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Belagavi, Karnataka-590 018

A Project Report on

"Fetal Heart Rate Monitor and a Study on Heart Diseases"

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering
in
Electrical & Electronics Engineering

Submitted by

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Certificate

Certified that the project work entitled **"Fetal Heart Rate Monitor and a Study on Heart Diseases"** carried out by **Ms.Sristi (1CR17EE070), Ms.Sowmya S (1CR17EE69), Ms. Swathi Chandru (1CR17EE073), Ms.Shamema Firdous (1CR17EE064)** are bonafide students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2020-2021. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

Signature of the Guide	*Signature of the HOD*	*Signature of the Principal*
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DECLARATION

We, [**Ms Sristi (1CR17EE070), Ms Sowmya S (1CR17EE069), Ms Swathi Chandru (1CR17EE073), Ms Shamema Firdous (1CR17EE064)**], hereby declare that the report entitled **"Fetal Heart Rate Monitor and a Study on Heart Diseases"** has been carried out by us under the guidance of **Dr.Hemachandra G**, Assistant Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2020-21. The work done in this report is original and it has not been submitted for any other degree in any university.

Place : Bengaluru

Date :

Abstract

In the year 2020, WHO, the World Health Organisation, reported that the birth rate for India was 17.4 per 1,000 births. Out of the births that happened 29.6 in 2,000 were still births. The number of children born with CHD, or Congenital Heart Disease, in India was approximately 2,40,000. Many of these heart diseases and still births could have been prevented with regular monitoring of the fetal heart rate and monitoring the mother's heart rate. Many families cannot afford getting tests done and since these tests require trained professionals, the availability of doctors is also not enough. The rate and rhythm of a foetus' heartbeats are monitored through foetal heart rate monitoring. It checks for any changes in the baby's heartbeat. It also monitors the baby's heart rate fluctuations. A foetal heart rate of 110 to 160 beats per minute is considered normal. As the infant reacts to conditions in the uterus, the foetal heart rate may alter. A foetal heart rate or rhythm that is abnormal could indicate that the baby is not getting enough oxygen or that there are other issues. Atypical patterns may indicate the necessity for an emergency caesarean section (C-section).

Monitoring techniques provide the foundation for evaluating patients' clinical status and assessing changes in their conditions, allowing for timely interventions. Both of these goals can be addressed by combining technology advancements with methodological tools, allowing for accurate classification and extraction of diagnostic data. The study focuses on using monitoring approaches to determine fetal well-being using fetal heart rate variability (FHRV) signals gathered during pregnancy. The use of electronic foetal heart rate monitoring to check foetal status during labour is common. Despite the lack of evidence for its usefulness, this method is nonetheless widely utilised in every modern labour and delivery hospital in industrialised countries. In order to improve outcomes and patient safety, all providers of health care to the woman in labour and her newborn must have a comprehensive understanding of the underlying pathophysiology of foetal heart rate monitoring as well as an awareness for the labour course and issues as they occur.

A simple, non-invasive, inexpensive fetal heart rate monitor should solve this problem. A study on the heart rate fluctuations and the heart problems the mother could have is also as important.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project and who made it possible, because success is the outcome of hard work and perseverance, but steadfast of all is encouraging guidance. So with gratitude we acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

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CHAPTER 1

INTRODUCTION

What Is Fetal Heart Rate Monitoring?

Fetal heart rate monitoring is a process that lets the doctor see how fast the baby's heart is beating. If a woman is pregnant, the doctor will want to make sure the baby is healthy and growing as they should. One of the ways they do that is to check the rate and rhythm of the baby's heartbeat.

Fetal heart rate monitoring is used to notify us if the baby is not getting enough oxygen. To ensure that the stress of childbirth does not endanger the health of the baby.

During labour, a baby's heart rate should be between 110 and 160 beats per minute, but it may be higher or lower for a variety of reasons. Short bursts of increased heart rate in the newborn are frequent and signal that the baby is obtaining enough oxygen. When the baby's head is pressured while in the birth canal, brief decelerations in the baby's heart rate are also common.

If these accelerations or decelerations are not occurring at the stages they should be, or if they are prolonged, it could mean a number of things, such as the umbilical cord is compressed and blood flow to the baby has been slowed.

One of the key instruments for exploring the evolution of disease states is the monitoring of biological signals, which involves the measurement, quantification, evaluation, and classification of signal features. In order to extract usable information to detect a patient's state, the entire architecture of a monitoring system must integrate technology instruments with signal analysis approaches.

It is critical to choose processing methods that can enhance pathophysiological signal characteristics, thus tying parameters to physiological events, within these operations (and maybe to physical quantities).

The development of the various organs during pregnancy normally occurs in phases that begin at different times. The heart begins to beat at the fourth week of life, and the foetus begins to use its own bloodstream at this point. From the seventh week onwards, specialised instruments, such as ultrasound-based ones, can be used to monitor foetal cardiac activity. Fetal heartbeats can be heard without amplification starting around the 20th week, and the foetal heart rate (FHR) usually ranges between 110 and 150 beats per minute (BPM). It is critical to monitor cardiac activity as soon as possible, utilising accurate and dependable systems, particularly ultrasound techniques.

Project Description

This project aims at reducing fetal death by monitoring the heart rate of the fetus and studying data to predict the heart diseases the parents could have. "Fetal death" refers to the death of a human conception product before to its complete ejection or extraction from its mother, regardless of pregnancy duration, and which is not an induced termination of pregnancy. The fetus's death is evidenced by the fact that, following such ejection or extraction, the fetus does not breathe or show any other signs of life, such as heartbeat, umbilical cord pulsation, or definite movement of voluntary muscles. Heartbeats should be recognised from transient cardiac contractions, and respirations should be recognised from brief respiratory efforts or gasps.

Based on this knowledge of the situation, a method for less-trained healthcare personnel to swiftly measure the fetal heart rate so that cardiovascular problems may be consistently recognised must be developed. To make this device a lot more accessible than standard heart rate monitors, simple but precise equipment must be used. It should be acceptable as long as the variation in value is within +2 or -2 BPM.

The heart and circulatory system are among the first organs to develop in the foetus, with the foetal experiencing the first heartbeat by the third week of life. The term anatomy and physiology of the foetal heart and the neonatal heart vary. Fetal heart circulation differs from neonatal heart circulation throughout pregnancy. Because the placenta supplies oxygen to the foetus, the heart's main role is to pump oxygenated blood throughout the body, including the lungs. The lungs, on the other hand, will deliver oxygen to the newborn heart in the same way that they do to adults.

Fetal heart rate is an essential metric that may be tracked and used to determine foetal well-being. Fetal movement monitoring is another method of determining foetal well-being throughout pregnancy. However, there are several flaws in monitoring foetal movements. It is critical to monitor because anomalies in the foetal heart rate, which cause prematurity and miscarriage, can be prevented. It is critical to monitor all pregnant women, especially those who are at high risk and have had a previous loss.

When a heart beats, oxygenated blood is pumped throughout the foetal body. Adequate prenatal oxygenation is critical to preventing hypoxia that affects the whole foetal body. There may be a reduction in foetal cerebral blood flow if hypoxia occurs. As a result, foetal heart rate monitoring can detect foetal hypoxia. Fetal asphyxia is severe enough to cause neurological damage or perhaps death. Furthermore, foetal heart rate monitoring can solve two problems: it may be used as a screening test for severe asphyxia and it can detect early asphyxia, allowing timely obstetric intervention to avert asphyxia-induced brain damage or death in the infant.

We describe our concept for a novel compact and low-cost foetal heart rate monitor (FHRM) based on a condenser microphone and an Arduino microcontroller in this study. The average foetal heart rate is shown on a tiny LCD as the output of FRHM.

Inspiration of the Idea

A Netflix episode on YouTube called Babies | Love was released in 2020 which explains a lot about the connection between parents and babies. After watching that show and learning the feelings between parents and children and what parents go through when they're waiting for their baby but they don't get to meet them after all the wait. This felt unfair and a solution was needed for this as soon as possible. The initial problem statement was to just reduce still births and mortality rates. When we then learnt that most these births could be reduced by monitoring heart beats. This then made the problem statement to monitor fetal heart rates to reduce mortality rates. After this we learnt that the lesser trained professionals cannot use the heart rate monitors. An addition to that was studying the heart diseases that the parents could have.

Based on this knowledge of the situation, a method for less-trained healthcare personnel to swiftly measure the foetal heart rate so that cardiovascular problems may be consistently recognised must be developed. However, due to anticipated fluctuations in the foetal heart rate, a foetal heart rate measured for a short period of time has limited diagnostic utility. Listening to the foetal heart rate at an antenatal checkup serves little use other than to reassure the mother. Normal variability indicates a healthy cardiovascular and nervous system.

Technologies Used and Alternative Technologies

In our design, the input device used is a condensed microphone, the filtration technique used is an acoustic amplifier, which is necessary for the acquisition of the fetal heart rate. This requirement was met by utilising foam sound insulation as well as analogue filtration techniques to filter out frequencies over 200Hz. The device's parts were then chosen and arranged, and pseudocode was created as an overview of the logic required to handle the analogue input into the Arduino.

For studying the heart diseases in the parents Python is used. For this, a lot more other data like cholesterol, blood pressure, blood sugar, and others that contribute to the heart attacks or other problems in the heart. Different classifiers were used out of which Random Forest Classifier was most accurate.

The alternative technologies to measure heart rates are:

- Fetal Echocardiogram- The test employs sound waves that "echo" off the structures of the fetus's heart. A machine analyses these sound waves and generates an image of their heart's inside, known as an echocardiogram. This picture shows how your baby's heart developed and whether it is functioning normally.

- Echocardiogram- When sound waves bounce off blood cells travelling through the heart and blood arteries, their pitch changes. These variations (Doppler signals) can assist your doctor in determining the pace and direction of blood flow in the heart. Transthoracic and transesophageal echocardiograms commonly employ Doppler methods. Doppler methods can also be used to check for blood flow issues and high blood pressure in heart's arteries, which conventional ultrasonography may miss.

- Electrocardiogram- An electrocardiogram (ECG) is one of the most basic and quick diagnostics for evaluating the heart. Electrodes (tiny, plastic patches that adhere to the skin) are implanted at strategic locations on the chest, arms, and legs. Lead cables connect the electrodes to an ECG machine. The heart's electrical activity is then monitored, analysed, and printed. There is no electricity introduced into the body.

- Chest X-ray- An X-ray is a type of imaging test that utilises small quantities of radiation to create images of the body's organs, tissues, and bones. It can detect anomalies or illnesses of the airways, blood vessels, bones, heart, and lungs when focused on the chest. Chest X-rays can also reveal if you have fluid in your lungs or whether there is fluid or air surrounding your lungs.

- Pulse oximetry- Pulse oximetry is a test that measures the amount of oxygen in the blood (oxygen saturation). It is a simple, painless test that determines how well oxygen is delivered to regions of your body farthest from your heart, such as your arms and legs. A probe, which is a clip-like device, is put on a bodily part such as a finger or ear lobe. The probe measures the amount of oxygen in the blood using light. This information assists a healthcare professional in determining if a patient requires additional oxygen.

- Cardiac catheterization- Your doctor will insert a very small, flexible, hollow tube (called a catheter) into a blood artery in the groyne, arm, or neck during cardiac catheterization (also known as cardiac cath). The needle is then threaded into the blood artery, through the aorta, and into the heart. Several tests may be performed once the catheter is in place. Your doctor can insert the catheter tip into different regions of the heart to monitor pressures within the chambers or collect blood samples to test oxygen levels.

- Magnetic Resonance Imaging (MRI)- Magnetic resonance imaging (MRI) is a medical imaging technology used in radiology to provide images of the body's architecture and physiological processes. MRI scanners create pictures of the organs in the body by using high magnetic fields, magnetic field gradients, and radio waves.

CHAPTER 2

LITERATURE REVIEW

Similar Work and Important Discussions

There were four methods of similar drives made in the past:

a) The Pinard stethoscope (or fetoscope) is a lightweight, low-cost gadget that was designed in 1895 and is still widely used in impoverished nations today. The fetoscope can be made of a variety of materials, including but not limited to wood, aluminium, and plastic (Medical Antiques Online, 2011). The materials used are designed to be inexpensive, with non-wholesale prices ranging from $10 to $30 USD. This gadget has a distinctive "trumpet" design, with the wide end put against the mother's abdomen and the other end pressed on the physician's ear. The trumpet shape amplifies the slight sound of the fetal heartbeat, allowing the physician to easily hear it and count it out to calculate the fetal heart rate.

b) The gold standard in non-CTG fetal heart monitoring is the Doppler Fetal Monitor. The majority of developed countries utilise this gadget. The gadget is typically made up of two parts: a probe and a processing unit. Depending on the technology, the probe may display statistics, a graphical representation of the rate, or just an amplified fetal heart pulse on the screen (Freeman, 2003). This is prohibitively expensive for many developing-world hospitals to obtain. This device's high price is owing to its usage of ultrasonic technology. The Doppler Fetal Monitor, like the fetoscope, lacks the ability to measure fetal heart rate accelerations and decelerations.

c) A fetal microphone monitor serves the same purpose as a Doppler monitor. The primary distinction between a microphone-based monitor and a Doppler monitor is how the signal is acquired. A microphone-based monitor passively receives a signal by electroacoustic means, whereas a Doppler monitor actively probes for a signal using ultrasound techniques. This provides a huge economic benefit in terms of manufacturing – a microphone-based probe is significantly less expensive than an ultrasound-based probe.

d) Cardiotocography (CTG) machines include all of the functions of the three devices stated above, as well as several extra features that doctors find useful. The CTG machine generates a graphical output of the data collected. There are two lines on the printout. The top line shows the fetal heart rate with time: the x-axis represents the elapsed time of the readout, while the y-axis represents the instantaneous fetal heart rate. Uterine contractions are shown at the bottom of the graph. CTG has the benefit that, unlike other devices, accelerations and decelerations are visible in this time-dependent readout.

Although Fetal Heart Rate Monitors are widely used everywhere, places with low income where pre-natal mortality is high or in remote places, Fetal stethoscopes / Pinnard stethoscopes / Fetoscopes are used. Hand held dopplers are rarely available or are battery / electricity dependent.

Pinnard stethoscopes are detectable only between 18^{th} and 20^{th} week. They cannot be used to hear fetal heart in the early stages which makes it hard if the baby has complications.

Doppler devices are hand held ultrasound devices that use doppler effect to heart the fetal heart rate. They reduce the risk of mortality for both the mother and the baby when compared to the fetal stethoscopes.

In Fetal Heart Rate Monitor, there are two types of monitoring devices

- Invasive Fetal Heart Rate Monitor
- Non-Invasive Fetal Heart Rate Monitor.

Non- Invasive Method uses a probe that is either hand held or fastened to the abdomen to listen to and record the fetal heart rate. The most commonly used device is the doppler device.

Invasive Method uses an electrode probe to place it on the baby's scalp. The wire is connected to the device. The Invasive method gives accurate results as there are not interferences from the muscle contraction and the mother's heartbeat. This method may be used when non-invasive method doesn't give good readings or during labour to closely monitor the fetus in complicated situations or when either life is in danger

Non-Invasive method is preferred over invasive method as there are risks of infection for the mother or the baby from outside sources.

Bruising or scratching of the baby's scalp. Restriction of movement for the mother and the baby.

There are various Fetal heart rate monitors which are designed to monitor the fetal heart rate ranging from the type which can be used at home which are mostly wireless and hand held, to complex machines which uses probes that are either hand held, attached to the abdomen or have probes which can be placed on the fetus to get accurate information. Most commonly used monitor is a doppler ultrasound device. It's often used during the prenatal visits.

Clinical Value of Fetal Heart Rate

The baseline heart rate is utilised as a reference norm to detect and investigate substantial variations from the baseline. A healthy fetal heart rate should be between 110 and 160 beats per minute at birth. The fetal heart rate should gradually decrease during pregnancy as the foetus' central nervous system develops. The heart rate of a mid-trimester foetus should be between 150 and 170 beats per minute, whereas that of a post-term foetus should be between 110 and 120 beats per minute. This decrease is attributed to central nervous system development and the increasing dominance of the parasympathetic response. The most essential indicator of a healthy pregnancy is moderate fetal heart rate variability. The amplitude of peak-to-trough observations in beats per minute is defined as variability. Variations in heart rate between 6 and 25 beats per minute represent normal fetal movement, responsiveness to stimuli such as temperature changes, loud noises, or maternal activity, sleep cycles, and the influence of the developing sympathetic and parasympathetic neural systems on the heart rate. Changes in the fetal heart rate suggest that the foetus is getting enough oxygen.

Umbilical cord compression, which can cause hypoxia and frequently happens during the second stage of labour, can generate variations of more than 25 beats per minute. A fetal heart rate acceleration is defined as a rise in the baseline rate that occurs in less than 30 seconds. A baseline change is defined as an acceleration lasting more than ten minutes. Accelerations can be caused by a uterine contraction (periodic) or, more usually, by an unrelated uterine contraction (episodic). Periodic accelerations can be caused by fetal stimulation or umbilical vein compression. Early in labour, a slowing during a contraction could suggest cephalopelvic disproportion, a condition that demands a caesarean section. Uteroplacental insufficiency can induce decelerations that begin after the end of a contraction. In this situation, there is a difficulty with uterine perfusion, uterine activity, or the placenta.

Fetal monitoring is an important technique for recognising foetal discomfort and anomalies so that appropriate actions may be done to address a disease. The baseline foetal heart rate is the average number of beats per minute over ten minutes, rounded to the nearest increment of five beats per minute, omitting instances when the heartbeat differs from the baseline by more than 25 beats per minute. The baseline heart rate is utilised as a reference norm to detect and examine significant variations from the baseline. A healthy foetal heart rate should be between 110 and 160 beats per minute at birth.

CHAPTER 3

PROPOSED MODEL WITH THEORETICAL BACKGROUND

Input and Considerations

The patient is communicated with via the acoustic amplifier. The hollow cone is positioned on the maternal abdomen, collecting and focusing sound waves toward the condenser microphone near the neck. By palpating the maternal abdomen and looking for the fetal back, the correct location of the cone on the belly should be determined. To detect a clear heartbeat, the cone should be put as close to the fetal back as feasible. The lip around the cone's border is utilised to secure it to the abdomen. This report's final design contains a new noise and vibration reduction technology.

Instead of a layer of foam on the outside of the cone, a layer of foam is placed around the microphone in the cone's throat. The foam dampens mechanical vibrations in the plastic cone caused by movements and shocks, preventing them from reaching the microphone and producing interference, but it has little effect on blocking out ambient sounds. Because the sound of the fetal pulse travels as a pressure wave through the air in the middle of the cone, inserting insulating foam between the microphone and the cone has no effect on how the microphone identifies fetal heart tones.

Circuitry

The final design circuit comprises of a preamplifier and a Butterworth filter. It is fueled by 5V from the Arduino's power source. The circuit diagram may be found below. The output of this circuitry goes to the arduino.

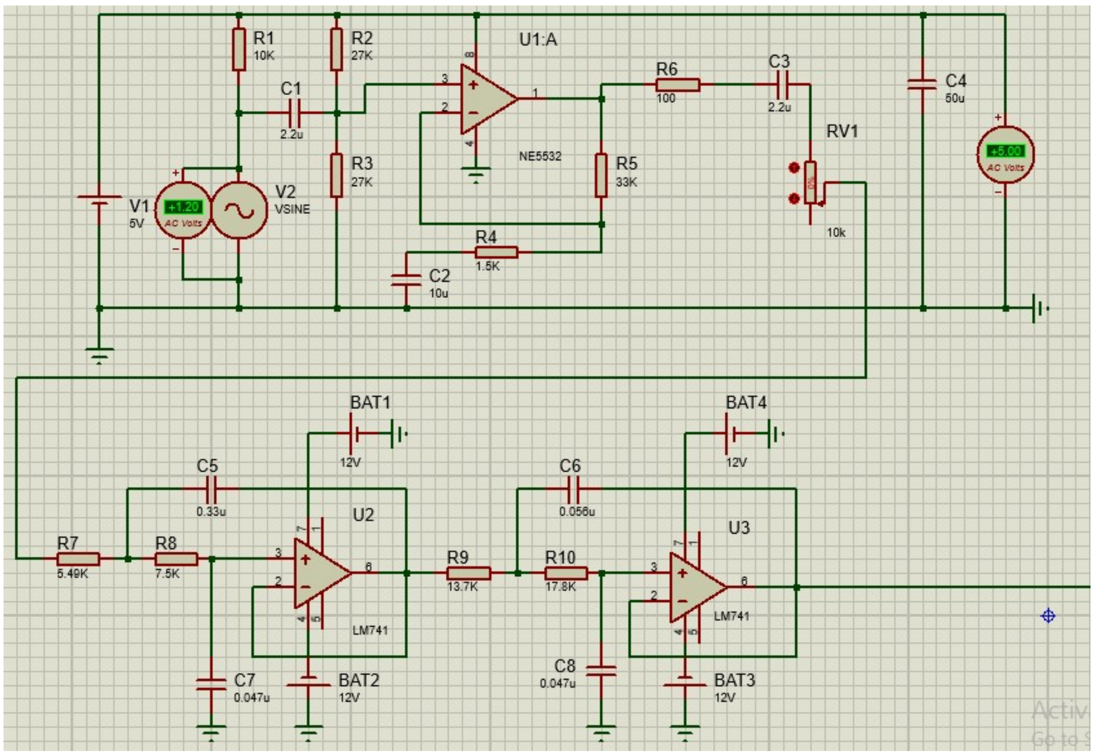

Fig. 1: Circuitry

The condenser microphone signal is routed through a pre-amplifier, a low pass Butterworth filter, and finally to the Arduino for digital processing. The Arduino's 5V DC power source will power the entire circuit. The circuit will be built on a breadboard.

CHAPTER 4

DESIGN PROCESS

Analog Pre-Amplification

A preamplifier, often known as a preamp, is an electronic amplifier that transforms a weak electrical input into an output signal that is noise-tolerant and powerful enough to be sent to a power amplifier and a loudspeaker. The final signal would be loud or distorted if this was not done. Typically, they are employed to amplify signals from analogue sensors such as microphones and pickups. As a result, the preamplifier is frequently placed near the sensor to decrease the impacts of noise and interference.

A good preamp will be linear (having a consistent gain over its working range), have a high input impedance (requiring just a small amount of current to perceive the input signal), and have a low output impedance (when current is drawn from the output there is minimal change in the output voltage). It is used to increase signal intensity in order to drive the cable to the primary instrument without drastically lowering the signal-to-noise ratio (SNR). A preamplifier's noise performance is essential. When the gain of the preamplifier is high, the SNR of the final signal is dictated by the SNR of the input signal and the noise figure of the preamplifier, according to Friis' formula.

There are three main types of preamplifiers:

1. current-sensitive preamplifier
2. parasitic-capacitance preamplifier
3. charge-sensitive preamplifier.

A preamplifier is used to prepare the microphone signal for additional amplifying, filtering, and processing. First, a low noise audio operational amplifier (op-amp) was chosen to serve as the preamplifier. The LM833, NE5532, OP27, and OP37 op-amps were selected for their high quality attributes and reputations for usage in audio applications, as well as their low-to-medium price points to keep the device low cost. Both the OP27 and OP37 require an excessively high supply voltage (15 V) for the microphone and the possible low-resource environment power source that will be created in the future. The LM833 and NE5532 require a sufficient supply voltage, which may be supplied by a 9V battery or the Arduino's 5V.

At the end of the microphone's frequency range, 20 kHz, the NE5532 op-amp has a higher open loop gain (approximately 60+ dB) than the LM833 (around 55 dB). Because of this, the NE5532 is a suitable op-amp for the preamplifier circuit. The closed loop gain of this circuit is little about 2.

The higher the open loop gain, the more linear the amplifier will be and the output voltage will be proportionate to the input voltage. The 27 k resistor in the lower centre section of the design was removed to enhance the gain of the preamplifier.

After this resistor is removed, the amplifier's gain is 23 dB.

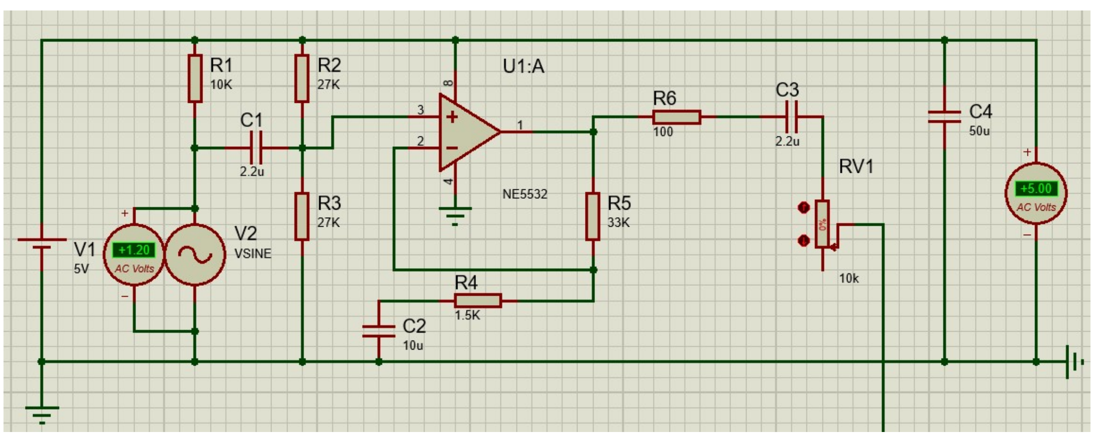

Fig. 2: Analog Pre-amplification

Analog Low-Pass Signal Filtration

A low-pass filter is a filter that allows signals with frequencies lower than a certain cutoff frequency to pass while attenuating signals with frequencies greater than the cutoff frequency. The frequency response of the filter is determined by its design. In audio applications, the filter is also known as a high-cut filter or treble-cut filter. A low-pass filter is a high-pass filter's inverse. Because frequency and wavelength of light are inversely linked, high-pass and low-pass may have distinct meanings in optics. High-pass frequency filters might be used as low-pass wavelength filters, and vice versa. To prevent misunderstanding, it is best to refer to wavelength filters as short-pass and long-pass, which correspond to high-pass and low-pass frequencies.

Low-pass filters can be found in a variety of configurations, including electronic circuits such as a hiss filter used in audio, anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, image blurring, and so on. The moving average operation, which is utilised in sectors such as finance, is a type of low-pass filter that may be examined using the same signal processing techniques as other low-pass filters. Low-pass filters smooth out a signal, eliminating short-term oscillations but preserving the longer-term trend.

An perfect low-pass filter fully removes all frequencies above the cutoff frequency while passing all frequencies below unaltered; it has a rectangular frequency response and is a brick-wall filter. An ideal filter lacks the transition area found in practical filters. Mathematically (theoretically), an ideal low-pass filter may be achieved by multiplying a signal by the rectangle function in the frequency domain or, equivalently, convolution with its impulse response, a sinc function, in the time domain.

Real-time filters approximate the ideal filter by truncating and windowing the infinite impulse response to produce a finite impulse response; applying that filter necessitates delaying the signal for a reasonable amount of time, allowing the computer to visualize the future. The result of this delay is a phase shift. Greater approximation precision necessitates a longer wait.

However, because the sinc function's support area spans to all past and future periods, the ideal filter is difficult to actualize without also having signals of indefinite length in time. As a result, the ideal filter must typically be approximated for genuine continuing signals. In order to conduct the convolution, the filter would need to have unlimited delay or knowledge of the infinite future and past. It is successfully realisable for pre-recorded digital signals by assuming zero extensions into the past and future, or, more often, by making the signal repeating and employing Fourier analysis.

In order to obtain higher and faster attenuation, a second fourth-order Butterworth filter was created with differing resistance and capacitance values. For a cutoff frequency of 200 Hz, this filter was built using the online Butterworth calculator.The first filter's inadequate sound intensity reduction percentages were found again in the second filter. The second filter, on the other hand, attenuated the signal at all frequencies less. As a result, the second filter was employed in the final prototype.

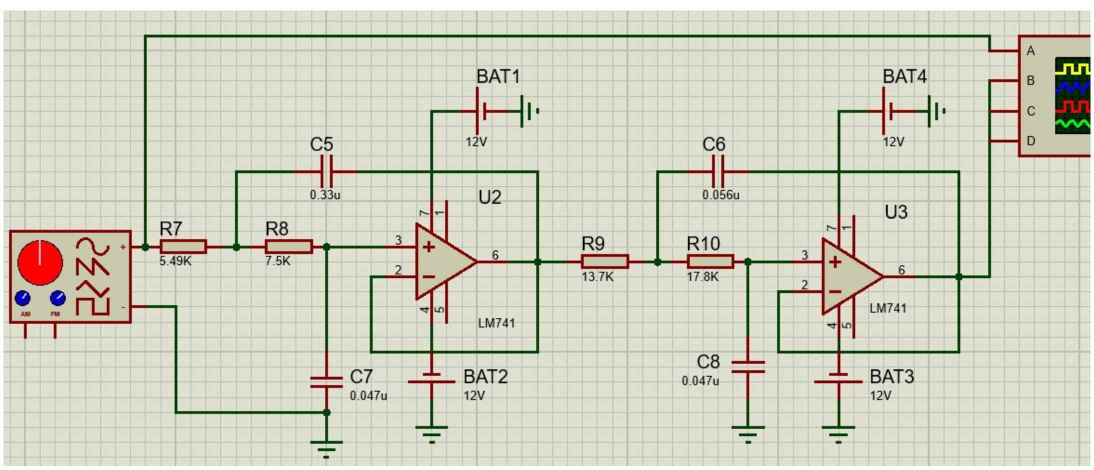

Fig. 3: Fourth Order Low Pass Butterworth Filter

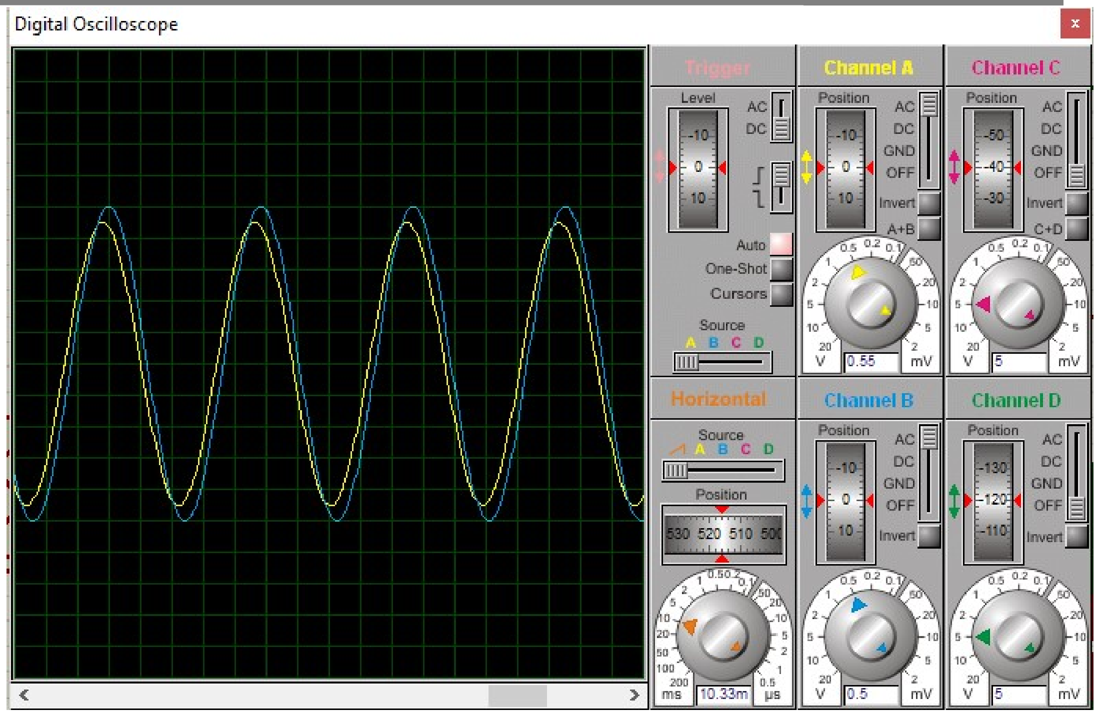

Fig. 4: Fourth Order Low Pass Butterworth Filter Output

Arduino

Arduino is an open-source hardware and software business, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits used in the construction of digital devices. Its hardware is released under a CC-BY-SA licence, while its software is licenced under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), allowing anyone to produce Arduino boards and distribute software. Arduino boards are commercially accessible through the official website or approved dealers.

Arduino board designs make use of a wide range of microprocessors and controllers. The boards are outfitted with sets of digital and analogue I/O pins that may be connected to various expansion boards ('shields') or breadboards (for prototyping) and other circuits. Serial communications interfaces, including Universal Serial Bus (USB) on some versions, are provided on the boards, which are also utilised for software loading. The C and C++ programming languages, as well as a common API known as the "Arduino language," may be used to programme the microcontrollers.

The Arduino integrated development environment (IDE) is a Java-based cross-platform application (available for Windows, macOS, and Linux). It evolved from the IDE for the programming languages Processing and Wiring. It contains a code editor with text cutting and copying, text finding and replacement, automated indenting, brace matching, and syntax highlighting, as well as easy one-click procedures for compiling and uploading programmes to an Arduino board. It also has a message area, a text terminal, a toolbar with buttons for common functions, and an operation menu hierarchy.

The filtered signal is sent into the "0" port of an Arduino after exiting the analogue circuit. This device then executes all of the digital calculations required to generate diagnostically useful information about instantaneous and baseline heart rates, as well as the variability of this data. The code is divided into two parts: the setup function and the loop function. They are denoted by the functions void setup() and void loop(), respectively. The setup begins by wiping the screen, and then it initialises the LCD screen, stating the screen size to be 16 characters by 2. The loop section of the code continues indefinitely as long as the device is powered on, repeating as many times as the Arduino's processing power allows. This code contains multiple components, just as there are several pieces to the logic required to produce an output to the Arduino screen. The initial section of this code includes acquiring and counting the raw signals outputted by the onboard A/D converter. Following that, the device run time is checked to determine whether it has exceeded 5000 milliseconds.

CHAPTER 5

RESULTS AND DISCUSSIONS

Discussions

Though the gadget has outperformed expectations in terms of completion this semester, there are still several problems in achieving all of the engineering criteria. The design's signal acquisition is the most difficult issue in meeting these. The hollow cone amplifier should theoretically be able to ideally amplify the sound of the heartbeat, however even this amplification may not be sufficient to allow the microphone to get a signal. Implementing sound processing techniques is another important problem. Analog sound processing techniques are currently being investigated and applied, however the team has had trouble getting a signal after it has been filtered using a Butterworth filter. As a result, the team intends to handle noise reduction digitally.

However, as digital sound processing would have to be implemented as a separate function or integrated into the design of the current software, this provides a final hurdle in the programming logic required to transform these signals into diagnostically useful data.

Using Hyperparameter Tuning to Apply Machine Learning Algorithms:

- Hyperparameters: There are no hyperparameters in vanilla linear regression. Regularization is a hyperparameter in linear regression variants (ridge and lasso). As hyperparameters, the decision tree has a maximum depth and a minimum number of observations in each leaf.

- Optimal Hyperparameters: Hyperparameters govern the model's over-fitting and under-fitting. Optimal hyperparameters frequently change between datasets. The following procedures are used to obtain the optimum hyperparameters:

1. The model is tested for each suggested hyperparameter setting

2. The hyperparameters that provide the best model are chosen.

- Grid Search: Grid search selects a grid of hyperparameter values and assesses them all. The min and max values for each hyperparameter must be estimated. A random search values a random sample of grid points at random. It outperforms grid search in terms of efficiency. Intelligent hyperparameter tuning selects a few hyperparameter settings, assesses the validation matrices, modifies the hyperparameters, and re-evaluates the validation matrices. Spearmint (hyperparameter optimization using Gaussian processes) and Hyperopt are two examples of smart hyper-parameters (hyperparameter optimization using Tree-based estimators).

Prediction of Heart Diseases on the Parents

The dataset used is from kaggle. And the dataset is called Heart Disease UCI. The information given includes age, sex, chest pain type, rest blood pressure, cholesterol, fasting blood sugar, resting electrocardiographic results, maximum heart rate achieved, and many more that contribute to the heart diseases in a grown person.

It is important to study the heart diseases that the parents might have to predict the child's heart condition too. Machine Learning is utilised in a variety of fields all around the world. The healthcare business is no different. Machine Learning can help forecast the existence or absence of locomotor problems, heart disease, and other illnesses. Such information, if anticipated in advance, can give crucial insights to clinicians, allowing them to tailor their diagnosis and treatment to each individual patient.

The python libraries include pandas, matplotlib, seaborn and numpy. The classifiers used are Logistic Regression, K-Nearest Neighbours Classifier, Support Vector machine, Decision Tree Classifier and Random Forest Classifier out of which RF Classifier showed the best results. The question we try to solve here is given clinical parameters about a patient, can we predict whether or not they have heart disease?

1. age - age in years
2. sex - (1 = male; 0 = female)
3. cp - chest pain type
   0: Typical angina: chest pain related decrease blood supply to the heart
   1: Atypical angina: chest pain not related to heart
   2: Non-anginal pain: typically esophageal spasms (non heart related)
   3: Asymptomatic: chest pain not showing signs of disease
4. trestbps - resting blood pressure (in mm Hg on admission to the hospital) anything above 130-140 is typically cause for concern

5. chol - serum cholestoral in mg/dl

6. serum = LDL + HDL + .2 * triglycerides above 200 is cause for concern

7. fbs - (fasting blood sugar > 120 mg/dl) (1 = true; 0 = false) '>126' mg/dL signals diabetes

8. restecg - resting electrocardiographic results
   0: Nothing to note
   1: ST-T Wave abnormality can range from mild symptoms to severe problems signals non-normal heart beat
   2: Possible or definite left ventricular hypertrophy

9. Enlarged heart's main pumping chamber

10. thalach - maximum heart rate achieved

11. exang - exercise induced angina (1 = yes; 0 = no)

12. oldpeak - ST depression induced by exercise relative to rest looks at stress of heart during excercise unhealthy heart will stress more

13. slope - the slope of the peak exercise ST segment
    0: Upsloping: better heart rate with excercise (uncommon)
    1: Flatsloping: minimal change (typical healthy heart)
    2: Downslopins: signs of unhealthy heart

14. ca - number of major vessels (0-3) colored by flourosopy colored vessel means the doctor can see the blood passing through the more blood movement the better (no clots)

15. thal - thalium stress result
    1,3: normal

16. fixed defect: used to be defect but ok now

17. reversable defect: no proper blood movement when excercising

18. target - have disease or not (1=yes, 0=no) (= the predicted attribute)

cp Chest Pain: People with cp values of 1, 2, or 3 are more likely to develop heart disease than those with cp values of 0 or 1.

Resting electrocardiographic findings (resting electrocardiogram): People with value 1 (signals non-normal heart rhythm, can vary from moderate symptoms to serious issues) are more likely to develop heart disease.

Persons with value 0 (No= exercice caused angina) have greater heart disease than people with value 1 (Yes= exercice induced angina).

People with a slope value of 2 (Downsloping: indications of an unhealthy heart) are more likely to suffer heart disease than those with a slope value of 0 (Upsloping: improved heart rate with activity) or 1 (Flatsloping: minimal change (typical healthy heart)).

ca number of main vessels (0-3) coloured by flourosopy: the more the blood movement, the better, thus those with ca equal to 0 are more prone to develop heart disease.

thal thalium stress result : People with a thal value of 2 (fixed defect: used to be a defect but is now normal) are more likely to develop heart disease.

trestbps : resting blood pressure (in mm Hg on arrival to the hospital): anything above 130-140 is usually cause for worry cholserum cholestoral in mg/dl: anything above 200 is usually cause for concern

Maximum heart rate attained: People who have a maximum heart rate of greater than 140 are more prone to develop heart disease.

oldpeak ST depression produced by activity compared to rest examines heart stress during exercise a diseased heart will stress more.

Correlation matrix:

A correlation matrix is a table that displays the coefficients of correlation between variables. Each cell in the table represents the relationship between two variables. A correlation matrix can be used to summarise data, as an input for a more advanced analysis, or as a diagnostic for further studies. A correlation matrix is computed for three general reasons:

1. To summarise a huge quantity of data in order to discover patterns. In our previous example, the observable pattern is that all of the variables are significantly correlated with one another.

2. To be used as input for further analysis. When eliminating missing data pairwise, individuals frequently utilise correlation matrices as inputs for exploratory component analysis, confirmatory factor analysis, structural equation models, and linear regression.

3. When additional analyses are being checked, use this as a diagnostic. In the case of linear regression, for example, a high number of correlations indicates that the linear regression estimates would be inaccurate.

When displaying a correlation matrix, you must evaluate many alternatives, including whether to show the entire matrix, as shown above, or simply the non-redundant bits, as shown below (arguably the 1.00 values in the main diagonal should also be removed).

- How to Present the Numbers (for example, best practise is to remove the 0s prior to the decimal places and decimal-align the numbers, as above, but this can be difficult to do in most software).

- Whether or not to demonstrate statistical significance (e.g., by color-coding cells red).

- Whether or not to color-code the numbers based on the correlation statistics (as shown below).

- Rearranging the rows and columns to make the patterns more visible.

Missing values are common in the data we use to construct correlations. This might be because we did not gather the data or because we do not know the replies. There are several techniques for dealing with missing values when computing correlation matrices. Multiple imputation is typically recommended as a best practise. People, on the other hand, are more likely to employ pairwise missing values (sometimes known as partial correlations). This entails calculating correlation for the two variables using all of the non-missing data. Some people, on the other hand, employ listwise deletion, also known as case-wise deletion, which only uses observations with no missing data.

Data scientists utilise exploratory data analysis (EDA) to examine and investigate data sets and describe their major features, typically using data visualisation approaches. It aids in determining how to effectively modify data sources to obtain the answers required, making it simpler for data scientists to identify patterns, detect anomalies, test hypotheses, and validate assumptions.

EDA is largely used to discover what data may disclose beyond the formal modelling or hypothesis testing tasks, and it offers a deeper knowledge of data set variables and their interactions. It can also assist you evaluate whether the statistical approaches you're thinking about using for data analysis are acceptable. Developed in the 1970s by American mathematician John Tukey, EDA techniques are still frequently employed in the data discovery process today.

The primary goal of EDA is to aid in the examination of data prior to forming any assumptions. It can assist in identifying obvious mistakes, as well as better understanding patterns within the data, detecting outliers or abnormal occurrences, and discovering intriguing relationships between variables. Exploratory analysis may be used by data scientists to guarantee that the results they create are legitimate and appropriate to any targeted business outcomes and goals. EDA also assists stakeholders by ensuring they are asking the appropriate questions. EDA may assist in determining standard deviations, categorical variables, and confidence intervals. When EDA is finished and insights are obtained, its characteristics can be used for more complex data analysis or modelling, including machine learning.

- Clustering and dimension reduction procedures, which aid in the creation of graphical representations of high-dimensional data including many variables, are examples of statistical functions and techniques that may be performed with EDA tools.
- Each field in the raw dataset is shown in univariate form, along with summary statistics.
- Bivariate visualisations and summary statistics that allow you to evaluate the link between each variable in the dataset and the target variable under consideration.
- Multivariate visualisations are used to map and analyse relationships between multiple variables in data.
- K-means Clustering is an unsupervised learning clustering approach in which data points are assigned to K groups, i.e. the number of clusters, depending on their distance from the centroid of each group. The data points closest to a specific centroid will be grouped together in the same category. Market segmentation, pattern identification, and picture compression are all typical applications for K-means Clustering.
- Predictive models, such as linear regression, rely on statistics and data to make predictions.

There are four primary types of EDA:

1. Univariate non-graphical. This is simplest form of data analysis, where the data being analyzed consists of just one variable. Since it's a single variable, it doesn't deal with causes or relationships. The main purpose of univariate analysis is to describe the data and find patterns that exist within it.

2. Univariate graphical. Non-graphical methods don't provide a full picture of the data. Graphical methods are therefore required. Common types of univariate graphics include:

   Stem-and-leaf plots depict all data values as well as the distribution's form.

   Histograms are a type of bar plot in which each bar indicates the frequency (count) or proportion (count/total count) of instances for a given set of values.

   Box plots show a five-number overview of the minimum, first quartile, median, third quartile, and maximum.

3. Nongraphical multivariate data: Data that is generated by more than one variable. Multivariate non-graphical EDA approaches often use cross-tabulation or statistics to demonstrate the link between two or more variables of data.

4. Multivariate graphical data: Multivariate data displays relationships between two or more sets of data using visuals. A grouped bar plot or bar chart is the most commonly used visual, with each group representing one level of one of the variables and each bar inside a group reflecting the levels of the other variable.

Scatter plots, which are used to plot data points on a horizontal and vertical axis to demonstrate how much one variable is impacted by another, are another frequent kind of multivariate graphics.

A multivariate chart is a graphical depiction of the connections between variables and responses.

A run chart is a time-plotted line graph of data.

A bubble chart is a type of data visualisation in which numerous circles (bubbles) are shown in a two-dimensional plot.

A heat map is a graphical representation of data in which values are represented by colour.

Python: An interpreted, object-oriented programming language with dynamic semantics, is one of the most often used data science tools for creating an EDA. Its high-level, built-in data structures, along with dynamic typing and dynamic binding, make it highly appealing for quick application creation as well as usage as a scripting or glue language to link existing components. Python and EDA may be used in tandem to discover missing values in a data collection, which is useful for deciding how to treat missing values in machine learning.

R is a free and open-source programming language and software environment for statistical computation and graphics that is sponsored by the R Foundation for Statistical Computing. The R programming language is frequently used by statisticians in data science to create statistical observations and data analysis.

CHAPTER 6

CONCLUSIONS AND FUTURE DIRECTIONS

In the current model there are a lot of ifs. The certainty of the cone being able to amplify the sounds within the required noise levels is uncertain. The entire model is scattered and the pieces need to be put together. A single device that takes into consideration the parents health conditions, and predicts the child's heart diseases based on constant monitoring of the child's heart rate and other predictions through the fetal growth per week. An overall system for the prediction, which could be the combination of all parts of the current project in one with the addition of a few other prediction methods will be ideal for the future scope of this project.

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