Smart Rehab

Final Year Project

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Project Detail

Type (Nature of project)	[ ] **D**evelopment [ ] **R**esearch [*] **R**&**D**			
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*The candidates confirm that the work submitted is their own and appropriate credit has been given where reference has been made to work of others.

Plagiarism Free Certificate

This is to certify that, I am **Imtisal Ahmed** S/D/o **Abid Azhar**, group leader of FYP under registration no CIIT/FA16-BCS-045/LHR at Computer Science Department, COMSATS Institute of Information Technology, Lahore. I declare that my FYP proposal is checked by my supervisor and the similarity index is 17% that is less than 20%, an acceptable limit by HEC. Report is attached herewith as Appendix A.

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Abstract

Parkinson's disease is a neurodegenerative disorder that affects the part of your brain that controls body movements. More than 10 million people are affected by motion diseases like Parkinson's disease around the globe which is alarming. So, experts around the world are working to find new and effective ways to cure these patients using various technologies and experimenting with many upcoming technologies. The proposed system targets Parkinson's disease patients and provides an interactive and innovative solution using cutting-edge technology like Mo-Cap Rokoko smart suit. The main architecture of the project works on motion sensors. Pre-defined tasks like exercise will be performed by the patient wearing the Mo-cap suit and the values obtained from movement through the sensors will be used by the system to evaluate the task, based upon the progress made by the patient after completing the task. An Artificial intelligence module will acquire the motion data from the smart suit and train the model which will evaluate whether the person is Parkinson's patient or not. The recovery rate and performance of the patients are monitored, observed, and stored in the database which will be used to create progress reports/ rate of recovery.

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1 Introduction:

1.1 Project Overview

Motor neuron diseases also known as motion diseases affect a person's physical movements causing problems in gait movement, tremor, lack of control in balance, stiffness in limbs and muscles and slow movement, etc. These diseases include Parkinson's disease, Cerebral Palsy, and Dyskinesia, etc. Parkinson's disease is a progressive neurodegenerative disorder that affects the part of your brain that controls body movements. An estimated 10 million people around the globe suffer from motion diseases like Parkinson's disease which is an alarming number. These diseases affect patients' quality of life, making their social life very difficult and disturbing their financial condition, because of the expenses related to the disease.

Population studies about Parkinson's are important to scientists' understanding of the history of the disease, its evolution, and the risks associated with it. The information about the disease can help healthcare experts in designing different cures to meet patients' needs [1]. According to experts by capturing motion details of motion impaired patients and analysing the collected data to find specific patterns can be very helpful in finding a cure for these diseases. Motion capture known as Mo-Cap is the process of recording/capturing physical movements of objects or people used for medical applications, military purposes, games and validation of computer vision, etc. [2]. Motion capture smart suit is a device that captures and measures the real-time movement of people and provides necessary data which can be used to create 3D animations, evaluate different types of motions.

There are two basic types of motion capture suits:

- Optical Mo-Cap Suit.
- IMU Sensor based Mo-Cap Suit.

1.2 Optical Mo-Cap Suit

Optical Mo-Cap systems (as shown in figure 1) use video cameras and depth sensors to track the motion of markers attached to specific locations of the user`s body. It's a process of recording human actions and translating them into animations by filming sensors on every point on the patients` body. The footage is captured and then converted into a 3D humanoid model. It is mostly used in film making and game making etc. [3].

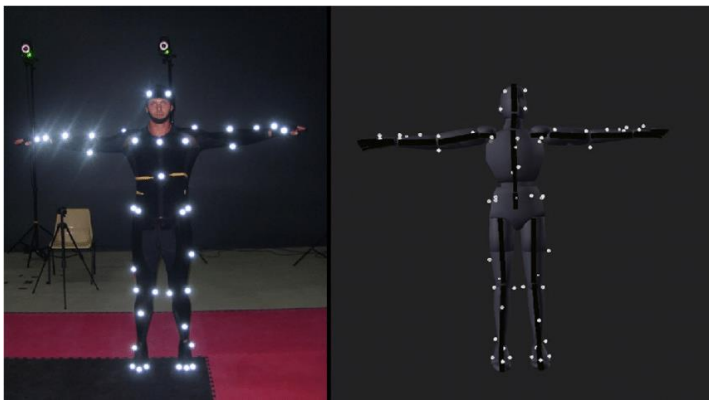

Figure 1- Optical Mo-Cap suit [3]

1.3 IMU Sensor-based Mo-Cap Suit

IMU-based (Inertial Measurement Units) Mo-Cap systems (as shown in figure 2) use IMUs to capture and rebuild human pose without the need of external visual sensing. The key goal is to capture people moving in the wild, performing unscripted actions and natural interactions without constraints. IMU sensors measure rotations and decode them onto a humanoid rig in the software. The more IMU sensors used the more natural the data. This system does not require any cameras, markers, and emitters. IMU systems capture the complete 6 degrees of body motion of a user in real-time. These are mostly used for medical applications and aeronautics etc. [4, 5].

Figure 2- IMU Mo-Cap suit [6]

The motion capture system was initially used for the assessment of motion-impaired individuals to analyse patients' walking gait patterns and movement of different body parts. The movement of each body joint is recorded accurately and by merging this data with the results of physical inspections, doctors can understand how and why a patient is moving in a specific way and makes some recommendations for the cure and therapy.

This project will use a motion capture suit to collect data from the body joints of a person and use this data in various forms to create an accurate rehabilitation system for Motion-Impaired (Parkinson's disease) patients.

1.4 Objectives:

- Improve the exercise methods of rehabilitation to new accuracy by using cutting-edge technology**.**
- Introduce an easy, fun, and interactive way of therapy that will increase doctor-patient engagement.
- Continuous performance tracking by measuring the smoothness, range, and agility of each body joint.
- Making it easy for doctors to get adequate and detail information about the motion of body parts of the patients with a visual representation.
- Record keeping of each patient, his history, recovery, and progress in a secured database.
- An innovative rehabilitation system for motion-impaired (Parkinson's) patients for the improvement of their body movements with the help of various Interactive exercise tasks and games.
- The system will assist the doctor in the rehabilitation process of Parkinson's disease patient.
- The system includes an artificial intelligence server that will help the doctor by deeply learning the body movement of the patient and evaluating whether the person is diseased with Parkinson's or not.

1.5 Problem Statement:

According to Neurology Awareness & Research Foundation (NARF) Pakistan, a rough estimate is that 1 million Pakistanis suffer from Parkinson’s disease [7], moreover an estimated 10 million people worldwide have Parkinson’s disease [8]. Parkinson's disease is a nervous system disorder that affects the part of your brain that controls body movements. Its symptoms start slowly, sometimes are barely visible but worsen with time and can lead to severe motion impairments like rigid muscles, slow movement, and tremors, etc. In spite of its high prevalence globally, no authentic early diagnostic system is yet available for its early diagnosis. Owing to this reason, there is a great need to design a smart diagnosis system for diagnosing this disease in its early stages. Early diagnosis of Parkinson’s disease can prevent further damage to the brain and thus can improve the quality of life of patients suffering with parkinsonism. Even though Parkinson's disease can't be cured, but exercises can improve the range of body movement a lot. However, the conventional physiotherapy treatments are available but the maneuvers and exercises physiotherapy offers are quite dull, dreary and less engaging to the patient so the patient tends to lose interest which in turn hinders their prognosis of the rehabilitation process. Thus, this creates a massive need to establish an assistive system that will assist the physiotherapists in replacing the dull and boring exercises into attractive and engaging tasks, thus keeping patient’s enthusiasm high and improving their prognosis of the rehabilitation process.

1.6 Assumptions and Constraints:

1.6.1 Assumptions:

- The system is being developed for the rehabilitation of Parkinson`s disease patients and for the doctors to provide them assistance towards the rehabilitation of motion impaired patients using cutting-edge technology like Rokoko Smart Suit.

- A platform for doctors to examine the detailed motion data of a patient`s body joints with accuracy and visual representation.

- This platform will be used by motion impaired patients to perform interactive physical exercise and tasks that will help in the rehabilitation of their motion disease.

- An online database-oriented system will keep the detailed data of each patient organized.

- An artificially intelligent system that will identify the disease and learn from the data acquired each time a patient uses the system and give useful suggestion towards the best rehabilitation techniques.

1.6.2 Constraints:

- To use this system, the user must have Mo-cap Smart Suit.

- The project must be completed in the giving period.

- Most of part of data will be stored on a cloud database, not on local devices.

1.7 Project Scope:

Mo-Cap has been leaving its unique mark on a numeral other industry, mostly in the medical field. This cutting-edge technology has allowed the quality of healthcare to improve for several people with devastating injuries and long-lasting circumstances that affect their capability to move and function in their daily lives, as well as changing the way many physiotherapists approach patient's rehabilitation and care [9]. Motion capture suites expand the possibility of recognition and rehabilitation of various motion diseases by providing detailed data of movements of different body parts. In medicine, Mocap is mostly used in gait analysis, but many different applications for this technology are also being discovered day by day, as well as the connection between body motion and the brain, including hand-eye synchronization [9]. The proposed system will have pre-recorded 3D animations of various exercises created through the date provided by Mo-Cap Suit of a healthy person loaded in this interactive system which will then be compared against the real-time movement of the patient. The patient will have to wear a Mo-Cap Suit which will provide real-time motion data of the patient. The patient`s task will be to try to copy/overlap the pre-recorded animations and the system will use an AI Server that will identify the difference between the healthy person`s movement and patients' motion and evaluate that

whether a person is a Parkinson’s patient or not. So, by performing these tasks the patients will undergo exercise therapy in an accurate way. The progress made by completing those tasks will provide sufficient information and data to the system, which will then evaluate the rate of recovery of the patient. Similarly, different interactive tasks in the form of games will be present in the system to reduce the motion of fear and for balance problems faced by some patients.

2 Requirements Analysis

2.1 Related Work:

A VR dodge ball game based on the trending motion capture technology has been developed by the researchers with the target of reducing the fear induced by the motion. The purpose of this game was the transformation in the methods of movement of patients to upgrade their motion ranges [10].

Motion capture is being used to track athletes' body motion to see how they can enhance their performance reducing the risk of injury with the help of the data obtained using Mo-Cap. Motion capture tracks athletes' real-time body motion and analyses their performance, technical expertise, physical condition, and injury mechanism, etc. for example balance and neuro cognition are the two main factors being studied to help sports medicine staff choose when its safe for concussed persons to return playing the game [10,11].

Recently some studies were conducted to see if a video game could replace regular exercises for Parkinson's or not. Experts and game developers came together to create beneficial games and consoles that display a player's movements. They deduced that these games can help patients as they do technically tested movements for the improvement of mobility, balance and overall wellness [12,13].

Interactive systems are being made day by day to provide aid and assistance in the engagement of patients on many different therapies. In recent technological improvements, Kinect by Microsoft has helped the user interaction with technology, complements many different clinical applications (as shown in figure 3 below) [14].

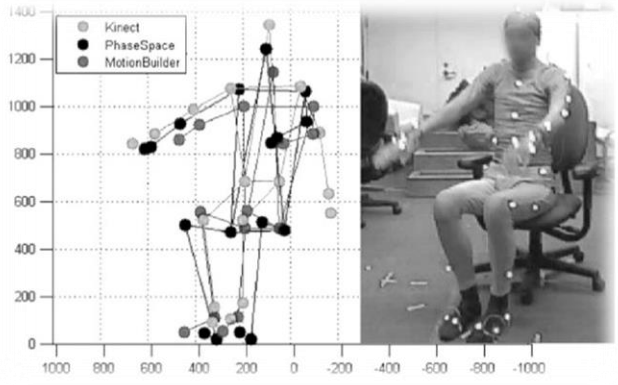

Figure 3- Motion-Builder [14]

Biofeedback for neuro-motor rehabilitation. According to the Journal of Neuro-Engineering and Rehab. The idea of task-oriented training proposes that biofeedback therapy should be carried during dynamic movements to improve motorized function improvement, a framework to increase the usage of task-oriented biofeedback therapy in Parkinson's treatment [15].

According to a study, a newly emerging area of research based on games and their use in the field of healthcare can play a very important role in the rehabilitation of Parkinson's patients as they deal with 3d input and output. A full-body Mo-cap system with bio-signal attainment is recently integrated with 3D games for this purpose. Also, a system is established to acquire skeletal data from serious games and a serious game is deployed for the rehabilitation of the patient's neck and lower back pain [16].

According to the journal of Neuro-Engineering and Rehabilitation leap-motion based video game therapy for Parkinson`s patients is currently being used as a rehab device for Parkinson`s disease. the main goal was to evaluate the accuracy and efficiency of the Leap Motion Controller (LMC) between patients in different stages of the disease. LMC uses a sensor that captures the movement of the patient's forearms and hands without placing sensors and markers on the whole body. This creates a 3D image of the upper limbs of the patient and as the patient moves their body to perform movements according to the functional task proposed. So, by performing these functional tasks, the patient undergoes through therapy that will help him in rehabilitation [17].

A paper on Vision-based System for the Movement Analysis like Parkinson`s disease was published. According to this paper, they used a low-cost vision system to help the rehabilitation process for diagnosis and monitoring purposes they were able to successfully classify the difference between a healthy person and a patient [18].

Video games are being developed for Parkinson's rehabilitation which helps the patient in strengthening their limbs. The main object of that these interactive video games is to involve the patients to act as the player, moving their body as a means to play, allows them to perform effective tasks that help them in rehab but in a more fun and engaging way without getting bored or tired. As they have to perform these tasks daily, they won't get bored. These games are referred to as serious games. these games are not designed for entertainment purposes but learning, the behaviour changes for Parkinson patients [19].

As we know that rehabilitation therapy requires a direct supervision of skilled therapists, but due to increasing number of patients is making it difficult so to overcome this problem rehabilitation assistance using motion capture devices and VR feedback to support the rehab therapy for Parkinson`s disease (PD) patients is purposed using information and communication technology (ICT)-based equipment's like motion capture devices such as Microsoft Kinect and VR headset that record body motion in real-time and with this that a 3d virtual image is created and placed on a 3d humanoid character that will follow the movement as the user moves[20].

The Balloon Goon game is Kinect-Based Exergames for Parkinson Patients to support their rehabilitation process. This is a score based game and gameplay is based on gestures .the game is controlled with arm and leg movement mapped for punches and kicks to pop out balloons that fall randomly in the scene .the object is to pop balloons by punching and kicking balloons with arms and legs as the real-time gesture is detected and pre-defined animations on the avatar are played .there are 3 difficulty levels in this game as the player progress in the game the difficulty of the game is increased by increasing the number and speed of balloons and on the final level cognitive and motor capabilities and triggered as

they final round is very difficult. When the game overs the score of the game is used for the evaluation purpose [21].

The Slope Creep game is also developed for the rehabilitation of Parkinson`s patients which is a gesture-driven 3D game where the player controls the movements of a skier through his real-time body movements. The skier slides on a snowy landscape environment aimed to collect coins and avoid any kind of obstacles along the way. The gameplay is defined such that the player pushes two virtual sticks down and backward to make the virtual 3d avatar slide forward on the snow, by leaning left or right make the avatar to change lanes respectively. There are some coins with high values that can only be collected by jumping high so to collect these coins the player needs to jump in real-time over the platform. If the jump was high enough the player will be able to collect the high-value coin. The player dies if collided by any obstacle and game ends otherwise the game end if the player reached the finish line successfully. The number of collected coins will be used to evaluate the progress of the player as a result of rehabilitation [21].

A paper was published by Arizona University. This paper proposes an interactive real-time multimedia environment system for rehabilitation the Parkinson's disease patients. This system is based upon two main physical therapy techniques, one is a BIG protocol and the other is multimodal sensory cueing with auditory and visual feedback to develop an interactive and engaging environment. This system is developed to fulfil the needs of both, the doctor and the patient [22].

IEEE published a paper on quantitative measurement of motor functions with full-body motion data in Parkinson`s disease patients. In this paper use of motion data for the quantitative measurement analysis of motor disease patients is described. They performed a complete body motion capture of Parkinson's patients with and without a deep brain stimulator. Their experimental results show a distinctive difference between severe symptoms and mild symptoms. They used a Support Vector Machine (SVM) classifier for differentiating severe vs mild symptoms with approximately 90% accuracy. So, they concluded that Mo-Cap technology could be a reliable, accurate, and very effective tool for tracking the progress of Parkinson`s disease [23].

A study was conducted to examine the effects of Virtual and Augmented Reality Balance Training on Parkinson`s disease patients. About 42 Parkinson's disease patients of stages 2-3 were recruited and a randomized controlled trial was used. After sir week of training. The sensory organization tests digitalized their motion and compared their score with other persons with non-VR training and the result of Virtual and Augmented-Reality trained patients were significantly more than that of the non-VR trained patients [24].

2.2 Stakeholders List

1. Administrator
2. Doctor
3. Patient

4. AI Server
5. Project Supervisor
6. Project Development Team

2.3 Requirements Elicitation

2.3.1 Functional Requirements

FR01: Signup

Req. No.	Functional Requirements
FR01-01	The system shall enable the doctor to add his/her name, email, contact number, address, specialization, hospital/clinic name. The new doctor record will be saved automatically into the database by the system.
FR01-02	The system shall allow the access of the profile to the doctor and his registered patients after authorization of that doctor.

FR02: Edit Doctor`s Profile

Req. No.	Functional Requirements
FR02-01	The system shall enable the doctor to edit his/her profile from the system database.

FR03: Register New Patient

Req. No.	Functional Requirements
FR03-01	The system shall enable the doctor to add the Patient`s first name, last name, gender, age, email, date of birth, home address Parkinson's notes, and medical history. The new Patient`s record will be saved automatically into the database by the system.
FR03-02	The system shall allow the access of the profile to the Patient by registering the new Patient.

FR04: Edit Patient`s Profile

Req. No.	Functional Requirements
FR04-01	The system shall enable the doctor to edit his/her Patient`s profile from the system database.

FR04: Remove Patient

Req. No.	Functional Requirements
FR04-01	The system shall enable the doctor to remove his/her patient from the system database.

FR04: Login

Req. No.	Functional Requirements
FR04-01	The system shall enable the doctor to access the features of the system after system authorization or login.
FR04-01	The system shall enable the Patient to access the provided features after getting logged in to the system.

FR05: Search and access to Patient

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to view the list of all his/her patients.
FR05-02	The system shall enable the doctor to view complete details of all his/her patients.
FR05-03	The system shall allow the doctor to Search his/her patients.

FR05: Run Patient Diagnosis

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to run disease diagnosis on his/her patient.
FR05-02	The system shall enable the doctor to view the complete results of the diagnosis.

FR05: Disease Identification

Req. No.	Functional Requirements
FR05-01	The system shall allow the AI server to get the patient`s motion data from the system and train model which will then be used to extract features from the dataset and identify the disease.
FR05-02	The system shall enable the AI server to set the disease identification report back to the system.

FR05: Create Standard Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the Administrator to create tasks in the system.
FR05-02	The system shall enable the Administrator to set up the task parameters in the system.

FR05: Edit Standard Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the Administrator to edit tasks in the system.

FR05: Delete Standard Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the Administrator to delete tasks from the system.

FR05: Create Personalized Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to create a personalized task in the system.
FR05-02	The system shall enable the doctor to set up the task parameters in the system.

FR05: Edit Personalized Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to edit a personalized task in the system.

FR05: Delete Personalized Task

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to delete a personalized task from the system.

FR05: Create Patient`s task plan

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to create a customized task plan for his/her patient according to patient rehabilitation.
FR05-02	The system shall enable the doctor to set the difficulty level of the task according to the patient state and assign stage/category depending upon the type of disease.

FR05: Edit Patient`s task plan

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to edit the task plan for his/her patient.
FR05-02	The system shall enable the doctor to reset the difficulty level of the task and reassign stage/category.

FR05: View Patient`s task plan

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to view the task plan for his/her patient.
FR05-02	The system shall allow the Patient to view his/her task plan.

FR05: Remove Patient`s task plan

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to remove the task plan for his/her patient from the system database.

FR05: Task Assignment to patient

Req. No.	Functional Requirements
FR05-01	The system shall allow the doctor to assign a task to the patient.
FR05-02	The system shall enable the doctor to set up the task parameters in the system.

FR05: Task Performance

Req. No.	Functional Requirements
FR05-01	The system shall allow the patient to wear the smart suit and perform the assigned task by the doctor.

FR05: Provide feedback

Req. No.	Functional Requirements
FR05-01	The system shall allow the patient to provide feedback about the task and the overall experience during the rehabilitation process.
FR05-01	The system shall allow the doctor to provide feedback about the task the patient just performed and his overall progress throughout the whole process.

FR05: View Report

Req. No.	Functional Requirements
FR05-01	The system shall allow the patient to view his/her progress report.
FR05-01	The system shall allow the doctor to view his/her patient`s progress report.

FR09: Database Management

Req. No.	Functional Requirements
FR09-01	The system shall enable the administrator to backup data monthly, half-yearly and yearly.
FR09-02	The system shall enable the administrator to restore any backup file when needed.

2.3.2 Non-Functional Requirements

NFR01: Performance

NFR01-01	Average load time of the starting page of the system should not be greater than 5 seconds.
NFR01-02	The average processing time taken by the system to complete the authentication process should not be greater than 5 seconds.
NFR01-03	System Mean Time to Failure should not be more than 1 minute.
NFR01-04	The average system response time should not be greater than 10 seconds.
NFR01-05	The system must successfully run on a client machine with 2 GB RAM or above and 10 GB storage and a good internet connection.
NFR01-06	20 users should be able to access the system at the same time and update the database.

NFR02: Security

NFR02-01	The system should provide access to only authorized users.
NFR02-02	The system should not allow any unauthorized user to update the database.
NFR02-03	No User can view the reports, task plans and personalized tasks of other Users.
NFR02-04	After the end of a user session, all data and progress made are directly saved to the cloud database.

NFR03: Defects-Maintenance

NFR03-01	Post Release average defects of the system must not exceed 5 critical bugs per month.
NFR03-02	Post Release bug fixing should not take more than 6 hours.
NFR03-02	Post Release bug should be fixed on system updates.

NFR04: User Documentation

NFR04-01	Complete Documentation of each module should be provided to help out the user in every phase.

NFR04-02	Help options must be easily accessible throughout the system to avoid any problem.
NFR04-03	Help must be written using tooltips and graphical representation.

NFR05: Disaster Recovery

NFR05-01	In case of system /server crashes all data should be recoverable within 30 minutes.

NFR06: Usability

NFR06-01	The system shall provide a clear and responsive on each element.
NFR06-02	The system shall provide an icon for each element in the system.
NFR06-03	The system shall provide the use of sliders, tooltips and icons.

2.4 Use Case Descriptions

2.4.1 UC01: Signup

Use Case Name	Signup
Abstract	No
Purpose	To authorize users to use/access system.
Actors	Doctor
Importance	Primary
Overview	This use case authorizes users to use system features according to user type.
Requirements	
Status	Essential
Uses	Login, Reset Password
Pre-conditions	None
Post-conditions	If signup is successful, the user will be authorized into the system.

	Actor Actions	**System response**
	Typical Course of Actions	
	1. User starts the system.	
		1a. System requests to enter email, username and password.

	2. User enters email, username and password.	
	3. User clicks on ‘Signup’ button.	
		3a. System gets the user information and logs user into the system.
	Alternative Course	
	1. User already exists.	
		1a. System checks the user information and displays error message
	Exceptional Course	
		Database connection error occurs.

2.4.2 UC02: Login

Use Case Name	Login
Abstract	No
Purpose	To authenticate users to use/access system.
Actors	Doctor, Patient
Importance	Primary
Overview	This use case authenticates users and authorizes them to use system features according to user type.

Requirements	
Status	Essential
Uses	Reset Password
Pre-conditions	None
Post-conditions	If authentication is successful, the user will be logged into the system.

	Actor Actions	**System response**
	Typical Course of Actions	
	1. User starts the system.	
		1a. System requests to select user type and enter username and password.
	2. User selects user type and enters username and password.	
	4. User clicks on ‘Sign In’ button.	
		3a. System validates the user input and logs user into the system.
	Alternative Course	
	2. User entered invalid username and/or password.	
		1a. System validates the user input and displays error message

	Exceptional Course	
		Database connection error occurs.

2.4.3 UC03: Reset Password

Use Case Name	Reset Password
Abstract	No
Purpose	To authenticate users to reset login password.
Actors	Doctor, Patient
Importance	Primary
Overview	This use case enables users to reset the passwords to their accounts.
Requirements	
Status	Essential
Uses	n/a
Pre-conditions	User is logged in using old password.
Post-conditions	Password is set/changed.

	Actor Actions	**System response**
	Typical Course of Actions	
	1. User clicks on "Forget Password" button.	
		1a. System displays a form with fields; current password, new password, confirm new password,

	2. User enters current password, new password, confirm new password,	
	3. User clicks on “Reset” button.	
		3a. System validates the user input and updates the current user password.
	Alternative Course	
	1. User entered invalid password format.	
		1a. System validates the user input and displays error message.
	Exceptional Course	
		1a. Database connection error occurs.
		2a. Internet connection error occurs.

2.4.4 UC04: Create Standard Tasks

Use Case Name	Create Standard Tasks
Abstract	
Purpose	To enable admin to create standard tasks that will be used by all the doctors using this system.
Actors	Admin
Importance	Primary
Overview	This use case will enable admin to record animations using smart suit and create standard tasks that can be used by any doctor using this system.
Requirements	Recording animations
Status	Essential
Uses	
Pre-conditions	Smart suit is connected and configured properly and system is working.
Post-conditions	Standard tasks are created.

	Actor Actions	**System response**
	Typical Course of Actions	
	Admin records animations and create standard tasks for all doctors.	
		Standard tasks are created and added to the system.

	Alternative Course	
		Error creating task– System displays error message.
	Exceptional Course	
		Smart suit connection/configuration error occurs. System error occurs.

2.4.5 UC05: Edit Standard Tasks

Use Case Name	Edit Standard Tasks
Abstract	
Purpose	To enable admin to edit standard tasks that will be used by all the doctors using this system.
Actors	Admin
Importance	Primary
Overview	This use case will enable admin to record animations using smart suit and edit standard tasks created earlier that can be used by any doctor using this system.
Requirements	
Status	Essential
Uses	Recording Animations
Pre-conditions	Smart suit is connected and configured properly and system is working.
Post-conditions	Standard tasks are edited.

	Actor Actions	**System response**
	Typical Course of Actions	
	Admin records animations and edits standard tasks for all doctors.	
		Standard tasks are created and updated in the system.

	Alternative Course	
		Error updating task– System displays error message.
	Exceptional Course	
		Smart suit connection/configuration error occurs. System error occurs.

2.4.6 UC06: Delete Standard Tasks

Use Case Name	Delete Standard Tasks
Abstract	
Purpose	To enable admin to delete standard tasks from the system.
Actors	Admin
Importance	Primary
Overview	This use case will enable admin to delete standard tasks from the system.
Requirements	
Status	Essential
Uses	
Pre-conditions	Standard tasks are present in the system.
Post-conditions	Standard tasks are deleted.

	Actor Actions	**System response**
	Typical Course of Actions	
	Admin deletes standard tasks from the system.	
		Task is removed from the system.
	Alternative Course	

2		Required action failed – System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.7 UC07: Edit Profile

Use Case Name	Edit Profile
Abstract	No
Purpose	To enable Patients and doctors to edit profile information.
Actors	Patient, doctor
Importance	Primary
Overview	This use case will enable Patients and doctors to edit their profile information like contact number, address, email address.
Requirements	
Status	Essential
Uses	Authentication
Pre-conditions	Patient/doctor is logged in and authorized.
Post-conditions	Patient/doctor has made changes in profile information.

	Actor Actions	**System response**
	Typical Course of Actions	
	Patient/doctor enters 'Edit Profile' section.	
	Patient/doctor clicks on the text field that is to be edited.	

	Patient/doctor inputs new details and click on 'Update Info' button.	
		System validates the input data from Patient/doctor.
		System updates the new profile details in database and displays success message.
	Alternative Course	
		Data input format not correct – System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.8 UC08: Add Patient

Use Case Name	Add Patient
Abstract	No
Purpose	To enable doctor to add patient into his database. Add patient includes Patient's basic information, medical history and Parkinson disease notes.
Actors	Doctor
Importance	Primary
Overview	This use case will allow doctor to add his patients in the system. Doctor can add patient's basic information, his medical history and Parkinson disease notes.
Requirements	
Status	Essential
Uses	n/a
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	Patient has been added to the database of the system and doctor can view patent's details whenever he wants.

	Actor Actions	**System response**
	Typical Course of Actions	
	Doctor clicks on 'Add Patient' section.	
		System processes the query given by the doctor.

		System adds a new patient to the database.
	Alternative Course	
		Nothing to add against doctor's query – System displays error message.
	Exceptional Course	
		Database connection error occurs.

2.4.9 UC09: Edit Patient

Use Case Name	Edit Patient
Abstract	No
Purpose	To enable doctor to edit patient from his database. Edit patient includes editing/changing Patient's basic information, medical history and Parkinson disease notes.
Actors	Doctor
Importance	Primary
Overview	This use case will allow doctor to add his patients in the system. Doctor can add patient's basic information, his medical history and Parkinson disease notes.
Requirements	Patient is added in the database and is present at the time of editing.
Status	Essential
Uses	n/a
Pre-conditions	Doctor is logged in and authorized. Doctor is in 'Edit Patient' section.
Post-conditions	Patient has been edited from the database of the system and doctor can view patent's details whenever he wants.

	Actor Actions	**System response**
	Typical Course of Actions	
	Doctor clicks on 'Edit Patient' section.	

	Doctor edits patient’s profile	
		System opens edit patient section.
		System edits the patient’s profile.
	Alternative Course	
		Profile editing failed– System displays error message.
	Exceptional Course	
		Database connection error occurs.

2.4.10 UC10: Delete Patient

Use Case Name	Delete Patient
Abstract	No
Purpose	To enable doctor to delete patient from his database.
Actors	Doctor
Importance	Primary
Overview	This use case will enable doctor to delete patient from his database.
Requirements	
Status	Essential
Uses	n/a
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	The requested patient is deleted from the database.

	Actor Actions	**System response**
	Typical Course of Actions	
	Doctor clicks on delete Patient button	System asks for confirmation of deletion.
	Doctor clicks on confirm button to delete.	
		System deletes the patient from the database.

	Alternative Course	
		Unable to delete Patient – System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.11 UC11: Search Patient

Use Case Name	Search Patient
Abstract	No
Purpose	To enable doctor to search patient from the database and view his profile.
Actors	doctor
Importance	Primary
Overview	This use case will enable doctors to search patients from the database and view his profile information and perform any other action he is allowed to perform.
Requirements	
Status	Essential
Uses	n/a
Pre-conditions	Doctor is logged in and authorized. Patient is added and present in the database
Post-conditions	Patient is displayed.

	Actor Actions	**System response**
	Typical Course of Actions	
	Patient enters ‘Search Patients’ section.	
		System displays list of all the Patients in database.

	Alternative Course	
		No Patient is found– System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.12 UC12: View Patient

Use Case Name	View Patient
Abstract	No
Purpose	To enable doctor to view details of patient.
Actors	Doctor
Importance	Primary
Overview	This use case will allow doctor to view details of patient.
Requirements	
Status	Essential
Uses	n/a
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	Doctor has been displayed detailed information of product.

	Actor Actions	**System response**
	Typical Course of Actions	
	Doctor clicks on patient.	
		System processes the query given by doctor.
		System displays the details of patient selected by Doctor.

	Alternative Course	
		Nothing to display against doctor's query – System displays error message.
	Exceptional Course	
		Database connection error occurs.

2.4.13 UC13: Data Acquisition

Use Case Name	Data Acquisition
Abstract	
Purpose	Enable system to acquire data from the smart suit for the disease identification.
Actors	AI Server
Importance	Primary
Overview	This use case will enable AI server to get data from the bodysuit, process it, extract required features from it and identify disease or whether the person has disease or not.
Requirements	
Status	Essential
Uses	
Pre-conditions	Smart suit is connected and configured properly.
Post-conditions	Data is acquired from the smart suit.

	Actor Actions	**System response**
	Typical Course of Actions	
1	Smart suit is configured and patient wears it.	
		AI server gets all the data coming from the sensors of smart suit.

	Alternative Course	
1		Smart suit not connected or configured properly– System displays error message.
	Exceptional Course	
		Connection error occurs. Configuration error occurs.

2.4.14 UC14: Data Processing

Use Case Name	Data Processing
Abstract	
Purpose	To enable system to process the acquired data.
Actors	AI Server
Importance	Primary
Overview	This use case will enable AI server to process the data acquired from the smart suit. Processing includes noise removal from the data and data normalization to remove any unnecessary data.
Requirements	
Status	Essential
Uses	Data Acquisition
Pre-conditions	Data is acquired from the smart suit.
Post-conditions	The data is processed properly and is ready for further use.

	Actor Actions	System response
	Typical Course of Actions	
	AI server gets the data and applies some methods to process it.	
		Data is processed and ready for further use.

	Alternative Course	
		Data not found or unable to process data– System displays error message.
	Exceptional Course	
		Data acquisition error occurs. System error occurs.

2.4.15 UC15: Feature Extraction

Use Case Name	Feature Extraction
Abstract	
Purpose	To enable AI server to extract required features from the processed data.
Actors	Patient
Importance	Primary
Overview	This use case will enable AI server to extract required features from the processed data that will be further classified and on the basis of these features, disease will be identified.
Requirements	
Status	Essential
Uses	
Pre-conditions	Data is acquired and processed properly.
Post-conditions	Required features from the data are extracted.

	Actor Actions	System response
	Typical Course of Actions	
	AI server will extract required features for disease identification from the processed data.	
		Required features for disease identification are extracted.

	Patient enters his/her review and clicks on “Add” button.	
	Alternative Course	
		Unable to perform the required action– System displays error message.
	Exceptional Course	
		System error occurs.

2.4.16 UC16: Disease Identification

Use Case Name	Disease Identification
Abstract	
Purpose	To enable system to identify disease or whether the patient has disease or not.
Actors	AI server
Importance	Primary
Overview	This use case will enable system to identify whether the patient has disease or not and if he has then what stage of disease he is on and which body parts are most affected by it.
Requirements	
Status	Essential
Uses	
Pre-conditions	Smart Suit is connected/configured Properly
Post-conditions	Disease is identified and details are displayed to the doctor.

	Actor Actions	**System response**
	Typical Course of Actions	
	AI server identifies the disease using some machine learning algorithm.	
		Disease is identified and displayed to doctor.

	Alternative Course	
		System failed– System displays error message.
	Exceptional Course	
		System error occurs.

2.4.17 UC17: Task Assignment

Use Case Name	Task Assignment
Abstract	
Purpose	To enable Doctor to assign task to the patient.
Actors	Doctor
Importance	Primary
Overview	This use case will enable doctor to assign a task to patient which he will perform. The task will be from the task plan that the doctor has created for that specific patient.
Requirements	
Status	Essential
Uses	
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	Task will be assigned to the patient for performance.

	Actor Actions	System response
	Typical Course of Actions	
	Doctor will go to “Assign Task” section and clicks on “Assign” button.	
		System will assign that task to the patient.

	Alternative Course	
		Task not assigned – System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.18 UC18: Task Performance

Use Case Name	Task Performance
Abstract	
Purpose	Enable patient to perform task selected from the task plan that doctor created.
Actors	Patient
Importance	Primary
Overview	This use case will enable patients to perform task that will be selected from the task plan created by the doctor. Task progress will be monitored and then it will be submitted and stored in the system.
Requirements	
Status	Essential
Uses	
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	Patient will perform the task and doctor will be able to see his progress.

	Actor Actions	System response
	Typical Course of Actions	
	Doctor selects the “Select Task” section.	
		System starts the task that is performed by the Patient.

	Alternative Course	
		No Task was Selected.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.19 UC19: Provide Feedback

Use Case Name	Provide Feedback
Abstract	
Purpose	To enable patient and doctor to provide feedback.
Actors	Patient, Doctor
Importance	Primary
Overview	This use case will enable patients and doctor to provide feedback about the task performed and the current condition of patient.
Requirements	
Status	Essential
Uses	
Pre-conditions	Patient/Doctor is logged in and authorized.
Post-conditions	Patient/Doctor feedback is added to the system.

	Actor Actions	**System response**
	Typical Course of Actions	
	Patient/doctor goes to add feedback section and click "Submit Feedback" button.	
		Patient/Doctor write feedback.
	Patient on "Submit" button.	

		Feedback is submitted and stored into the database.
	Alternative Course	
		Patient/Doctor has not given any feedback– System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.20 UC20: View Report

Use Case Name	View Report
Abstract	
Purpose	To enable Patient to view report generated by the system.
Actors	Patient, Doctor
Importance	Primary
Overview	This use case will enable Patient/Doctor to view report generated by the system with the help of task progress, medical analysis and Patient and doctor feedback.
Requirements	
Status	Essential
Uses	
Pre-conditions	Patient/Doctor is logged in and authorized.
Post-conditions	Patient/doctor has viewed the report.

	Actor Actions	**System response**
	Typical Course of Actions	
	Patient/Doctor goes to view report section click “View Report” button.	
		System displays report about selected patient.

	Alternative Course	
		No report available to display – System displays error message.
	Exceptional Course	
		Database connection error occurs. Internet connection error occurs.

2.4.21 UC21: Future Prediction

Use Case Name	Future Prediction
Abstract	
Purpose	To enable system to show future predictions based on the patient recovery evaluation generated.
Actors	AI server/Doctor
Importance	Primary
Overview	This use case will enable AI server to perform future predictions using machine learning algorithms based on patient recovery evaluation and the data gathered by the previous patients in the system database.
Requirements	
Status	Essential
Uses	
Pre-conditions	Doctor is logged in and authorized.
Post-conditions	AI sever has generated some future prediction.

	Actor Actions	**System response**
	Typical Course of Actions	
	AI server will perform future predictions by applying machine learning Algorithms.	
		Future course of action for the patient is displayed.

	Alternative Course	
		Unable to perform required action– System displays error message.
	Exceptional Course	
		System error occurs.

2.5 Use case design

Use case Design Diagram for the System is shown in the *Figure 4* below.

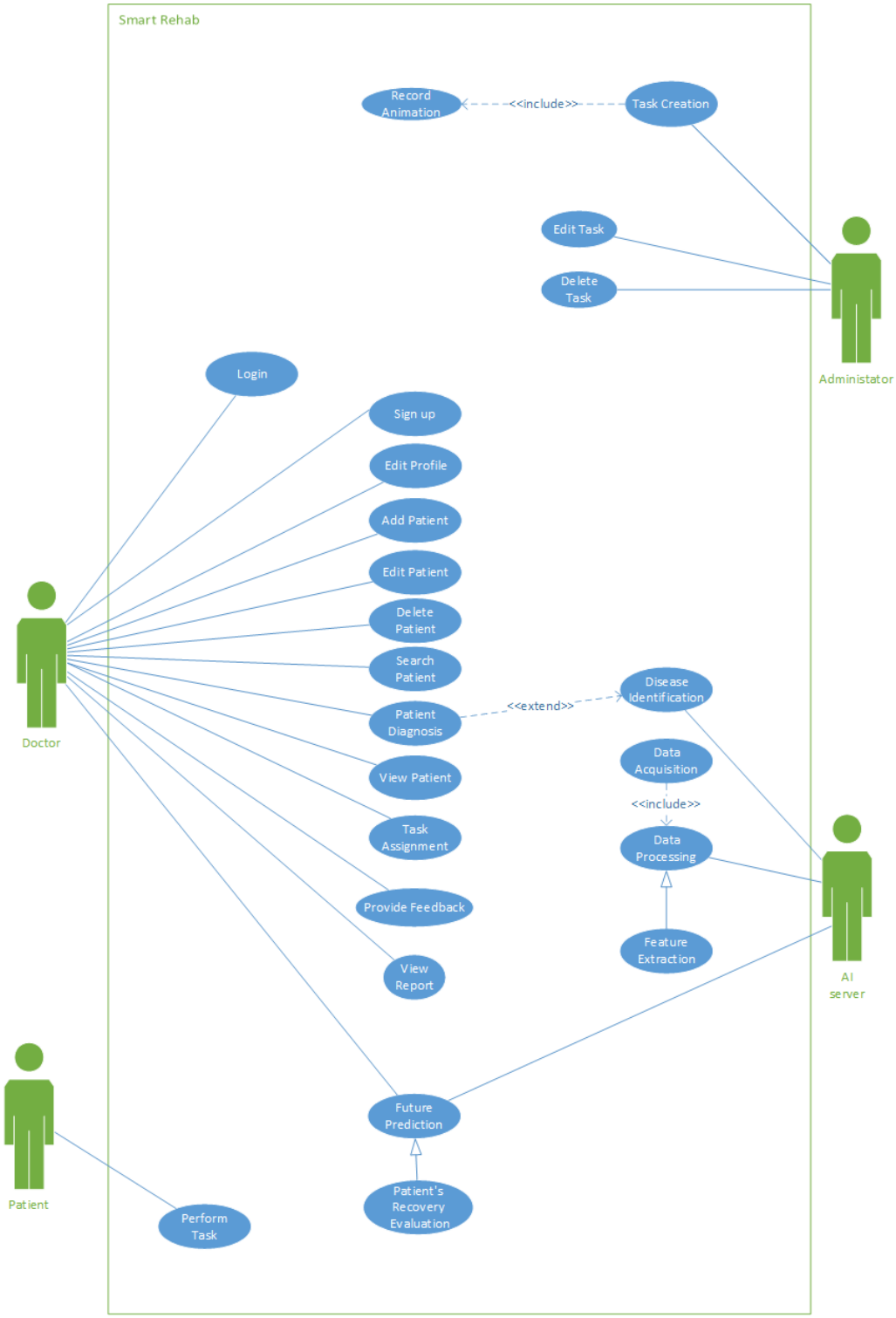

Figure 4- Use Case Design for the System

2.6 Software Development Life Cycle Model

For the design, we are going to use a combination of SCRUM model and Agile Methodology.

2.6.1 Why Use SCRUM Model:

Scrum is a lightweight framework used to manage knowledge work using agile methodology. It is mainly used for software development. We are using this approach because it emphasizes teamwork, makes work faster, maximizes responsiveness, makes changing easy and is iterative so makes developing complex systems faster and easier.

2.6.2 Why Use Agile Methodology?

To implement these requirements, agile methodology is used as it assists developer teams in constructing software. This uses incremental and iterative work sequences that are called sprints. A sprint is a dedicated time period for each phase in the project. As there can be some differences between team members whether the development is acceptable enough or not. But the other phases of the project will be continued within their time period.

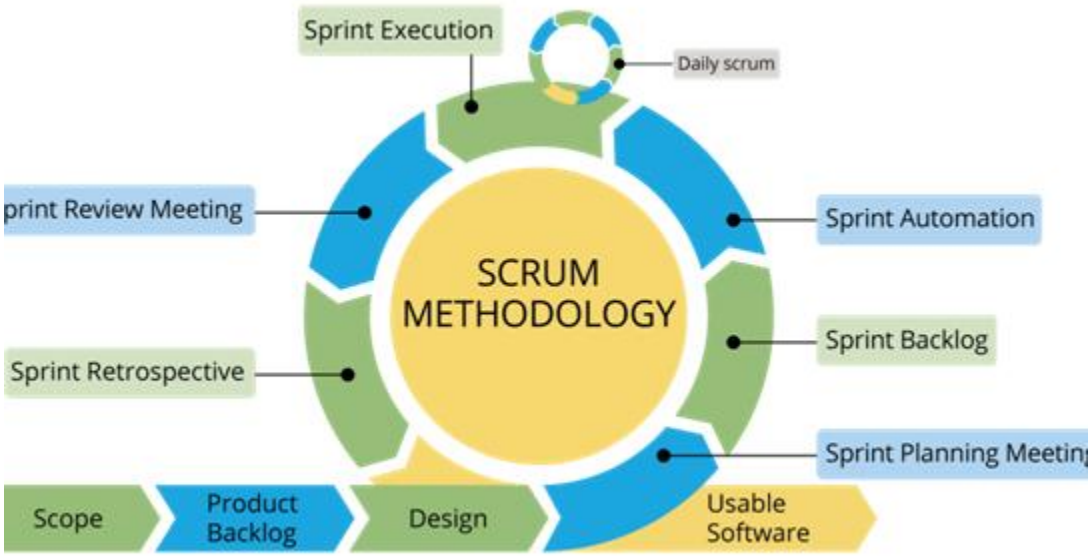

Figure 5- SDLC Model for the System[25]

3 System Design

3.1 Work Breakdown Structure (WBS)

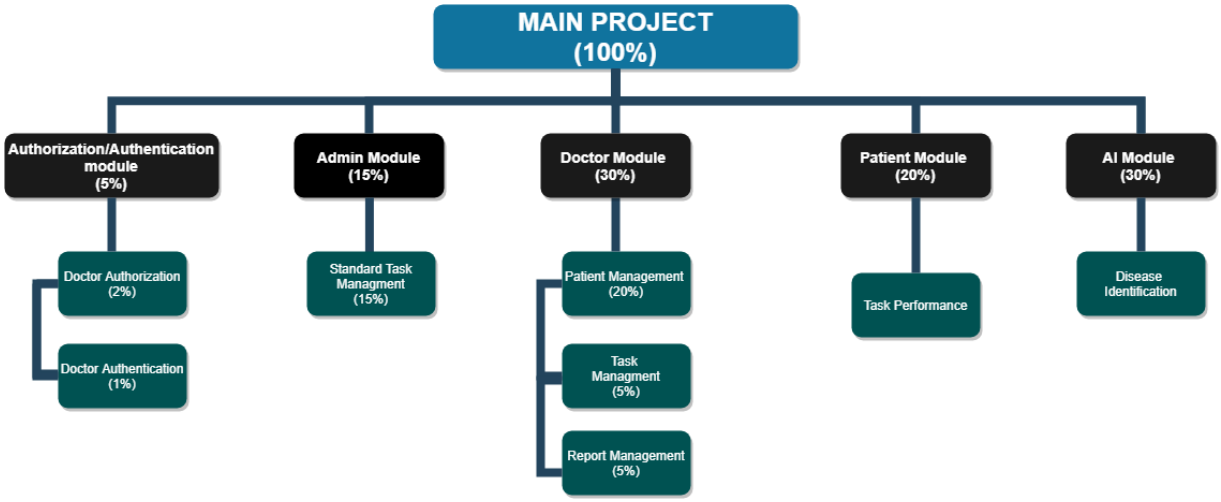

Figure 6- Work Breakdown Structure of the System

3.2 Activity Diagram

3.2.1 Login

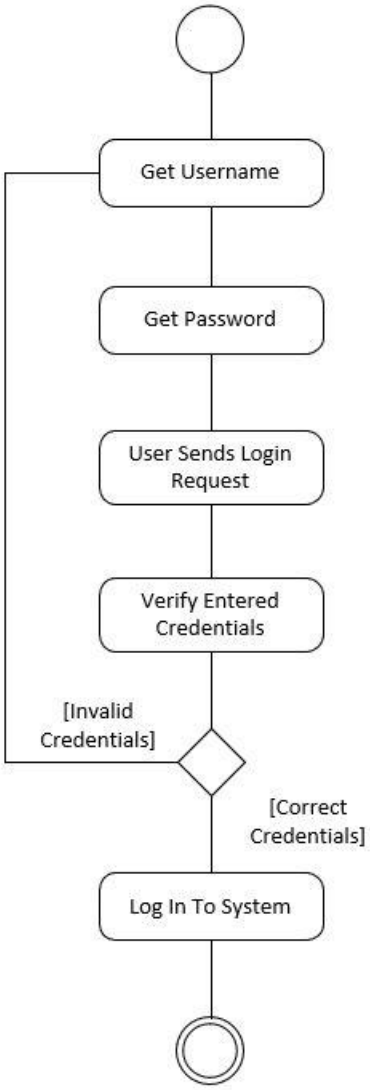

Figure 7- Activity Diagram for User Login

3.2.2 Create Standard Task

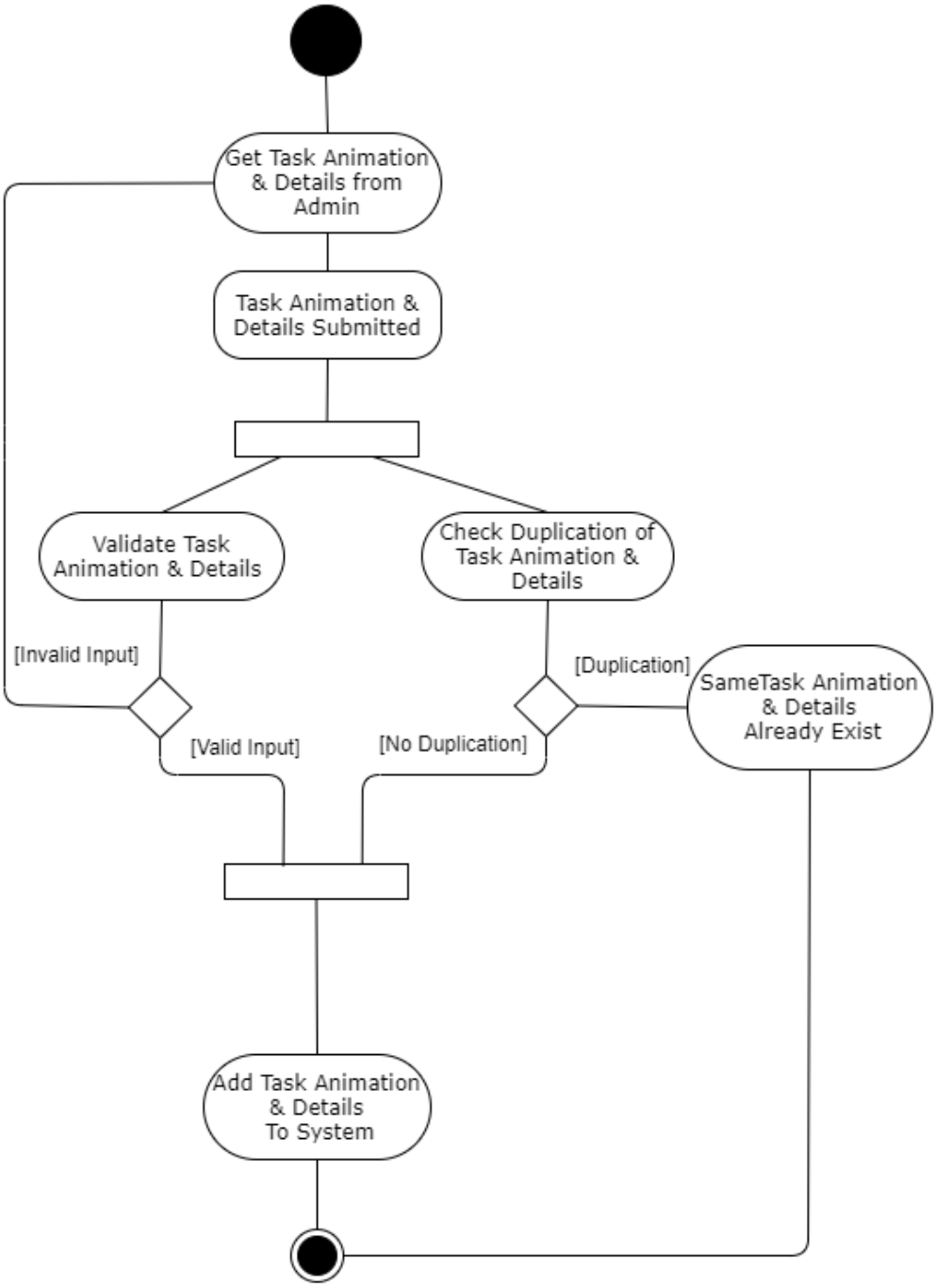

Figure 8- Activity Diagram to Create Standard Task

3.2.3 Edit Standard Task

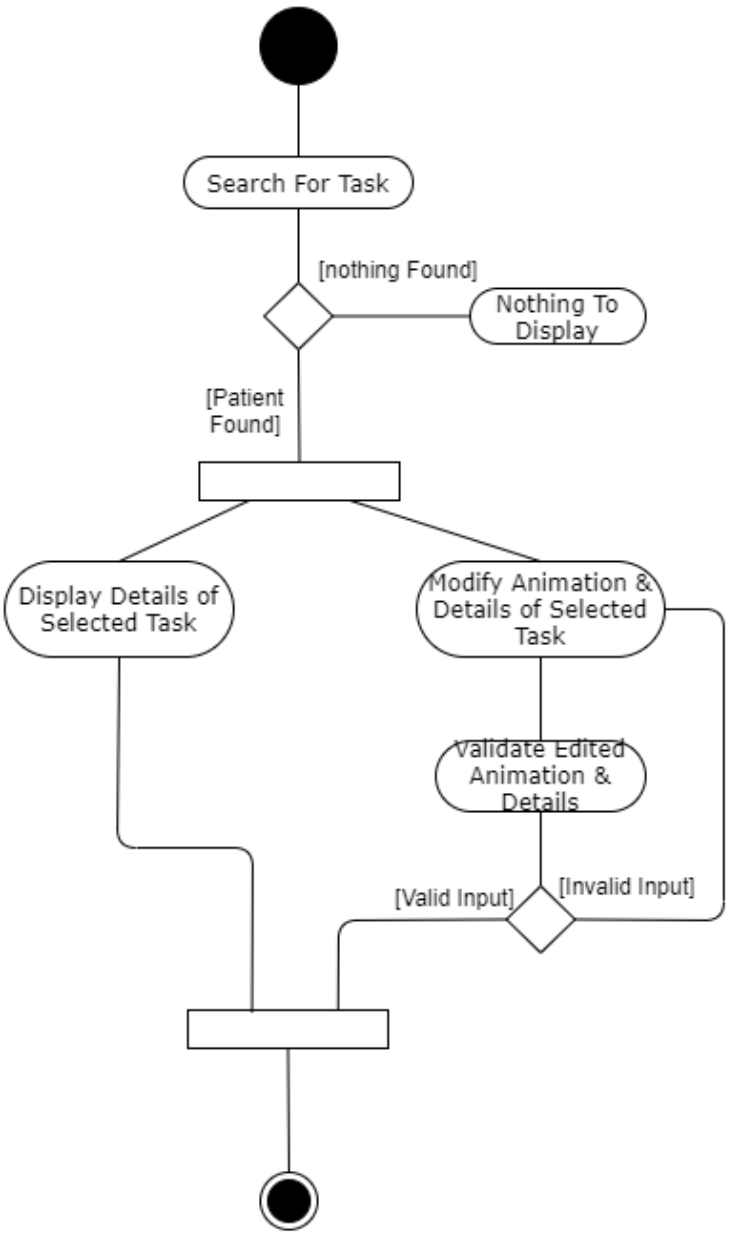

Figure 9- Activity Diagram to Edit Standard Task

3.2.4 Delete Standard Task

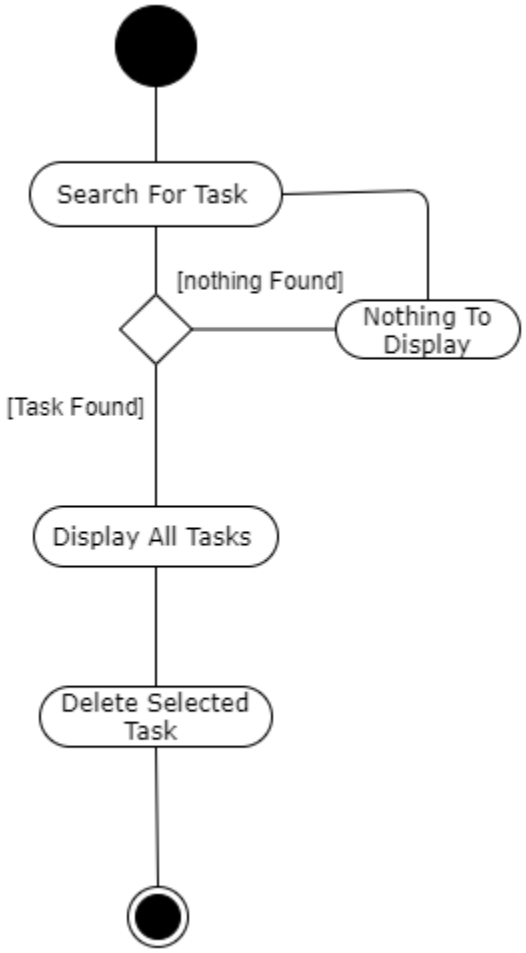

Figure 10- Activity Diagram to Delete Standard Task

3.2.5 Add Patient

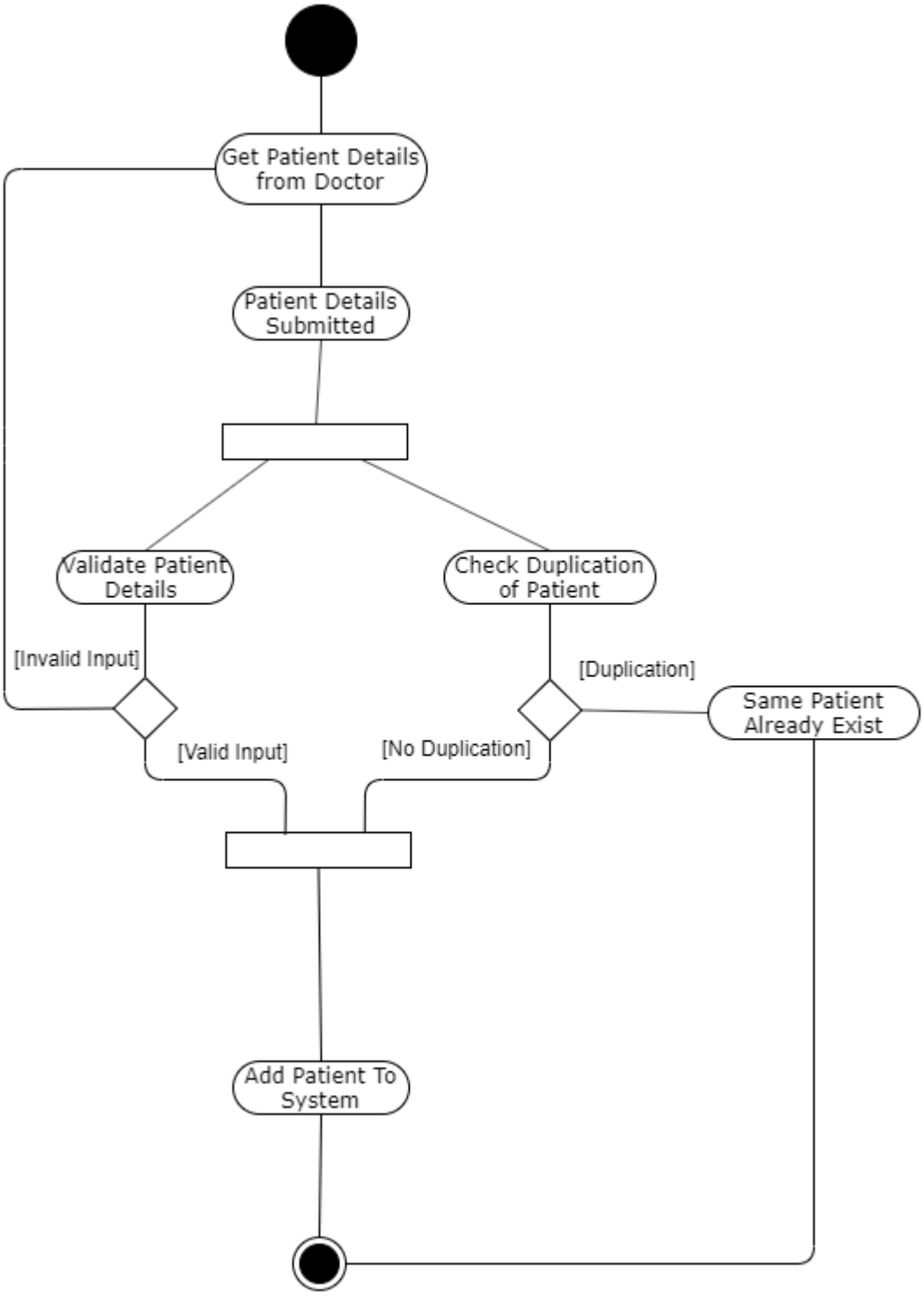

Figure 11- Activity Diagram to Add Patient

3.2.6 Edit Patient

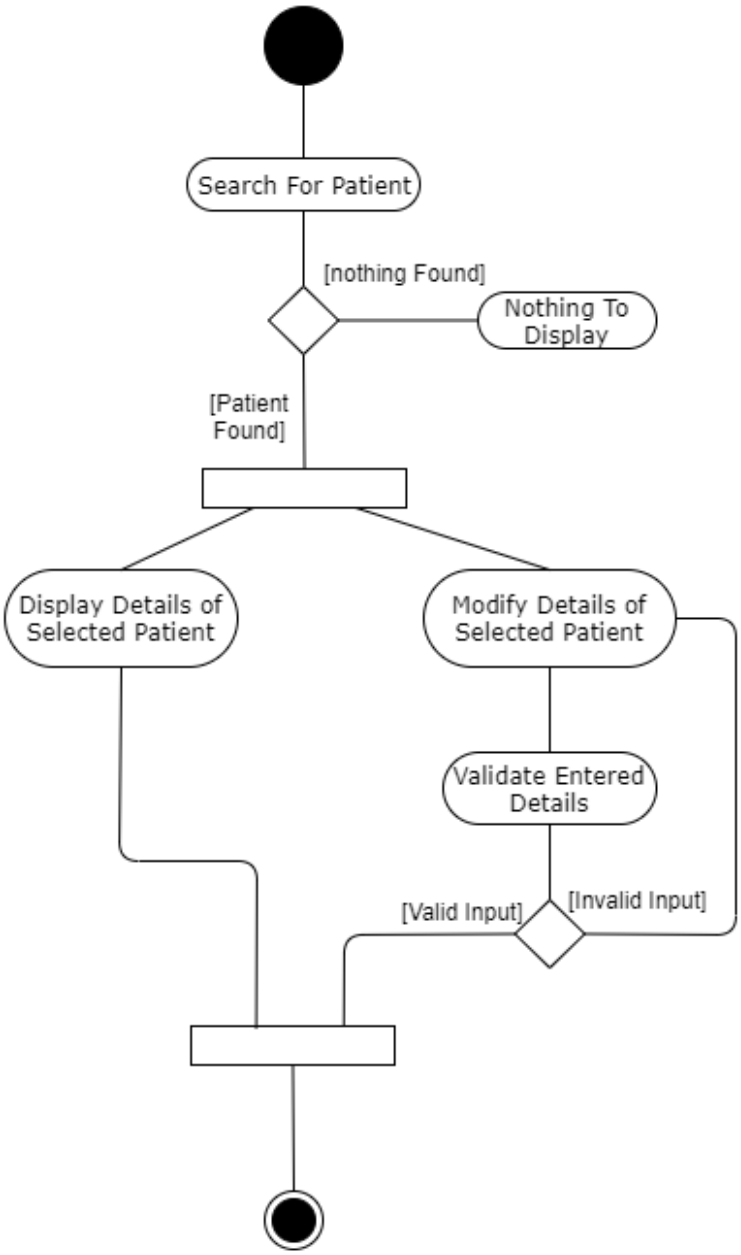

Figure 12- Activity Diagram to Edit Patient

3.2.7 Delete Patient

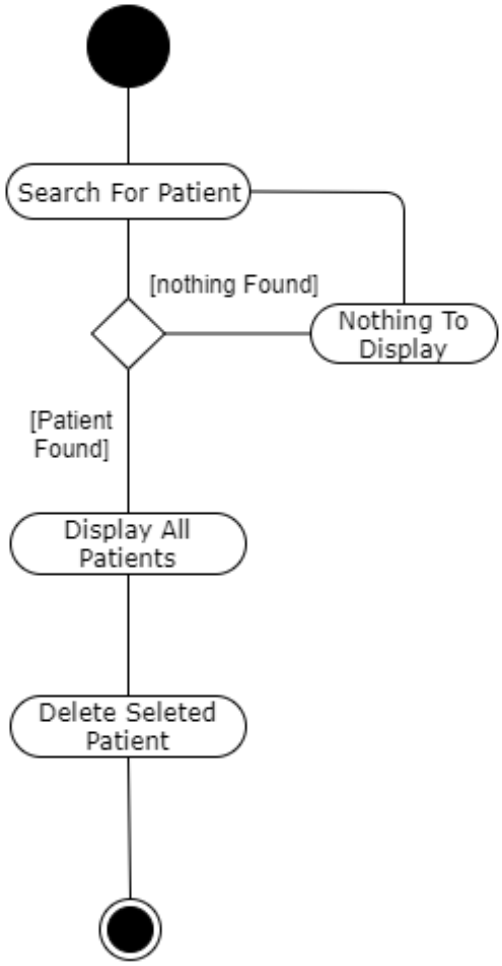

Figure 13- Activity Diagram for Delete Patient

3.2.8 View Patient

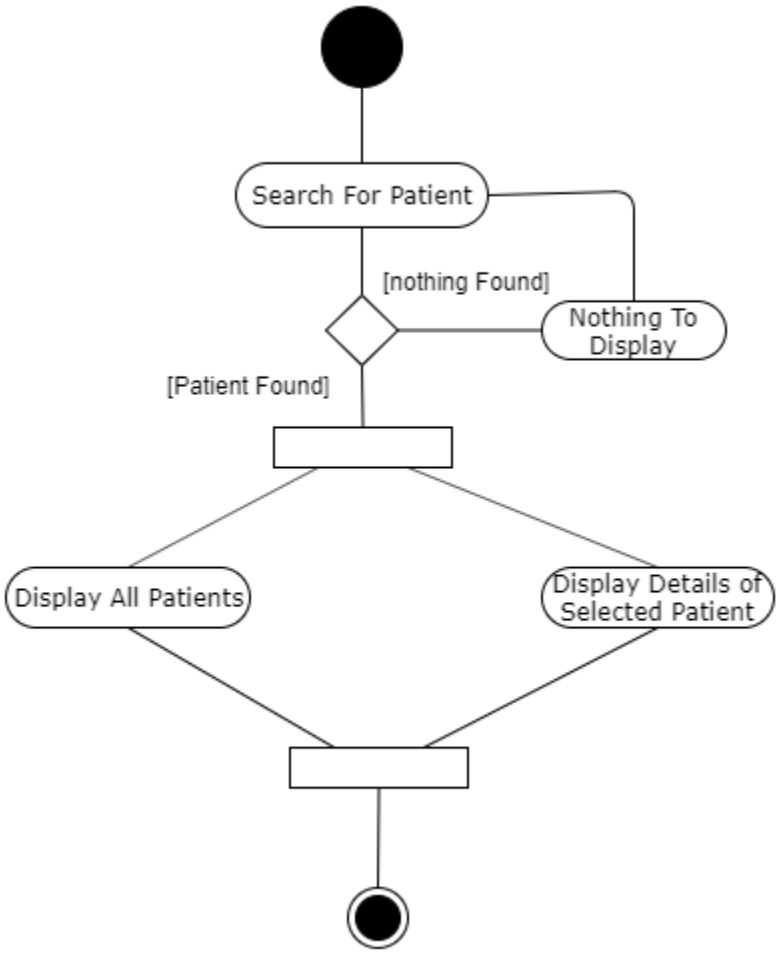

Figure 14- Activity Diagram for View Patient

3.2.9 Disease Identification

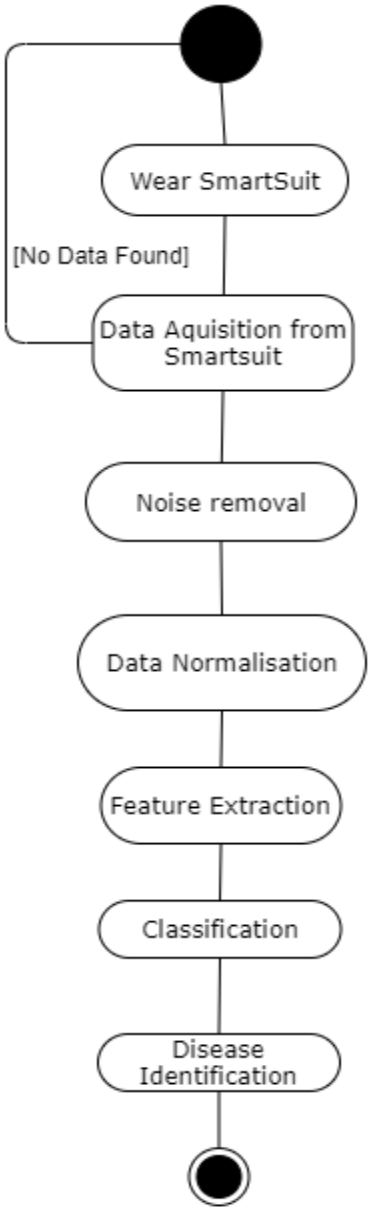

Figure 15- Activity Diagram for Disease Identification

3.2.10 Task Assignment

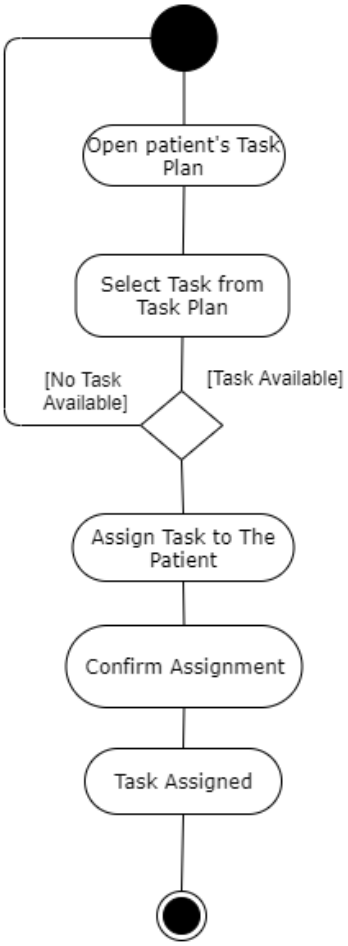

Figure 16- Activity Diagram for Task Assignment

3.2.11 Task Performance

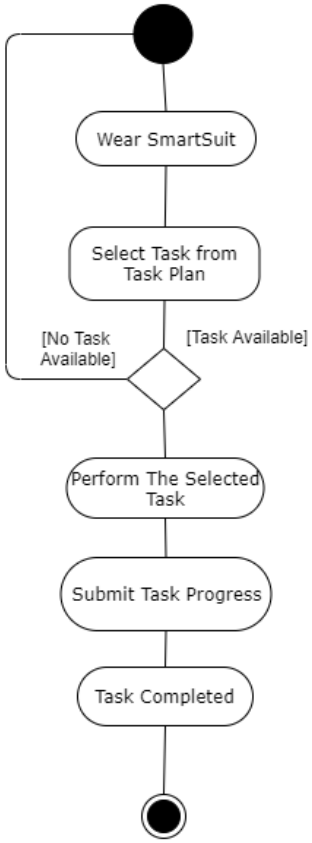

Figure 17- Activity Diagram for Task Performance

3.2.12 Feedback

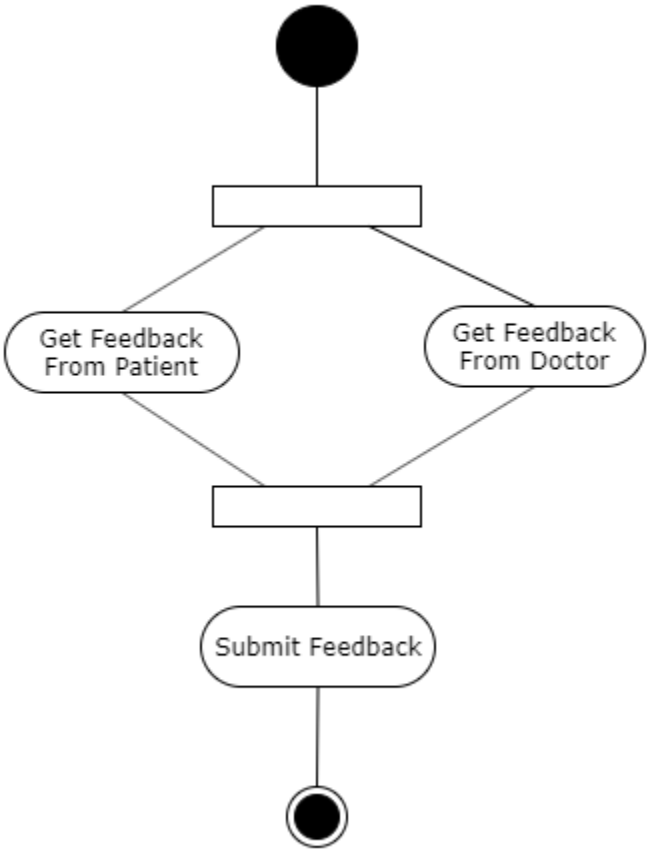

Figure 18- Activity Diagram for Feedback

3.2.13 View Report

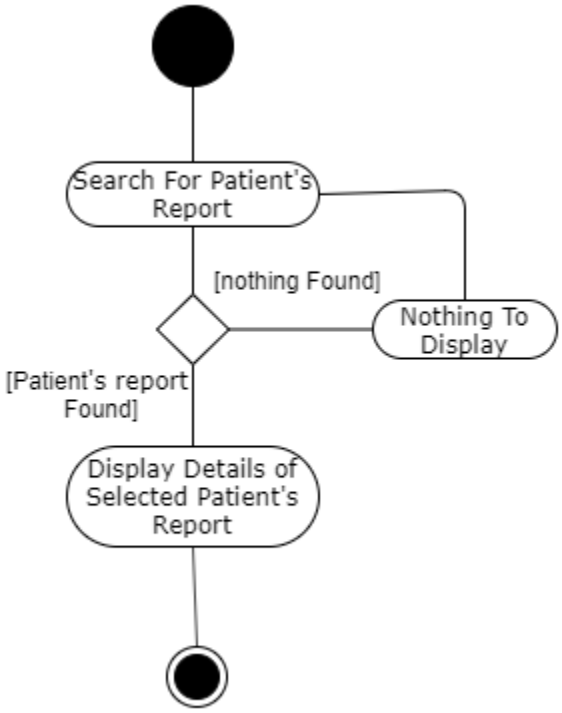

Figure 19- Activity Diagram for View Report

3.3 Sequence diagram

3.3.1 Login

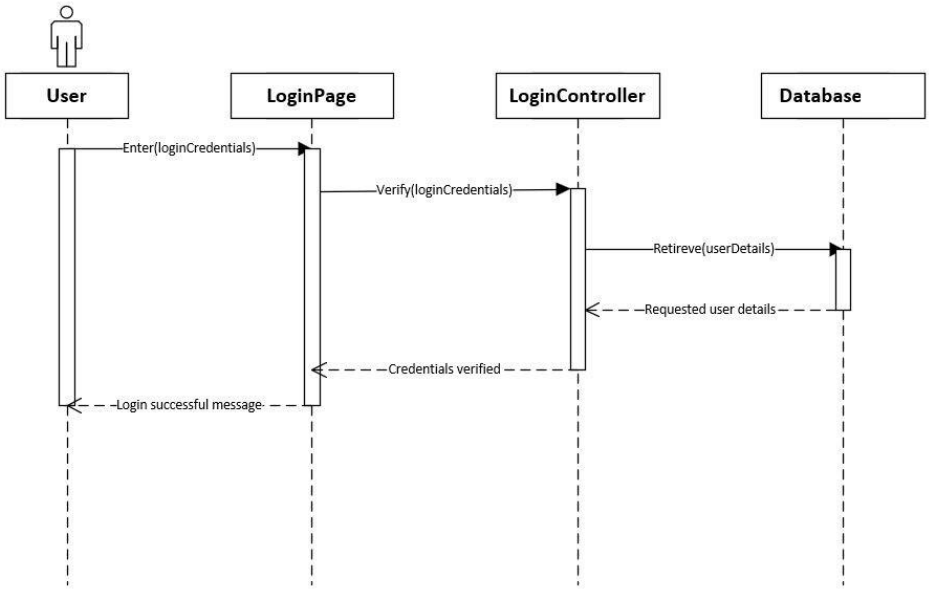

Figure 20- Login Sequence Diagram

3.3.2 Task Management

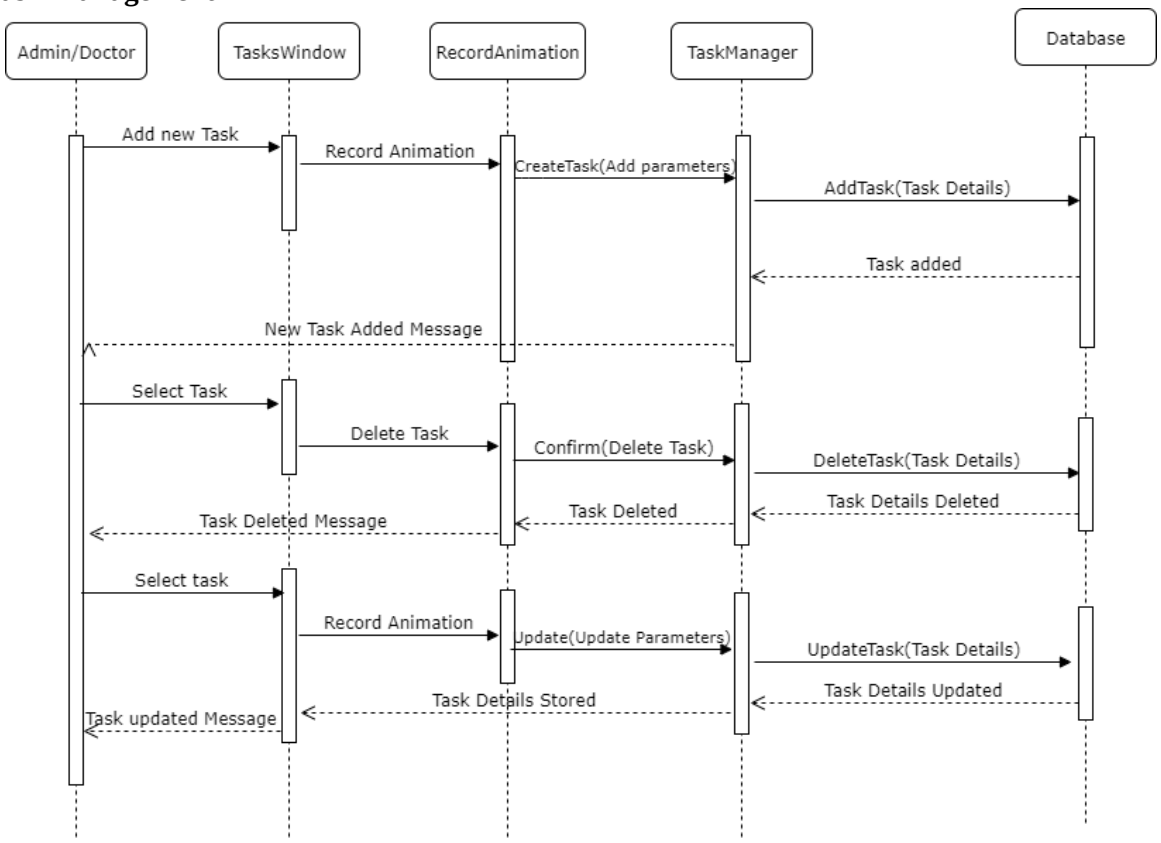

Figure 21- Task Management Sequence Diagram

3.3.3 Patient Management

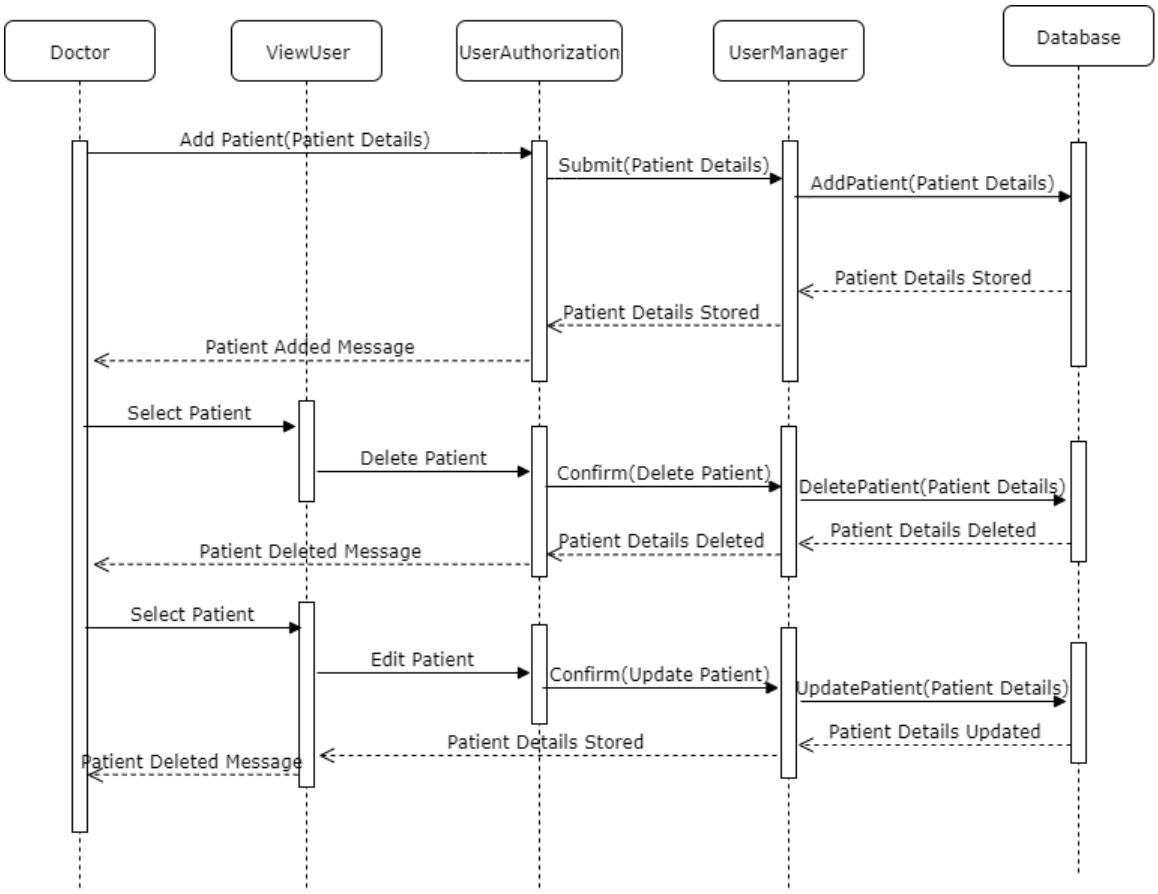

Figure 22- Patient Management Sequence Diagram

3.3.4 Disease Identification

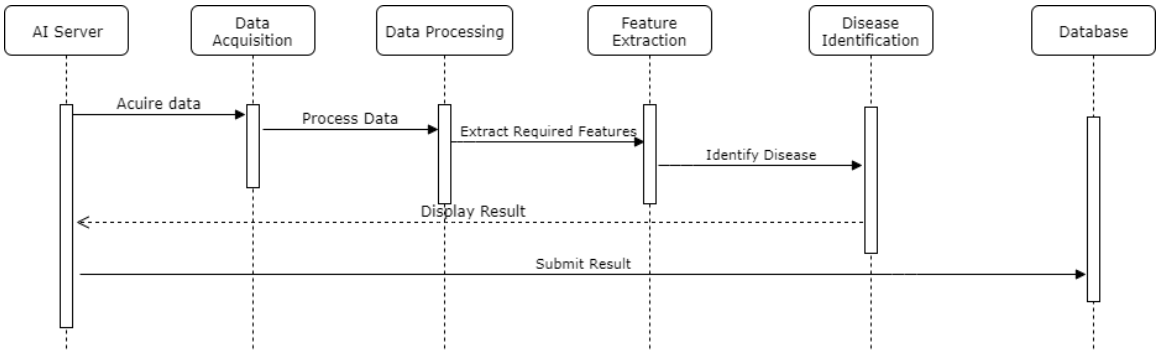

Figure 23- Disease Identification Sequence Diagram

3.3.5 Task Assignment

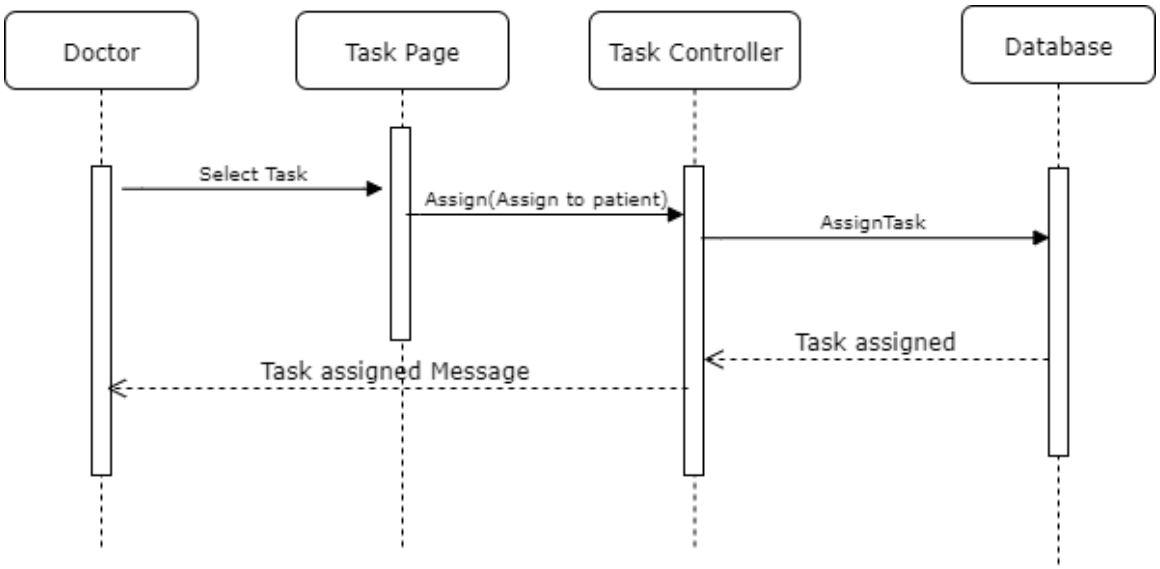

Figure 24- Task Assignment Sequence Diagram

3.3.6 Task Performance

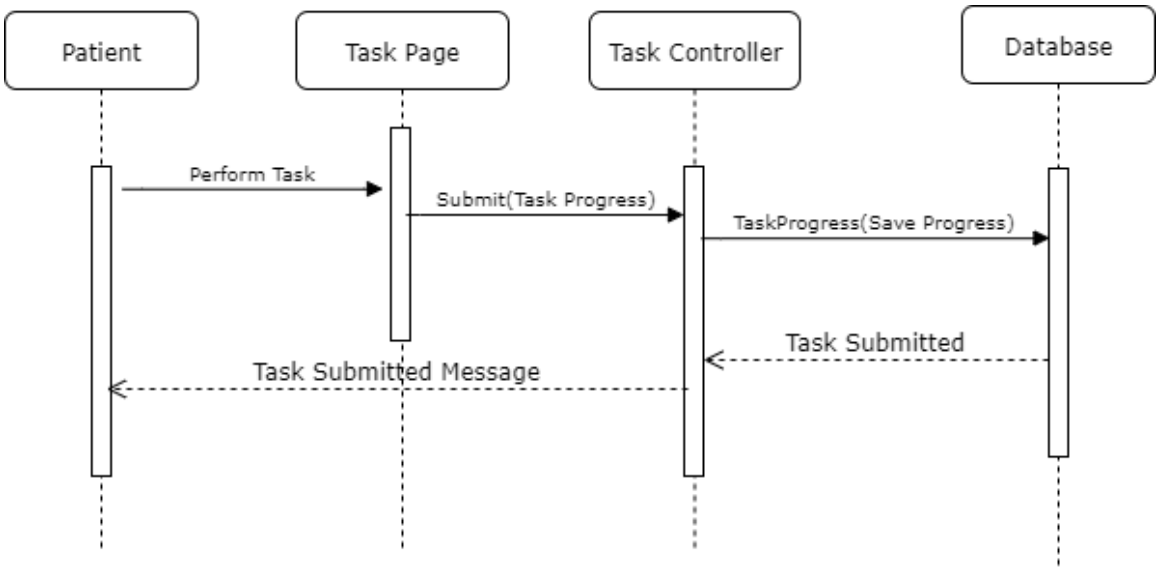

Figure 25- Task Performance Sequence Diagram

3.3.7 Submit/view Feedback

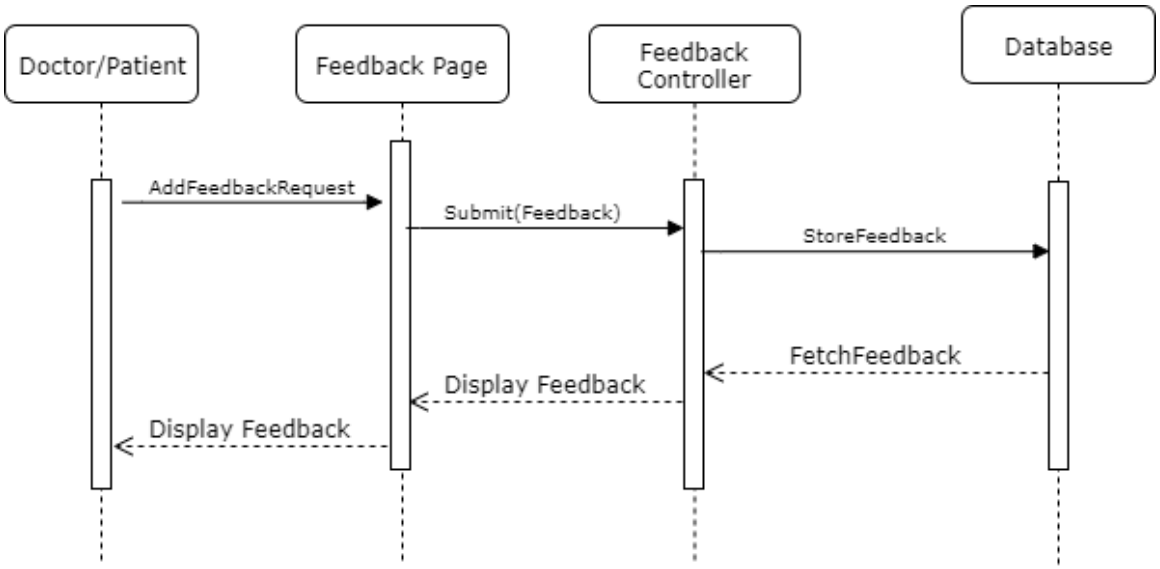

Figure 26- Submit/View Feedback Sequence Diagram

3.3.8 View Report

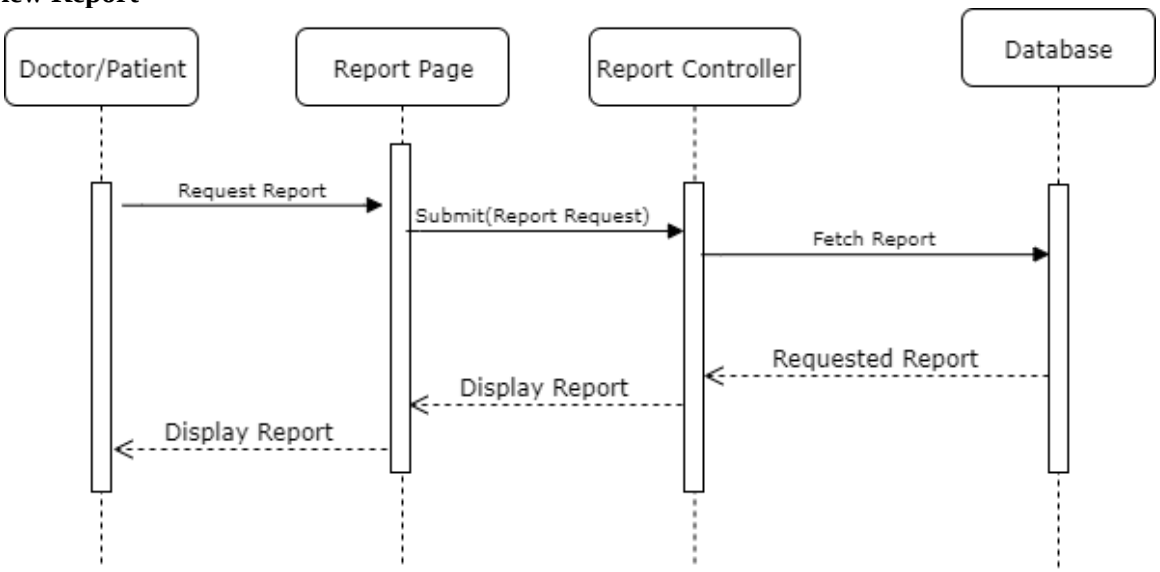

Figure 27- View Report Sequence Diagram

3.4 Software Architecture

The system Architecture as shown in the Figure 28 below consists of 5 modules

- Authorization and Authentication Module
- Admin Module
- Doctor Module
- Patient Module
- AI Module

The above-mentioned modules are explained in detail below.

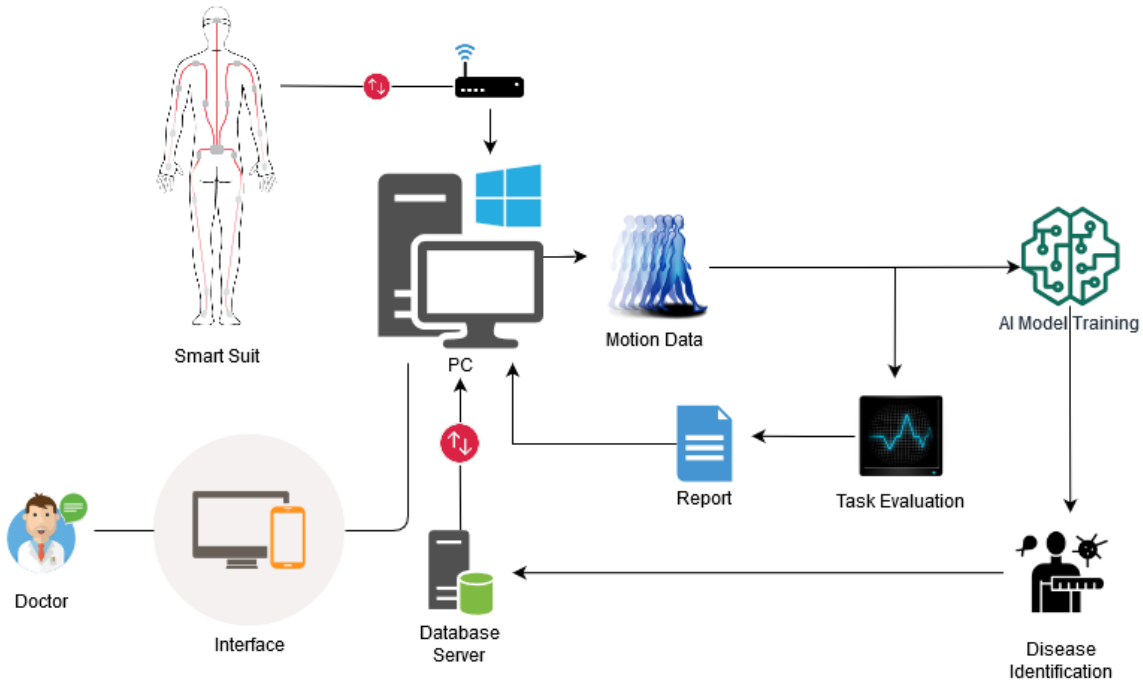

Figure 28- Software Architecture of the System

3.4.1 Authorization and Authentication Module

Doctors will be able to create their accounts and then login using the information they entered while creating their profile. Once logged in doctors will be able to use services/features provided by the system. Patients will be added by the doctors to the system and once a doctor adds any patient and saves his information in the system the patient will get an email/Text message with the login credentials to access the services/features provided by the system.

3.4.2 Admin Module

Admin will be able to create Standard tasks and store them into the system database. Admin will also be able to edit the created Tasks and also delete the created tasks.

3.4.3 Doctor Module

In Doctor module, doctors will able to create personalized tasks according to their needs and likes which will only be accessible by them. Doctors will also be able to edit their personalized task and will also be able to delete those tasks. Doctors will be able to manage patients, managing patients include adding new patients to the system, editing details of the previously added patients and also delete the patients from the system database. Doctors will also be able to diagnose the patients and add their diagnostics report to the system. Doctors will able to manage patient's task plan, managing patient's task plan includes creating, updating and deleting the task plan. Doctors will be able to assign patient's tasks to perform and also be able to give feedback about the task performed by the patient. Doctors will also be able to view the report generated by the system based on task progress, medical analysis, patient and doctor feedback.

3.4.4 Patient Module

In Patient module, patients will be able to perform the task assigned by the doctor and their progress will be monitored and evaluated.

3.4.5 AI Module

In AI module, the AI agent will be able to acquire data from the smart suit, process the data and extract required features from it using machine learning algorithms. AI agent will then identify the disease and tell whether our patient has the disease or not if he has than which part of the body with the help of a model trained by the machine learning algorithms.

3.4.5.1 Data Acquisition

IMU sensor-based data of a person wearing Rokoko Smartsuit pro will be collected by recording animation in rokoko studio which includes position, rotation and velocity of various body parts in three-dimensional plane with respect to some root reference point.

3.4.5.2 Pre-Processing

The data collected from the suit will be pre-processed as the data contains abnormalities due to frame loss and other minor connection losses during the acquisition or animation recording. The frame loss data is then eliminated from the main data file and is filled with correctly obtained frames and the data is then labelled.

3.4.5.3 Feature extraction

As IMU sensor data is complex and contains various other attributes it becomes difficult to extract the feature vectors that we require therefore we eliminate the

attributes that are less useful or are not useful and only keep attributes that are of highest value.

3.4.5.4 Model Training and Deployment

The labelled data will be split into train (80%) and test (20%). The labelled train dataset will be used to train Python (Pandas) machine learning algorithms such as Random Forrest Classifier, Bernoulli Naïve Bayes etc.

After the models are trained then test data will be used to predict the classification from these models. The label will be used to check the accuracy between the predicted result and the actual labelled result. The Model with the highest accuracy score will be chosen for implementation.

3.4.5.5 Real Time Classification

The Rokoko smartsuit pro will be used by the user to obtain motion data of the Individual. The data will be then used as input for the selected ML model. The model will classify the signal.

3.5 Database Diagram

Database Design for the Smart Rehab System Application is shown below in *Figure 37*.

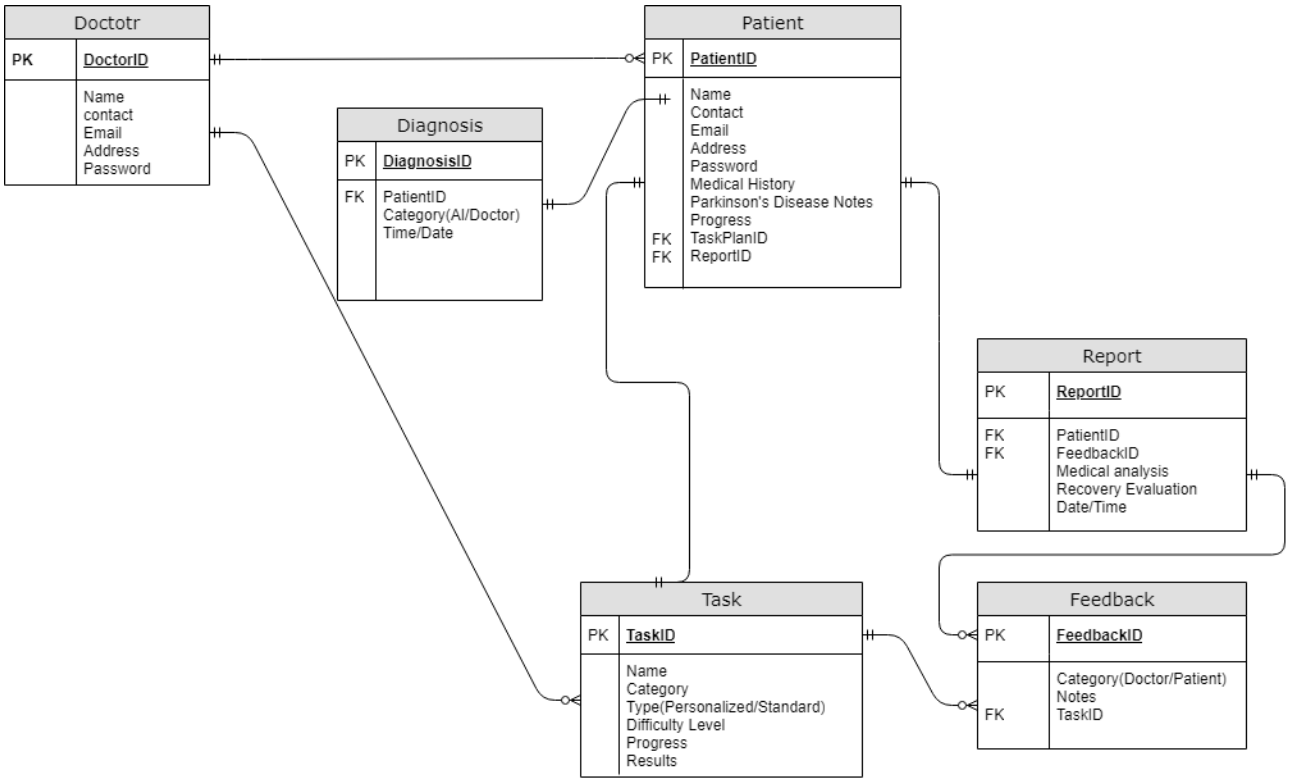

Figure 29- Smart Rehab Database Design

3.6 Network Diagram (Gantt chart)

Network Diagram scheduled for the Smart Rehab System is shown below in Figure 3.6.

Figure 30- Smart Rehab Network Diagram

4 System Testing

4.1 Test cases

Following are the test cases for different modules of our system

TC-01: Signup

TC-ID: TC-01	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/20
Name: Sign-Up	**Executed By:** Arslan Riaz
Title: Add a new user to the system and verifying their given information	**Executed At:** 01/07/20
Description: Check the proper working of Signup page	
Pre-conditions: User should be navigated to the signup page	

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/ Fail)	Notes
1	Go to the Signup page		An account for the user should be created	Account created successfully	Pass	
2	Email	Dotor1@gmail.com			Pass	
3	password	“12345678”			Pass	
4	Click on the “Create” button				Pass	

5	Generate id				Pass	After successful account creation

TC-02: Login

TC-ID: TC-02	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/2020
Name: Login	**Executed By:** Arslan Riaz
Title: To verify the details of the user and to open their account	**Executed At:** 01/07/2020
Description: Check the proper working of the login page	
Pre-conditions: User should provide a valid email and password.	

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the Login page		User should be able to log in	User is navigated to their dashboard after logging in	Pass	
2	Provide email	doctor1@gmail.com			Pass	
3	Provide password	“12345678”			Pass	
4	Click login				Pass	

	button					

Post Condition:

Doctor is taken to their dashboard

TC-03: Reset Password

TC-ID: TC-03	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/2020
Name: Rest Password	**Executed By:** Arslan Riaz
Title: To rest the login password of the user account	**Executed At:** 01/07/2020
Description: Check the proper working of the reset password page	

Pre-conditions: User should provide a valid email and password.

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the Login page		Login page should be opened	User is navigated to login page	Pass	
2	Click forgot password		Rest password page should be opened	User is navigated to Rest password page	Pass	
3	Provide email	Doctor1@gmail.com			Pass	
4	Click rest button		Rest password link should be	Rest password link sent on user	Pass	

			sent on email	email address		
Post Condition: Doctor is taken to their dashboard						

TC-04: Create Standard Tasks

TC-ID: TC-04	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/2020
Name: Create Standard Tasks	**Executed By:** Arslan Riaz
Title: To create standard tasks for patients	**Executed At:** 01/07/2020
Description: Check the proper working of standard tasks	
Pre-conditions: Smart Suit should be ready and configured.	

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Wear Smart Suit		Smart Suit should be worn	User is wearing the suit	Pass	
2	Configure and connect suit on Wi-Fi with system	Ip:”192.168.1.13”	Smart Suit should be connected with system on Wi-Fi	Smart Suit is connected to the system	Pass	
3	Calibrate suit with body and avatar		Smart suit should be properly calibrated	Smart suit is calibrated and ready	Pass	

4	Click record animation button		Animation recording should be start	Animation is recording	Pass	
Post Condition: Standard task is created.						

TC-05: Edit Standard Tasks

TC-ID: TC-05	**Author of Test Case:** Arslan Riaz
Priority: Low	**Created At:** 01/07/2020
Name: Edit Standard Tasks	**Executed By:** Arslan Riaz
Title: To Edit standard tasks for patients	**Executed At:** 01/07/2020
Description: Check the proper working of edit standard tasks	
Pre-conditions: Select the task you want to edit .	

Step	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Notes**
1	Select the task		The task should be edited	Task is edited	Pass	
2	Click on edit task button				Pass	
3	Make changes in task				Pass	
4	Click save			Task is edited and saved	Pass	

Post Condition: Standard task is edited.

TC-06: Delete Standard Tasks

TC-ID: TC-06	**Author of Test Case:** Arslan Riaz
Priority: Low	**Created At:** 01/07/2020
Name: Delete Standard Tasks	**Executed By:** Arslan Riaz
Title: To delete standard tasks for patients	**Executed At:** 01/07/2020
Description: Check the proper working of delete standard tasks	

Pre-conditions: Select the task you want to delete.

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Select the task		The task should be deleted	Task is deleted from the system	Pass	
2	Click on delete task button				Pass	
3	Click save			Task is deleted	Pass	

Post Condition: Standard task is deleted .

TC-07 Edit Profile

TC-ID: TC-07	**Author of Test Case:** Arslan Riaz
Priority: Low	**Created At:** 02/07/2020
Name: Edit Profile	**Executed By:** Arslan Riaz
Title: Change user information	**Executed At:** 02/07/2020
Description: Allow the user to change the information of their profile	

Pre-conditions: User should be available in the database and logged in the system.

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the user profile page		Users profile page should be opened	User is navigated to the profile page	Pass	
2	Change the desired information	Name: Doctor2 Phone: 03004001234			Pass	
4	Click on Save Button				Pass	

Post Condition:

User`s profile is edited and successfully updated.

TC-08 Add Patient

TC-ID: TC-08	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 02/07/2020
Name: Add patient	**Executed By:** Arslan Riaz
Title: Add patient	**Executed At:** 02/07/2020
Description: Allow the doctor to add the information of their patient in the system	
Pre-conditions: Doctor should be logged in the system.	

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the patient's page		Patients list page should be opened	Doctor is navigated to the patients list page	Pass	
2	Click Add new patient button				Pass	
4	Enter the patient information	Name:" Arslan" Last Name: "Riaz" Contact: 03004001122 Age: 18 Gander: Male Address: "Lahore, Pakistan" Parkinson Stage: Stage 1			Pass	

		Symptoms: Slow Movements History: “Having medications for a month”				
5	Click add patient button		Patient is added successfully pop up window should appear	Patient is added in the database	Pass	
Post Condition: Patient is added in the database.						

TC-09 View Patient

TC-ID: TC-09	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 02/07/2020
Name: View patient	**Executed By:** Arslan Riaz
Title: View patient	**Executed At:** 02/07/2020
Description: Allow the doctor to view the information of their patient in the system	
Pre-conditions: Doctor should be logged in the system and the patient should be available in the database.	

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the patient’s		Patients list page	Doctor is navigated	Pass	

	page		should be opened	to the patients list page		
2	Select the patient				Pass	
3	Click view patient button		Patient profile page should be opened	Patient information page is displayed	Pass	
Post Condition: Patient information is opened.						

TC-10 Edit Patient

TC-ID: TC-010				**Author of Test Case:** Arslan Riaz		
Priority: Low				**Created At:** 02/07/2020		
Name: Edit patient				**Executed By:** Arslan Riaz		
Title: Edit patient				**Executed At:** 02/07/2020		
Description: Allow the doctor to edit the information of their patient in the system						
Pre-conditions: Doctor should be logged in the system and the patient should be available in the database.						
Step	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Notes**
1	Go to the patients page		Patients list page should be	Doctor is navigated to the patients list	Pass	

			opened	page		
2	Select the patient				Pass	
3	Click edit patient button		Patient profile page should be opened	Patient information page is displayed and is editable	Pass	
2	Change the desired information	Name: “Ali” Phone: 03004001234			Pass	
4	Click on Save Button				Pass	
Post Condition: Patient information is edited and Updated.						

TC-11 Delete Patient

TC-ID: TC-11	**Author of Test Case:** Arslan Riaz
Priority: Low	**Created At:** 02/07/2020
Name: Delete patient	**Executed By:** Arslan Riaz
Title: Delete patient	**Executed At:** 02/07/2020
Description: Allow the doctor to Delete their patient from the system	
Pre-conditions: Doctor should be logged in the system and the patient should be available in the	

database.						
Step	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Notes**
1	Go to the patient's page		Patients list page should be opened	Doctor is navigated to the patients list page	Pass	
2	Select the patient				Pass	
3	Click Delete patient button		Patient should be removed from the list	Patient is deleted	Pass	
Post Condition: Patient profile is deleted from the database.						

TC-12: Data Acquisition

TC-ID: TC-12	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/2020
Name: Data Acquisition	**Executed By:** Arslan Riaz
Title: Collect patient`s motion data	**Executed At:** 01/07/2020
Description: Check the proper working of recording animation.	
Pre-conditions: Smart Suit should be ready and configured.	

Ste	**Test**	**Test Data**	**Expected**	**Actual**	**Status (Pass/F**	**Notes**

p	Steps		Result	Result	ail)	
1	Wear Smart Suit		Smart Suit should be worn	suit is worn by the user	Pass	
2	Configure and connect suit on Wi-Fi with system	Ip:”192.168.1.13”	Smart Suit should be connected with system on Wi-Fi	Smart Suit is connected to the system	Pass	
3	Calibrate suit with body and avatar		Smart suit should be properly calibrated	Smart suit is calibrated and ready	Pass	
4	Click record animation button		Animation recording should be start	Animation is recording	Pass	
5	Click export in CSV File		Motion data should be exported	Motion data is collected and stored in CSV file	Pass	
Post Condition: Standard task is created.						

TC-13: Disease Identification

TC-ID: TC-13	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 01/07/2020
Name: Data Acquisition	**Executed By:** Arslan Riaz

Title: Collect patient`s motion data to identify.				**Executed At:** 01/07/2020		
Description: Check the proper working of recording animation.						
Pre-conditions: Smart Suit should be ready and configured.						
Step	**Test Steps**	**Test Data**	**Expected Result**	**Actual Result**	**Status (Pass/Fail)**	**Notes**
1	Wear Smart Suit		Smart Suit should be worn	suit is worn by the user	Pass	
2	Configure and connect suit on Wi-Fi with system	Ip:”192.168.1.13”	Smart Suit should be connected with system on Wi-Fi	Smart Suit is connected to the system	Pass	
3	Calibrate suit with body and avatar		Smart suit should be properly calibrated	Smart suit is calibrated and ready	Pass	
4	Click record animation button		Animation recording should be start	Animation is recording	Pass	
5	Click export in CSV File		Motion data should be exported	Motion data is collected and stored in CSV file	Pass	
6	Run Python	File:”Test1.csv”	Result should be	Results are generated	Pass	

	file and select the CSV File		generated by the AI program	and save in a CSV File		
Post Condition: Results are displayed that is the person is healthy or a Parkinson's patient.						

TC-14 Task Assignment

TC-ID: TC-14	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 02/07/2020
Name: Assign task to patient	**Executed By:** Arslan Riaz
Title: Assign task to patient	**Executed At:** 02/07/2020
Description: Allow the doctor to view the information of their patient in the system	

Pre-conditions: Doctor should be logged in the system and the patient should be available in the database .

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Go to the patients' page		Patients list page should be opened	Doctor is navigated to the patients list page	Pass	
2	Select the patient				Pass	
3	Click view patient button		Patient profile page should be opened	Patient information page is displayed	Pass	

4	Click on Task management button		Task management page should be opened	User is navigated to task page	Pass	
5	Select the task you want to assign	Selected: “Walking 10 meters”			Pass	
6	Click start task		3D Task scene should be open	A New 3D environment is Opened	Pass	
Post Condition: Task is assigned and 3D Task scene is opened.						

TC-15 Task Performance

TC-ID: TC-15	**Author of Test Case:** Arslan Riaz
Priority: High	**Created At:** 02/07/2020
Name: Task Performance	**Executed By:** Arslan Riaz
Title: Task Performance	**Executed At:** 02/07/2020
Description: Patient will perform the rehabilitation task assigned by the doctor.	

Pre-conditions:

Doctor should be logged in the system and the patient should be available in the database.

Patient should be wearing the Smartsuit.

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes

1	Go to the patients' page		Patients list page should be opened	Doctor is navigated to the patients list page	Pass	
2	Select the patient				Pass	
3	Click view patient button		Patient profile page should be opened	Patient information page is displayed	Pass	
4	Click on Task management button		Task management page should be opened	User is navigated to task page	Pass	
5	Select the task you want to assign	Selected: "Walking 10 meters"			Pass	
6	Wear Smart Suit		Smart Suit should be worn	User is wearing the suit	Pass	
7	Configure and connect suit on Wi-Fi with system		Smart Suit should be connected with system on Wi-Fi	Smart suit is connected	Pass	
8	Calibrate suit with body and		Smart suit should be properly	Smart suit is calibrated	Pass	

	avatar		calibrated	and ready		
9	Click start Task button		Task should be started	Tasked is started	Pass	
Post Condition: Patient has performed the task.						

5 Conclusion

In this report, a system for the rehabilitation of Motion-Impaired (Parkinson's) patients has been presented. The proposed system will provide a dedicated Rehabilitation of Motion-Impaired (Parkinson's) patients with the help of a motion-capture suit. games have a positive impact on patients' rehabilitation. This system will increase the rehabilitation rate of the motion impaired people and motivates the patients toward therapy. To help with the physical symptoms of PD patients, our main goal was to create activities that offer a wide range of joints movements, while keeping them very simple, interactive and motivating for patients. In this system, we will convert everyday tedious therapy into entertaining exercises. Therefore, by performing these interactive games, exercises/tasks the patient will undergo a bunch of physical exercises that will affect the patients' body motion. The system will take the real-time data of the movement of the body joints of the patients and compare them with the values of the healthy person to evaluate the difference.

5.1 Problems Faced and Lessons Learned

After submission of the proposal, problems related to the domain, tools and technologies for the system were to be faced. The first issue encountered was that weather we use machine learning algorithms or deep learning algorithms. So, after consulting with our field related teacher we decided to use a machine learning algorithm. Another issue encountered and that was the decision of choosing an appropriate cloud database server was difficult as it had to be compatible with the cross-platform. After a detailed analysis, the firebase cloud server database was selected. These problems helped us to learn about the system domain, required tools and in detail and depth.

5.2 Future Work

- New game tasks for Tremor control using ‘Leap Motion’ for hand gestures and controls which will help the patients for a better and strong grip.
- The whole system will be in Virtual Reality which will help the patient to completely indulge in the system helping the patient in a unique environment.
- Improvement in the preloaded tasks based on feedback and more features that will help both patients and doctors.
- More advance AI will learn and train to suggest the best possible tasks that will increase the rate of rehabilitation.

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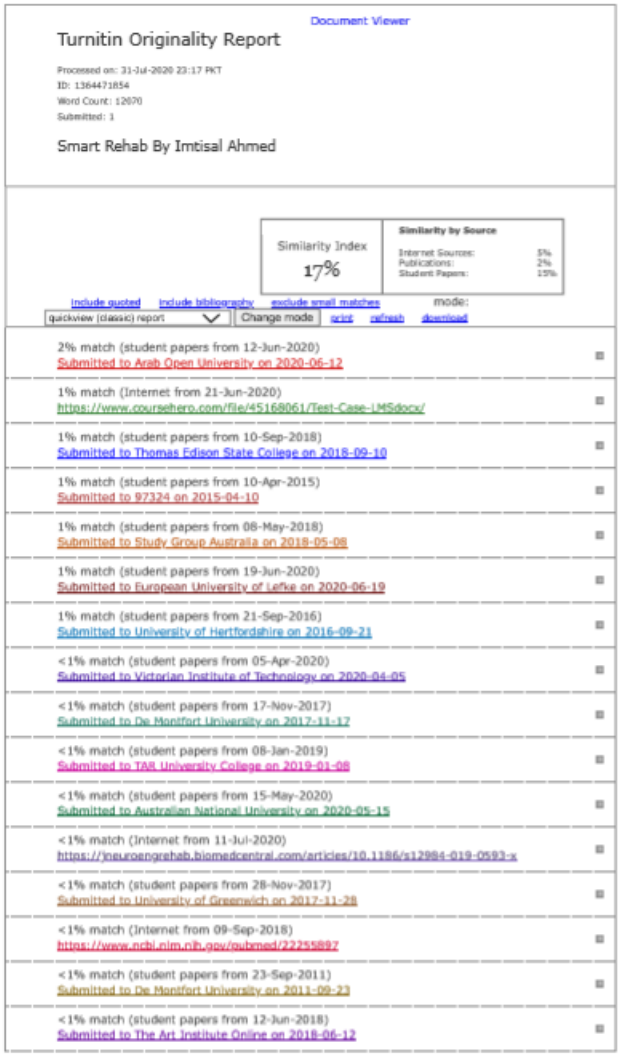
Appendix A



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