FINAL YEAR PROJECT - FIRST REVIEW

25-02-2022

DESIGN AND DEVELOPMENT OF
IOT BASED HEALTH CARE MONITORING DEVICE
FOR
EARLY DIAGNOSIS OF HEART DISEASE USING AI

PROJECT GUIDE - DR. GEETHA C

TEAM MEMBERS

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Introduction

Cardiovascular diseases (CVDs) are the number 1 cause of death globally, taking an estimated 17.9 million lives each year, which accounts for 31% of all deaths worldwide. Four out of 5CVD deaths are due to heart attacks and strokes, and one-third of these deaths occur prematurely in people under 70 years of age. Heart failure is a common event caused by CVDs and this dataset contains 6 features that can be used to predict possible heart disease. People with cardiovascular disease or who are at high cardiovascular risk (due to the presence of one or more risk factors such as hypertension, diabetes, hyperlipidaemia, or already established disease) need early detection and management wherein a machine learning model can be of great help.

Work plan

Tasks Accomplished:

1. Literature review - Hemangani, Akshyah
2. Dataset collection - Hemangani
3. Sensor selection and purchase - Hemangani
4. Fabrication, testing, calibration, and thresholding of sensors - Hemangani
5. Circuit design and implementation - Hemangani
6. C programming for data acquisition from sensors and display - Hemangani
7. Pre-processing, and analysis of data and feature engineering - Hemangani
8. Design and development of machine learning algorithms - Hemangani
9. Training, testing, and debugging of the model - Hemangani
10. Documentation - Hemangani, Akshyah

Upcoming Tasks:

1. Addition of blood pressure monitoring sensor
2. Integration of wi-fi, GPS and RFID
3. Establishing wireless communication
4. Compact fabrication with inbuilt power supply
5. Integrating python and Arduino codes

Dataset creation

Attribute Information:

1. Age: age of the patient [years]
2. Sex: sex of the patient [M: Male, F: Female]
3. ChestPainType: chest pain type [TA: Typical Angina, ATA: Atypical Angina, NAP: Non-Anginal Pain, ASY: Asymptomatic]
4. RestingBP: resting blood pressure [mm Hg]
5. MaxHR: maximum heart rate achieved [Numeric value between 60 and 202]
6. ExerciseAngina: exercise-induced angina [Y: Yes, N: No]
7. HeartDisease: output class [1: heart disease, 0: Normal]

This dataset was created by combining different datasets already available independently but not combined before. In this dataset, 5 heart datasets are combined over 6 common features which makes it the largest heart disease dataset available so far for research purposes.

The five datasets used for its curation are:

1. Cleveland: 303 observations
2. Hungarian: 294 observations
3. Switzerland: 123 observations
4. Long Beach VA: 200 observations
5. Stalog (Heart) Data Set: 270 observations

Total: 1190 observations

Duplicated: 272 observations

Final dataset: 918 observations

Every dataset used can be found under the Index of heart disease datasets from UCI Machine Learning Repository on the following link:

https://archive.ics.uci.edu/ml/machine-learning-databases/heart-disease/

Acknowledgments

Creators:

1. Hungarian Institute of Cardiology. Budapest: Andras Janosi, M.D.
2. University Hospital, Zurich, Switzerland: William Steinbrunn, M.D.
3. University Hospital, Basel, Switzerland: Matthias Pfisterer, M.D.
4. V.A. Medical Centre, Long Beach, and Cleveland Clinic Foundation: Robert Detrano, M.D., Ph.D.

Donor:

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This dataset is to be used for building a predictive machine learning model for early-stage heart disease detection.

Components

xcluma Heart-Beat Pulse Sensor Module

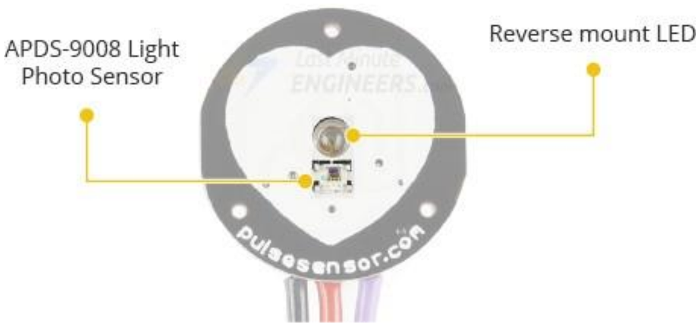
Description:

Pulse sensor is used to test the heart rate. Sensors can be worn on the finger or earlobe and can be connected with an Arduino line via the internet. It also has an open-source app program, which can put the heart rate in real time displayed by the graph. Essence is an integrated optical heart rate sensor amplifier and noise elimination circuit. The Pulse Sensor is a well-designed low-power plug-and-play heart-rate sensor for the Arduino. It can be used to incorporate live heart-rate data into the project. And the best part is that this sensor plugs right into Arduino and easily clips onto a fingertip or earlobe. It is also super small (button-shaped) with holes, so it can be sewn into fabric.

Product Dimensions:8 x 4 x 10 cm; 4 Grams

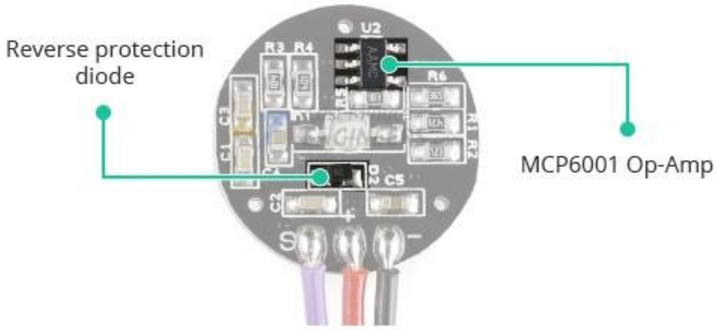
Hardware Overview:

The front of the sensor is the side with the heart logo. This is where we place our finger. On the front side there is a small round hole, from where the King Bright's reverse mounted green LED shines.



Just below the LED is a small ambient light photo sensor – APDS-9008 from Avago, similar to that used in cell phones, tablets and laptops, to adjust the screen brightness in different light conditions.

On the back of the module is the rest of the components including a microchip's MCP6001 Op-Amp and a bunch of resistors and capacitors that make up the R/C filter network. There is also a reverse protection diode to prevent damage if the power leads are accidentally reversed.



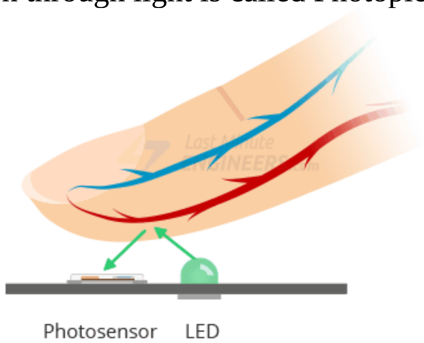
The module operates from a 3.3 to 5V DC Voltage supply with an operating current of < 4mA.

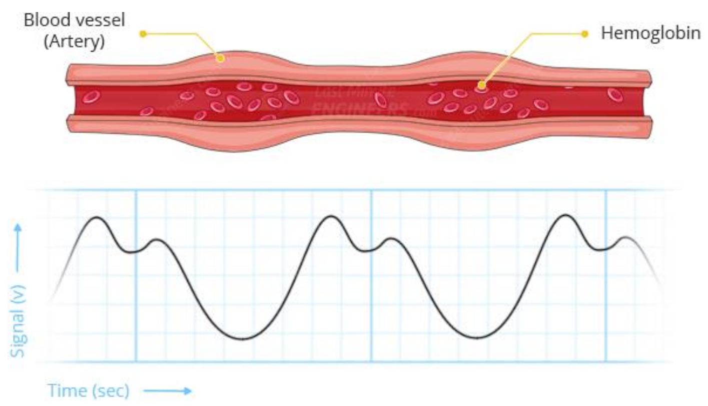
Technical specifications:

Maximum Ratings	VCC	3.0 – 5.5V
	IMax (Maximum Current Draw)	< 4mA
	VOut (Output Voltage Range)	0.3V to Vcc
Wavelength	LED Output	565 nm
	Sensor Input	525 nm
Dimensions	L x W (PCB)	15.8mm (0.625″)
	Lead Length	20cm (7.8″)

Pulse Sensor Working:

A pulse sensor or any optical heart-rate sensor, for that matter, works by shining a green light (~ 550 nm) on the finger and measuring the amount of reflected light using a photosensor. This method of pulse detection through light is called Photoplethysmogram.





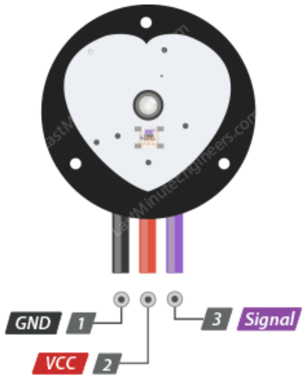
The oxygenated haemoglobin in the arterial blood has the characteristic of absorbing green light. The redder the blood (the higher the haemoglobin), the more green light is absorbed. As the blood is pumped through the finger with each heartbeat, the amount of reflected light changes, creating a changing waveform at the output of the photosensor.

As we continue to shine light and take photo sensor readings, we quickly start to get a heart-beat pulse reading.

This signal from the photosensor is generally small and noisy, therefore the signal is passed through an R/C filter network and then amplified using an Op Amp to create a signal that is much larger, cleaner and easier to detect.

Pulse Sensor Pinout:

The sensor comes with a 24" flat ribbon cable with 3 male header connectors. The following diagram shows the pinout.



S (Signal) is the signal output. Connects to analog input of an Arduino.
+ (VCC) is the VCC pin. Connects to 3.3 or 5V.
– (GND) is the Ground pin.

Wiring Pulse Sensor with Arduino:

The module can be powered from 3.3 or 5V. The positive voltage connects to '+' and ground connects to '-'. The 3rd 'S' wire is the analog signal output from the sensor and this will connect to the A0 analog input of an Arduino.

Machine learning

Dataset:

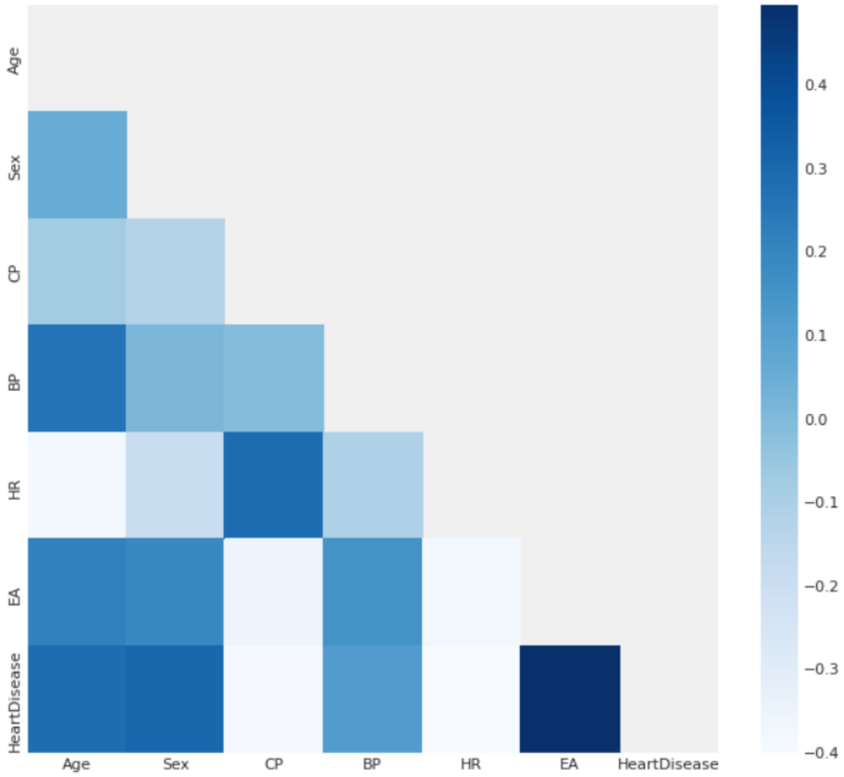
```
Rows     =  917
Columns  =  7
```

	Age	Sex	CP	BP	HR	EA	HeartDisease
0	40	M	ATA	140	172	N	0
1	49	F	NAP	160	156	N	1
2	37	M	ATA	130	98	N	0
3	48	F	ASY	138	108	Y	1
4	54	M	NAP	150	122	N	0

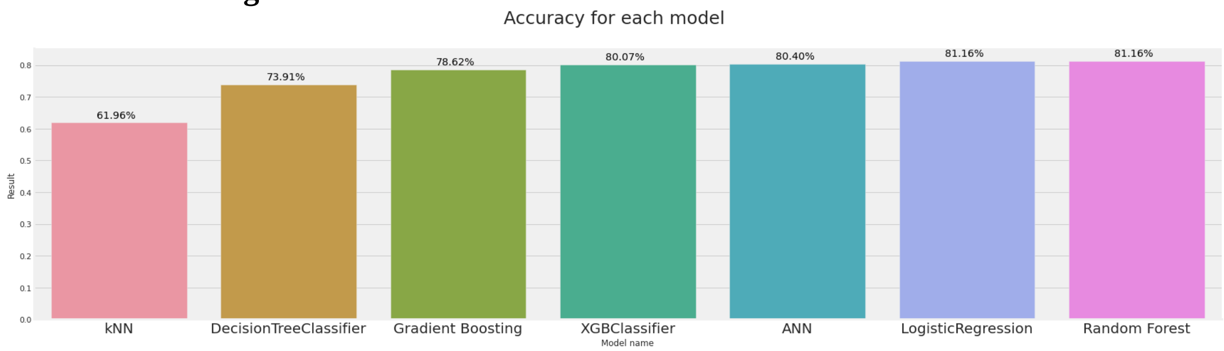
	count	mean	std	min	25%	50%	75%	max
Age	917.0	53.509269	9.437636	28.0	47.0	54.0	60.0	77.0
BP	917.0	132.540894	17.999749	80.0	120.0	130.0	140.0	200.0
HR	917.0	136.789531	25.467129	60.0	120.0	138.0	156.0	202.0
HeartDisease	917.0	0.552890	0.497466	0.0	0.0	1.0	1.0	1.0

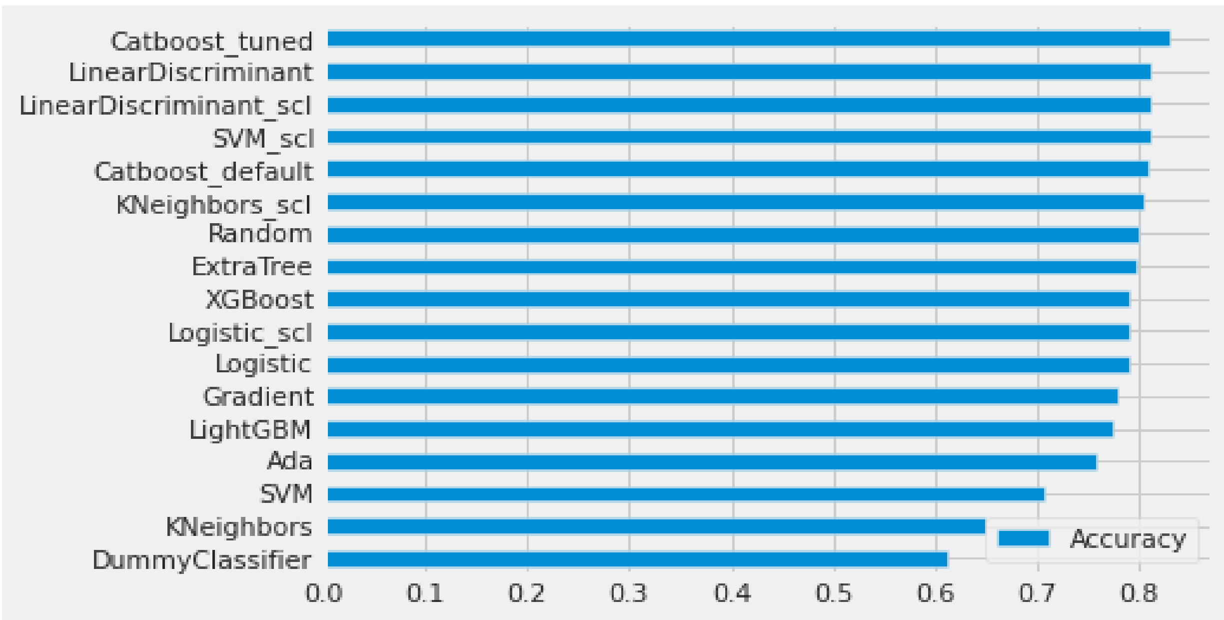
Distribution of the features:

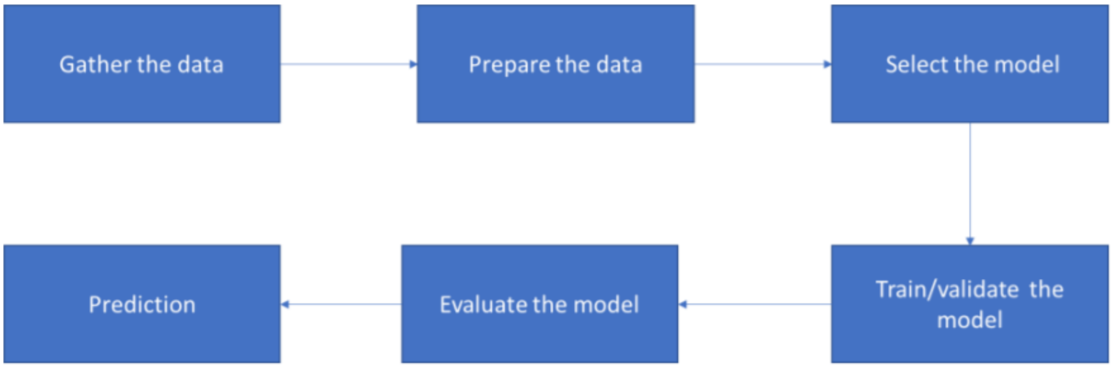
Heatmap:



Models Evaluating:

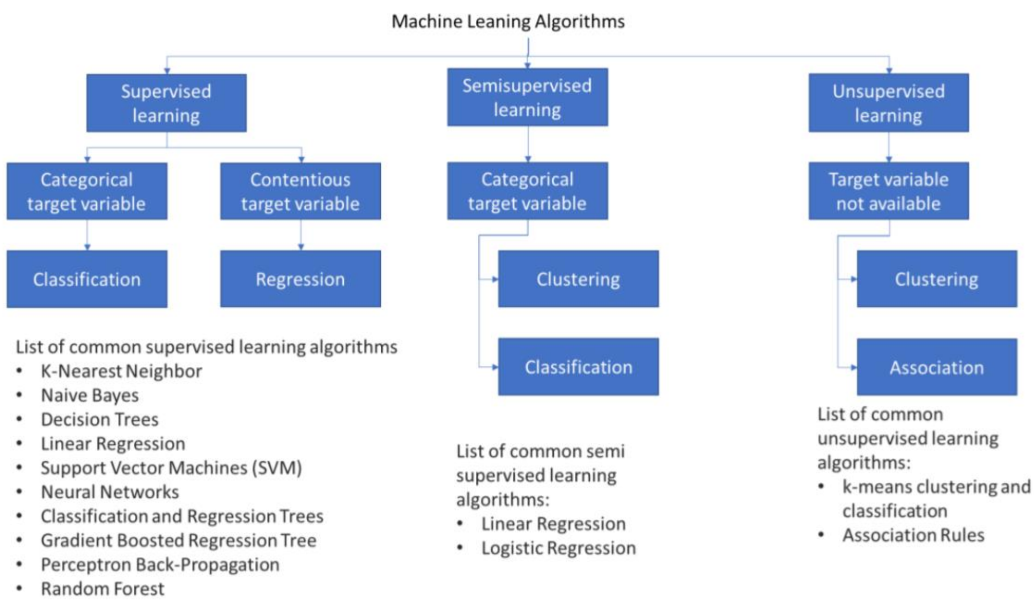




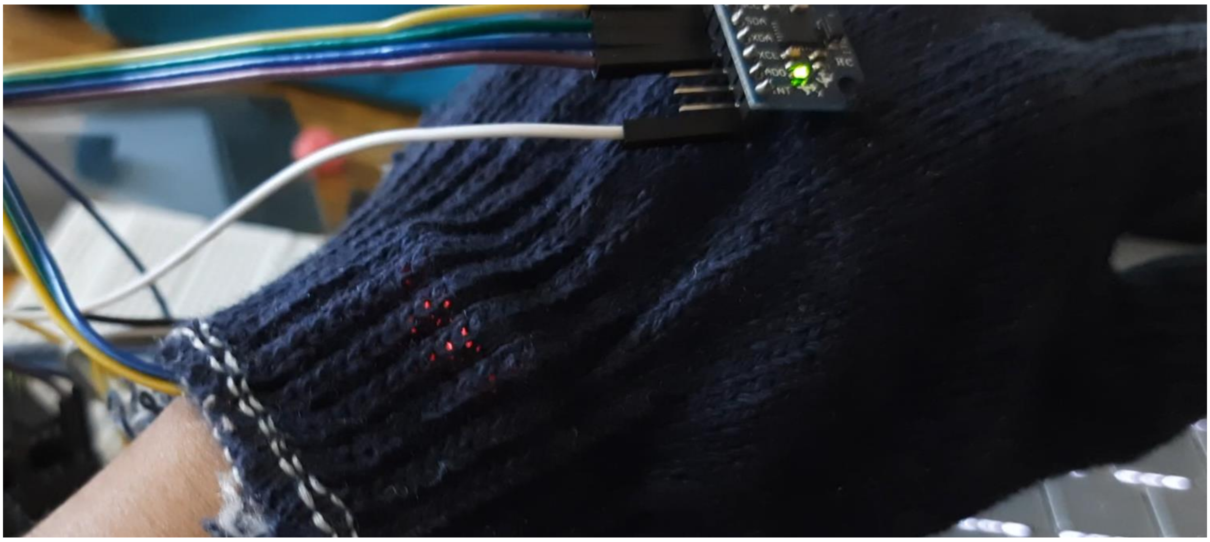


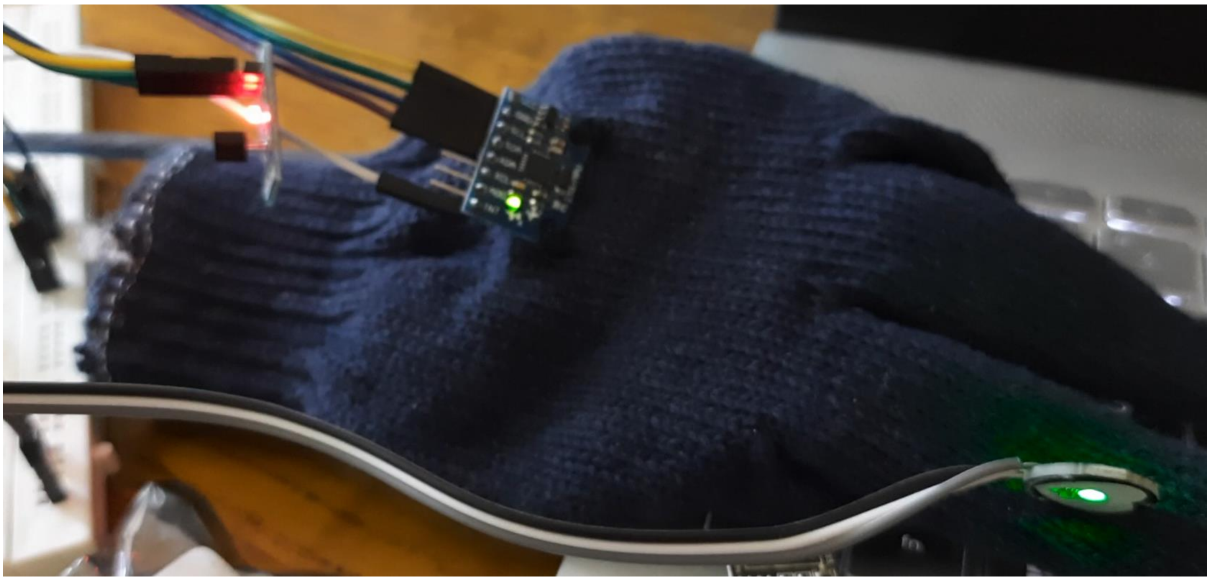
- ➢ Developed model to classify heart disease cases.
- ➢ Made the detailed exploratory analysis.
- ➢ Decided which metric to use.
- ➢ Analysed both target and features in detail.
- ➢ Transformed categorical variables into numeric so we can use them in the model.
- ➢ Used pipeline to avoid data leakage.
- ➢ Looked at the results of each model and selected the best one for the problem on hand.
- ➢ Made hyperparameter tuning of the Catboost with Optuna to see the improvement.
- ➢ Looked at the feature importance.

Algorithms used:

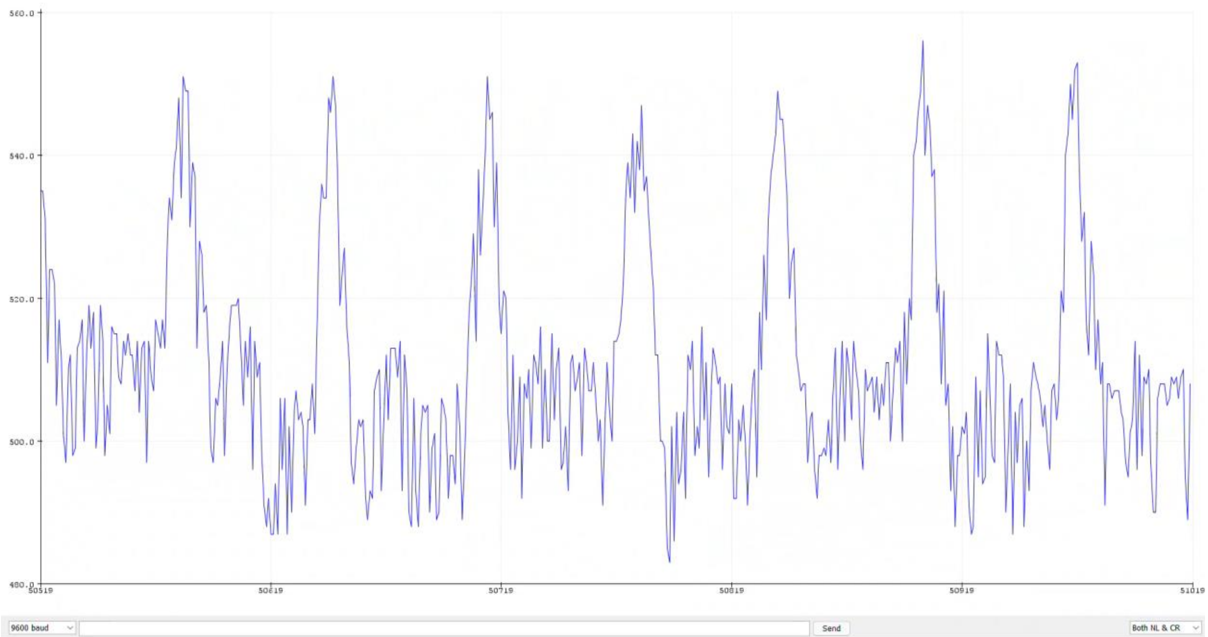


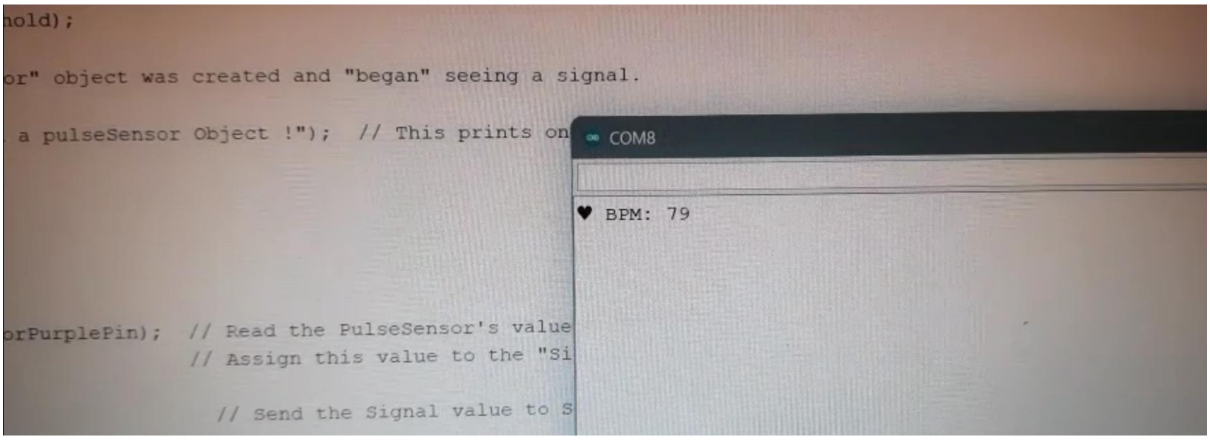
Hardware:





Heart rate sensor output:





Temperature sensor output: