EFFECTIVE HEART DISEASE PREDICTION USING IBM AUTO AI SERVICE

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1.ABSTRACT

In the developing age of automation, the medical field is advancing towards automatic disease detection. Globally, cardiovascular diseases (CVDs) are taking a toll on the death rate resulting in the loss of more than 17.9 million lives per year which is contributing 31% to the total mortality rate worldwide. Most commonly CVDs result in heart failure and there are nine features (Age, Average heart beats per min, BMI, Cholesterol, Exercise min per week, Family history, Palpitations per day, Sex, Smoker last 5yrs) in the collected dataset to predict the mortality due to heart failure. So far, defect detection in ECG involves human inspection and automatic detection of the CVDs remains crucial as they involve a huge set of data. To prevent the human death rate, an automatic and trusted classification system is essential to be built. As a result, effective automatic prediction of heart disease is developed for saving time and obtaining tested accuracy. The complexity and variance in heart disease create complications in ECG detection. In this project, machine learning algorithms and image classifiers are proposed to detect heart disease efficiently by overcoming the drawbacks of traditional classifiers. An automatic model is built using artificial intelligence and a web application is developed where the prediction of heart failure can be showcased. This proposed model provides an enhanced performance level with an accuracy level of 85.6% through the prediction model for heart disease with the decision tree classifier.

Keywords: IBM Watson Machine Learning , Node-RED , Cognos, heart disease prediction, prediction model, classification algorithms, cardiovascular disease (CVD), .

2. INTRODUCTION

2.1 Overview

The identification of heart disease gets tough due to numerous risk factors including high blood pressure, abnormal pulse rate, high cholesterol, diabetes and many others [9]. The severity of heart disease among mankind is discovered by using several techniques of data mining and neural networks [4, 8, 10 and 11]. Whereas, the rate of disease severity can be classified using algorithms such as, K-Nearest Neighbor Algorithm (KNN), Genetic algorithm (GA), and Naïve Bayes (NB). Data mining is used in medical science with the perspective of discovering metabolic syndromes [6]. Data mining and classification plays a significant role in predicting heart disease and data investigation [12].

2.2 Purpose

In the field of medical imaging, automated defect detection arises as an emergent field using machine learning in various applications of medical diagnostic. The heart disease detection application remains crucial since it provides insights on abnormal ECG that can be helpful in planning treatment. Recent studies in the literature have also suggested that the diagnosis of disease based on medical image analysis and automation decisions from computers could be a good alternative for saving radiologists time and obtaining a tested accuracy.

3. LITERATURE SURVEY

3.1 Existing problem

In the field of healthcare, automation of defect detection arises as an emergent field using machine learning and medical imaging [1]. Generally, the diagnosis of heart disease begins with testing the patient’s heart rhythm and electrical activity with the help of an electrocardiogram (ECG) [2 and 5]. Once the obtained result from ECG shows the presence of change in the heart concluding the disease, the echo samples are used for determining the correct classification of the heart attack [3].

3.2 Proposed solution

In the proposed system, the human-trained model is designed to detect heart disease. The dataset of the trained model consists of more than 10,800 data and the results are obtained with better accuracy. The results are collected, details are filled in and uploaded to the website from where the patients can get information regarding their heart diseases. The patient can then decide regarding further steps on surgery and medications.

4. THEORETICAL ANALYSIS

The dataset clustering is carried out based on the criteria and variables of Decision Tree (DT) features. Each clustered dataset is applied with the classifiers for estimating the performance and from the result, best performing models are identified based on the low rate of error. The DT clusters that result in producing a high rate of error are chosen and their classifier features are extracted to optimize the performance. The classifier performance is then evaluated after the error optimization.

Sl.No	Column	Type
1	AGE	"integer"
2	AVGHEARTBEATSPERMIN	"integer"
3	BMI	"integer"
4	CHOLESTEROL	"integer"
5	EXERCISEMINPERWEEK	"integer"
6	FAMILYHISTORY	"other"
7	PALPITATIONSPERDAY	"integer"
8	SEX	"other"
9	SMOKERLAST5YRS	"other"

Table 1 : Dataset nine features and type

The dataset with nine features such as age, average heartbeat per minute, BMI value, cholesterol, Exercise minutes per week, family history, palpitations per day, sex and details of being a smoker in the last 5 years along with its data types are shown in Table 1. The sample data of the patients consisting of the mentioned features can be seen in Figure 1.

	A	B	C	D	E	F	G	H	I	J
1	AVGHEARTBEATSPERMIN	PALPITATIONSPERDAY	CHOLESTEROL	BMI	HEARTFAI	AGE	SEX	FAMILYHISTORY	SMOKERLAST5YRS	EXERCISEMINPERWEEK
2	93	22	163	25	N	49	F	N	N	110
3	108	22	181	24	N	32	F	N	N	192
4	86	0	239	20	N	60	F	N	N	121
5	80	36	164	31	Y	45	F	Y	N	141
6	66	36	185	23	N	39	F	N	N	63
7	125	27	201	31	N	47	M	N	N	13
8	83	27	169	20	N	71	F	Y	N	124
9	107	31	199	32	N	55	F	N	N	22
10	92	28	174	22	N	44	F	N	N	107
11	84	12	206	25	N	50	M	N	N	199
12	60	1	194	28	N	71	M	N	N	27
13	134	7	228	34	Y	63	F	Y	N	92
14	103	0	237	24	N	64	F	Y	N	34
15	101	39	157	20	N	49	M	N	N	33
16	92	2	169	26	N	36	M	N	N	217
17	80	27	234	27	N	50	M	N	N	28
18	82	14	155	30	N	70	F	N	N	207
19	63	9	204	26	N	42	M	N	N	88
20	83	12	209	29	N	38	M	Y	N	220
21	80	37	157	20	N	48	M	N	N	54
22	83	19	223	21	N	72	M	N	N	36
23	89	35	197	20	N	64	F	N	N	84
24	69	33	183	28	N	50	F	N	N	148
25	83	37	199	25	N	43	F	N	N	248
26	96	29	229	21	N	62	M	Y	N	135
27	50	22	230	25	N	34	M	N	N	224

Figure 1: patient data v6 dataset of 10,800 data with nine features

When experimenting with the dataset, an investigation is done on what AI and ML, how to utilize the algorithms to develop a model efficiently for performing image processing. The study was mainly focused on decision trees as the solution to automate the disease detection system is based on decision trees.

Artificial Intelligence: The intelligence of humans is simulated by machines where the computer is capable of mimicking human behaviors which are termed Artificial intelligence (AI). Some of the applications include Speech Recognition, Natural Language Processing, Computer Vision, Robotics, etc.

Transfer Learning: In both data mining and machine language algorithms, there exists an assumption that training data along with its future dataset must have the same distribution and be present in the same feature space which may not be true while handling applications that use real-time data [7]. For example, A classification task may be in the domain of interest A, however sufficient training data may be in the domain of interest B which is in a different feature space or follows a different data distribution. In such situations, knowledge transfer helps in improving the learning performance and also reduces the efforts on expensive data labeling. Transfer learning has also emerged as a new learning framework in recent years addressing the relevant problems.

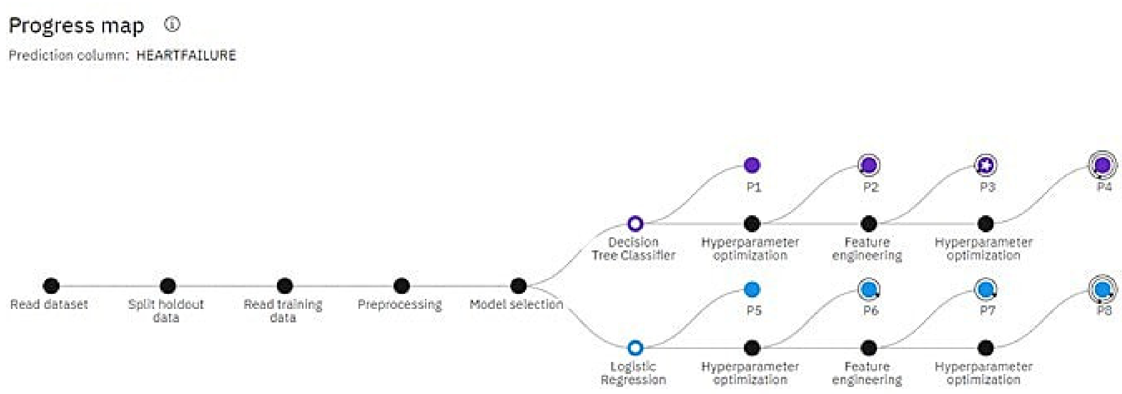

Figure – 2 Progress map of different classifiers in IBM Watson studio

The IBM Watson studio consists of various classifiers and their progress maps are visualized in Figure 2 from reading the dataset to hyper-parameter optimization.

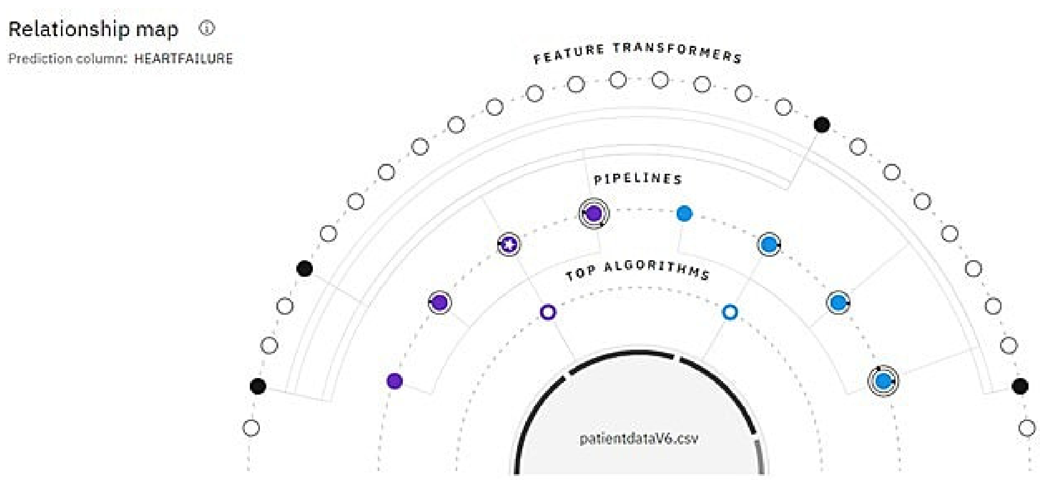

Figure – 3 Relationship map of different classifier in IBM Watson studio

The various classifiers present in the IBM Watson studio are analyzed to find the relationship among each classifier and the relationship map is shown in Figure 3.

4.2 Hardware / Software designing:

Software Requirements:

- **IBM Watson Studio**
- **IBM Watson Machine Learning**
- **Cognos**
- **Node-RED**
- **IBM Cloud Object Storage**

Technical Architecture:

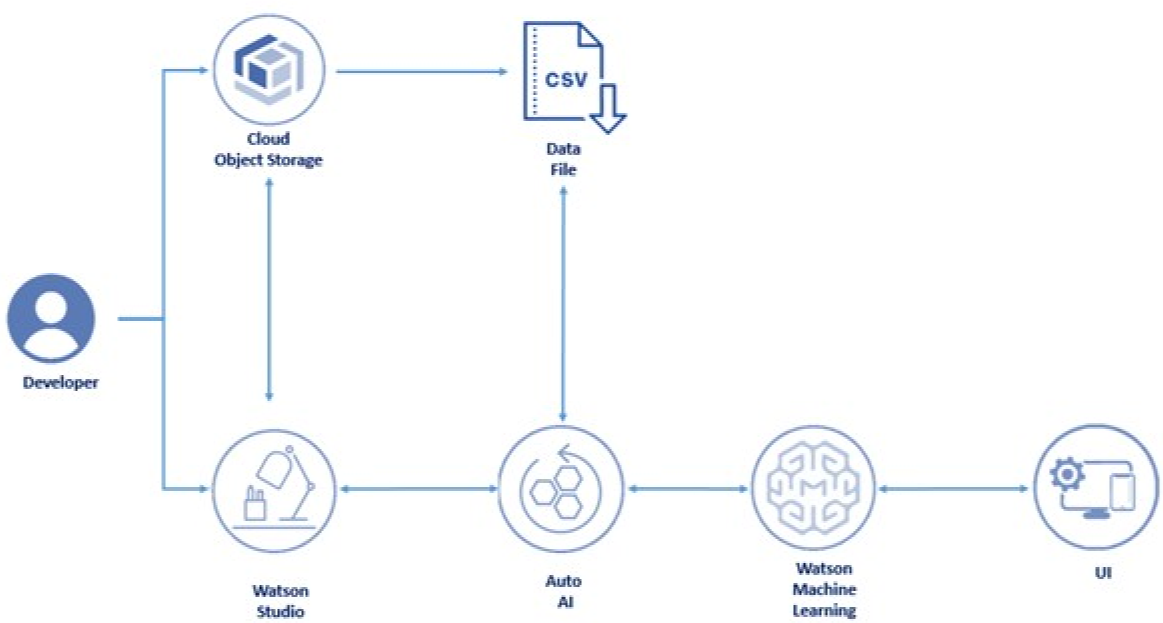

Figure 4 – Technical Architecture

The technical architecture involves various nodes and tools that are listed in Figure 4 along with the process flow of the system.

Hardware Requirements:

Processor: Intel® Core™ i3-2350M CPU @ 2.30GHz

Installed memory (RAM):4.00GB

System Type: 64-bit Operating System

5. EXPERIMENTAL INVESTIGATIONS

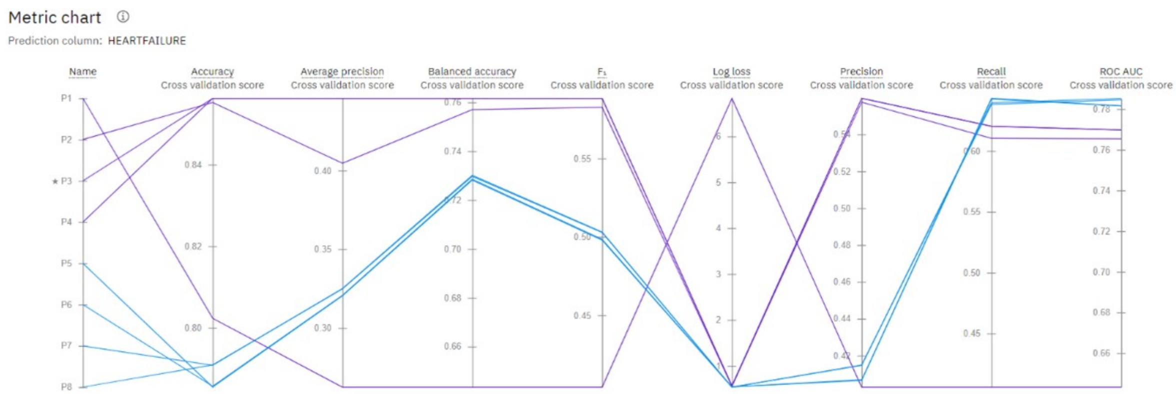

Figure 5 – Metric Chart

The metric chart as shown in Figure 5 lists the results of predicting various types of heart failures in terms of accuracy, precision, f1-score, recall, log loss and ROC AUC scores.

	Rank	Name	Algorithm	Accuracy (Optimized) Cross Validation	Enhancements	Build time
★	1	Pipeline 3	Decision Tree Classifier	0.856	HPO-1 FE	00:00:24
	2	Pipeline 4	Decision Tree Classifier	0.856	HPO-1 FE HPO-2	00:00:32
	3	Pipeline 2	Decision Tree Classifier	0.855	HPO-1	00:00:03
	4	Pipeline 1	Decision Tree Classifier	0.802	*None*	00:00:01
	5	Pipeline 8	Logistic Regression	0.791	HPO-1 FE HPO-2	00:01:19
	6	Pipeline 7	Logistic Regression	0.791	HPO-1 FE	00:00:47
	7	Pipeline 6	Logistic Regression	0.786	HPO-1	00:00:07
	8	Pipeline 5	Logistic Regression	0.785	*None*	00:00:01

Table 2 – Different Classifier Details

Table 2 details the usage of different classifiers of the algorithm in the dataset along with their accuracy, enhancements and build time.

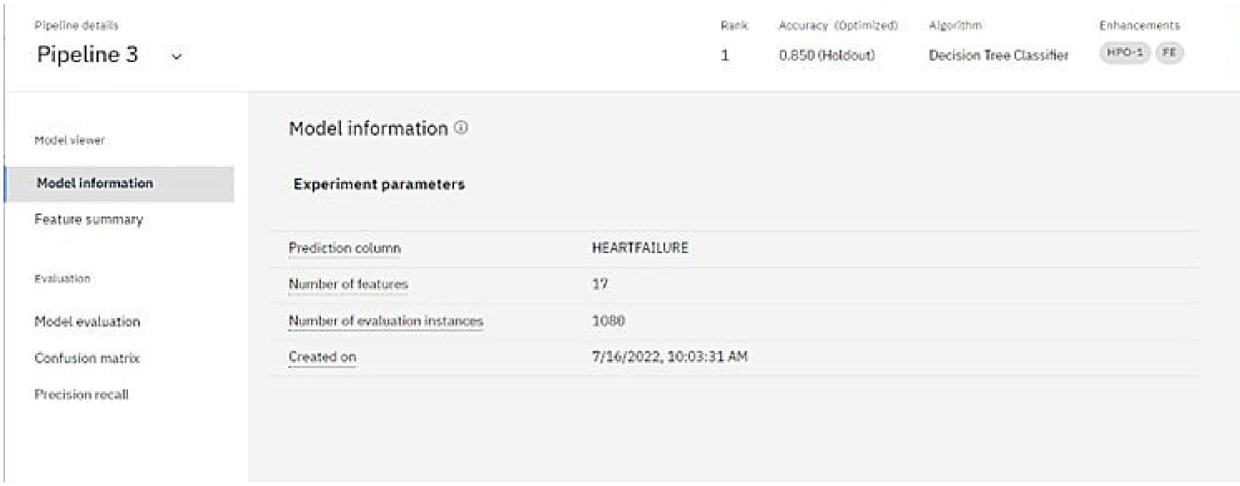

Figure 6 – Proposed Model Information

The information regarding the proposed model is expressed in Figure 6 detailing the experimented parameters.

Feature summary

High correlation

All features | Search feature or transformer names

Feature name	Transformation	Feature importance
FAMILYHISTORY	None	100.00%
BMI	None	25.00%
NewFeature_3 Most improved	sqrt(AVGHEARTBEATSPERMIN)	12.00%
NewFeature_2	square(EXERCISEMINPERWEEK)	11.00%
NewFeature_1	square(PALPITATIONSPERDAY)	9.00%
NewFeature_0	square(AVGHEARTBEATSPERMIN)	4.00%
NewFeature_4	sqrt(EXERCISEMINPERWEEK)	2.00%
AGE	None	1.00%
PALPITATIONSPERDAY	None	1.00%
SMOKERLAST5YRS	None	0.00%
CHOLESTEROL	None	0.00%
EXERCISEMINPERWEEK	None	0.00%
NewFeature_7	sqrt(square(EXERCISEMINPERWEEK))	0.00%
NewFeature_5	sqrt(square(AVGHEARTBEATSPERMIN))	0.00%
SEX	None	0.00%
NewFeature_6	sqrt(square(PALPITATIONSPERDAY))	0.00%
AVGHEARTBEATSPERMIN	None	0.00%

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Table – 3 Feature Summary

The feature summary including the feature names, transformation and their importance are discovered and listed in Table 3.

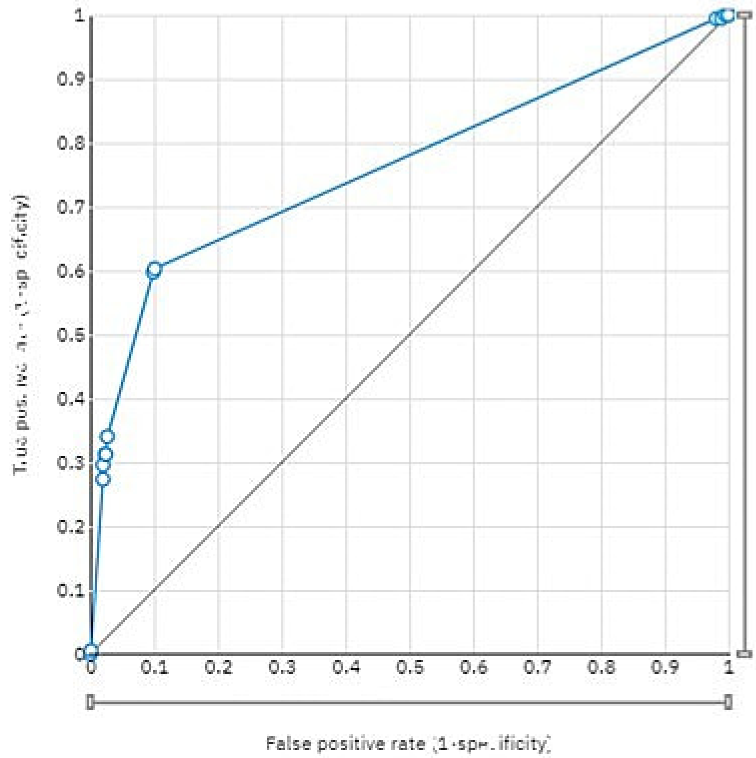

Figure 7 – ROC Curve

ROC Curve is determined in Figure 7 where the true positive rate and the false positive rate are Y-axis and X-axis respectively.

Model evaluation measure

Measures	Holdout score	Cross validation score
Accuracy	0.850	0.856
Area under ROC	0.762	0.770
Precision	0.543	0.560
Recall	0.603	0.620
F1	0.571	0.588
Average precision	0.458	0.446
Log loss	0.520	0.560

Table – 4 Model evaluation measure

The model is evaluated based on various measures of hold-out scores and cross-validation scores are listed in Table 4.

Confusion matrix

Observed	Predicted		
	Y	N	Percent correct
Y	108	71	60.3%
N	91	810	89.9%
Percent correct	54.3%	91.9%	85.0%

Less correct — More correct

Figure – 8 Confusion Matrix

The confusion matrics consist of true positive, false positive, true negative and false negative counts of the data in the dataset are shown in Figure 8.

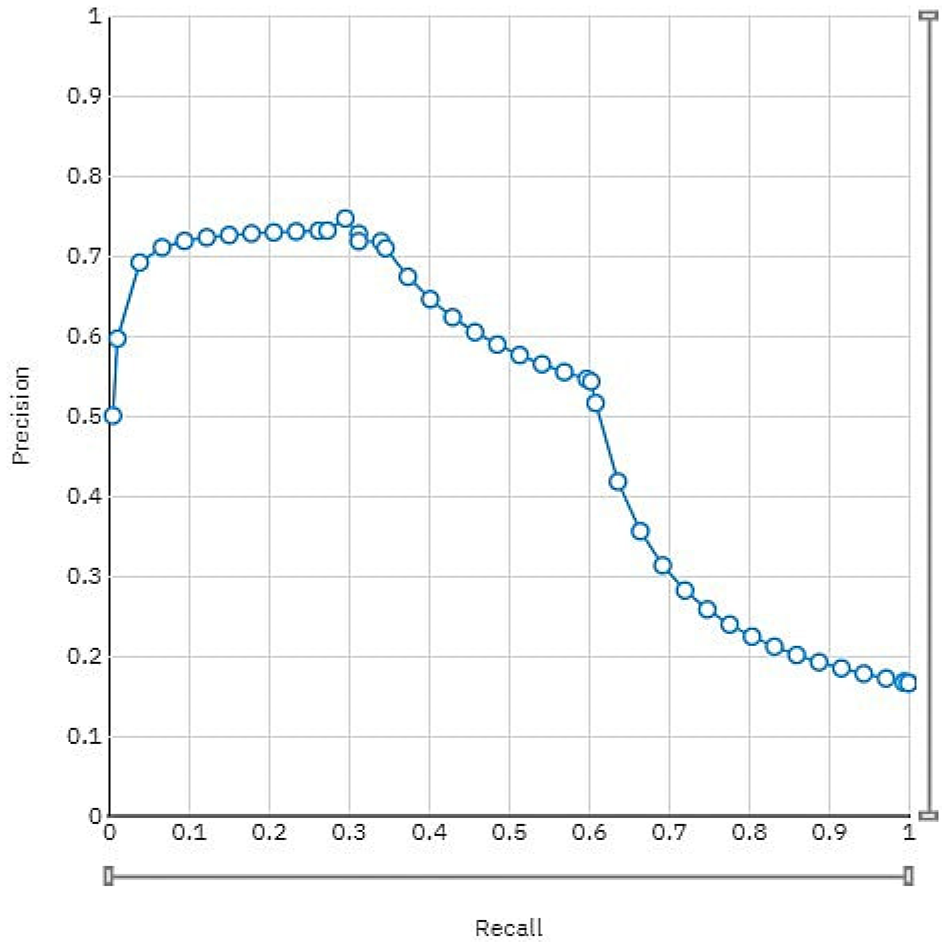

Figure 9 Precision and Recall Curve

The relationship between precision and recall is visualized as a curve in the graph as shown in Figure 8.

6. FLOW CHART

The Flow flowchart of the proposed model is shown in Figure 9, starting with the data collection the images are pre-processed, Watson Studion project is created, auto AI experiments are added, the model is constructed, run AI experiments with machine language algorithms performing training, heart disease prediction and classification are performed, unknown test samples are validated, analyzed and concluded.

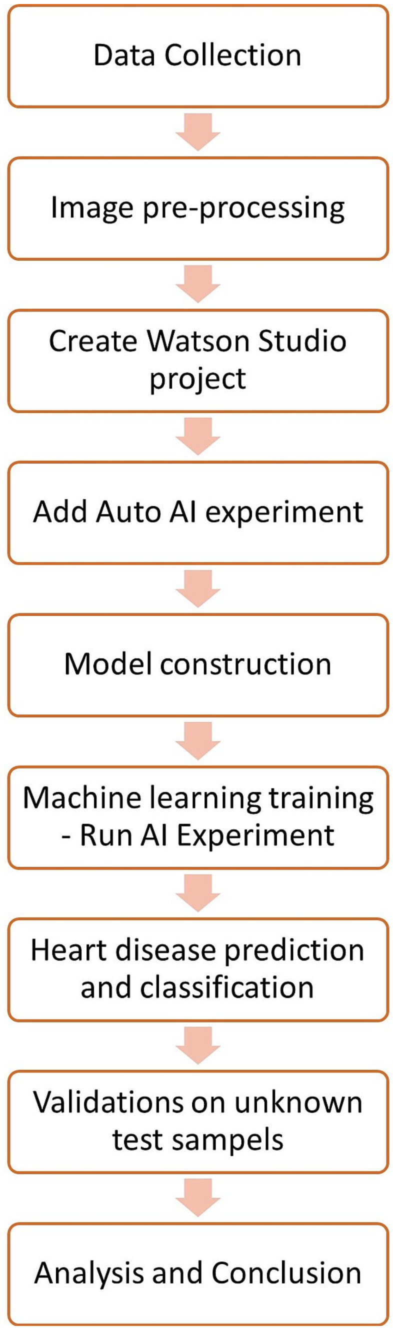

Figure 10 Flowchart of the proposed model

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7. RESULT

Figure – 9 IBM Endpoint link for the deployment model

The IBM Endpoint link for deploying the proposed model is shown in Figure 10 that is predicting heart disease.

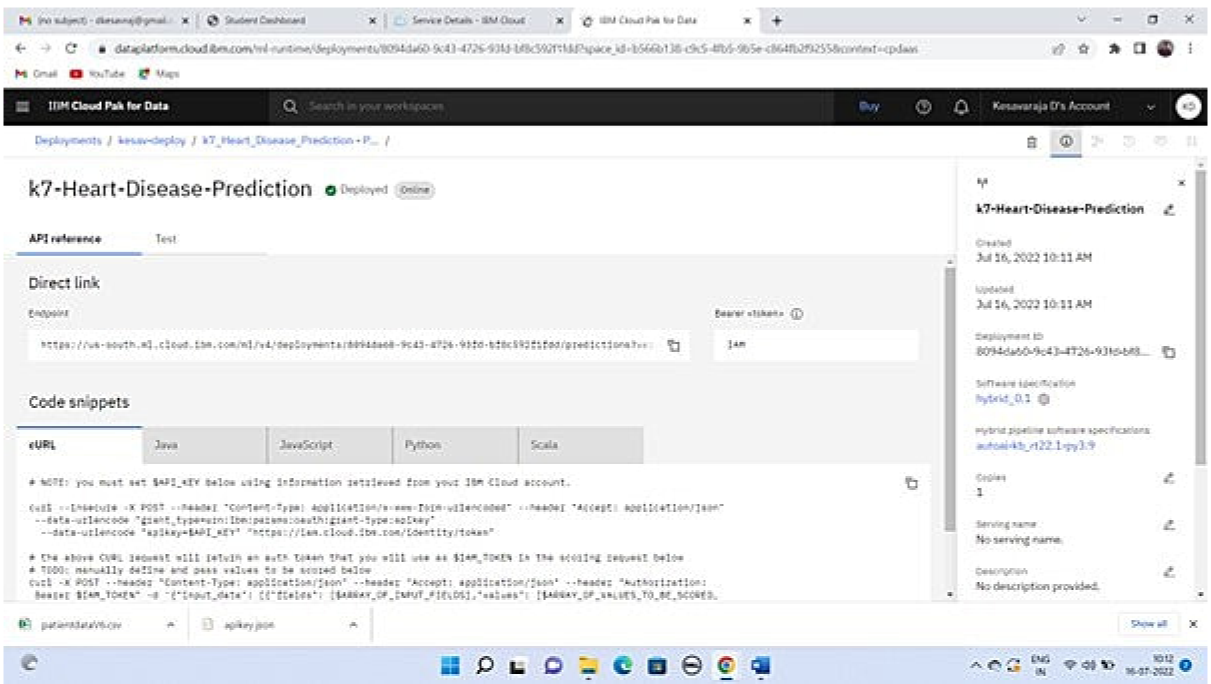

Figure -11 Node Red Proposed Model

The node-red of the proposed model is shown in Figure 11 and the dashboard of the proposed model is shown in Figure 12.

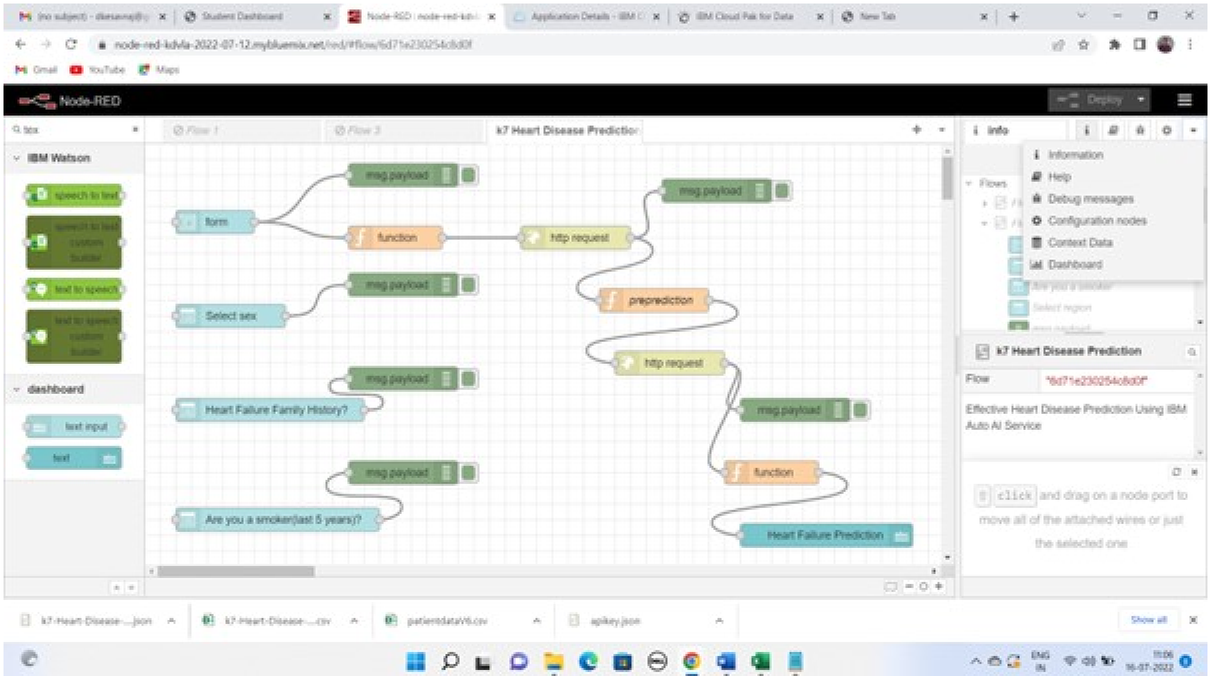

Figure 12 Proposed Model Dashboard

The dashboard of the proposed model shows the nine feature details of the patients which can be filled in and submitted.

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8. ADVANTAGES & DISADVANTAGES

Advantages:

1. The proposed model emerges as the best ML image classification technique on account of having high accuracy.

2. While comparing with other algorithms, it requires less amount of image pre-processing

3. It reduces images without losing features making them much easier to process by using relevant filters and reusability of weights resulting in good prediction

4. It can learn to perform any given task automatically by learning from the training data i.e. prior knowledge is not necessary

Disadvantages:

1. The proposed model requires a huge set of training data to get better results.

2. An appropriate model is required.

3. The total process is time-consuming.

4. The process is a more tedious and exhaustive procedure.

9. APPLICATIONS

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Predicting heart disease is the main application of this model. As the model is well trained with a huge database, the prediction of data will be more accurate.

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10. CONCLUSION

The healthcare raw data and the information regarding the heart are identified and the traditional data processing is studied which will be highly helpful in the early identification of abnormalities in the heart that leads to saving human lives. In this work, various machine learning algorithms are used for processing the raw data and providing a novel discernment of heart disease. One of the challenging yet important in the field of healthcare is to predict heart disease and the rate of mortality can be drastically controlled by detecting the disease in its early stages. Preventive measures can also be adopted by the patients at the earliest as possible.

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11.FUTURE SCOPE

In the future, the test accuracy can be improved and the computation time can be decreased with the help of classifier boosting techniques such as fine-tuning hyperparameters, using an even larger dataset with added data augmentation, adding several appropriate layers, training longer by using more epochs, etc. The use of classifier boosing can make the model faster in which the first model is built from the training dataset whereas a second model is built correcting the errors of the first model. Thus, all these techniques can help raise the accuracy of the model and the tool will be a significant asset in various medical facilities operating on heart disease.

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Appendix

JSON code:

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heartbeatspermin)\nglobal.set(\"palpitationsperday\",msg.payload.palpitationsperday)\ngl

obal.set(\"cholesterol\",msg.payload.cholesterol)\nglobal.set(\"bmi\",msg.payload.bmi)\n
global.set(\"age\",msg.payload.age)\nglobal.set(\"exerciseminperweek\",msg.payload.exe
rciseminperweek)\nvar apikey=\"_GyaJazpbomEr0QKRrrQoZoO-O1wM1hL79-
IRruiIYr5\"\nmsg.headers={\"content-type\":\"application/x-www-form-
urlencoded\"}\nmsg.payload={\"grant_type\":\"urn:ibm:params:oauth:grant-
type:apikey\",\"apikey\":apikey}\nreturn
msg;","outputs":1,"noerr":0,"initialize":"","finalize":"","libs":[],"x":300,"y":100,"wires":[
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,"type":"number","required":true,"rows":null},{"label":"cholesterol","value":"cholesterol
","type":"number","required":true,"rows":null},{"label":"bmi","value":"bmi","type":"nu
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History?","tooltip":"FAMILYHISTORY","place":"Select
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"261e0a50532c9196","aba4057f75791af3"]]},{"id":"11f7122ad7e5ed8d","type":"ui_drop
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Python Code :

```
import requests

# NOTE: you must manually set API_KEY below using information retrieved from your IBM Cloud account.

API_KEY = "<your API key>"

token_response = requests.post('https://iam.cloud.ibm.com/identity/token', data={"apikey":

 API_KEY, "grant_type": 'urn:ibm:params:oauth:grant-type:apikey'})

mltoken = token_response.json()["access_token"]

header = {'Content-Type': 'application/json', 'Authorization': 'Bearer ' + mltoken}

# NOTE: manually define and pass the array(s) of values to be scored in the next line

payload_scoring = {"input_data": [{"fields": [array_of_input_fields], "values": [array_of_values_to_be_scored, another_array_of_values_to_be_scored]}]}

response_scoring = requests.post('https://us-south.ml.cloud.ibm.com/ml/v4/deployments/8094da60-9c43-4726-93fd-bf8c592f1fdd/predictions?version=2022-07-16', json=payload_scoring,

 headers={'Authorization': 'Bearer ' + mltoken})

print("Scoring response")

print(response_scoring.json())
```