“ Interactive Physiotherapy using Kinect 2.0 ”

Bachelor of Engineering
in
Computer Engineering

Submitted by

Mr. Animesh Barmukh	**15CE7008**
Mr. Akshay Pakhle	**15CE7047**
Mr. Ashvin Khairnar	**15CE7013**
Mr. Mohammed Waqar Ali	**16CE5502**

Guided by

Ms. Namita Pulgam

Department of Computer Engineering

Ramrao Adik Institute Of Technology

Dr. D. Y. Patil Vidyanagar, Sector-7, Nerul, Navi Mumbai-400706.

(Affiliated to University of Mumbai)

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Interactive Physiotherapy using Kinect 2.0

B.E. Project Report

Submitted in partial fulfillment of the requirements

For the degree of

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D Y PATIL
RAMRAO ADIK
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NAVI MUMBAI

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CERTIFICATE

This is to certify that, the dissertation titled

“ Interactive Physiotherapy using Kinect 2.0 ”

is a bonafide work done by

Mr. Animesh Barmukh	**15CE7008**
Mr. Akshay Pakhle	**15CE7047**
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and is submitted in the partial fulfillment of the requirement for the degree of

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to the
University of Mumbai

Supervisor

(Ms. Namita Pulgam)

Project Co-ordinator	Head of Department	Principal
(Ms. Smita Bharne)	**(Dr. Leena Ragha)**	**(Dr. Ramesh Vasappanavara)**

Project Report Approval for B.E

This is to certify that the project 'B' entitled ***"Interactive Physiotherapy using Kinect 2.0"*** is a bonafide work done by ***Mr. Animesh Barmukh***, ***Mr. Akshay Pakhle***, ***Mr. Ashvin Khairnar*** and ***Mr. Mohammed Waqar Ali*** under the supervision of ***Ms. Namita Pulgam***. This dissertation has been approved for the award of ***Bachelor's Degree in Computer Engineering, University of Mumbai***.

Examiners :

1. . . . .

2. . . . .

Supervisors :

1. . . . .

2. . . . .

Principal :

. . . .

Date : . . . /. . . /. . . . . .

Place : . . . .

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Mr. Animesh Barmukh	**15CE7008**	____________________
Mr. Akshay Pakhle	**15CE7047**	____________________
Mr. Ashvin Khairnar	**15CE7013**	____________________
Mr. Mohammed Waqar Ali	**16CE5502**	____________________

Date : .../.../......

Abstract

Physical therapy has become a big part of life for patients suffering from orthopedic injuries. But as time goes by, patients tend to get tired and demotivated due to repetitive and tedious exercises. So, an interactive motion detection system with the help of Kinect can be a boon to this problem. The use of interactive physiotherapy system makes the treatment more encouraging and entertaining. Unity3D has been used for designing the interactive environment and games because it is easy from Unity to deploy applications on different platforms. It is much easier to measure the readings and values from the sensor than using manual tools like goniometer. It also allows a therapist to customize exercises according to the specific needs and challenges of individual patients. The Microsoft Kinect sensor gives three-dimensional information about the users body, recognizing skeleton and joint positions. This data in turn can be used to create interactive games that cater to the physiotherapeutic needs of the patients. This enables an immersive and natural interaction between the user and the system. Most importantly, the recorded skeletal joint data facilitates quantitative analysis and feedback of patients body movements.

Contents

List of Figures

Chapter 1

Introduction

1.1 Overview

Rehabilitation and physical therapy are optimal when assessment, monitoring, adherence to the therapy program and patient engagement can be achieved. In traditional physical therapy and rehabilitation practice, different processes are involved [?]. These processes are usually intensive, time consuming, dependent on the expertise of the therapist and implies the collaboration of the patient who is usually asked to perform the therapy multiple times at home with no supervision [?].
Injury or disease of bone, articular, or soft tissue structures of the joints can cause pain and compromised mobility, strength, stability and functional use of the upper or lower body. [?]. Traditional methods of rehabilitation is quite tedious and boring. As exercises are to be done for a long period of time, patients tends to loose interest over time because of monotonous exercises routines. Also, traditional physiotherapy involve use of goniometer which is a very old device used to measure degrees of flexion and extension of joints but it is inaccurate.

The Microsoft Kinect sensor incorporates several advanced sensing hardware. Most notably, it contains a depth sensor, a color camera, and a four-microphone array that provide full-body 3D motion capture, facial recognition, and voice recognition capabilities. A Kinect-based system can facilitate proper performance of rehabilitation exercises, increase patient accountability, allow the clinician to correct errors in exercise performance.

Figure 1.1: Digital Goniometer

Figure 1.1 shows a Digital Goniometer. A goniometer is a device that either measures an angle or moves an object along a fixed point to a specific angular position. Goniometers have many uses and can be found in a number of industries. They measure range of motion, determine direction, and measure an objects dimensions. Goniometers are relatively simple in design and have been used since 1780.

Goniometers are portable and are simple enough to be mass produced in a short amount of time. They are inexpensive and have many different purposes, ranging from those found in the medical industry to applications in physical science.

Goniometers must be carefully labeled with respect to the angles that they measure. Goniometers are limited by the materials that they can be constructed from and must be used in conjunction with a surface medium in order to provide any significant results. Kinect can detect the angles of the elbow and other joints without the need of old and traditional goniometers. The cameras of Kinect are much more accurate than goniometer. Kinect can detect the angles of the elbow and other joints without the need of old and traditional goniometers.

As show in Figure 1.2, Microsoft Kinect 2.0 is a device which can offer innovative and exciting ways to rehabilitate, making treatment more enjoyable thus increasing motivation and therefore adherence. This is an important area for physiotherapists to develop their skills in, as technology is beginning to thrive in the health sector and is becoming a part of therapy treatment options. In addition, it reduces workload by utilizing physiotherapy time effectively while still providing therapy. The Kinect can allow the patient to interact with the system, where they perform multiple movement combinations without the need of an attached device or a controller. [**?**].

Figure 1.2: Microsoft Kinect 2.0

1.2 Objective

- To improve mobility and strength and to help reduce the pain that patients might suffer due to an injury or disability.
- To develop interactive games using Unity3D to perform physiotherapy exercises.
- The system should provide updated information about the progress that will update their respective doctors with accurate results.
- Develop a profile based system to keep track of every individual's activity.

1.3 Motivation

Expected higher number of such cases is a challenge for physiotherapy, and therefore calls for introduction of innovative methods for rehabilitation of patients after orthopedic injuries [**?**]. Consider tennis elbow, it is one of the most common orthopedic injury and a major cause of disability, mostly for sportsmen and athletes. With the development of science and technology neurological patients are faced with new possibilities of regaining psychomotor fitness. It is obvious that any additional form of improving patient's motor functions is no substitute for individual work with a physiotherapist, which is adapted to the individual patient's needs. However, there is a clear need to search for new attractive and modern forms of medical rehabilitation.

1.4 Problem Definition

The traditional approach in medical science for physiotherapy is now been in practice since years and its been very tedious for the instructor and boring for the patient. Problems like effective elbow rehabilitation is dependent on patients performing their exercise programs continuously. Due to the repetitive, tedious and time consuming exercise programs in traditional physiotherapy and outdated tools like goniometer, the patient tends to lose interest and gets tired. To solve this problem, a new concept of motion detection using Kinect can be used for physiotherapy in a way which patient may find interesting and engaging. Hence using this concept, Interactive Physiotherapy System using Microsoft can be developed to offer innovative and exciting ways to rehabilitate, making treatment more enjoyable thus increasing motivation and therefore adherence. This is an important area for physiotherapists to develop their skills in, as technology is beginning to thrive in the health sector and is becoming a part of therapy treatment options. In addition, it reduces workload by utilizing physiotherapy time effectively while still providing therapy.

1.5 Organization of Report

The rest of the report is organized as follows. Chapter 1 discusses objective and problem definition with respect to the existing system. The related work of this research is surveyed in Chapter 2. The proposal and requirements for this research is defined in Chapter 3 followed by the solution. Chapter 4 discusses the Planning and Formulation i.e. the schedule of the proposed work. Design of System is included in Chapter 5. Chapter 6 discusses the results and outcomes of this project. The concluding remarks have been given in Chapter 7. And finally, the future improvement possibilities are discussed in Chapter 8.

Chapter 2

Literature Survey

In clinical settings and experimental studies of muscular disorders, participants emerged in interactive experience reduced level of pain, general distress/unpleasantness and report a desire to use Interactive approaches for medical procedures of these kind. Literature survey includes study of various research papers about Physiotherapy using Kinect. Following research papers were studied based on physiotherapy and similar existing projects were compared and analyzed.

2.1 Research Papers Survey

A.D. Cualin, H.F. Pop, and R.F. Boian [**?**]. This study uses machine learning methods to analyze Kinect body gestures involved in the user interaction with exergaming systems designed for physical rehabilitation. They propose a method to improve gesture recognition accuracy and motion analysis, by extracting from the full body motion data recorded by the Kinect sensor three important features which are relevant to physical therapy exercises: body posture, movement trajectory and range of motion. Thus, this approach has the potential to improve gesture recognition accuracy and provide user feedback on how to improve the movement performed, in particular, the movement amplitude.

Jungpil Shin, (Member, IEEE) et al [**?**]. The paper proposes an aerial keyboard system. As aerial keyboards are very time consuming and difficult to detect, they proposed a system that can use hand tapping gestures for Japanese hiragana and English characters. This will facilitate human machine interaction. In order to detect accurate motions and gestures the system will use Microsoft Kinect sensors. By using this, users can interact with computers using their non-touch input system.

Juraj Mihalov et al [?]. This paper talks about how the new motion sensing controllers bring the gaming to a whole another level and how this technology can be used for scientific purposes and not just for entertainment. A few years ago, the world has experienced the birth of a new approach to the game controlling. Although the classic mouse & keyboard configuration will not be beaten so easily, The purpose of this publication is to bring a general information about Kinect, its history and future as well as its bright and dark sides.

Carlo Camporesi et al [?]. The authors proposed a new solution based on Virtual Reality technologies for improving the delivery of physical therapy and rehabilitation. Three main aspects are addressed: 1)t he ability to allow therapists to create new exercises and therapy programs intuitively by direct demonstration, 2) automatic therapy delivery and monitoring with the use of an autonomous virtual tutor that can monitor and quantitatively assess the motions performed by the patient, and 3) networked collaborative remote therapy sessions via connected applications displaying the motions of both the therapist and the patient.

Grigore Burdea et al [?]. This paper reviews the benefits brought by VR-enhanced and VR-based rehabilitation to the patient groups. Also discussed are the many challenges in integrating this new technology into the medical care system. Virtual rehabilitation represents the provision of therapeutic interventions locally or at a distance, using Virtual Reality hardware and simulations. Such therapy has been applied to various patient populations, including muscular-skeletal and cognitively impaired.

Mateus Trombetta et al [?]. This paper proposes a serious game for post-injury rehabilitation with six different levels of exercises. This solution allows to assist the traditional therapy and motivate the patient to execute his/her rehabilitation program, under health professional supervision. A preliminary study shows good results in user preferences. This approach supports first- and third-person point of views and virtual reality devices, like head-mounted displays and motion sensors.

J. Rosen, J.C. Perry, N. Manning, S. Burns, and B. Hannaford [?]. The aim of the research is to study the kinematics and the dynamics of the human arm during daily activities in a free and unconstrained environment as part of an on-going research involved in the design of a 7 degree of freedom (DOF) powered exoskeleton for the upper limb. The kinematics of the upper limb was acquired with a motion capture system while performing a wide verity of daily activities. Utilizing a model of the human as a 7 DOF system, the equations of motion were used to calculate joint torques given the arm kinematics. During positioning tasks, higher angular velocities were observed in the gross manipulation joints (the shoulder and elbow) as compared to the fine manipulation joints (the wrist).

E. E. Stone and M. Skubic [?]. This paper presents a method for detecting falls in the homes of older adults using the Microsoft Kinect and a two-stage fall detection system. The first stage of the detection system characterizes a person's vertical state in individual depth image frames, and then segments on ground events from the vertical state time series obtained by tracking the person over time. The second stage uses an ensemble of decision trees to compute a confidence that a fall preceded on a ground event. Evaluation was conducted in the actual homes of older adults, using a combined nine years of continuous data collected in 13 apartments. The dataset includes 454 falls, 445 falls performed by trained stunt actors and nine naturally occurring resident falls. The extensive data collection allows for characterization of system performance under real-world conditions to a degree that has not been shown in other studies. Cross validation results are included for standing, sitting, and lying down positions, near (within 4 m) versus far fall locations, and occluded versus not occluded fallers. The method is compared against five state-of-the-art fall detection algorithms and significantly better results are achieved.

J. Han, L. Shao, D. Xu, and J. Shotton [?]. This paper presents a comprehensive review of recent Kinect-based computer vision algorithms and applications. The reviewed approaches are classified according to the type of vision problems that can be addressed or enhanced by means of the Kinect sensor. The covered topics include preprocessing, object tracking and recognition, human activity analysis, hand gesture analysis, and indoor 3-D mapping. For each category of methods, their main algorithmic contributions hass been outlined and their advantages/differences compared to their RGB counterparts is summarized. Finally, overview of the challenges in this field and future research trends has been given. This paper is expected to serve as a tutorial and source of references for Kinect-based computer vision researchers.

B. Lange, C.-Y. Chang, E. Suma, B. Newman, A. S. Rizzo, and M. Bolas [?]. This paper talks about developing applications that leverage recent advances in commercial video game technology to provide full-body control of animated virtual characters. A key component of this approach is the use of newly available low cost depth sensing camera technology that provides markerless full-body tracking on a conventional PC. The aim of this research was to develop and assess an interactive game-based rehabilitation tool for balance training of adults with neurological injury. As motion tracking controllers such as the Nintendo Wiimote are not sensitive enough to accurately measure performance in all components of balance. Additionally, users can figure out how to ”cheat” inaccurate trackers by performing minimal movement (e.g. wrist twisting a Wiimote instead of a full arm swing). Physical rehabilitation requires accurate and appropriate tracking and feedback of performance.

2.2 Outcome of Literature Survey

After performing the literature survey, what has been understood is that the the exisiting system is usually intensive, time consuming and uninteresting. As exercises are to be done for a long period of time, patients tends to loose interest over time because of monotonous exercises routines. Also, traditional physiotherapy involve use of goniometer which is a very old device used to measure degrees of flexion and extension of joints but it is inaccurate. In the rehabilitation program for an affected/restricted joint, one of the main goals is to help the patient achieve a normal standard range of motion (ROM) for a functional limb and also to strengthen their muscles. This is achieved using physical therapy exercises but process requires dedication so that patient can stick to the dail exercise schedule.

This problem can be solved using Microsoft Kinect. It is a motion sensing device which can been utilized to allow interactive rehabilitation differing from conventional therapy in its ability to provide more innovative and exciting ways to rehabilitate. The use of interactive physiotherapy system makes the treatment more encouraging and entertaining. The sensor gives 3D information about the users body, recognizing skeleton and joint positions. This data in turn can be used to create interactive games that cater to the physiotherapeutic needs of the patients. This enables an immersive and natural interaction between the user and the system. Kinect can detect the angles of the elbow and other joints without the need of old and traditional goniometers. The cameras of Kinect are much more accurate than goniometer. Kinect sensor has three important features which are relevant to physical therapy exercises: body posture, movement trajectory and range of motion. Thus, this approach has the potential to improve gesture recognition accuracy and provide user feedback on how to improve the movement performed.

The most comprehensive Kinect training system Doctor Kinetic has exercises for almost entire body parts. It can improve patients ROM, strength, coordination, ADL abilities and cognition.

Chapter 3

Project Proposal

3.1 Proposed Work

What is mainly targeted in this project is elbow rehabilitation using Kinect 2.0 and Unity. Therapy programs can be performed in an interactive environment performing various exercises which will monitor and log patient execution. Monitoring and progress tracking improves patient understanding, motivation and helps in engaging more in these activities. As shown in Figure 3.1, this is the normal range of movement of a normal healthy elbow. As opposed to this, an injured elbow has restricted movement which can sweep angles within a specified range only.

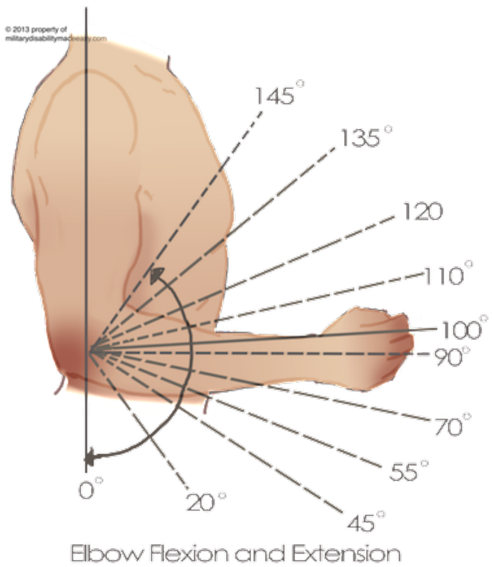


Figure 3.1: Angles that can be Sweeped by a Normal Elbow

The image in Figure 3.2 shows wrist flexion and extension. When wrist is bent downwards, it is known as flexion. And when it is extended upwards, it is called extension or hyperextension. These are the two fundamental movements of any healthy joint.

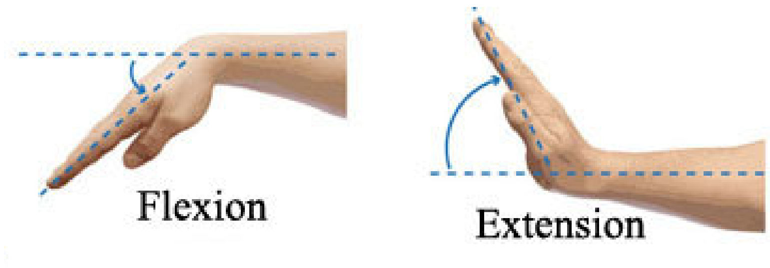


Figure 3.2: Normal movements of a Healthy Wrist

Figure 3.3 shows a blueprint of how the entire setup would look like when the patient is interacting with the system and performing physiotherapeutic exercises.

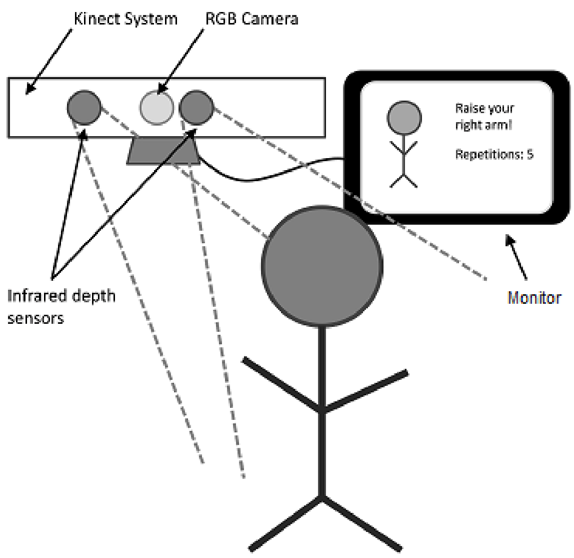


Figure 3.3: Schematic overview of the intended setup

3.2 Hardware/Software Requirement

Hardware Requirements:

- Microsoft Kinect 2.0
- Computer
  - Processor: Minimum Intel / AMD Dual Core
  - RAM: Minimum 4GB
  - Hard Disk: Minimum 15GB Free
  - Graphics: Minimum Integrated Graphics Card
- Internet Connection

Software Requirements:

- Unity 3D
- C#
- Microsoft Visual Studio 2017
- Microsoft Windows 7/8/10
- PostgreSQL
- ReactJS
- NodeJS
- Web Browser

3.3 Proposed Methodology/Techniques

The patient will perform different sets of therapy exercises in form of interactive games. Movements of which will be captured by the Kinect Sensor and according to that the score will be set. This score will be monitored by doctor to see the patients progress and also to prescribe new level of exercises. The overall data of patient and be used for future recovery reports and profile analysis.

The following methodology has been proposed for implementing the proposed modules:

- **Web Module**
  The web module will have a registration form which consists of three parts: Admin's module, Patient's module and Doctor's module.

  - The Admin's module will be used to monitor the doctor's and the patient's activities, record values and generate reports.
  - The Doctor's module will be used to retrieve patient's information, track their improvements and suggest appropriate exercises for them. Also, the doctors can view patient's game data in the form of interactive charts & graphs so that it is easy for the doctor to track patient's improvement.
  - The Patient will use their module to create their profile, update their information and view the assigned doctors and exercises. He will also be able to view the interactive charts so that he can se his progress too. All database manipulations will be done using PostgreSQL.

- **Game Module**
  Physiotherapy exercise based interactive games will be developed on Unity 3D. Unity is a game development tool with a set of resources for rapid development of interactive 3D or 2D applications using C#. In the initial version of system, two types of games will be displayed: one for elbow rehabilitation and one for wrist rehabilitation. The patient can choose the one which he has been assigned by the doctor, then play the game for the allotted time, and exit the game. After this, the scores will be available in the doctor's section with date and time. The recent scores will be updated in the chart also.

This methodology of taking the measurements and data from the Kinect instead of traditional goniometer is better than the preivous one as it reduces the inaccuracies that used to occur in the traditional methods.

Figure 3.4 shows the skeletal points tracked and monitored through the joint functions provided in the Kinect code library. Kinect can track more than 20 skeletal points of human body.

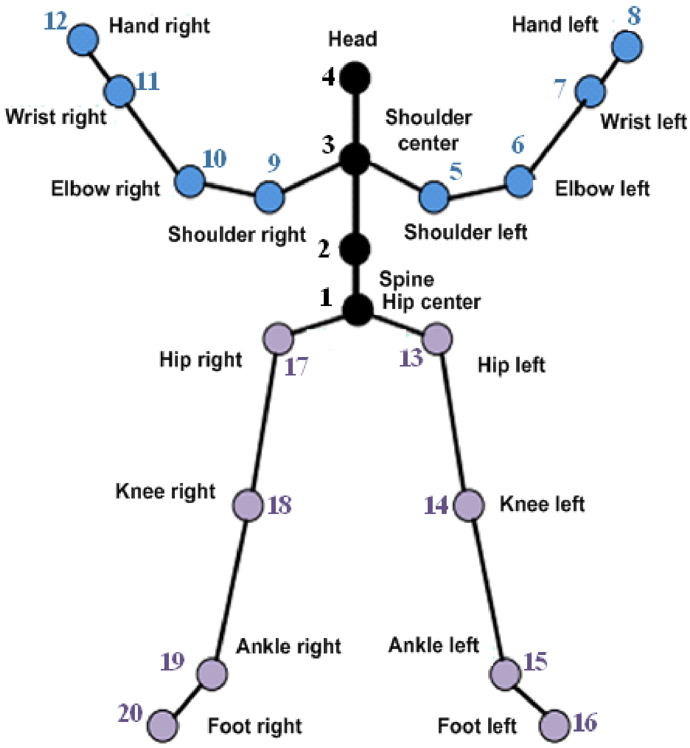


Figure 3.4: Skeletal joints tracked by Kinect 2.0

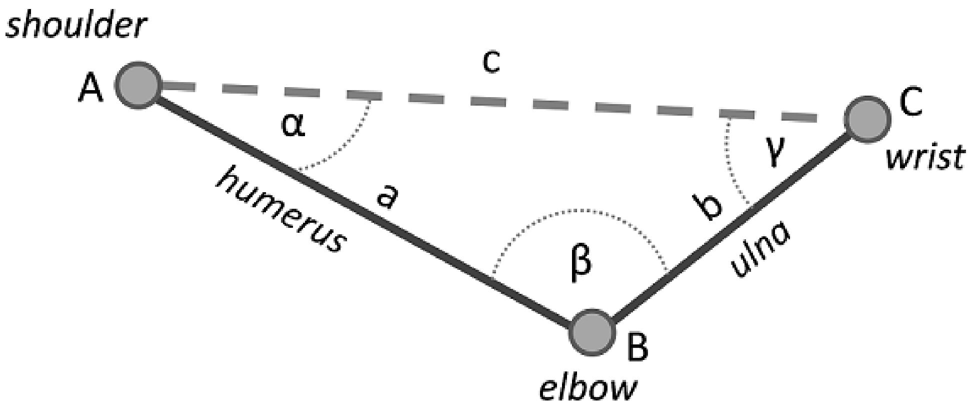


Figure 3.5: Calculating the Elbow Angle

For example, in this methodology the distance between the elbow joint and wrist joint is calculated with Kinect using the formula:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

From the perspective of geometry, it looks something like:

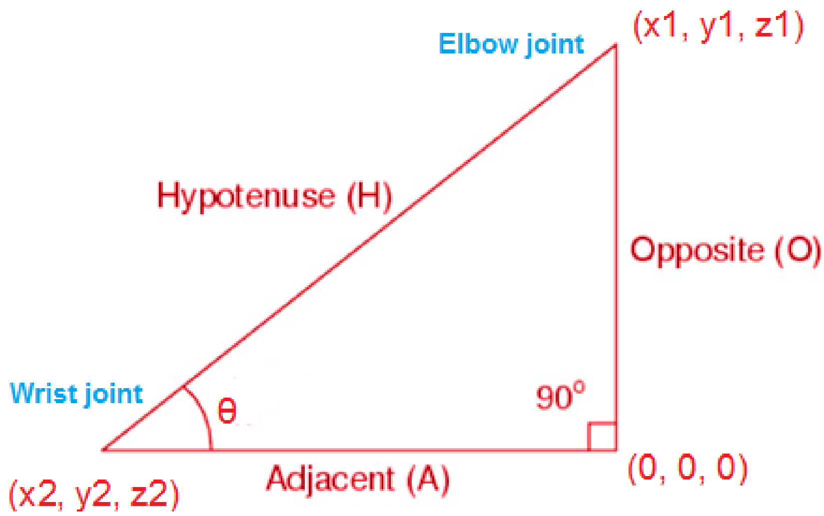


Figure 3.6: Geometrical representation of Elbow

Chapter 4

Planning And Formulation

4.1 Schedule for Project

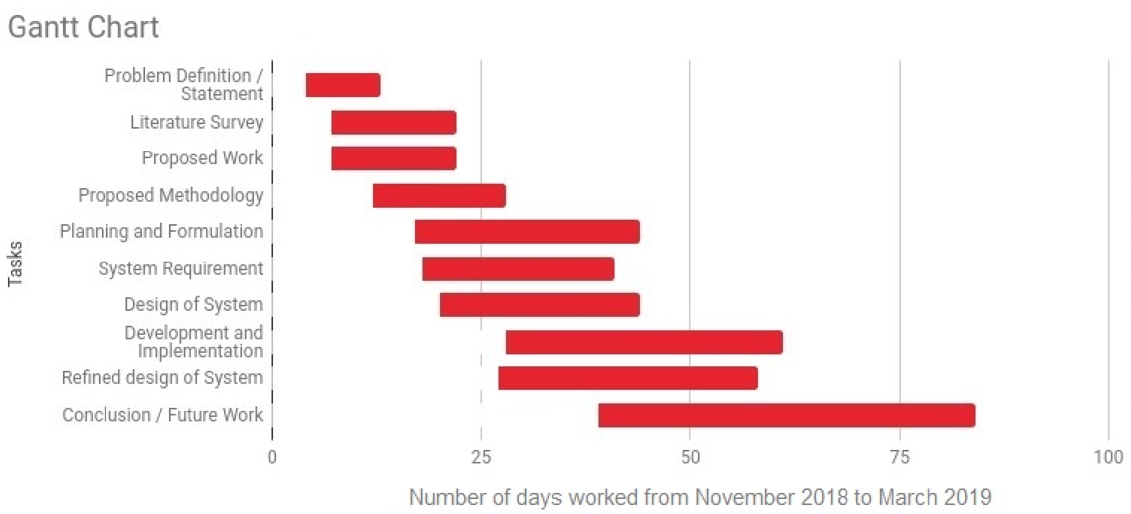


Figure 4.1: Project Schedule (Gantt Chart)

4.2 Detail Plan of Execution

1. Problem Definition: Carefully determining the problem and a few drawbacks that can be improved upon. Then a detailed problem statement must be formulated within the First 4 weeks of the timeline.

2. Literature Survey: Multiple research papers and online content must be perused through

to gain knowledge of that specific domain of the already formulated problem statement and to gain an insight on how to approach for a solution to the problem statement. Approximately 8-15 research papers must be referred before proceeding to the next step.This step can take about 8-12 weeks to complete.

3. Proposed Methodology: Based on the literature survey, a solution in the form of a proposition must be addressed for the problem statement. In this case, the planning and design, interfacing and architecture of the system must be sketched and finalized. In this case, it refers to the designing of games, layout of web module, their interaction, etc. This step must take a maximum of 8 weeks.

4. Implementation: This step requires the finalization of the technologies to be used, their dependencies checked and a proper module-based plan in place to proceed. After these, the actual implementation in the form of coding, graphical designing and interfacing modules can be prepared and integrated. In this case, it refers to the development of Games and the Web Module. This step may take about 16 weeks to complete.

5.Testing : After the implementation, the software must be tested using multiple test cases, depending upon the problem statement. In our case, it would be different kinds of patients with different physical characteristics and the output to be tested would be their overall improvement and response to the system.

Chapter 5

Design of System

5.1 Diagram and Explanation

This section involves all the UML diagram related to the system. It gives a complete diagrammatic overview of the physiotherapy system and how actual data flows in the system. It also explains the role of every entity in the proposed system.

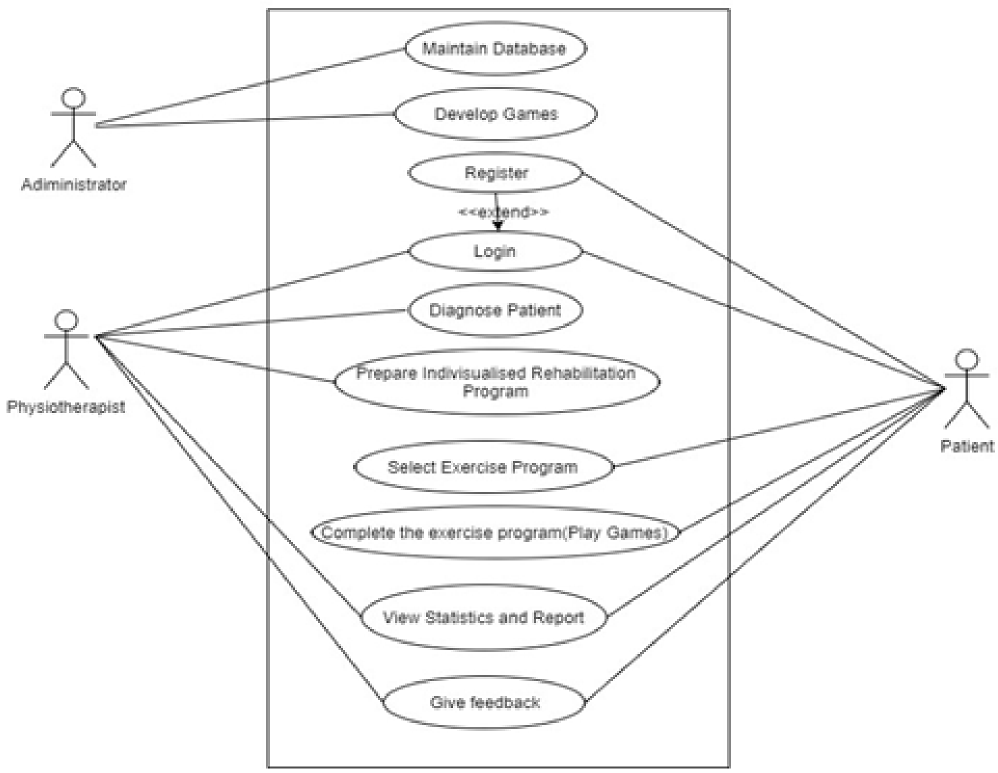


Figure 5.1: Use Case Diagram

Figure 5.1 illustrates the use case diagram of the system. The administrator is responsible for maintaining the whole system and the database. The Physiotherapist has to first login to the system. After diagnosing the patient, the Physiotherapist will prepare individualized rehabilitation program for the patient. The patient will select the exercise program and will play the assigned games. After completion of the exercise program, patient as well as physiotherapist can view the reports and can give the feedback.

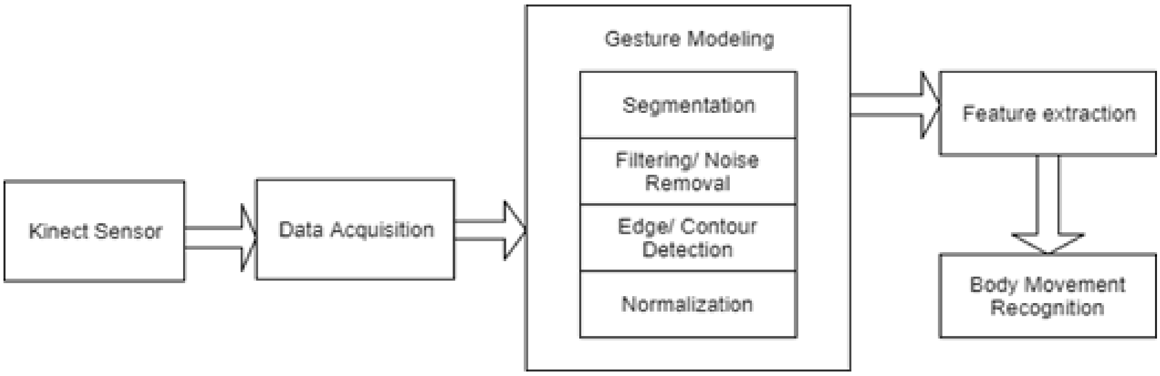


Figure 5.2: Generalized System Architecture for Gesture Recognition [**?**]

Figure 5.2 illustrates the system architecture for gesture recognition. Gesture recognition system has been divided into five different phases. They are data acquisition, segmentation and pre-processing, feature extraction and finally the recognition. Data acquisition involves capturing the image using Microsoft Kinect. The image needs to be segmented in order to remove the unwanted background details.

The third phase of this process is the image processing which is further subdivided into a number of steps which include noise removal, edge detection, contour detection, and normalization of the image to add the accuracy of the detection. The features are then extracted from the segmented and pre-processed image for recognition. Finally, the image is recognized as a meaningful gesture based on the gesture analysis. [**?**]

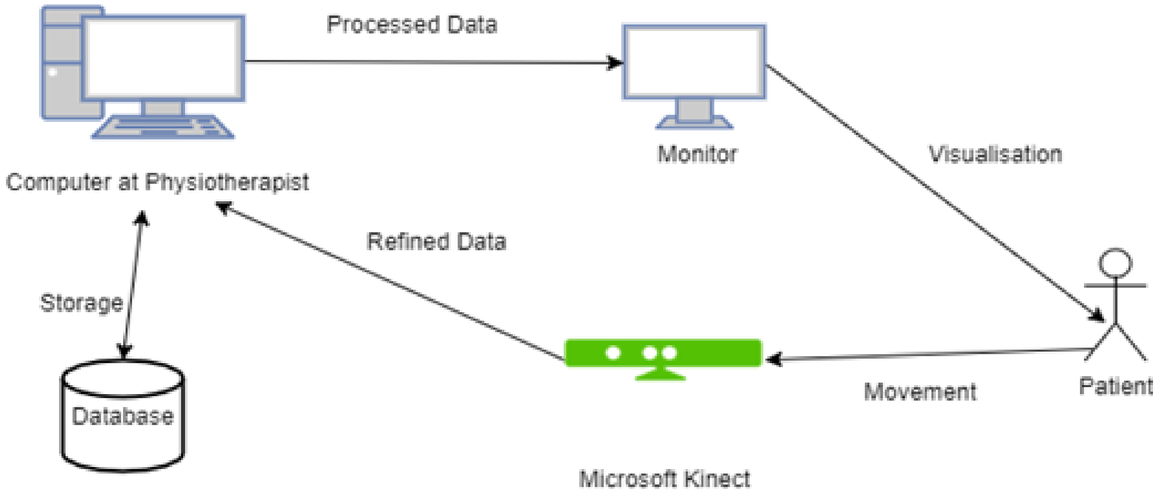


Figure 5.3: System Flow Diagram

In Figure 5.3, the System Flow Diagram is explained. The physiotherapist will prepare rehabilitation program for the patient and the processed data will be transferred and displayed at the monitor screen. The patients body movements will be captured by the Microsoft Kinect sensor. The Microsoft Kinect sensor will forward the refined data to the computer. The reports will then be generated and will be stored in the database for further monitoring.

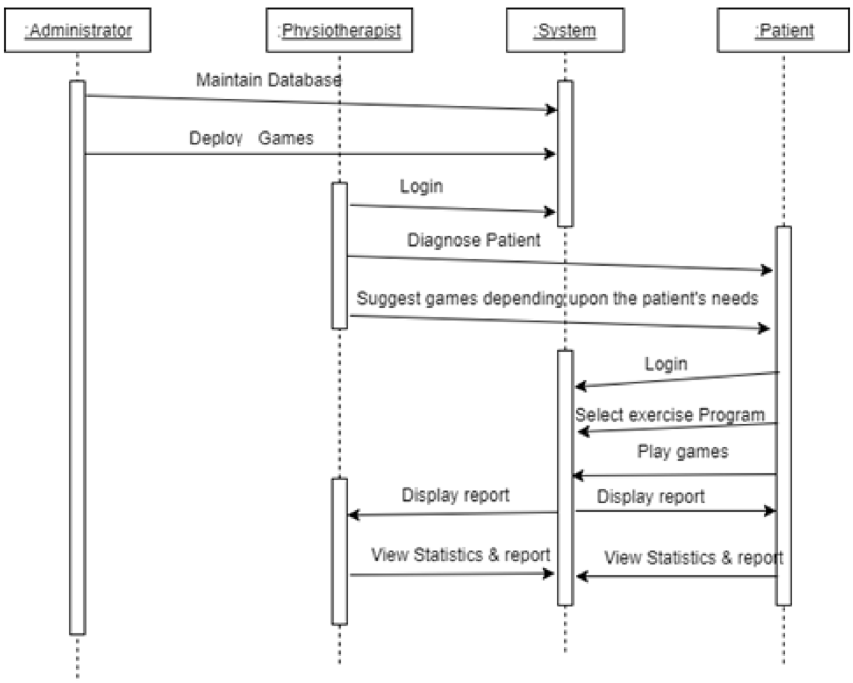


Figure 5.4: Sequence Diagram

Figure 5.4 illustrates the sequence diagram of the system. The administrator is responsible for maintaining and monitoring the whole system. The physiotherapist first logs in to the system and depending on the patients needs suggests games. The patient logs in to the system and then plays games. Depending on the performance of the patient, the system generates reports which can be viewed by patient as well as doctor.

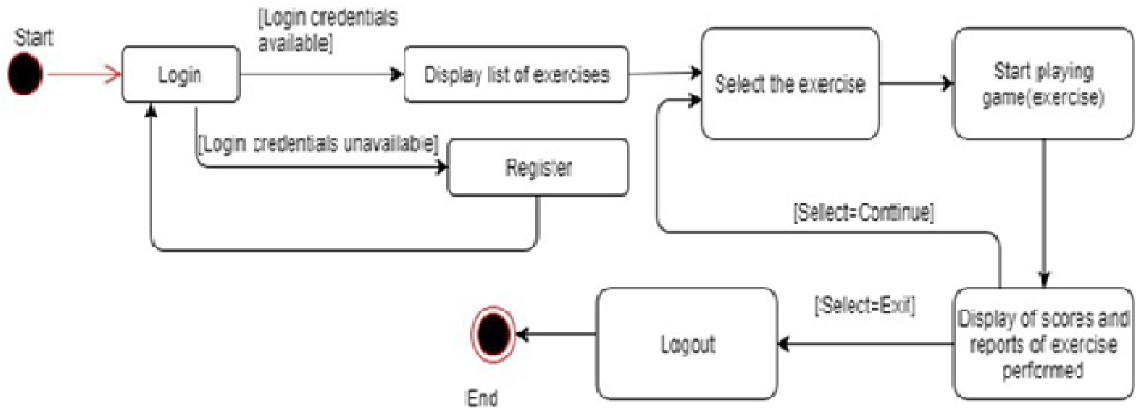


Figure 5.5: State Transition Diagram

Figure 5.5 illustrates the state transition diagram of the system. The patient has to first login to the system and after logging in the patient can start with the physiotherapy exercise game. After completion of the game, the report of the patient is displayed.

Chapter 6

Results And Discussion

6.1 Implementation

Game Module:

Figure 6.1: Home Screen of the Game

Figure 6.1 shows the initial startup screen that is shown when the patient starts the game. From here, patient can choose from the Elbow and Wrist Rehab games, or he can quit.

Figure 6.2: Game Login Page

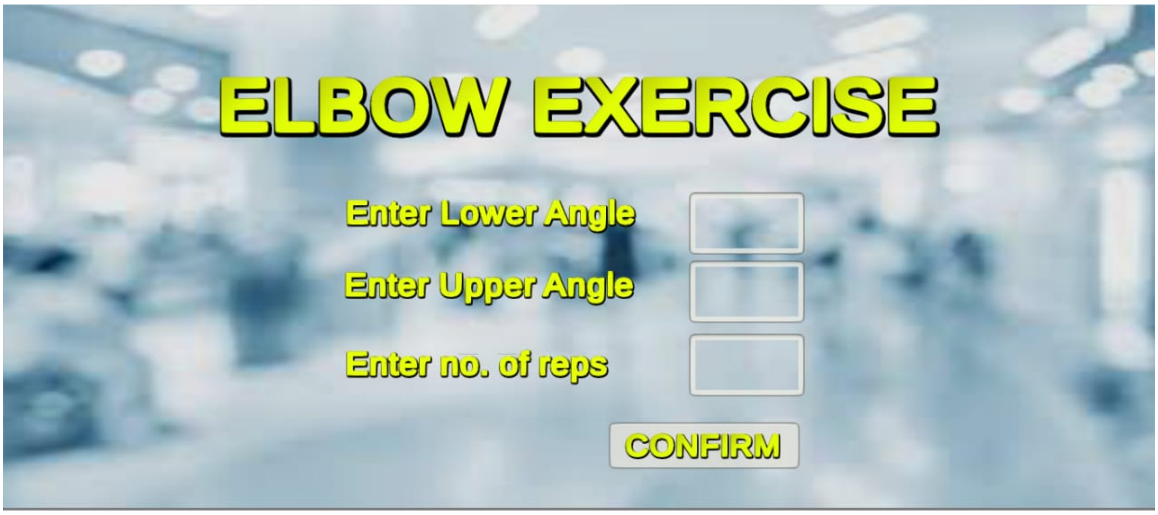


Figure 6.3: Elbow Rehabilitation Game

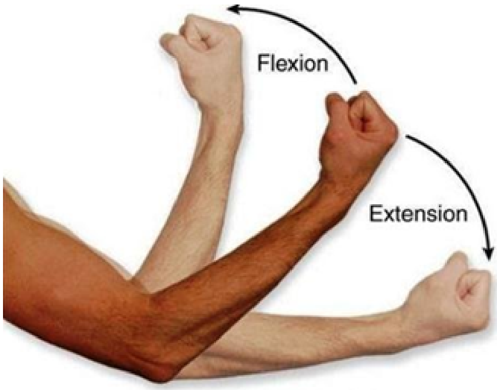


Figure 6.4: Elbow Movements

Figure 6.4 shows the types of elbow movements which patient has to perform properly to play the game. Generally, these movements are restricted due to patient's injury or fracture. This game aims to treat the injury.

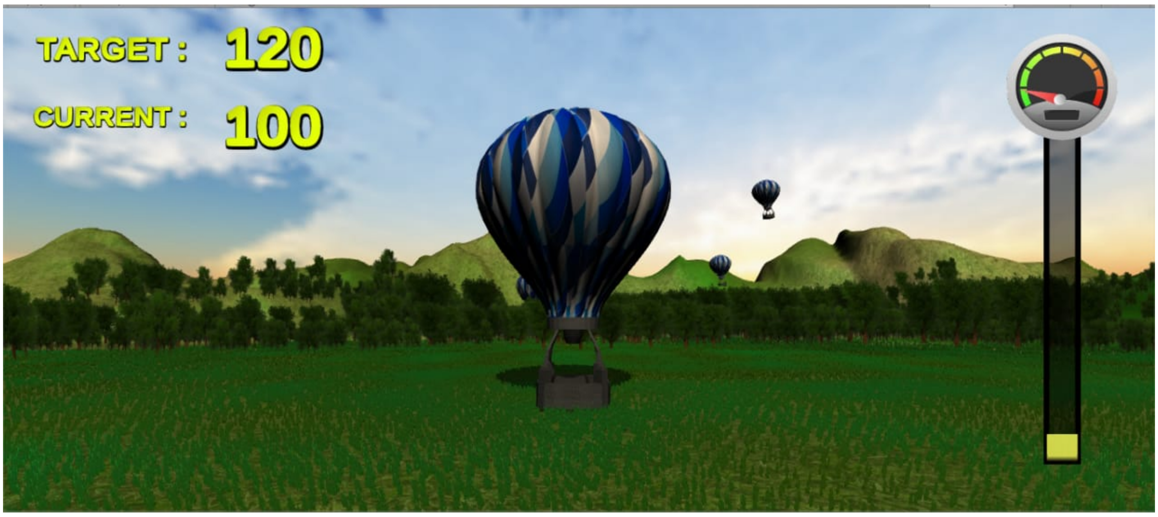


Figure 6.5: Elbow Rehabilitation Game

Figure 6.3 and 6.5 shows the Elbow rehabilitation game where the patient has to flex his elbow so that the ball can jump over the obstacles and then again put his elbow in extension position. The more repetitions the patient makes, the more will be his score and elbow health improvement and recovery

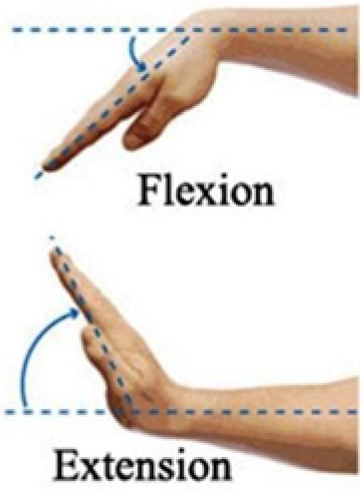


Figure 6.6: Wrist Movements

Figure 6.6 shows the types of wrist movements which patient has to perform properly to play the game. Generally, these movements are restricted due to patient's injury or fracture. This game aims to treat the injury.

Figure 6.7: Wrist Rehabilitation Game

Figure 6.7 shows the Wrist rehabilitation game where the patient has to perform wrist flexions and extensions so that the spider in the game can crawl to the other side to avoid the obstacles.

Web Module:

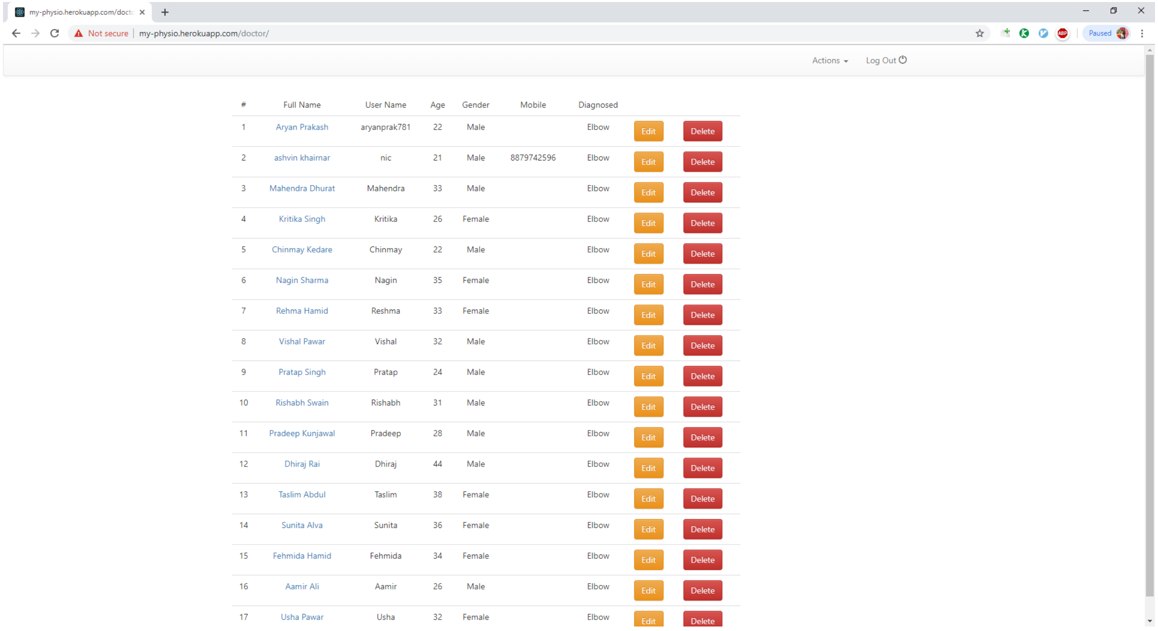


Figure 6.8: List of All Patients

Figure 6.8 shows the Web Portal for the Doctor/Administrator to view the list of all patients. Each name can be clicked upon to view detailed info.

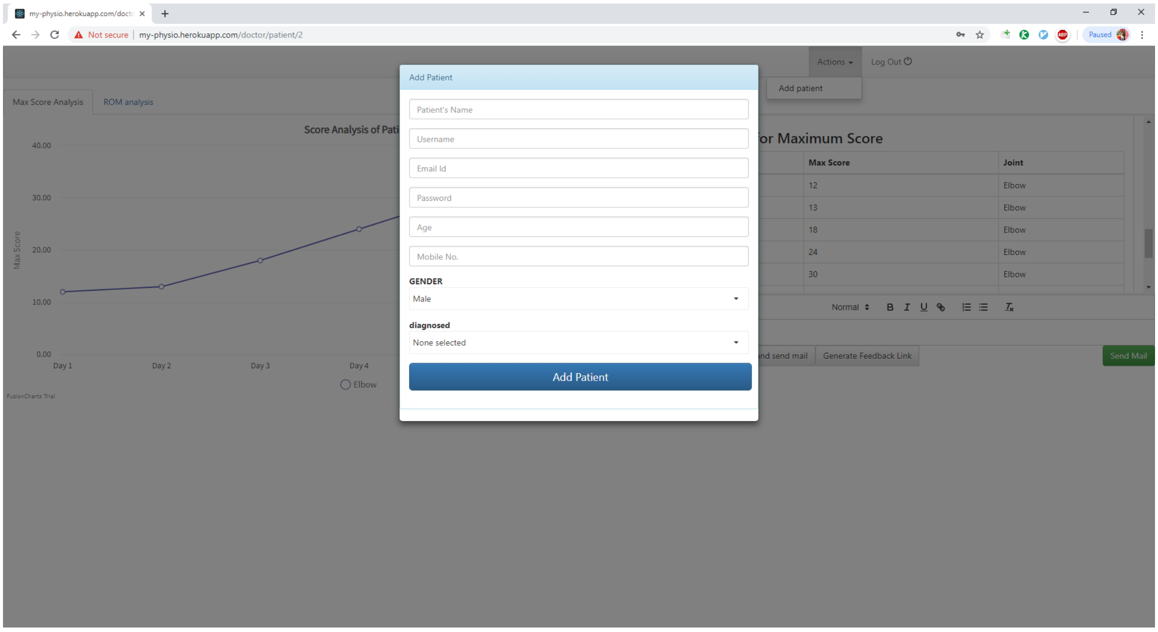


Figure 6.9: Add New Patient Screen

Figure 6.9 shows the modal view of the add patient option for the Doctor/Administrator to add the information of a new incoming patient into the system.

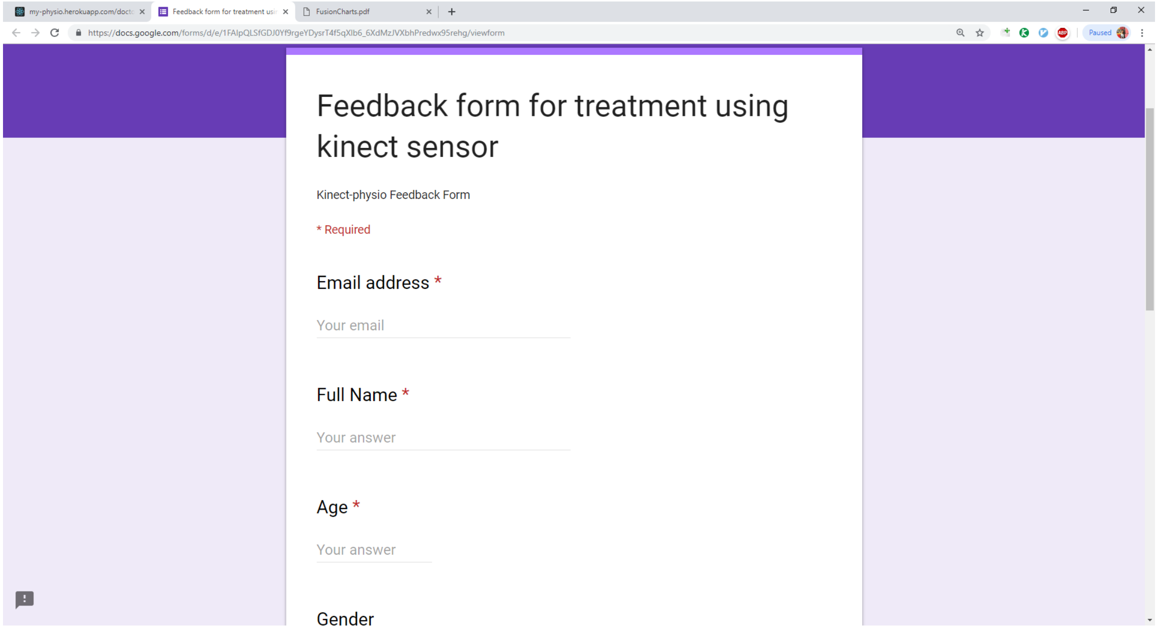


Figure 6.10: Patient's Feedback Page

Figure 6.10 shows the feedback form that is sent via an Email to each patient along with his progress report by the Doctor.

6.2 Project Outcomes

The project outcomes are as follows:

- Combine a computer with a camera-based controller such as the Microsoft Kinect system to create a novel physiotherapy system for convenient and easy use in such conditions.
- Increase patient's interest in rehabilitation due to interactive games.
- Providing instant feedback to the patient. It will be capable of identifying when the patient is carrying out the exercises correctly, warning him/her otherwise and also saving the statistics in a report for a further professional analysis.
- Augment the ability of Range of Motion (ROM) exercises to improve a compromised level of range of flexion and extension movements at the elbow joint as well as wrist joint.

- Individual monitoring for each patient.
- Provides objective rehabilitation measurements.
- Quick and efficient record-keeping.

6.3 Result and Analysis

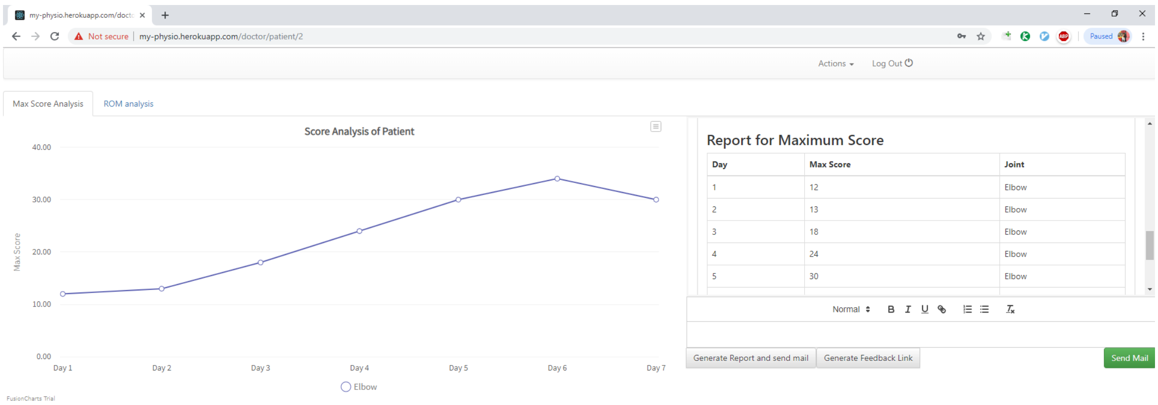


Figure 6.11: Graphical Analysis of Patient's Game Data

Figure 6.11 shows graphical and tabular progress of each patient based on his Game Scores and ROM. It also has a button to generate a pdf of the report and send it as an email to the patient.

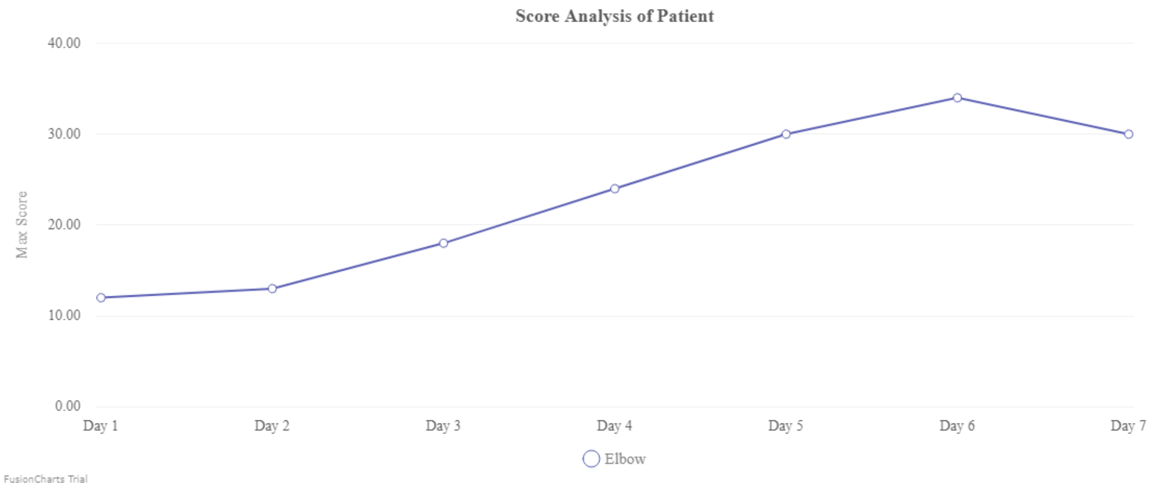
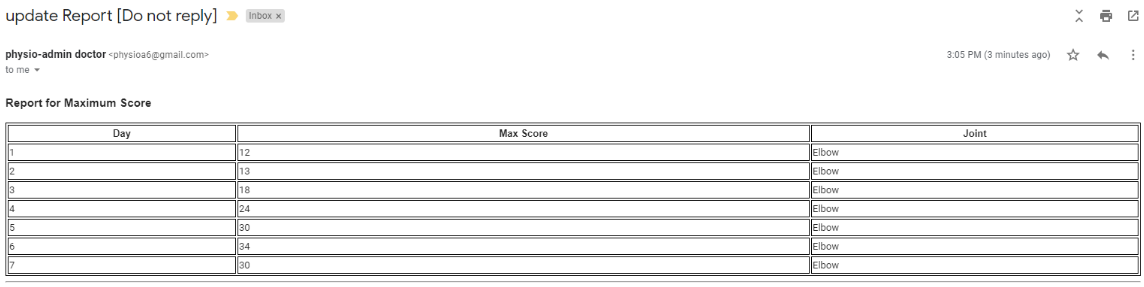


Figure 6.12: Score Analysis of Patient

Figure 6.12 shows the detailed line-graph of the patient's Scores vs No. of Days he has played the game. It can be used to get a quick insight on the improvement of the patient.


update Report [Do not reply] Inbox ×

physio-admin doctor <physioa6@gmail.com>
to me

3:05 PM (3 minutes ago)

Report for Maximum Score

Day	Max Score	Joint
1	12	Elbow
2	13	Elbow
3	18	Elbow
4	24	Elbow
5	30	Elbow
6	34	Elbow
7	30	Elbow

Figure 6.13: Patient's Report sent to his Email

Figure 6.13 shows the view of the tabular report that can be sent as an email to the patient.

6.4 Cost and Benefit Analysis

The Current costing of sensors used by physiotherapist: Rs 8,07,960/-

Cost breakdown of this project:
Unity license cost/month: $150 = Rs 8,200/-
Kinect hardware cost: $145 = Rs 9,999/-
Miscellaneous: Rs 2,000/-

Total expenditure for development: Rs 20,199/-

The above amount is just 2.5% of the current industry expenditure for this job.

Chapter 7

Conclusion and Future Work

In traditional physiotherapy patients tend to get tired and tend to lose interest due to repetitive and tedious exercises. And it also involves use of manual devices like goniometer which is very old and inaccurate. So, an interactive motion detection system including Kinect can be a boon to this problem. Microsoft Kinect is a device which can been utilized to allow interactive rehabilitation differing from conventional therapy in its ability to provide more innovative and exciting ways to rehabilitate. Kinect based games for rehabilitation can increase motivation by offering a rich and distinctive environment for the patient. It can also allow networked sessions for rehabilitation where clinicians will still be able to monitor patient progress. The Kinect is continuing to advance, update and develop into a very feasible option for rehabilitation of joint injuries. So, Kinect has solved this problem in this way. Also, the directions for future work are vast and have promise to enhance elderly care; patient motivation to accurately complete rehabilitation exercises record keeping, and future medical diagnostic and rehabilitation methods. The major impact this product will create for elderly people with installations at old age homes and healthcare centres. Elderly people can have easy access to the most enjoyable and interactive physiotherapy routines at no cost at all. This will affect and change lives of many people.

The system can be extended to cover rehabilitation of all the major body parts and joints. Injuries can be anywhere on the body mostly due to accidents and fractures. So this system can be used to treat those injuries.

- Rehabilitation games for Knee related injuries (like Runner's Knee) can be made as they are very common and thousands of people around the world suffer from them.
- Appropriate games can be developed on our system for treating osteoarthritis of the spine (like Spondylosis).
- A game for Shoulder joint can provide rehabilitation for stroke patients.
- Many other physical injuries that occur in joints and require regular exercise; their treatment can be facilitated properly through this system

Appendices

Appendix A

Weekly Progress Report

Appendix B

Paper Publication

Published research paper titled *Kinect: From Gaming to Measuring to Improvements in Physical Therapy* in 10th International Conference on Intelligent Systems and Communication Networks (IC-ISCN 2019) in Thakur College of Engineering & Technology (TCET), Mumbai under MULTICON-W 2019 (in process).

Appendix C

Project Competition

Participated in *Avishkar* an inter-collegiate district/zonal level research project competition in December, 2018 and cleared the first two rounds.

Acknowledgement

We accept this chance to show our huge gratitude to Department of Computer Engineering of Ramrao Adik Institute of Technology for sanctioning us the project topic ”Interactive Physiotherapy using Kinect 2.0” and for allowing us to use various resources in the institute. We thank our supervisor **Ms. Namita Pulgam** who nourished our mind and has been a tremendous source of encouragement. We received all the essential technical reviews and guidance along the way from her and she has truly been an inspiring source of energy for us.

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Last but not least we would also wish to thank all those who directly or indirectly helped us in the completion of this report.

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Mr. Ashvin Khairnar
Mr. Mohammed Waqar Ali