Robo-Litation

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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 **Arsham Azam**, group leader of FYP under registration no BSSE-FYL-FALL22-030 at Software Engineering Department, The Superior University, Lahore. I declare that my FYP report is checked by my supervisor.

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Robo-Litation

Change Record

Author(s)	Version	Date	Notes	Supervisor's Signature
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APPROVAL

PROJECT SUPERVISOR

Comments: ____

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PROJECT MANAGER

Comments: ____

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HEAD OF THE DEPARTMENT

Comments: ____

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Date: _________________________________ Signature: ____________________________

Dedication

This work is dedicated to our Family.

Acknowledgements

We are really thankful to our supervisor who has who has help us a lot in this venture. Our FYP Manager, FYP Supervisor & Co-Supervisor made our mind clear about the ambiguities as well as improvements about our project though their guidelines.

Executive Summary

Strokes can cause weakness or paralysis on one side of the body, and can result in problems with co-ordination and balance. There exists treatment for stroke patients which is Physiotherapy, the treatment of disease, injury, or deformity by physical methods such as massage, heat treatment, and exercise rather than by drugs or surgery. Physiotherapists help people affected by injury, illness or disability through movement and exercise, manual therapy, education and advice. The sessions normally last for about minimum half an hour and maximum of 2.5 hours on average. Proposed Solution aims to provide a Machine Learning based Self-Help End-Effector Physiotherapist Glove for stroke patients which can:

1) Understand the state of patients and generate report to be given to specialist

2) Help in improving the state of patients by performing different exercises referred by the specialist.

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Chapter 1
Introduction

Chapter 1: Introduction

Robots are involved nowadays in every industry to perform challenging tasks. To keep up with the aim of such industries; insistence, changeability and pre-back learning are necessary in robotics. Particularly one of the biological inspired techniques is learning by indication method, where robots learn from teaching agents to execute a particular task. An issue related to the stroke patients arises in the healthcare industry. As the Stroke can cause weakness or paralysis on one side of the body. Its solution is Physiotherapy, which can help restore the loss of movement & such Effective treatment can help in regaining strength and movement of stroke patients. There exists a problem; A physiotherapist performs exercises on such patients which can result in 1-2 hours long sessions. These sessions are meant to never be skipped nor canceled during treatment. For that, proposed solution is Machine learning based self-help End-Effector physiotherapist Glove for stroke patients that work autonomously. This solution helps the physiotherapist and the patient, as the end-effector is capable of performing exercises even when the specialist is not present near the patients. This is highly effective in terms of time effectiveness as the specialist can inform and make amendments in the exercises from anywhere, anytime for End-Effector to perform on such patients.

1.1. Background

Stroke is the third leading cause of disability worldwide and as the Physiotherapist charges high fee for even a single day therapy session, most of the times people cannot afford such therapists. If someone has to change their therapist willingly/unwillingly then there will be change in pace of sessions and the exercises may also differ with new therapist. Some Physiotherapist purposely charges a lot more than they should and Some of the Physiotherapists delays the sessions for their own good. Research studies have proven that intensive, repeated and long-term rehabilitation training are critical for enhancing the physical mobility of stroke patients, thus help alleviating post-stroke symptoms such as disability. Stroke patients also find it challenging to travel from home to outpatient clinics.

1.2. Motivations and Challenges

Our motivation is to be helpful to the community and bring some betterment in terms of physiotherapy. We want the patient to feel at ease and not to worry much about the high fee of physiotherapists, our product helps them to be recovered asap with the help of AI and Robotics which performs autonomous special physiotherapy exercises on patients saving a lot of time of both patients and physiotherapists as well. Challenges to face are the increase in prices of individual module which will be used in our product. Retrieving datasets and training a special model for physiotherapy, making our product fully AI based and letting it work autonomously without any need human interaction.

1.3. Goals and Objectives

The goal of this product is to achieve betterment in stroke patients. The exercises which are done on patients are designed by consulting multiple senior physiotherapist doctors which then neglects the need to worry about interaction with physiotherapist doctor.

1.4. Literature Review/Existing Solutions

Table 1 Competitor PolyU Information

Competitor	**PolyU**
Date created	**31 October 2018**
Analysis by	Dr Hu Xiao-ling
Tier (1-3)	Tier 1 - major competitor

Dr Hu Xiao-ling [1] and her research team in PolyU's Department of Biomedical Engineering (BME). The robotic arm facilitates self-help and upper-limb mobile rehabilitation for stroke patients. The lightweight device enables the patients to engage in intensive and effective self-help rehabilitation exercise anywhere, anytime after they are discharged from hospital. The robotic arm, called "mobile exo-neuro-Musculo-skeleton", is the first-of-its-kind integration of exo-skeleton, soft robot and exo-nerve stimulation technologies. The "mobile exo-neuro-Musculo-skeleton", developed by Dr Hu Xiao-ling and her research team in the Department of

Biomedical Engineering (BME) of PolyU [2], features lightweight design (up to 300g for wearable upper limb components, which are fit for different functional training needs), low power demand (12V rechargeable battery supply for 4-hour continuous use), and sportswear features. The robotic arm thus provides a flexible, self-help, easy-to-use, mobile tool for patients to supplement their rehabilitation sessions at the clinic. The innovative training option can effectively enhance the rehabilitation progress.

Table 2 Competitor PolyU Profile

Company mission	**PolyU robotic facilitates self-help and upper-limb mobile rehabilitation for stroke patients.**
Key objectives	To enable the patients to engage in intensive and effective self-help rehabilitation exercise.
Capabilities	Enables exercise anytime, anywhere.
Revenue	Est. Annual Revenue $5-$25 M

Competitor Profile:

- **Key differentiators:** Mobile Application to monitor and guide end effector as well as auto generate medical report.

Table 3 Competitor's Target market & market Share

	Competitor	Your company
Target market	Health Care	Health Care
Verticals	Stroke Patients	Stroke Patients & Doctors
Market share	77%	0%

Table 4 Competitor PolyU Product offering

	Competitor	Your company
Product overview	The robotic arm facilitates self-help and upper-limb mobile rehabilitation for stroke patients.	A machine learning based End-Effector physiotherapist glove for stroke paralyzed patients, doctors which performs autonomous exercise with Mobile applications features.
Positioning/ Category	First motorized robotic arm	Bio-inspired cheap end-effector glove
Monitoring	✓	✓
Guidance	✗	✓

1.5. Gap Analysis

Table 5 Gap Analysis

Reference	[3]	[4]	[5]
Title	Bringing Psychological Strategies to Robot-Assisted Physiotherapy for Enhanced Treatment Efficacy	A Comparative Study of Conventional Physiotherapy versus Robot-Assisted Gait Training Associated to Physiotherapy in Individuals with Ataxia after Stroke	Robot-mediated upper limb physiotherapy: review and recommendations for future clinical trials
Current	This study proposed eight psychological strategies that promote trust and acceptance of rehabilitation robots by users. It is essential to consider these factors in developing new robot-assisted techniques, in mechanical design, functional design, and the training.	This study concluded that chronic stroke patients with ataxia sequela had a significant improvement in balance and independence in activities of daily living after treatment with RAGT along with conventional therapy and home exercises.	First of all, the trials were very heterogenic. The acute/ subacute/chronic phases were not always clearly defined and, in some trials, mixed patient populations were included. The outcome measures used were also varied thus making the trials difficult to compare
Future	Future work should investigate specific mechanisms by which human users maintain positive attitudes towards robot-assisted physiotherapy and	Future studies should evaluate a longer follow-up time and patients in acute and subacute stroke phases	Clarify the acute/subacute/chronic categories. Application of these tools would be standard for all robotic trials, whereas any other scale could be used supplementary to these.
Gap	The other is that the proposed factors of F1 to F8 are part of psychological considerations. Psychological factors are not mutually exclusive, but must understand the potential and benefits to maximize recovery for optimal robot-assisted rehabilitation practice.	This study has some limitations. In particular, some limitations are related to the small sample size.	Time for post-stroke, condition of the patient, intensity and frequency of the treatment, and the possibility to use other modalities during treatment are questions that have yet to be answered completely
Action	Target the psychological factors for intervention to maximize the positive outcomes of rehabilitation.	Author suggests the investigation of supplementary interventional methods to gain a comprehensive understanding of the balance control mechanism in ataxic patients.	Provide a clear description of the intervention, the duration of one session, and the number of sessions. Understanding the procedure could be supported by photographic material
Year	2019	2018	2011

1.6. Proposed Solution

A machine learning based intelligent End-Effector physiotherapist glove for stroke paralyzed patients, which performs autonomous special physiotherapy exercises on patients. The exercises are designed by consulting multiple senior physiotherapist doctors. End effector glove is capable of monitoring user's health status as well as ensuring improvement in the movement of arm muscles. The consulted doctors are informed about the exercises, quantity and length of exercises as well as frequency, and when the exercise should be done by the End-Effector. The information about user's health, changes in muscle movement, history of treatment are transferred from End-Effector to a dedicated Mobile App, which then generates a report after each session autonomously and shares it with doctor who then further informs the End-Effector for exercises to be performed in upcoming sessions.

1.7. Project Plan

The Project Plan for Robo-Litation is prepared using the software from Microsoft called: Microsoft Project, is a project management software product, it is designed to assist a project manager in developing a schedule, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

1.7.1. Work Breakdown Structure

Robo-Litation

ID	Task Mode	WBS	Name	Duration	Start	Finish	Persons	Predecessors
1		**1**	**Research**	**62 days**	**Wed 8/10/22**	**Thu 11/3/22**		
2		1.1	Preparing Questionaire	7 days	Wed 8/10/22	Thu 8/18/22	Arsham, Bareerah	
3		1.2	Interview Patients	7 days	Wed 8/24/22	Thu 9/1/22	Arsham, Bareerah	2
4		1.3	Interview Physiotherapists	7 days	Tue 9/13/22	Wed 9/21/22	Arsham, Bareerah	2
5		1.4	Analyzing Exercises	7 days	Wed 9/28/22	Thu 10/6/22	Arsham, Bareerah, Rasikh	4
6		1.5	Analyzing Techniques	6 days	Thu 9/22/22	Thu 9/29/22	Arsham, Bareerah, Rasikh	4
7		1.6	Brainstorming about working	6 days	Wed 10/12/22	Wed 10/19/22	Arsham, Bareerah, Rasikh	5,4
8		1.7	Brainstorming about Design	6 days	Thu 10/27/22	Thu 11/3/22	Arsham, Bareerah, Rasikh	5
9		**2**	**Design**	**47 days**	**Thu 11/10/22**	**Fri 1/13/23**		
10		2.1	Choosing Colors & Logo	5 days	Thu 11/10/22	Wed 11/16/22	Arsham, Bareerah	8
11		2.2	Mobile App UI	6 days	Wed 11/30/22	Wed 12/7/22	Arsham, Bareerah, Rasikh	10
12		2.3	Wearable Arm Design	7 days	Thu 1/5/23	Fri 1/13/23	Arsham, Bareerah, Rasikh	8
13		**3**	**Implementation**	**33 days**	**Wed 1/25/23**	**Fri 3/10/23**		
14		3.1	Training ML Model	7 days	Wed 1/25/23	Thu 2/2/23	Arsham, Rasikh	7
15		3.2	Connecting Mobile App to Arm	6 days	Tue 2/14/23	Tue 2/21/23	Rasikh	11,12
16		3.3	Implementing Model on End-Effect	6 days	Fri 3/3/23	Fri 3/10/23	Arsham, Rasikh	15,14
17		**4**	**Summary**	**32 days**	**Thu 3/23/23**	**Fri 5/5/23**		
18		4.1	Unit Testing	5 days	Thu 3/23/23	Wed 3/29/23	Arsham, Bareerah, Rasikh	16
19		4.2	Integration Testing	5 days	Thu 4/13/23	Wed 4/19/23	Arsham, Bareerah	16
20		4.3	Giving Patients & Doctors to Test	7 days	Thu 4/27/23	Fri 5/5/23	Arsham, Bareerah, Rasikh	19,18

Fig. 1 Work Breakdown Structure

1.7.2. Roles & Responsibility Matrix

Robo-Litation

ID	WBS	Name	Duration	Responsible Members	Roles
1	**1**	**Research**	**62 days**		
2	1.1	Preparing Questionaire	7 days	Arsham, Bareerah	Preparing Questions
3	1.2	Interview Patients	7 days	Arsham, Bareerah	Interviewing, Taking Notes
4	1.3	Interview Physiotherapists	7 days	Arsham, Bareerah	Interviewing, Taking Notes
5	1.4	Analyzing Exercises	7 days	Arsham, Bareerah, Rasikh	Understanding Exercises
6	1.5	Analyzing Techniques	6 days	Arsham, Bareerah, Rasikh	Understanding Techniques
7	1.6	Brainstorming about working	6 days	Arsham, Bareerah, Rasikh	Discuss Working
8	1.7	Brainstorming about Design	6 days	Arsham, Bareerah, Rasikh	Discuss Designs
9	**2**	**Design**	**47 days**		
10	2.1	Choosing Colors & Logo	5 days	Arsham, Bareerah	Finalize Colors
11	2.2	Mobile App UI	6 days	Arsham, Bareerah, Rasikh	Design UI
12	2.3	Wearable Arm Design	7 days	Arsham, Bareerah, Rasikh	Finalize Design
13	**3**	**Implementation**	**33 days**		
14	3.1	Training ML Model	7 days	Arsham, Rasikh	Develop & Train Model
15	3.2	Connecting Mobile App to Arm	6 days	Rasikh	Develop Mobile app & Connect
16	3.3	Implementing Model on End-Effector	6 days	Arsham, Rasikh	Connect Model to End-Effector
17	**4**	**Summary**	**32 days**		
18	4.1	Unit Testing	5 days	Arsham, Bareerah, Rasikh	Testing Individual Modules
19	4.2	Integration Testing	5 days	Arsham, Bareerah	Testing Combined Modules
20	4.3	Giving Patients & Doctors to Test	7 days	Arsham, Bareerah, Rasikh	Handing out for testing purpose, Taking Remarks, Making Changes

Fig. 2 Roles & Responsibility Matrix

1.7.3. Gantt Chart

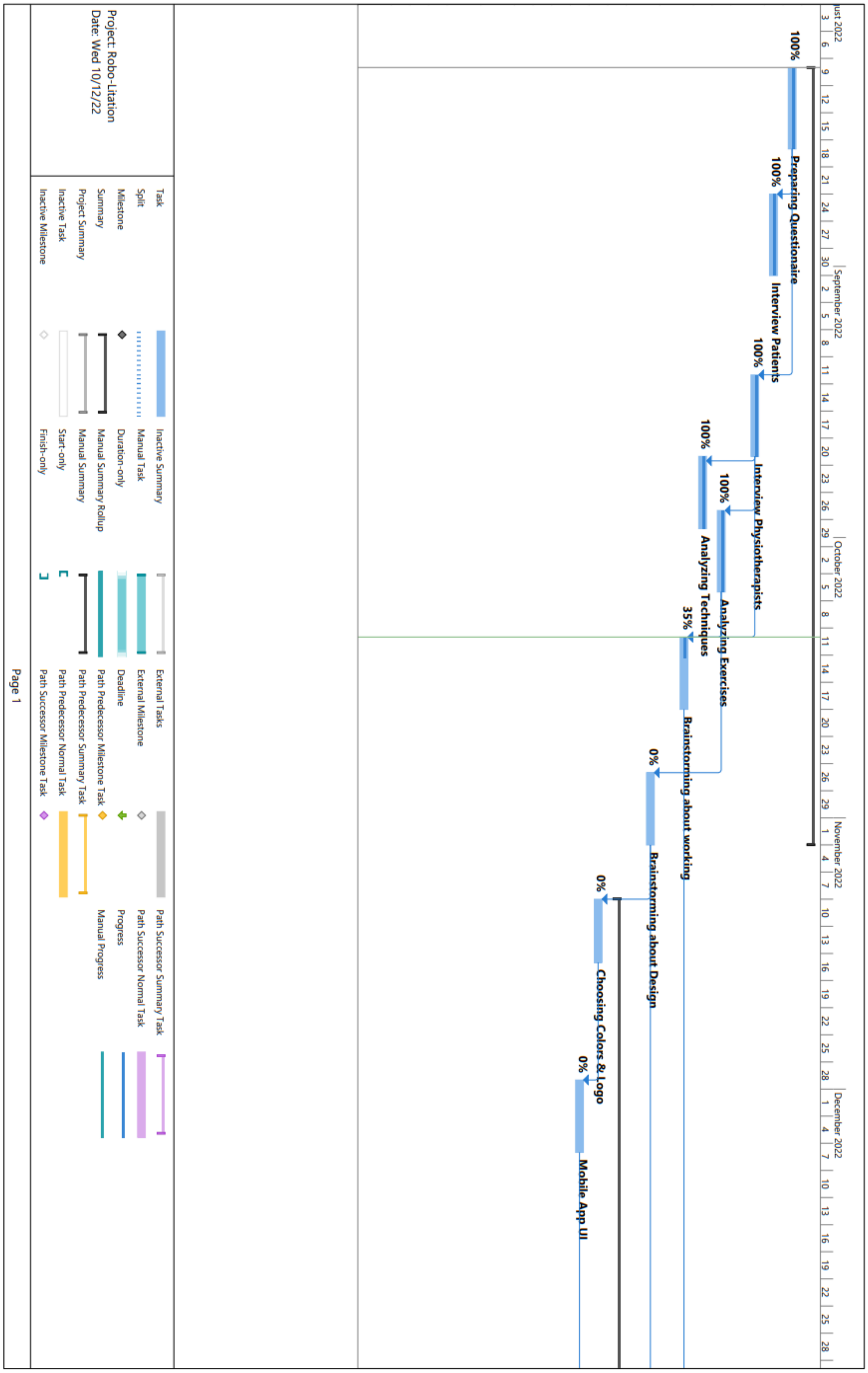


Fig. 3 Gantt Chart [1/2]

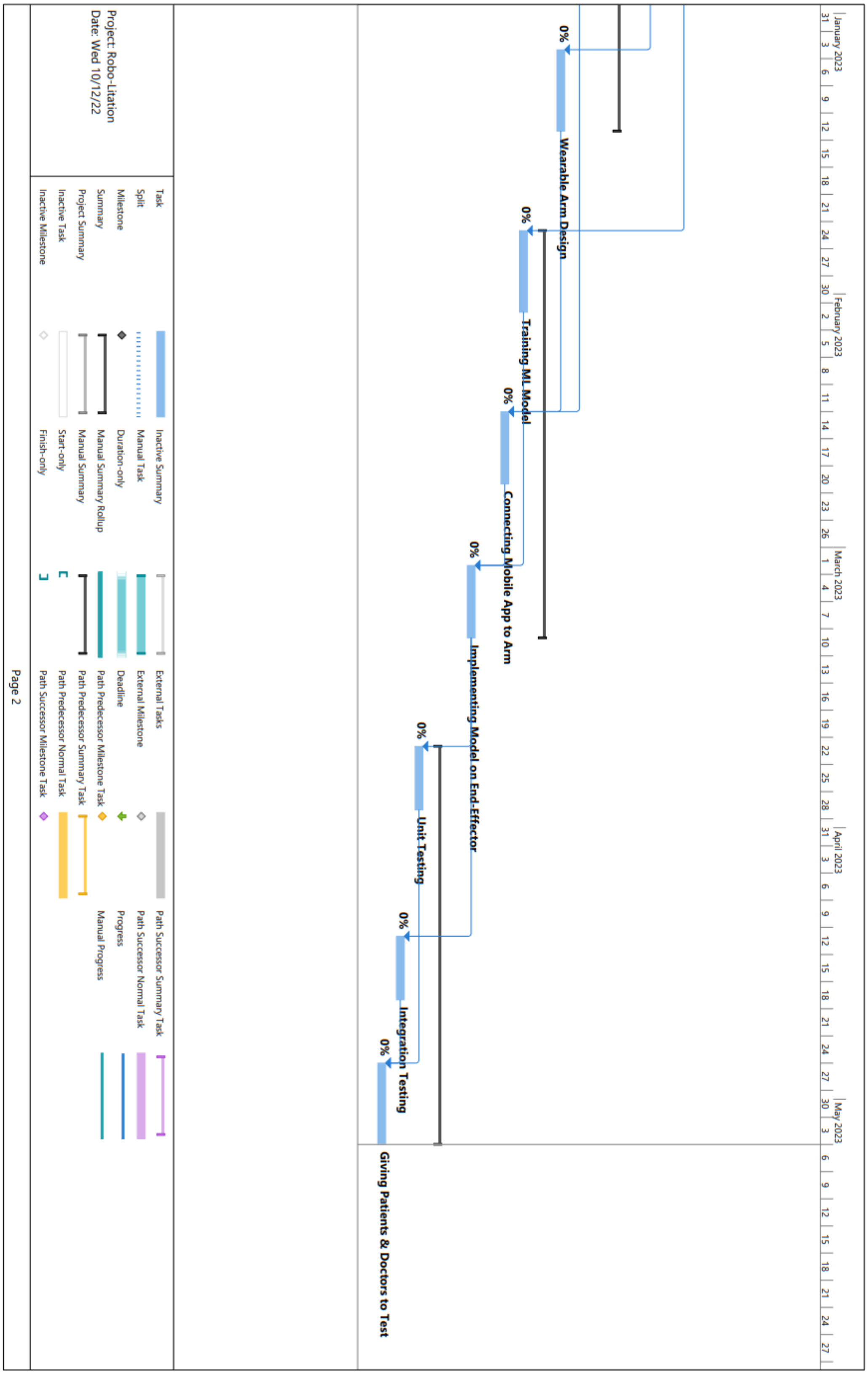


Fig. 4 Gantt Chart [2/2]

1.8. Report Outline

Title: Robo-Litation

Executive summary: Strokes can cause weakness or paralysis on one side of the body, and can result in problems with co-ordination and balance. There exists treatment for stroke patients which is Physiotherapy, the treatment of disease, injury, or deformity by physical methods such as massage, heat treatment, and exercise rather than by drugs or surgery. Physiotherapists help people affected by injury, illness or disability through movement and exercise, manual therapy, education and advice. The sessions normally last for about minimum half an hour and maximum of 2.5 hours on average. Proposed Solution aims to provide a Machine Learning based Self-Help End-Effector Physiotherapist Glove for stroke patients which can:

1) Understand the state of patients and generate report to be given to specialist

2) Help in improving the state of patients by performing different exercises referred by the specialist.

Introduction: Robots are involved nowadays in every industry to perform challenging tasks. To keep up with the aim of such industries; insistence, changeability and pre-back learning are necessary in robotics. Particularly one of the biological inspired techniques is learning by indication method, where robots learn from teaching agents to execute a particular task. An issue related to the stroke patients arises in the healthcare industry. As the Stroke can cause weakness or paralysis on one side of the body. Its solution is Physiotherapy, which can help restore the loss of movement & such Effective treatment can help in regaining strength and movement of stroke patients. There exists a problem; A physiotherapist performs exercises on such patients which can result in 1-2 hours long sessions. These sessions are meant to never be skipped nor canceled during treatment. For that, proposed solution is Machine learning based self-help End-Effector physiotherapist Glove for stroke patients that work autonomously. This solution helps the physiotherapist and the patient, as the end-effector is capable of performing exercises even when the specialist is not present near the patients. This is highly effective in terms of time effectiveness as the specialist can inform and make amendments in the exercises from anywhere, anytime for End-Effector to perform on such patients.

Goals: The goal of this product is to achieve betterment in stroke patients. The exercises which are done on patients are designed by consulting multiple senior physiotherapist doctors which then neglects the need to worry about interaction with physiotherapist doctor.

1.9. Empathy Map

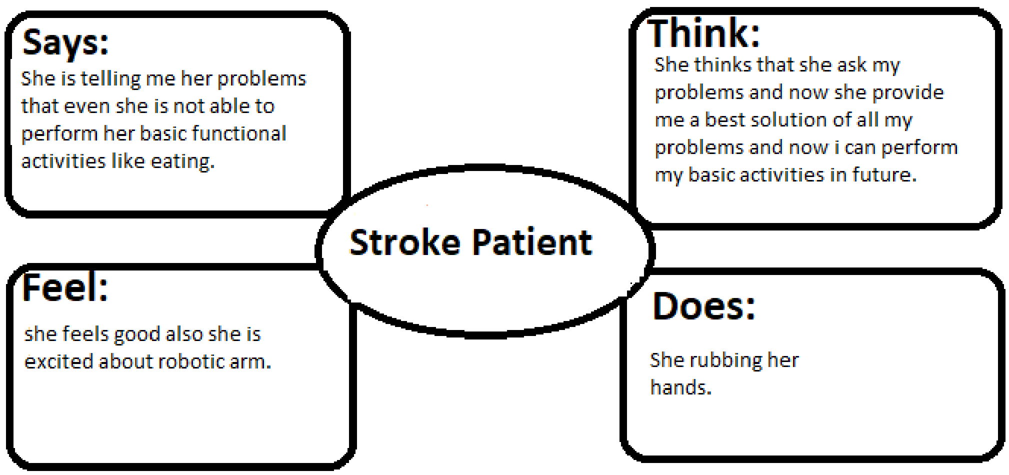


Fig. 5 Empathy Map

Chapter 2

Software Requirement Specifications

Chapter 2: Software Requirement Specifications

2.1. Introduction

This chapter is all about the Software Requirement Specifications (SRS) of the Intelligent Glove of Robo-Litation. In this chapter, it has been described that how all the features of the Gloves will be working and how the Mobile App will work with what features. Through functional and non-functional requirement, we determine how to achieve the desired outcome of the project.

2.1.1. Purpose

An Intelligent Glove for the physiotherapy exercises of stroke patients. The Glove is for the whole arm, having individual movable parts; elbow to wrist, wrist to hand, and individual moveable fingers. It also includes sensors monitoring health and sending those details to a Mobile App which then autonomously converts the details into a report and shares with user. The sole purpose of SRS is to specify the requirements on which the Robo-Litation is build and to be able to work with all Stakeholders and implementing the requirements given and accepted by all the stakeholders so that there exists no ambiguity.

2.1.2. Document Conventions

As the SRS asks for full determination and is a major part of any project, it is divided into multiple parts with each part describing its purpose. The SRS is part of our FYP project so the font being followed throughout the FYP is **Calibri** with font size of 12 for paragraphs, font size 14 for sub-heading and font size 16 for headings.

2.1.3. Intended Audience and Reading Suggestions

This document is intended for the project managers to have a complete breakthrough of the product, developers to understand and implement the requirements & for future upgradations, marketing staff, testers as well as users for understanding of the product. Robo-Litation is implemented under the guidance of FYP Manager and with the help of our Team. It is useful for the stroke patients who are having hard time with physiotherapy or physiotherapists. This document is also readable for the stakeholders, NGOs and other Companies.

2.1.4. Product Scope

A machine learning based intelligent End-Effector physiotherapist glove for stroke paralyzed patients, which performs autonomous special physiotherapy exercises on patients. The consulted doctors are informing about the exercises, quantity and length of exercises as well as frequency, and when the exercise should be done by the End-Effector. The information about user's health, changes in muscle movement, history of treatment are transferred from End-Effector to a dedicated Mobile App, which then generates a report after each session autonomously and shares it with user. The goal of this product is to achieve betterment in stroke patients. The exercises which are done on patients are designed by consulting multiple senior physiotherapist doctors which then neglects the need to worry about interaction with physiotherapist doctor.

2.2. Overall Description

2.2.1. Product Perspective

Robo-Litation is introduced to reduce / replace the old approaches for physiotherapy such as having a doctor physically available to monitor and help in exercise of patients. Using the modern approach of Robotics & AI, developed an intelligent wearable glove which is effective for all stroke patients, helps in exercises and generates autonomous reports for user as well as physiotherapist to read even when they're not physically available to each other. Robo-Litation consists of a Wearable Glove; wearable material, nylon string, rotatory motors (servo motor), small module for programming (raspberry pi), power source (battery) and Mobile App wirelessly connected to wearable glove.

2.2.2. User Classes and Characteristics

Following are the user classes for this system:

1. **Patient:** the most important user for our product who will experience the improvements in their health, no knowledge needed about how the arm is moving, etc. Feedbacks matters the most, should have full ease and comfort while wearing product.
2. **Doctor:** the user who isn't needed always but is good if he's included in the physiotherapy, even for monitoring of reports and addressing the improvements.
3. **Demonstrator:** the technical user which showcase how to wear the glove, how to remove the wearable glove, how to force stop the device and how to start it.

2.2.3. Operating Environment

There is no restriction about where the hardware will perform and where it won't. User can use it in hospital, in clinic, in rehab centers or even in personal space. Only requirement for this device to work is having a power source and having a function mobile for monitoring purpose.

2.2.4. Design and Implementation Constraints

Hardware limitations: Raspberry Pi is needed for the implementation of AI for controlling wearable glove, instead of programming certain exercises.

Specific Technologies: Python for Machine Learning, Java & Flutter for Mobile App, Having Knowledge about Robotics and Electricals for Designing and Implementation of Wearable Glove.

Security Consideration: High, as the product is wearable and is electronic.

Design Conventions: Standard, according to healthcare wearables.

2.2.5. Assumptions and Dependencies

Dependent on Raspberry Pi, for the implementation of AI for controlling wearable glove, instead of programming certain exercises. Need strong knowledge about electronics (electrical engineering) and robotics for the design and development of the product. Need Strong knowledge of Mobile App Development.

2.3. External Interface Requirements

2.3.1. User Interfaces

The UI interface of the mobile app of Robo-Litation is very simple and streamline for the User. The app is developed keeping the target audience in mind so that more portion of the screen is available to interact and showing the stats coming from the hardware. There is no screen layout constraint as the relative is used so the app can adapt itself to ant screen layout. Standard ways to interact is with mouse and touch is available. There's also a drawer to navigate through different sections of app.

2.3.2. Hardware Interfaces

Wearable Glove having stings coming from each of the individual finger of glove, having servo motors to control each of the strings' movement, servo motor being powered by a power bank attached to the waist / bag which also includes Raspberry pi / Arduino. For Mobile App, device should be android version 7+ & good internet connectivity.

2.3.3. Software Interfaces

For developing mobile app, Java & Flutter is used. For software running on Arduino / raspberry pi, of wearable glove, Python & Java is used. Data is transferred to mobile app where reports are generated and stored in Database; Firebase Real-time Database, Fire Store. Authentication is used for logging in user. Notification Manager is used to notify the user about the major details being transmitted from wearable glove.

2.3.4. Communications Interfaces

Network server protocols are used for the receiver build in mobile app and transmitters of the wearable glove which is sending data using the module connected (Arduino / raspberry pi). Firebase Real-Time Database, Fire Store requires good internet connection to work seamlessly.

2.4. System Features

2.4.1. Individual Finger Movement

2.4.1.1. Description and Priority

This feature is of high priority, the all 3 portions of finger should be able to move 90° maximum. The finger should be able to move collectively (from all 3 portions) 180°. There should be atleast a motor controlling individual finger.

2.4.1.2. Stimulus/Response Sequences

Each portion of finger should be able to move individually too, rather than only movable as a whole finger.

2.4.1.3. Functional Requirements

REQ-SF1-1: Strings used for moving of finger / finger parts should not cause any harm.

REQ-SF1-2: Strings used for moving of finger / finger parts should not cause any pain.

REQ-SF1-3: Motors attached to those strings should not cause any harm to skin.

REQ-SF1-4: Motors attached to those strings should not be able to move finger more than 180° (as whole) / 90° (per portion of finger)

2.4.2. Palm Movement

2.4.2.1. Description and Priority

This feature is of high priority, the palm should be able to move 90° maximum in forward direction. There should be a motor controlling the whole palm's movement.

2.4.2.2. Stimulus/Response Sequences

The palm must not bend for more than 90° in forward direction.

2.4.2.3. Functional Requirements

REQ-SF2-1: String(s) used for the movement of palm must not cause any harm to skin.

REQ-SF2-2: String(s) used for the movement of palm must not cause any pain to user.

REQ-SF2-3: Motor(s) attached to those strings must not cause any harm to the skin.

REQ-SF2-4: Motor(s) attached to those strings must not move palm more than 90°.

2.4.3. Report Generation

2.4.3.1. Description and Priority

This feature is of medium priority, Reports are generated from the data given by hardware to mobile app.

2.4.3.2. Stimulus/Response Sequences

The data transmitted to mobile app should be stored in a report format and saved in database as well.

2.4.3.3. Functional Requirements

REQ-SF3-1: The data read and transmitted should be accurate.

REQ-SF3-2: It should not take more than 1 minute to generate report.

REQ-SF3-3: The transfer rate of data should not be more than 100ms.

2.5. Nonfunctional Requirements

2.5.1. Performance Requirements

- Mobile application shall provide accurate results based on the conditions of the patients
- Application's response time should be 0.1 second
- Worst response time shall not be more than 10 seconds
- Application shall be able to process 10000 logged in users at the same time.

2.5.2. Safety Requirements

- Physiotherapist glove shall be made of good solid materials which will let it safely working on the hands of the users.
- All the motors and wires of on the gloves shall be covered which will prevent it from environmental damage.
- User's personal record on the mobile application should be safe and secure.

2.5.3. Security Requirements

- User must be login with username and password
- Assuring that users have continued access to information and resources.
- Assuring that information and programs are changed only in a specified and authorized manner.
- No information should display to unauthorized person

2.5.4. Usability Requirements

- The Physiotherapist glove should be easy to use.
- Mobile application should be easy to learn and easy to use.
- Users shall be able to see his progress in daily exercise in application easily.
- Patient should be satisfied after exercising with the Physiotherapist glove.

2.5.5. Reliability Requirements

- The Physiotherapist glove shall be able to help in daily exercise routine of the patients.
- No maintenance or service should be required for the Physiotherapist glove for one year.
- The Physiotherapist glove's length shall be adjustable according to the patient's glove.
- Mobile application will receive live updated data from the glove after exercising.
- The physiotherapist's glove's quality shall be durable.

2.5.6. Maintainability/Supportability Requirements

- The Physiotherapist glove shall be easily repairable in case of any damage.
- The Physiotherapist glove and changing defected parts shall not cause any malfunction in the working of the glove.
- Repairing of the Physiotherapist glove shall increase its lifecycle and shall meet the new requirements.
- The Physiotherapist glove shall be easily maintainable

2.5.7. Portability Requirements

- Our mobile application shall be used on cross platform mobile devices.
- Application shall be used on android operating system.
- Application shall be used on IOS operating systems.
- If a user changes its mobile device which cause change of operating system, all users' data shall be transferred to new installed application after logging in.

2.5.8. Efficiency Requirements

- Our Mobile Application shall not drain a lot of mobile's battery power.
- Mobile Application shall not use a lot of internet MBs for usage.
- The Physiotherapist glove shall be able to provide correct and accurate results to the mobile application.
- Application shall provide daily progress reports to the users.
- Application shall be able to perform accurate calculations of progress made for the users.

2.6. Domain Requirements

Domain requirements typically arise in military, medical and financial industry sectors, among others. A domain need for software in medical equipment is as follows:

- With regard to the fundamental performance and safety requirements for medical electrical equipment, the software must be created in line with IEC 60601.
- Software may be useable and functional, but it may not be suitable for production since it does not adhere to domain standards.

Chapter 3

Use Case Analysis

Chapter 3: Use Case Analysis

The use case analysis describes the different scenarios or interactions that are possible with the wearable glove for stroke patients and the mobile app. It outlines the steps and preconditions for each scenario, as well as the postconditions after the scenario has been completed.

In the context of this wearable glove, the use case analysis covers the different ways in which the wearable glove and mobile app can be used to perform physiotherapy exercises, generate reports, and monitor the patient's recovery. It describes how the patient can start and end an exercise session, view the reports generated by the mobile app, and communicate with the physiotherapist. It also describes how the physiotherapist can review the reports and update the patient's exercise plan as needed.

Overall, the use case analysis provides a high-level overview of the functionality and features of the wearable glove and mobile app, and how they work together to support the physiotherapy needs of stroke patients.

3.1. Use Case Model

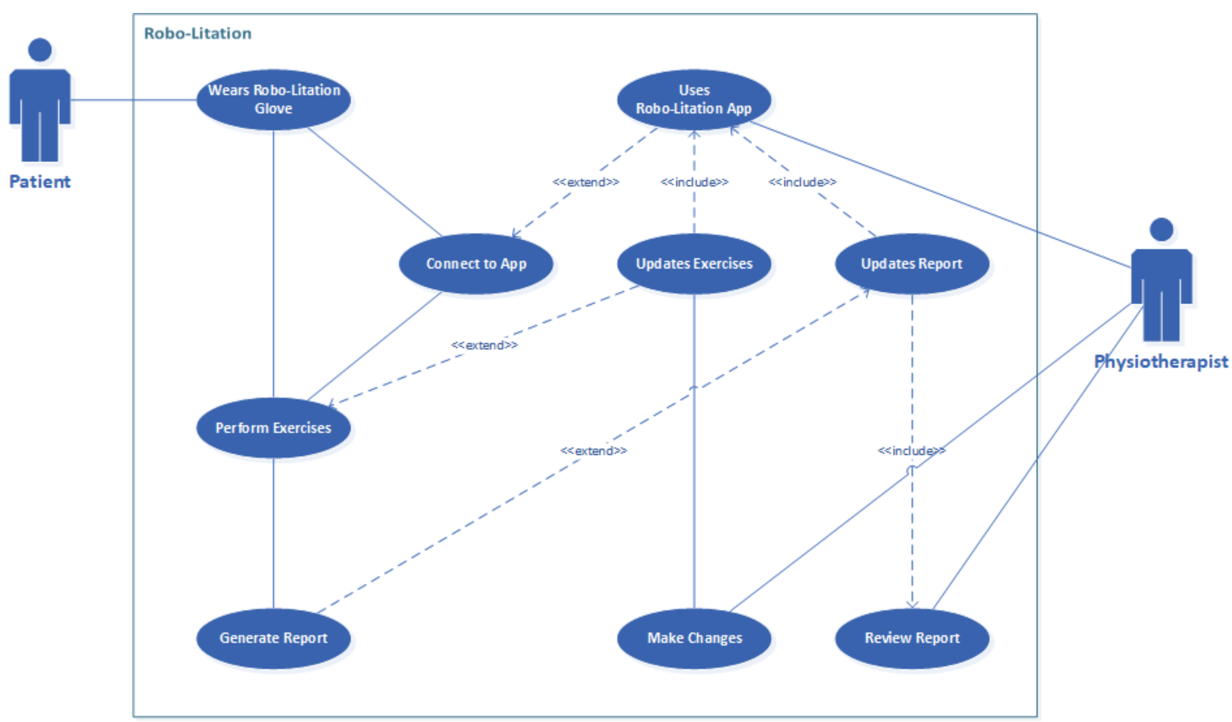


Fig. 6 Use Case Model

3.2. Use Cases Description

The wearable glove is a device that is worn by stroke patients to assist in their physiotherapy exercises. The glove is equipped with sensors that track the patient's muscle movement during the exercises. The data collected by the sensors is sent to a connected mobile app, which generates a report after each exercise session. The report includes information such as the duration of the exercise, the number of repetitions completed, and any deviations from the prescribed exercise. The report is stored on the mobile app and can be accessed by the patient and their physiotherapist at any time. The physiotherapist can use the report to monitor the patient's recovery and make any necessary changes to their exercise routine or prescribe new exercises. The mobile app also provides the patient with instructions on what exercises to perform, when to perform them, and for how long.

Chapter 4

System Design

Chapter 4: System Design

The Robo-Litation project consist of Mobile Application and a wearable Glove which is connected to Mobile App via Bluetooth connectivity, The Mobile App is connected to server to securely store the data and transfer the reports to the physiotherapists.

4.1. Architecture Diagram

An architecture diagram for the "Robo-Litation" project would show the different components of the system and how they interact with each other. It would include a representation of the patient with wearable glove connected to app. It would also show the mobile app informing exercises to glove, report generation and storing it in database. The diagram would also depict the flow of data from the glove to the mobile app and then to the physiotherapist for monitoring and making adjustments. Overall, the diagram would help to visually communicate the overall design and functionality of the system.

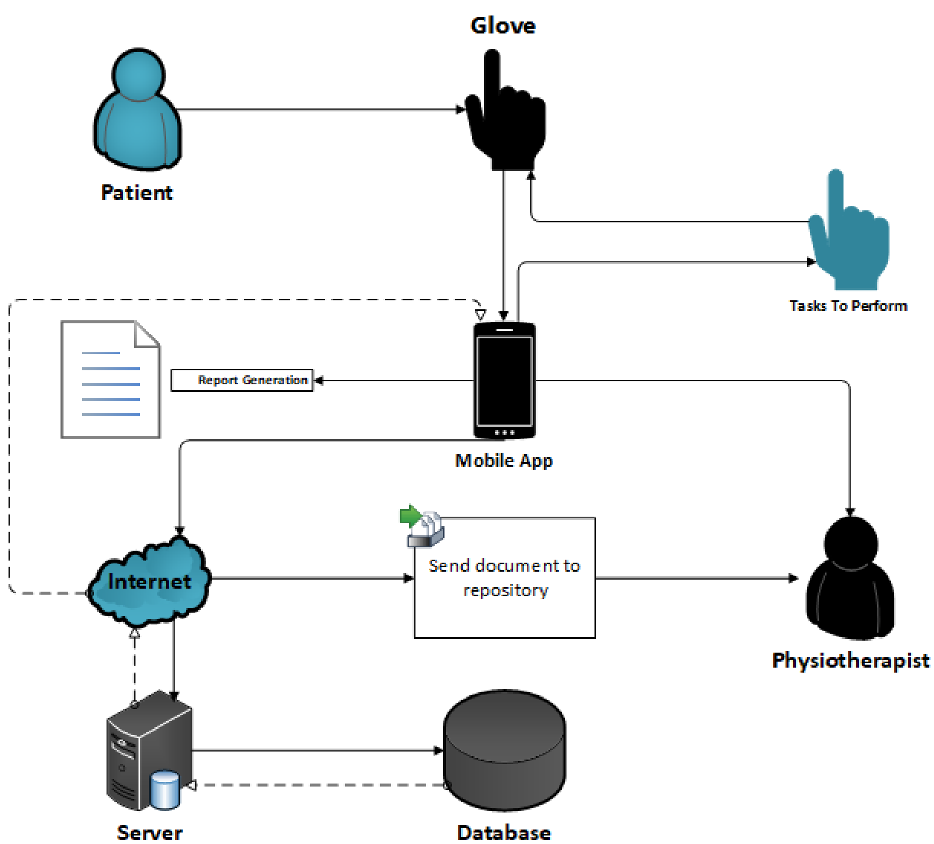


Fig. 7 Architecture Diagram

4.2. Domain Model

A domain model is a representation of the problem domain or the specific area of knowledge that a system is designed to address. The purpose of the domain model for the "Robo-Litation" project is to provide a clear and comprehensive understanding of the key concepts and relationships within the problem domain, which in this case is physiotherapy for stroke patients. It helps to identify the main classes, their properties, and the relationships between them. The domain model would include classes such as Patient, Physiotherapist, Glove, Mobile app and Report. It would also show how these classes interact with each other, for example, how a patient performs exercises using glove connected to mobile app, and how reports are generated and shared between the patient and physiotherapist.

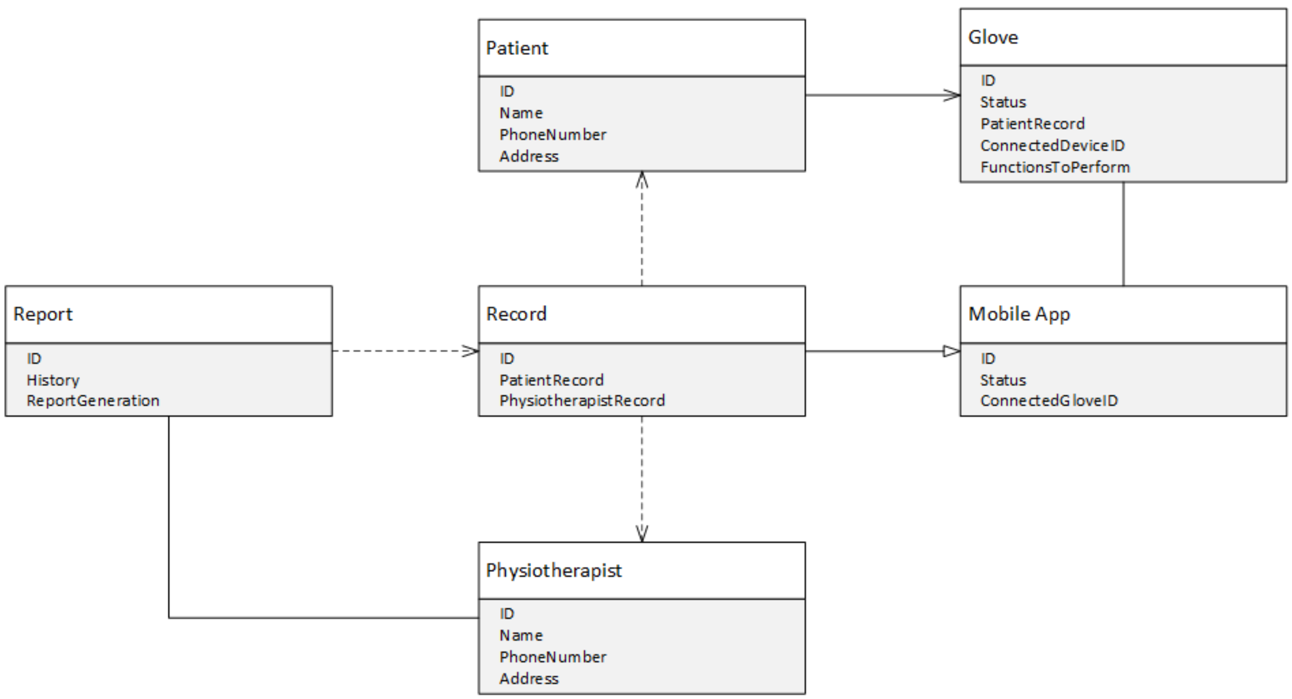


Fig. 8 Domain Model

4.3. Entity Relationship Diagram with data dictionary

An ERD is a graphical representation of the entities and their relationships within a system. The purpose of the ERD for the "Robo-Litation" project is to provide a detailed and visual representation of the data and how it is organized and stored in the system. The ERD would include entities such as Patient, Physiotherapist, Mobile App, Glove, and Report, and show the relationships between them. It would also show the attributes of each entity, such as the patient's name, the physiotherapist's name, and the report's info.

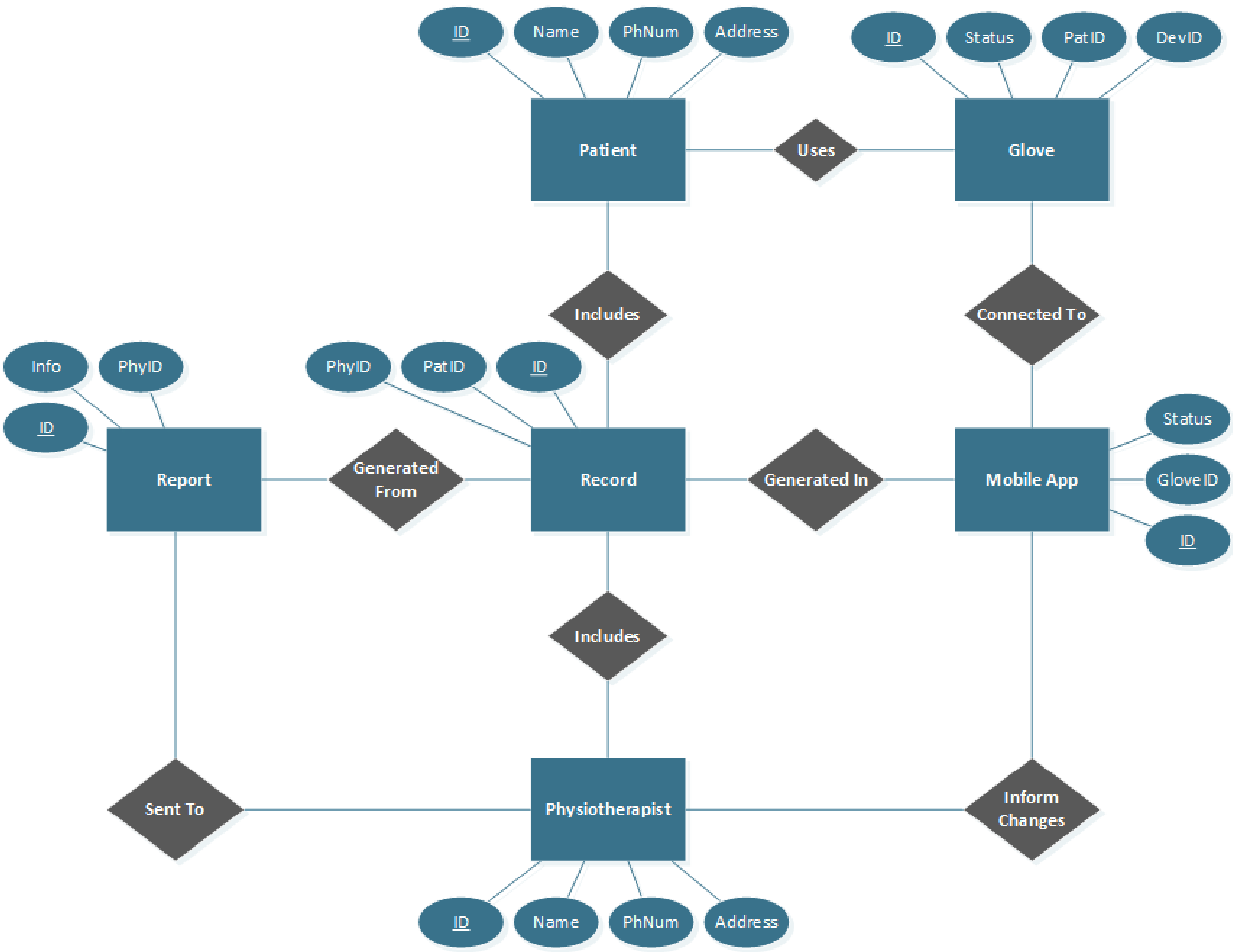


Fig. 9 Entity Relationship Diagram

4.4. Class Diagram

A class diagram represents the classes, interfaces, and objects in a system, as well as their relationships and interactions. The purpose of the class diagram for the "Robo-Litation" project is to provide a detailed and visual representation of the object-oriented design of the system. The class diagram would include classes such as Patient, Physiotherapist, Glove, Mobile App, and Report, and show the relationships between them. It would also show the attributes and methods of each class, such as the patient's name and getRecord() method, the physiotherapist's name and getRecord() method, the glove's connectivity method to mobile app, and the report's getReport() method.

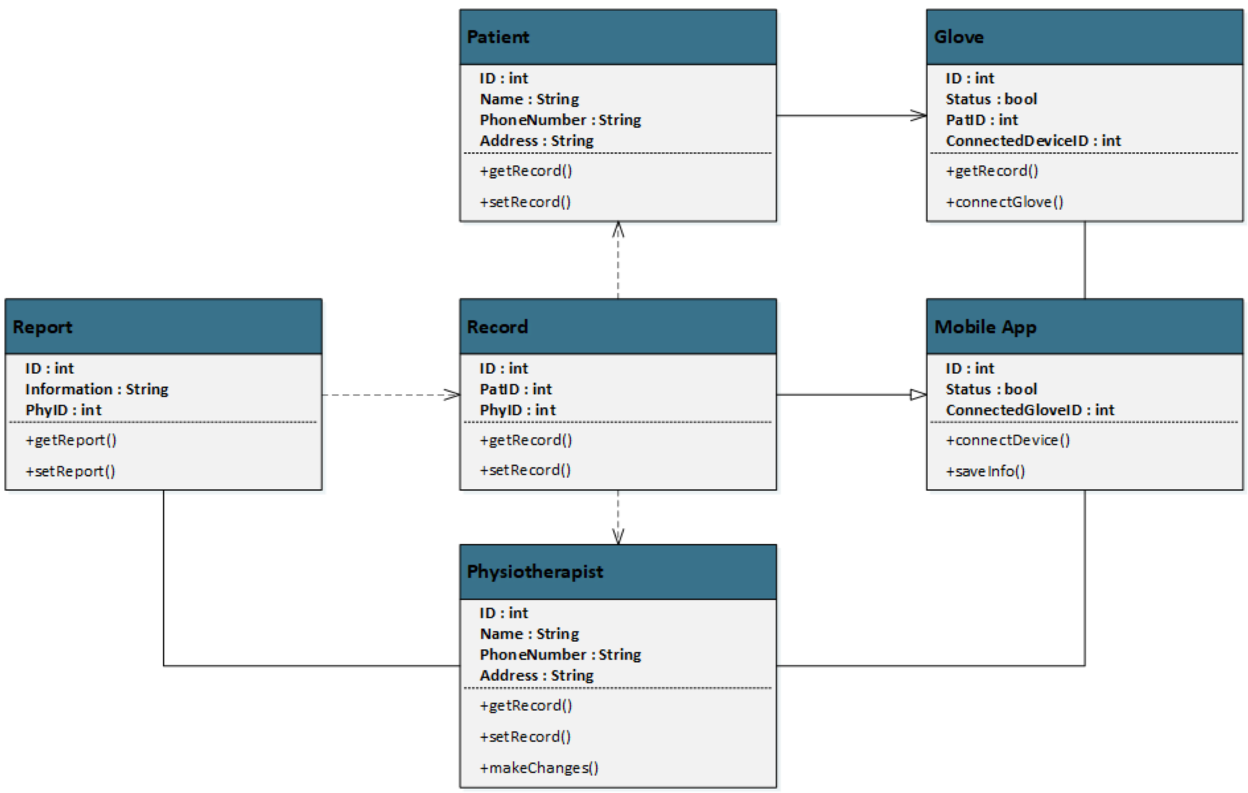


Fig. 10 Class Diagram

4.5. Sequence / Collaboration Diagram

A sequence diagram represents the interactions and sequences of messages between objects or components in a system. The purpose of the sequence diagram for the "Robo-Litation" project is to show how objects or components interact with each other over time to complete a specific task or accomplish a goal. The sequence diagram would show the interactions between objects such as the wearable glove, the mobile app, the physiotherapist, report and the patient. It would also depict the flow of messages between these objects, such as the message sent from the wearable glove to the mobile app to retrieve exercise details and the message sent from the mobile app to the physiotherapist to send the report after each exercise session. The sequence diagram would also show the order in which messages are sent and received.

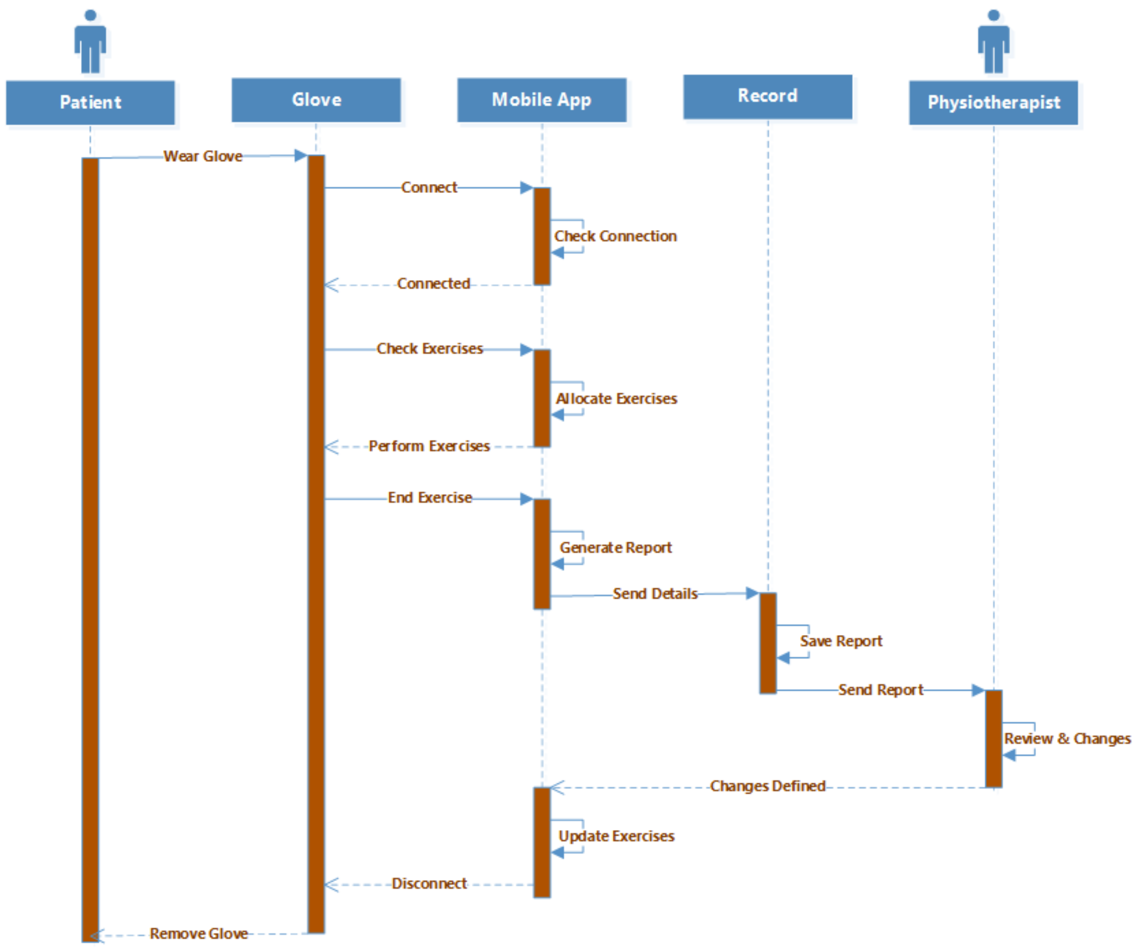


Fig. 11 Sequence Diagram

4.6. Activity Diagram

An activity diagram represents the flow of activities in a system and how they are related to each other. The purpose of the activity diagram for the "Robo-Litation" project is to show how the system's various actions and tasks are organized and how they are related to each other. The activity diagram would show the flow of activities in the system, such as the process of connectivity of glove to mobile app, performing the exercise, and generating report. It would also depict the flow of control, such as the branching or looping between different activities, and the decision points in the process, such as whether or not a glove is connected to app.

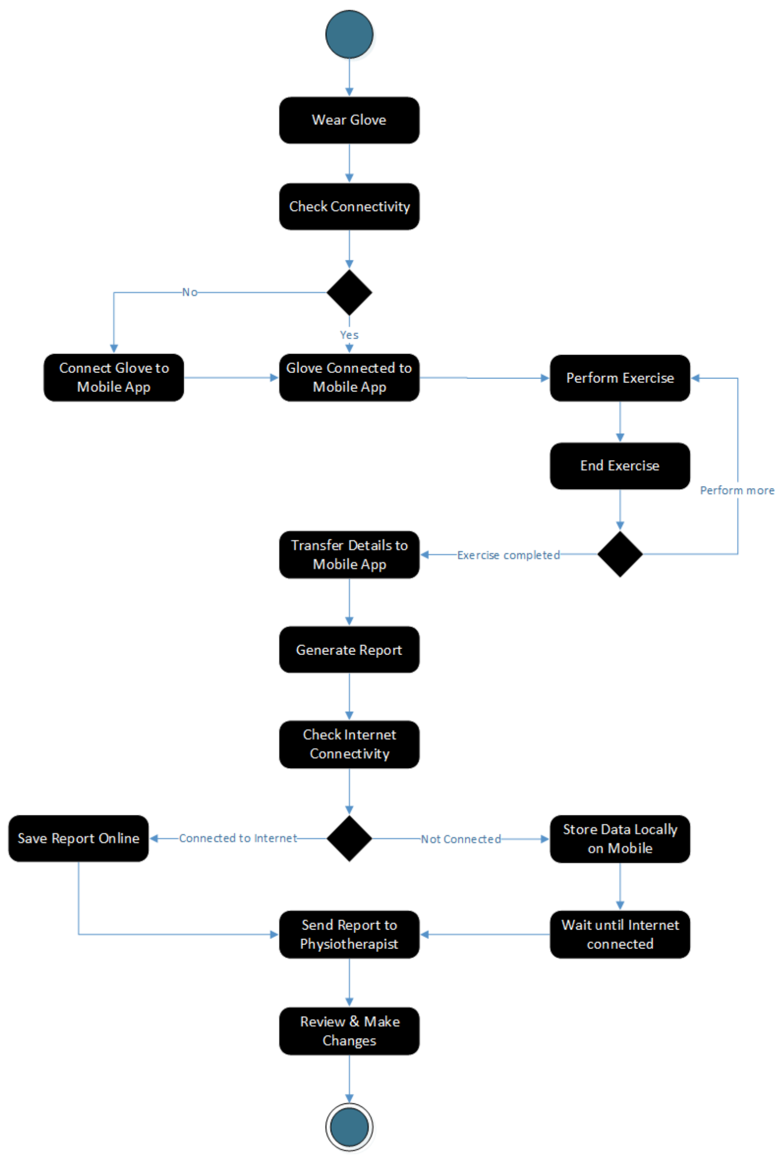


Fig. 12 Activity Diagram

4.7. State Transition Diagram

A state transition diagram represents the possible states of an object or system and the transitions between those states. The purpose of the state transition diagram for the "Robo-Litation" project is to show how the system's different states are related to each other and how the system behaves in response to different events or actions. It would also depict the events or actions that trigger the transitions between states, such as the patient starting an exercise, the exercise being completed, and the report being generated.

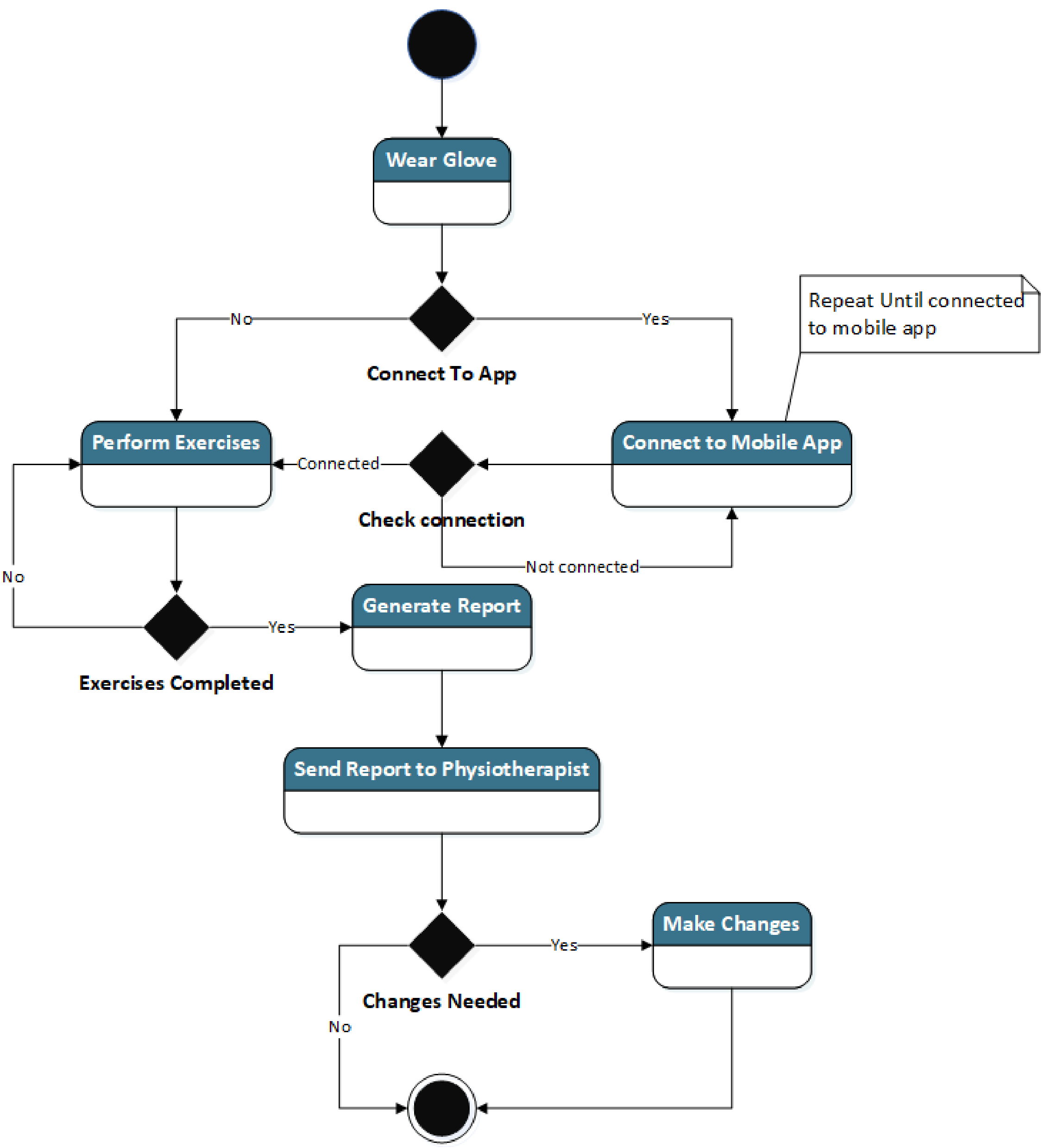


Fig. 13 State Transition Diagram

4.8. Component Diagram

A component diagram represents the components of a system and how they are connected and interact with each other. The purpose of the component diagram for the "Robo-Litation" project is to show the components of the system and how they are connected, assembled and work together to deliver the expected functionality. The component diagram would show the components of the system such as the wearable glove, the mobile app, the report, as well as the connections between them.

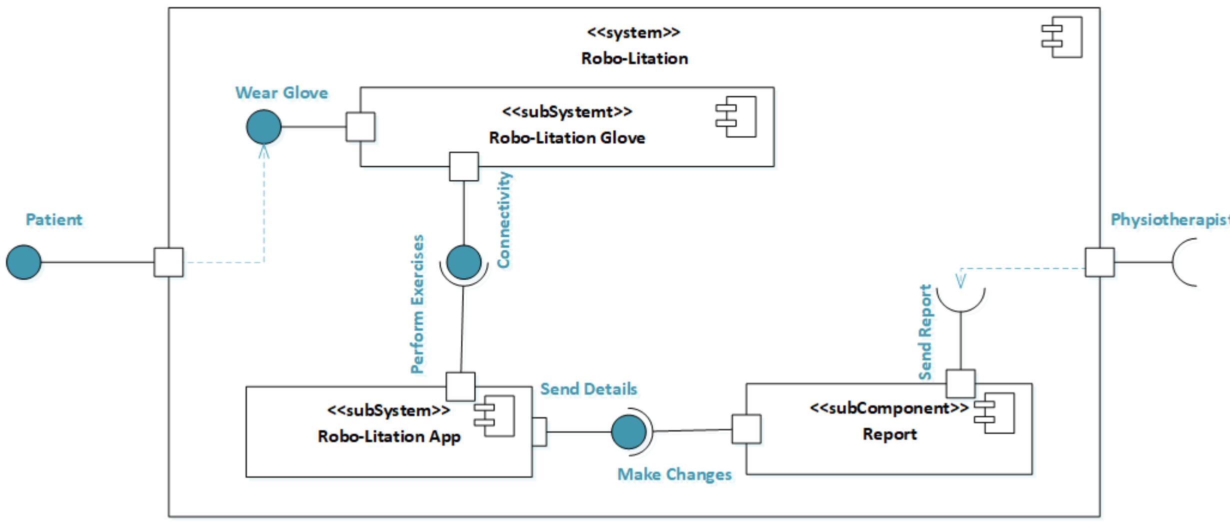


Fig. 14 Component Diagram

4.9. Deployment Diagram

A deployment diagram represents the deployment of the system's components on hardware or in a network environment. The purpose of the deployment diagram for the "Robo-Litation" project is to show how the system's components are deployed and configured in the target environment and how they interact with each other and with external systems. The deployment diagram would show the hardware and software components of the system, such as the wearable glove, the mobile app, the storage, as well as the connections between them.

Fig. 15 Deployment Diagram

4.10. Data Flow diagram

A data flow diagram (DFD) represents the flow of data within a system, including the inputs, processes, outputs, and storage of data. The purpose of a DFD for the "Robo-Litation" project is to show how data is input into the system, how it is processed and transformed, and how it is output and stored. A DFD for the "Robo-Litation" project would show the flow of data between the wearable glove, the mobile app, and the physiotherapist. It would depict the processes such as data analysis, report generation, connection, and the outputs such as exercise instructions and reports sent to the physiotherapist.

Level 0:

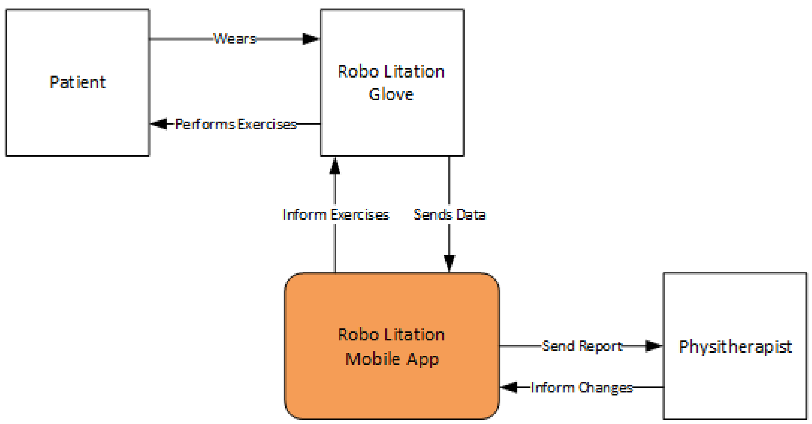


Fig. 16 Data Flow Diagram (Level 0)

Level 1:

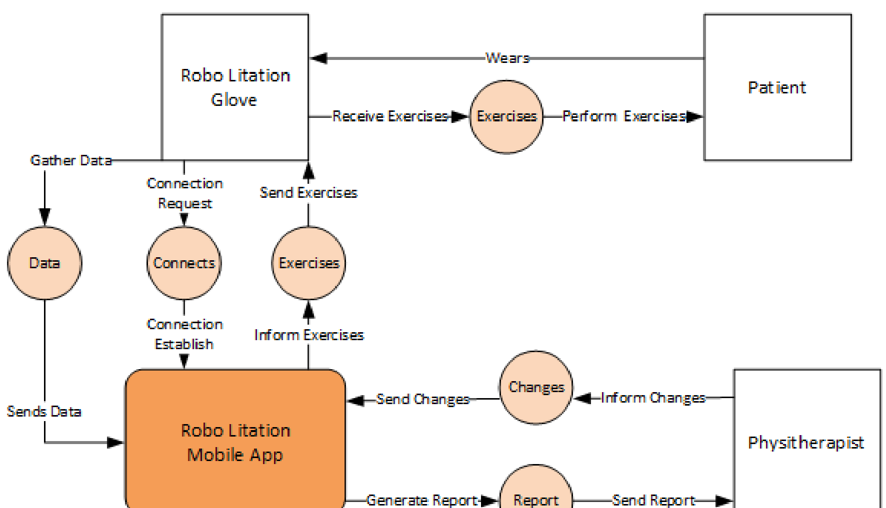


Fig. 17 Data Flow Diagram (Level 1)

4.11. Internal Working of system

The purpose of an internal working of the system diagram is to provide a detailed and visual representation of the internal workings of the system, including the functional and technical components and how they work together to deliver the expected functionality. For the "Robo-Litation" project, an internal working of the system diagram would show the functional and technical components such as the wearable glove, the mobile app, the sensors, and the Bluetooth connectivity, as well as the connections between them. It would also depict the internal processes and algorithms that are used to control the system's functionality such as muscle movement tracking, exercise performing and report generation. Additionally, the diagram would also show connection between the components and how they interact with each other, such as the Bluetooth communication between the wearable glove and the mobile app. It helps to understand the overall internal architecture of the system and the communication between the components, and also helps to identify any potential issues or inefficiencies in the internal workings of the system.

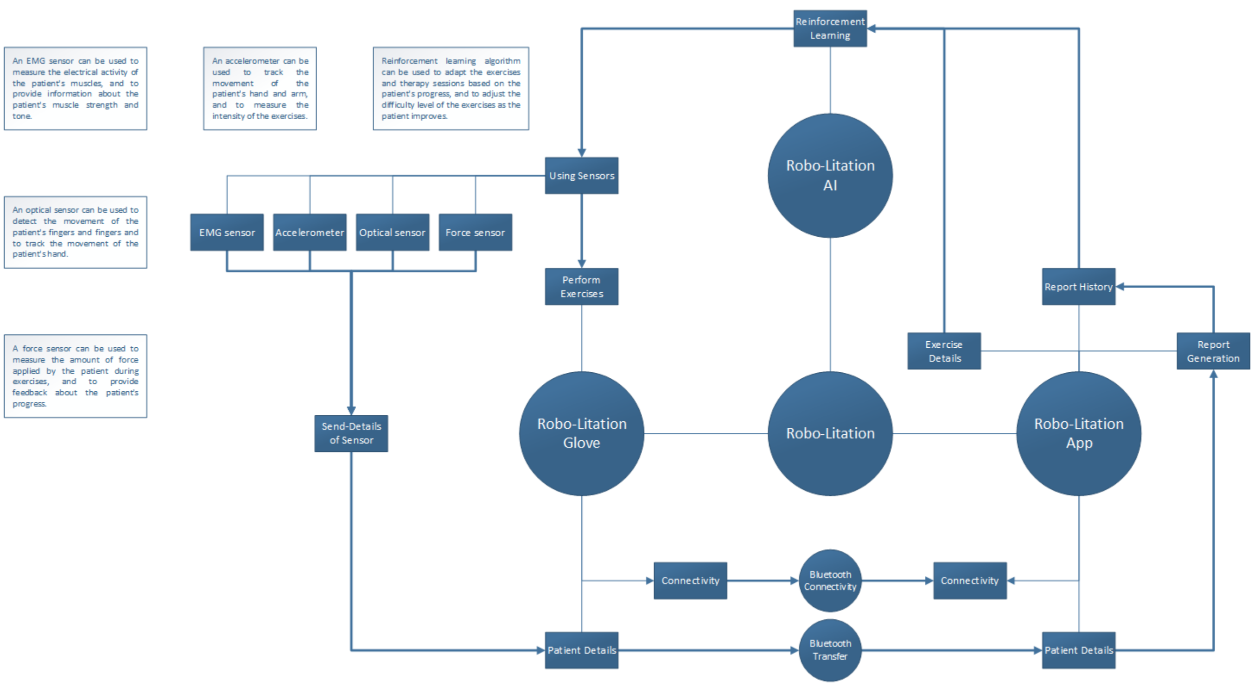


Fig. 18 Internal Working of system

Chapter 5

Implementation

Chapter 5: Implementation

General outline of the steps that might be involved in implementing such a project:

1. Set up a server to store and manage data about the patients, exercises, and progress. This might involve creating a database, setting up secure communication protocols, and creating APIs to allow the mobile application and wearable glove to access and update the data.
2. Develop the mobile application, which will be the main interface for the patient to use the system. This might involve designing the UI, implementing the logic for displaying exercises, tracking progress, and generating reports, and setting up communication with the server and the wearable glove.
3. Develop the wearable glove, which will provide additional feedback and guidance to the patient as they perform the exercises. This might involve designing the hardware and sensors for the glove, implementing the logic for providing feedback and guidance, and setting up communication with the mobile application.
4. Test and debug the system to ensure that it is functioning correctly and providing a good user experience. This might involve conducting user testing and gathering feedback, fixing any bugs or issues that are discovered, and improving the system based on user feedback.
5. Deploy the system and make it available to patients and physiotherapists

5.1. Important Flow Control/Pseudo codes

Implementation pseudo code for Robo-Litation project:

1. Install and import necessary libraries and modules for Bluetooth connection and server communication
2. Define function to initialize Bluetooth connection between mobile app and wearable glove
3. Define function to connect mobile app to server and securely store data
4. Define function to start collecting data from wearable glove
5. Define function to analyze collected data to understand state of patient

6. Define function to generate report based on patient data and send to specialist
7. Define function to retrieve recommended exercises from specialist
8. Define function to display recommended exercises to patient on mobile app
9. Define function to track progress of patient as they complete recommended exercises
10. Define function to update report with progress and send updated report to specialist
11. Call necessary functions in main program to execute Robo-Litation project

Note: This pseudo code is a detailed implementation of the steps involved in the Robo-Litation project and is intended to provide a general idea of the process and may need to be adjusted and refined based on the specific requirements of the project. It is not intended to be a complete or fully functional code.

5.2. Components, Libraries, Web Services and stubs

The following are some of the components, libraries, web services, and stubs that may be required for the implementation of the Robo-Litation project:

Components:

- Mobile app with Bluetooth connectivity to communicate with the glove and display exercises
- Wearable glove with Bluetooth connectivity and sensors to track muscle movement
- Database to store data from the glove

Libraries:

- Python libraries for Bluetooth communication (e.g., PyBluez)
- Python libraries for database management (e.g., SQLite)
- Flutter libraries for building the mobile app user interface and interacting with the database and Bluetooth

Web Services:

- Web service for sending reports from the mobile app to the physiotherapist
- Web service for receiving updates from the physiotherapist and updating the exercise plan in the mobile app

Stubs:

- Stub for simulating the wearable glove during testing and development
- Stubs for testing the Bluetooth communication between the glove and the mobile app
- Stubs for testing the database management and report generation functionality in the mobile app

5.3. Deployment Environment

Some possible deployment environments for the project could include:

- Mobile devices: The mobile application for the Robo-Litation project will likely need to be deployed to mobile devices such as smartphones or tablets in order to be used by patients. This may require testing and debugging on a range of different device models and operating systems.
- Server: The server for the Robo-Litation project will need to be deployed in a suitable environment such as a cloud platform or a dedicated server. This will involve setting up and configuring the server, as well as ensuring that it is secure and scalable to meet the needs of the project.
- Wearable devices: The wearable glove for the Robo-Litation project will need to be deployed to patients and tested to ensure that it is functioning properly and providing accurate data. This may involve coordinating with manufacturers and suppliers to ensure that the device is available and compatible with the mobile app.

Other considerations for the deployment environment may include network infrastructure, security measures, and data privacy regulations.

5.4. Tools and Techniques

Some tools and techniques that may be useful for the implementation of the Robo-Litation project include:

- Development tools: These may include integrated development environments (IDEs) such as Android Studio or Visual Studio, as well as tools for version control (e.g. Git), testing (e.g. JUnit), and debugging (e.g. logcat).

- Bluetooth tools: These may include libraries or APIs for establishing and maintaining a Bluetooth connection between the mobile app and wearable glove, as well as tools for testing and debugging the Bluetooth connection.
- Server communication tools: These may include libraries or APIs for connecting to and communicating with the server, as well as tools for testing and debugging server communication.
- Data analysis tools: These may include libraries or frameworks for analyzing and processing data collected from the wearable glove, such as machine learning libraries or data visualization tools.
- Testing and debugging techniques: These may include techniques such as unit testing, integration testing, and user acceptance testing to ensure that the project is functioning correctly and meeting the needs of patients and specialists.
- Project management techniques: These may include techniques such as agile development, to help organize and track the progress of the project.

5.5. Best Practices / Coding Standards

Some best practices and coding standards that may be useful for the implementation of the Robo-Litation project include:

- Code formatting: Adhering to a consistent code formatting style, such as the Google Java Style Guide or the Microsoft C# Coding Conventions, can help make the code more readable and maintainable.
- Naming conventions: Using descriptive and consistent naming conventions for variables, functions, and other code elements can also help make the code more readable and maintainable.
- Comments: Adding comments to the code can help explain the purpose and function of different code elements, making it easier for other developers to understand and maintain the code.

- Documentation: Providing clear and thorough documentation for the project, including API documentation, user guides, and technical documentation, can help ensure that the project is easy to use and understand.
- Testing: Implementing robust testing and debugging practices, such as unit testing and user acceptance testing, can help ensure that the project is reliable and meets the needs of patients and specialists.
- Security: Adhering to best practices for data security and privacy, such as encrypting data and implementing secure authentication and authorization protocols, can help ensure that the project is secure and compliant with relevant regulations.

5.6. Version Control

Version control is a system that tracks and manages changes to code and other project assets over time. It can be useful for the implementation of the Robo-Litation project in order to:

- Keep track of changes to the project: Version control allows developers to see what changes have been made to the project and who made those changes. This can be useful for understanding the history of the project and identifying when and why certain changes were made.
- Collaborate with other developers: Version control systems often allow multiple developers to work on the same project simultaneously, without overwriting each other's changes. This can be useful for collaborating on the Robo-Litation project and ensuring that everyone is working with the most up-to-date version of the code.
- Roll back changes: If changes to the project cause problems or introduce bugs, version control allows developers to revert back to previous versions of the code to fix those issues.

There are many different version control systems available, such as Git, Subversion, and Mercurial.

Chapter 6

Testing and Evaluation

Chapter 6: Testing and Evaluation

This chapter is focused on the process of testing and evaluating the Robo-Litation project. In this chapter, we describe the various methods used to test the Glove and the Robo-Litation App. The chapter covers the different stages of testing, From Use case testing to ensure that the project's functions met the intended use cases to Performance testing and stress testing were carried out to test the system's performance. It also includes a discussion of the challenges faced during testing and how they were overcome. The goal of this chapter is to provide a comprehensive overview of the testing and evaluation process and to demonstrate the effectiveness of the Robo-Litation project in meeting its objectives.

6.1. Use Case Testing

The use case testing for Robo-Litation involved testing various scenarios and user interactions within the application. The testing covered several use cases such as

- User signup
- Login
- Navigation through the app
- Profile settings
- Exercise details
- Progress reports

The main objective of the testing was to ensure that the app's functionalities were working as expected and provided a seamless user experience. The testing process involved creating test cases for each use case, outlining the prerequisites, test procedures, and expected results. The test data used for the testing was based on the different scenarios that a user might encounter while using the app. The testing was performed by a team of testers who recorded the actual results and compared them with the expected results. Any deviations were reported, and the development team worked to address them.

The use case testing helped ensure the quality and usability of the Robo-Litation application. It provides valuable insights into how users interacted with the app and identified any issues that needed to be addressed before the product's release.

Test Case 1: User Registration - Allows a new user to create an account on the Robo-Litation app by providing their full name, email, password, phone number, and selecting their profile type (patient or physiotherapist).

Table 6 User Registration

Test Case	UC-001
Actor	Unregister user
Summery	To verify that Signup button saves new user.
Related Requirement	New user must be signup before using application
Prerequisites	None
Test Procedure	Fill user signup form requirements, click signup button to save the data
Test Data	User’s details & role
Expected Result	If user provided information for signup form is valid the data will successfully save the login screen will appear.
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 2: User Login - Allows a user to log in to their existing account on the Robo-Litation app by providing their email and password.

Table 7 User Login

Test Case	UC-002
Actor	Registered user
Summery	To verify that the Login button logs in a registered user
Related Requirement	A registered user must log in to use the application
Prerequisites	User must already be registered
Test Procedure	Fill user login form requirements, click login button to log in
Test Data	Registered user email and password
Expected Result	If the user provided information for the login form is valid, the user will be successfully logged in and directed to the homepage
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 3: Navigation for Patient & Physiotherapist - Allows a user to log in to their existing account and navigate thought the application.

Table 8 Navigation for Patient & Physiotherapist

Test Case	UC-003
Actor	Patient / Physiotherapist
Summary	To verify that the Navigation Drawer displays the correct information and options
Related Requirement	Navigation Drawer must display the correct information and options based on the user's role
Prerequisites	User must be logged in
Test Procedure	Open Navigation Drawer and check the displayed options and information
Test Data	Registered user's role
Expected Result	If the user is a patient, the Navigation Drawer will display options for the homepage, profile page, report page, and exercise page. If the user is a physiotherapist, the Navigation Drawer will display options for the homepage, patient list page, profile page, and about devs page
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 4: View Profile - Allows a user to view their own profile information, including their profile picture, name, email, phone number, and profile type (patient or physiotherapist).

Table 9 View Profile

Test Case	UC-004
Actor	Registered user
Summary	To verify that the Profile Page displays the correct user information
Related Requirement	Profile Page must display the correct user information.
Prerequisites	User must be logged in
Test Procedure	Open Profile Page and check the displayed user information
Test Data	Registered user information
Expected Result	The Profile Page will display the registered user's profile picture, name, email, phone number, and role
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 5: Edit Profile - Allows a user to edit their profile information, including their profile picture, name, email, phone number, and password.

Table 10 Edit Profile Page

Test Case	UC-005
Actor	Registered User
Summary	Verify username information
Related Requirement	User will able to edit their profile
Prerequisites	User must be logged in to the system
Test Procedure	Open profile button should appear username information screen.
Test Data	Button: edit profile
Expected Result	edit profile button must shows the user info edit screen and successfully save the new user input in database
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 6: View Exercises - Allows a user to view a list of different exercises available on the Robo-Litation app.

Table 11 View Exercises

Test Case	UC-006
Actor	Registered User
Summary	To verify that the Exercise Page displays the correct exercises
Related Requirement	Exercise Page must display the correct exercises
Prerequisites	User must be logged in
Test Procedure	Open Exercise Page and check the displayed exercises
Test Data	Registered user's role and available exercises
Expected Result	The Exercise Page will display the available exercises based on the user's role
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 7: View Exercise Details - Allows a user to view details about a specific exercise, including the number of repetitions and any special instructions.

Table 12 View Exercises Details

Test Case	UC-007
Actor	Patient
Summary	To verify that the patient can view exercise details
Related Requirement	Exercise details must be displayed to the patient
Prerequisites	Patient must have logged in to the system
Test Procedure	Click on the Exercise Page tab, select any exercise to view its details
Test Data	N/A
Expected Result	Exercise details should be displayed to the patient
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 8: Perform Exercise - Allows a user to perform a specific exercise by following the instructions provided and completing the required number of repetitions.

Table 13 Perform Exercise

Test Case	UC-008
Actor	Patient
Summary	To verify that the patient can view their exercise completion percentage
Related Requirement	Patient must be able to view their progress
Prerequisites	Patient must have logged in and performed exercises
Test Procedure	Click on the Report Page tab to view the completion percentage
Test Data	N/A
Expected Result	Patient should be able to view their completion percentage
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 9: View Report - Allows a user to view their progress report, which shows the percentage of completion for each exercise.

Table 14 View Report

Test Case	UC-009
Actor	Physiotherapist
Summary	To verify that the physiotherapist can view the patient's progress report
Related Requirement	Physiotherapist must be able to view patient's progress
Prerequisites	Physiotherapist must have logged in and have patients
Test Procedure	Click on the Report Page tab and be able to view the patients' progress report
Test Data	N/A
Expected Result	Physiotherapist should be able to view the patients' progress report
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

Test Case 10: Logout User - Allows a user to successfully logout from the App.

Table 15 Logout User

Test Case	UC-010
Actor	Logged in User
Summary	To verify that user can successfully logout from the application
Related Requirement	User must be logged out from the application to secure the account and data
Prerequisites	User must be logged in to the application
Test Procedure	Click on the "Logout" button from the Navigation Drawer
Test Data	N/A
Expected Result	User will be logged out from the application and directed to the Login Screen
Actual Result	Test successful
Status	Pass
Executed by	Arsham Azam
Date of Execution	10/04/2023

6.2. Equivalence partitioning

Equivalence partitioning is a software testing technique used to divide the input data into different groups that behave similarly. In the context of the Robo-Litation project, equivalence partitioning was used to identify and group similar inputs of the Robo-Litation App. For instance, the inputs for the app can be broadly classified into login credentials, user data, and patient data. These input groups were then further divided based on their characteristics, such as valid or invalid data, numeric or text data, etc.

6.3. Boundary value analysis

Boundary value analysis is a software testing technique that involves testing the boundary values of input parameters to check if the system behaves as expected at the edge of the input domain. In the context of Robo-Litation, boundary value analysis was used to test the Robo-Litation App's input fields such as the angle and force values. It helps to identify potential problems before they become major issues and improve the overall quality of the system.

6.4. Data flow testing

Data flow testing is a software testing technique that focuses on testing the flow of data through a system. In the context of the Robo-Litation project, data flow testing was used to ensure that the data transmitted between the Glove and the Robo-Litation App was processed correctly. The test cases were designed to validate the correctness of the data flow in different scenarios, such as when the user performs a gesture, when the system receives data from the Glove, or when the data is transmitted to the App. The purpose of data flow testing is to identify any defects or issues that may affect the accuracy and reliability of the system's data processing functionality.

6.5. Unit testing

Unit testing is a type of testing where individual units or components of a system are tested in isolation from the rest of the system. In the context of the Robo-Litation project, unit testing was performed on the various software components of the Glove and the Robo-Litation App. The purpose of unit testing is to ensure that each unit or component of the system functions correctly and meets the specified requirements. In the Robo-Litation project, unit testing was performed using various testing frameworks and tools, such as JUnit and Mockito. The unit tests were designed to cover all possible scenarios and edge cases to ensure that the code was robust and reliable. Any defects or errors identified during unit testing were addressed promptly to ensure that the code met the required quality standards.

6.6. Integration testing

Integration testing is the process of testing the interactions between different modules or components of the software system to ensure they work together seamlessly as a whole. In Robo-Litation, integration testing helped ensure that the Glove and App worked seamlessly together, enabling the user to control the robotic arm using the hand movements detected by the Glove.

6.7. Performance testing

Performance testing is a type of testing used to evaluate the speed, responsiveness, stability, and scalability of the software system under different load conditions. It is performed to ensure that the system meets the performance requirements specified in the project scope. For the Robo-Litation project, performance testing was conducted to evaluate the speed and responsiveness of the Robo-Litation App under different load conditions. The testing was done using different types of mobile devices, network conditions, and server loads. The goal was to identify any performance bottlenecks or issues and optimize the app for maximum performance.

During performance testing, various metrics were measured, such as response time, throughput, and resource utilization. Load testing was also performed to determine the maximum number of concurrent users that the system could handle without degrading performance. Based on the performance testing results, improvements were made to the app's code and infrastructure to optimize its performance. For example, caching mechanisms were implemented to reduce server load, and code optimization was done to reduce response time.

6.8. Stress Testing

Stress testing is a type of testing that evaluates the robustness and reliability of a system under extreme conditions. In the context of the Robo-Litation project, stress testing was used to evaluate the performance of the system under high loads and stressful scenarios. The goal was to identify any performance bottlenecks or system failures that may occur under such conditions and to ensure that the system can handle unexpected situations. During stress testing, the system was subjected to heavy loads and simulated stressful scenarios to evaluate its performance. The stress testing results revealed that the system was able to handle heavy loads and stressful scenarios without any major issues. The system remained stable and responsive under all tested conditions, indicating its robustness and reliability.

Chapter 7

Summary, Conclusion and Future Enhancements

Chapter 7: Summary, Conclusion & Future Enhancements

7.1. Project Summary

Robo-Litation is a revolutionary project that aims to transform physiotherapy exercises for stroke patients using modern technology such as Machine Learning. The project involves the creation of a glove equipped with multiple sensors that can perform various physiotherapy exercises autonomously. The glove is connected to a mobile app that provides patients with detailed exercise instructions, tracks their progress, and enables them to report their results to their physiotherapists. By providing an accessible and cost-effective tool for rehabilitation, the project seeks to empower stroke patients to take charge of their rehabilitation process and improve their quality of life. The project is aligned with several Sustainable Development Goals, including Good Health and Well-being and Industry, Innovation, and Infrastructure. Through partnerships with healthcare organizations and patient advocacy groups, the project aims to raise awareness about the benefits of physiotherapy and the role of technology in improving patient outcomes.

7.2. Achievements and Improvements

As the Robo-Litation project progressed, several achievements and improvements were made. Some of these include:

1. **Enhanced Patient Engagement:** The Robo-Litation project has improved patient engagement and compliance by providing patients with an interactive and autonomous solution that can be used at home. This has led to better patient outcomes and improved quality of life for stroke patients.
2. **Cost-Effective Solution:** The project has addressed the limitations of traditional physiotherapy, which can be time-consuming and expensive, by providing an affordable and accessible solution. This has enabled more patients to access rehabilitation services and has contributed to the project's impact on healthcare delivery.

3. **Machine Learning Algorithm:** The project's Machine Learning algorithm has been improved to provide more accurate analysis of patient data, leading to more personalized exercise routines and better patient outcomes.
4. **Improved Sensor Technology:** The project has improved its sensor technology to provide more precise detection and analysis of hand movements, enabling the glove to perform more complex exercises.
5. **Increased Awareness:** The project has increased awareness about stroke and other conditions that require physiotherapy, leading to better understanding and early diagnosis of these conditions.
6. **Future Applications:** The project has potential future applications beyond stroke rehabilitation. The technology developed for the project could be used for other rehabilitation programs, such as those for spinal cord injuries, or for gaming and entertainment purposes.

These achievements and improvements have contributed to the overall success of the Robo-Litation project, and the project team continues to explore new avenues for innovation and impact in the healthcare industry.

7.3. Critical Review

Robo-Litation is a groundbreaking project that seeks to revolutionize physiotherapy for stroke patients by integrating cutting-edge technology. The project's primary objective is to provide an autonomous, interactive, and cost-effective solution that can be used at home. The Glove, the centerpiece of the project, is equipped with multiple sensors, including accelerometers, gyroscopes, and flex sensors, making it capable of detecting and analyzing hand movements with precision. The Robo-Litation App, which is connected to the Glove, provides patients with detailed instructions and tracks their progress, enabling them to monitor their performance and improve their outcomes.

One of the key achievements of the Robo-Litation project is its innovative approach to physiotherapy. By leveraging technology, the project seeks to overcome the limitations associated with traditional physiotherapy, such as the need for continuous supervision. The

Glove allows patients to perform various exercises autonomously, reducing the burden on caregivers and providing patients with greater independence. The project's approach also seeks to empower patients by enabling them to take charge of their rehabilitation process and improve their quality of life.

Another significant achievement of the Robo-Litation project is its alignment with the Sustainable Development Goals (SDGs). The project's focus on improving the health and well-being of stroke patients aligns with **SDG 3:** Good Health and Well-Being. Furthermore, the project's contribution to innovation and infrastructure in the healthcare industry aligns with **SDG 9:** Industry, Innovation, and Infrastructure.

Despite its many achievements, the Robo-Litation project also faces several challenges and areas for improvement. One potential issue is the cost of the equipment required for the project, which may limit its accessibility to patients from low-income backgrounds. Additionally, the project's reliance on technology may pose challenges for older patients who are not familiar with digital devices or have limited access to them. The project also face regulatory challenges in terms of obtaining the necessary approvals from healthcare regulatory bodies.

In conclusion, the Robo-Litation project is an innovative and impactful project that seeks to transform physiotherapy for stroke patients. By leveraging technology and promoting patient empowerment, the project has the potential to improve the quality of life for stroke patients and contribute to the achievement of several Sustainable Development Goals. However, the project faces several challenges and areas for improvement, and it will be essential to address these to ensure its success and impact in the long term.

7.4. Lessons Learnt

From the Robo-Litation project, several lessons can be learned, including:

1. **Integration of modern technology:** The project highlights the importance of integrating modern technology, such as Machine Learning and sensors, in healthcare to improve patient outcomes. By leveraging technology, the project provides patients with an accessible and affordable tool for rehabilitation, which can be used at home, thereby reducing the burden on patients and their caregivers.

2. **User-centered design:** The project highlights the importance of user-centered design in healthcare technology development. By involving patients and healthcare providers in the design process, the project was able to create a solution that meets the needs of the end-users, thereby improving its usability and effectiveness.
3. **Cost-effectiveness:** The project highlights the importance of cost-effectiveness in healthcare technology development. By using affordable and readily available materials, the project was able to create a solution that is accessible to a larger patient population, especially those in low-resource settings.
4. **Continuous improvement:** The project highlights the importance of continuous improvement in healthcare technology development. By gathering feedback from patients and healthcare providers, the project was able to identify areas of improvement and implement changes to enhance the solution's effectiveness and usability.

7.5. Future Enhancements/Recommendations

Based on the critical review and lessons learned, the following future enhancements and recommendations are suggested for the Robo-Litation project:

1. **Expand the scope:** Currently, the Robo-Litation project is focused on hand rehabilitation for stroke patients. However, the project can be expanded to include other areas of rehabilitation, such as arm, shoulder, and leg exercises.
2. **Improve user interface:** While the current version of the Robo-Litation app is user-friendly, it can be improved by incorporating features that enhance the user experience, such as voice commands, augmented reality, and gamification.
3. **Develop a customized version for children:** Creating a version of the Robo-Litation project specifically for children would be beneficial since stroke and other conditions requiring physiotherapy affect children as well.
4. **Enhance machine learning algorithms:** The project's machine learning algorithms can be further improved by incorporating more data and refining the algorithm to better understand user behavior and personalize the rehabilitation process.

5. **Expand partnerships:** The Robo-Litation project can partner with more healthcare organizations and patient advocacy groups to raise awareness of the project's benefits and reach a broader audience.
6. **Develop a cost-effective version:** While the current version of the project is cost-effective, there is always room for improvement. By exploring alternative components and materials, the cost of the project can be reduced, making it more accessible to patients.
7. **Incorporate feedback from patients and physiotherapists:** Obtaining feedback from patients and physiotherapists can help identify areas for improvement and guide the development of future iterations of the project.

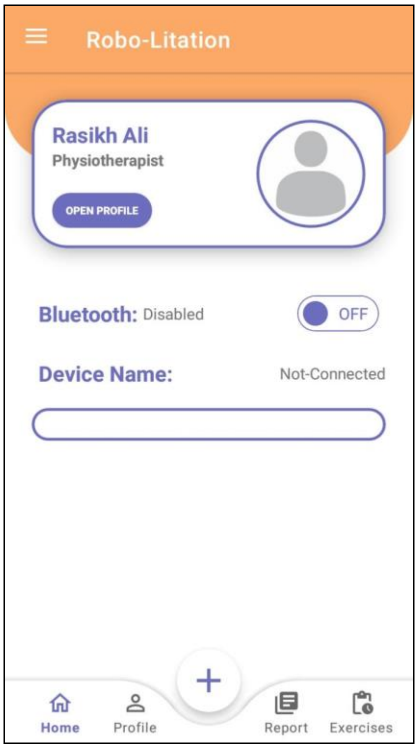
By implementing these recommendations, the Robo-Litation project can continue to evolve and provide a more comprehensive and effective solution for stroke patients and other individuals requiring physiotherapy.

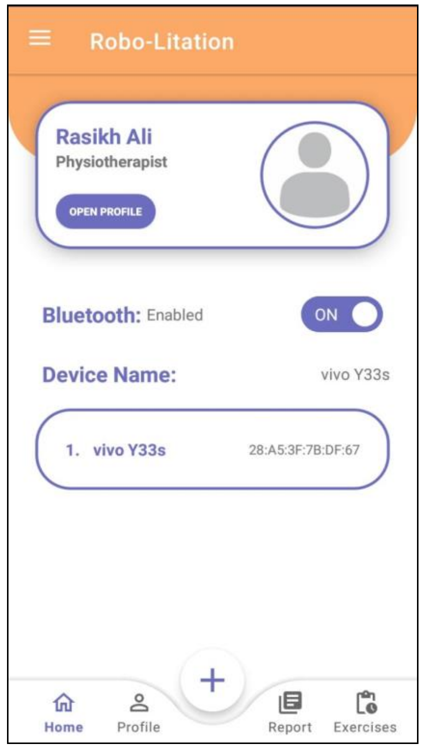
Appendices

Appendix A: Robo-Litation App

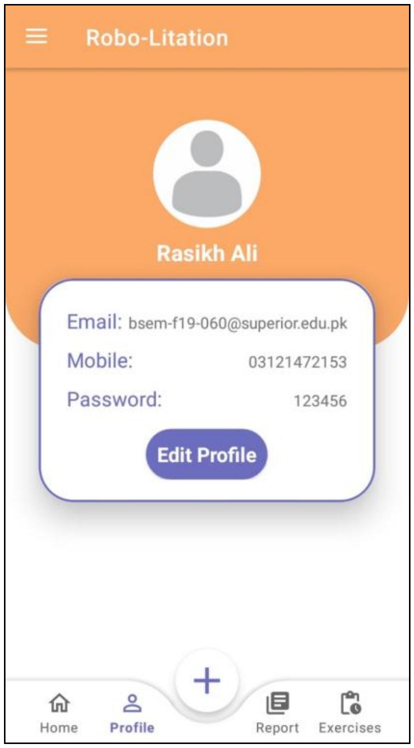
A.1. Robo-Litation App (Physiotherapist)

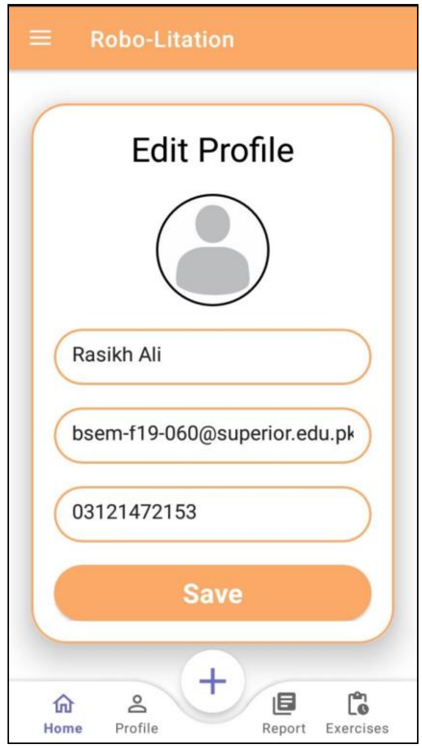
A.1.1. Dashboard



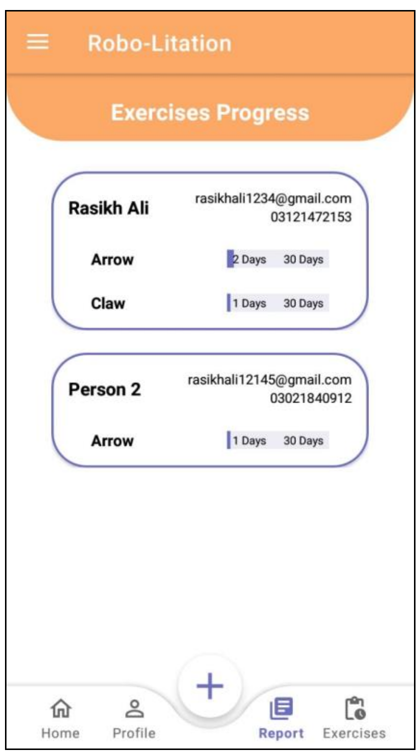


A.1.2. Profile



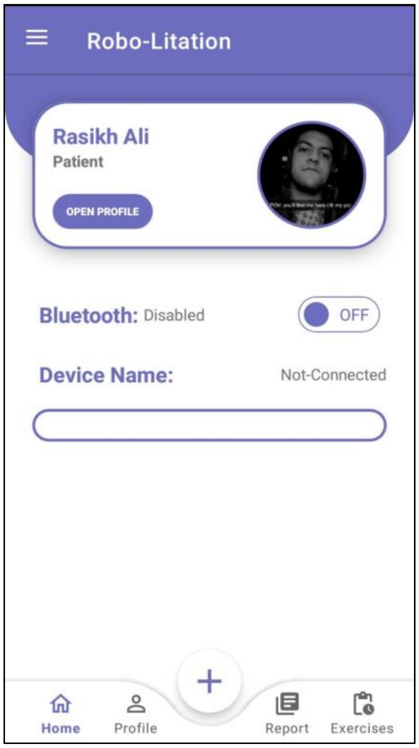


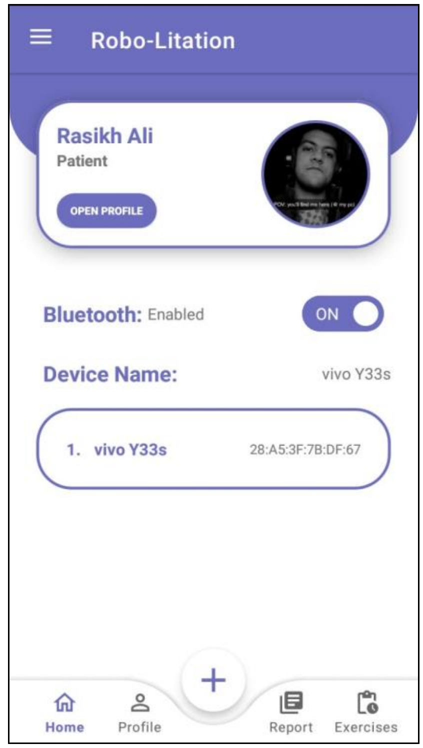
A.1.3. Report



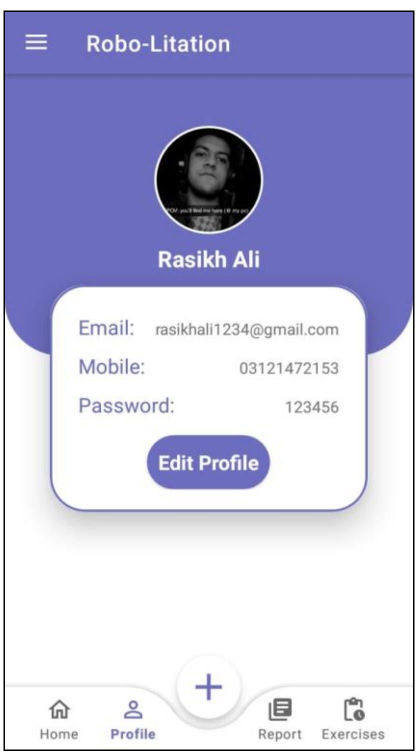
A.2. Robo-Litation App (Patient)

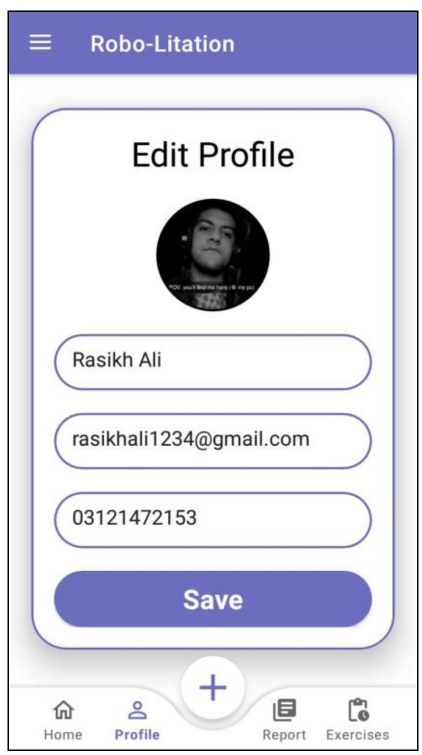
A.2.1. Dashboard



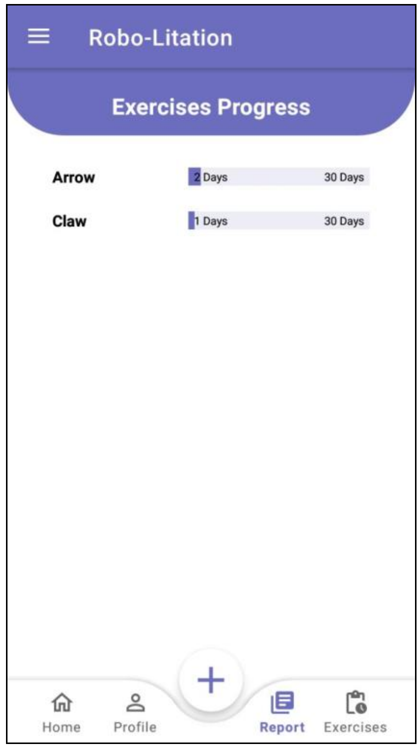


A.2.2. Profile

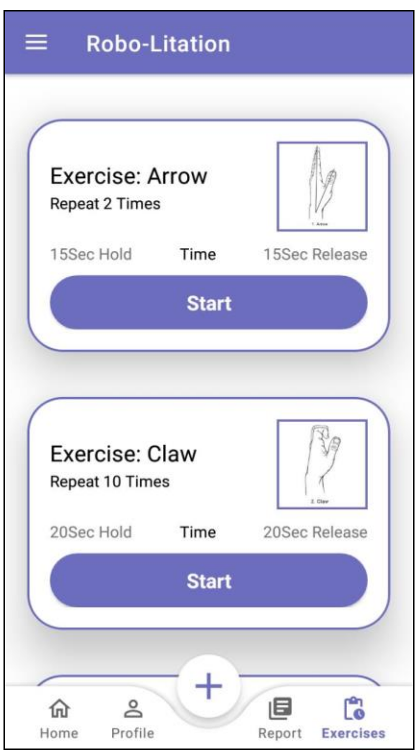


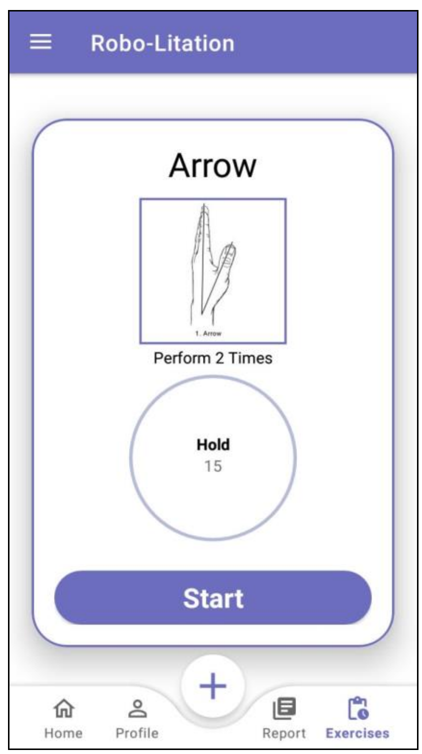


A.2.3. Report

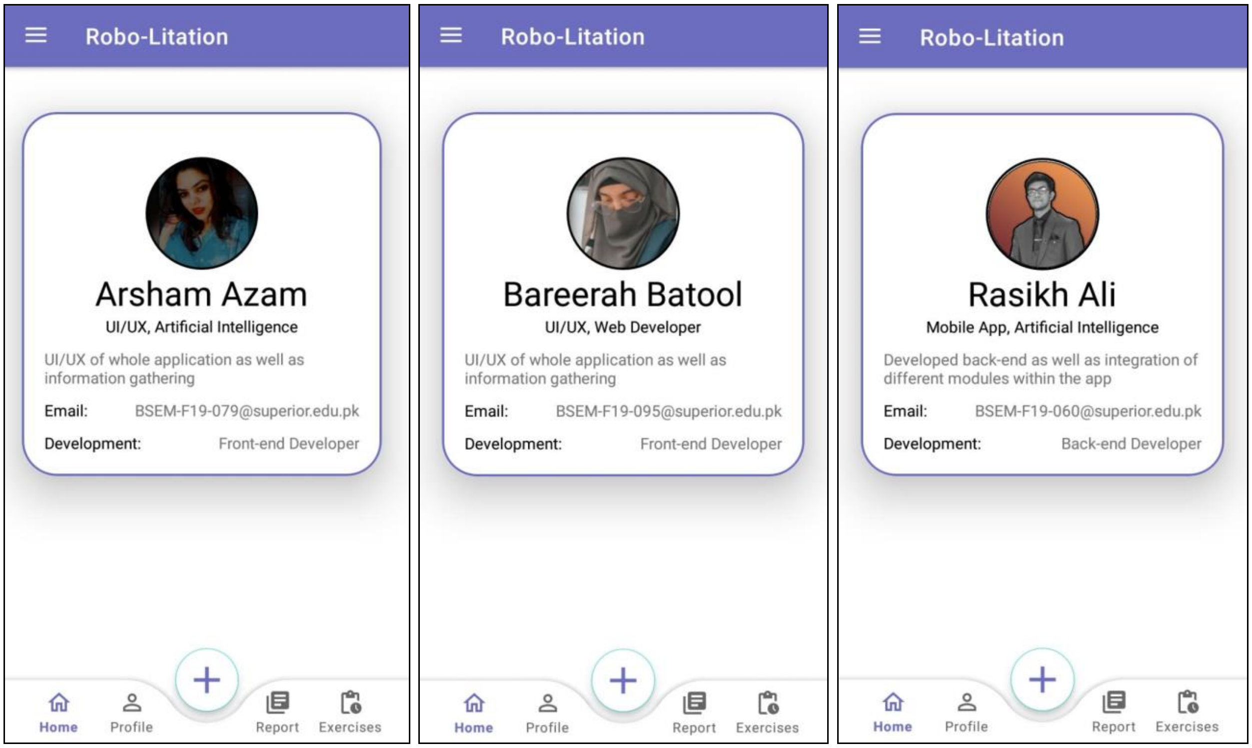


A.2.4. Exercises





A.2.5. About Us


Robo-Litation
Arsham Azam
UI/UX, Artificial Intelligence
UI/UX of whole application as well as information gathering
Email: BSEM-F19-079@superior.edu.pk
Development: Front-end Developer
Home
Profile
Report
Exercises
Robo-Litation
Bareerah Batool
UI/UX, Web Developer
UI/UX of whole application as well as information gathering
Email: BSEM-F19-095@superior.edu.pk
Development: Front-end Developer
Home
Profile
Report
Exercises
Robo-Litation
Rasikh Ali
Mobile App, Artificial Intelligence
Developed back-end as well as integration of different modules within the app
Email: BSEM-F19-060@superior.edu.pk
Development: Back-end Developer
Home
Profile
Report
Exercises

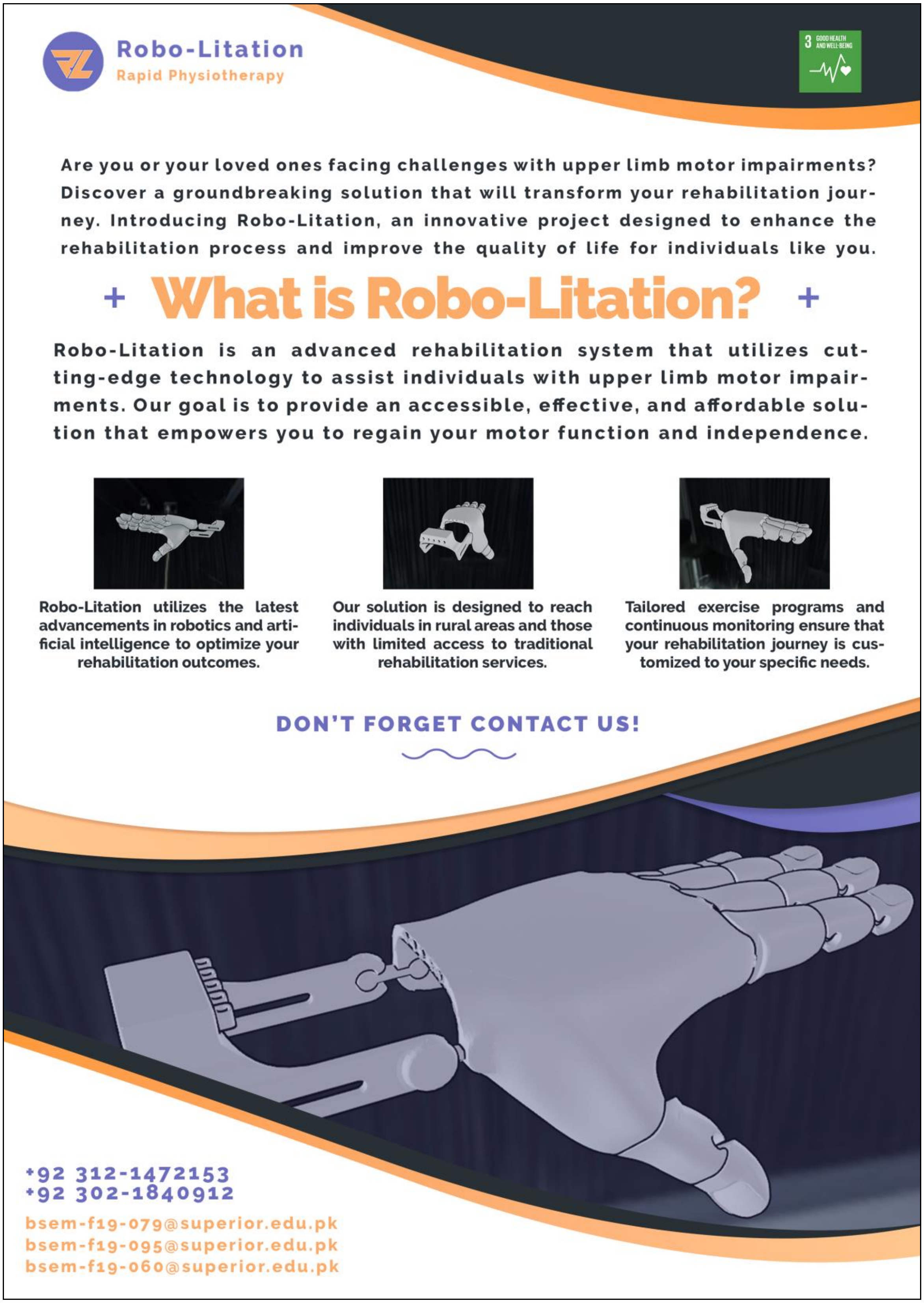
Appendix B: Information / Promotional Material

B.1. Broacher

B.1.1. Broacher Back

B.1.1. Broacher back

B.2. Flyer


Robo-Litation
Rapid Physiotherapy
3 GOOD HEALTH AND WELL-BEING
Are you or your loved ones facing challenges with upper limb motor impairments? Discover a groundbreaking solution that will transform your rehabilitation journey. Introducing Robo-Litation, an innovative project designed to enhance the rehabilitation process and improve the quality of life for individuals like you.
+ What is Robo-Litation? +
Robo-Litation is an advanced rehabilitation system that utilizes cutting-edge technology to assist individuals with upper limb motor impairments. Our goal is to provide an accessible, effective, and affordable solution that empowers you to regain your motor function and independence.
Robo-Litation utilizes the latest advancements in robotics and artificial intelligence to optimize your rehabilitation outcomes.
Our solution is designed to reach individuals in rural areas and those with limited access to traditional rehabilitation services.
Tailored exercise programs and continuous monitoring ensure that your rehabilitation journey is customized to your specific needs.
DON'T FORGET CONTACT US!
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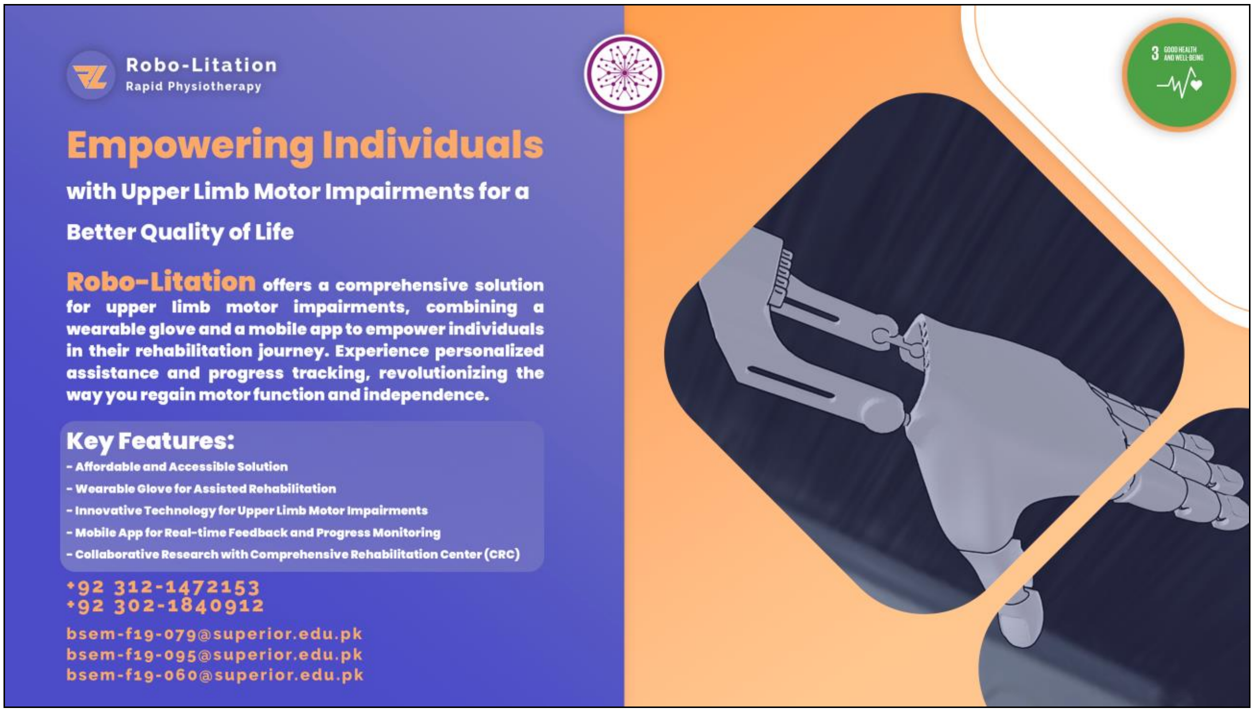
bsem-f19-079@superior.edu.pk
bsem-f19-095@superior.edu.pk
bsem-f19-060@superior.edu.pk

B.3. Standee


FALCONICTECH
Let's Talk About Idea
Robo-Litation
Rapid Physiotherapy
Solution To Provide Best Physiotherapy For Stroke Patients.
BSSE-FYP-FALL22-030
Our Team
Arsham Azam
Bareerah Batool
Rasikh Ali
Mr. Muhammad Ahmad
Dr. Tehreem Masood
Dr. Arfan Jaffar
Why Need
- Frequent clinic visits
- Cost-effective alternative
- Perform exercises at home
- Access in rural areas
- Access in disaster affected areas
- Limited to traditional rehabilitation
- Long-lasting sessions in physiotherapy
- Personalize exercises for individual needs
- Remote monitoring and feedback for patients
- Accessible solution for everyone
Our Solution
Solution
- Wearable Glove Technology
- Mobile App Integration
- Convenience and Accessibility
- Remote Monitoring
- Personalized Rehabilitation
Tools
- Python
- Java / Flutter
- Raspberry Pi 4
- Servo Motors
- Nylon Strings
- Sensors
- Optical
- EMG
- Force
Challenges
- Limited accessibility
- Limited Remote Support
- Time and cost constraints
- Lack of personalized feedback
- Limited mobility and convenience
Superior University
Gold Campus
Faculty of CS & IT
Software Engineering Department

B.4. Banner


Robo-Litation
Rapid Physiotherapy
Empowering Individuals
with Upper Limb Motor Impairments for a Better Quality of Life
Robo-Litation offers a comprehensive solution for upper limb motor impairments, combining a wearable glove and a mobile app to empower individuals in their rehabilitation journey. Experience personalized assistance and progress tracking, revolutionizing the way you regain motor function and independence.
Key Features:
- Affordable and Accessible Solution
- Wearable Glove for Assisted Rehabilitation
- Innovative Technology for Upper Limb Motor Impairments
- Mobile App for Real-time Feedback and Progress Monitoring
- Collaborative Research with Comprehensive Rehabilitation Center (CRC)
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bsem-f19-060@superior.edu.pk
3 GOOD HEALTH AND WELL-BEING

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