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"Heart Risk Prediction Model"

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***Abstract*-- Cardiovascular diseases (CVDs) remain one of the leading causes of mortality worldwide, largely due to sedentary lifestyles, stress, unhealthy dietary habits, and lack of regular health monitoring. Early detection and awareness of heart-related risks can significantly reduce severe outcomes such as heart attacks and strokes. This paper presents the design and implementation of a Heart Risk Prediction Model using an embedded system approach. The proposed system utilizes a pulse sensor interfaced with an Arduino microcontroller to measure real-time heart rate and classify the user's heart condition into predefined risk levels such as low, medium, and high. Visual and audio feedback is provided through an LCD display, LED indicators, and a buzzer for immediate awareness. The system aims to serve as a cost-effective, portable, and non-invasive preliminary heart risk assessment tool for personal health monitoring and educational applications.**

***Keywords*-- Heart risk prediction, pulse sensor, Arduino, embedded system, heart rate monitoring, preventive healthcare, biomedical electronics.**

I. INTRODUCTION

Heart-related diseases have become a major public health concern across the globe. Rapid urbanization, lack of physical activity, increased stress levels, and unhealthy food habits have significantly increased the risk of cardiovascular disorders among people of all age groups. Despite advancements in medical technology, many individuals fail to detect early symptoms due to lack of awareness or access to regular medical check-ups.

Technological advancements in embedded systems and biomedical sensors have made it possible to develop compact, affordable, and user-friendly health monitoring devices. The Heart Risk Prediction Model is designed as a simple yet effective solution that allows individuals to monitor their heart condition in real time. By measuring pulse rate and categorizing it into risk levels, the system encourages users to take preventive actions and seek medical consultation when necessary. This project does not aim to replace professional diagnosis but acts as an early warning and awareness tool.

A. Purpose of study

The purpose of this research is to design and analyze a hardware-based heart risk prediction system that can:

- Measure real-time heart rate using a pulse sensor
- Categorize heart risk into low, medium, and high levels
- Provide instant visual and audio alerts to the user
- Offer a portable, non-invasive, and cost-effective health monitoring solution

B. Scope of study

This paper focuses on:

- Development of a heart risk prediction model using an embedded system
- Integration of pulse sensing technology with Arduino microcontroller
- Classification of heart risk based on predefined heart rate thresholds
- Applications of the system in personal healthcare and education

Limitations and possible future enhancements.

II. BACKGROUND AND MOTIVATION

A. Growing burden of cardiovascular diseases

Cardiovascular diseases (CVDs) are among the most serious health challenges faced by modern society. According to global health studies, heart-related ailments such as coronary artery disease, arrhythmia, heart attacks, and strokes account for millions of deaths each year. A significant factor contributing to this rise is the modern lifestyle, which includes physical inactivity, high stress levels, irregular sleep patterns, smoking, and unhealthy dietary habits.

One of the major concerns associated with heart diseases is that early symptoms often remain unnoticed or are ignored by individuals. By the time medical attention is sought, the condition may already be critical. This highlights the importance of early-stage monitoring and risk prediction, which can significantly reduce mortality rates through timely medical intervention.

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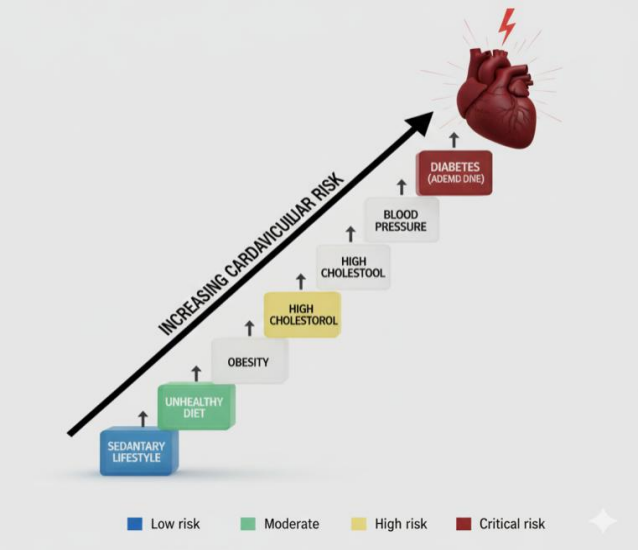

Figure 1: Heart risk prediction

B. Need for early and preventive heart monitoring

Conventional heart monitoring techniques such as Electrocardiograms (ECG), Holter monitoring, and stress tests require hospital visits, trained professionals, and expensive equipment. These factors limit their accessibility, especially in rural or economically weaker regions. As a result, many individuals do not undergo regular heart health assessments.

There is a growing demand for simple, affordable, and portable health monitoring systems that can be used by individuals in their daily lives. A preliminary heart risk prediction system based on heart rate analysis can serve as an effective preventive tool. Such systems can create awareness, promote healthy lifestyle choices, and encourage users to seek professional medical advice when abnormal readings are detected.

C. Motivation behind the proposed system

The motivation behind developing the heart risk prediction model is to bridge the gap between complex medical diagnostic tools and easily accessible personal health monitoring devices. Advances in embedded systems, low-cost microcontrollers, and biomedical sensors have made it possible to design compact devices capable of real-time physiological data acquisition.

By utilizing a pulse sensor and an Arduino-based platform, the proposed system offers **a** non-invasive, cost-effective, and user-friendly solution for basic heart risk assessment.

The project aims to empower individuals by providing immediate feedback on their heart condition and promoting preventive healthcare practices.

III. Technlogical Components And Functionality

A. Pulse Sensor Technology

The pulse sensor used in the proposed system operates on the principle of Photoplethysmography (PPG). It measures variations in blood volume within the microvascular tissue of the fingertip caused by heartbeats. Each heartbeat results in a change in light absorption, which is converted into an electrical signal.

These signals are processed to detect peaks corresponding to heartbeats, allowing accurate calculation of heart rate in beats per minute (BPM).

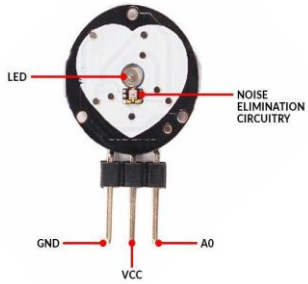

Figure 2: Pulse sensor

Advantages of Pulse Sensor:

- Non-invasive and painless measurement
- Compact and lightweight design
- Suitable for continuous real-time monitoring
- Low power consumption

B. Microcontroller Unit

The Arduino Uno microcontroller serves as the core processing unit of the system. It receives analog input signals from the pulse sensor, digitizes them using its internal ADC, and executes programmed algorithms to calculate heart rate.

Based on predefined threshold values, the microcontroller categorizes the heart condition into different risk levels. It also controls the output devices such as LCD, LEDs, and buzzer.

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Figure 3: Arduino Uno as a microcontroller

C. Output and Alert Mechanism

To ensure clear and immediate communication with the user, multiple output devices are employed:

- 16×2 LCD Display: Displays heart rate (BPM) and corresponding risk level
- LED Indicators:
  - Green LED – Normal / Low Risk
  - Yellow LED – Moderate / Medium Risk
  - Red LED – High Risk

Buzzer: Provides an audible alert during high-risk detection to draw immediate attention

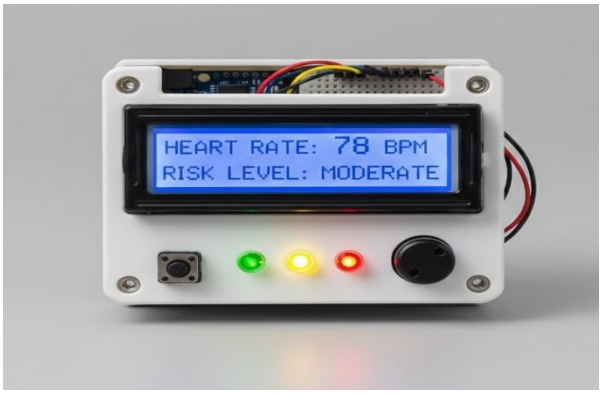

Figure 4: Images of LCD display and LED's

This multi-level alert system ensures that the user can easily understand their heart condition even without technical knowledge.

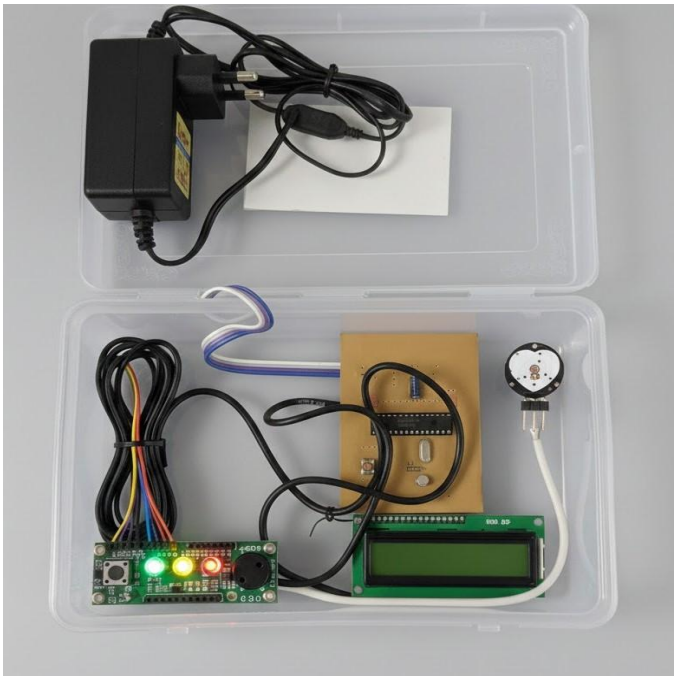

Figure 5: Image of the prototype

IV. WORKING PRINCIPLE

The working of the Heart Risk Prediction Model follows a systematic sequence:

1. When the system is powered ON, the Arduino initializes all connected components.
2. The user places a finger on the pulse sensor.
3. The pulse sensor detects heartbeat signals and sends analog data to the Arduino.
4. The Arduino processes the signal, removes noise, and calculates heart rate in BPM.
5. The calculated BPM is compared with predefined standard heart rate ranges.
6. Based on this comparison, the heart risk is classified as low, medium, or high.
7. The result is displayed on the LCD, and the corresponding LED is activated.
8. In case of high risk, the buzzer generates an alert signal.

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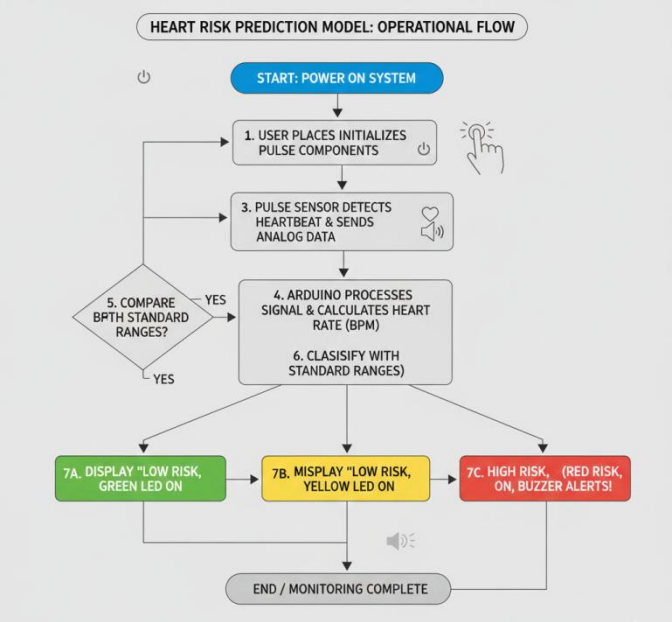

Figure 6:Operational flow of the hardware

V. Health And Safety Benefits

A. Real-time heart health awareness

The system provides real-time heart rate monitoring, enabling users to understand their current cardiovascular condition instantly. Continuous awareness plays a crucial role in preventing severe cardiac events.

B. Early detection and preventive care

By identifying abnormal heart rate patterns at an early stage, the system encourages users to take preventive measures such as lifestyle modification or medical consultation, thereby reducing long-term health risks.

C. *Non-Invasive and user-friendly design*

The device requires only finger placement for measurement, making it safe, comfortable, and suitable for people of all age groups.

VI. Potentail Challenges And Limitations

- Accuracy may be affected by finger movement or improper sensor placement
- External noise and ambient light interference
- Limited to heart rate-based assessment only
- Cannot replace professional medical diagnosis

VII. Applications

The Heart Risk Prediction Model has wide applicability across various domains due to its simplicity, portability, and cost-effectiveness.

A. Personal Health Monitoring

The system can be used by individuals at home for regular monitoring of heart rate, enabling early identification of abnormal patterns and encouraging proactive health management.

B. Preventive healthcare and awareness

By providing instant feedback on heart risk levels, the device promotes preventive healthcare practices and raises awareness about cardiovascular health, especially among individuals with sedentary lifestyles or high stress levels.

C. Educational and academic use

The model serves as an excellent educational tool for students studying biomedical engineering, electronics, and embedded systems. It demonstrates real-time signal acquisition, data processing, and hardware-software integration.

D. Rural and remote healthcare support

In areas with limited access to medical facilities, the device can act as a basic screening tool, helping healthcare workers identify individuals who may require further medical evaluation.

E. Fitness and wellness monitoring

The system can also be used in fitness environments to monitor heart rate during light physical activities or recovery phases, assisting users in maintaining safe exercise limits.

VIII. Future Enhancements

A. Advanced sensor integration

Additional sensors such as SpO_2 , temperature, blood pressure, and ECG can be integrated to provide a more complete assessment of cardiovascular health.

B. Wireless connectivity

Incorporating Bluetooth or Wi-Fi will enable real-time data transfer to mobile applications or cloud platforms for remote monitoring.

C. Data storage and analysis

Data logging facilities can help store historical heart rate data and support trend analysis for early risk detection.

D. Machine learning-based prediction

Machine learning algorithms can be applied to improve personalized heart risk prediction using user-specific health data.

E. Power and design optimization

Improved power management and compact hardware design can enhance battery life, portability, and user comfort.

IX. Conclusion

The Heart Risk Prediction Model presented in this work demonstrates a practical and efficient approach toward preliminary cardiovascular health assessment using an embedded system framework. By integrating a pulse sensor with an Arduino-based microcontroller, the system enables real-time monitoring of heart rate and categorization of cardiac risk into easily understandable levels. The inclusion of visual indicators and audible alerts ensures that users receive immediate and clear feedback regarding their heart condition, even without technical or medical expertise.

One of the key strengths of the proposed system is its simplicity, affordability, portability, and non-invasive operation, which make it suitable for personal health monitoring, educational demonstrations, and basic screening applications, particularly in rural and resource-limited regions. The system encourages preventive healthcare by increasing awareness and motivating users to seek timely medical consultation when abnormal heart rate patterns are detected. Although the device is not intended to replace clinical diagnostic equipment, it effectively bridges the gap between professional healthcare systems and everyday health monitoring solutions.

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