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

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1.Introduction:

1.1 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 convolution al 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 Problem Statement:

2.2.1 Patient Problem Statement:

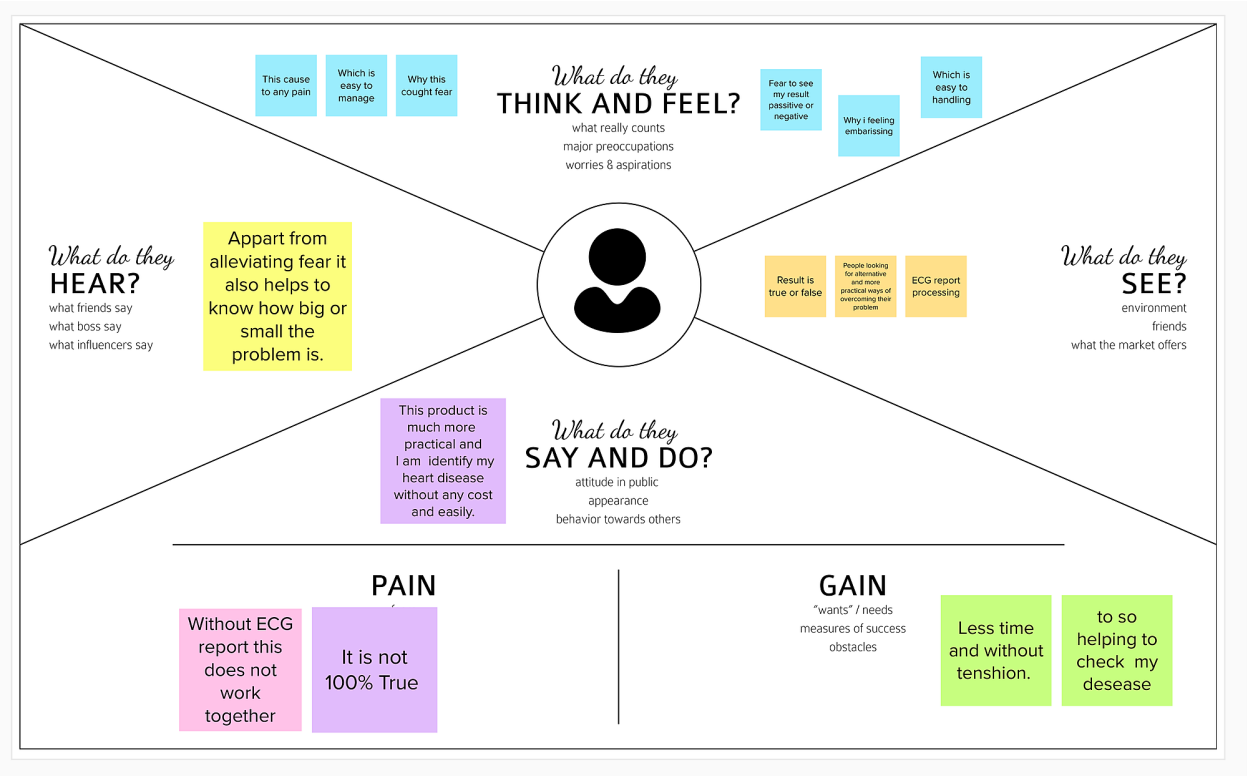
Mr .Bhargav has affect by heart disease he can't identify his disease and what type his have. After he taking ECG report but he cannot identify his problem was severely affecting some heart problems and types.

2.2.2Doctor Problem Statement:

Doctors may not assume the perfect solution for the patient. They did not identify the solution and the have lots of work so there will be not doing some of the small times. And its gives frustrated mental pressure. It takes lot of time to find accurate solution. But doctors face issues on more patient in emergency situation occurs regarding patient count , they are confusing which one to give the first preference.

3. Ideation & proposed solution:

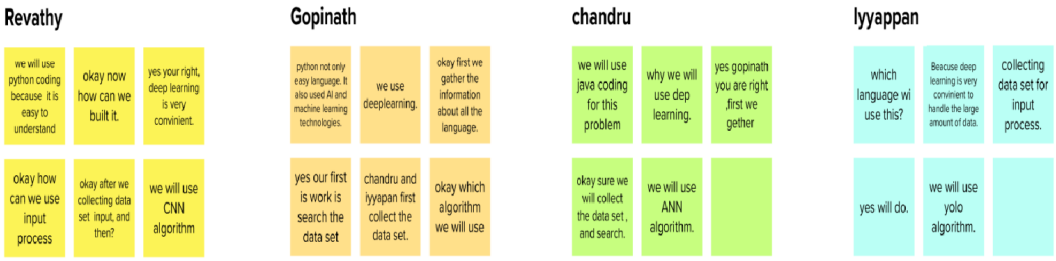
3.1 Empathy Map Canvas:



3.2 Ideation & Brainstorming :

We connecting with each other, consult and take decision for which kind of data types , and input process types we doing and selecting method. Our team members shared their own points and ideas we take his ideas and fixed this .

we four are comparing together and consulting there own individual opinion and we gave the performance to own team members to taking deision.



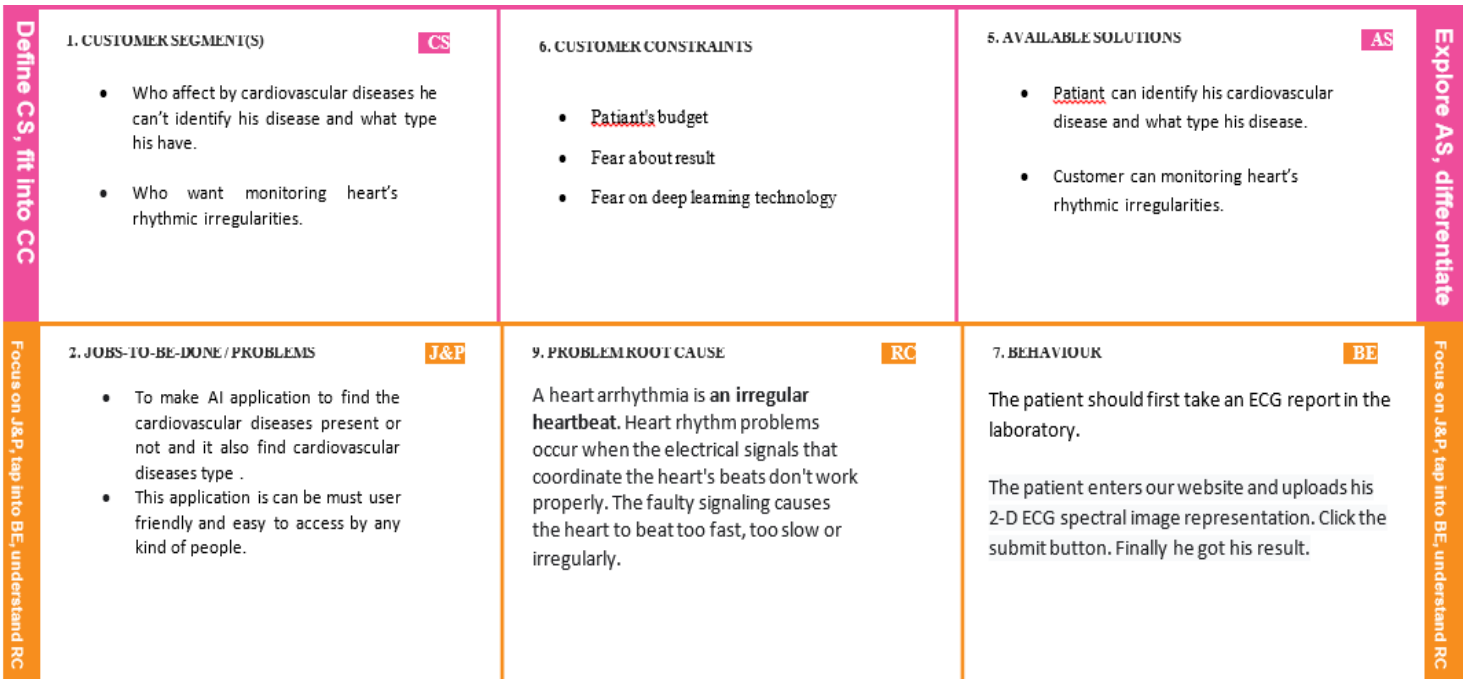
3.2.1 Idea prioritation:

we gave the individual performance to all the team members and take decision each and collaborate with each other . To input process and output process we give the priority to our team members ideas.

3.3 Proposed solution:

S.No	Parameter	Description
1.	Problem Statement (Problem to be solved)	The Patient affect by cardiovascular diseases he can't identify his disease and what type his have. After he taking ECG report but he cannot identify his problem was severely affecting some heart problems and types.
2.	Novelty / Uniqueness	Spectrograms (2-D images) are employed, which are generated from the 1-D ECG signal using STFT. A state-of-the-art performance was achieved in ECG arrhythmia classification by using the proposed CNN-based method with 2-D spectrograms as input.
3.	Social Impact / Customer Satisfaction.	An accurate taxonomy of ECG signals is extremely helpful in the prevention and diagnosis of cardiovascular diseases
4.	. Business Model (Revenue Model)	Patient may need further monitoring of his heart using Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image Representation
5.	Scalability of the Solution	100% prediction is impossible. But in this system can provide 87% or above accuracy.
6.	Scalability of the Solution	100% prediction is impossible. But in this system can provide 87% or above accuracy.

3.4 Problem Solution fit:



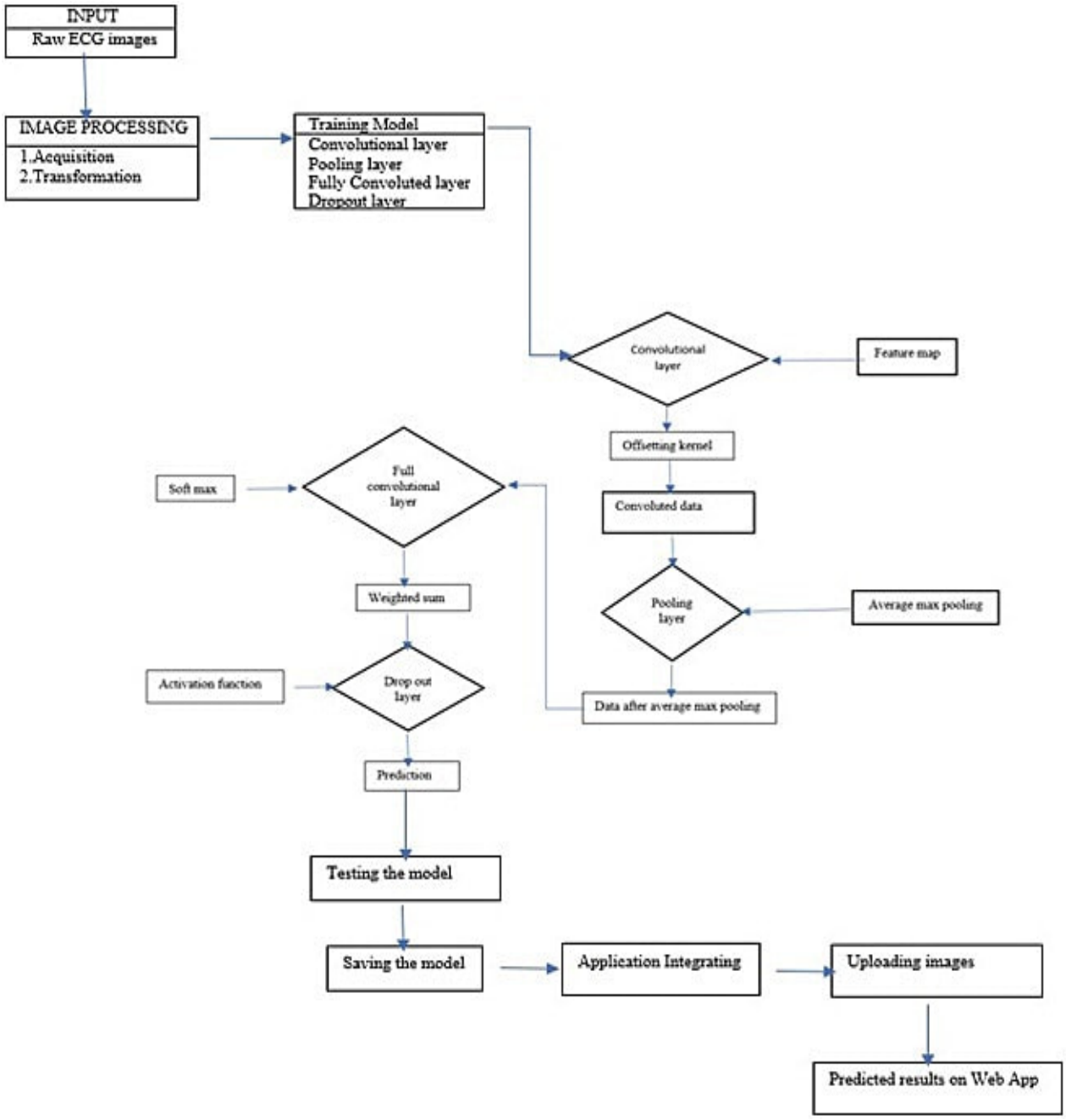
4. Requirement Analysis:

- Install Anaconda python and Jupiter notebook,
- Python Package installations for Machine Learning and Deep Learning
- Anaconda Navigator
- JupyterLab
- Jupyter Notebook
- QtConsole
- Glueviz
- Orange
- Rstudio
- Visual Studio Code .

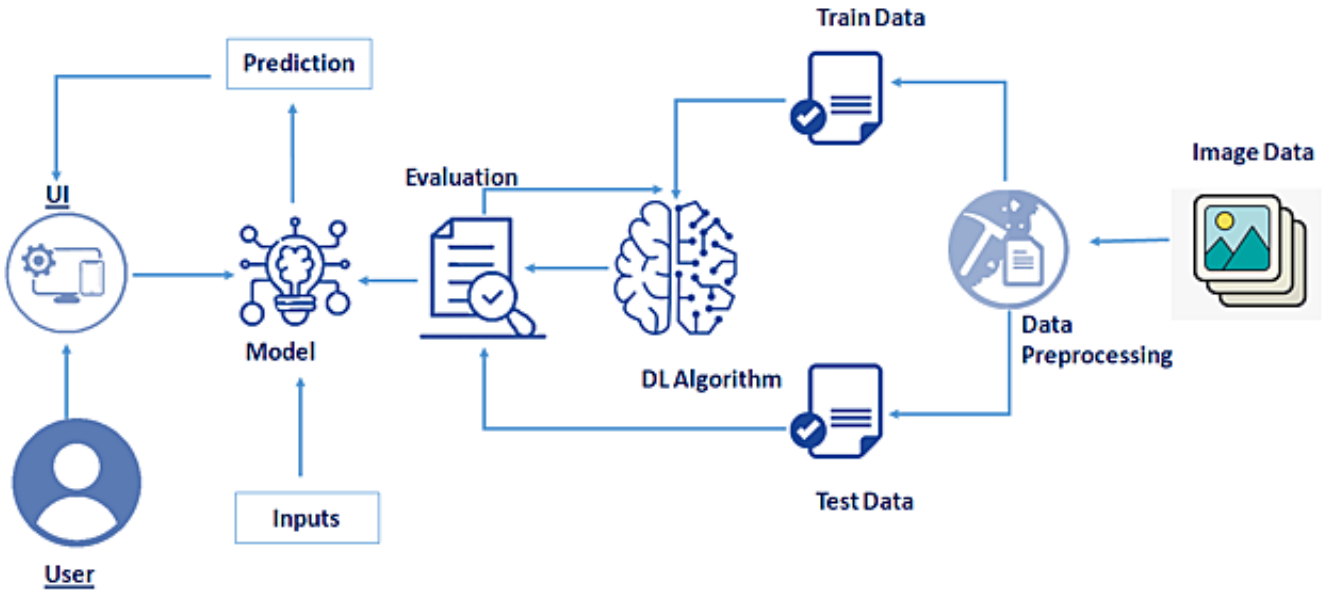
5. Project design:

5.1 Data flow diagram:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



5.2 Solution & Technical Architecture:



5.3 User stories:

- As a user, I can enter into the application by click link.
- As a user, I can upload an image by clicking upload button then select my image after clicking submit button.
- As a user, I can predict the result by clicking predict button.

6. Project planning and \scheduling:

6.1 Sprint Delivery Schedule:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Dataset Collection	NIL	Task : Dataset Collection for Classification of Arrhythmia by Using Deep Learning with 2-DECG Spectral Image Representation	2	High	1
Sprint-1	Image Preprocessing	NIL	Task : Image Preprocessing i.e Configure the Image width,height, horizontal flip,vertical flip,rotates via the rotation range, brightness via the brightness range, zooms via thezoom range.	1	High	1
Sprint-2	Model Building	NIL	Task : the augmented and pre-processed image data, Lets begin our model building.	2	High	2

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Application Building	NIL	Task: building a web application that is integrated into the model we built.	2	Medium	2
Sprint-3	Enter into the application.	USN-1	As a user, I can enterinto the application byclick link.	1	High	
Sprint-3	upload an image	USN-2	As a user,I can upload an image by clickingupload button then select my image after clicking submit button.	0	High	
Sprint-3	Predict the Result	USN-3	As a user, I can predict the result by clickingpredict button.	0	High	
Sprint-3	Train The Model OnIBM	NIL	Train The ModelOn IBM	2	High	3

7. Coding and Sheduling

7.1 Html home page code

```
<!DOCTYPE html>
<html>
<head>
<meta charset="UTF-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<meta name="viewport" content="device-width,initial-scale=1.0">
<link rel="stylesheet" href="/static/home_style.css">
</head>
<body>
<div id="header">
        <ul>
```

```
        <li><a href="/">Home</a></form></li>
        <li><a href="/info">Info</a></form></li>
<li><a href="/predict">Predict</a></form></li>
        </ul>
</div>

<div id="container">
        <div id="content">
        <h1 class="title">Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral <br>Image Representation</br></h1>
        <p class="para1">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>
```

7.2 Html info page code

```
<!DOCTYPE html>
<html>
<head>
<title>info</title>
<meta charset="UTF-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<meta name="viewport" content="device-width,initial-scale=1.0">
<link rel="stylesheet" href="/static/info_style.css">
</head>
<body>
<div class="header">
<ul>
        <li><a href="/">Home</a></form></li>
        <li><a href="/info">Info</a></form></li>
<li><a href="/predict">Predict</a></form></li>
</ul>
</div>

<section class="sec1">
        <div class="content">
                <h1>ECG</h1>
                <p>An electrocardiogram (ECG or EKG) records the electrical signal
                from the heart to check for different heart conditions. </P>
                <p>An electrocardiogram records the electrical signals in the heart.
                It's a common and painless test used to quickly detect heart
                problems and monitor the heart's health.

                An electrocardiogram — also called ECG or EKG — is often
                done in a health care provider's office, a clinic or a hospital room.
                ECG machines are standard equipment in operating rooms and
ambulances.
                Some personal devices, such as smartwatches, offer ECG monitoring.
```

Ask your health care provider if this is an option for you.

</section>

<section class="sec7">

<h1>Normal</h1>

Arrhythmia is an abnormal rhythm of the heart. The only normal rhythm of the heart is a normal sinus rhythm. In this rhythm, an impulse is generated in the sinoatrial (SA) node, which is conducted through and slowed down while passing through the atrioventricular node (AV). It is then conducted through the bundle of His, to the left and right bundle branches, and eventually into the Purkinje fibers. Any deviation from this conduction pathway results in arrhythmia. Arrhythmias can be classified based on various criteria. The most common way to categorize them is based on the rate of conduction as bradyarrhythmia with a heart rate of fewer than 60 beats per minute (bpm) and tachyarrhythmia with a heart rate higher than 100 bpm.

</section>

<section class="sec2">

<h1>Left Bundle Branch Block</h1>

Left bundle branch block sometimes makes it harder for the heart to pump blood efficiently through the circulatory system.

Most people don't have symptoms. If symptoms occur, they include fainting or a slow heart rate.

If there's an underlying condition, such as heart disease, that condition needs treatment. In patients with heart failure, a pacemaker can also relieve symptoms as well as prevent death.

</section>

<section class="sec3">

<h1>Premature Atrial Contraction</h1>

What are premature atrial contractions? Premature atrial contractions (PACs) are extra heartbeats that start in the upper chambers of your heart. When the premature, or early, signal tells the heart to contract, there may not be much

blood in the heart at that moment. That means there's not much blood to pump out

</section>

<section class="sec4">

<h1>Premature Ventricular Contractions</h1>

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.

</section>

<section class="sec5">

<h1>Right Bundle Branch Block</h1>

Right bundle branch block is a problem with your right bundle branch that keeps your heart’s electrical signal from moving at the same time as the left bundle branch. Instead of moving together on the left and right sides, the signal on the right side is running behind. This creates an irregular heartbeat. Usually, the problem isn’t serious.

</section>

<section class="sec6">

<h1>Ventricular Fibrillation</h1>

Ventricular fibrillation is a type of irregular heart rhythm (arrhythmia). During ventricular fibrillation, the lower heart chambers contract in a very rapid and uncoordinated manner. As a result, the heart doesn't pump blood to the rest of the body.

</section></body></html>

7.3 Html predict page code

```
<!DOCTYPE html>
<html>
<head>
<link rel="stylesheet" href="/static/predict_style.css">
</head>
<body>
<div img id="bg-image" ></div>

<div id="header">
<ul>
<li><a href="/">Home</a></form></li>
            <li><a href="/info">Info</a></form></li>
<li><a href="/predict">Predict</a></form></li>
</ul>
</div>
<h1>try to success</h1>
<div id="container">
<form action="/predict" , method="post" enctype="multipart/form-data">
<p><input type="file" id="file_upload" name="imagefile" onchange="loadFile(event)"></p>
<p><imgsrc="{{path}}"id="output" width="200" /></p>
<input type="submit" class="predict_bt" value="Predict">
</form></div>
   {% if predition %}
<center><p id="result"> The Result is :  <b>  {{predition}}</b></p></center>
   {% endif%}
<script>
varloadFile = function(event) {
var image = document.getElementById('output');
image.src = URL.createObjectURL(event.target.files[0]);
      };</script></body></html>
```

8.Testing:

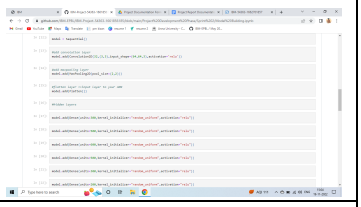
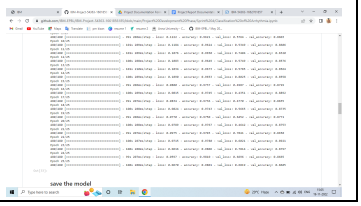
8.1 User accseptance testing:

Resolution	Severity1	Severity2	Severity3	Severity4	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'tFix	0	5	2	1	8
Totals	24	14	13	26	77

Section	TotalCases	Not Tested	Fail	Pass
PrintEngine	7	0	0	7
ClientApplication	51	0	0	51
Security	2	0	0	2
OutsourceShipping	3	0	0	3
ExceptionReporting	9	0	0	9
FinalReportOutput	4	0	0	4
VersionControl	2	0	0	2

9.Results:

Model Performance Testing:

S.No.	Parameter	Values	Screenshot
1.	Model Summary	-	
2.	Accuracy	Training Accuracy - 0.8578 Validation Accuracy -0.7821	

10. Advantages & Disadvantages

10.1 Advantages

- Patient can easily identify his disease and problems.
- It will happened on fraction of seconds.
- They will including a single ecg pic can find the problem easily.
- Low time consumption.
- low cost.

10.2 Disadvantages

- when the patient did not take the ECG report the would not able to chech it.
- The prediction accuracy is not possible in 100 percent.

11. Conclusion

In this study, we proposed a 2-D CNN-based classification model for automatic classification of cardiac arrhythmias using ECG signals. An accurate taxonomy of ECG signals is extremely helpful in the prevention and diagnosis of CVDs. 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 eight kinds of arrhythmia, namely, NOR, VFW, PVC, VEB, RBB, LBB, PAB, and APC, and it achieved 97.91% average sensitivity, 99.61% specificity, 99.11% average accuracy, and 98.59% positive predictive value (precision). 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 CVDs.

12. Future scope

- We will searching about the arrythmia without using image of ECG report.
- Improve our model without errors and improve accuracy of results

13. APPENDIX

13.1 source code

13.1.1 Python code

```
from flask import Flask,render_template,request
importnumpy as np
fromtensorflow.keras.models import load_model
fromtensorflow.keras.preprocessing import image

#import tensorflow

app = Flask(__name__)
model=load_model('model.h5')
@app.route('/',methods=['GET'])
def home():
        returnrender_template('home.html')
@app.route('/info',methods=['GET'])
def info():
```

```
        returnrender_template('info.html')
@app.route('/predict',methods=['GET'])
defhello_world():
returnrender_template('predict.html')
@app.route('/predict',methods=['GET','POST'])
def predict():
        ifrequest.method=='POST':
                imagefile=request.files['imagefile']
                image_path="./static/images/" +imagefile.filename
                imagefile.save(image_path)

                img=image.load_img(image_path,target_size=(64,64))
                x=image.img_to_array(img)
                x=np.expand_dims(x,axis=0)

                pred = model.predict(x)
                print("prediction",pred)

                class_name=["Left Bundle Branch Block","Normal","Premature Atrial
Contraction","Premature Ventricular Contractions","Right Bundle Branch
Block","Ventricular Fibrillation"]
                pred_id = pred.argmax(axis=1)[0]
                result = str(class_name[pred_id])
                returnrender_template('predict.html',predition=result,path=image_path)
        returnrender_template('predict.html')



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

13.2 GitHub & Project Demo Link

GitHub link : https://github.com/IBM-EPBL/IBM-Project-54363-1661856185

Project Demo Link : https://youtu.be/oFoL5riq-GY

Source code link : final project folder link

AI model link : AI_model_link