

# **CLASSIFICATION OF ARRHYTHMIA BY USING DEEP LEARNING WITH 2-D ECG SPECTRAL IMAGE REPRESENTATION**

**A PROJECT REPORT**

*Submitted by*

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Title	Project - Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image Representation

## Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image Representation

### 1. INTRODUCTION

#### 1. Project Overview

According to the World Health Organization (WHO), cardiovascular diseases (CVDs) are the number one cause of death today. Over 17.7 million people died from CVDs in the year 2017 all over the world which is about 31% of all deaths, and over 75% of these deaths occur in low and middle-income countries. Arrhythmia is a representative type of CVD that refers to any irregular change from the normal heart rhythms. There are several types of arrhythmia including atrial fibrillation, premature contraction, ventricular fibrillation, and tachycardia. Although a single arrhythmia heartbeat may not have a serious impact on life, continuous arrhythmia beats can result in fatal circumstances. In this project, we build an effective electrocardiogram (ECG) arrhythmia classification method using a convolutional neural network (CNN), in which we classify ECG into seven categories, one being normal and the other six being different types of arrhythmia using deep two-dimensional CNN with grayscale ECG images. We are creating a web application where the user selects the image which is to be classified. The image is fed into the model that is trained and the cited class will be displayed on the webpage.

#### 2. Purpose

Due to its ability to handle large amounts of data, Deep Learning has become an increasingly popular tool over the past few decades. The use of hidden layers has surpassed traditional techniques, especially in pattern recognition. In terms of deep neural networks, Convolutional Algorithms are among the most popular. The convolution to the neural network (CNN/ConvNet)

is a class of deep neural networks most commonly used to analyze visual imagery. ConvNet differs from neural networks in that it doesn't involve matrix multiplications like neural networks do. It uses a special technique called Convolution. Now in mathematics convolution is a mathematical operation on two functions that produces a third function that expresses how the shape of one is modified by the other.

## 2. LITERATURE SURVEY

### 1. Existing problem

The number one cause of death today is cardiovascular diseases (CVDs). Globally, 17.7 million people died of CVDs in 2017 which is about 31% of all deaths, and over 75% of these deaths occur in low- and middle-income countries. Cardiovascular diseases, such as arrhythmia, refer to any deviation from normal heart rhythms.

Tachycardia, atrial fibrillation, premature contraction, and ventricular fibrillation are all types of arrhythmia.

### 2. References

1. <https://github.com/Anshuman151/ECG-Image-Based-Heartbeat-Classification-for-Arrhythmia-Detection-Using-IBM-Watson-Studio/blob/main/README.md>
2. <https://www.analyticsvidhya.com/blog/2021/05/convolutional-neural-networks-cnn/>
3. <https://www.mathworks.com/help/deeplearning/ref/nnet.cnn.layer.convolution2dlayer.html;jsessionid=0a7e3bc26fabda07a5032030294b>

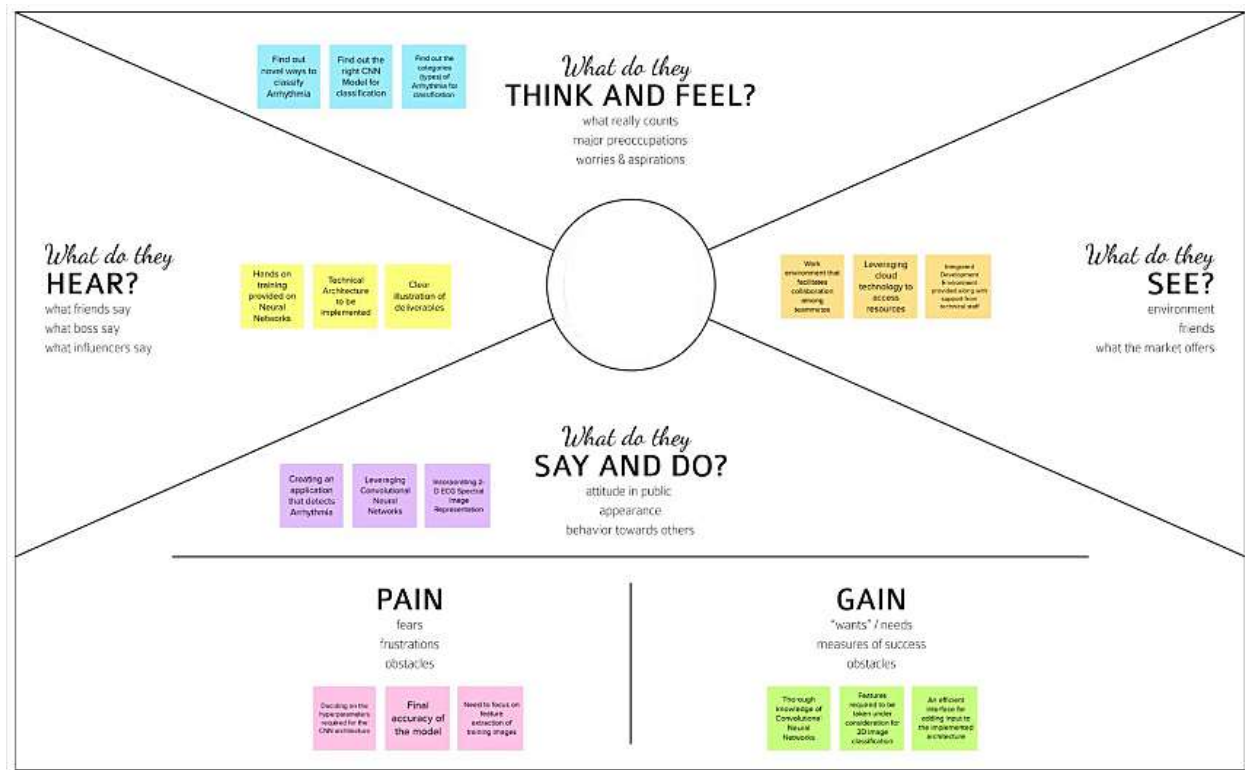
### 3. Problem Statement Definition

An "ambulatory electrocardiogram" or an ECG) about the size of a postcard or digital camera that the patient will be using for 1 to 2 days, or up to 2 weeks. The test measures the movement of electrical signals or waves through the heart. These signals tell the heart to contract (squeeze) and pump blood. The patient will have electrodes taped to your skin. It's painless, although some people have mild skin irritation from the tape used to attach the electrodes to the

chest. They can do everything but shower or bathe while wearing the electrodes. After the test period, patient will go back to see your doctor. They will be downloading the information.


### 3. IDEATION & PROPOSED SOLUTION

#### 1. Empathy Map Canvas



## 2. Ideation & Brainstorming


Template



### Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.


🕒 10 minutes to prepare  
🕒 1 hour to collaborate  
👤 2-8 people recommended



#### Before you collaborate


A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

🕒 10 minutes




##### Team gathering

Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.



##### Set the goal


Think about the problem you'll be focusing on solving in the brainstorming session.



##### Learn how to use the facilitation tools

Use the Facilitation Superpowers to run a happy and productive session.

[Open article](#) ➔




#### Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

🕒 5 minutes


PROBLEM


Classification of Arrhythmias by Using Deep Learning with 2-D ECG Spectral Image Representation





#### Key rules of brainstorming


To run an smooth and productive session


 Stay in topic.

 Encourage wild ideas.

 Defer judgment.

 Listen to others.

 Go for volume.

 If possible, be visual.

2

## Brainstorm

Write down any ideas that come to mind that address your problem statement.

10 minutes

### TIP

You can select a sticky note and hit the pencil (switch to sketch) icon to start drawing

### JEYA SUNDARI

Helps to identify the types of Anytime	It should not have any limited amount of users or data	It should have full protection and security over the competency
People must feel ease to use this model	No age limits of patients for diagnosis	Can give suggestion for patients also for clarity
It should always have two step verification for correct results	It should give the satisfaction of both doctors and patients	What will happen if the results are not accurate?

### JOTHILAKSHMI M

Effective remote communication	It should maintain remote access	It should always have patients care safety
Adjust according to each patient	Delivering more preventive care	Remote access and availability
Must be user convenient	Provides more efficient management for the professionals	Lifetime must be long

### AHASH RAM R L

Safe and Painless	ECG test is cheap in cost	Quick access
Detection of various heart problems	Less time consumption	Doctors need to know about the patients medical history
Measures outcome performance and metrics	Must categorize the diseases according to risk levels	Must do more analysis for effective results

### BUVANESH K K

Detection of irregular heartbeats	Long term monitoring	Checking the environment at the ECG to avoid medical error
Multiple cardiac cycle available during data acquisition	Poor electrodes can give poor results	ECG uses wires and prone for tearing, it may restrict the body movements
Results can be obtained anytime	Cheap in cost and efficient	A life can be saved by early detection of diseases

3

### Group Ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

⌚ 20 minutes

#### TIP

Add customizable tags to sticky notes to make it easier to find, browse, organize, and categorize important ideas as themes within your mural.

#### What went well

TIME

SUGGESTIONS

POSITIVE

SAFETY  
AND  
SECURITY

NO  
LIMITATIONS

#### What didn't go well

NEGATIVES

FEARS

Questionmarks

#### Actions

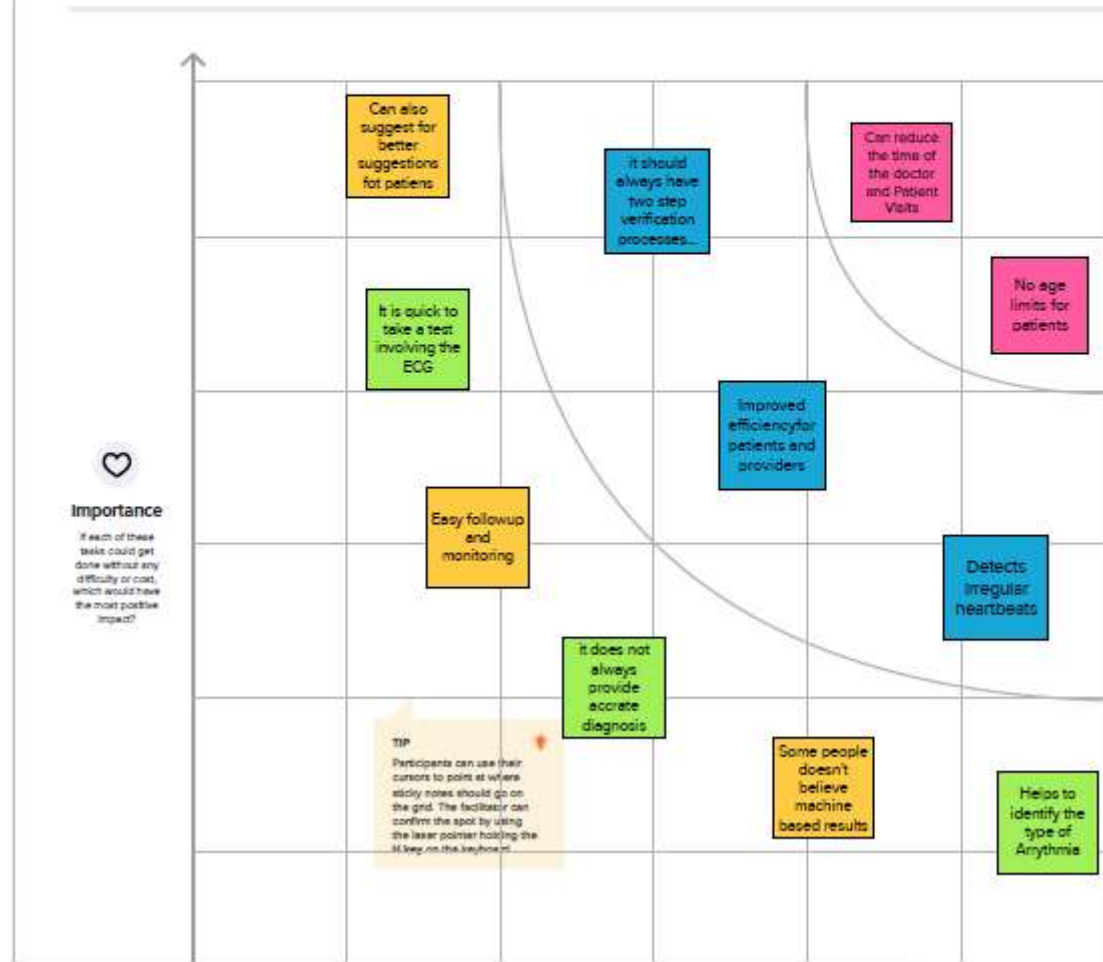
SATISFACTION



## Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

⌚ 20 minutes





### 3. Proposed Solution

S.No.	Parameter	Description
S.No		
1.. 1.	Problem Statement (Problem to be solved)	A Deep Learning Model for analyzing 2-D ECG Spectral Images to classify various types of arrhythmia.
2. 2.	Idea / Solution description	The ECG signals are pre processed by removing electromyographic noise using wavelet-based thresholding. An ECG signal is then transformed into a 2-D representation using a 2D CNN model. Various architectures are analyzed in order to implement an efficient CNN model. This CNN model is intended to classify different types of Arrhythmias.
3. 3.	Novelty / Uniqueness	Our goal is to create an API that will be capable of handling inputs and producing the appropriate Arrhythmia class. Using this API, you will be able to simulate a seamless user experience that is interactive.
4. 4.	Social Impact / Customer Satisfaction	Senior citizens represent the largest stakeholder group in this project. Customer's can benefit greatly from early diagnosis of heart ailments by learning about irregularities in ECG signals.
5. 5.	Business Model (Revenue Model)	The market does not contain any applications that detect arrhythmia. The integration of our novel product with a smart wearable device will enable us to launch a new line of smart devices that track one's health.
6.6.	Scalability of the Solution	We can make our idea a reality by pitching it to Angel Investors and Venture Capitalists and launching a full-fledged startup to market it.

## 4. Problem Solution fit

Define CS, fit into CC	1. CUSTOMER SEGMENT(S)	6. CUSTOMER CONSTRAINTS	5. AVAILABLE SOLUTIONS	Explore AS, differentiate
	<p>Who is your customer? i.e. working parents of 0-5 y.o. kids</p> <p>People who are diagnosed with heart ailments or people who at risk of developing heart complications. Average age of target customers is above fifty</p>	<p>What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.</p> <p>Lack of awareness about checking for heart ailments due to Arrhythmia (irregular heart beats). Quite often, people think that it is not required to invest in an application that they think is unimportant to have.</p>	<p>Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros &amp; cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking</p> <p>The existing norm followed by people is get themselves diagnosed only after an accident occurs (such as a heart attack). Our idea goes by the saying 'prevention is better than cure'. By detecting the presence of heart ailments at the early stages, customers can benefit greatly by taking preventing measures.</p>	
Focus on J&P, tap into BE, understand RC	2. JOBS-TO-BE-DONE / PROBLEMS	9. PROBLEM ROOT CAUSE	7. BEHAVIOUR	Focus on J&P, tap into BE, understand RC
	<p>Which jobs to-be-done (or problems) do you address for your customers? There could be more than one, explore different sides.</p> <p>The major problem faced by people diagnosed with Arrhythmia related issues is the lack of awareness. Almost everyone is unaware of the fact that one can detect the type of heart ailment that the particular individual can be affected of, by analyzing the ECG patterns of heart beats. A simple software hardware solution that addresses this issue can be a lifesaver for many.</p>	<p>What is the real reason that this problem exists? What is the back story behind the need to do this job? i.e. customers have to do it because of the change in regulations.</p> <p>Negligence in taking care of health is the major reason for heart related risks. Also, the lack of an easy to use product that diagnoses the heart ailment makes it further complicated for people to get themselves diagnosed. The only solution that currently exists is going to hospitals once they get into an accident. The void present in this context promoted us to work on this particular product, and the goal is to make it easy to use so that everyone can benefit.</p>	<p>What does your customer do to address the problem and get the job done? (i.e. directly related, find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)</p> <p>At present, the only solution that exists is to go to a hospital, more preferably - a multi-specialty clinic and consult with a cardiologist and get themselves diagnosed. While visiting hospitals is absolutely necessary in this context, the lack of a tool that detects such ailments in advance might turn out to be quite problematic to people.</p>	
Identify strong TR & EM	3. TRIGGERS	10. YOUR SOLUTION	8. CHANNELS of BEHAVIOUR	Identify strong TR & EM
	<p>What triggers customers to act? i.e. seeing their neighbour install solar panels, reading about a more efficient solution in the news</p> <p>The need to prevent any heart related untoward incident that causes loss of life</p>	<p>If you are working on an existing business, write down your current solution that <u>exists</u> in the canvas, and check how much it <u>fits</u> reality.</p> <p>If you are working on a new business proposition, then keep it blank until you <u>fill</u> the canvas and come up with a solution that <u>fits</u> within customer limitations, solves a problem and matches customer <u>expectations</u>.</p> <p>Develop an easy-to-use application that efficiently classifies and indicates the type of heart ailment (heart attack, myocardial infarction etc.) based on analyzing 2D spectral images of Arrhythmia. The application should indicate the type of risk, and at the same time it should indicate the preventive measures that need to be followed in order to keep Fear of health deterioration -&gt; Confidence to keep themselves healthy oneself healthy.</p>	<p>What kind of actions do customers take online? Extract online channels from #7</p> <p>Customers do basic googling to know about heart ailments in general. But there is no efficient online tool that studies Arrhythmia and gives out the heart ailment.</p> <p>What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.</p> <p>Customers visit hospitals and go for general check-ups</p>	
	4. EMOTIONS: BEFORE / AFTER			
	<p>How do customers feel when they face a problem or a job and afterwards? i.e. lost, insecure -&gt; confident, in control - use it in your communication strategy &amp; design.</p> <p>Fear of health deterioration -&gt; Confidence to keep themselves healthy</p>			

#### 4. REQUIREMENT ANALYSIS

##### 1. Functional requirement

FR No.	Functional Requirement(Epic)	Sub Requirement (Story/ Sub-Task)
FR-1	User Registration	Registration through FormRegistration via Gmail
FR-2	User Confirmation	Confirmation via e-mailConfirmation via OTP
FR-3	User selection	select the ECG image to be classified
FR-4	User input	Images need to be uploaded
FR-5	Save image	Images are saved in a folder for future reference
FR-6	Predict ECG image	User ECG images in our web application Collectionof data setsDatabase read ECGimages

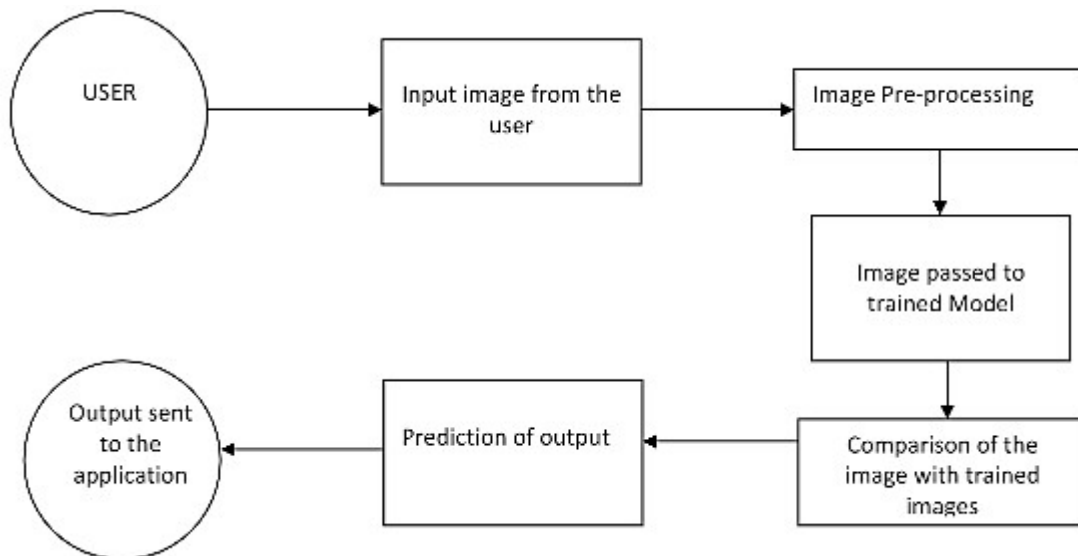
##### 2. Non-Functional requirements

FR No.	Non-Functional Requirement	Description
NFR-1	<b>Usability</b>	An user friendly and simple UI Webapplication . Easy drag and drop options
NFR-2	<b>Security</b>	No third party web and UI is used for prediction of data Details about user interaction with the web application areprotected

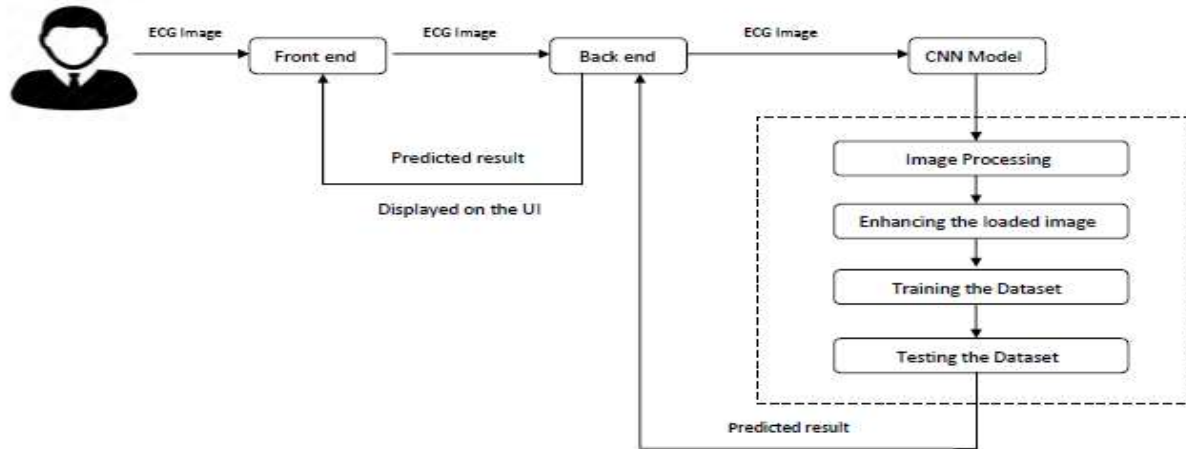
NFR-3	<b>Reliability</b>	Higher accuracy rate Defect free
NFR-4	<b>Performance</b>	Fast and quick classification of the required class is done
NFR-5	<b>Availability</b>	Availability describes how likely the system is accessible to a user at a given point in time and the periodically for a solutions.
NFR-6	<b>Scalability</b>	The ability of the user problem in arrhythmia disease to handle an increase in workload without performance degradation

## 5. PROJECT DESIGN

### Data Flow Diagrams



## 2. Solution & Technical Architecture



### 3. User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Patient/Doctor (Web User)	Web interface	USN-1	As a user, I can access the web interface	I can login to my account	High	Sprint-1
Patient/Doctor (Web User)	Dashboard	USN-2	As a user, I can access the dashboard/homepage	I can view the homepage	High	Sprint-1
Patient/Doctor (Web User)	Types of Arrhythmia	USN-3	As a user, I can view various articles about different kinds of Arrhythmia	I can view the articles	Low	Sprint-1
Patient/Doctor (Web User)	Page Navigation	USN-4	As a user, I can access several tabs and pages on the interface	I can view different pages and navigate	Medium	Sprint-2
Patient/Doctor (Web User)	Info and About Page	USN-5	As a user, I can see the info and about page for the web interface	I can view the info and about page	Medium	Sprint-2
Patient/Doctor (Web User)	Page to send input	USN-6	As a user, I can see an option to upload input image of ECG	I can view the input page	High	Sprint-3
Patient/Doctor (Web User)	Prediction result page	USN-7	As a user, I can see the predicted result for the given ECG image	I can view the prediction	High	Sprint-3
Patient/Doctor (Web User)	Type of Arrhythmia	USN-8	As a user, I can see the type of Arrhythmia	I can view the type of Arrhythmia page	High	Sprint-3
Patient/Doctor (Web User)	Side-effects page	USN-9	As a user, I can see the various side effects of the predicted Arrhythmia	I can view the side effects page	Low	Sprint-4
Patient/Doctor (Web User)	Prediction history page	USN-10	As a user, I can see the various predictions done in the past	I can view the prediction history page	Medium	Sprint-4
Patient/Doctor (Web User)	Type of CVD page	USN-11	As a user, I can see the predicted type of CVD based on predicted arrhythmia	I can view the type of CVD page	High	Sprint-4
Administrator	Performance metrics	USN-12	As an administrator, I can see the number of people who are using the developed interface	I can view the performance metrics	Medium	Sprint-4

## 6. PROJECT PLANNING & SCHEDULING

### 1. Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Dataset Collection	USN-1	Collect the dataset for classification from sources available on the internet.	10	High	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-1	Image Preprocessing	USN-2	Remove noise present in the images collected and perform data pre-processing	10	High	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-2	Build the CNN Model	USN-3	Identify the appropriate layers required for the model and determine the model parameters	2	High	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-2	Configure the model	USN-4	Perform model configuration by compiling it and implement techniques for loss reduction	5	Medium	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-2	Train, test and validate	USN-5	Initiate model training phase, later based on modeland validation loss values, start test phase	13	High	Jeya Sundari Jothilakshmi M

Sprint-3	Register for IBM Cloud	USN-6	Set up IBM Watson Assistant with Cloud Service	2	High	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-3	Develop the web interface using Flask	USN-7	Design a UI for the web interface, with login, registration and input adding features	5	High	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K
Sprint-3	Perform server-side scripting	USN-8	Develop an application using python for back-end functions	13	Medium	Jeya Sundari Jothilakshmi M Ahash Ram R L Buvanesh K K

## 2. Sprint Delivery Plan

2.	Ideation Phase	Literature Survey	29 Aug 2022 - 03 Sept 2022
		Empathy Map	05 Sept 2022 - 7 Sept 2022
		Problem Statement	08 Sept 2022 - 10 Sept 2022
		Ideation	12 Sept 2022 - 16 Sept 2022
3.	Project Design Phase -I	Proposed Solution	19 Sept 2022 - 23 Sept 2022
		Problem Solution Fit	24 Sept 2022 - 26 Sept 2022
		Solution Architecture	27 Sept 2022 - 30 Sept 2022
4.	Project Design Phase -II	Customer Journey	03 Oct 2022 - 08 Oct 2022
		Requirement Analysis	09 Oct 2022 - 11 Oct 2022
		Data Flow Diagrams	11 Oct 2022 - 14 Oct 2022
		Technology Architecture	15 Oct 2022 - 16 Oct 2022
5.	Project Planning Phase	Milestones & Tasks	17 Oct 2022 - 18 Oct 2022
		Sprint Schedules	19 Oct 2022 - 22 Oct 2022
6.	Project Development Phase	Sprint-1	24 Oct 2022 - 28 Oct 2022
		Sprint-2	30 Oct 2022 - 04 Nov 2022
		Sprint-3	06 Nov 2022 - 11 Nov 2022
		Sprint-4	13 Nov 2022 - 18 Nov 2022
	Sprint-1	<ul style="list-style-type: none"> <li>Download The Dataset</li> <li>Import Image-DataGenerator Library</li> <li>Configure Image-DataGenerator class</li> </ul>	24 Oct 2022 – 28 Oct 2022
	Sprint – 2	<ul style="list-style-type: none"> <li>Configure The LearningProcess</li> <li>Build Python code</li> <li>Adding Dense Layer</li> <li>Adding CNN layer</li> </ul>	30 Oct 2022 – 04 Nov 2022
	Sprint – 3	<ul style="list-style-type: none"> <li>Register IBM Cloud</li> <li>Develop the web interface using Flask</li> <li>Perform server-sidescripting</li> </ul>	06 Nov 2022 –11 Nov 2022
	Sprint – 4	<ul style="list-style-type: none"> <li>Train the model on IBM</li> <li>Create Html files</li> <li>Integrate CNN Modelwith Web interface</li> <li>Deployment and Testing</li> </ul>	13 Nov 2022 –18 Nov 2022

## 7. CODING & SOLUTIONING (Explain the features added in the project along with code)

### ROUTING FOR HTML PAGES

```
import os
import numpy as np
from flask import Flask, request, render_template, send_from_directory, make_response
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image

app = Flask(__name__, template_folder='template') #initializing a flask app
model=load_model('ECG.h5')

@app.route("/")
@app.route("/index.html")

def home():
    return render_template("index.html")
@app.route("/info.html")
def info():
    return render_template("info.html")
@app.route("/predict.html", methods=['GET', 'POST'])
def upload():
    if request.method=="POST":
        f=request.files['file']
        basepath=os.path.dirname('__file__')
        filepath=os.path.join(basepath,"uploads",f.filename)
        f.save(filepath)
        img=load_img(filepath,target_size=(64,64))
```



```

x=img_to_array(img)
x=np.expand_dims(x,axis=0)
pred=model.predict_classes(x)
print("prediction",pred)
index=['Left Bundle Branch Block','Normal','Premature Atrial Contraction','Premature
Ventricular Contraction','Right Bundle Branch Block','Ventricular Fibrillation']
result=str(index[pred[0]])
return result
return render_template("predict.html")

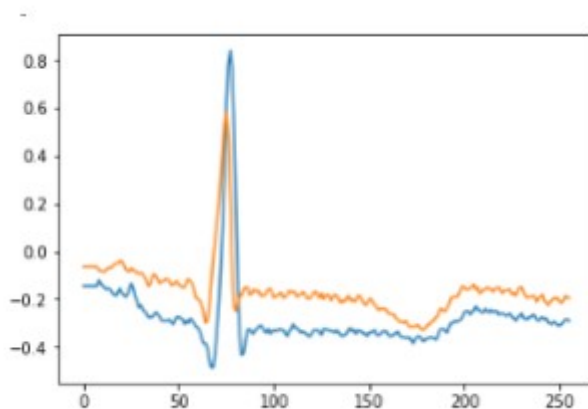
def favicon():
    return send_from_directory(os.path.join(app.root_path, 'static'),
                              'favicon.ico', mimetype='image/vnd.microsoft.icon')

if __name__ == "__main__":
    app.run(debug=True)

```

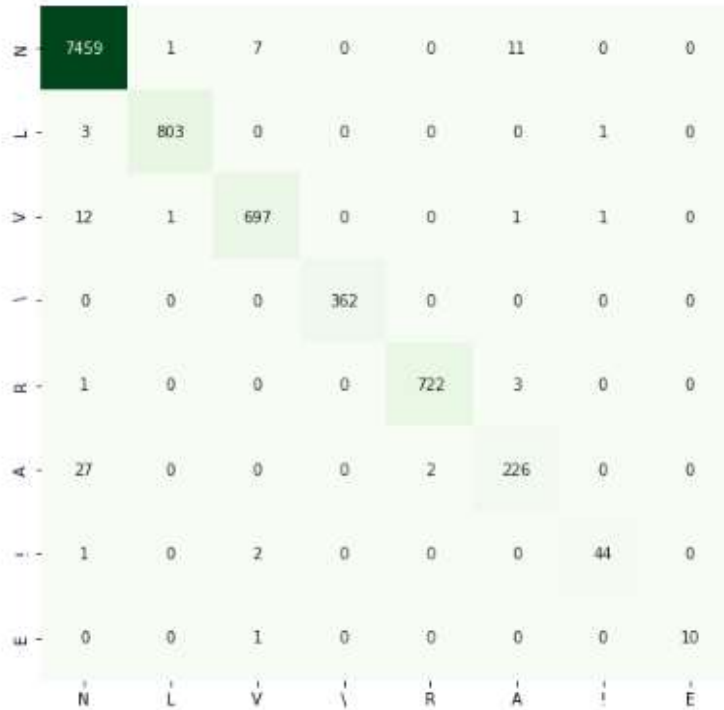
## 8. RESULTS

### ACCURACY OF THE TRAINED MODEL



## 1. Confusion Matrix:

```
In [22]: ax = sns.heatmap(confusion_matrix(gt, preds), annot=True, cmap="Greens", fmt='g',
                        xticklabels=mapping.keys(), yticklabels=mapping.keys(), cbar=False, square=False)
```



## 9. ADVANTAGES

1. The proposed model predicts Arrhythmia in images with a high accuracy rate of nearly 86%
2. The early detection of Arrhythmia gives better understanding of disease causes, initiates therapeutic interventions and enables developing appropriate treatments.

## DISADVANTAGES

1. Not useful for identifying the different stages of Arrhythmia disease.
2. Not useful in monitoring motor symptoms

## 10. CONCLUSION

1. Cardiovascular disease is a major health problem in today's world. The early diagnosis of cardiac arrhythmia highly relies on the ECG.

2. Unfortunately, the expert level of medical resources is rare, visually identify the ECG signal is challenging and time-consuming.
3. The advantages of the proposed CNN network have been put to evidence.
4. It is endowed with an ability to effectively process the non-filtered dataset with its potential anti-noise features. Besides that, ten-fold cross-validation is implemented in this work to further demonstrate the robustness of the network.

## 11. FUTURE SCOPE

For future work, it would be interesting to explore the use of optimization techniques to find a feasible design and solution. The limitation of our study is that we have yet to apply any optimization techniques to optimize the model parameters and we believe that with the implementation of the optimization, it will be able to further elevate the performance of the proposed solution to the next level.

## 12. APPENDIX

Source Code

### MODEL BUILDING:

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

```
train_datagen = ImageDataGenerator(rescale = 1./255, horizontal_flip = True, vertical_flip  
= True, zoom_range = 0.2)
```

```
test_datagen = ImageDataGenerator(rescale = 1./255)
```

```
x_train = train_datagen.flow_from_directory("C:/Users/Admin/Desktop/data/train", target_size  
= (64,64), batch_size = 100, class_mode = "categorical")
```

```
x_test = test_datagen.flow_from_directory("C:/Users/Admin/Desktop/data/test", target_size =  
(64,64), batch_size = 100, class_mode = "categorical")
```

```
x_train.class_indices
```

```
from tensorflow.keras.models import Sequential
```

```
from tensorflow.keras.layers import Convolution2D
```

```
from tensorflow.keras.layers import MaxPooling2D
```

```
from tensorflow.keras.layers import Flatten
```

```
from tensorflow.keras.layers import Dense
```

```
Initializing the Model
```

```
model = Sequential()
```

```
model.add(Convolution2D(32, (3,3), input_shape = (64,64,3), activation = "relu"))
```

```
model.add(MaxPooling2D(pool_size = (2,2)))
```

```
model.add(Convolution2D(32, (3,3), activation = "relu"))
```

```
model.add(MaxPooling2D(pool_size = (2,2)))
```

```
model.add(Flatten())
```

```
model.add(Dense(units=128, kernel_initializer='random_uniform', activation="relu"))
```

```
model.add(Dense(units=128, kernel_initializer='random_uniform', activation="relu"))
```

```
model.add(Dense(units=128, kernel_initializer='random_uniform', activation="relu"))
```

```
model.add(Dense(units=128, kernel_initializer='random_uniform', activation="relu"))
```

```
model.add(Dense(units=128, kernel_initializer='random_uniform', activation="relu"))
```

```

model.add(Dense(units=6, kernel_initializer='random_uniform', activation="softmax"))

model.summary()

model.compile(optimizer = "Adam", loss = "categorical_crossentropy", metrics = ["accuracy"])

model.fit(x_train, steps_per_epoch = len(x_train), epochs=9, validation_data=x_test,\
        validation_steps = len(x_test))

model.save('ECG.h5')

from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image

model = load_model("ECG.h5")
img = image.load_img("C:/Users/Admin/Desktop/data/prediction/fig_2114-n.png", target_size =
(64,64))

x = image.img_to_array(img)

import numpy as np

x = np.expand_dims(x,axis = 0)

pred = model.predict(x)
y_pred=np.argmax(pred)
y_pred
index=['Left Bundle Branch Block',
      'Normal',
      'Premature Atrial Contraction',
      'Premature Ventricular Contractions',
      'Right Bundle Branch Block',
      'Ventricular Fibrillation']

```

```
result = str(index[y_pred])
```

```
result
```

## TRAINING THE MODEL ON IBM:

```
In [29]: !tar -zcvf ECG-arrhythmia-classification-model_new.tgz ECG.h5
```

```
ECG.h5
```

```
In [30]: ls -l  
  
data/  
ECG-arrhythmia-classification-model_new.tgz  
ECG.h5
```

```
In [31]: !pip install watson-machine-learning-client --upgrade
```

```
Collecting watson-machine-learning-client  
  Downloading watson_machine_learning_client-1.0.391-py3-none-any.whl (538 kB)
```

```
In [33]: from ibm_watson_machine_learning import APIClient  
wml_credentials={  
    "url": "https://us-south.ml.cloud.ibm.com",  
    "apikey": "XKr8dWsa1JPjnDh8Xf5E--Uv3Ef_vdN2deYyEdj2rEth"  
}  
client=APIClient(wml_credentials)
```

```
In [34]: client=APIClient(wml_credentials)
```

```
In [36]: def guid_from_space_name(client, space_name):  
    space = client_spaces.get_details()  
    return(next(item for item in space['resources'] if item['entity']['name'] == space_name)['metadata']['id'])
```

```
In [37]: client.spaces.list()
```

```
Note: 'limit' is not provided. Only first 50 records will be displayed if the number of records exceed 50
```

ID	NAME	CREATED
1a6dcfa8-a632-4da1-b2e3-1e28f2cc97a3	Classification	2022-11-15T13:02:02.173Z

```
In [38]: space_uid='1a6dcfa8-a632-4da1-b2e3-1e28f2cc97a3'
```

```
In [39]: client.set.default_space(space_uid)
```

```
Out[39]: 'SUCCESS'
```

```
In [40]: client.software_specifications.list()
```

```
In [43]: model_id
```

```
Out[43]: '0f611e10-dcf0-4a70-b8c8-6c5269bde33c'
```

```
In [44]: client.repository.download(model_id, 'my_model.tar.gz')
```

```
Successfully saved model content to file: 'my_model.tar.gz'
```

```
Out[44]: '/home/wsuser/work/my_model.tar.gz'
```

## HTML CODES:

INDEX.HTML:

```
<!DOCTYPE html>
```

```
<html lang="en">
```

```
<head>
```

```
  <meta charset="UTF-8">
```

```
  <title>Home</title>
```

```
  <link rel="stylesheet" href="index.css">
```

```
  <link rel="preconnect" href="https://fonts.googleapis.com">
```

```
<link rel="preconnect" href="https://fonts.gstatic.com" cross origin>
```

```
<link
```

```
href="https://fonts.googleapis.com/css2?family=Dancing+Script&family=Edu+NSW+ACT+Foundation:wght@500&display=swap" rel="stylesheet">
```

```
  <script src="predict.js"></script>
```

```
  <link rel="shortcut icon" href="favicon.ico">
```

```
<style>
```

```
a{
```

```
  text-decoration: None;
```

```
}
```

```
body{
```

```
background-image:
url('https://images.hindustantimes.com/img/2022/06/30/550x309/6b242762-f891-11ec-8608-
e101559032f3_1656606499620.jpg');
background-repeat: no-repeat;
background-size: 1560px 800px;
}
a:visited{
color: black;
}
.nav-div{
margin: 0;
background: #ffffff;
border-radius: 5px;

}
nav{
display: flex;
justify-content: flex-end;
}

.active{
color: blue;
}

.nav-tab{
margin-top: 15px;
margin-bottom: 15px;
margin-left: 20px;
cursor: pointer;
}
.nav-tab-last{
```



```
    margin-right: 50px;
}
```

```
.home-heading{
    display: flex;
    color: #000000;
    margin: 0;
    justify-content: center;
    font-family: 'Gabriola', sans-serif;
}
```

```
.home-content-para{
    display: flex;
    color: white;
    margin: 0;
    align-items: center;
    font-family: 'Gabriola', sans-serif;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 26px;
}
```

```
.home-content{
    margin: 50px;
    background-color: rgb(79, 78, 78);
    border: 1px solid black;
    border-radius: 16px;
    opacity: 93%;
}
```

```
.predict-content{
    display: flex;
```

```
    color: white;
    margin-left: 500px;
    margin-right: 500px;
    border-radius: 16px;
    opacity: 70%;
    justify-content: center;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 20px;
    background: #595858;
}
.btn {
    border: none;
    color: black;
    padding: 15px 32px;
    text-align: center;
    text-decoration: none;
    display: inline-block;
    font-size: 16px;
    cursor: pointer;
    margin: 20px;
    border-radius: 16px;
}
.btn-choose {
    background-color: white;
}
.btn-predict{
    color: white;
    background-color: palevioletred;
}
```

```
.info-content{  
    margin : 30px;  
    padding: 10px;  
    background-color: rgb(66, 66, 66);  
    opacity: 0.8;  
    display: flex;  
    border-radius: 16px;  
}
```

```
.content,.image{  
    flex: 50%;  
    margin: 30px;  
}
```

```
.image{  
    display: flex;  
    flex-direction: row;  
    justify-content: space-around;  
    align-items: center;  
    padding: 30px;  
}
```

```
.info-content-heading{  
    color: #ffffff;  
    font-family: 'Gabriola', sans-serif;  
    padding-left: 100px;  
    padding-right: 100px;  
    text-align: center;  
    font-size: 30px;  
    margin: 0 0 20px;
```

```

}
.info-content-para{
    color: #ffffff;
    font-family: 'Gabriola', sans-serif;
    padding-left: 100px;
    padding-right: 100px;
    text-align: justify;
    font-size: 26px;
}
.info-content-picture{
    margin:0;
}
</style>
</head>
<body>
<div class="bg_image_body"></div>
<div class="nav-div">
    <nav class="index-nav">
        <a class="active nav-tab">Home</a>
        <a class="nav-tab" href="info.html">Info</a>
        <a class="nav-tab nav-tab-last" href="predict.html">Predict</a>
    </nav>
</div>
<div class="home-heading">
    <h1>ECG arrhythmia classification using CNN</h1>
</div>
<div class="home-content">
    <div class="home-content-para">
        <p>

```

According to the World Health Organization (WHO), cardiovascular diseases (CVDs) are the number one cause of death today. Over 17.7 million people died from CVDs in the year

2017 all over the world which is about 31% of all deaths, and over 75% of these deaths occur in low and middle-income countries. Arrhythmia is a representative type of CVD that refers to any irregular change from the normal heart rhythms. There are several types of arrhythmia including atrial fibrillation, premature contraction, ventricular fibrillation, and tachycardia. Although a single arrhythmia heartbeat may not have a serious impact on life, continuous arrhythmia beats can result in fatal circumstances. In this project, we build an effective electrocardiogram (ECG) arrhythmia classification method using a convolutional neural network (CNN), in which we classify ECG into seven categories, one being normal and the other six being different types of arrhythmia using deep two-dimensional CNN with grayscale ECG images. We are creating a web application where the user selects the image which is to be classified. The image is fed into the model that is trained and the cited class will be displayed on the webpage.

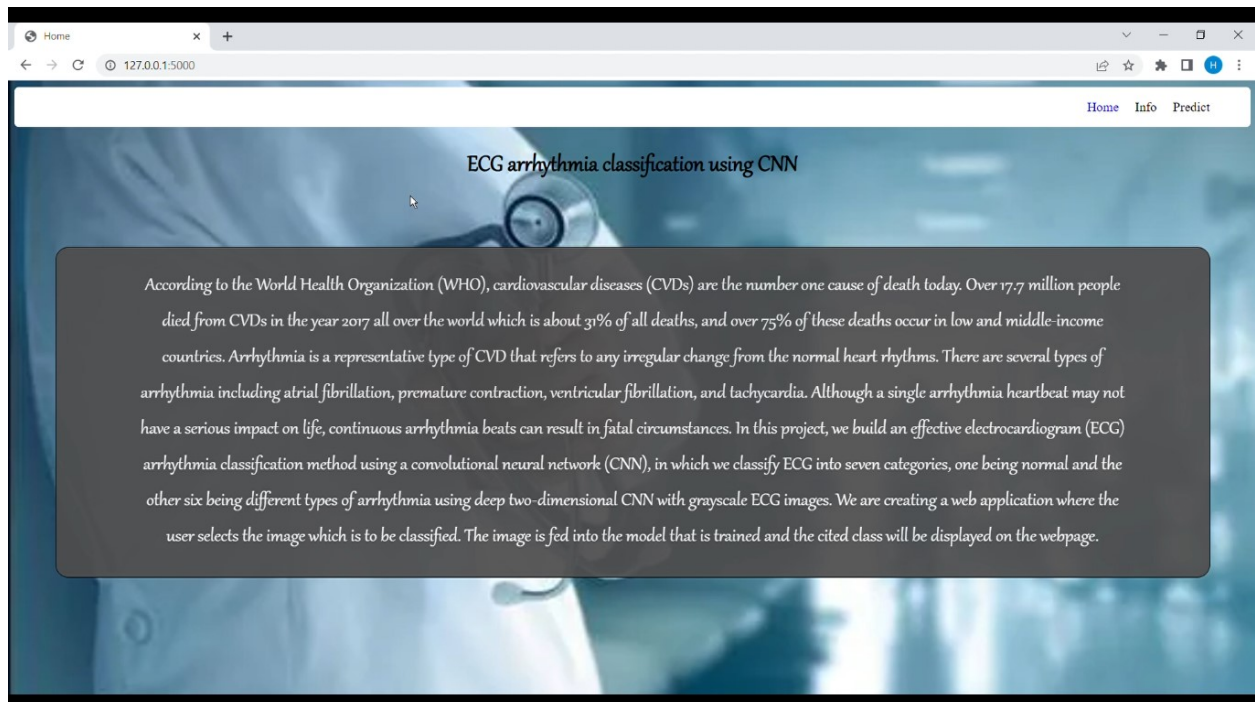
</p>

</div>

</div>

</body>

</html>



INFO.HTML:

```
<!DOCTYPE html>
```

```
<html lang="en">
```

```
<head>
```

```
    <meta charset="UTF-8">
```

```
    <title>Info</title>
```

```
    <link rel="stylesheet" href="index.css">
```

```
<style>
```

```
a{
```

```
    text-decoration: None;
```

```
}
```

```
body{
```

```
    background-image:
```

```
url('https://images.hindustantimes.com/img/2022/06/30/550x309/6b242762-f891-11ec-8608-  
e101559032f3_1656606499620.jpg');
```

```
    background-repeat: no-repeat;
```

```
    background-size: 1560px 2800px;
```

```
}
```

```
a:visited{
```

```
    color: black;
```

```
}
```

```
.nav-div{
```

```
    margin: 0;
```

```
    background: #ffffff;
```

```
    border-radius: 5px;
```

```
}
```

```
nav{
```

```
    display: flex;
```

```
    justify-content: flex-end;
```

```
}
```

```
.active{  
  color: blue;  
}
```

```
.nav-tab{  
  margin-top: 15px;  
  margin-bottom: 15px;  
  margin-left: 20px;  
  cursor: pointer;  
}
```

```
.nav-tab-last{  
  margin-right: 50px;  
}
```

```
.home-heading{  
  display: flex;  
  color: #000000;  
  margin: 0;  
  justify-content: center;  
  font-family: 'Gabriola', sans-serif;  
}
```

```
.home-content-para{  
  display: flex;  
  color: white;  
  margin: 0;  
  align-items: center;  
  font-family: 'Gabriola', sans-serif;  
  padding-left: 100px;  
  padding-right: 100px;
```

```
    text-align: center;
    font-size: 26px;
}
.home-content{
    margin: 50px;
    background-color: rgb(79, 78, 78);
    border: 1px solid black;
    border-radius: 16px;
    opacity: 93%;
}
.predict-content{
    display: flex;
    color: white;
    margin-left: 500px;
    margin-right: 500px;
    border-radius: 16px;
    opacity: 70%;
    justify-content: center;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 20px;
    background: #595858;
}
.btn {
    border: none;
    color: black;
    padding: 15px 32px;
    text-align: center;
    text-decoration: none;
    display: inline-block;
```



```
font-size: 16px;
cursor: pointer;
margin: 20px;
border-radius: 16px;
}
.btn-choose {
background-color: white;
}
.btn-predict{
color: white;
background-color: palevioletred;
}
.info-content{
margin : 30px;
padding: 10px;
background-color: rgb(66, 66, 66);
opacity: 0.8;
display: flex;
border-radius: 16px;
}

.content,.image{
flex: 50%;
margin: 30px;
}

.image{
display: flex;
flex-direction: row;
justify-content: space-around;
```

```
    align-items: center;
    padding: 30px;
}

.info-content-heading{
    color: #ffffff;
    font-family: 'Gabriola', sans-serif;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 30px;
    margin: 0 0 20px;
}

.info-content-para{
    color: #ffffff;
    font-family: 'Gabriola', sans-serif;
    padding-left: 100px;
    padding-right: 100px;
    text-align: justify;
    font-size: 26px;
}

.info-content-picture{
    margin:0;
}

</style>

</head>
<body>
<div class="nav-div">
```

```
<nav class="index-nav">
```

```
<a class="nav-tab" href="index.html">Home</a>
```

```
<a class="active nav-tab">Info</a>
```

```
<a class="nav-tab nav-tab-last" href="predict.html">Predict</a>
```

```
</nav>
```

```
</div>
```

```
<div class="info-content">
```

```
<div class="content">
```

```
<h2><p class="info-content-heading">Normal</p></h2>
```

```
<p class="info-content-para">
```

A normal ECG is illustrated here. Note that the heart is beating in a regular sinus rhythm between 60 - 100 beats per minute (specifically 82 bpm)

```
</p>
```

```
</div>
```

```
<div class="image info-content-picture">
```

```

```

```
</div>
```

```
</div>
```

```
<div class="info-content">
```

```
<div class="content">
```

```
<h2><p class="info-content-heading">Left Bundle Branch Block</p></h2>
```

```
<p class="info-content-para">
```

Left bundle branch block is a conduction abnormality in the heart that can be seen on an electrocardiogram (ECG). In this condition, activation of the left ventricle of the heart is delayed, which causes the left ventricle to contract later than the right ventricle.

```
</p>
```

</div>

<div class="image info-content-picture">



</div>

</div>

<div class="info-content">

<div class="content">

<h2><p class="info-content-heading">Premature Atrial Contraction</p></h2>

<p class="info-content-para">

Premature atrial contractions are extra heartbeats that begin in one of your heart's two upper chambers (atria). These extra beats disrupt your regular heart rhythm.

</p>

</div>

<div class="image info-content-picture">



</div>

</div>

<div class="info-content">

<div class="content">

<h2><p class="info-content-heading">Premature Ventricular Contractions</p></h2>

<p class="info-content-para">

Premature ventricular contractions (PVCs) are extra heartbeats that begin in one of the heart's two lower pumping chambers (ventricles). These extra beats disrupt the regular heart rhythm, sometimes causing a sensation of a fluttering or a skipped beat in the chest.

</p>

</div>

<div class="image info-content-picture">



</div>

</div>

<div class="info-content">

<div class="content">

<h2><p class="info-content-heading">Right Bundle Branch Block</p></h2>

<p class="info-content-para">

A right bundle branch block (RBBB) is a heart block in the right bundle branch of the electrical conduction system. During a right bundle branch block, the right ventricle is not directly activated by impulses travelling through the right bundle branch. The left ventricle, however, is still normally activated by the left bundle branch.

</p>

</div>

<div class="image info-content-picture">



</div>

</div>

<div class="info-content">

<div class="content">

<h2><p class="info-content-heading">Ventricular Fibrillation</p></h2>

<p class="info-content-para">

Ventricular fibrillation is a type of abnormal heart rhythm (arrhythmia). During ventricular fibrillation, disorganized heart signals cause the lower heart chambers (ventricles) to twitch (quiver) uselessly. As a result, the heart doesn't pump

blood to the rest of the body.

</p>

</div>

<div class="image info-content-picture">

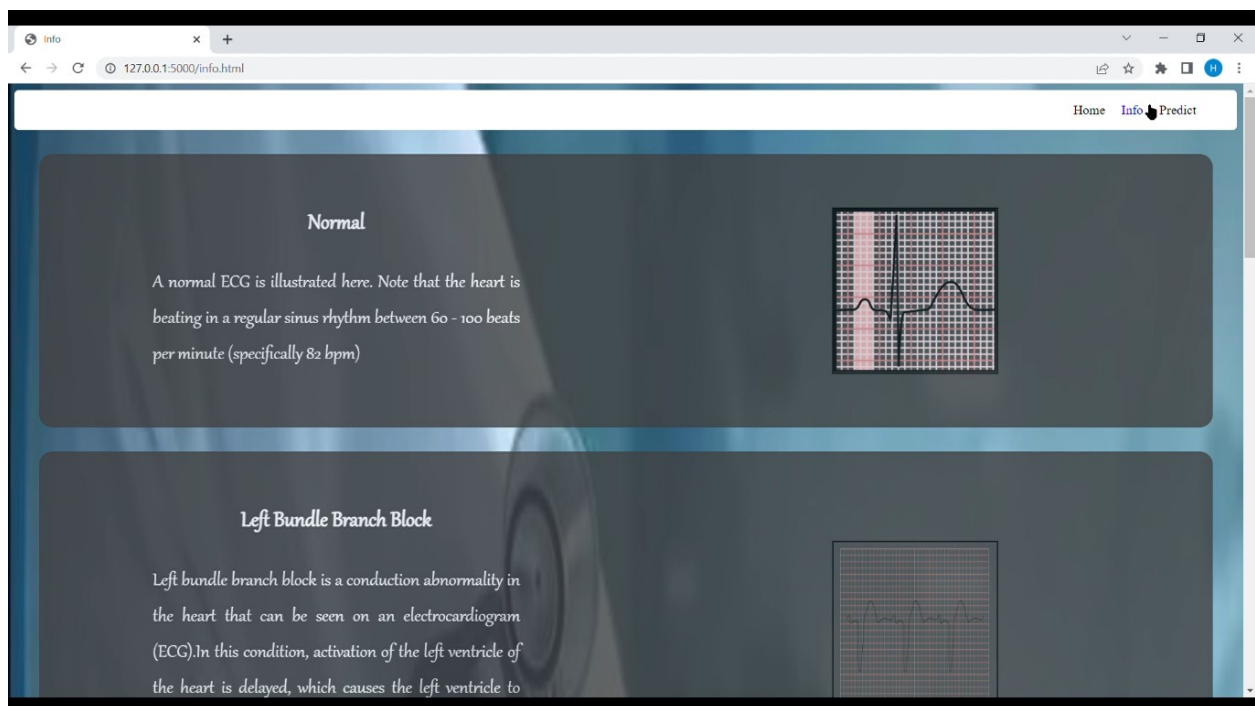


</div>

</div>

</body>

</html>



PREDICT.HTML:

```
<!DOCTYPE html>
```

```
<html lang="en">
```

```
  <head>
```

```
    <meta charset="UTF-8">
```

```
    <title>Predict</title>
```

```
    <link rel="stylesheet" href="index.css">
```

```
    <script src="predict.js"></script>
```

```
  <style>
```

```
    a{
```

```
      text-decoration: None;
```

```
    }
```

```
    body{
```

```
      background-image:
```

```
url('https://images.hindustantimes.com/img/2022/06/30/550x309/6b242762-f891-11ec-8608-e101559032f3_1656606499620.jpg');
```

```
      background-repeat: no-repeat;
```

```
      background-size: 1560px 800px;
```

```
    }
```

```
    a:visited{
```

```
      color: black;
```

```
    }
```

```
    .nav-div{
```

```
      margin: 0;
```

```
      background: #ffffff;
```

```
      border-radius: 5px;
```

```
}  
nav{  
    display: flex;  
    justify-content: flex-end;  
}  
  
.active{  
    color: blue;  
}  
  
.nav-tab{  
    margin-top: 15px;  
    margin-bottom: 15px;  
    margin-left: 20px;  
    cursor: pointer;  
}  
.nav-tab-last{  
    margin-right: 50px;  
}  
  
.home-heading{  
    display: flex;  
    color: #000000;  
    margin: 0;  
    justify-content: center;  
    font-family: 'Gabriola', sans-serif;  
}  
  
.home-content-para{  
    display: flex;
```



```
    color: white;
    margin: 0;
    align-items: center;
    font-family: 'Gabriola', sans-serif;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 26px;
}
.home-content{
    margin: 50px;
    background-color: rgb(79, 78, 78);
    border: 1px solid black;
    border-radius: 16px;
    opacity: 93%;
}
.predict-content{
    display: flex;
    color: white;
    margin-left: 500px;
    margin-right: 500px;
    border-radius: 16px;
    opacity: 70%;
    justify-content: center;
    padding-left: 100px;
    padding-right: 100px;
    text-align: center;
    font-size: 20px;
    background: #595858;
}
.btn {
```

```
border: none;
color: black;
padding: 15px 32px;
text-align: center;
text-decoration: none;
display: inline-block;
font-size: 16px;
cursor: pointer;
margin: 20px;
border-radius: 16px;
}
.btn-choose {
background-color: white;
}
.btn-predict{
color: white;
background-color: palevioletred;
}
.info-content{
margin : 30px;
padding: 10px;
background-color: rgb(66, 66, 66);
opacity: 0.8;
display: flex;
border-radius: 16px;
}
.content,.image{
flex: 50%;
margin: 30px;
}
.image{
```

```
display: flex;
flex-direction: row;
justify-content: space-around;
align-items: center;
padding: 30px;
}

.info-content-heading{
  color: #ffffff;
  font-family: 'Gabriola', sans-serif;
  padding-left: 100px;
  padding-right: 100px;
  text-align: center;
  font-size: 30px;
  margin: 0 0 20px;
}

.info-content-para{
  color: #ffffff;
  font-family: 'Gabriola', sans-serif;
  padding-left: 100px;
  padding-right: 100px;
  text-align: justify;
  font-size: 26px;
}

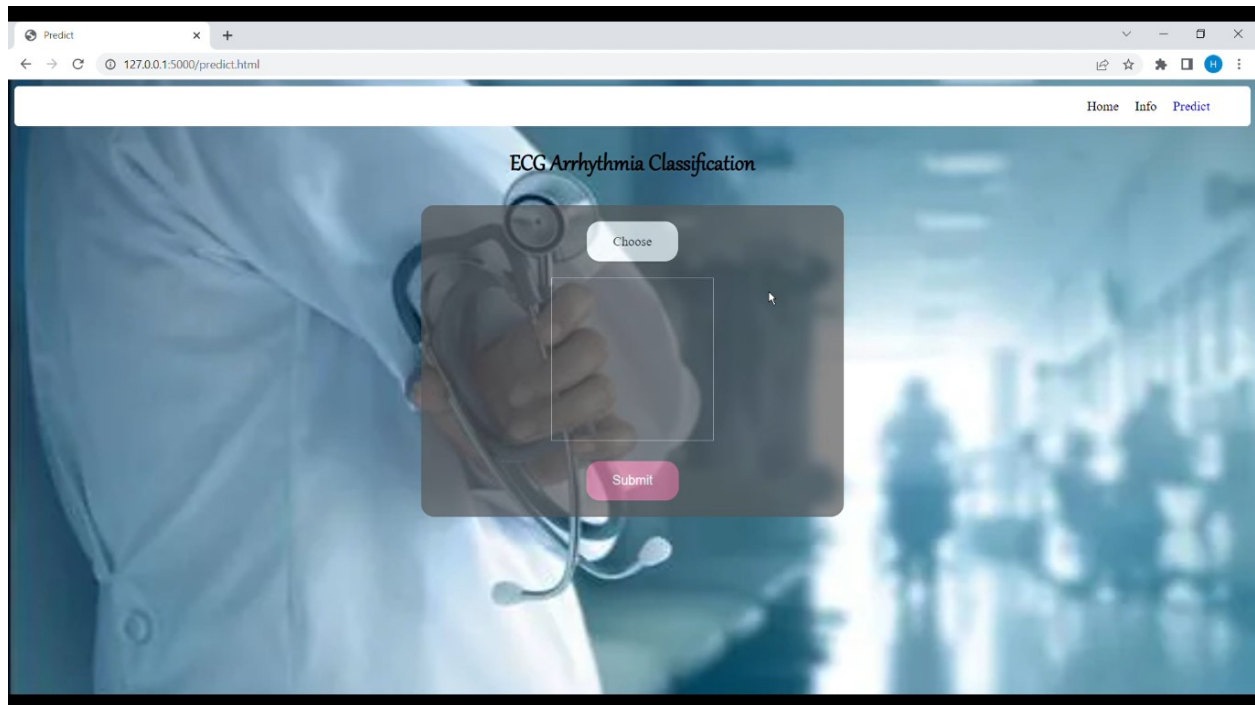
.info-content-picture{
  margin:0;
}

</style>
</head>
<body>
  <div class="nav-div">
```

```

    <nav class="index-nav">
    <a class="nav-tab" href="index.html">Home</a>
    <a class="nav-tab" href="info.html">Info</a>
    <a class="active nav-tab nav-tab-last">Predict</a>
    </nav>
</div>
<div class="home-heading">
    <h1>ECG Arrhythmia Classification</h1>
</div>
<div class="predict-content">
    <form          id="predict_form"          action="premature_atrial_contraction.html"
enctype="multipart/form-data">
        <input          type="file"  accept="image/*"          name="image"
id="file"  onchange="loadFile(event)" style="display: none;" />
        <label for="file" class="btn btn-choose">Choose</label><br/>
        <img id="output" width="200" height="200" style="border: none;"/><br/>
        <input class="btn btn-predict" type="submit" onclick="clickEvent()">
        <script>
function clickEvent(){
    }
let loadFile = function(event) {
const image = document.getElementById('output');
image.src = URL.createObjectURL(event.target.files[0]);
    };
        </script>
    </form>
</div>
</body>
</html>

```



### **app.py file:**

```
import os
import numpy as np
from flask import Flask, request, render_template, send_from_directory, make_response
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image

app = Flask(__name__, template_folder='template') #initializing a flask app
model=load_model('ECG.h5')

@app.route("/")
@app.route("/index.html")

def home():
    return render_template("index.html")
@app.route("/info.html")
```

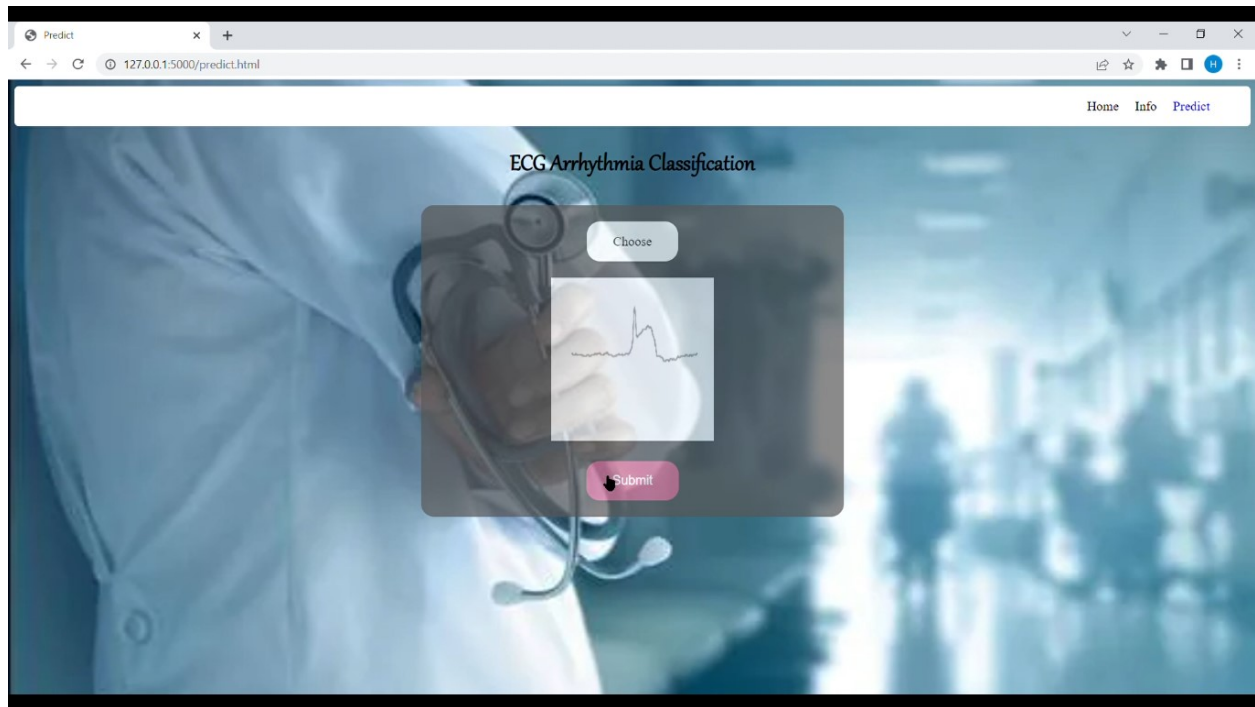
```

def info():
    return render_template("info.html")
@app.route("/predict.html", methods=['GET', 'POST'])
def upload():
    if request.method=="POST":
        f=request.files['file']
        basepath=os.path.dirname('__file__')
        filepath=os.path.join(basepath,"uploads",f.filename)
        f.save(filepath)
        img=load_img(filepath,target_size=(64,64))
        x=img_to_array(img)
        x=np.expand_dims(x,axis=0)
        pred=model.predict_classes(x)
        print("prediction",pred)
        index=['Left Bundle Branch Block','Normal','Premature Atrial Contraction','Premature
Ventricular Contraction','Right Bundle Branch Block','Ventricular Fibrillation']
        result=str(index[pred[0]])
        return result
    return render_template("predict.html")
def favicon():
    return send_from_directory(os.path.join(app.root_path, 'static'),
                              'favicon.ico', mimetype='image/vnd.microsoft.icon')

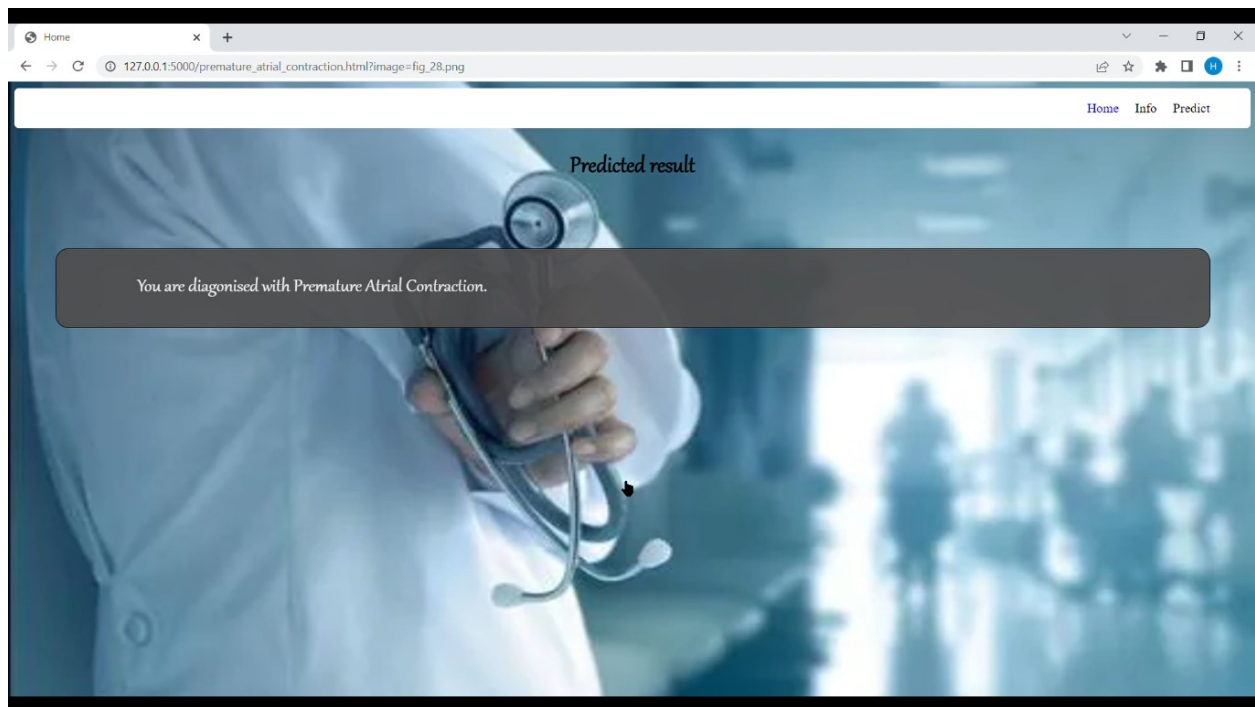
if __name__ == "__main__":
    app.run(debug=True)

```

**GIVING USER INPUT:**



**OUTPUT:**



**GitHub Repository Link:**

<https://github.com/IBM-EPBL/IBM-Project-19183-1659694105>

**Project Demo Link:**

[https://drive.google.com/file/d/1aMzy28m1vW0lh9aTJCfN6odTEB9kUaYe/view?usp=share\\_link](https://drive.google.com/file/d/1aMzy28m1vW0lh9aTJCfN6odTEB9kUaYe/view?usp=share_link)