Arrhythmia Detection Using Deep Learning With 2-D spectrum image Representation

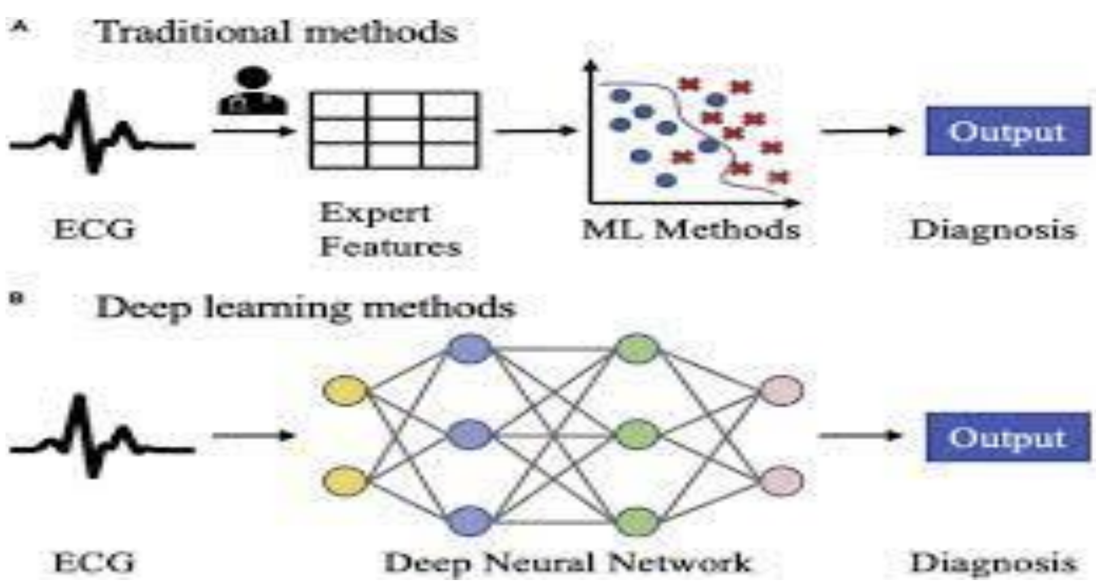
1. INTRODUCTION

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 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

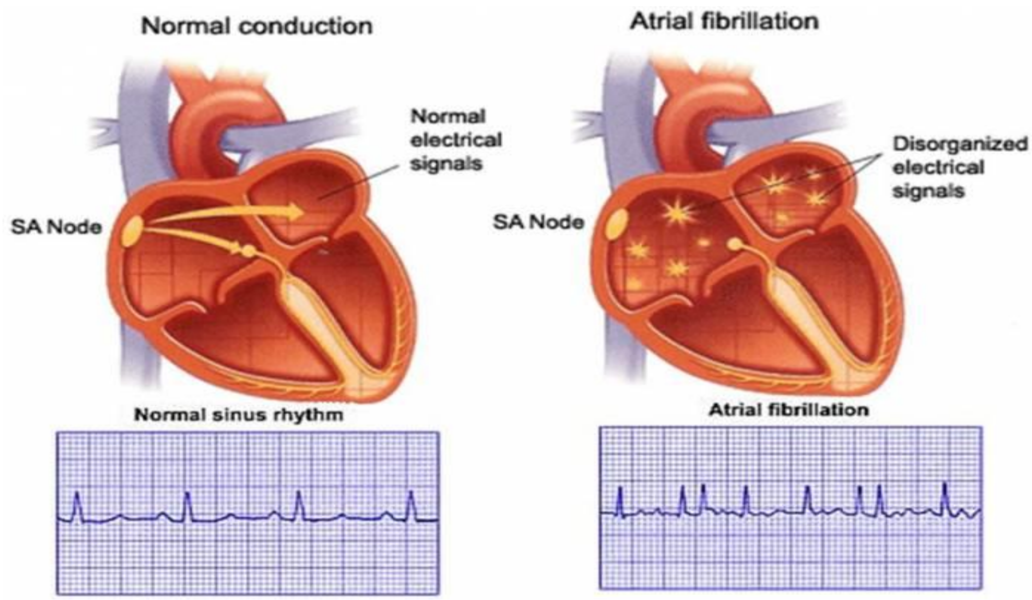
In the past few decades, Deep Learning has proved to be a compelling tool because of its ability to handle large amounts of data. The interest to use hidden layers has surpassed traditional techniques, especially in pattern recognition. One of the most popular deep neural networks is Convolution al Neural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



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

Topic	Authors	Published Year	Abstract
Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image Representation	Amin Ullah,Syed Muhammad Anwar,Muhammad Billal,Raja Mehmood	2020	In this study they have proposed a two-dimensional(2D) convolutional neural network (CNN) model for the classification of ECG signals into the eight classes. The eight classes are the normal beat, premature ventricular contraction beat, paced beat, right bundle branch block beat, left bundle branch block beat, atrial premature contraction beat, ventricular flutter wave beat and ventricular escape beat. The proposed CNN classifier was implemented in Python with the open-source library Tensor Flow which was developed by Google for deep learning. This research paper uses only a single-lead ECG signal.
Cardiac Arrhythmia Detection from 2D	E. Izci, M. A. Ozdemir, M. Degirmenci and A.	2019	In this research paper, they proposed a deep learning approach using convolutional neural

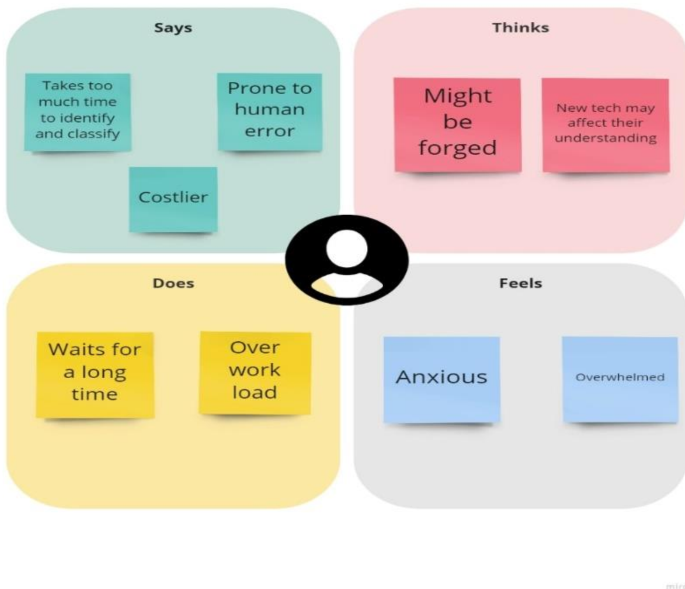
ECG Images by Using Deep Learning Technique	Akan		network for classifying the five different types of arrythmia disease. They segmented the heartbeats out of the ECG radio signals and all the images are converted into grayscale images. They implemented novel preprocessing, extraction and selection. They achieved an accuracy of 97.52%
Cyberbullying Detection Using Machine Learning	Aaminah Ali, Adeel M.Syed	2020	In this study they used numeric data for training, So the text was first converted into the numerical form using a label encoder. After that, the dataset divided into 80% training set, and 20% test and then classification algorithms were applied. The algorithms were used in classification are SVM, naïve Bayes, Random Forest and then an ensemble approach. The ensemble approach was a hybrid model, In this approach, a soft voting criterion was used. Which predicts the class label utilizing the maximum sum of the predicted probabilities.
Social Media Cyberbullying Detection using Machine Learning	John Hani , Mohamed Nashaat , Mostafa Ahmed	2019	In this research paper, they have proposed an approach to detect cyberbullying using machine learning techniques. And they evaluated their model on two classifiers SVM and neural network and they used TFIDF and sentiment analysis algorithms for features extraction. The dataset has been taken from Kaggle. Thus, a larger cyberbullying data is needed to improve the performance. Hence, deep learning techniques will be suitable in the larger data as they are proven to outperform machine learning approaches over larger size data.

2.3 Problem Statement Definition

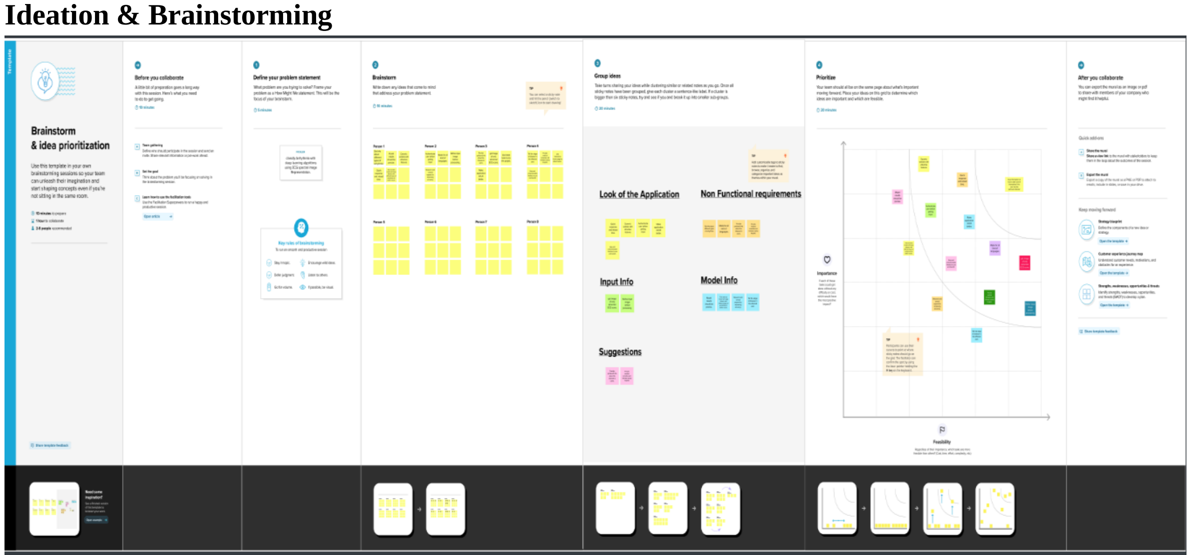
The presented problem wants us to identify and classify the types of Arrhythmias provided in the dataset using spectral images of the Electrocardiogram that are employed for prediction of cardiovascular diseases

3. IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



3.2 Ideation & Brainstorming



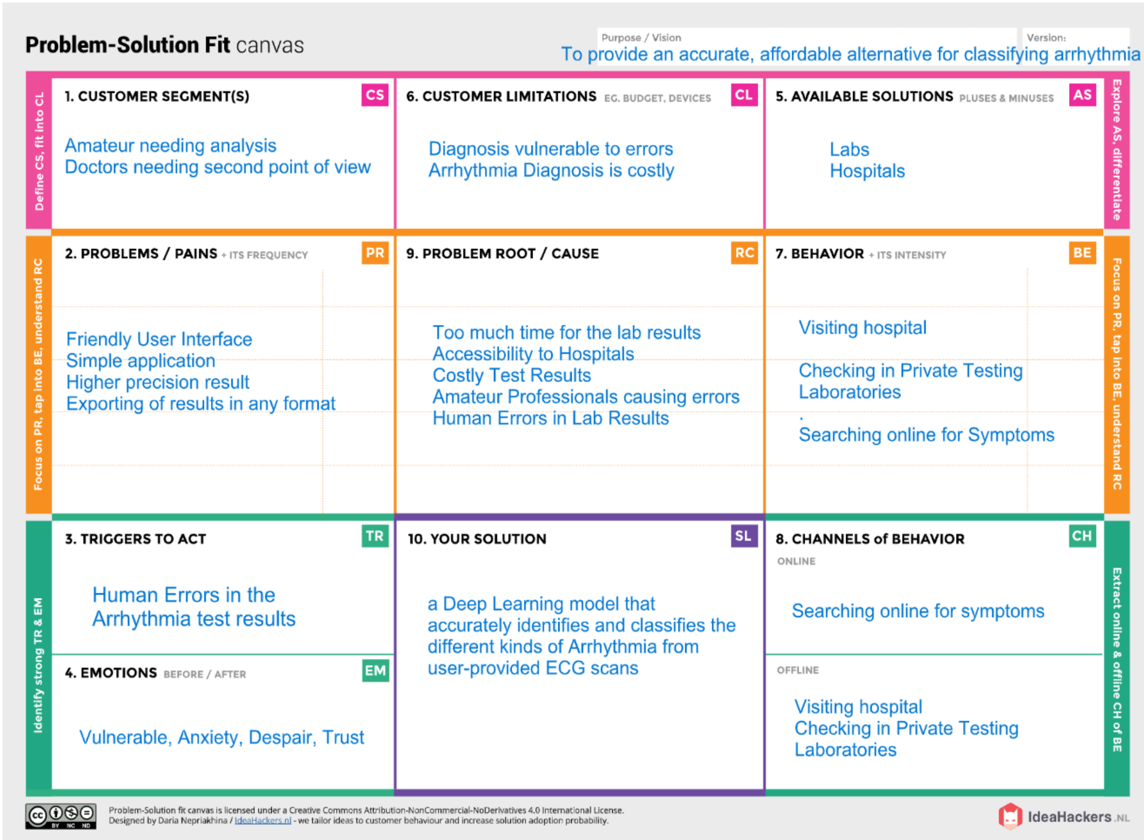
3.3 Proposed Solution

S.No.	Parameter	Description

1.	Problem Statement (Problem to be solved)	The presented problem wants us to identify and classify the types of Arrhythmias provided in the dataset using spectral images of the Electrocardiogram that are employed for prediction of cardiovascular diseases.
2.	Idea / Solution description	The given dataset for this problem initially undergoes various data pre-processing steps to identify various forms of noise in the dataset and denoise them to make the data suitable for training a deep learning model. We will employ 2-Dimensional Convolutional Neural Network Model to carry out this classification.
3.	Novelty / Uniqueness	• Deploys the model to a mobile application by assigning all heavy pre-processing to the cloud through an API. • Usage of cloud-based ML-training services. • Proposed solution will be deployed in the cloud making it easily accessible over the internet to people across the globe. • Provide well detailed instructions or point the user to well-equipped hospitals to get good treatment.
4.	Social Impact / Customer Satisfaction	• Promotes Simplicity. • Promotes Self-Diagnosis. • Requires minimal effort and time. • Proposed solution abides by privacy laws and no private information of user is stored. • Delivers highly accurate results(classification of arrhythmia) in a short span of time.
5.	Business Model (Revenue Model)	• Our business model primarily covers the expense we incur by deploying the service in cloud platforms.

		• Primary consumers of our proposed service are hospitals who seek immediate consultation or use our service as a reference. • Our service can be used by anybody who has access to internet services. • Most of the competing products do not offer a Revenue is generated from Corporate Editions which has a monthly subscription, whereas the Community Edition is free for individuals. • Users who would like to not travel to hospitals to get an ECG or get a selfdiagnosis can rent/buy an ECG Machine through our service which will be the secondary source of income.
6.	Scalability of the Solution	• Increasing the dataset used for model training will in turn increase the application's scalability. • Making the model more reliable will lead to hospitals using this application, this also eliminates human error. • More powerful Cloud Instances for Concurrent use of the application. • Periodically expanding the dataset and updating the model to increase scalability and reliability. • Cloud services guarantee high availability so there is very little probability that the service will face serious down times.

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-I	User Registration	registration on a website utilising an email address for confirmation
FR-2	User Confirmation	OTP verification on the webpage
FR-3	User Data	uploading the ECG image used to diagnose arrhythmias
FR-4	User Diagnosis Results (Single Input)	The website displays the results of the arrhythmia prediction and classification.
FR-5	User Diagnosis Results (Multiple Input)	The Arrhythmia Prediction & Classification results are emailed to the registered email.

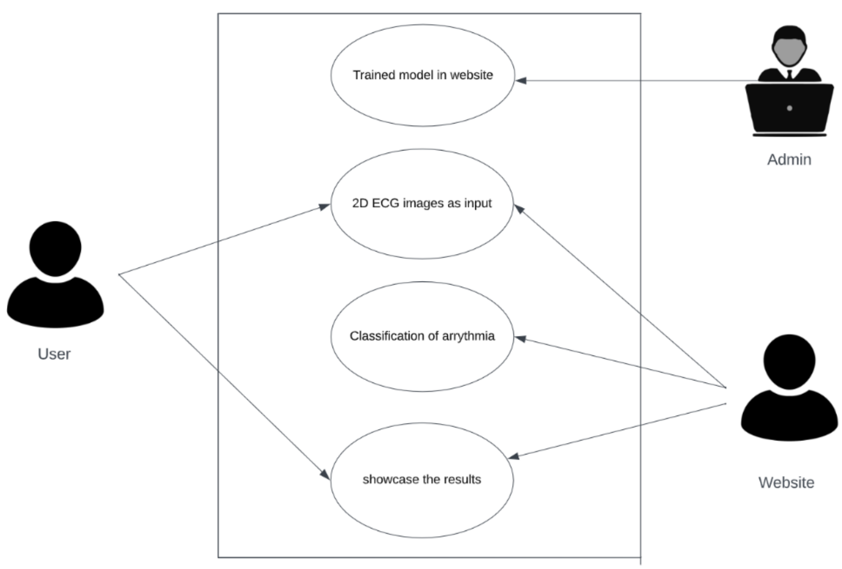
4.2 Non-Functional requirements

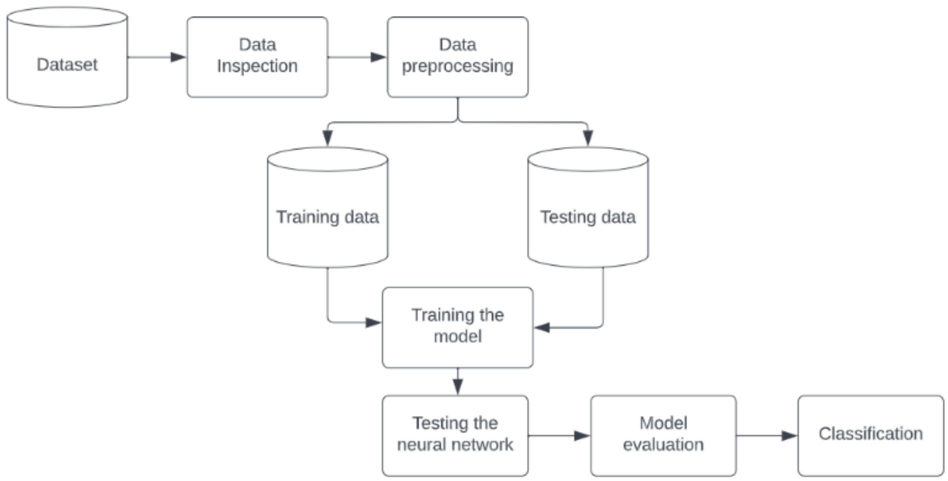
Following are the non-functional requirements of the proposed solution.

NFR No.	Non-Functional Requirement	Sub Requirement (Story/Sub-Task)
NFR-I	Reliability	Probability of successful operations in each environment for a certain period of time
NFR-2	Scalability	The website's ability to accommodate expansion
NFR-3	Security	Authentication and Authorization of the website
NFR-4	Usability	efficient and overall user satisfaction with the diagnosis service provided by the website
NFR-5	Availability	All users should be able to access the service easily.

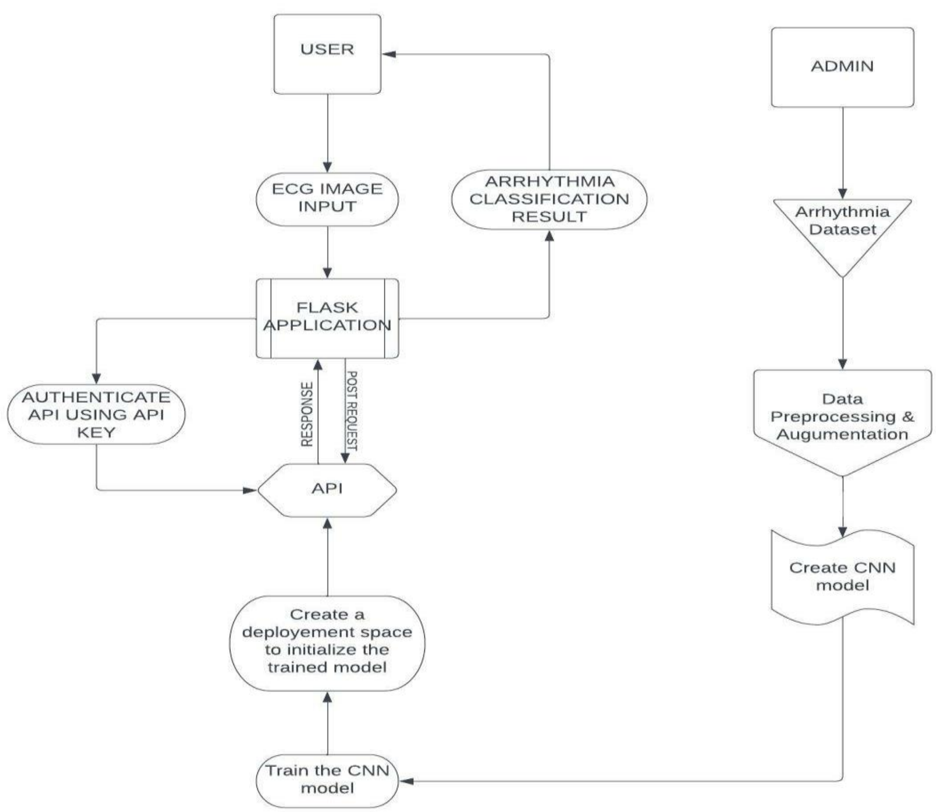
5. PROJECT DESIGN

5.1 DataFlowDiagrams





5.2 Solution & Technical Architecture



5.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story/Task	Acceptance Criteria	Priority	Release
Customer (Web User)	Registration	USN-1	As a user I can register an account on the website	I can access classification page	High	Sprint-1
	Login	USN-2	As a user I can login into the website using credentials	I can access classification page	High	Sprint-1
	Arrhythmia Classification page	USN-3	User uploads the data	Input for the model	High	Sprint-1
	Info page	USN-4	Info page displays information about Arrhythmia	User can learn about Arrhythmia	Medium	Sprint-2

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation

Title	Description	Date
Literature Survey and Information Gathering	Technical papers were referred to gather information	10 September 2022
Prepare Empathy Map	Problem statement was addressed by considering user pain and gain	17 September 2022

Ideation	Determine the importance and viability of the top three concepts.	18 September 2022
Proposed Solution	organizational innovation, scalability, and business the solution's model, economic effect, and scalability	1 October 2022
Problem Solution Fit	Document-fitting solution	1 October 2022
Solution Architecture	Structure of the Solution	1 October 2022
Customer Journey	to comprehend user interactions and application experiences	8 October 2022
Functional Requirement	To comprehend user needs and create functional requirements	9 October 2022
Data flow Diagrams	Data flow diagram	11 October 2022
Technology Architecture	Technology Architecture diagram	15 October 2022
Milestone & sprint delivery plan	Activity what we done &further plans	21 October 2022
Project Development-Delivery of sprint 1,2,3 &4	Submission of code after testing using software	24 October 2022 – 19 November 2022

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

7.1 Application Building

We created a website using HTML, CSS which helps the user to classify the type of arrhythmia by inputting their ECG image into the website. Flask was also used to render our HTML files and also to integrate our model to the website which helps in classification of the disease.

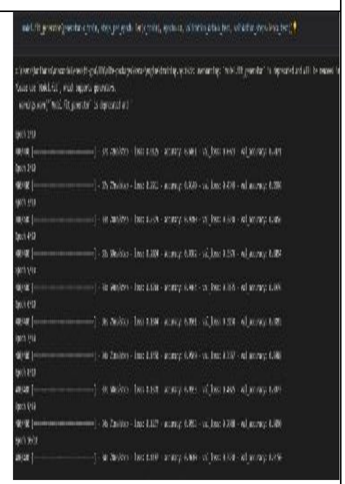
7.2 Model Building

Model Building is one of the most important parts of the application which helps to classify the arrhythmia disease. We imported various packages and libraries such as TensorFlow, Pandas, NumPy, etc. for data manipulation and pre-processing. Dataset was taken from Kaggle and we trained and tested using ImageDataGenerator.

We used the Sequential CNN (Convolution Neural Network) model as our classifying model which had 2 hidden layers. Model was made to run a total of 10 epochs for higher accuracy and we attained an accuracy of 92% which is a very high accuracy for disease prediction

8. RESULTS

8.1 Performance Metrics

S. No.	Parameter	Values	Screenshot
1.	Metrics	**Regression Model:** MAE - , MSE - , RMSE - , R2 score - **Classification Model:** Confusion Matrix - , Accuray Score- & Classification Report -	

9. ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- Very fast and time-efficient
- Easy to access and communicate
- Cost-efficient

DISADVANTAGES:

- Low chance of error in classification
- No emotion in conveying the result

- Requires good internet access for accessing the website which may not be available in an urgent situation

10. CONCLUSION

Application was built using various web technologies such as HTML, CSS, Flask, etc and model was also build using Machine Learning Techniques such as Data Preprocessing and model building using TensorFlow and other packages to classify arrhythmia accurately and time-efficiently.

11. FUTURE SCOPE

This application can help other classification of diseases much more easier as it is nearly equivalent to this application and can further be researched to improve accuracy and other metrics.

12. APPENDIX

Source Code

Model code

```
from keras.preprocessing.image import ImageDataGenerator
import numpy as np
import tensorflow as tf
import PIL
from PIL import Image
from tensorflow.keras import datasets, layers, models
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers
from tensorflow.keras.layers import Dense,Flatten
from tensorflow.keras.layers import Conv2D,MaxPooling2D
train_datagen= ImageDataGenerator(rescale=1./255, shear_range=0.2,
zoom_range=0.2, horizontal_flip= True)
test_datagen= ImageDataGenerator(rescale=1./255)

import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

# @hidden_cell
```

```
# The following code accesses a file in your IBM Cloud Object Storage. It
includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='mN-ebj9Okze1dUnk6NRehD1nG6pbj_9LEkFJyxCLIMg8',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'arrhythmiaclassification-donotdelete-pr-4avxy8o7d2xjtk'
object_key = 'Classification of Arrhythmia by Using Deep Learning with 2-D ECG
Spectral Image Representation.zip'

streaming_body_3 = cos_client.get_object(Bucket=bucket, Key=object_key)['Body']

# Your data file was loaded into a botocore.response.StreamingBody object.
# Please read the documentation of ibm_boto3 and pandas to learn more about the
possibilities to load the data.
# ibm_boto3 documentation: https://ibm.github.io/ibm-cos-sdk-python/
# pandas documentation: http://pandas.pydata.org/

from io import BytesIO
import zipfile
unzip = zipfile.ZipFile(BytesIO(streaming_body_3.read()),'r')
file_paths= unzip.namelist()
for path in file_paths:
    unzip.extract(path)
import os
filenames=os.listdir('/home/wsuser/work/Classification of Arrhythmia by Using
Deep Learning with 2-D ECG Spectral Image Representation/Dataset')
filenames
x_train=train_datagen.flow_from_directory(directory=r'/home/wsuser/work/Classific
ation of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image
Representation/Dataset/train', target_size=(64,64), batch_size=32,
class_mode='categorical')
x_test=train_datagen.flow_from_directory(directory=r'/home/wsuser/work/Classifica
tion of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image
Representation/Dataset/test', target_size=(64,64), batch_size=32,
class_mode='categorical')
model=models.Sequential()
model.add(layers.Conv2D(32,(3,3), input_shape=(64, 64, 3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))

model.add(layers.Conv2D(32,(3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
```

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

model.add(Dense(32))
model.add(Dense(6, activation='softmax'))

model.summary()
model.compile(optimizer='adam', loss='categorical_crossentropy',
metrics=['accuracy'])
model.fit_generator(generator=x_train, steps_per_epoch=len(x_train), epochs=10,
validation_data=x_test, validation_steps=len(x_test))
model.save('ECG.h5')
!tar -zcvf classification-model.tgz ECG.h5
from ibm_watson_machine_learning import APIClient
wml_credentials={
    "url":"https://us-south.ml.cloud.ibm.com",
    "apikey":"ur2JUzcKDS7x3V4Y0m4sVewkTi-qifnbCQpI1t-Yf4-D"}
client=APIClient(wml_credentials)
def guid_from_space_name(client, space_name):
    space=client.spaces.get_details()
    #print(space)
    return(next(item for item in space ['resources'] if
item['entity']["name"]==space_name)['metadata']['id'])
space_uid= guid_from_space_name(client,'model_deployment')
print("Space UID -" + space_uid)
client.set.default_space(space_uid)
client.software_specifications.list(limit=100)
software_spec_uid =
client.software_specifications.get_uid_by_name("tensorflow_rt22.1-py3.9")
software_spec_uid
model_details= client.repository.store_model(model='classification-
model.tgz',meta_props={
    client.repository.ModelMetaNames.NAME:"CNN" ,
    client.repository.ModelMetaNames.TYPE:"tensorflow_2.7" ,
    client.repository.ModelMetaNames.SOFTWARE_SPEC_UID:software_spec_uid})
model_id = client.repository.get_model_uid(model_details)
client.repository.download(model_id,'my_model.tar.gz' )
from tensorflow.keras.models import load_model
from keras.preprocessing import image
import tensorflow as tf
from tensorflow import keras
model = load_model("ECG.h5")
```

```
x= image.load_img('/home/wsuser/work/Classification of Arrhythmia by Using Deep
Learning with 2-D ECG Spectral Image Representation/Dataset/train/Ventricular
Fibrillation/VFEfig_182.png',target_size=(64,64))
x= np.expand_dims(x, axis=0)
pred= model.predict(x)
pred
index=['Left Bundle Branch Bloack','Normal','Premature Atrial
Contraction','Premature Ventricular Contraction','Right Bundle Branch
Block','Ventricular Fibrillation']
result=str(index[pred[0].tolist().index(1.)])
result
```

App.py

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


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

@app.route("/") #default routC:\Users\hariharan\Documents\Projects\Untitled
Foldere
def about():
    return render_template( "about.html")
@app.route("/about")
def home():
    return render_template("about.html")

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

@app.route("/upload")
def test():
    return render_template("index6.html")

@app.route("/predict",methods=["GET","POST"])
def upload():
    if request.method=='POST':
```

```python
        f=request.files['file']
        basepath=os.path.dirname('__file__')
        filepath=os.path.join(basepath,"uploads",f.filename)
        f.save(filepath)

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

        pred=(model.predict(x) > 0.5).astype("int32")
        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].tolist().index(1.)])
        return render_template("base.html", name = result)

    return None


if __name__=="__main__":
    app.run(debug=True)
    app.run(host='127.0.0.1', port=5000)
```

GitHub & Project Demo Link

Github: https://github.com/IBM-EPBL/ECG-Project