Savitribai Phule Pune University

A PRELIMINARY PROJECT REPORT
ON

DETECTION OF HEART FAILURE

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CERTIFICATE

This is to certify that project entitled

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is a bonafide work carried out by Students under the supervision of Prof.S.R.Khade and it is submitted towards the partial fulfillment of the requirement of Bachelor of Engineering (Computer Engineering).

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ABSTRACT

One of the major reasons for deaths, not only in India but all over the world is Cardiovascular diseases. Every year, almost a million people die due to these heart diseases. In this study, we will be focusing on heart failure (or congestive heart failures), which is a form of heart disease. In order to reduce the number of deaths due to these heart diseases, there needs to be a quick and efficient detection technique. Though the accurate diagnosis of heart failure in patients is quite important, it is quite difficult due to our insufficient understanding of the characteristics of heart failure. Knowledge of each factor that contributes in a heart disease is crucial for prevention. The healthcare industry generates a huge amount of data on these diseases on daily basis. This paper provides a brief review of the various deep learning techniques used to detect heart failure.

KEYWORDS-*Congestive Heart Failure, Deep Learning, Heart Rate Variability, Recurrent Neural Network, Convolutional Neural Network.*

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Chapter 1

Introduction

Heart failure is due to its severity has emerged as a syndrome rather than a disease.

Heart failure, also known as congestive heart failure, occurs when the heart muscle does not pump blood as well as it should. There are certain conditions that impair the performance of heart such as high blood pressure, narrowed arteries. These make the heart stiff to fill and pump efficiently.

Though treatments can improve the heart health but heart failure prevention, which is the main concern, is still to be achieved. Heart failure occurs when the heart is unable to either pump enough blood or fill enough blood in its ventricle. This leads to two types of congestive heart failures Systolic heart failure and Diastolic heart failure.

Systolic failure occurs when the ventricle fails to contract normally; the reduced force makes it difficult to pump the blood into circulation.
Diastolic failure is when the muscles of the ventricle become stiff which hinders the filling of blood between the beats.

Diagnosis of CHF includes methods making use of HRV and non-HRV measures. Machine learning techniques have been studied and implemented quite successfully towards HF detection. There exist systems that implement data mining techniques to gain knowledge from the available information.

Chapter 2

Literature Survey

1) SUPPORT VECTOR MACHINE: Yang et al. [2] proposed a scoring-based model based on SVM. SVM is a non-probabilistic binary linear classifier. A scoring model based on SVM was proposed and samples were classified into two groups HF-prone and HF-group. The model gives a 74.4% accuracy. However, the speed of SVM is a bit slow.

2)DECISION TREES: Son et al. [3] designed a decision-making model by making use of a model that uses rough sets(RSs) and decision trees. They compared the discriminatory power of decision-making model that makes use of RS and linear regression decision models.This model gives an accuracy of 97.2%. But Decision tree is prone to noise during learning.

3)A DEEP-LEARNING CLASSIFIER IDENTIFIES PATIENTS WITH CLINICAL HEART FAILURE USING WHOLE-SLIDE IMAGES OF H&E TISSUE: Deep convolutional neural networks (CNN) have been applied successfully to various diseases in medical imaging. The authors et al. [4] have developed a CNN to detect HF from H&E strained whole-slide images. The CNN was able to identify patients with HF with a 99% sensitivity and 94% specificity on the test set.

4)DEEP NEURAL NETWORKS FOR DETECTING HEART DISEASES: The authors et al. [5] developed a five-layer DNN architecture named Heart Evaluation for Algorithmic Risk-reduction and Optimization Five(HEARO-5). They used k-way cross validation and Matthews correlation coefficient to tune the architectures.The model yielded 95% accuracy.

5)HEART ATTACK PREDICTION USING DEEP LEARNING: The authors et al. [6]proposed a heart attack prediction system using Deep learning techniques, specifically Recurrent Neural Networks to predict the possibilities of heart related diseases. RNN is a neural network which has an extra hidden layer wherein the hidden layer influences the output of the network.

6)REPRESENTATION LEARNING FROM ELECTRONIC HEALTH RECORDS: The authors et al. [7] built an efficient method for patient and medical concept representation learning. They transformed clinical data from electronic health records into meaningful constructed features. Their model improves the predictive modelling performance for onset of heart failure up to 23%.

7)RECURRENT NEURAL NETWORKS TO PREDICT HEART FAILURE: The authors et al. [8] explored whether use of deep learning to model temporal relations among events in Electronic Health Records could improve the model performance in predicting early diagnosis of heart failure. DL models adapted to leverage temporal relations. Deep learning models showed improvement in the performance of models with a window period of 12-18 months.

8)A CHF BASED DEEP LEARNING METHOD USING RR INTERVALS: The intervals between the heartbeats in the ECG or electrocardiogram is called as R-R interval. The authors et al. [9] checked for robustness of CHF detection based on heart rate variability. They applied a sparse auto-encoder based deep learning algorithm in CHF detection with RR intervals. Their model achieved an accuracy of 72.41%. However, R-R intervals dont have the potential to detect CHF and cant reflect dynamic change in 24-hr.

Chapter 3

Software Requirement Specification

3.1 Introduction

3.1.1 Project Scope

The system of heart failure detection is developed with a purpose of contributing towards healthcare industry. The system is based on Machine Learning techniques such as Deep Learning, Convolutional Neural Network. The motive is to have an improved accuracy than the existing systems. Patients' medical history will be used for the effective learning of the system and detection of the failure as early as possible. Above all,saving as many lives as possible is the main motive.

3.1.2 User Classes and Characteristics

Users of the system should be able to get prediction of the risk he is at.User can access and update his medical data.User will also know the details about the category of failure he is prone to.The system will also predict the adverse events that are possible to occur.

3.1.3 Assumptions and Dependencies

Let us Assume:
1.User has access to his data and can update anytime.
2.The modifications get updated in the hospital's database.
3.It is assumed that the maintenance of the database will be assigned to the authorized person only.
4.Only authorized persons will be allowed inside the system.
Dependencies:
1.We are dependent on hospital to provide these facilities.

3.2 Functional Requirements

3.2.1 Heart Failure Detection Requirements

The system should provide failure detection functions which can take various medical data from patients and classify them as heart prone or not.

3.2.2 Heart Failure Subtype Classification Requirements

The system should classify the patients according to various heart failure classification methods in practice.

3.2.3 Heart Failure Severity Measurement Requirements

The system should measure the severity of the patient diagnosed with heart failure according to NYHA or ACC/AHA.

3.2.4 Adverse Event Prediction due to Heart Failure

The system should also predict further adverse events that could possibly take place as a result of the syndrome diagnosed.

3.3 Non-Functional Requirements

3.3.1 Performance Requirements

The performance measures of the classifier should be high for accurate prediction. The measures to be considered are sensitivity, specificity, positive and negative prediction values of different classes.

3.3.2 Safety Requirements

Information transmission should be securely transmitted to server without any changes in information.All transactions, logged information, updates, user activities are backup at the end of each day automatically.

3.3.3 Security Requirements

Any modification (insert, delete and update) for the Database shall be synchronized and done only by the System administrator.

3.3.4 Software Quality Attributes

Availability

Even if the system fails, the classifier should be able to access the database.

Usability

The system will be able to analyse the patients data and try to predict the proneness to HF with the help of historic data.

Maintainability

The system shall provide the capability to back-up the Data.

3.4 System Requirement

3.4.1 Database Requirements

- **Database:** SQL

3.4.2 Hardware Requirements

- **CPU:** at least Dual Core 3.6MHz.
- **Space:** Minimum of 500MB
- **Ram:** Minimum of 4GB
- **Wifi:** Minimum signal strength for reliable packet delivery.

3.4.3 Software Requirements

- **Platform:** Python

3.5 Analysis Model: SDLC Model to be applied

Agile SDLC Model

In the agile methodology after every development iteration, the customer is able to see the result and understand if he is satisfied with it or he is not. This is one of the advantages of the agile software development life cycle model. One of its disadvantages is that with the absence of defined requirements it is difficult to estimate the resources and development cost. Extreme programming is one of the practical use of the agile model. The basis of such model consists of short weekly meetings Sprints which are the part of the Scrum approach.

Use cases for the Agile model:

- The users needs change dynamically
  - Less price for the changes implemented because of the many iterations
  - Unlike the Waterfall model, it requires only initial planning to start the project

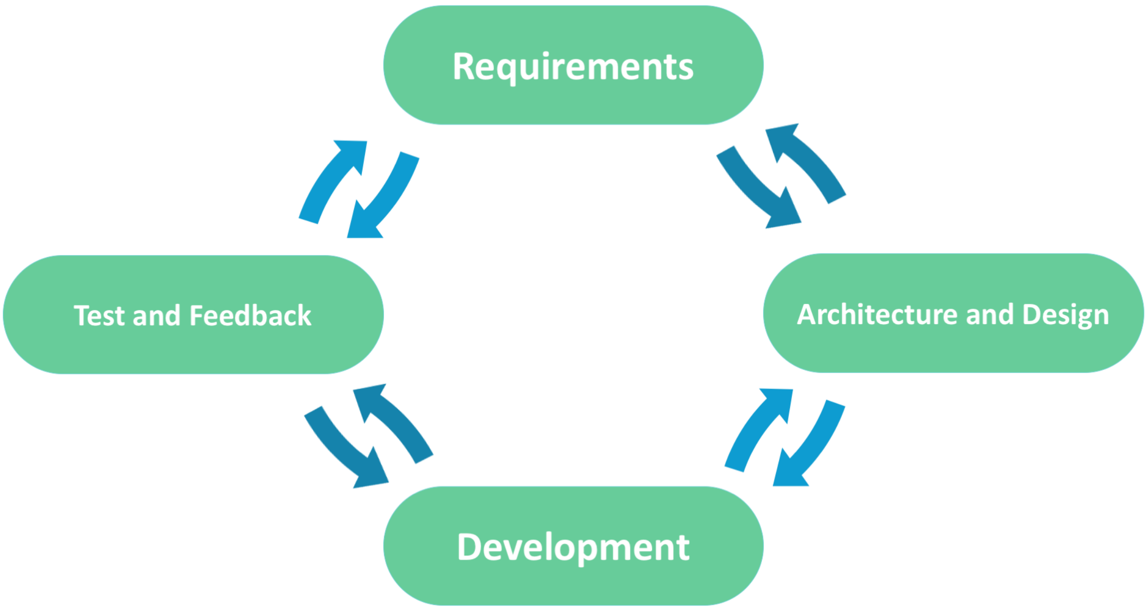

Figure 3.1: Agile SDLC Model

3.6 System Implementation Plan

The system consists of 4 modules. The patient first enters his report into the system. The first module detects the patient whether he is heart failure prone or not. If he is detected as a HF prone patient the data is sent over to the next module, else the system will give a view that the patient is not prone to HF. In the second module the system checks what type of HF the patient has. This classification is based on Systolic and Diastolic HF. Once this is dected it forwardsthe data and result of this module over to the next module. The third module then dectects the severity of the heart failure of the patient. This is mainly done on the basis of NYHA or ACC/AHA. Lastly the system will also be able to predict futher adverse conditions if any the patient will go through. The system will be trained on neural networks and other classification techniques. The first module will be trained using deep neural networks which are capable of extracting useful features and do analysis accurately. Altough the training period of the networks may be high the system will be roboust so that if a new patient with unique symptoms has arrived the system will be able to predict the outcome. On a failed predicition the system is again going to train itself so as to update it's accuracy. The end user has to finally update the success of the classifier. Then system will be used by any medical practioner which will assist in their diagnosis.

Chapter 4

System Design

4.1 System Architecture

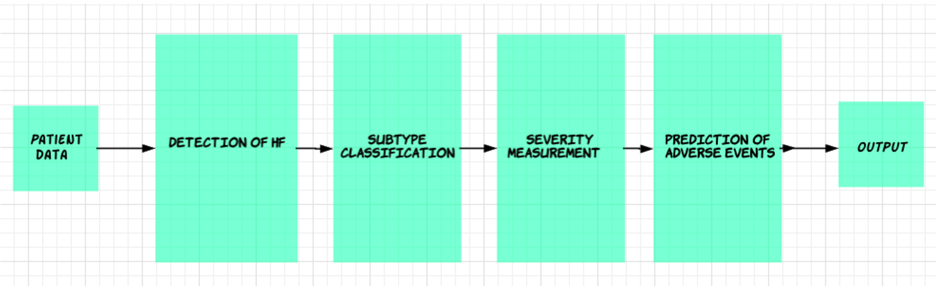

Figure 4.1: Design and Architecture of Smart Mirror

4.1.1 Heart Failure Detection

This model is the first step in diagnosis of Heart Failure. It helps to detect the measure of much a patient is prone to heart failure. It uses various pathology results and on the classification based on deep neural networks is able to accurately predict it.

4.1.2 Heart Failure Subtype Classification

Once the proneness to Heart Failure is detected the next step will be to classify the patients into 2 major sybtypes based on the measurement of left ventricular ejection fraction(LVEF). This module classify the patients intro HRpEF(diastolic) and HRrEF(systolic). Diastolic HF causes heart muscle thickening which may lead to hold an abnormally small volume of blood therby supplying less blood to the body. In Systolic HF, the heart muscle is not able to contract properly and hence supplies less oxygen-rich blood to the body.

4.1.3 Severity Measurement

Although HF does not show signs in the early stages, early assessment becomes necessary. This module makes use of NYHA(New York Heart Association) or ACC/AHA(Americam College of Cardiology/American Heart Association). The NYHA does measurement on syptoms and physical activity. It focuses on exercise capacity of the patient and the status of showing symptooms of the disease. While the ACC/AHA does it based on the structural changes and syptoms. It marks the indication of the developement and progression of HF.

4.1.4 Prediction of Adverse Events

This module detect the adverse events associated with HF. These include mortality, destablization and re-hospitlization. Various simultaneous multiple factors from patients report are taken into account and afterwards the events are predicited.

4.2 Data Flow Diagram

4.2.1 DFD Level-0

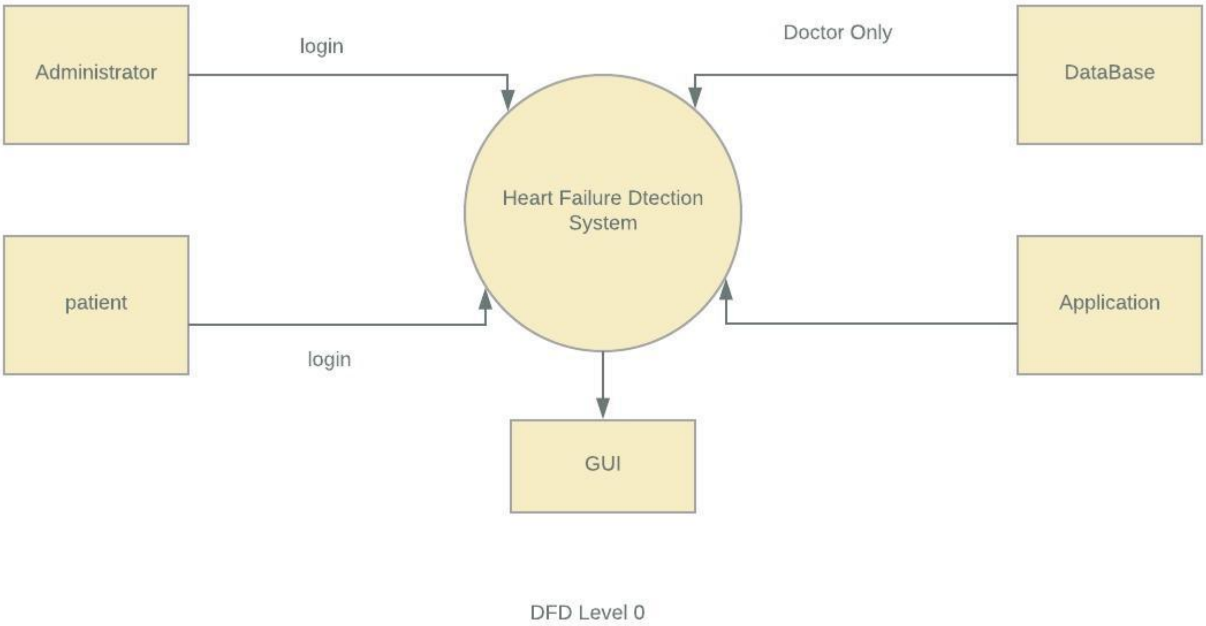

Figure 4.2: DFD Level-0

4.2.2 DFD Level-1

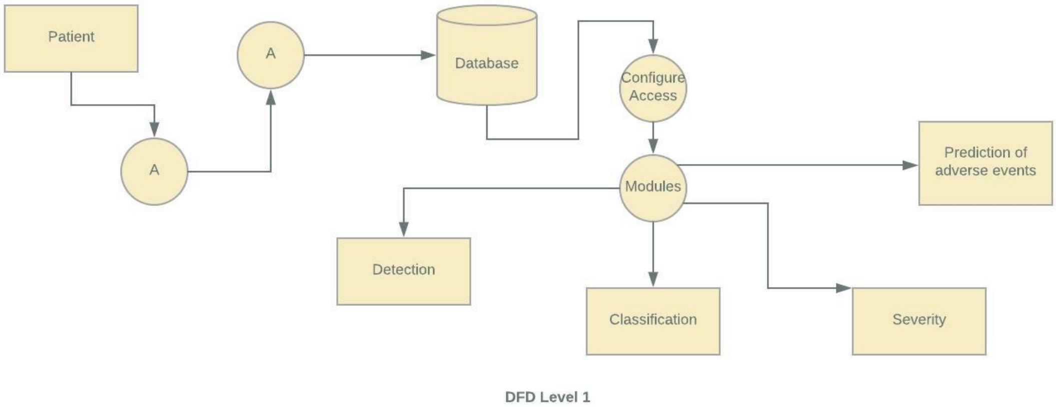

Figure 4.3: DFD Level-1

4.2.3 DFD Level-2

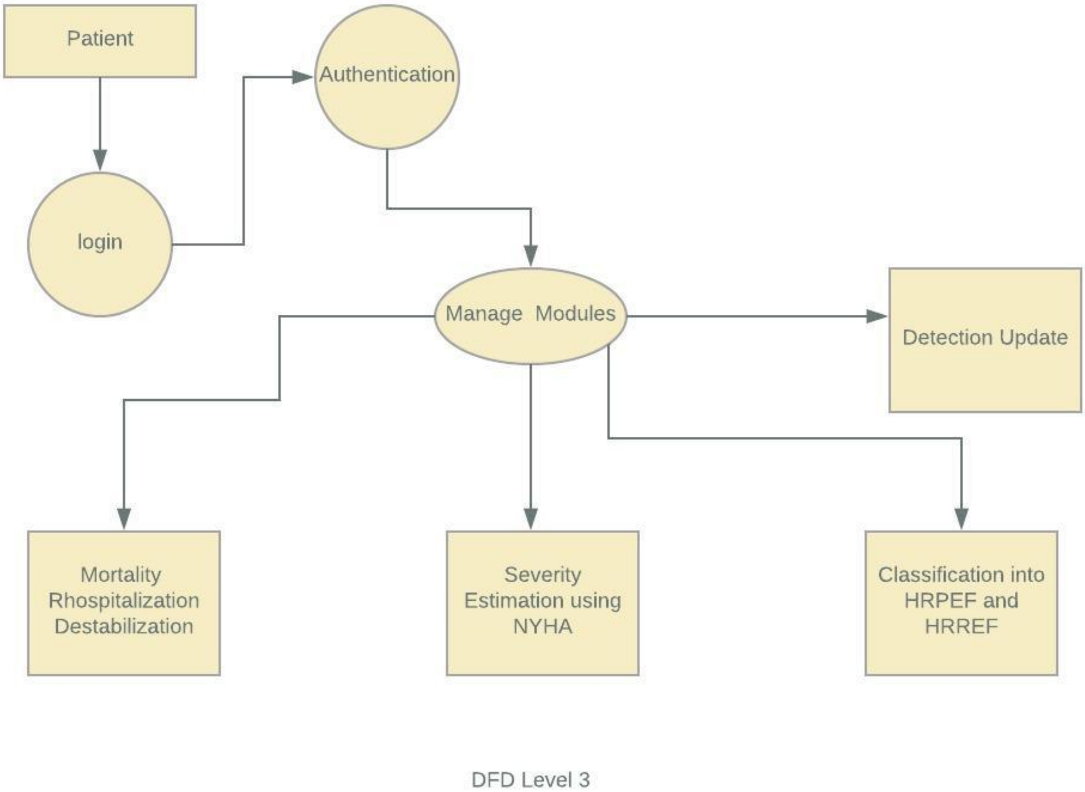

Figure 4.4: DFD Level-2

4.3 UML Diagrams

4.3.1 Use Case Diagram

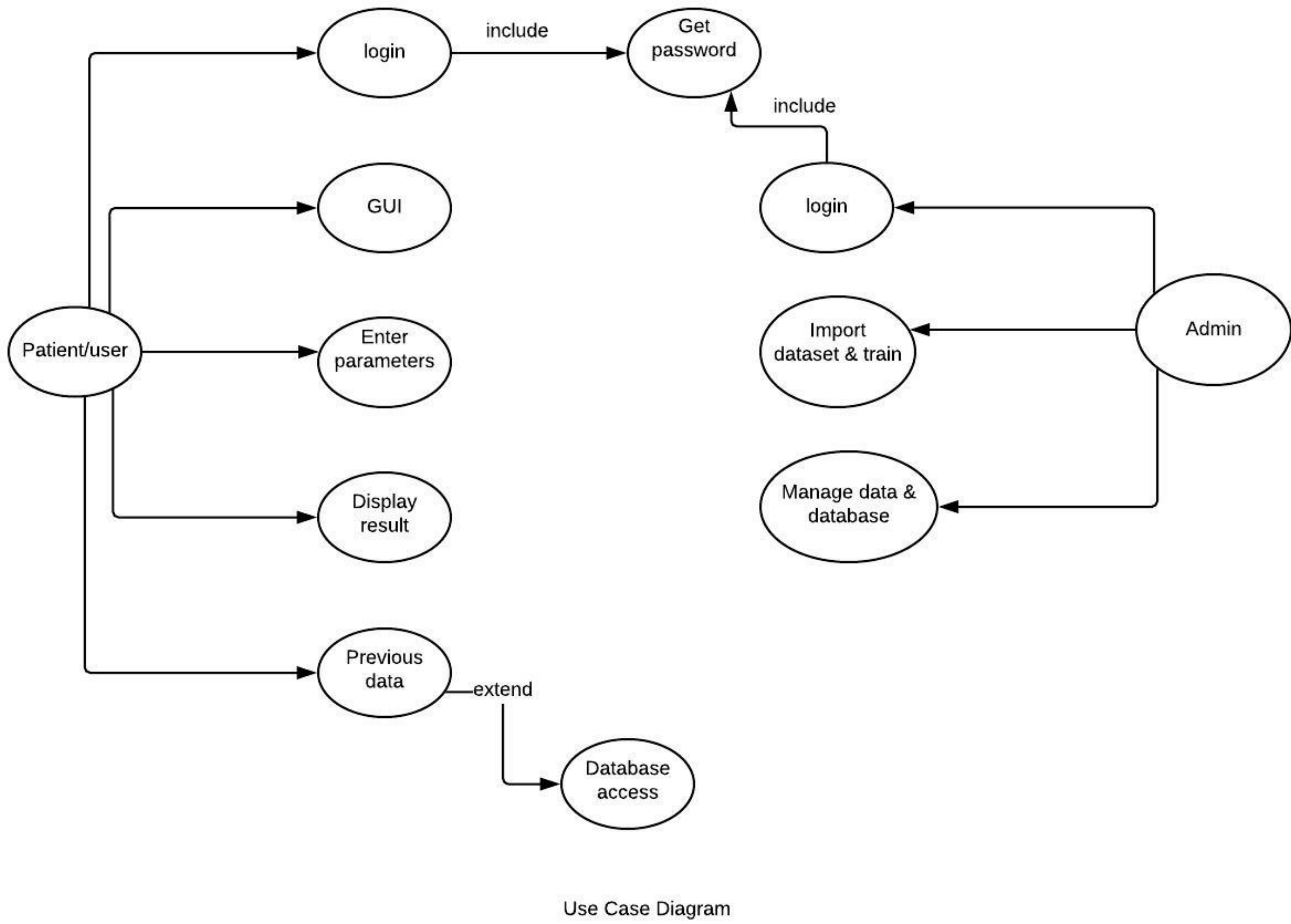

Figure 4.5: Use Case Diagram

4.3.2 Sequence Diagram

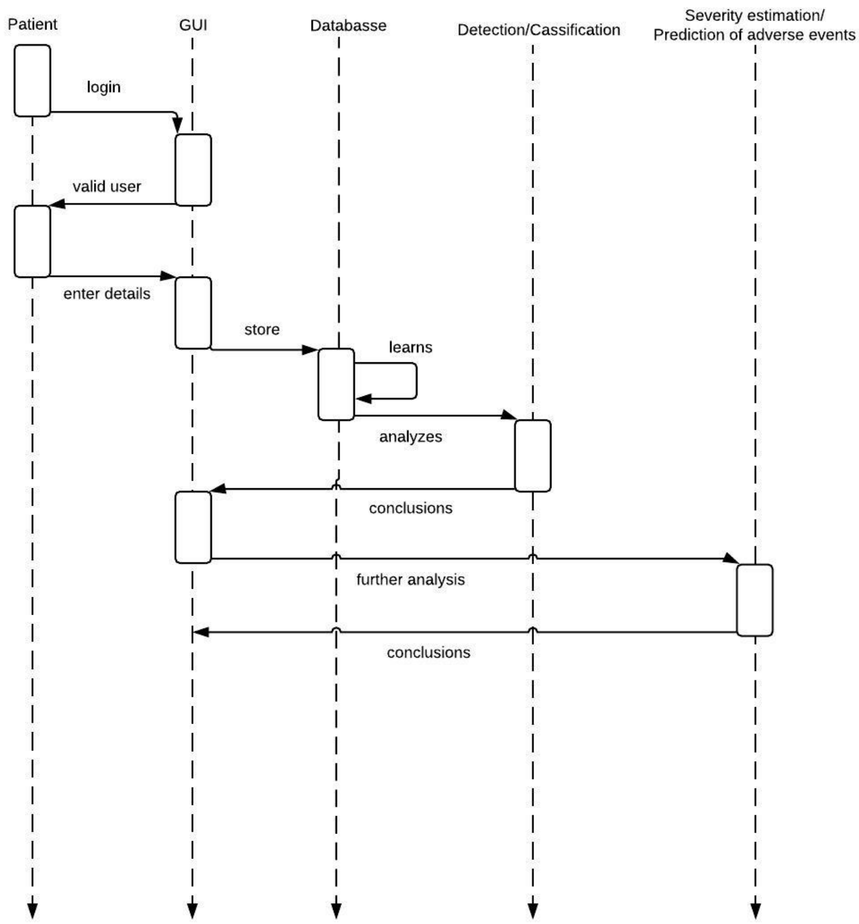

Figure 4.6: Sequence Diagram

4.3.3 ER Diagram

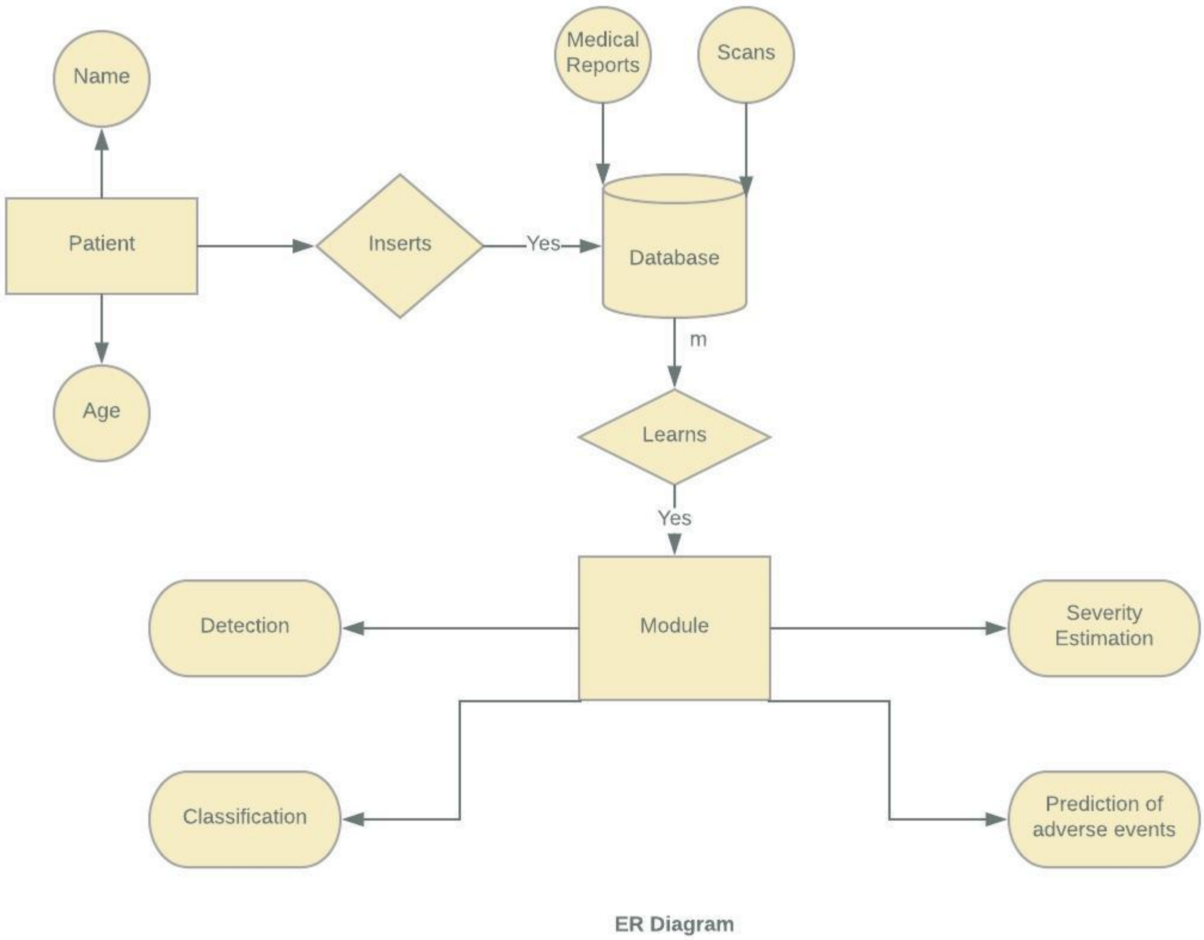

Figure 4.7: ER Diagram

4.3.4 Class Diagram

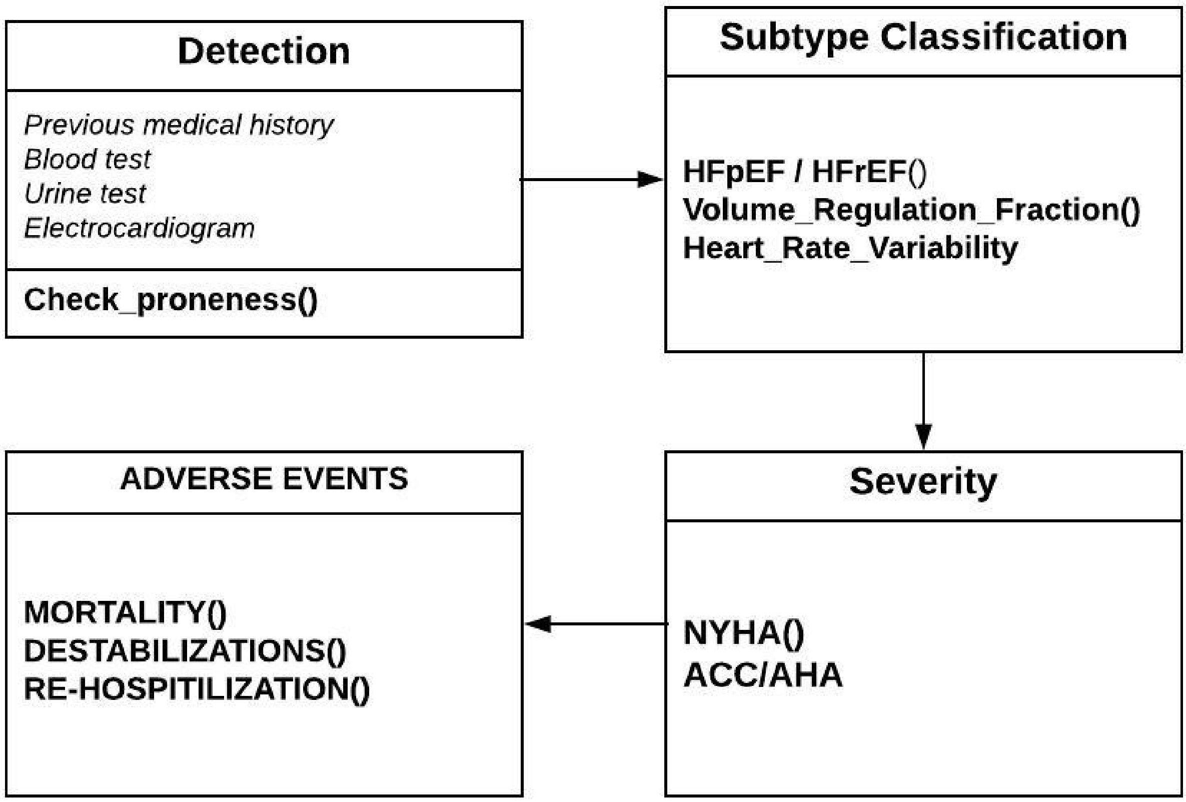

Figure 4.8: Class Diagram

4.3.5 Component Diagram

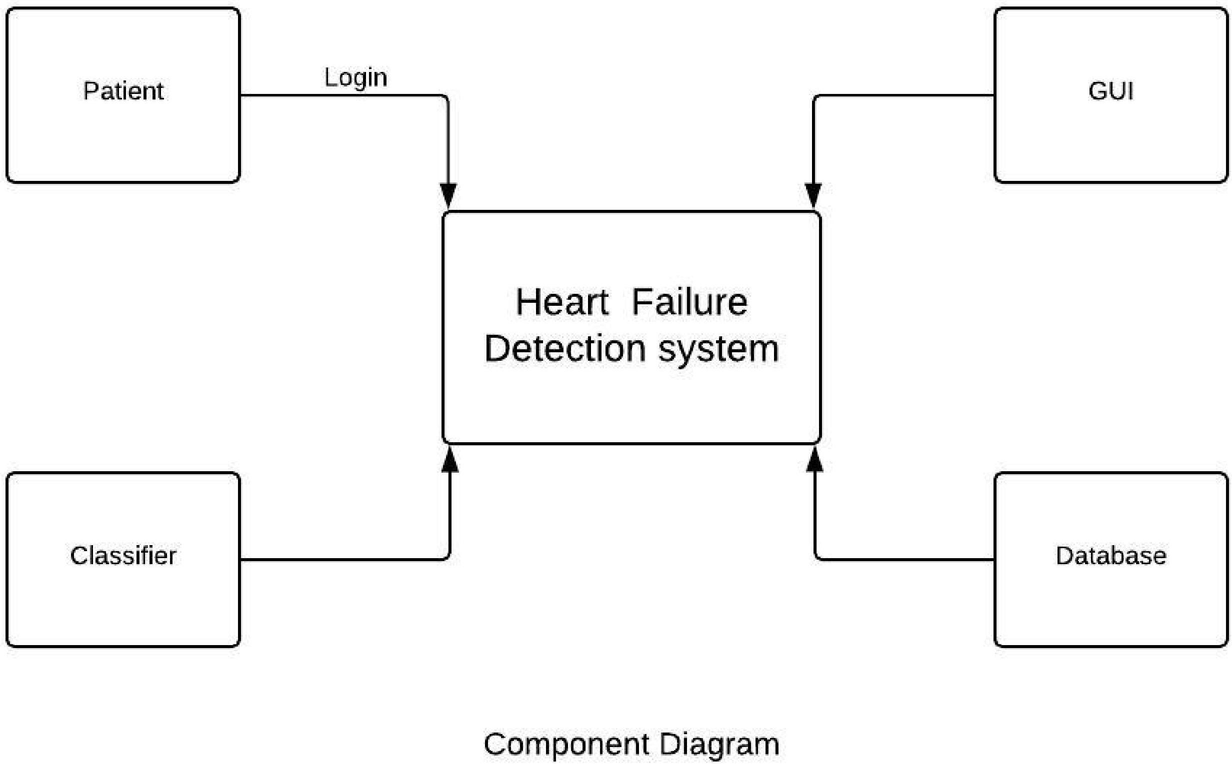

Figure 4.9: Component Diagram

4.3.6 Deployment Diagram

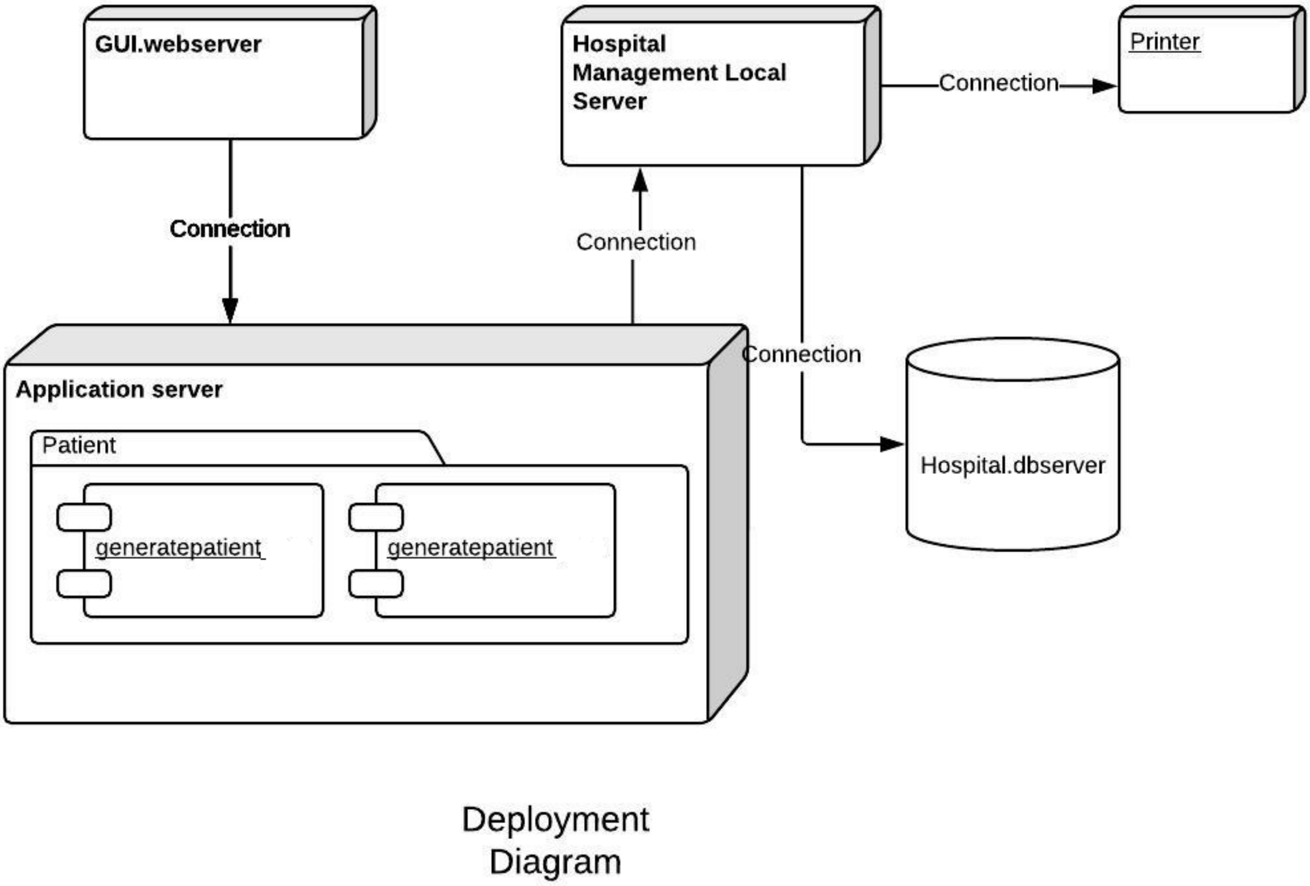

Figure 4.10: Deployment Diagram

4.3.7 State Machine Diagram

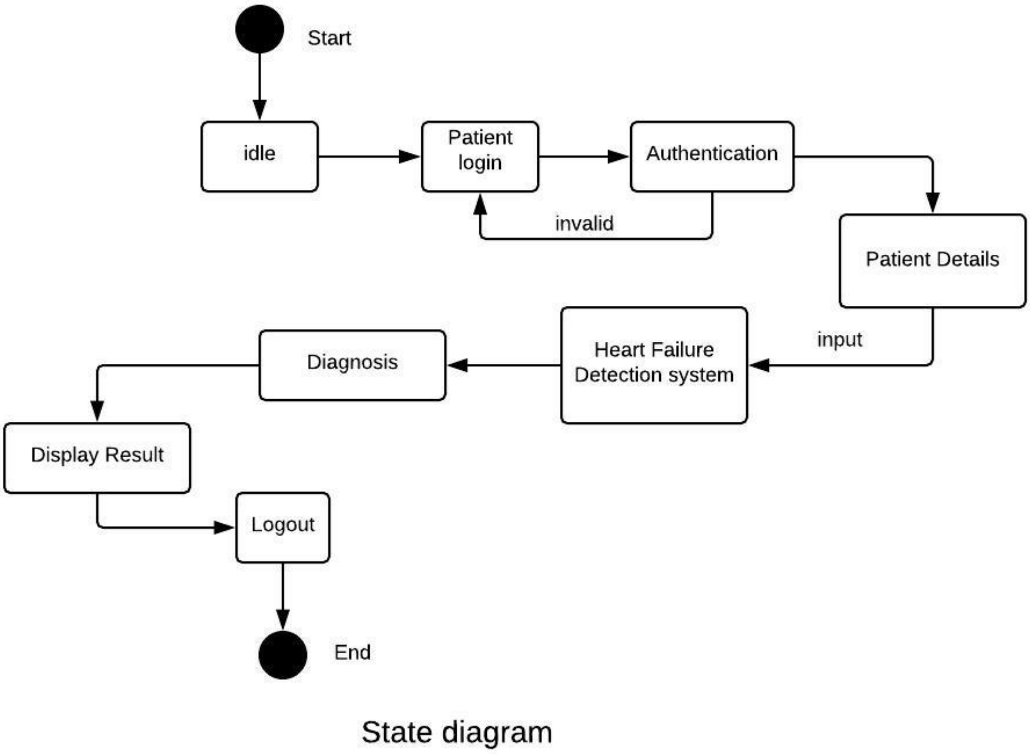

Figure 4.11: State Machine Diagram

Chapter 5

Other Specifications

5.1 Advantages

1. Low cost predicting system(without any additional exclusive tests)
2. High accuracy
3. Easy and quick detection of HF.

5.2 Limitations

The system will be able to predict the proneness of a person to heart failure, but does not provide remedies on the condition. Patient must seek the doctors help for clinical decision making to improve ones condition.

5.3 Applications

The proposed CHF detection system will perform the following tasks:
1. It will be able to detect proneness of a patient to heart failure based on prior clinical history and the physical conditions of the patient.
2. It will be able to classify the heart failure subtype.
3. It will be able to estimate the severity of heart failure.
4. The early prediction of those events will allow experts to achieve effective risk stratification of patients and to assist in clinical decision making.

Chapter 6

CONCLUSION

Various Deep Learning models to detect heart failure have been studied. Although the training window period may be larger than traditional machine learning algorithms, Deep learning models are more robust and can extract features more precisely as compared to Traditional Machine Learning Algorithms.

Chapter 7

FUTURE WORK

Some additional features can be extracted from the data for prediction of the other heart diseases effectively.Further, the system can be extended to provide remedies and suggestions to improve patients conditions.

References

[1] Tripoliti, E. E., Papadopoulos, T. G., Karanasiou, G. S., Naka, K. K., Fotiadis, D. I. (2017). Heart Failure: Diagnosis, Severity Estimation and Prediction of Adverse Events Through Machine Learning Techniques. Computational and Structural Biotechnology Journal, 15, 2647.

[2] Yang G, Ren Y, Pan Q, Ning G, Gong S, Cai G, et al. A heart failure diagnosis model based on support vector machine. 2010 3rd international conference on biomedical engineering and informatics (BMEI), vol. 3; 2010. p. 11058.

[3] Son C-S, Kim Y-N, Kim H-S, Park H-S, Kim M-S. Decision-making model for early 915 diagnosis of congestive heart failure using rough set and decision tree approaches. 916 J Biomed Inform 2012.

[4] Jeffrey J. Nirschl, Andrew Janowczyk, Eliot G. Peyster, Renee Frank, Kenneth B. Margulies, Michael D. Feldman, Anant Madabhushi. A deep-learning classifier identifies patients with clinical heart failure using whole-slide images of HE tissue.

[5] Nathalie-Sofia Tomov, StanimireTomov. On Deep Neural Networks for Detecting Heart Disease.

[6] Abhay Kishore, Ajay Kumar, Karan Singh, Maninder Punia, Yogita Hambir. Heart Attack Prediction Using Deep Learning

[7] Edward Choi, Andy Schuetz, Walter F. Stewart, Jimeng Sun. Medical Concept Representation Learning from Electronic Health Records and its Application on Heart Failure Prediction

[8] Edward Choi, Andy Schuetz, Walter F Stewart, and Jimeng Sun. Using recurrent neural network models for early detection of heart failure onset.

[9] Wenhui Chen, Guanzheng Liu, Steven Su, Qing Jiang and Hung Nguyen. A CHF Detection Method based on Deep Learning with RR Intervals