

# Chapter 1

## Introduction

With the advance of big data analytics equipment, more devotion has been paid to disease expectation from the perception of big data inquiry, various experiment have been conducted by choosing the features mechanically from a large number of data to improve the truth of menace classification rather than the formerly selected physiognomies. However, those prevailing work mostly measured structured data. Number of researches have been conducted to select the characteristics of a disease prediction from a large volume of data. Most of the existing work is based on structured data. For the unstructured data one can use a convolutional neural network. Convolutional neural networks are made up of a neuron, each neuron receives some inputs and performs operations and the whole network expresses a single differentiable score function.

The system analyses the structured and unstructured data in the healthcare field to assess the risk of disease. First, it uses Decision tree map algorithm to generate the pattern and causes of disease. Second, by using Map Reduce algorithm for partitioning the data such that a query will be analyzed only in a specific partition, which will increase the operational efficiency but reduce query retrieval time. Map reducing algorithm is used for partitioning the medical data based on the output of Decision Tree map algorithm. Compared to several typical prediction algorithms, the prediction accuracy of our proposed algorithm increases.

The primary aim of this project is to analyze the “Pima Indian Diabetes Dataset” and “Cleveland Heart Disease Dataset” and use Logistic Regression, Support Vector Machine, Naïve Bayes, K-Nearest Neighbors and Multi-Layer Perceptron (Neural Network) for prediction and develop a prediction engine. Using structured and unstructured data from hospital it uses Machine Learning Decision Tree algorithm and Map Reduce algorithm. To the best of our knowledge in the area of medical big data analytics none of the existing work focused on both data types.

## 1.1 Background Study

### 1.1.1 Motivation

The main motivation of doing this research is to present a heart disease prediction model for the prediction of occurrence of heart disease. Further, this research work is aimed towards identifying the best classification algorithm for identifying the possibility of heart disease in a patient. This work is justified by performing a comparative study and analysis using three classification algorithms namely Naïve Bayes, Decision Tree, KNN, Logistic Regression and Random Forest are used at different levels of evaluations. Although these are commonly used machine learning algorithms, the heart disease prediction is a vital task involving highest possible accuracy. Hence, the three algorithms are evaluated at numerous levels and types of evaluation strategies. This will provide researchers and medical practitioners to establish a better understanding and help them identify a solution to identify the best method for predicting the heart diseases.

A key challenge confronting healthcare organization (hospitals, medical centers) is the facility of quality services at reasonable prices. Quality amenities suggest diagnosing patients accurately and regulating medications that are effective. Poor clinical choices can prompt deplorable results, which are in this manner unsatisfactory. Hospitals should limit the cost of clinical tests. They can accomplish these outcomes by utilizing fitting PC based data and additionally choice emotionally supportive networks. The heart is the essential piece of our body. Life is itself reliant on effective working of the heart. If task of the heart isn't legitimate, it will influence the other body parts of human, for example, cerebrum, kidney and so on. Coronary illness is a sickness that effects on the activity of the heart.

There are several elements which builds danger of Heart ailment. Some of them are listed below:

- The family history of heart disease
- The family history of heart disease
- The family history of heart disease
- Smoking
- Cholesterol
- High blood pressure
- Obesity
- Lack of physical exercise

Because of a wide accessibility of superlative measure of information and a need to change over this accessible huge measure of information to helpful data requires the utilization of information mining strategies. Information Mining and KDD (learning disclosure in the database) have turned out to be prominent as of late. The popularity of information mining and KDD (information revelation in database) shouldn't be an amazement since the measure of the information increases that are accessible are extremely extensive to be analyzed physically and even the techniques for programmed information investigation in view of established insights and machine adapting frequently threaten issues when preparing large, dynamic information increases comprising of complex items [12]. Information Mining is the center piece of Knowledge Discovery Database (KDD). Numerous individuals regard Data Mining as an equivalent word for KDD since it's a key piece of KDD process. There are sure stages of information mining that you will need to get comfortable with, and these are exploration, pattern identification, and deployment. Information mining is an iterative procedure that commonly includes the accompanying stage.

- About 23 lakh people die of heart disease in India every year, that's 1 in every 4 deaths.
- Heart disease is the leading cause of death for both men and women. More than half of the deaths due to heart disease in the year 2009 were in men.
- In the India, someone has a heart attack every 40 seconds.
- 1% of women of age 40 who participate in routine screening have heart problems.
- A lot of amount is spent by the government on the patients diagnosed with heart diseases. The amount spent includes the cost of healthcare services, medications, and lost productivity.

### 1.1.2 Social Impact

In day to day life many factors that affect a human heart. Many problems are occurring at a rapid pace and new heart diseases are rapidly being identified. In today's world of stress Heart, being an essential organ in a human body which pumps blood through the body for the blood circulation is essential and its health is to be conserved for a healthy living. The health of a human heart is based on the experiences in a person's life and is completely dependent on professional and personal behaviors of a person. There may also be several genetic factors through which a type of heart disease is passed down from generations. According to the World Health Organization, every year more than 12 million deaths are occurring worldwide due to the various types of heart diseases which is also known by the term cardiovascular disease. The term Heart disease includes many diseases that are diverse and specifically affect the heart and the arteries of a human being. Even young aged people around their 20-30 years of lifespan are getting affected by heart diseases. The increase in the possibility of heart disease among young people may be due to the bad eating habits, lack of sleep, restless nature, depression and numerous other factors such as obesity, poor diet, family history, high blood pressure, high blood cholesterol, idle behavior, family history, smoking and hypertension. The diagnosis of heart diseases is very important and is itself the most complicated task in the medical field. All the mentioned factors are taken into consideration when analyzing and understanding the patients by the doctor through manual check-ups at regular intervals of time.

The symptoms of heart disease greatly depend upon which of the discomfort felt by an individual. Some symptoms are not usually identified by the common people. However, common symptoms include chest pain, breathlessness, and heart palpitations. The chest pain common to many types of heart disease is known as angina, or angina pectoris, and occurs when a part of the heart does not receive enough oxygen. Angina may be triggered by stressful events or physical exertion and normally lasts under 10 minutes. Heart attacks can also occur as a result of different types of heart disease. The signs of a heart attack are like angina except that they can occur during rest and tend to be more severe. The symptoms of a heart attack can sometimes resemble indigestion. Heartburn and a stomach ache can occur, as well as a heavy feeling in the chest. Other symptoms of a heart attack include pain that travels through the body, for example from the chest to the arms, neck, back, abdomen, or jaw, lightheadedness and dizzy sensations, profuse sweating, nausea and vomiting.

Heart failure is also an outcome of heart disease, and breathlessness can occur when the heart becomes too weak to circulate blood. Some heart conditions occur with no symptoms at all, especially in older adults and individuals with diabetes. The term 'congenital heart disease' covers a range of conditions, but the general symptoms include sweating, high levels of fatigue, fast heartbeat and breathing, reathlessness, chest pain. However, these symptoms might not develop until a person is older than 13 years. In these types of cases, the diagnosis becomes an intricate task requiring great experience and high skill. A risk of a heart attack or the possibility of the heart disease if identified early, can help the patients take precautions and take regulatory measures. Recently, the healthcare industry has been generating huge amounts of data about patients and their disease diagnosis reports are being especially taken for the

prediction of heart attacks worldwide. When the data about heart disease is huge, the machine learning techniques can be implemented for the analysis.

## 1.2 Related Work

The healthcare industry collects huge amounts of healthcare data which, unfortunately, are not “mined” to discover the hidden information for effective decision making. Discovery of hidden patterns and relationships often goes unexploited. The healthcare environment is still ‘information rich’ But ‘knowledge poor’. There is a wealth of data available within the health care systems. However, there is a lack of effective analysis tools to discover hidden relationships in data. Today medical services have come a long way to treat patients with various diseases. Among the most lethal one is the heart disease problem which cannot be seen with a naked eye and comes instantly when its limitations are reached. Today diagnosing patients correctly and administering effective treatments have become quite a challenge. This section provides the basic concepts of classifier as Naive Bayes and feature subset selection method as PSO.

### 1.2.1 Particle swarm optimization (PSO)

PSO is an Evolutionary Computation technique proposed by Kennedy et al. in 1995. PSO is motivated by social behaviors such as bird flocking and fish schooling. In PSO population swarm consists of “n” particles, and the position of each particle stands for the potential solution in D-dimensional space. The particles change its condition based on three aspects: To keep its inertia; To change the condition according to its most optimist position; To change the condition according to the swarm’s most optimist position. In PSO, a population are encoded as particles in the search space dimensionality D. PSO starts with the random initialization of a population of particles. Based on the best experience of one particle (pbest) and its neighboring particles (gbest), PSO searches for the optimal solution by updating the velocity and the position of each particle; PSO is used as feature subset selection method due to its advantages:

- Simple and easy to implement.
- Continuous optimization approach.

### 1.2.2 Naive Bayes Classifier

Naive Bayes classifiers are a family of simple probabilistic classifiers based by using Bayes theorem with strong (Naive) independence assumptions between the features. Naive Bayes classifiers are highly scalable by requiring several parameters linear for the number of features or predictors as variable in a learning problem. It is the simplest and the fastest probabilistic classifier especially for the training phase.

**Feature selection** - It is a process of removing the irrelevant and redundant features from dataset based on evaluation criterion which is used to improve accuracy. There are two approaches as individual evaluation and other one is subset evaluation. The process of feature selection is classified into three broad classes. One is filter and another one is wrapper and third one is embedded method based on how the feature selection is deployed by supervised learning algorithm. In this paper, they proposed a model which uses Naive Bayes as classifier and PSO as Feature subset selection measure for prediction of heart disease.

**Proposed system** - In this section, we propose a methodology to improve the performance of Bayesian classifier for prediction of heart disease. Algorithm for our proposed model is shown below:

**Algorithm 1: Heart disease prediction by using Bayes classifier and PSO.**

Input: Heart disease dataset.

Output: Classify patient dataset into heart disease or not (normal).

Step 1: Read the dataset.

Step 2: Apply particle swarm optimization for feature selection.

Step 3: Remove the features with low value of PSO.

Step 4: Apply Naive Bayes classifier on relevant features.

Step 5: Evaluate the performance of NB+PSO model.

The above algorithm divided into two sections, section 1 (step 2 and step 3) performs processing and feature subset selection. In section 2 (step 4 and step 5) Naive Bayes is applied on relevant features data and evaluate the performance in terms of accuracy. Cross validation technique used to split into training and testing data.

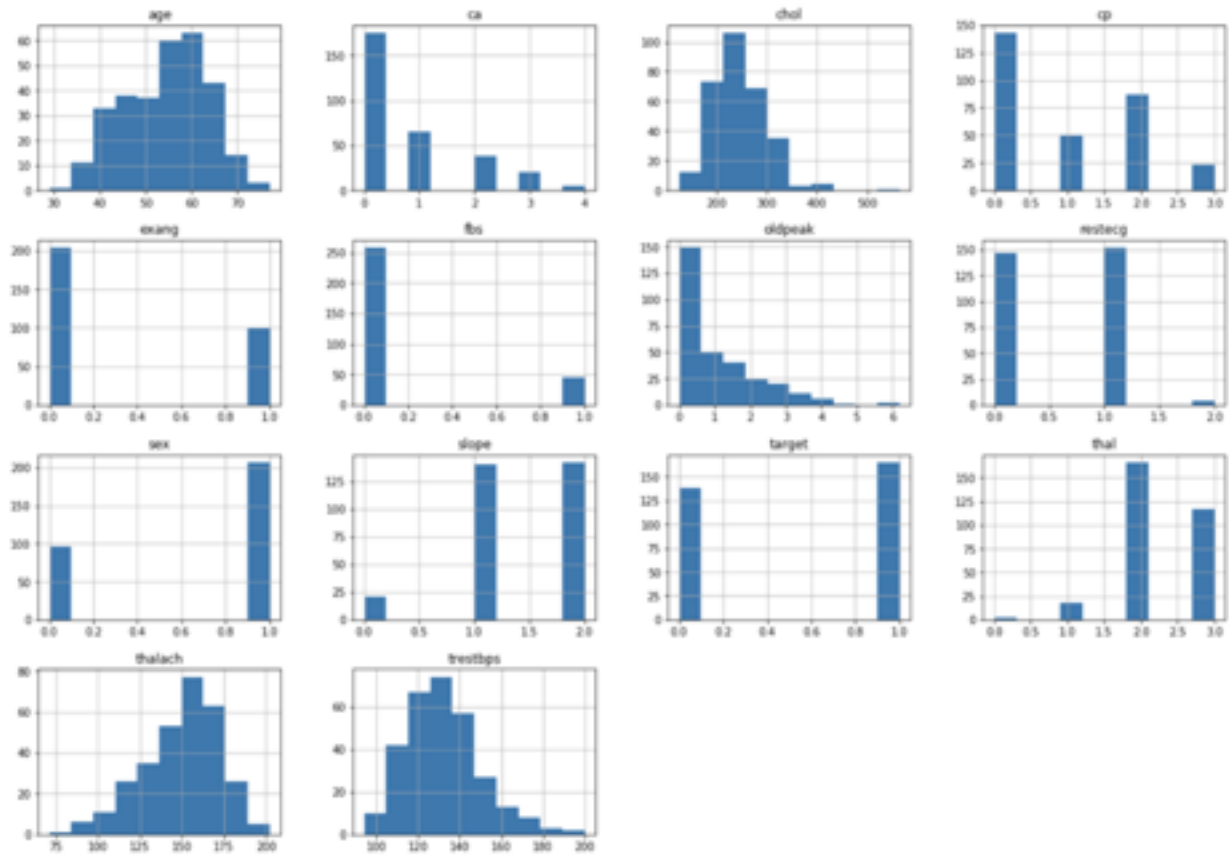
$$\text{Accuracy} = (\text{No. of objects correctly classified} / \text{Total no. of objects in test set})$$

### 1.2.3 Datasets

For this project we have used The Cleveland heart dataset from the UCI Machine Learning Repository as it is widely used by the Pattern design community. The dataset consists of 303 individual clinical reports in which 164 did not have any disease. In this dataset there is a total of 97 female patients in which 25 people are the affirmative case, also there are 206 male patients in which 114 are diagnosed with the disease. There are 6 missing values in this dataset and all numeric values are recognized as numeric. We have 13 features that are relevant to the specific disease regarding the dataset shown below:

- Age
- Sex
- Chest Pain Type
- Resting Blood Pressure
- Serum Cholesterol in mg/dl
- Fasting Blood Sugar
- Resting electrocardiographic result
- Maximum heart rate achieved
- Exercised-induced angina
- Old peak, ST depression induced by exercise relative to rest
- Number of major vessels colored by fluoroscopy
- Thal:3= Normal, 6=fixed defect, 7= reversible defect

The involvement of each attribute with respect to number of instances is as shown in the histogram below:





The Count of each target class for the given dataset is as depicted below. The two target classes are:

- 0: The instances that don't have involvement in the disease prediction.
- 1: The instances that have involvement in disease prediction.

### 1.3 Summary of Gaps identified

Medical diagnosis is considered as a significant yet intricate task that needs to be carried out precisely and efficiently. The automation of the same would be highly beneficial. Clinical decisions are often made based on doctor's intuition and experience rather than on the knowledge rich data hidden in the database. This practice leads to unwanted biases, errors and excessive medical costs which affects the quality of service provided to patients. Data mining has the potential to generate a knowledge-rich environment which can help to significantly improve the quality of clinical decisions.

### 1.4 Project problem statement and Objective

#### 1.4.1 Problem Statement

Doctors rely on common knowledge for treatment. When common knowledge is lacking, studies are summarized after some number of cases have been studied. But this process takes time, whereas if machine learning is used, the patterns can be identified earlier. For using machine learning, a huge amount of data is required. There is a very limited amount of data available depending on the disease. Also, the number of samples having no diseases is very high compared to the number of samples actually having the disease.

### 1.4.2 Objectives of the project

1. The proposed system predicts heart diseases as well as the chances of diabetes. 2. There are no proper methods to handle semi structured and unstructured data. The proposed system is expected to work well with both structured and unstructured data. 3. The secondary objective of the project is to develop a web application which allows users to predict diabetes and heart disease using the prediction engine.

## 1.5 Organization of the Report

The rest of the report is organized as follows, Chapter 2 shows some high level designs, software development methodology and architecture, Chapter 3 tells about detailed design, data structures and algorithms used and UML diagrams, chapter 4 tells about the implementation level information, chapter 5 is about the testing the project functionality and chapter 6 is all about conclusion and future scope of the project.



## Chapter 2

# High-level Design

This chapter covers the software engineering models on which this project is developed. Firstly, we describe briefly about the incremental model which included many cycles after which the current version of the Web App is achieved. Then, there is a description about agility which means regular check of the project status by the faculty panel and our respected guide. Then we describe briefly about scrum i.e., the regular meetings which the team members had.

### 2.1 Software Development Methodology

Software Development Life Cycle (SDLC) is a technique used by the merchandise to configuration, make and trial top notch programming's (as appeared in figure 2.1). The SDLC means to send superb programming that meets or exceeds client desires, completes consummation inside conditions and cost instruments. SDLC is a technique took after for a product scheme, inside a product association. It includes of a nitty gritty preparation depicting how to create, keep up, displace and improve particular programming. The following diagram is a graphical illustration of the various stages of a typical SDLC.

The detailed SDLC diagram in this report show how all the stages has been collaborated to make the working of proposed work accurate and precise. A typical Software Development Life Cycle consists of the following stages:

#### 2.1.1 Stage 1: Planning and Requirement Analysis

Requirement examination is one of the most essential and central stages in SDLC. It is done by the senior persons from the group with significant contributions from the client, the business office, advertise studies, space specialists in the business. This data is then made used for designing the essential undertaking approach and to direct item plausibility think about the effective, operational and specialized zones. Making courses of action for the quality affirmation necessities and recognizing evidence of the threats related with the wander is similarly done in the masterminding stage. The outcome of the particular good judgment considers is to depict the differing specific methods of insight that can be taken after to understand the errand adequately with minute perils.

#### 2.1.2 Stage 2: Defining Requirements

Once the essential examination is done the ensuing stage is to clearly portray and report the thing necessities and get them supported from the customer or the market agents. This is done through an SRS (Software Requirement Specification) report which contains all the thing essentials to be made and made in the midst of the undertaking life cycle.

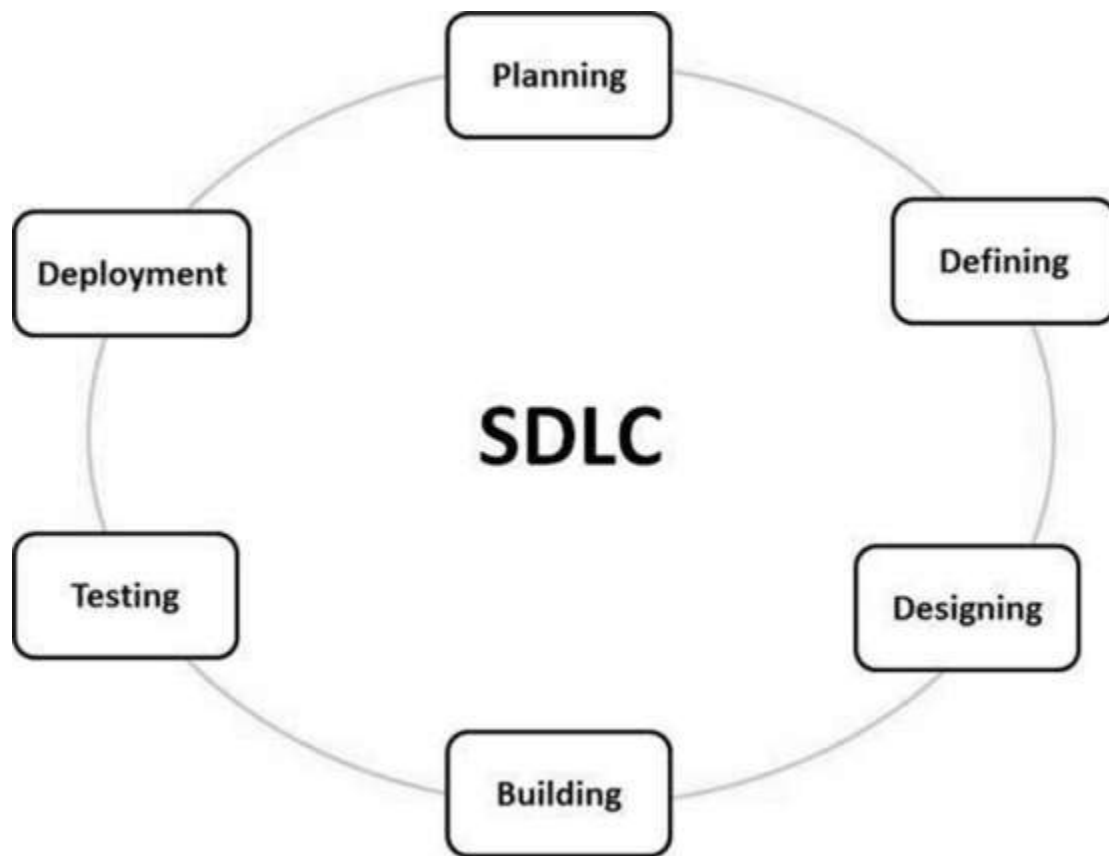


Figure 2.1 Software Development Life Cycle

### 2.1.3 Stage 3: Designing the Product Architecture

An arrangement approach clearly describes all the plan modules of the thing close by its correspondence and data stream depiction with the external and untouchable modules (expecting any). Within framework of the significant number of modules of the proposed designing should be obviously described with the minutest of the inconspicuous components in DDS.

### 2.1.4 Stage 4: Building or Developing the Product

In this period of SDLC the genuine change starts and the thing is made. The programming code is created by DDS in the midst of this stage. If the arrangement is performed in a positive and dealt with way, code age can be master absent much issue. Planners should take after the coding rules represented by their affiliation and programming gadgets like code compilers, middle people, checker debuggers, etcetera are made used to make the code. Differing anomalous state programming vernaculars, for instance, C, C++, Pascal, Java and Python are used for coding. The programming tongue is picked with respect to the sort of writing computer programs actually being delivered.

### 2.1.5 Stage 5: Testing the Product

This stage is normally a subset of the extensive number of stages as in the front line SDLC models, the testing practices are generally connected with each one of the periods of SDLC. Regardless, this stage suggests the testing simply period of the thing represented, took after, settled and retested, until the point that the thing accomplishes the quality measures portrayed in the SRS.

### 2.1.6 Stage 6: Deployment in the Market and Maintenance

Once the thing is attempted and arranged to be passed on it is released formally in the correct market. Now and again thing sending happens in stages as indicated by the business strategy of that affiliation. The thing may first be released in a confined part and attempted in the certifiable business condition (UAT-User affirmation testing). By then in perspective of the info, the thing may be released as it is or with suggested changes in the concentrating on promote parcel. After the thing is released in the market, its upkeep is enhanced the circumstance the present customer base.

## 2.2 Architecture

This paper will provide as a result that is distributed into three phases:

1. **Analysis Phase (Based on the Dataset):** In this stage the fundamental concentration is to the information from the dataset and do the examination in light of the medical data of the patient. In this stage we try to analyse which of the medical data or the medical values have more impact on the prediction of the disease and which attributes have the least impact.
2. **Combining analysis stage with the parameters:** In this stage we give a few parameters based on the condition of patient (whether the patient is suffering from heart disease and diabetes or not). The application then applies different machine learning algorithms to prepare a model which in turn is used in the prediction phase.
3. **Prediction Phase::** In this stage we display the outcome and declare the probability that the person is suffering from heart disease or diabetes. The result predicted using different machine learning algorithms from the values given by the user.

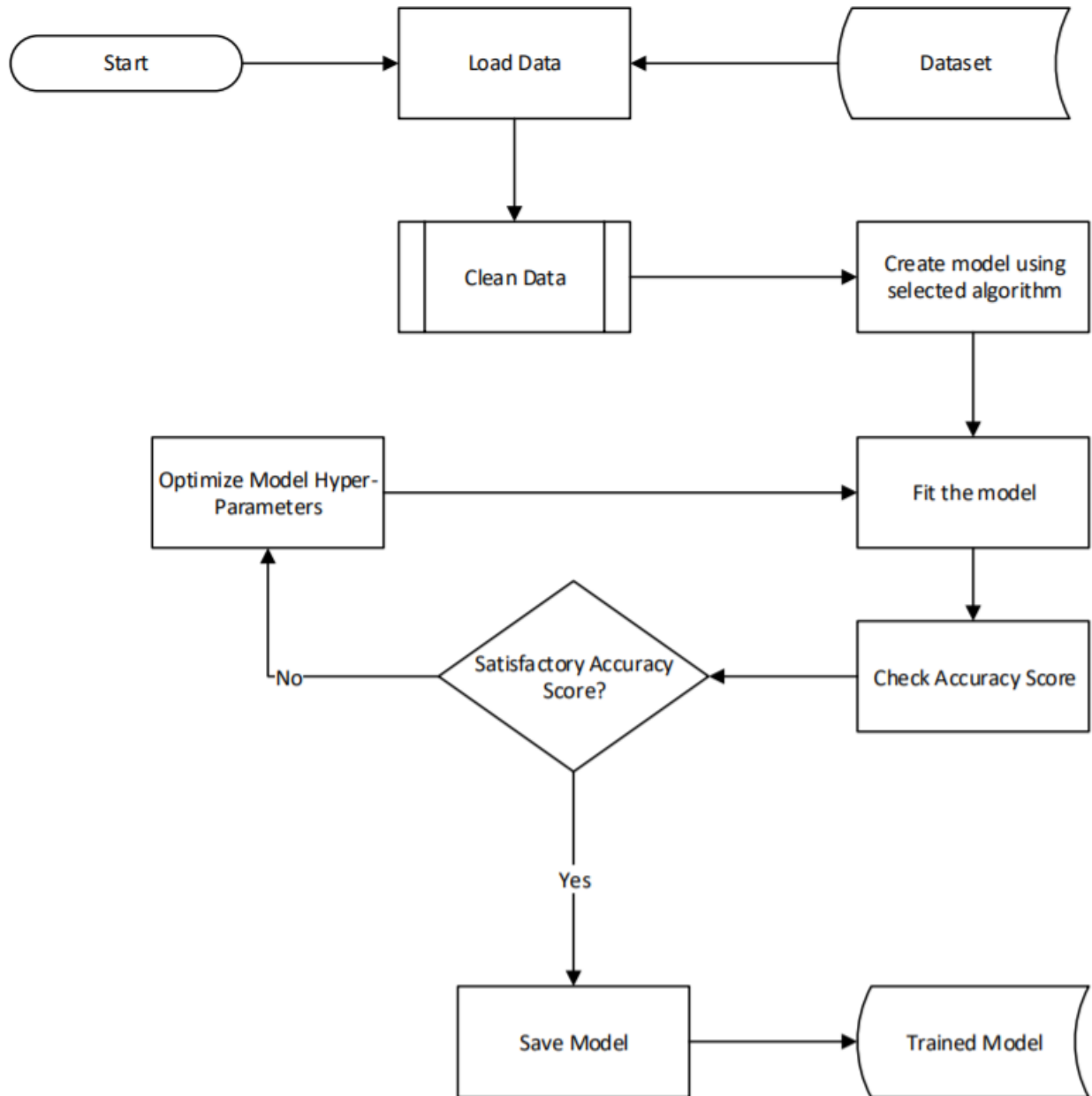


Figure 2.2: Initial design of the proposed system

## 2.3 Incremental Model

The incremental frame illustrate could be a strategy for programming movement where the thing is made, executed and endeavoured incrementally (to a few degrees more is consolidated each time) until the point that the thing is done (as showed up in figure 2.2). It joins both alter and back. The thing is depicted as wrapped up when it fulfills the more prominent portion of its necessities. This demonstrate consolidates the sections of the waterfall appear with the iterative basis of prototyping. The thing is weakened into distinctive parts, each one of which is organized and manufactured unreservedly (named as collects). Each part is passed on to the client when it is done. This gifts lacking utilization of the thing and maintains a strategic distance from a long progress time. It similarly keeps up a key remove from a significant beginning capital taken a toll and guaranteeing broad holding up period. This demonstrate of advancement in expansion makes a difference encourage the terrible impact of giving a totally modern system at the same time.

Characteristics of Incremental Model:

- System is isolated into various small headway wanders.
- Partial systems are com to convey the final framework.
- First dealt with most essential require necessities.
- The prerequisite of a portion is cemented once the expanded bit is produced

After each cycle, backslide testing ought to be facilitated. Within the middle of this testing, harmed parts of the thing can be rapidly seen in light of the way that few changes are made interior any single emphasis. It is by and large simpler to test and explore than different strategies for programming movement in light of the way that for the foremost portion tinier changes are made within the middle of each emphasis. This mulls over more centred around and seriously testing of each portion interior the common thing. Client seem respond to highlights and overview the thing utilized for any required changes. Essential thing movement is faster and less costly in the incremental model.

## 2.4 Agility and Scrum

Deft programming headway technique could be a strategy for making programming (like other programming alter systems - Waterfall appear, V-Model, Iterative show et cetera.) Be that as it may, dexterous framework moves in a common sense from different rationalities. In English, Dexterous implies 'ability to move rapidly and easily and reacting quickly to combination this is often a key piece of composed programming alters as well. In traditionalist programming headway procedures like Waterfall illustrate, an errand can surrender different months and a long time to adequate as client might not get the chance to see last result till the perfection of the undertaking. At an unusual state, non-Agile assignments assign wide time frames for Prerequisites gathering, arrange, progression, testing and Client Acknowledgement Testing, sometime recently at final, sending the undertaking. In capability to this, Spry works out have Sprints or accentuations which are littler in term (Sprints/cycles can move from 2 weeks to 2 months) within the middle of which pre-chosen capabilities.

### 2.4.1 Agility and the cost of change

The standard way of considering in programming progression (supported by numerous a long time of encounter) is that the fetched of advance increases nonlinearly as an undertaking progresses (Figure 2.3, solid dull twist). It is decently basic to oblige a alter when a item bunch is gathering prerequisites (right on time in a wander). A utilize circumstance must be changed, a rundown of capacities may well be broadened, or a composed specific can be changed. The costs of doing this work are immaterial, and

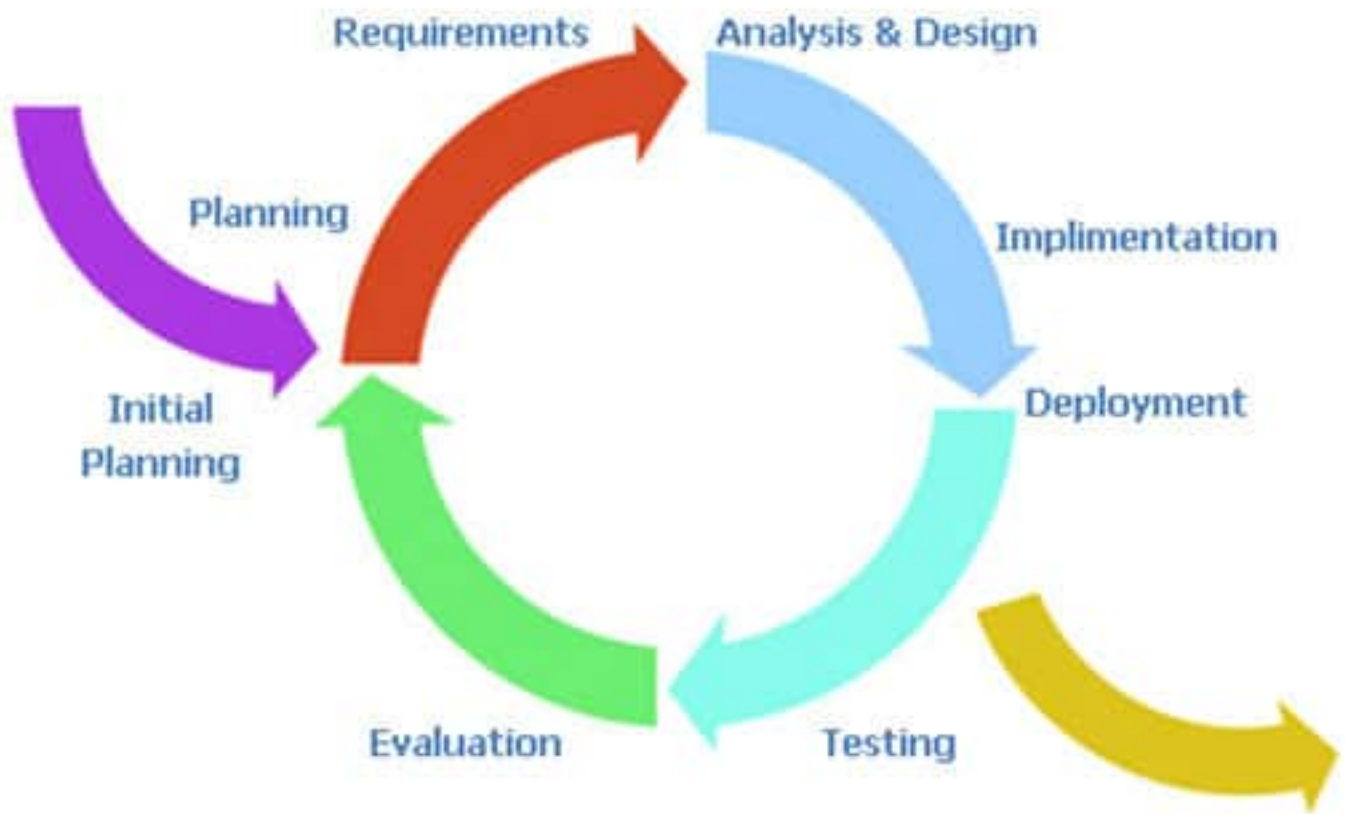


Figure 2.3: Incremental model for project

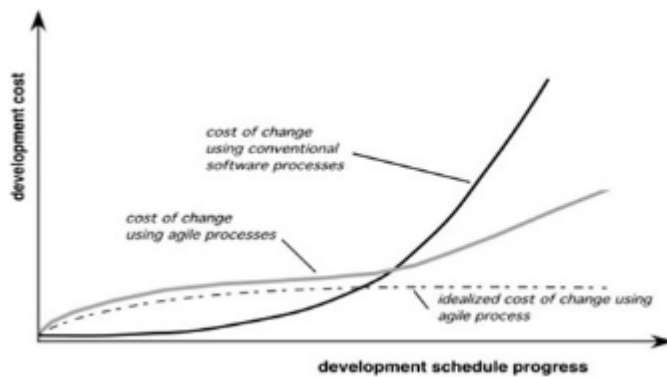


Figure 2.4: Agility and the cost of change

the time required won't ominously impact the result of the undertaking. However, envision a situation where we fast forward different months. The bunch is amidst approval testing (something that happens for the most part late within the wander), and a basic accomplice is inquiring for a vital viable alter. The alter requires an change to the compositional arrange of the item, the diagram and advancement of three modern parts, alterations to another five segments, the system of unused tests, and so on.

#### Advantages of Agile Methodology:

- In Dexterous system the development of composing computer programs is unremitting.
- The clients are fulfilled in light of the reality that after each Sprint working component of the thing is passed on to them.
- Clients can see of the working component which satisfied their needs.
- In case the clients have any criticism or any change within the portion at that point it can be obliged within the show section of the thing.
- In Spry system the step by step affiliations are required between the masters and the makers.
- In this system thought is paid to the impressive graph of the thing.

## 2.5 Scrum

Scrum could be a fast structure for coordinating work with a highlight on programming movement. It is arranged for get-togethers of three to nine fashioners who break their work into works out that can be done interior time boxed cycles, called runs (routinely two-weeks) and track advance and re-outline in 15-minute stand-up social undertakings, called step by step scrums. Ways to bargain with organizing made by diverse scrum bunches in more noteworthy afpucchi.pngfiliations solidify Large-Scale Scrum, Scaled Dexterous System (SAF) and Scrum of Scrums, among others.

Scrum has three roles: Product Owner, Scrum Master, and Team:

- **Item Owner:** The Item Owner ought to beware of commerce with vision, ace, and openness. The Item Proprietor is responsible for persistently passing on the vision and necessities to the alter gathering. It's occasionally difficult for Product Proprietors to strike the proper alter of thought. Since Scrum respects self-relationship among social occasions, a Item Proprietor must battle the

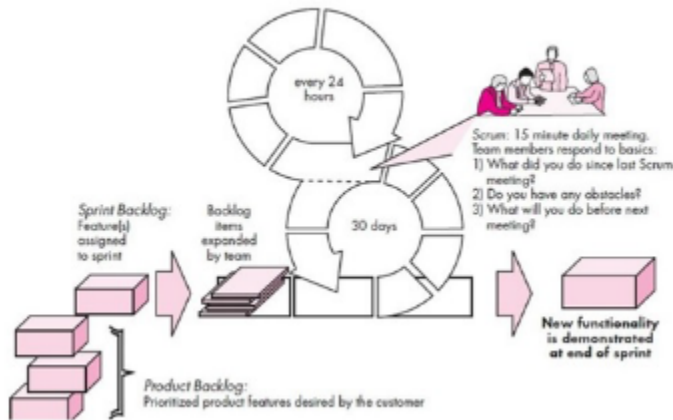


Figure 2.5: Scrum design of project

need. to littler scale direct. In the interim, Item Proprietors must be accessible to reply ask from the gathering.

- **Scrum Master:** The Scrum Master goes around as a aide for the Item Proprietor and the get-together. The Scrum Ace does not bargain with the social occasion. The Scrum Ace tries to cleanse any obstacles that are hindering the social issue from fulfilling its sprint destinations. This locks in the social occasion to remain imaginative and useful whereas guaranteeing its triumphs are clear to the Item Proprietor. The Scrum Ace other than tries to inquire the Item Proprietor around how to develop ROI for the social occasion.
- **Team:** As shown by Scrum’s coordinator, ”the gathering is completely self-managing.” The progress total is capable for self-orchestrating to total work. A Scrum movement amass contains around seven completely devoted individuals (formally 3-9), in a perfect world in one gathering room ensured from exterior redirections. For programming meanders, a ordinary gathering solidifies a blend of programming engineers, modellers, programming engineers, examiners, QA experts, analysers, and UI organizers.

## 2.6 Functional Requirements

- Predict the probability of Heart Disease and Diabetes with given user inputs.
- Contribute to the dataset or request to add functionalities.

## 2.7 Non-Functional Requirement

Non-down to earth necessities are requirements that demonstrate criteria that can be used to judge the action of a structure, rather than specific practices. This could be showed up distinctively in connection to valuable requirements that describe specific direct or limits.

Non-down to earth necessities are a significant part of the time called attributes of a structure. Distinctive articulations for utilitarian necessities are confinements, quality characteristics, quality targets, nature of organization requirements and nonbehavioral essentials.



## **2.8 Feasibility Analysis**

### **2.8.1 Technical feasibility**

The project is technically feasible as it can be built using the existing available technologies. It is a web based applications that uses Grails Framework. The technology required by Disease Predictor is available and hence it is technically feasible.

### **2.8.2 Economic feasibility**

The project is economically feasible as the cost of the project is involved only in the hosting of the project. As the data samples increases, which consume more time and processing power. In that case better processor might be needed.



## Chapter 3

# Detailed Design

This section will cover the design of our model in detail. Firstly with interface design that will provide a detailed explanation about the interface design, and then with the Data Structure and Algorithms that have been used in the project. The whole detailed system design with use case has been shown in Fig 3.1.

### 3.1 Interface Design

This section describes about the user's interaction with the interface. The inter-face designs/screen-shots have been added in order to give a better view of the user Interface.

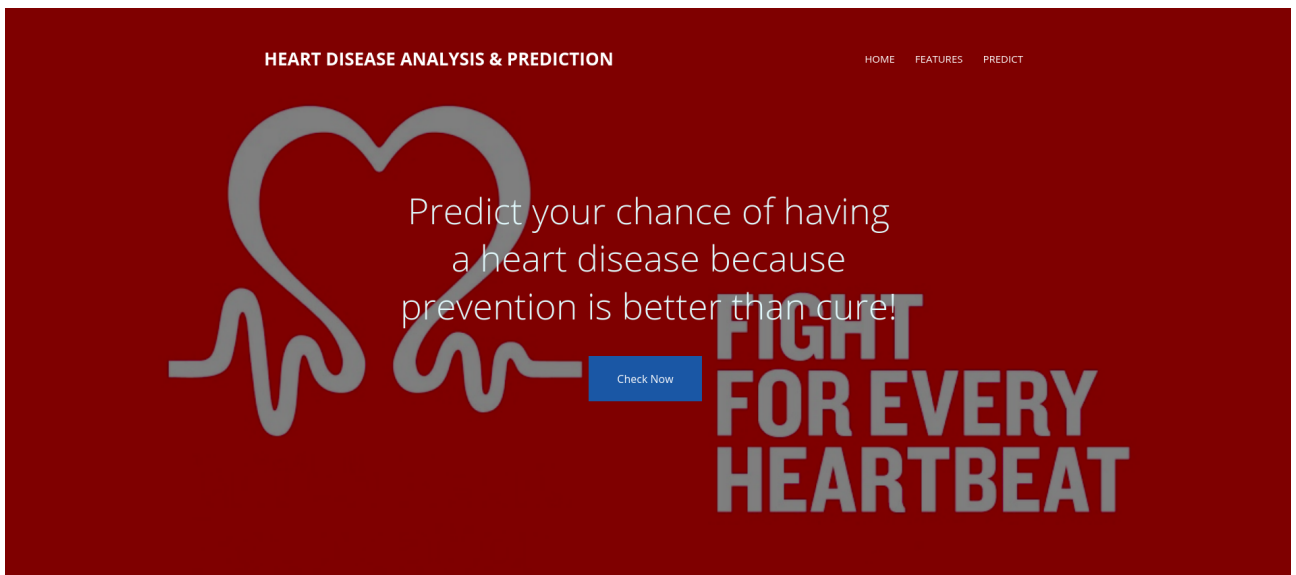


Figure 3.1: Home page

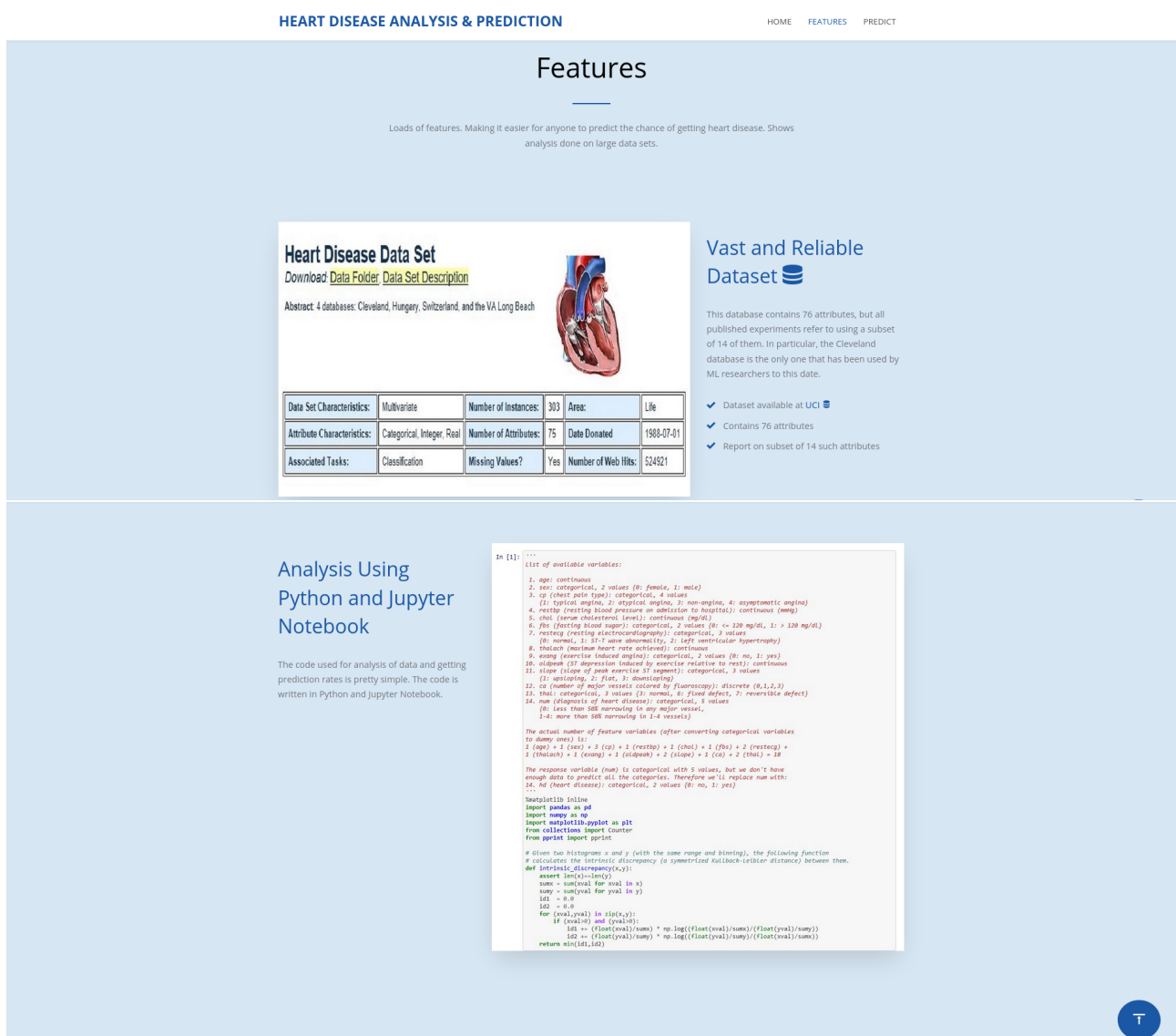


Figure 3.2: Feature of dataset

HEART DISEASE ANALYSIS & PREDICTION

HOMEFEATURESPREDICT

## Predict your Chance of Having a Heart Disease

Enter the appropriate values of symptoms you face. Get the chances of you contracting heart disease based on those values.

### Heart Disease Predictor

Sex (0=female,1=male)

0

Resting Blood Pressure (94 - 200 mmHg)

94

Thalium Stress Test Maximum Heart Rate (71 - 202)

71

Number of Major Vessels Colored by Fluoroscopy (0 - 3)

0

Chest Pain Type (1=typical angina, 2=atypical angina, 3=non-angina, 4=asymptomatic angina)

1

Peak Exercise ST Segment (0=flat or downsloping, 1=upsloping)

0

Thalium Test: (0=normal or fixed defect, 1=reversible defect)

0

Reset All Sliders

42.84%

Figure 3.3: Preiction Engine

## 3.2 Data Structures and Algorithms

This section deals with data structure and algorithms we have used in our project.

### 3.2.1 Naive Bayes Classifier

Naive Bayes classifiers are a family of simple probabilistic classifiers based by using Bayes theorem with strong (Naive) independence assumptions between the features. Naive Bayes classifiers are highly scalable by requiring a number of parameters linear for the number of features or predictors as variable in a learning problem. It is the simplest and the fastest probabilistic classifier especially for the training phase.

Naive Bayes classifier is based on Bayes theorem. This classifier uses conditional independence in which attribute value is independent of the values of other attributes. The Bayes theorem is as follows: Let  $X = x_1, x_2, \dots, x_n$  be a set of  $n$  attributes. In Bayesian,  $X$  is considered as evidence and  $H$  be some hypothesis means, the data of  $X$  belongs to specific class  $C$ . We have to determine  $P(H|X)$ , the probability that the hypothesis  $H$  holds given evidence i.e. data sample  $X$ . According to Bayes theorem the  $P(H|X)$  is expressed as:

$$P(H|X) = \frac{P(X|H) * P(H)}{P(X)}$$

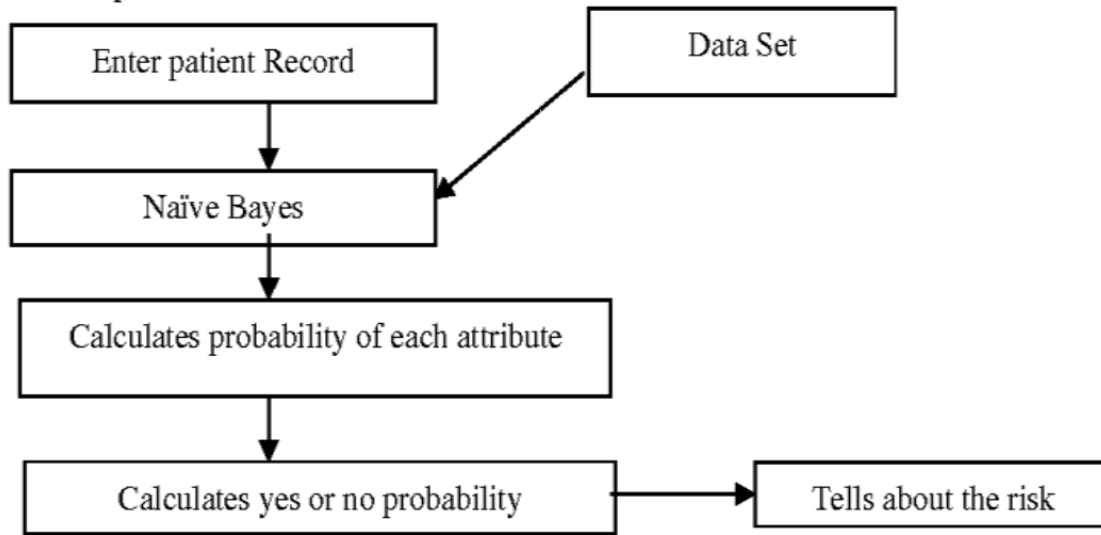


Figure 3.4: Implementation Flow of Naive Bayes Algorithm

Using Bayesian classifiers, the system will discover the concealed knowledge associated with diseases from historical records of the patients having heart disease. Bayesian classifiers predict the class membership probabilities, in a way that the probability of a given sample belongs to a particular class statistically. Bayesian classifier is based on Bayes' theorem. We can use Bayes theorem to determine the probability that a proposed diagnosis is correct, given the observation. A simple probabilistic, the naive Bayes classifier is used for classification based on which is based on Bayes' theorem. According to naive Bayesian classifier the occurrence or an occurrence of a particular feature of a class is considered as independent in the presence or absence of any other feature. When the dimension of the inputs is high and more efficient result is expected, the chief Naive Bayes Classifier technique is applicable. The Naive Bayes model identifies the physical characteristics and features of patients suffering from heart disease.

For each input, it gives the possibility of attribute of the acceptable state. Naive Bayes is a statistical classifier which assumes no dependency between attributes. This classifier algorithm uses conditional independence, means it assumes that an attribute value of a given class is independent of the values of other attributes. The advantage of using Naive Bayes is that one can work with the Naive Bayes model without using any Bayesian methods. (Brownlee, 2016).  $P(\text{Disease}|\text{symptom1}, \text{symptom2}, \dots, \text{symptomn}) = \frac{P(\text{Disease})P(\text{symptom1}|\text{Disease})P(\text{symptom2}|\text{Disease})\dots P(\text{symptomn}|\text{Disease})}{P(\text{symptom1})P(\text{symptom2})\dots P(\text{symptomn})}$ .

### 3.2.2 Decision Tree

Decision tree learning uses a decision tree as a predictive model which maps observations about an item to conclusions about the item's target value. It is one of the predictive modelling approaches used in statistics, data mining and machine learning. Tree models where the target variable can take a finite set of values are called classification trees. In these tree structures, leaves represent class labels and branches represent conjunctions of features that lead to those class labels. Decision trees where the target variable can take continuous values (typically real numbers) are called regression trees. In decision analysis, a decision tree can be used to visually and explicitly represent decisions and decision making. In data mining, a decision tree describes data but not decisions; rather the resulting classification tree can be an input for decision making. The classification tree literally creates a tree with branches, nodes, and leaves that lets us take an unknown data point and move down the tree, applying the attributes of the data point to the tree until a leaf is reached and the unknown output of the data point can be determined. In order to create a good classification tree model, we need to have an existing data set with known output from which we can build our model. We also divide our data set into two parts: a training set, which is used to create the model, and a test set, which is used to verify that the model is accurate and not over fitted.

This classifier creates a decision tree based on which it assigns the class values to each data point. Here, we can vary the maximum number of features to be considered while creating the model.

### 3.2.3 Support vector machine(SVM)

SVM was developed by Vladimir Vapnik at AT&T Bell Labs. It is based on the concept of decision planes that define decision boundaries. A decision plane is a hyperplane that separates the objects having different class memberships. SVM classifiers separate the observations into two or more classes in such a way that maximum separation is achieved. A hypothetical hyperplane is the separator in SVM classification problems. In other words, SVM constructs a hyperplane that separates the two sets so as to minimize the number of misclassified points. Generally, there are two types of SVM models: linear and nonlinear. Linear SVM works better on linearly separable datasets but nonlinear SVM model works well even on hardly separable datasets. Since we are dealing with hardly separable data in our experiments we use nonlinear SVM. The dual formulation of the nonlinear SVM function can be formulated as

$$MaxW(\alpha) = \sum_{i=1}^m \alpha_i - 0.5 \sum_{i,j=1}^m \alpha_i \alpha_j y_i y_j K(x_i, x_j)$$

subject to:

$$\sum_{i=1}^m \alpha_i y_i = 0,$$

$$0 \leq \alpha_i \leq C$$

Input vectors  $x_i \in R^m$ ,  $i = 1, 2, 3, \dots, m$ , which are called features or attributes are extracted from

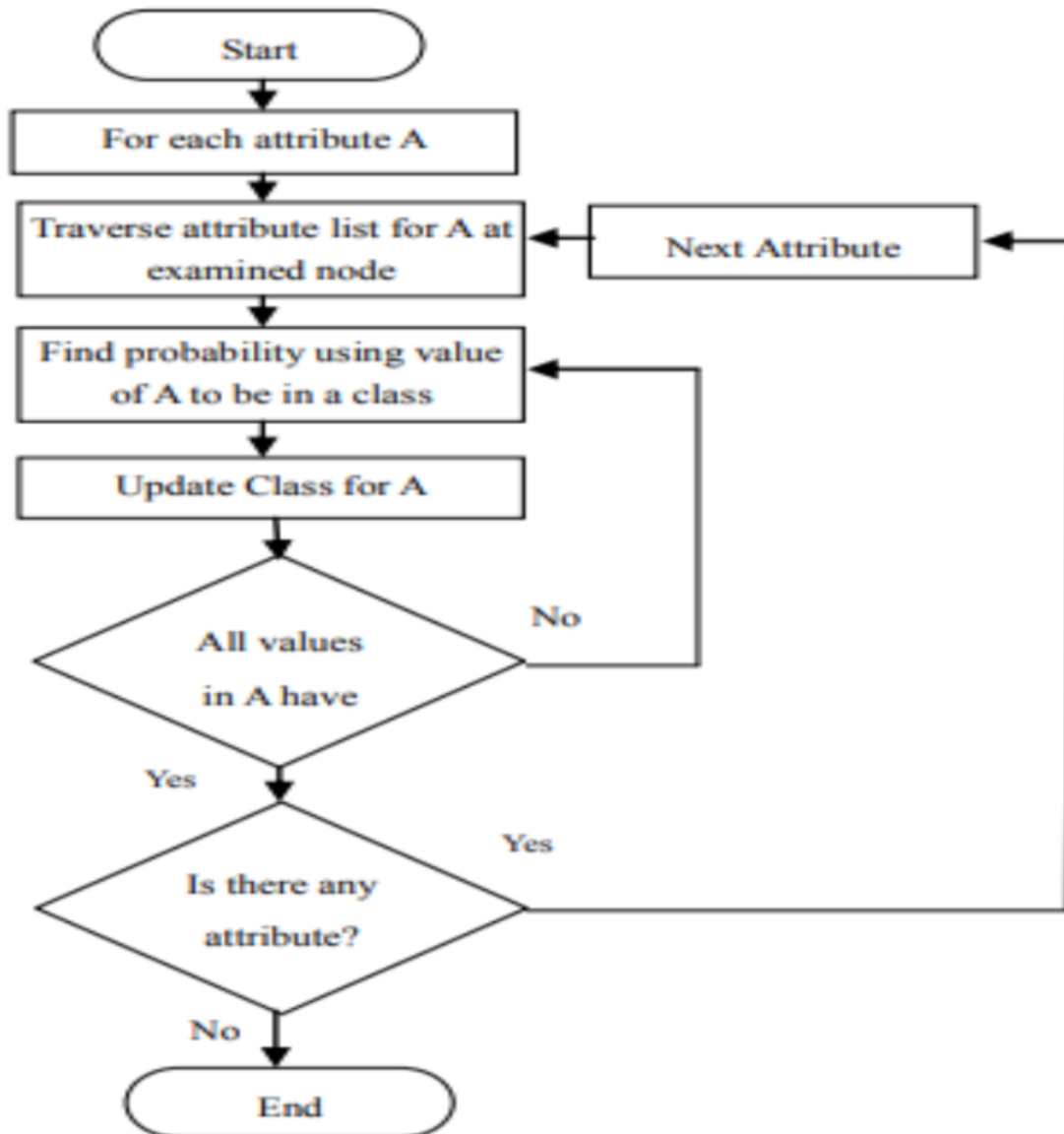


Figure 3.5: Flowchart for Decision Tree



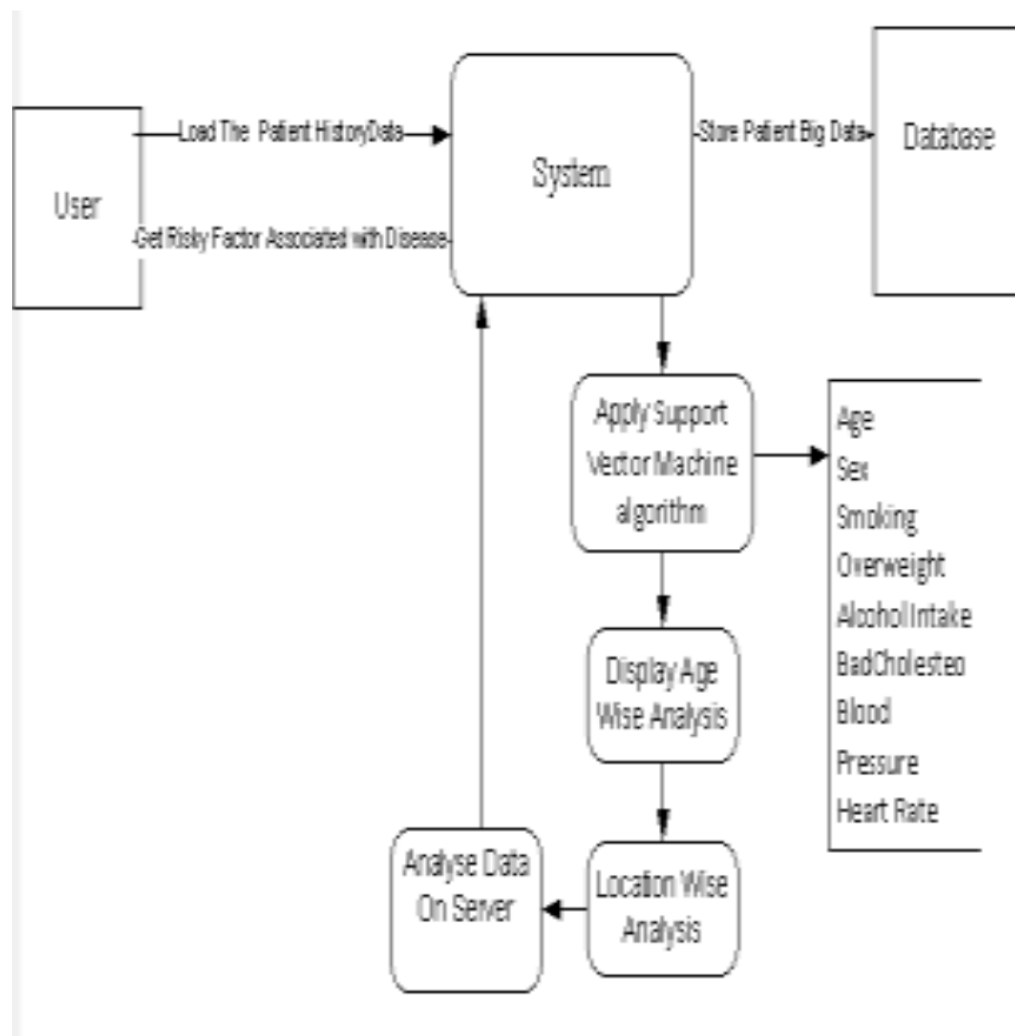


Figure 3.6: Flowchart For SVM

the database. Associated with every particular input we have a corresponding label ( $y_i = \pm 1$ ) which is called the target value or output in the database. The variable  $\alpha_i$  is the Lagrange multiplier in the dual formulation and  $C$  is a user-specified parameter representing the penalty for misclassification  $K(x_i, x_j)$  is the kernel function and maps the original data points to another space. One of the popular choices for the kernel is Gaussian kernel which is also known as Radial Basis Function (RBF) in the literature. The formulation for this kernel is

$$K(x_i, x_j) = e^{-\frac{\|x_i - x_j\|^2}{2\sigma}}$$

where parameter  $\sigma$  is known as the kernel width.

### 3.2.4 Logistic Regression

Logistic Regression is a statistical analysis technique that is used for predicting the data value based on the prior observation of the data set. The logistic regression model predicts the dependent data variable by analyzing the relationship between one or more existing independent variables. Logistic Regression is one of the important tools for prediction, which can also be used for classifying and predicting the data based on the historical data. The implemented model is a binary Logistic model that has dependent variables with only two possible outcomes i.e., one is a positive value and another one is the negative value which is having 0 or 1 as a class label. It mainly consists of two major phases: regularized cost function and regularized gradient descent. Cost Function is used for calculating the maximum likelihood estimation. Gradient descent is an iterative process for getting coefficients from training data. The process is repeated until we get the optimal parameters of train data. The model is trained with the optimal coefficient. Whenever a test data has been passed to the model based on the parameters is able to identify whether the person is having heart disease or not, it tests the data using the sigmoid function. The cost function is the method that is used for reducing the errors of the predicted label and the actual label. Gradient descent function is the method that is used for calculating the coefficient until we obtain a minimum value of the class label.

#### 3.2.4.1 Cost Function

A minimization function is used that is the cost function. It uses the Log Loss i.e. the logarithmic loss which measures the performance of the model where the prediction input value is the probability between the zero and one. The Log loss is the uncertainty of the prediction which is based on the how much it varies from the actual label. Cost function which helps the learner to correct or change the behavior to minimize the mistakes. The cost function can be estimated by iteratively running the model to compare the estimated predicted value and the known or actual value. The regularized cost function is a method that is used for overcoming the risk of over fitting. Lamda is the parameter which controls the regularization term. The cost function is calculated by the following:

$$J(\theta) = \frac{1}{m} \sum_{i=1}^m y^{(i)} \log[h_{\theta}(x^{(i)})] - (1 - y^{(i)}) \log(1 - h_{\theta}(x^{(i)})) + \frac{\lambda}{2m} \sum_{j=1}^n \theta_j^2$$

$m$  = number of instances

$n$  = number of attributes

$y$  = class label

$x$  = train data features

$\theta$  = coefficients

$\lambda$  = learning rate

#### 3.2.4.2 Gradient Descent

Gradient descent is an optimization method which is used to find the parameters or the coefficient of the cost function. Gradient descent is a repeated process in order to get the coefficients to minimize the

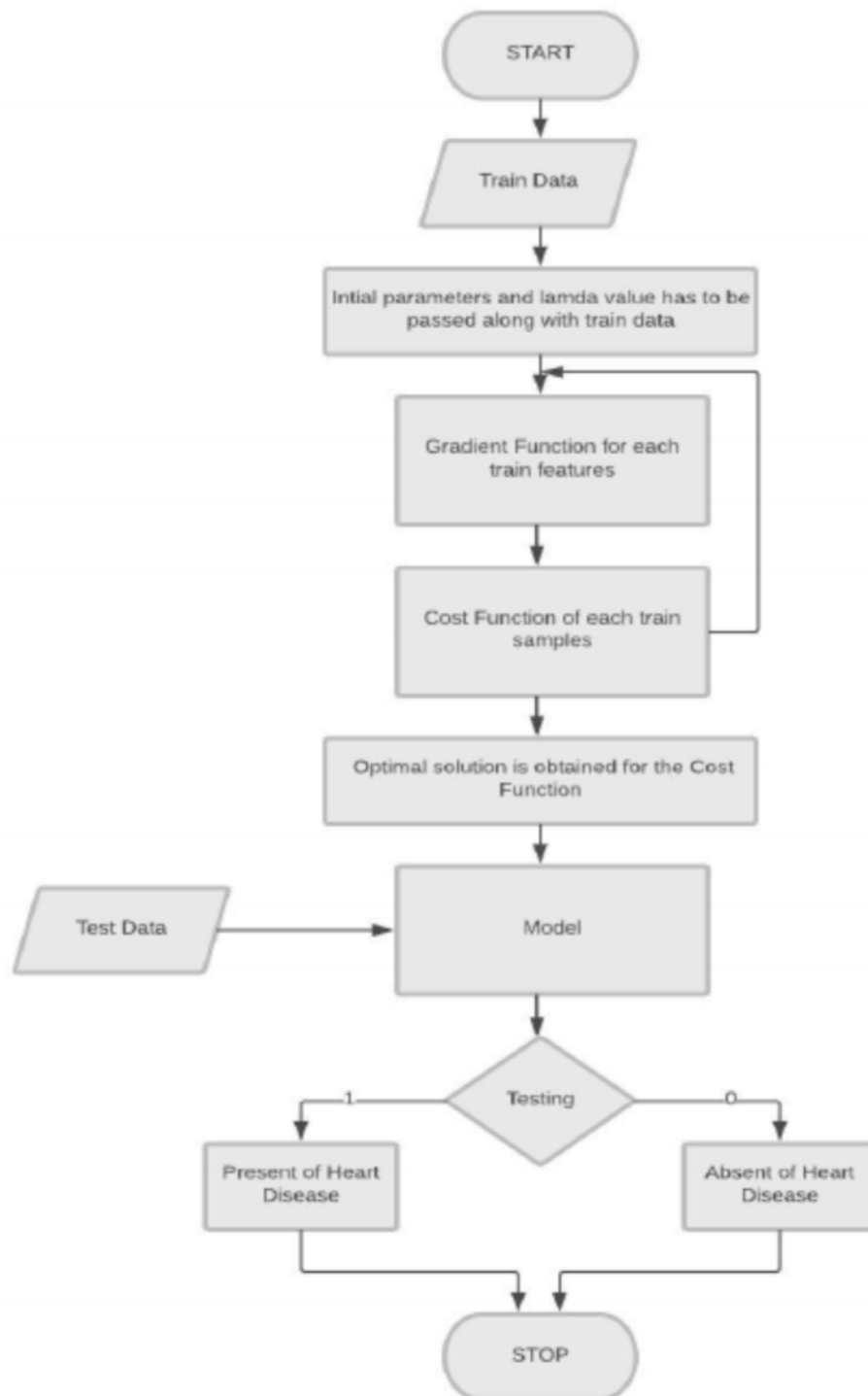


Figure 3.7: FlowChart For Logistic Regression

cost function. The Gradient descent is calculated for both the classes to get the pair of a coefficient for both class labels. The goal here is to continue the procedure to try the different value for the coefficient, evaluating their cost and selecting the new coefficient that is having the slightly lower cost. Considering this coefficient and storing them in the model. Gradient descent is calculates as the following:

$$\theta_{ji} = \theta_j - \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^i) - (y^i)) x_j^i + \frac{\lambda}{m} \theta_j$$

$m$  = number of instances

$x$  = train data features

$y$  = class label

$\theta$  = coefficients

$\lambda$  = learning rate

### 3.2.4.3 Sigmoid Function

Sigmoid function is the logistic function between. This takes the real input vales and output values between the 0 and 1 for logistic function [12]. This is interpreted as taking log odds and having the output probability. Generally sigmoid function is used to map predictions to probability it is defined as:

$$h_{\theta}(x) = \frac{1}{1 + e^{-\theta^T \cdot x}}$$

$x$  = test data features

$\theta$  = coefficients Whenever a test data is passed it calculates the value based on the parameters stored in the model. It calculates the probability of each class label. We return the maximum probability value of the class label  $x_i$ .

The test data contains the thirteen attributes that we need to pass and calculate for both the classes it will return the two values we take the maximum value of two values we will return the class label which is having the maximum probability.

### 3.2.5 K-Nearest Neighbour

K-Nearest neighbor (KNN) is a simple, lazy and nonparametric classifier. KNN is preferred when all the features are continuous. KNN is also called case-based reasoning and has been used in many applications like pattern recognition, statistical estimation. Classification is obtained by identifying the nearest neighbor to determine the class of an unknown sample. KNN is preferred over other classification algorithms due to its high convergence speed and simplicity.

KNN classification has two stages

1. Find the k number of instances in the dataset that is closest to instance S
2. These k number of instances then vote to determine the class of instance S

The Accuracy of KNN depends on distance metric and K value. Various ways of measuring the distance between two instances are cosine, Euclidean distance. To evaluate the new unknown sample, KNN computes its K nearest neighbors and assign a class by majority voting.

With KNN algorithm, we have chance to change the parameter's weight. It means that, we may assume that some parameters are more important or making more impact than others. Among 8 parameters we use, we can categorize them our data into 2 categories, one is "non-medical" parameters (Age and Sex) and the other is "medical" parameters (CP, Trestbps, Trestbpd etc). We may think that medical parameters are more important than non medical, which we will see in experimental results. Along with weighting, we should find the value of "k" so it gives the best classification result. Since it is a 2-choice classification ("yes") and ("No") k will be an odd number.

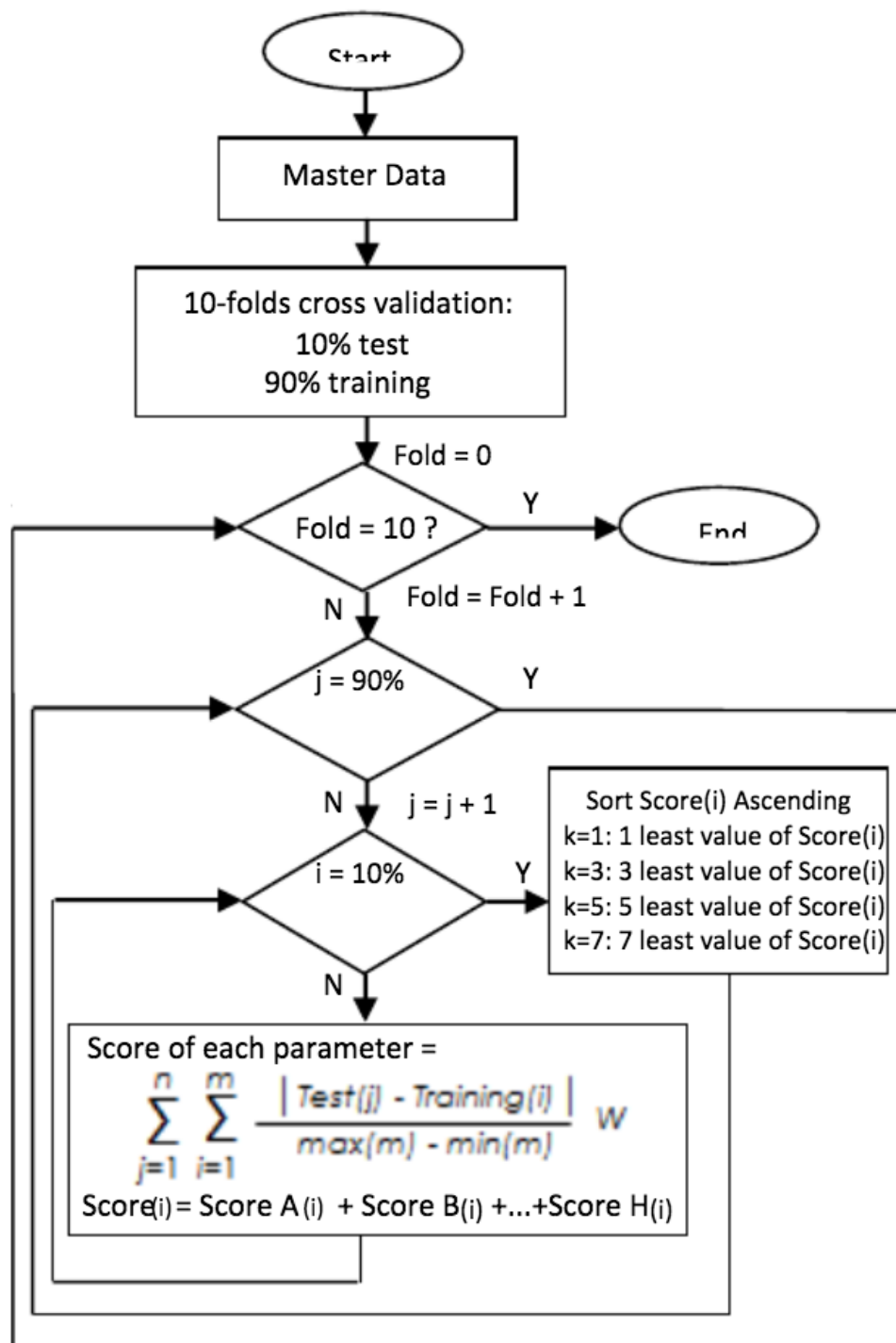
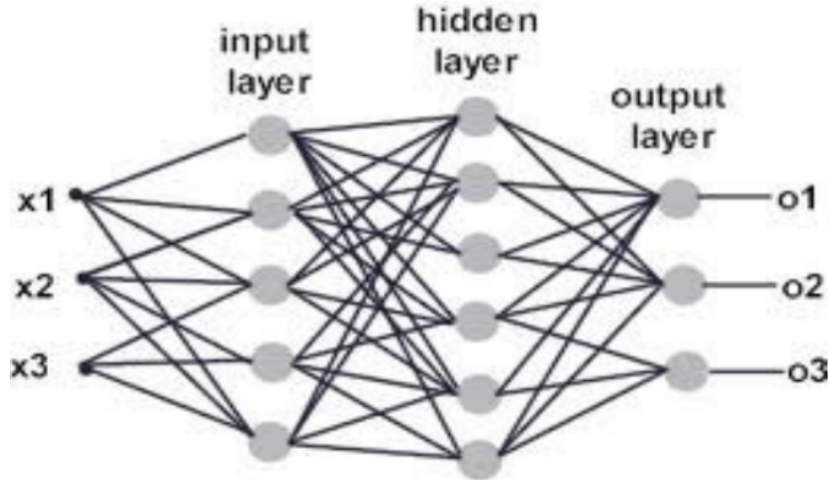


Figure 3.8: FlowChart for KNN

### 3.2.6 Neural Network

#### 3.2.6.1 Multilayer Perceptron Neural Network (MLPNN)

One of the most important models in Artificial Neural Network is Multilayer Perceptron (MLP). The type of architecture used to implement the system is Multilayer Perceptron Neural Network (MLPNN).



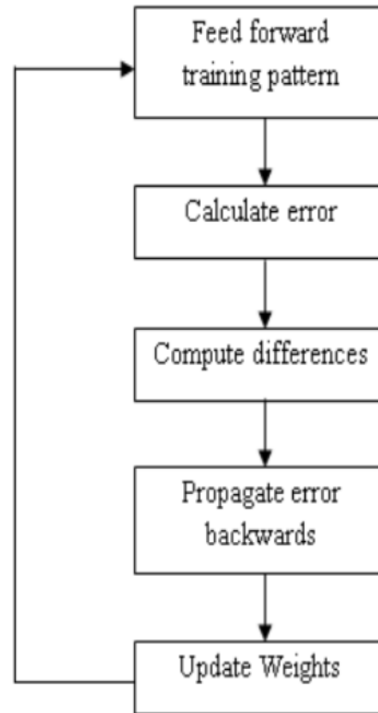
The MLPNN consists of one input layer, one output layer and one or more hidden layers. Each layer consists of one or more nodes, represented by small circles. The lines between nodes indicate flow of information from one node to another node. The input layer receives signals from external nodes. The output of input layer is given to hidden layer, through weighted connection links. It performs computations and transmits the result to output layer through weighted links. The output of hidden layer is forwarded to output layer, it performs computations and produce final result. The working of multilayer perceptron neural network is summarized in steps as mentioned Below:

1. Input data is provided to input layer for processing, which produces a predicted output.
2. The predicted output is subtracted from actual output and error value is calculated.
3. The network then uses a Backpropagation algorithm which adjusts the weights.
4. For weights adjusting it starts from weights between output layer nodes and last hidden layer nodes and works backwards through network.
5. When back propagation is finished, the forwarding process starts again.
6. The process is repeated until the error between predicted and actual output is minimized.

#### 3.2.6.2 Backpropagation network

The most widely used training algorithm for multilayer and feed forward network is Backpropagation. The name given is back propagation because it calculates the difference between actual and predicted values is propagated from output nodes backwards to nodes in previous layer. This is done to improve weights during processing. The working of Backpropagation algorithm is summarized in steps as follows:

1. Provide training data to the network.



2. Compare the actual and desired output.
3. Calculate the error in each neuron.
4. Calculate what output should be for each neuron and how much lower or higher output must be adjusted for desired output.
5. Then adjust the weights

### 3.3 UML diagrams with discussions

### 3.4 Data Source/Database used and Formats

#### 3.4.1 Heart Disease DataSet

The dataset used in this project is the Cleveland Heart Disease dataset taken from the UCI repository.

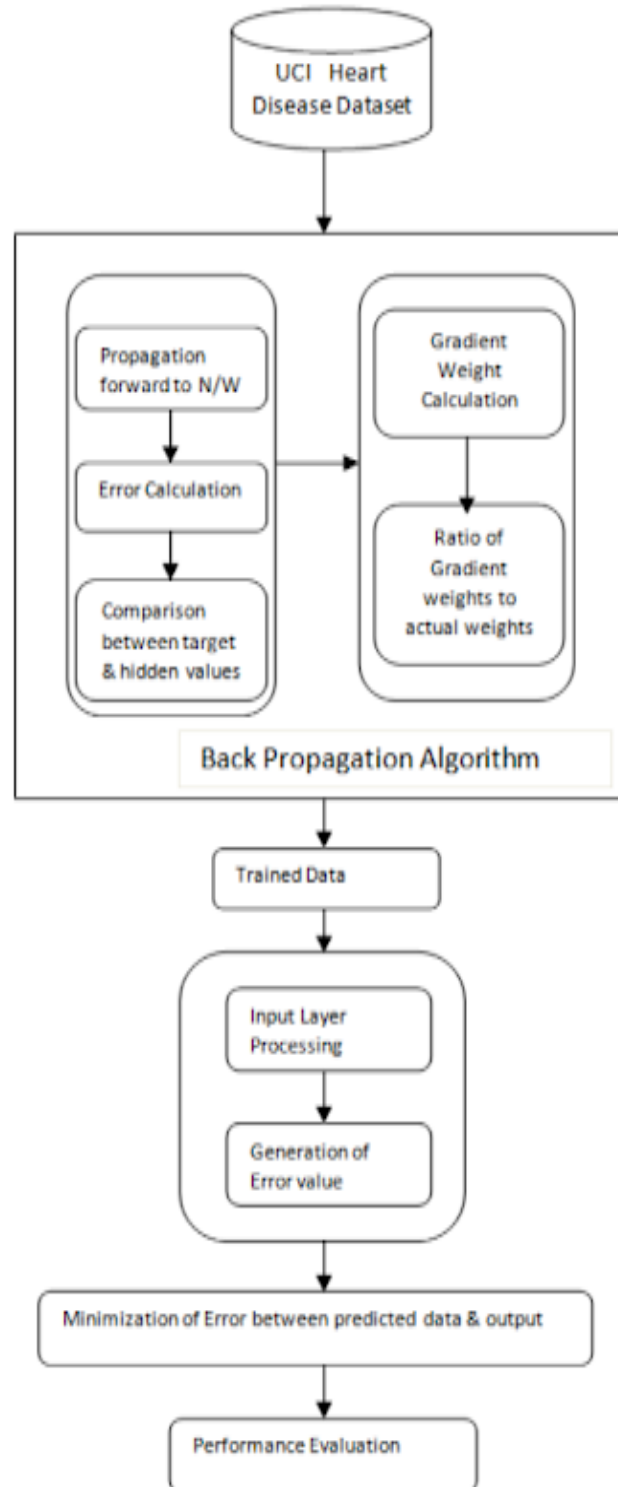


Figure 3.9: Flowchart for Neural Network



Index	age	sex	cp	resttsg	chol	tbs	restng	maxach	maxng	oldpeak	slope	ca	thal	target
0	63	1	1	145	233	1	1	250	0	1.3	1	0	1	0
1	67	1	0	148	286	0	1	286	1	1.5	2	1	1	2
2	67	1	0	120	229	0	1	170	1	1.6	2	2	1	1
3	71	1	3	130	250	0	0	267	0	1.5	3	0	1	0
4	41	0	2	130	204	0	1	212	0	1.4	1	0	1	0
5	56	1	2	129	216	0	0	276	0	0.8	1	0	1	0
6	52	0	1	140	268	0	1	300	0	1.6	3	1	1	1
7	57	0	0	120	254	0	0	265	1	0.5	1	0	1	0
8	63	1	0	130	216	0	1	247	0	1.4	2	1	1	2
9	51	1	0	100	201	1	1	201	1	1.1	0	0	1	1
10	57	1	0	140	210	0	0	240	0	0.4	2	0	1	0
11	56	0	1	140	204	0	1	253	0	1.3	2	0	1	0
12	56	1	1	130	256	1	1	242	1	0.5	2	1	1	2
13	55	1	2	120	261	0	0	275	0	0	1	0	1	0
14	72	1	1	172	299	1	0	362	0	0.5	1	0	1	0
15	57	1	3	150	300	0	0	314	0	1.5	1	0	1	0
16	46	1	1	110	229	0	0	260	0	1	1	0	1	1
17	54	1	0	100	210	0	0	200	0	1.2	1	0	1	0
18	48	0	1	130	275	0	0	330	0	0.2	1	0	1	0

The dataset consists of 303 individuals data. There are 14 columns in the dataset, which are described below.

1. **Age:** displays the age of the individual.
2. **Sex:** displays the gender of the individual using the following format :
  - 1 = male
  - 0 = female
3. **Chest-pain type:** displays the type of chest-pain experienced by the individual using the following format :
  - 1 = typical angina
  - 2 = atypical angina
  - 3 = non — anginal pain
  - 4 = asymptotic
4. **Resting Blood Pressure:** displays the resting blood pressure value of an individual in mmHg (unit)
5. **Serum Cholestrol:** displays the serum cholesterol in mg/dl (unit)
6. **Fasting Blood Sugar:** compares the fasting blood sugar value of an individual with 120mg/dl.
  - If fasting blood sugar  $\geq$  120mg/dl then : 1 (true)
  - else : 0 (false)
7. **Resting ECG:** displays resting electrocardiographic results
  - 0 = normal
  - 1 = having ST-T wave abnormality
  - 2 = left ventricular hypertrophy
8. **Max heart rate achieved:** displays the max heart rate achieved by an individual.
9. **Exercise induced angina :**
  - 1 = yes

- 0 = no
10. **ST depression induced by exercise relative to rest:** displays the value which is an integer or float.
  11. **Peak exercise ST segment:**
    - 1 = upsloping
    - 2 = flat
    - 3 = downsloping
  12. **Number of major vessels (0–3) colored by flourosopy :** displays the value as integer or float.
  13. **Thal :** displays the thalassemia :
    - 3 = normal
    - 6 = fixed defect
    - 7 = reversible defect
  14. **Diagnosis of heart disease :** Displays whether the individual is suffering from heart disease or not :
    - 0 = absent
    - 1, 2, 3, 4 = present.