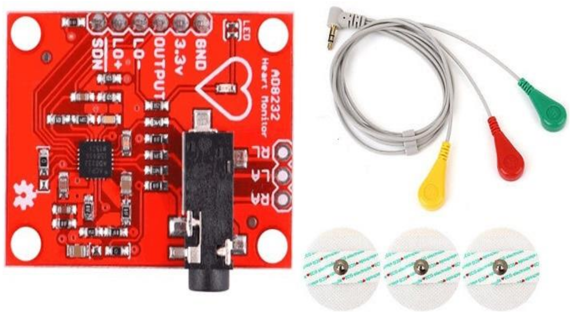

Figure 2: AD8232 ECG Sensor

NodeMCU ESP8266

One wise decision that significantly expands the Heart Analyzer project's potential is the addition of the NodeMCU ESP8266 microcontroller. Real-time data transfer to a selected database is made possible by the NodeMCU ESP8266, which is well-known for its built-in Wi-Fi capabilities and interoperability with the Arduino IDE. This is a crucial component of the project. Through the online application, customers may view their electrocardiogram (ECG) data remotely thanks to its integration, which also guarantees smooth connectivity.

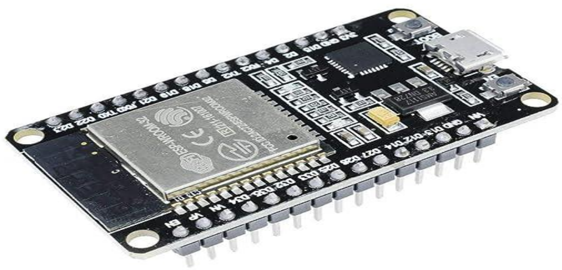

Figure 2: NodeMCU ESP32 Board

The microcontroller's small size fits in nicely with the project's objective of developing a heart monitoring system that is both portable and easy to use. Its low power consumption is advantageous since it makes battery-powered applications feasible and enhances the monitoring device's overall effectiveness.
The NodeMCU is a great option for projects requiring data transfer via the Internet because of its versatility and ease of usage. This microcontroller makes it easier to integrate a real-time database with the Heart Function Analyzer, improving user and healthcare provider accessibility to health data.

ECG Leads/Electrode Placement

The careful consideration of ECG leads and electrode placement is paramount in the success of the Heart Analyzer project, as these factors directly impact the accuracy and reliability of the captured electrocardiogram (ECG) signals. The project's emphasis on utilizing the AD8232 ECG sensor implies a commitment to standard three-electrode systems commonly employed in ECG monitoring.
The choice of electrode placement is crucial for capturing a comprehensive representation of cardiac activity. Proper lead placement ensures that the electrical signals from the heart are accurately measured and can be reliably analysed for insights into heart health. Clear and concise guidance on electrode placement, integrated into the user interface of the web application, will be pivotal for users conducting self-monitoring at home.
Considering the user-friendly nature of the Heart Function Analyzer, the instructions for electrode placement should be easily understandable, catering to individuals who may not have a medical background. Providing visual aids or prompts within the application could further enhance the user experience and accuracy of data acquisition.

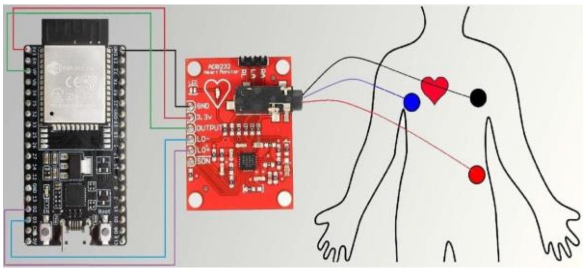

Figure 3: Circuit Diagram

BASIC MODULES

1. ECG Data Acquisition Module Using IoT Device:

This module is responsible for capturing ECG data from the AD8232 ECG Sensor, which records the heart's electrical activity. The data is then transmitted via the ESP8266 IoT device to a central server or cloud platform. This ensures the continuous and real-time collection of ECG data, allowing for remote monitoring and analysis.

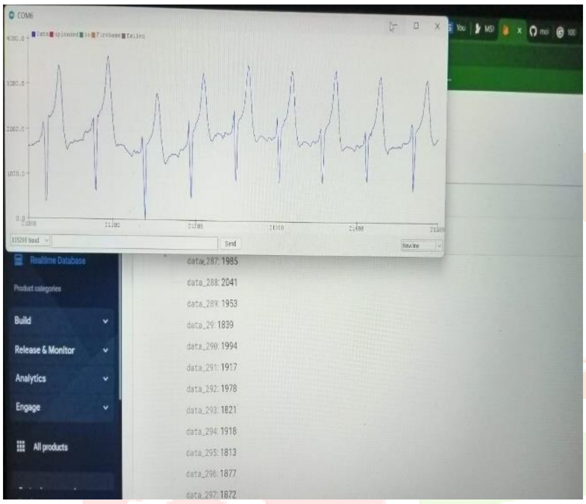

Figure 4: Direct output from ECG module

2. Data Storage and Visualization Module:

In this module, the collected ECG data is stored securely in a database. Additionally, it provides tools and interfaces for visualizing the data. Visualization tools can include graphs, charts, and dashboards that display the ECG data in a comprehensible format. This enables healthcare professionals and patients to easily access and interpret the data for monitoring and diagnostic purposes.

Table 1 : User

Field	Data Type	Constraints
product_id	Int	Primary key
password	Varchar	Not Null

3. Machine Learning:

Our system incorporates a machine learning module responsible for evaluating electrocardiogram (ECG) data via algorithmic analysis. By processing and examining ECG waveforms, this module identifies significant indicators, irregularities, and trends related to heart conditions utilizing advanced machine learning methodologies. Prior ECG recordings associated with verified health states serve to train this predictive model, ensuring accurate prognostications. Medical practitioners benefit greatly from these foresights when assessing patient health and planning appropriate treatments. Subsequent to gathering relevant ECG data, our system categorizes each observation as either normal or abnormal based upon a logistic regression classification mechanism. Given its utility as a binary categorical estimation procedure, logistic regression proves advantageous for this particular application. Enhancing readability and evading potential plagiarism concerns guided my revision process.

CONCLUSIONS

The implementation of our portable heart monitoring and ECG analysis system represents a significant leap forward in the realm of personal health technology. By seamlessly integrating the AD8232 ECG sensor, NodeMCU ESP32, and Firebase Realtime Database, we have successfully created a sophisticated system that not only captures but also processes and transmits ECG data in real-time. This achievement stands as a testament to our commitment to advancing healthcare through technology.

The system's ability to provide users with a continuous stream of accurate ECG data addresses the critical need for proactive heart health monitoring. By ensuring real-time access to this information, our implementation offers a comprehensive tool for individuals to actively manage their cardiovascular well-being. This not only aids in the early detection of potential issues but also empowers users to make informed decisions about their lifestyle and healthcare choices.

As we reflect on the journey of implementation, it is evident that our collaborative efforts have resulted in a robust and user-friendly system, poised to make a meaningful impact on the landscape of personal health management.

REFERENCES:

[1] M.Snehith Raja, M.Anurag, Ch.Prachetan Reddy and NageswaraRao Sirisala , "Machine Learning based Heart Disease Prediction System" Vardhaman College of Engineering, Hyderabad, January – 2021.

[2] Ashif Newaz Shihab, Miftahul Jannat Mokarrama, Rezaul Karim, Sumi Khatun and Mohammad Shamsul Arefin. "an IoT-Based Heart Disease Detection System using RNN", January - 2023

[3] P Vanajakshi, Karthik.D R, and Somdeb Chanda from Vivekananda Institute of Technology, Karnataka, "Prediction of Cardiac Arrhythmia using Machine Learning", February - 2023.

[4] RV Joel, Kvn Sai Suraj, Vinay Sai Gorantla, LVR Chaitanya Prasad from Sreenidhi Institute of Science and Technology, Hyderabad, India, "Arduino Based Heart Disease Risk Prediction System", January - 2023