Classification Of Arrhythmia By Using Deep Learning With 2-D ECG Spectral Image Representation

A PROJECT REPORT

Submitted By

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in partial fulfilment for the award of the degree

of

Bachelor of Engineering

IN

Computer Scince Engineering

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DECEMBER-2022

TABLE OF CONTENTS

TABLE OF CONTENTS

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

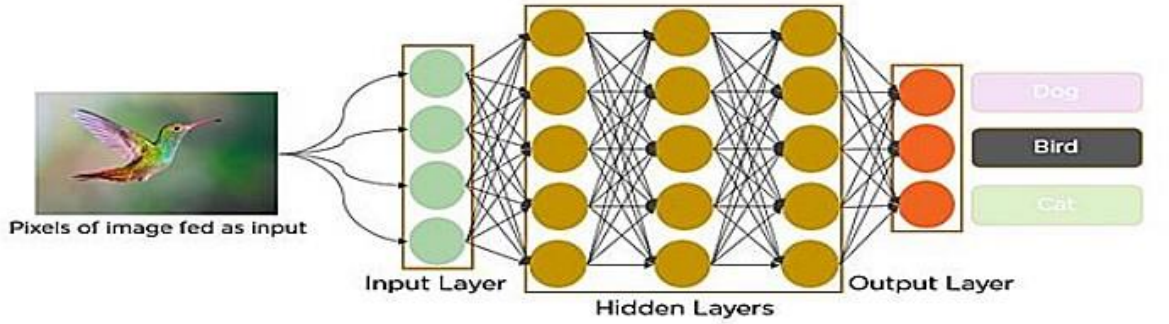
1.INTRODUCTION:

1.1.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.

1.2.PURPOSE*:*

In the past few decades, Deep Learning has proved to be a compelling tool because of its ability to handle large amounts of data. The interest to use hidden layers has surpassed traditional techniques, especially in pattern recognition. One of the most popular deep neural networks is Convolution al Neural Networks.



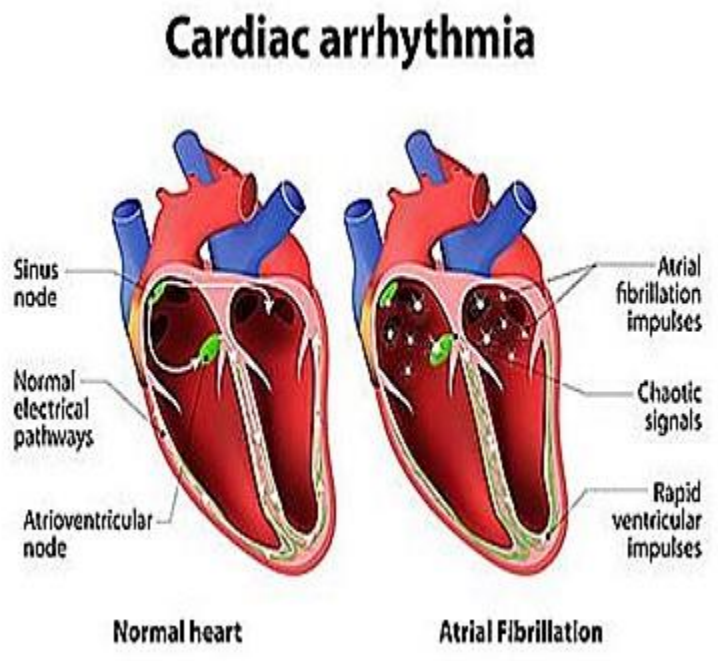
In deep learning, a convolution al neural network (CNN/ConvNet) is a class of deep neural networks, most commonly applied to analyze visual imagery. Now when we think of a neural network we think about matrix multiplications but that is not the case with ConvNet. It uses a special technique called Convolution. 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 :

2.1. EXISTING PROBLEM :

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.



2.2.REFERENCES:

- Amin Ullah Syed Muhammad Anwar, Muhammad Bilal, and Raja Majid Mehmood (2020)
- Bazi, Haikel AlHichri, Naif Alajlan, Farid Melgani, Ronald R Yager (2022)
- Faezeh Nejati Hatamian, Nishant Ravikumar, Sulaiman Vesal(2020)
- Fatma Murat, Ozal Yildirim, Muhammed Talo, Ulas Baran Baloglu, Yakup Demir, U Rajendra Acharya (2020)
- Han Lia, Xinpei Wanga, Changchun Liua, Peng Lib Yu Jiaoa (2021)
- Jagdeep Rahul Lakhan Devi Sharma (2022)

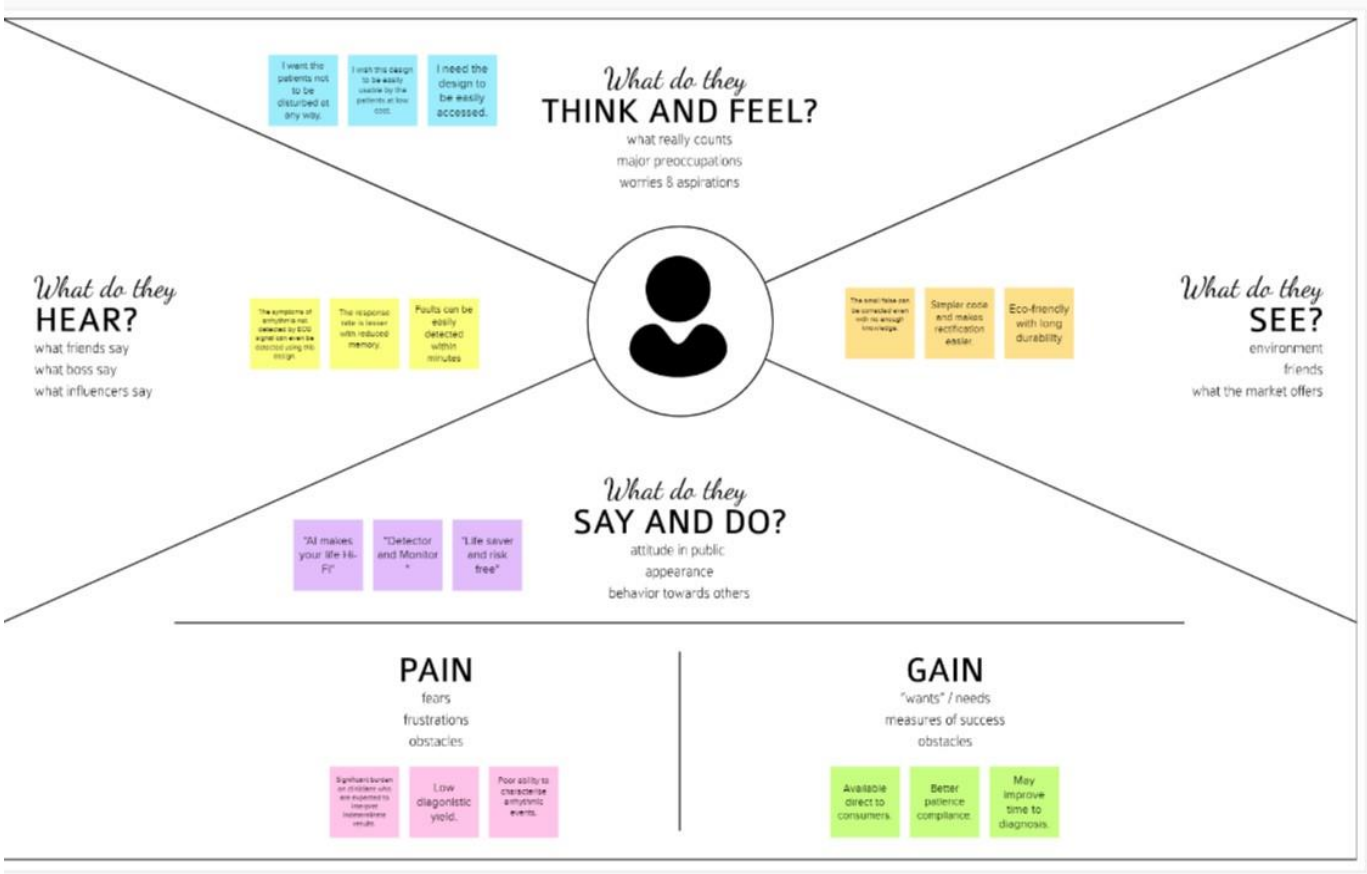
- Kurniawan, I Ketut Eddy Purnama, Mpu Hambyah Syah Bagaskara Aji (2021)
- Ozal Yildirima, MuhammedTaloa, BetulAybUlas BaranBalogluc, GalipAydinbU, RajendraAcharya (2020)
- Rashidah Funke Olanrewaju, S. Noorjannah Ibrahim, Ani Liza Asnawi, Hunain Altaf (2021)
- Rui Hu, Jie Chen, Li Zhou (2022)

2.3. PROBLEM STATEMENT DEFINITION:

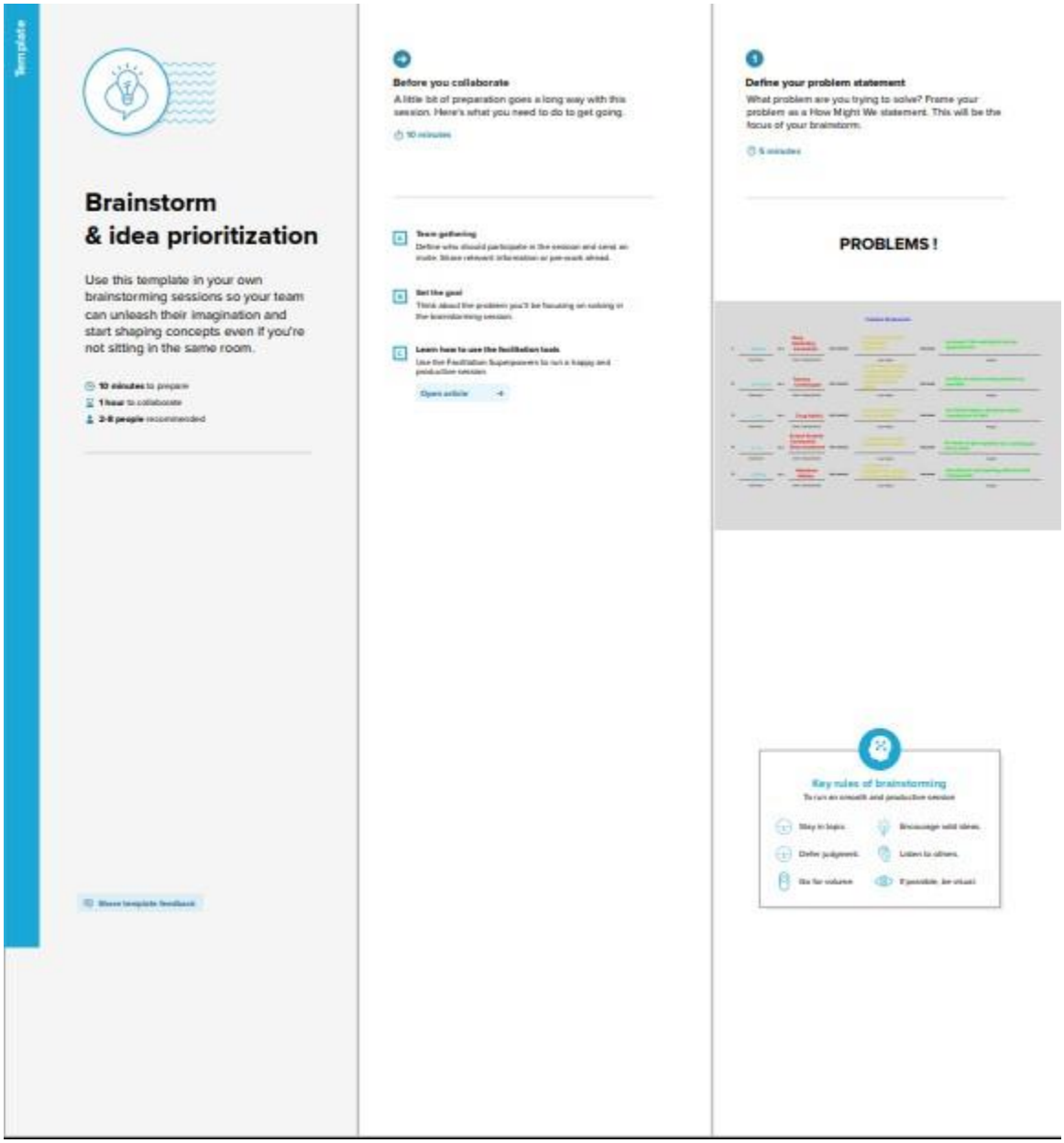
More than four million of people, mostly over age sixty, are suffering from various kinds of arrhythmias that cause discomfort or even sudden cardiac death (SCD).Fast and accurate classification of large set of Electrocardiogram (ECG) beats containing both normal and arrhythmic categories is still a challenging task for the state-of-the art classification algorithms. The ECG signals can capture the heart's rhythmic irregularities, commonly known as arrhythmias. A careful study of ECG signals is crucial for precise diagnoses of patients' acute and chronic heart conditions. A twodimensional (2-D) convolutional neural network (CNN) model is helpful for the classification of ECG signals into eight classes.The one-dimensional ECG time series signals are transformed into 2-D spectrograms through short-time Fourier transform. The 2-D CNN model consisting of four convolutional layers and four pooling layers is designed for extracting robust features from the input spectrograms. Using Deep Learning CNN we can enhance the accuracy of diagnosis algorithms in the fusion of medicine and modern machine learning technologies. The proposed CNN-based classification algorithm, using 2-D images, can classify eight kinds of arrhythmia.

3.IDEATION & PROPOSED SOLUTION :

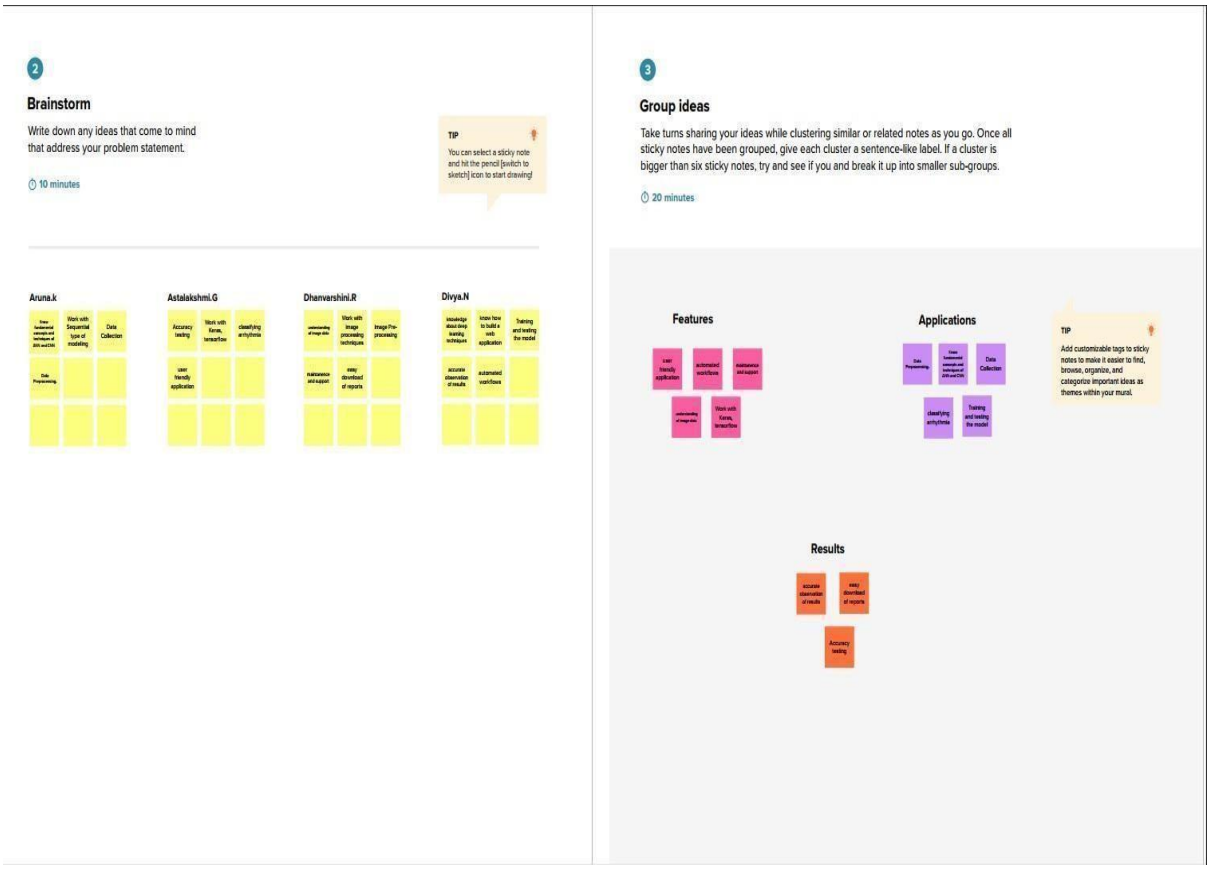
*3.1.*EMPATHY MAP CANVAS :

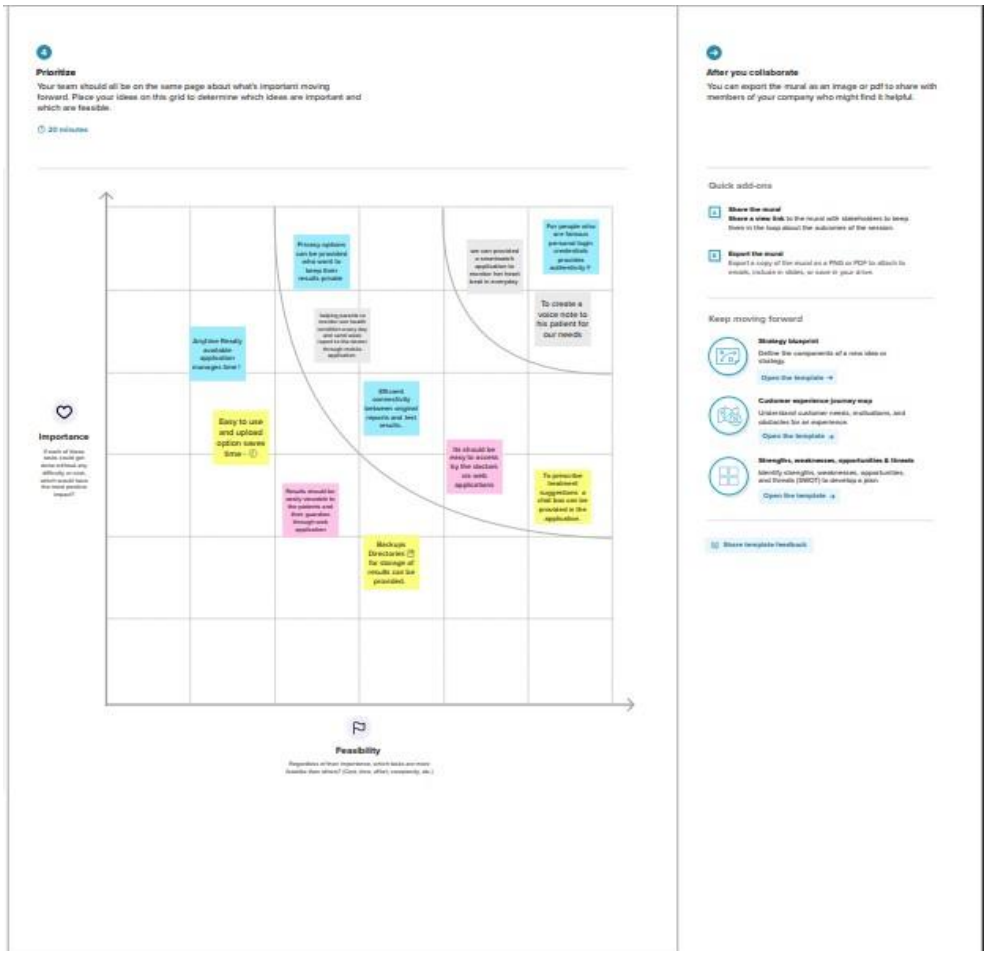


3.2.IDEATION & BRAINSTORMING:



Brainstorm, Idea Listing and Grouping





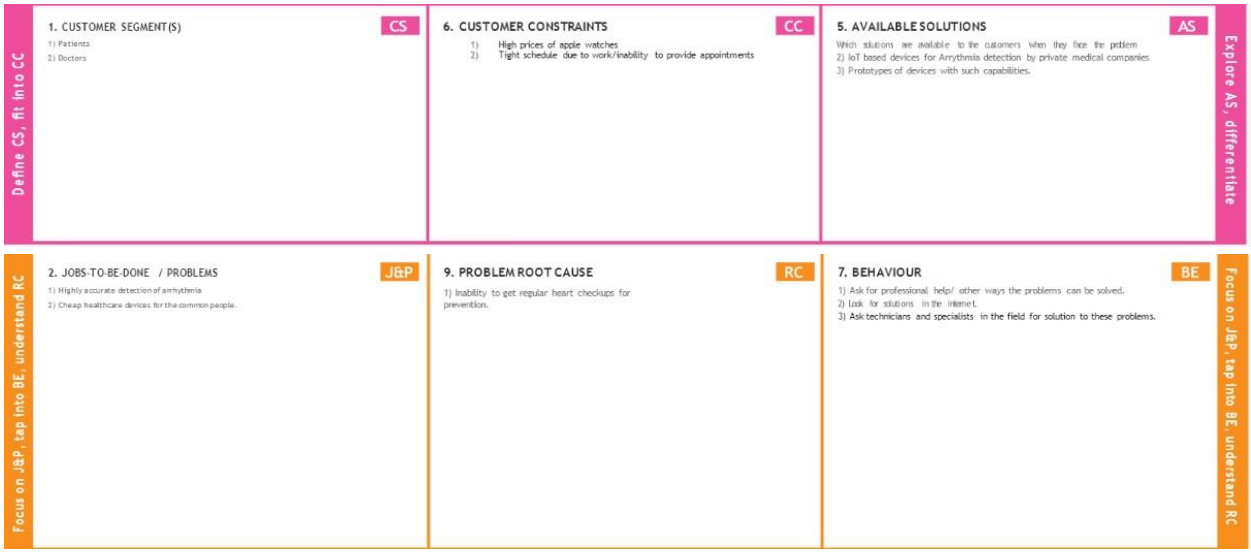
3.3.PROPOSED SOLUTION:

Proposed Solution Template:

Project team shall fill the following information in proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Medicines are used to control abnormal heart rhythms . Ablation procedure can cure some types of arrhythmia completely. Eat Healthy Food. Excersie Regularly.
2.	Idea / Solution description	Vitamin C. Arrythmia and other heart conditions associated oxident strees and Immplamation
3.	Novelty / Uniqueness	Users can Identify the Type of Arrhythmia
4.	Social Impact / Customer Satisfaction	Avoid smoking, Maintain a regular healthy wait, keep blood pressure and cholestreol level under control
5.	Business Model (Revenue Model)	We can provide the application in a subscription based.
6.	Scalability of the Solution	Identify the type of heart disease. An ECG is used to how the Heart is functioning. It can give about importance of heart attack and Irregular beat.

3.4.PROBLEM SOLUTION FIT :



4. REQUIREMENT ANALYSIS:

4.1.FUNCTIONAL *REQUIREMENT:*

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form , Registration through Gmail
FR-2	User Confirmation	Confirmation via Email , Confirmation via OTP
FR-3	Get User Input	Upload image as jpeg , Upload image as png
FR-4	Save Image	Images are saved in the uploads folder
FR-5	Chat with Doctor	Consult with Doctor
FR-6	Report Generation	Get complete Report

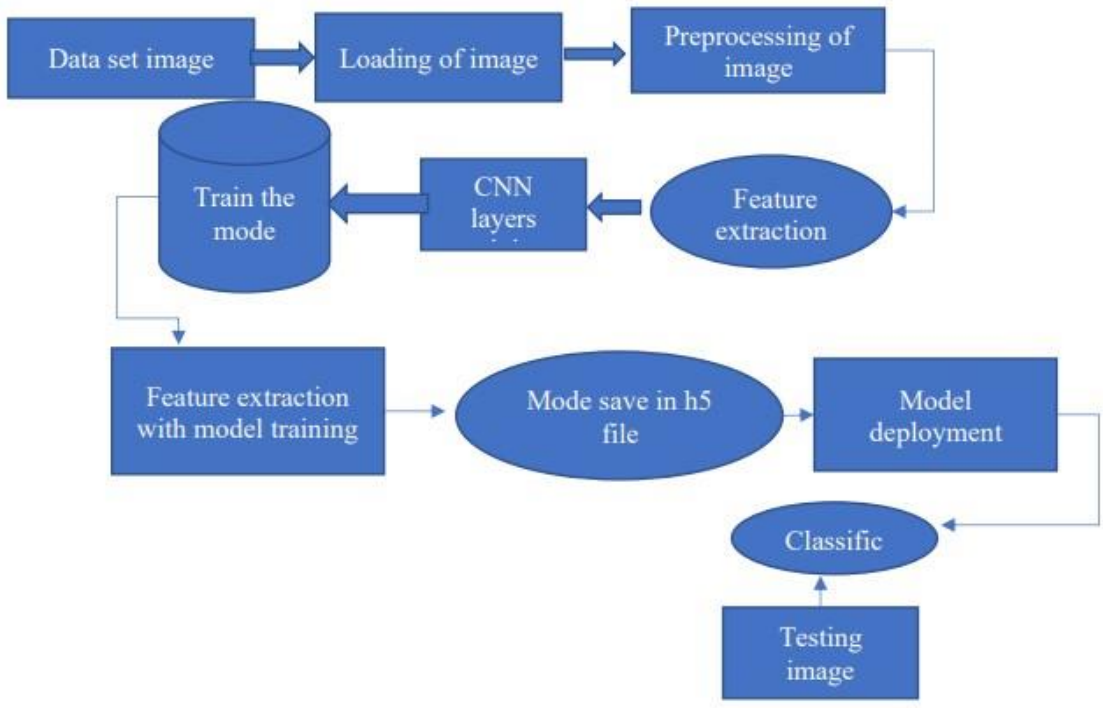
4.2.NON-FUNCTIONAL REQUIREMENTS :

Following are the non-functional requirements of the proposed solution.

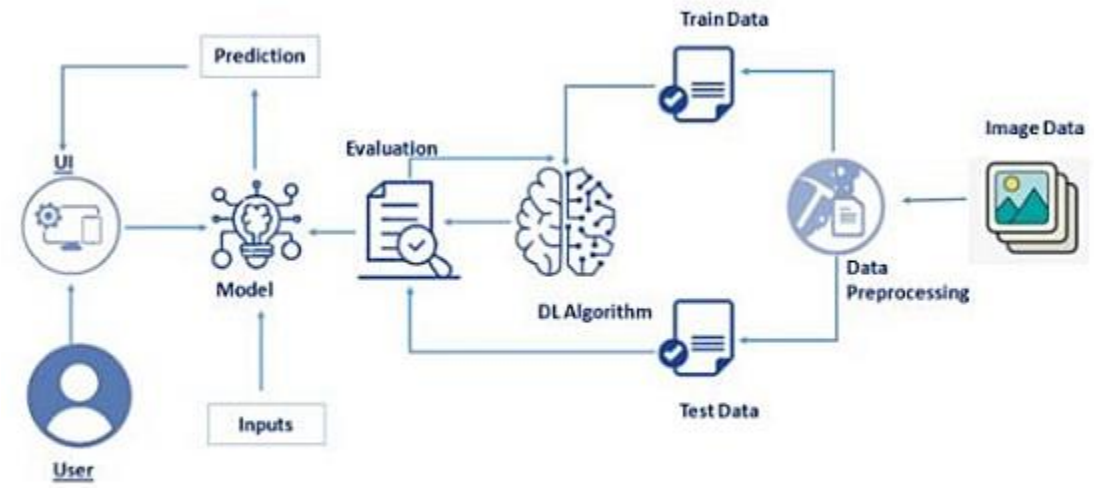
FRNo.	Non-Functional Requirement	Description
NFR-1	**Usability**	Classification of Arrhythmia with the help of AI.
NFR-2	**Security**	User's data cannot be accessed by unauthorized people.
NFR-3	**Reliability**	The system performs without failure.
NFR-4	**Performance**	High accuracy.
NFR-5	**Availability**	Anyone who is authorized.
NFR-6	**Scalability**	Does not affect the performance even though.

5. PROJECT DESIGN:

5.1. *DATA FLOW DIAGRAMS:*



5.2.SOLUTION & TECHNICAL ARCHITECTURE :



5.3.USER STORIES :

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I can register for the application using gmail	I can access my account/dashboard	High	Sprint-1
	Confirmation	USN-3	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
Data Input	Getting user input	USN-4	As a user, I can share my input like the medical reports to the application	I can proceed with further steps with no error	High	Sprint-2
	Save report	USN-5	The data that is provided by the user will be saved in the application backend for future purpose	If all the data is in correct format it will be stored	High	Sprint-2
Customer Interaction	Chat with doctor	USN-6	If the customer is interested he can consult with the doctor regarding doubts	If the doctor is free the appointment will be accepted.	Low	Sprint-1
Report Generation	Get complete report	USN-7	After the complete analysis the report will be generated	The results will be shown on the screen to the patients	High	Sprint-2

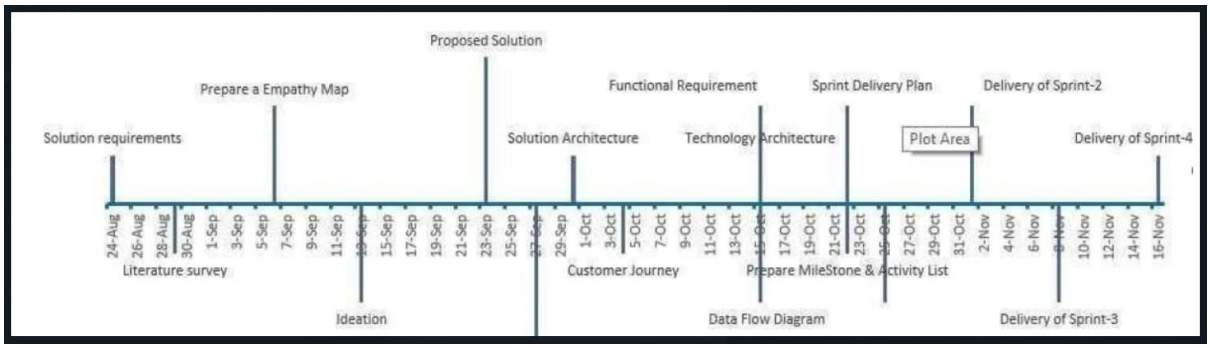
6.PROJECT PLANNING & SCHEDULING:

6.1. *SPRINT PLANNING & ESTIMATION:*

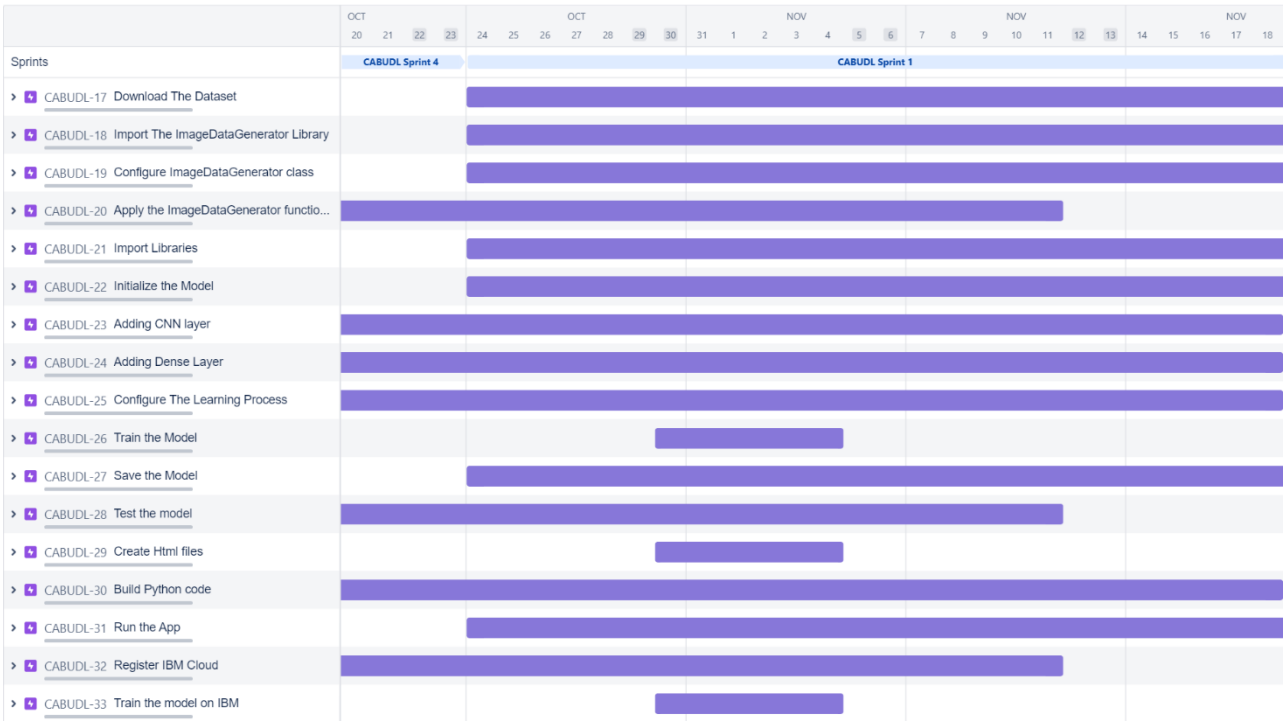
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	5	Medium	Devendiran
Sprint-3		USN-2	As a user, I will receive confirmation email once I have registered for the application	1	Medium	Monisha
Sprint-4		USN-3	As a user, I can register for the application through mobile OTP method	5	Low	Sareshkumar
Sprint-4		USN-4	As a user, I can register for the application through Gmail	5	Medium	Monisha
Sprint-3	Login	USN-5	As a user, I can log into the application by entering email & password	3	Medium	Devendiran ,Monisha
Sprint-1	Homepage	USN-6	As a user, the homepage must properly define the Arrhythmia, its causes and effects and understand how the application helps in solving the problem.	5	High	Sareshkumar
Sprint-1	More Information Page	USN-7	As a user, I must be able to comprehend all medical jargon related to Arrhythmia such as ECG, Coronary Heart Disease, Cardiomyopathy and its types.	5	High	Chirag
Sprint-2	Prediction Page	USN-8	As a user, I must be able to upload the ECG image for prediction.	8	High	Monisha Devendiran
Sprint-2	Results Page	USN-9	As a user, I must be able to view the results of the classification. For this purpose, an ML model must be trained on the dataset. Also, I must also receive additional information about the type of arrhythmia.	13	High	Dvendiran, Sareshkumar
Sprint-2	Contact Page	USN-10	As a user, I must be directed to further sources of help which would help in the treatment process.	5	Medium	Monisha, Sareshkumar
Sprint-4	Hosting	USN-11	As a user, it must be accessible on a single website for both mobile, PC users.	3	Medium	Devendiran, Sareshkumar

6.2.*SPRINT DELIVERY SCHEDULE:*

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022



6. 3.*REPORTS FROM JIRA:*



7.CODING & SOLUTIONING:

7. 1.FEATURE 1:

7.1.1 App.py

```python
import os
import numpy as np  # used for numerical analysis
from flask import Flask, request, render_template
# Flask-It is our framework which we are going to use to run/serve our application.
# request-for accessing file which was uploaded by the user on our application.
# render_template- used for rendering the html pages
from tensorflow.keras.models import load_model  # to load our trained model
from tensorflow.keras.preprocessing import image

app = Flask(__name__)  # our flask app
model = load_model('ECG.h5')  # loading the model

@app.route("/") #default route
@app.route("/home") #Home page set to default page
def default():
    return render_template('index.html') #rendering index.html

@app.route("/info") #route to info page
def information():
    return render_template("info.html") #rendering info.html

@app.route("/about") #route to about us page
def about_us():
    return render_template('about.html')  #rendering about.html

@app.route("/contact") #route to contact us page
def contact_us():
    return render_template('contact.html')  #rendering contact.html

@app.route("/upload") #default route
def test():
    return render_template("predict.html")  #rendering contact.html

@app.route("/predict",methods=["GET","POST"]) #route for our prediction
def upload():
    if request.method == 'POST':
        f = request.files['file']  # requesting the file
        basepath = os.path.dirname('__file__')  # storing the file directory
        filepath = os.path.join(basepath, "uploads", f.filename)  # storing the file in uploads folder
        f.save(filepath)  # saving the file

        img = image.load_img(filepath, target_size=(64, 64))  # load and reshaping the image
        x = image.img_to_array(img)  # converting image to array
        x = np.expand_dims(x, axis=0)  # changing the dimensions of the image

        preds = model.predict(x)  # predicting classes
        pred = np.argmax(preds, axis=1)  # predicting classes
        print("prediction", pred)  # printing the prediction
```

```python
        pred = np.argmax(preds, axis=1)  # predicting classes
        print("prediction", pred)  # printing the prediction

        index = ['Left Bundle Branch Block', 'Normal', 'Premature Atrial Contraction',
                 'Premature Ventricular Contractions', 'Right Bundle Branch Block', 'Ventricular Fibrillation']
        result = str(index[pred[0]])
        return result  # resturing the result
    return None


# port = int(os.getenv("PORT"))
if __name__ == "__main__":
    app.run(debug=False)  # running our app
    # app.run(host='0.0.0.0', port=8000)
```

7.2. FEATURE 2:

7.2.1Homepage.html

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

<head>
  <meta charset="UTF-8" />
  <meta http-equiv="X-UA-Compatible" content="IE=edge" />
  <meta name="viewport" content="width=device-width, initial-scale=1.0" />
  <title>Self Care - Heart Prediction Online</title>
  <link rel="shortcut icon" href="{{url_for('static', filename='images/fevicon.png' )}}" type="image/x-icon">
  <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/aos/2.3.1/aos.css" />
  <link href="https://fonts.googleapis.com/css2?family=Playfair+Display:wght@600&display=swap" rel="stylesheet" />
  <link rel="stylesheet" href="{{url_for('static', filename='css/style.css' )}}" />
  <script src="https://kit.fontawesome.com/64d58efce2.js" crossorigin="anonymous">
  </script>
</head>

<body>
  <div class="wrapper">
    <!--Navigation Bar-->
    <div class="nav">
      <div class="logo">
        <a href="/">
          <img src="static\images\SELF1 11.png" style="width:190px"/>
        </a>
      </div>
      <div class="links">
        <a href="/home" class="mainLink">Home</a>
        <a href="/info">Info</a>
        <a href="/about">About Us</a>
        <a href="/contact">Contact Us</a>
        <a href="/upload" class="btn1">Predict</a>
      </div>
    </div>
    <!--Landing Page-->
    <div class="landing">
      <div class="landingText" data-aos="fade-up" data-aous-duration="1000">
        <h1>
          Classification of Arrhythmia
          <span style="color: #e0501b; font-size: 4vw">Prediction</span>
        </h1>
        <h3>
          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...
        </h3>

        <div class="btn2"><a href="/info">Read more</a>
        </div>
```

```
    </div>
    <div class="landingImage" data-aos="fade-down" data-aous-duration="2000">
      <img src="static/images/banner_img.jpg" alt="bannerImg" style="width: 500px; height:360px" />
    </div>
  </div>

  <!--Service Section-->
  <div class="about">
    <div class="aboutText" data-aos="fade-up" data-aous-duration="1000">
      <h1 style="margin: 20px;">
        Our Patients Are at Centre
        <span style="color: #2f8be0; font-size: 3vw">of Every We Do</span>
      </h1>
      <div class="image-container">
        <img src="/static/images/connsultPationt.png" alt="consultPationt"
          style="width:400px; margin:100px 0px 0px 90px;"></img>
      </div>
    </div>
    <div class="aboutList" data-aos="fade-left" data-aous-duration="1000">
      <ol>
        <li>
          <span>01</span>
          <p>99.8% accurate result.</p>
        </li>
        <li>
          <span>02</span>
          <p>No need to go hospital.</p>
        </li>
        <li>
          <span>03</span>
          <p>No need to login</p>
        </li>
        <li>
          <span>04</span>
          <p>24/7 Support.</p>
        </li>
      </ol>
    </div>
  </div>

  <!--Info Section-->
  <div class="infoSection">
    <div class="infoHeader" data-aos="fade-up" data-aous-duration="1000">
      <h1>
        We Analyse Youe Health states <br /><span style="color: #e0501b">In Order to Top Service.</span>
      </h1>
    </div>
    <div class="infoCards">
```

```
                </a>
              </div>
            </div>
          </div>
        </div>

        <!--Banner And Footer-->
        <div class="banner">
          <div class="bannerText" data-aos="fade-right" data-aous-duration="1000">
            <h1>
              Download the SelfCare App Today <br /><span style="font-size: 1.6vw; font-weight: normal"
                class="bannerInnerText">Stay Updated and get all your medical needs taken care of!</span>
            </h1>
            <a href="/"><img src="static/images/AndroidPNG.png" alt="" /></a>
            <a href="/"><img src="static/images/iosPNG.png" alt="" /></a>
          </div>
          <div class="bannerImg" data-aos="fade-up" data-aous-duration="1000">
            <img src="static/images/app.png" alt="" />
          </div>
        </div>

        <div class="footer">
          <h1>SelfCare</h1>
          <div class="footerlinks">
            <a href="/home" class="mainLink">Home</a>
            <a href="/info">Info</a>
            <a href="/about">About Us</a>
            <a href="/contact">Contact Us</a>
          </div>
        </div>
      </div>
      <script src="https://cdnjs.cloudflare.com/ajax/libs/aos/2.3.1/aos.js"></script>
      <script>
        AOS.init();
      </script>
    </body>

    </html>
```

7.2.2. about.html

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

<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <link rel="shortcut icon" href="{{url_for('static', filename='images/fevicon.png' )}}" type="image/x-icon">
    <title>Self Care - About Us</title>
    <link rel="stylesheet" href="{{url_for('static', filename='css/about.css')}}">
    <link rel="stylesheet" href="{{url_for('static', filename='css/style.css')}}">
    <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/aos/2.3.1/aos.css" />
    <link href="https://fonts.googleapis.com/css2?family=Playfair+Display:wght@600&display=swap" rel="stylesheet" />
    <link href="https://cdnjs.cloudflare.com/ajax/libs/font-awesome/5.10.0/css/all.min.css" rel="stylesheet">
</head>
<style>
    .footer {
        margin-bottom: 20px;
    }

    h1 {
        margin: 21.44px 0px;
    }
</style>

<body>
    <div class="wrapper">
        <!--Navigation Bar-->
        <div class="nav">
            <div class="logo">
                <a href="/"><img src="static/images/SELF1 11.png" alt="Website Title" style="width:190px" /></a>
            </div>
            <div class="links">
                <a href="/">Home</a>
                <a href="/info">Info</a>
                <a href="/about" class="mainLink">About Us</a>
                <a href="/contact">Contact Us</a>
                <a href="/upload" class="btn1">Predict</a>
            </div>
        </div>
        <div class="landing">
            <div class="landingText" data-aos="fade-up" data-aous-duration="1000">
                <h1>
                    We are a team of
                    <span style="color: #e0501b; font-size: 4vw">Arrthymia Prediction</span>
                </h1>
                <h3>
                    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.
            </h3>
        </div>
        <div class="landingImage" data-aos="fade-down" data-aous-duration="2000">
            <img src="static/images/about_us.png" alt="aboutImg" style="width: 450px; height:450px" />
        </div>
    </div>
    <div class="main">
        <div class="profile-card">
            <div class="img">
                <img src="static/images/vjaavatar.jpg">
            </div>
            <div class="caption">
                <h3>Vijay Anand </h3>
                <p>Web Developer, Full Stack Developer, AI Learning Engineer</p>
                <div class="social-links">
                    <a href="#"><i class="fab fa-facebook"></i></a>
                    <a href="#"><i class="fab fa-instagram"></i></a>
                    <a href="#"><i class="fab fa-twitter"></i></a>
                </div>
            </div>
        </div>
        <div class="profile-card">
            <div class="img">
                <img src="static/images/profile_avatar.png">
            </div>
            <div class="caption">
                <h3>Pritha V </h3>
                <p>Front End Developer, Machine Learning Engineer</p>
                <div class="social-links">
                    <a href="#"><i class="fab fa-facebook"></i></a>
                    <a href="https://www.instagram.com/the_._._champ/"><i class="fab fa-instagram"></i></a>
                    <a href="#"><i class="fab fa-twitter"></i></a>
                </div>
            </div>
        </div>
        <div class="profile-card">
            <div class="img">
                <img src="static/images/profile_avatar.png">
            </div>
            <div class="caption">
```

```
                <div class="caption">
                    <h3>Ruhie N</h3>
                    <p>Back End Developer, AI Learning Engineer</p>
                    <div class="social-links">
                        <a href="#"><i class="fab fa-facebook"></i></a>
                        <a href="#"><i class="fab fa-instagram"></i></a>
                        <a href="#"><i class="fab fa-twitter"></i></a>
                    </div>
                </div>
            </div>
            <div class="profile-card">
                <div class="img">
                    <img src="static/images/sh.jpg">
                </div>
                <div class="caption">
                    <h3>Shyam Praveen Singh</h3>
                    <p>Full Stack Developer, Machine Learning Engineer</p>
                    <div class="social-links">
                        <a href="#"><i class="fab fa-facebook"></i></a>
                        <a href="#"><i class="fab fa-instagram"></i></a>
                        <a href="#"><i class="fab fa-twitter"></i></a>
                    </div>
                </div>
            </div>
        </div>
        <div class="footer">
            <h1>SelfCare</h1>
            <div class="footerlinks">
                <a href="/home">Home</a>
                <a href="/info">Info</a>
                <a href="/about" class="mainLink">About Us</a>
                <a href="/contact">Contact Us</a>
            </div>
        </div>
    </div>

    </div>
    <script src="https://cdnjs.cloudflare.com/ajax/libs/aos/2.3.1/aos.js"></script>
    <script>
        AOS.init();
    </script>
</body>

</html>
```

7.2.3. Predict.html

```
{% extends "predict_base.html" %} {% block content %}

<center>
    <h2 style="font-size: 40px;">
        ECG Arrhythmia
        <span style="color: #2f8be0; font-size: 3vw">Classification</span>
    </h2>
</center>

<div>
    <form id="upload-file" method="post" enctype="multipart/form-data">
        <center> <label for="imageUpload" class="upload-label">
                Choose...
            </label>
            <input type="file" name="file" id="imageUpload" accept=".png, .jpg, .jpeg">
        </center>
    </form>

    <center>
        <div class="image-section" style="display:none;">
            <div class="img-preview">
                <div id="imagePreview">
                </div>
            </div>
        </div>
    </center>
</div>
<center>
    <div class="btn3" id="btn-predict"
        style="padding: 8px 34px; width: 120px; margin-top: 30px; padding: 14px 20px 12px 20px; background-color: #007bff; border-radius: 45px; text-align: center; color: #fff; cu
        Predict</div>
    <div class="loader" style="display:none;"></div>
</center>

<h3 style="color:Black" id="result">
    <span> </span>
</h3>

</div>

</div>



{% endblock %}
```

8.TESTING:

8.1.TEST CASES:

Test case ID	Feature Type	Component	Test Scenario	Pre-Requisite	Steps To Execute	Test Data	Expected Result	Actual Result	Status
EditorPage_TC_OO1	Functional	Visual Studio Editor	Open the Visual Studio Editor and click the app.py	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		Working correctly	Working as expected	Pass
Navigation_TC_OO2	Functional	Home Page	Validate all the tabs in the navigator	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		All the 3 tabs should vissible	Working as expected	Pass
Home_TC_OO3	Functional	Home page	Verify the Visibility of the image	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		User should able to see the image	Working as expected	Pass
HomePage_TC_OO4	Functional	Home page	Validate the description of the image	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		Description should be visible on the window	Working as expected	Pass
HomePage_TC_OO5	Functional	Home page	Verify the user is able to navigate	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		It should redirect the user to the same window	Working as expected	Pass
InfoPage_TC_OO_1	Functional	Info Page	Verify the user is in the introduction	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		User should be in the introduction	Working as expected	Pass
InfoPage_TC_OO_2	Functional	Info Page	verify the page title and information	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		User should able to view the page	Working as expected	Pass
PredictPage	Functional	Predict	verify the working of predict page	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		User should be able to visit the page	Working as expected	Pass
PredictPage	Functional	Predict	verify the upload image option	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		Make sure the option works	Working as expected	Pass
Predict	Functional	Predict	Verify the choose button is enable	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		The Choose button option should	Working as expected	Pass
Predict	Functional	Predict	Verify the user is able to access	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		Image should be Uploaded	Working as expected	Pass
Predict	Functional	Predict	verify the selected image is same	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		Selected image should be ECG 2D array structure	Working as expected	Pass
Predict	Functional	Predict	verify the working condition	Knowledge about Python, keras, tensorflow	1.Enter URL and click go		The Type of Arrhythmia should be found and result is displayed in the predict window	Working as expected	Pass

8.2.USER ACCEPTANCE TESTING :

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the [ProductName] project at the time of the release to User Acceptance Testing (UAT).

2. Defect Analysis

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	10	4	2	3	20
Duplicate	1	0	3	0	4
External	2	3	0	1	6
Fixed	11	2	4	20	37
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	5	2	1	8
Totals	24	14	13	26	77

3. Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

Section	Total Cases	Not Tested	Fail	Pass
Predict Page	7	0	0	7
Different Types of ECG Images	10	0	0	10
Further Classification	4	0	0	4
Home Page	3	0	0	3
Info Page	6	0	0	6
Final Report Output	1	0	0	1

9.RESULTS:

9.1.PERFORMANCE METRICS :

The two significant optimization parameters in the proposed 2-D CNN model are the learning rate and the batch size of the data used. To improve the performance, these two optimization parameters must be selected carefully to obtain the best accuracy in the automatic classification of arrhythmia using the ECG signals. The proposed model was evaluated in different experiments with various values of learning parameters. For a smaller value of the learning rate (i.e., less than 0.0005), the speed of the convergence was very slow. However, when the value of the learning rate was large (i.e., greater than0.001), the speed of convergence improved. At the same time, asymmetrical changes were observed in the accuracy rate. Henceforth, we selected an optimum value of 0.001 for the learning rate, as this value can attain better accuracy for the proposed model (i.e., optimum value).

Batch sizes and average accuracy for a learning rate of 0.001.

Learning Rate	Batch Size	Average Accuracy
0.001	2800	99.11
0.001	2000	98.96
0.001	1000	99.00
0.001	500	98.95
0.001	100	98.93

Learning rate and average accuracy for a batch size of 2800.

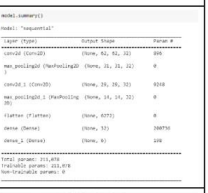
Batch Size	Learning Rate	Average Accuracy
2800	0.001	99.11
2000	0.001	98.96
1000	0.001	99.00
500	0.001	98.95
100	0.001	98.93

We compared the proposed CNN-based model with recent techniques for the automatic classification of arrhythmia where the algorithm achieved 97.88% average sensitivity, 99.61% specificity, 99.11% average accuracy, and 98.59% positive predictive value (precision). These values indicate improved performance when compared with recent methods using of 1-D and 2-D CNNs, given the same arrhythmia classification. The results also show that the proposed CNN algorithm has better results in terms of accuracy with both the augmented and without augmented data.

The proposed model has attained the highest sensitivity among all the compared CNN algorithms.It is pertinent to note that detecting these cardiac arrhythmias is a labor intensive task, where a clinical expert needs to carefully observe recordings that can go for up to hours. With such automated methods,the artificially intelligent system could augment the performance of clinical experts by detecting these patterns and directing the observer to look more closely at regions of more significance. This would ultimately improve the clinical diagnosis and treatment of some of the major CVDs.

Model Performance Testing:

Project team shall fill the following information in model performance testing template.

S.No.	Parameter	Values	Screenshot
1.	Model Summary	-	
2.	Accuracy	Training Accuracy - Validation Accuracy -	
3.	Confidence Score (Only Yolo Projects)	Class Detected - Confidence Score -	

10.ADVANTAGES & DISADVANTAGES: 10.1.ADVANTAGES :

- 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.
- To overcome the challenge for the visual and physical explanation of the ECG signal, computer-aided study has been developed to automatically identify such signals automatically.
- A careful study of ECG signals is crucial for precise diagnoses of patients' acute and chronic heart conditions.
- The performance is significant in other indices as well, including sensitivity and specificity, which indicates the success of the proposed method.
- A simple User Interface for the users to classify their ECG report.
- Great User Experience to make is simple and easy to use for users and patients while accessing the website

10.2 DISADVANTAGES:

- The efficiency and accuracy of could be negatively affected by the increasing size of data.
- The techniques presented been applied to smaller datasets.
- For the purpose of generalization, the performance should betested on larger datasets.
- Most methods have been tested on only a few types of arrhythmia and must be evaluated on all major types of arrhythmia.
- It should be noted that the performance of methods developed for 1-D ECG signals can be further improved.

11. CONCLUSION:

In this study, we proposed a 2-D CNN-based classification model for automatic classificationof cardiac arrhythmias using ECG signals. An accurate taxonomy of ECG signals is extremely helpful in the prevention and diagnosis of heart diseases. Deep CNN has proven useful in enhancing the accuracy of diagnosis algorithms in the fusion of medicine and modern machine learning technologies.The proposed CNN-based classification algorithm, using 2-D images, can classify seven kinds of arrhythmia. These results indicate that the prediction and classification of arrhythmia with 2-D ECG representation as spectrograms and the CNN model is a reliable operative technique in the diagnosis of heart diseases.The proposed scheme can help experts diagnose heart diseases by referring to the automated classification of ECG signals. The present research uses only a single-lead ECG signal. The effect of multiple lead ECG data to further improve experimental cases will be studied in future work.

12.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.

These are the further improvements that can be made in the future:-

- ➤ Further classification for upto 8-10 different types of arrhythmia will be possible.
- ➤ Improved accuracy for bigger data size.
- ➤ The techniques presented been applied to smaller datasets can be made much faster and efficient.
- ➤ Improved UI & UX for the users.

13. APPENDIX:

- **PROJECT DEMO LINK: https://drive.google.com/file/d/1CESQWEHjFXvu5jQpy0-ispaJT2gXn9PB/view?usp=share_link**
- **GITHUB LINK: https://github.com/IBM-EPBL/IBM-Project-12695-1659457983**