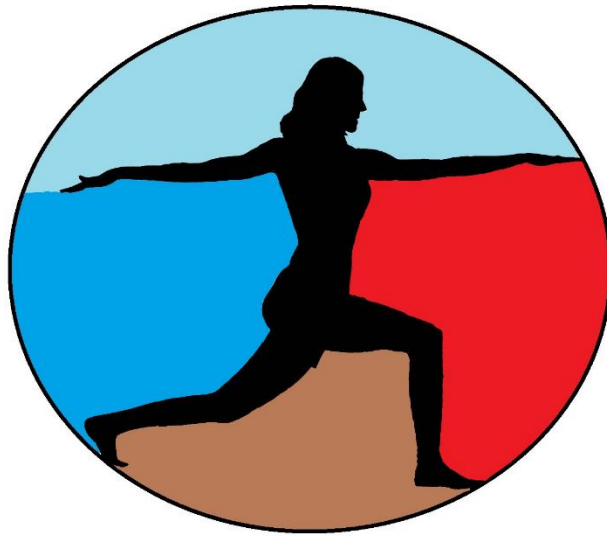


Elemental Kinection



Design

Version 2.1

2 May 2015

Revision History

All revision history listed below.

Version	Change Summary	Date
1.0	<ul style="list-style-type: none">• Initial Draft	3 December 2015
2.0	<ul style="list-style-type: none">• Updated Use Cases• Content changes to bring document more in line with actual product	22 April 2016
2.1	<ul style="list-style-type: none">• Minor formatting	2 May 2016

Revision Sign Off

The following asserts that all team members have read the document and asserts that the information contained within this document is complete and correct.

Name	Signature	Date
Samuel Kent		
Jack Kempner		
Nathan Johnson		
Aakash Tyagi		

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1 Introduction

1.1 Purpose

This document contains the overall design of the Elemental Kinection Kinect application and its accompanying website and database components. This document includes design constraints, system architecture, database design, UML models, UI interface and prototypes.

1.2 Intended Audience

The intended audience of this requirement document includes the development team, the faculty advisor/client of the project and any other interested parties as they arise.

1.3 Scope

The scope of Elemental Kinection is to provide therapists an engaging and insightful exercise application for remote therapy sessions.

1.4 References

[1] <https://dev.windows.com/en-us/kinect/hardware>

[2] <http://mobilehealthnews.com/25281/eight-ways-the-microsoft-kinect-will-change-healthcare/>

[3] <http://mobilehealthnews.com/22351/slideshow-7-startups-using-microsoft-kinect-for-online-physical-therapy/>

[4] Roy, A.K.; Soni, Y.; Dubey, S., "Enhancing Effectiveness of Motor Rehabilitation Using Kinect Motion Sensing Technology," in *Global Humanitarian Technology Conference: South Asia Satellite (GHTC-SAS), 2013 IEEE*, pp.298-304, 23-24 Aug. 2013

1.5 Overview

Section 2 – Design Constraints

Section 3 – System Architecture

Section 4 – Database Design

Section 5 – UML Models

Section 6 – User Interface

Section 7 – Glossary of Terms

Appendix A – Use Cases

2 Design Constraints

2.1 Assumptions and dependencies

- Kinect v2 for Windows
- A Windows 8 or above PC meeting the necessary hardware specifications
- Access to the web
- Therapist must have web access to access database and create sessions

2.2 General Constraints

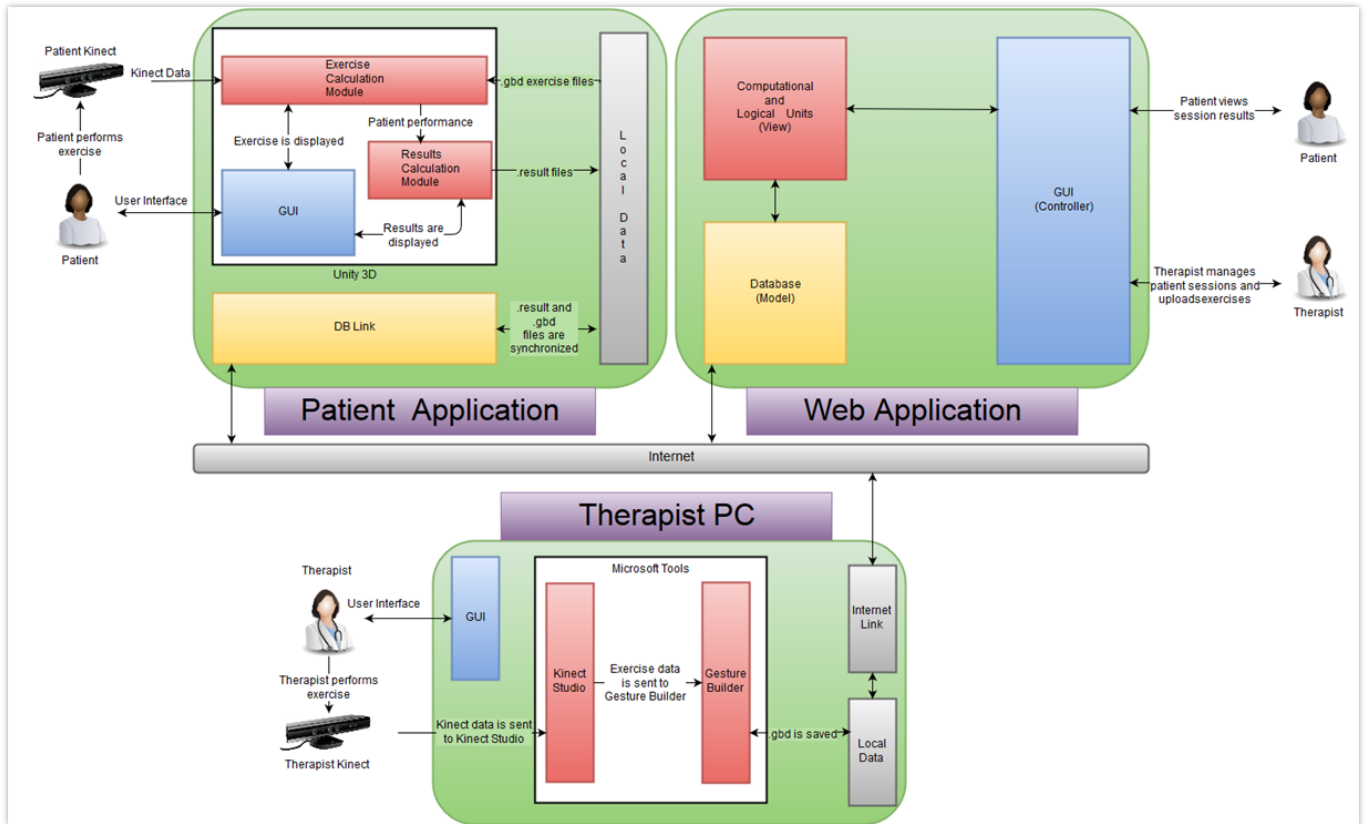
- Functionality Constraints:
 - The Kinect is limited to a capture rate of 30 fps in good lighting and 15 fps in poor lighting
 - Fast movements can be difficult to detect for the Kinect
 - Kinect is limited to measuring the accuracy of an exercise with a general confidence measurement
 - Design of the desktop application must be intuitive and readable for a wide range of ages
 - Exercises are most effective at being tracked by the Kinect when sitting or standing
 - Exercises are most effective at being tracked by the Kinect when the sensor has a higher amount of joints in view at a time
- Environment Constraints:
 - Patient must have a clear space of at least enough distance to fit their body within the view of Kinect. This will vary by body size but will be a range somewhere between 1 meter and 4.5 meters.
 - There must be ample light while the Desktop application is in use. The performance of the Kinect directly decreases with a decrease in light.
- External Constraints:
 - The refinement of design is limited by a deadline of Spring 2015
 - The system requires that there be an initial admin/therapist set up by the team delivering the product

2.3 Development Environment

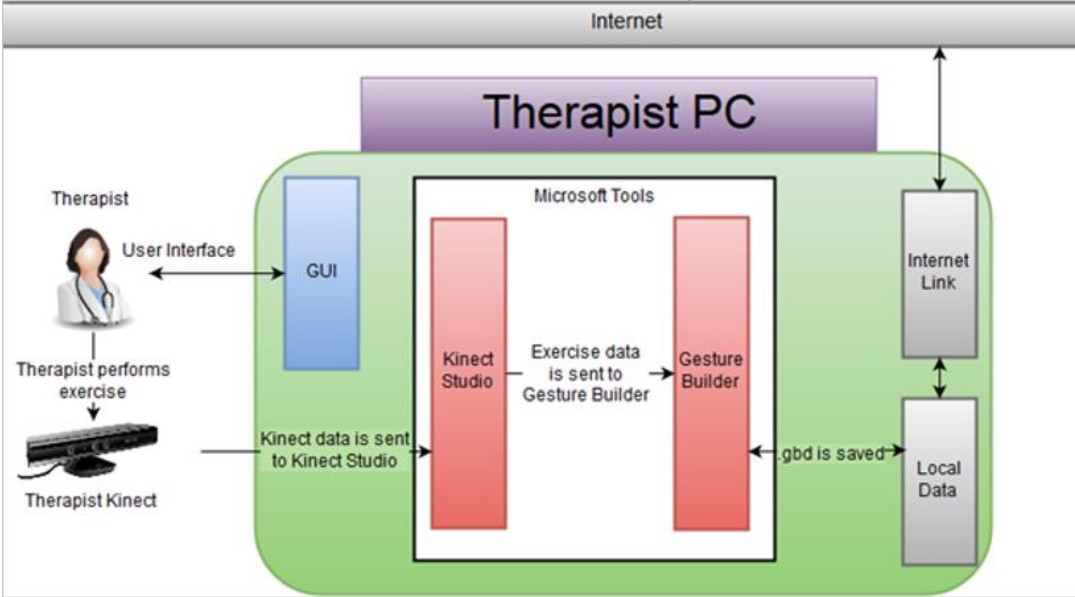
- Programming:
 - Amazon Web Services
 - Django
 - Kinect Studio
 - Kinect v2 SDK
 - Nginx
 - Microsoft Visual Gesture Builder
 - Visual Studio Enterprise 2015
- Support Environment:
 - Bitbucket (Git)
 - CoreFTP Lite
 - Microsoft Office products
 - Moqups
 - Slack Messaging

3 System Architecture

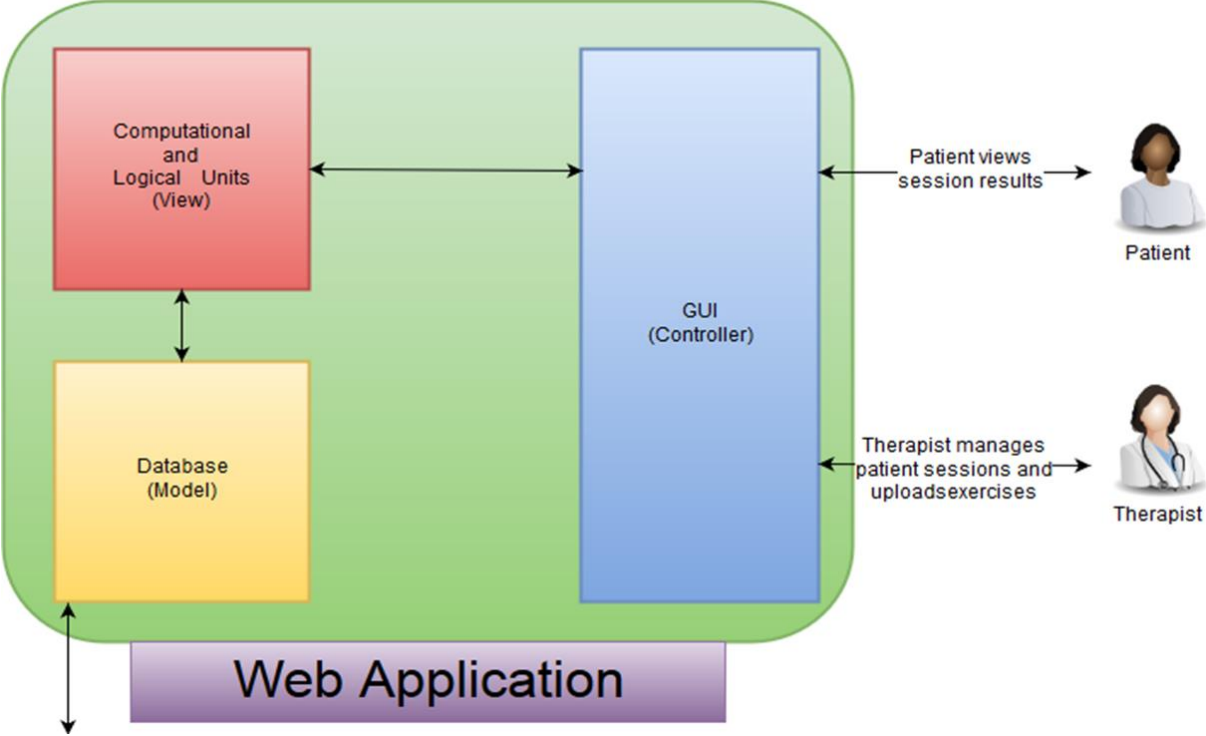
3.1 Complete View



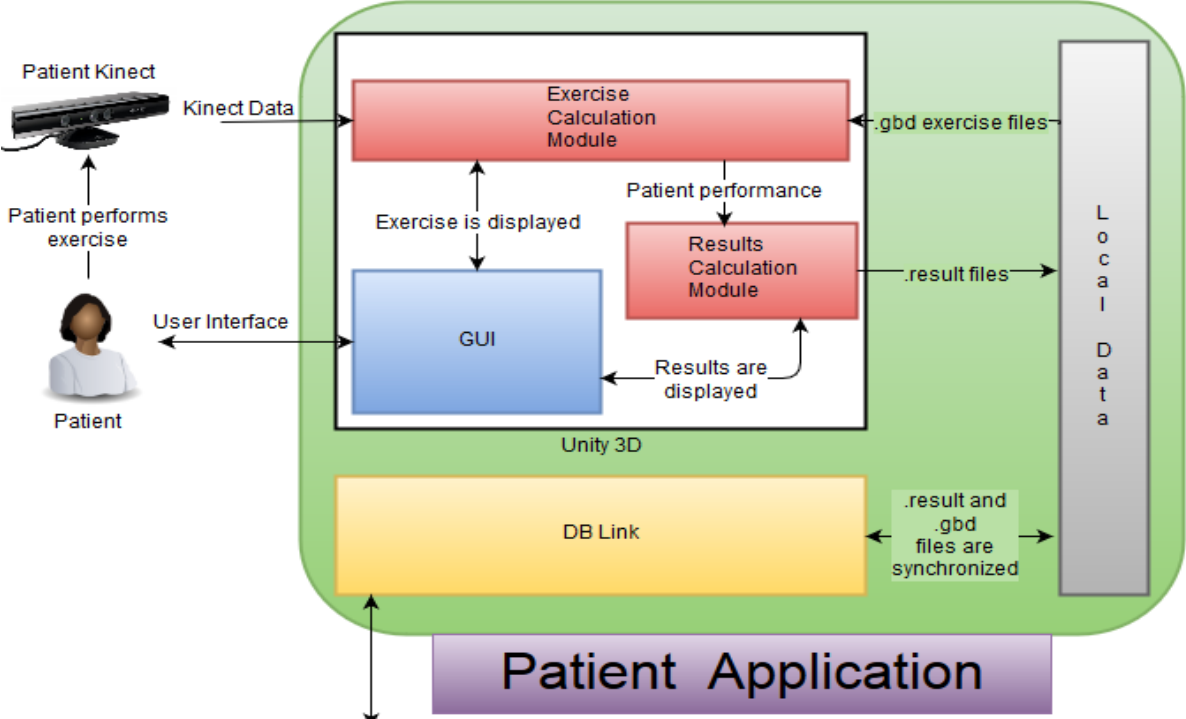
3.2 Therapist Close-up



3.3 Web Application Close-up



3.4 Patient Application Close-up



3.5 Database

Our database will store admin information, therapist information, patient information, therapy sessions uploaded by therapists, and patients' test scores.

3.6 Microsoft Kinect v2

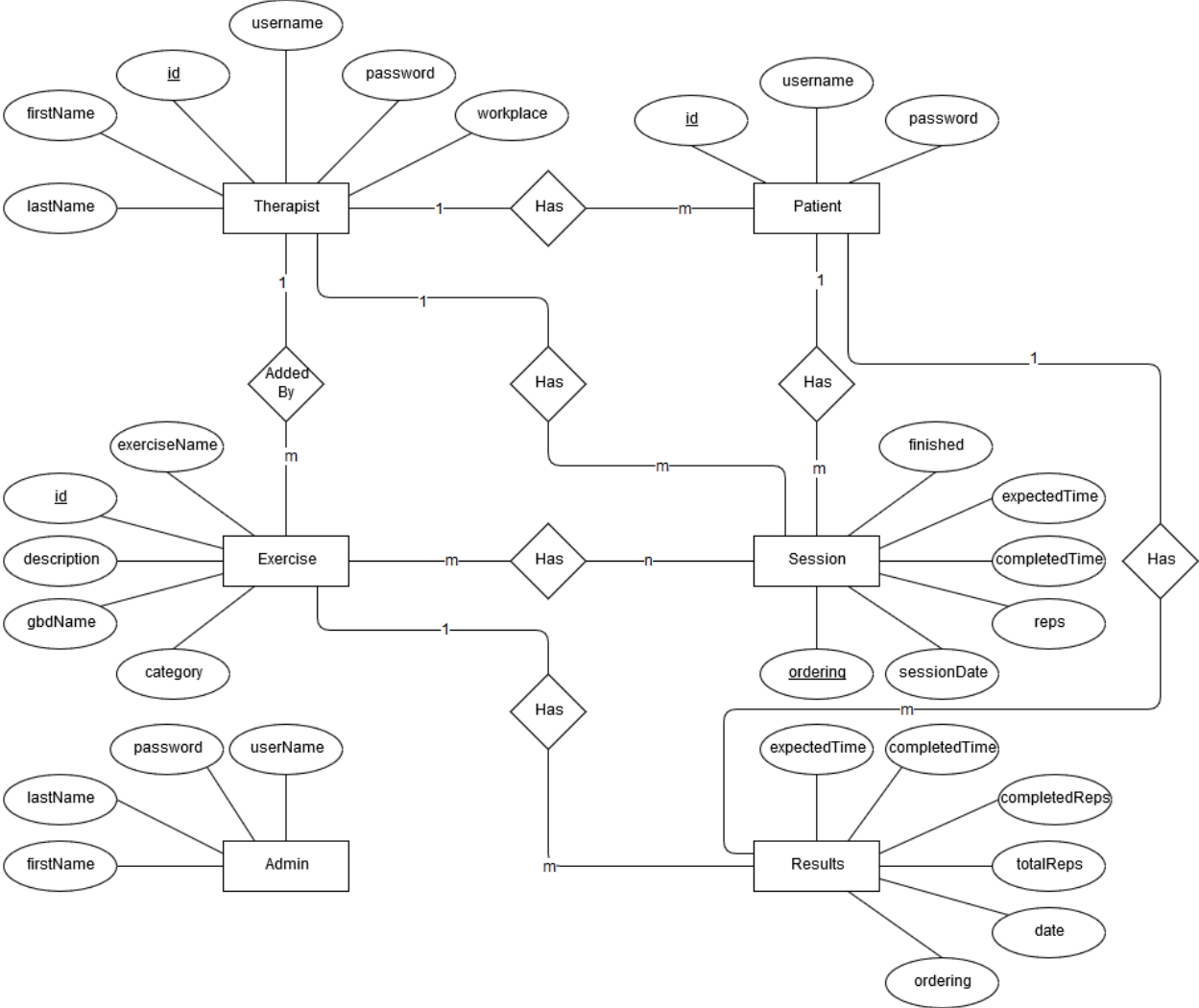
Microsoft Kinect v2 is hardware developed by Microsoft, which improves on Kinect v1 in many aspects such as improved body tracking, depth sensing, 1080p color camera, new active IP capabilities, and wider/ expanded field of view to name a few. In this project, we have used Kinect to capture joint positions in 3d space and compare them to pre-defined gestures.

3.7 Visual Gesture Builder

Visual Gesture Builder (VGB) generates data that applications use to perform gesture detection at run time. Even for simple cases, gesture detection is a challenging task that may require many lines of code to obtain reliable results, considering all of the different users and spaces that an application might encounter. By using a data-driven model, VGB shifts the emphasis from writing code to building gesture detection that is testable, repeatable, configurable, and database-driven. This method provides better gesture recognition and reduces development time.

4 Database Design

4.1 ER Diagram



4.2 Database Tables

Patients

This table stores the information for patient accounts. No personal information about the patient is stored in the database.

Attribute Name	Attribute Description
<u>id</u>	Primary key, used to uniquely identify a given patient in the database.
therapistId_id	Foreign key, referencing the therapist that is currently presiding over therapy sessions for the specific patient.
username	Used as part of the patient validation process, when the patient logs into the website or the Kinect application.
password	Used as part of the patient validation process, when the patient logs into the website or the Kinect application.
start_date	The starting date of the patient's therapy.
end_date	The ending date of the patient's therapy

Therapist

This table stores the information for therapist accounts.

Attribute Name	Attribute Description
<u>id</u>	Primary key, used to uniquely identify a given therapist in the database.
username	A string that is used as part of the validation process, when the therapist logs into the website.
password	A hashed string that is part of the validation process, when the therapist logs into the website.
firstname	First name of the therapist.
lastname	Last name of the therapist.
workplace	The therapist's place of work.

Admin

This table stores the information for admin accounts.

Attribute Name	Attribute Description
<u>id</u>	Primary key, used to uniquely identify a given patient in the database.
username	A string that is used as part of the validation process, when the admin logs into the website.
password	A hashed string that is part of the validation process, when the admin logs into the website.
lastname	Last name of the Administrator.
firstname	First name of the Administrator.

Session

This table stores the information for the patient therapy sessions.

Attribute Name	Attribute Description
<u>Id</u>	Primary key, used to uniquely identify a given session in the database.
ordering	Auto-incrementing field used to denote sequence of exercises in a
sessdate	Date the session this exercise is assigned to is due.
exercise	Foreign key, references the exercise table
reps	Total reps needed for this exercise
time	Time allotted to complete the exercise in seconds.
completed_time	Time elapsed for completion of this exercise.
finished	A status field for state of exercise. 0 = not done, not sequenced 1 = done 2 = not done, sequenced, available 3 = not done, sequenced, not available
user	Foreign key, referencing the patient to whom this therapy session is

Exercises

This table stores the exercises that the program supports.

Attribute Name	Attribute Description
<u>id</u>	Primary key, used to uniquely identify a given exercise in the
exerciseName	A string that contains the exercise name.
category	A string that contains the exercise category.
desc	A description of how to perform the exercise
date	Date that specifies when the exercise was added.
gbd_name	A string that contains the file name of the exercise
added_by_id	Foreign key, references the therapist id who added the exercise

Results

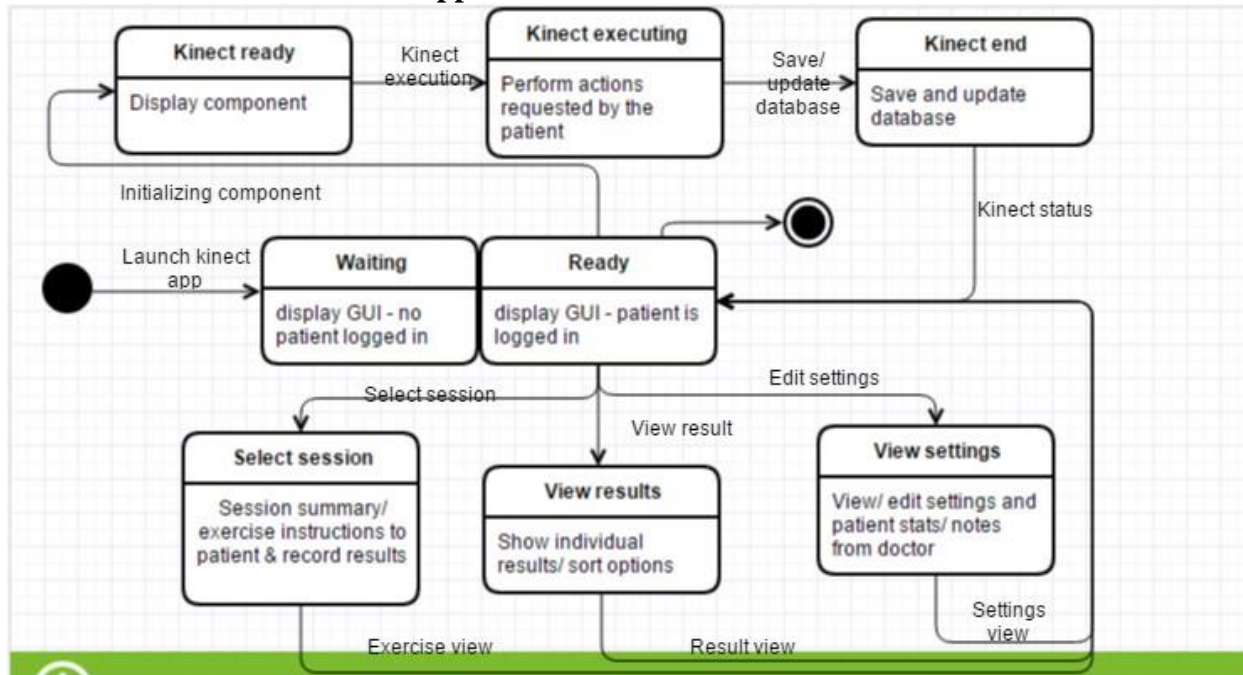
This table stores the results of session exercises.

Attribute Name	Attribute Description
<u>id</u>	Primary key, used to uniquely identify a given exercise in the database.
ordering	Field used to denote sequence of exercises in a session
date	Due date of the session the result belongs to
total_reps	Total number of reps to be completed by the patient
completed_reps	Number of reps completed by the patient
expected_time	Time allotted for the patient to complete the exercise
completed_time	Time taken to complete the exercise
patient_id	Foreign key, references the id of the patient who completed the
exercise_id	Foreign key, references the id in the exercise table

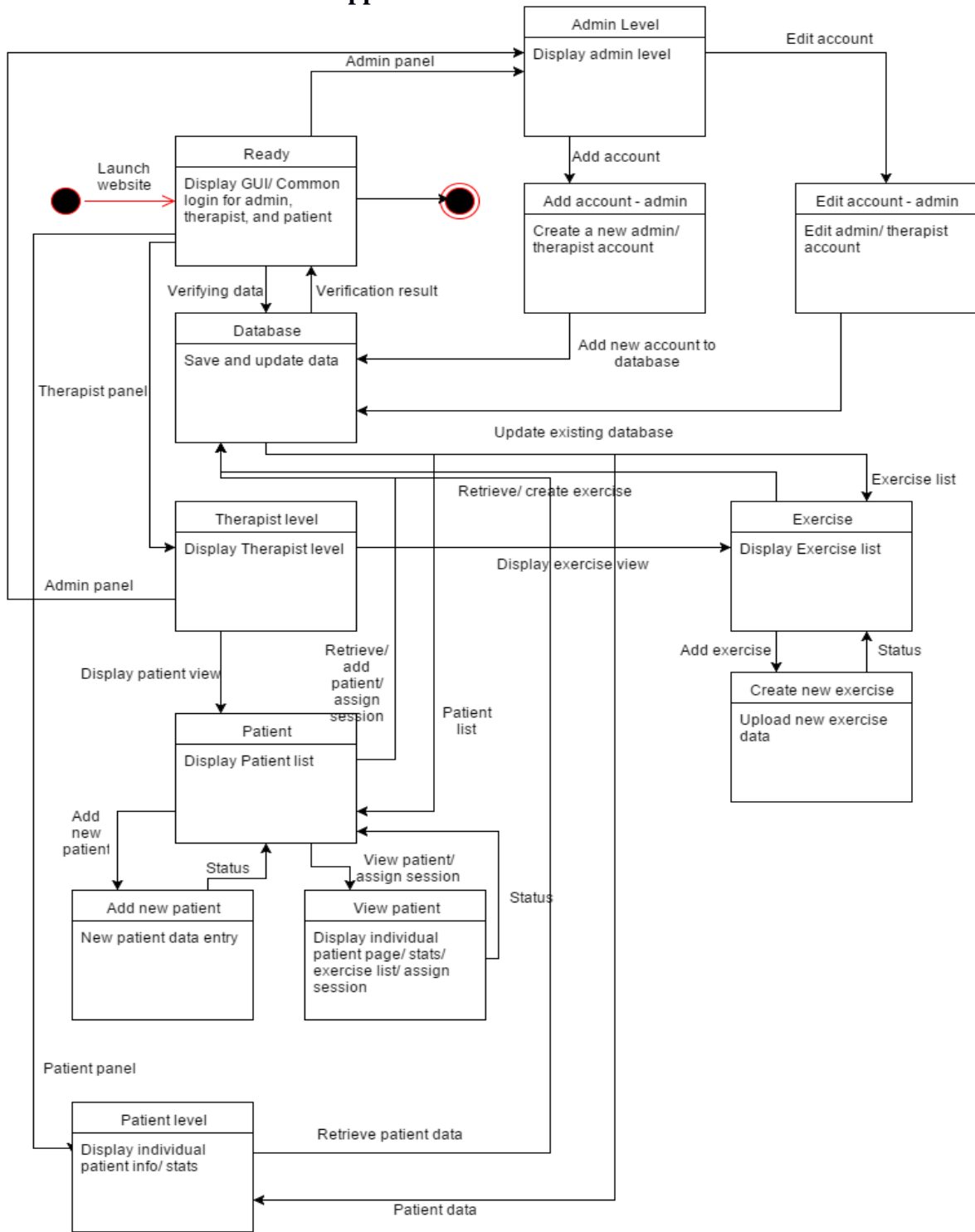
5 UML Models

5.1 State Diagrams

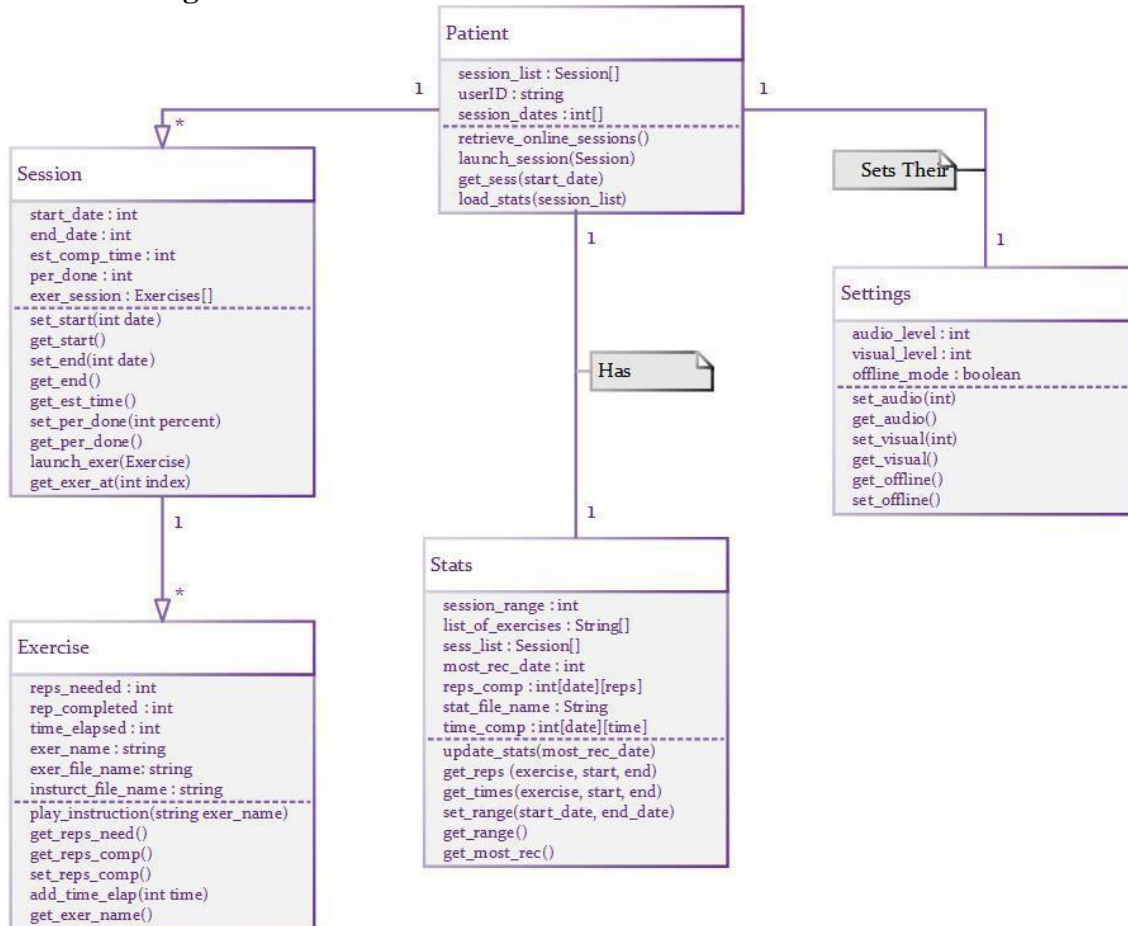
Elemental Kinection – Kinect App



Elemental Kinection – Web App

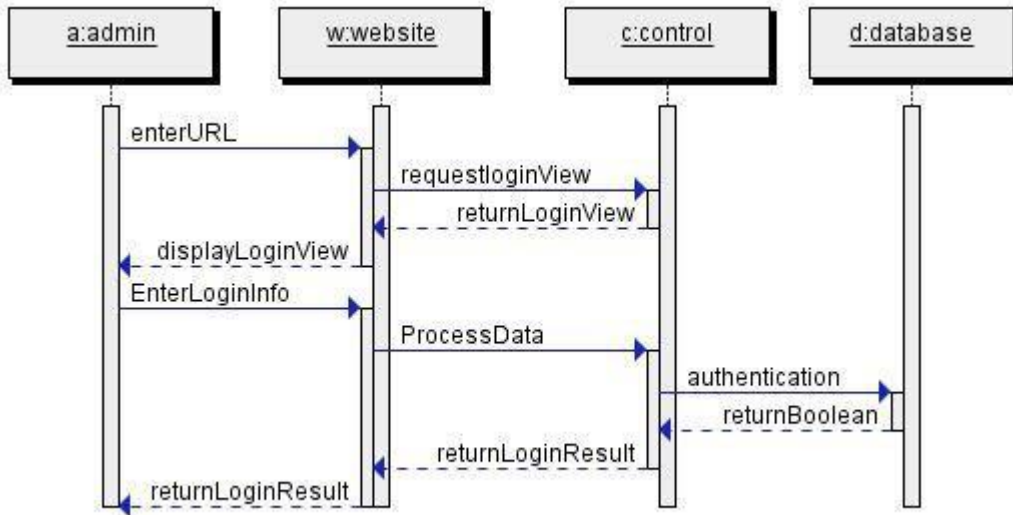


5.2 Class Diagrams

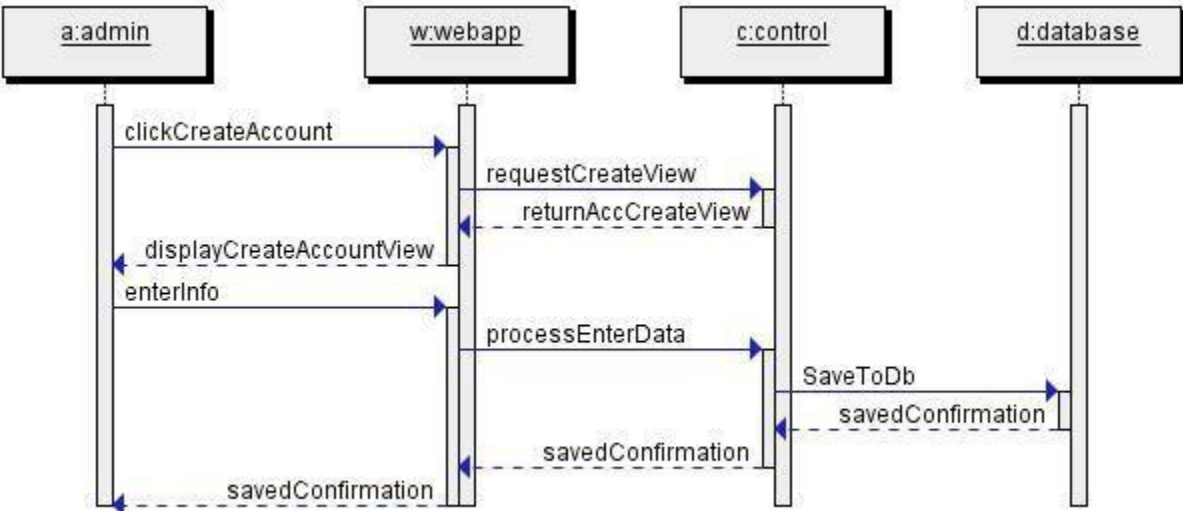


5.3 Sequence Diagrams

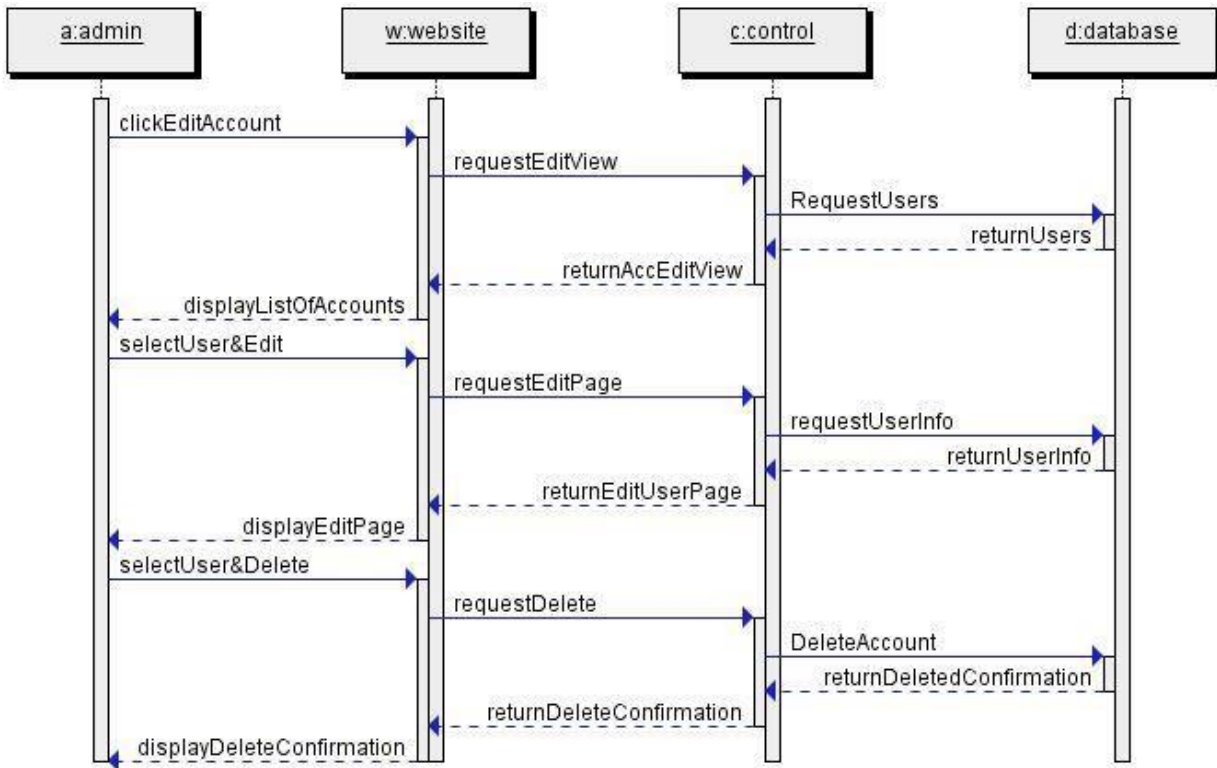
Admin login



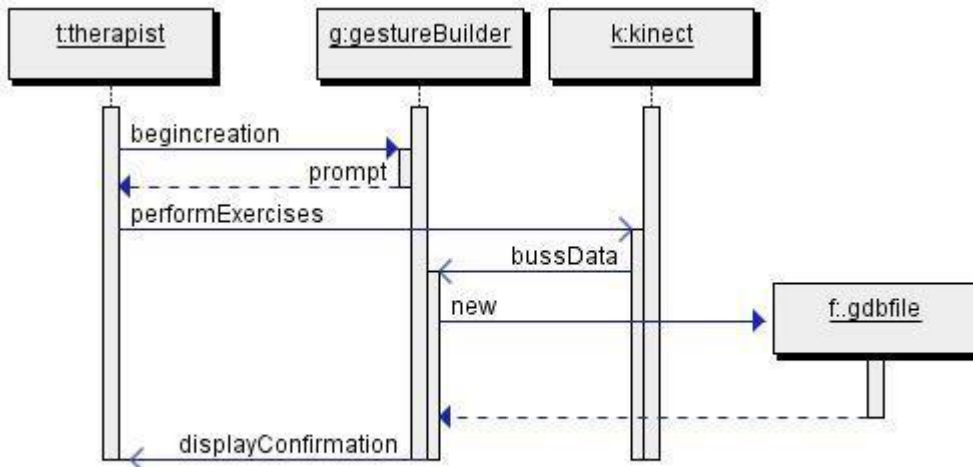
Admin creates account

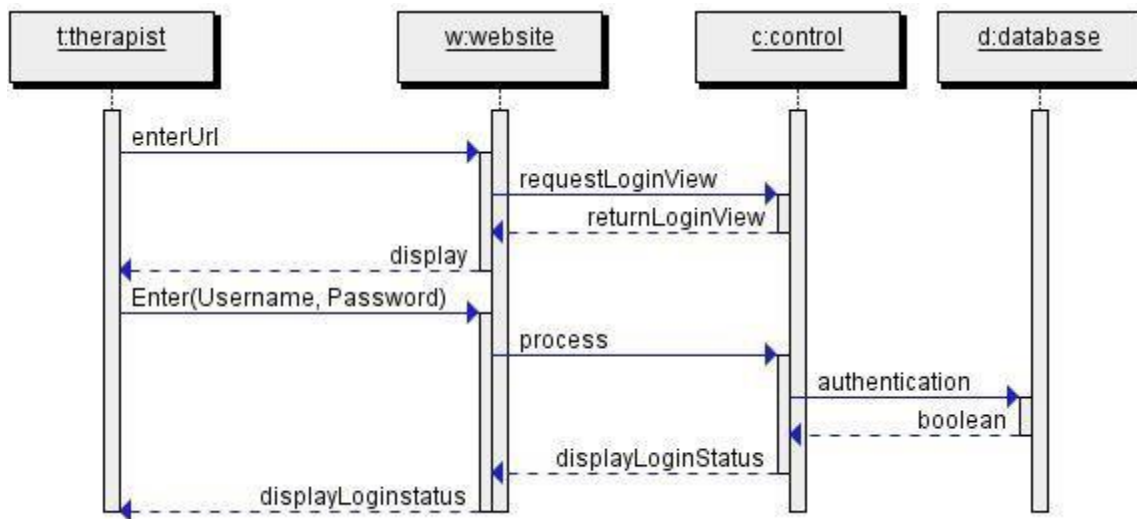
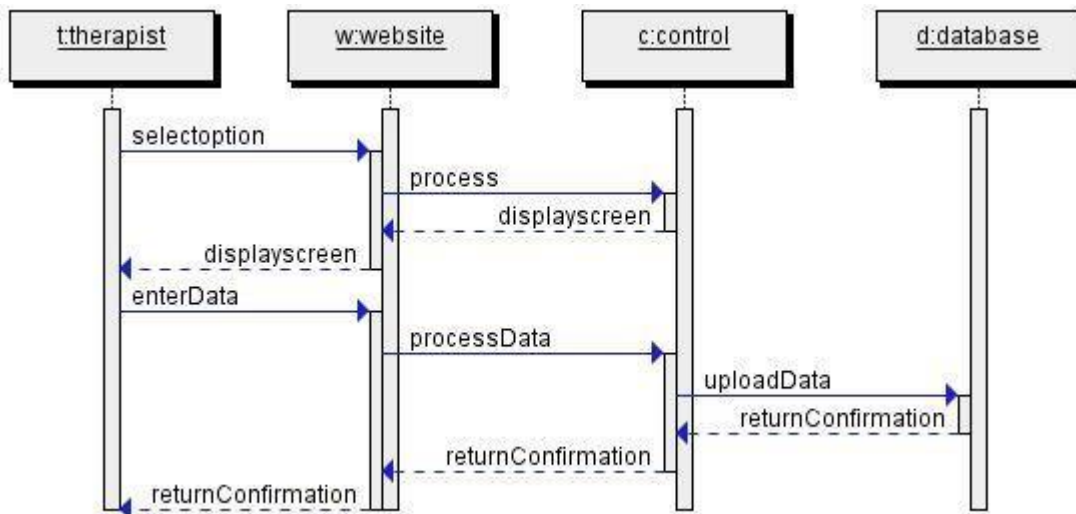


Admin edits account

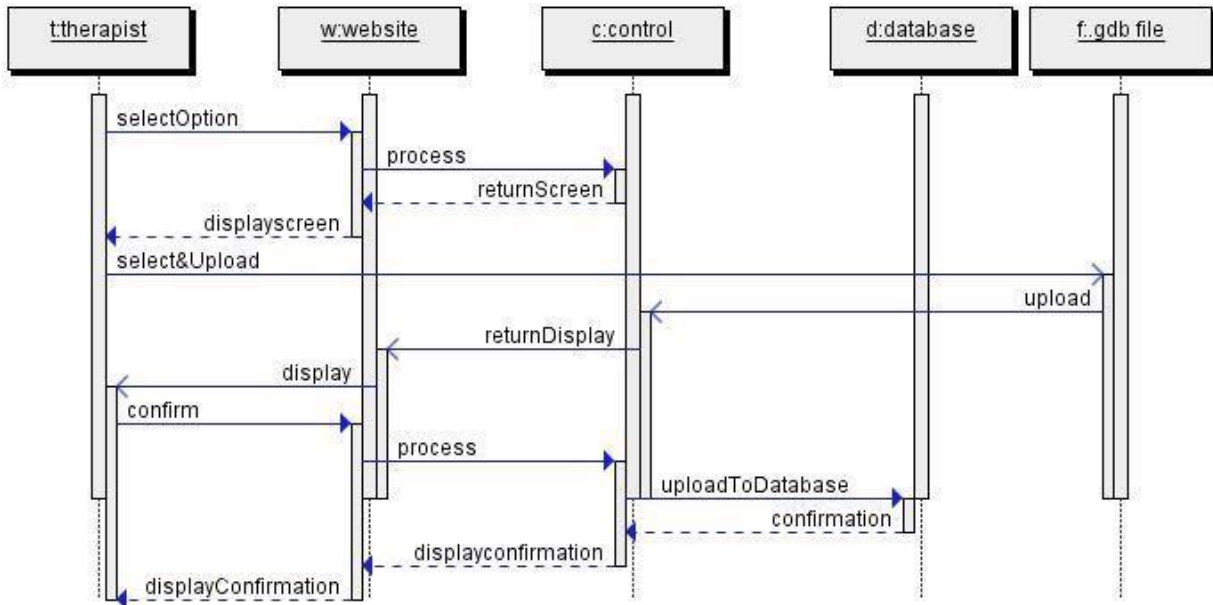


Therapist creates new session

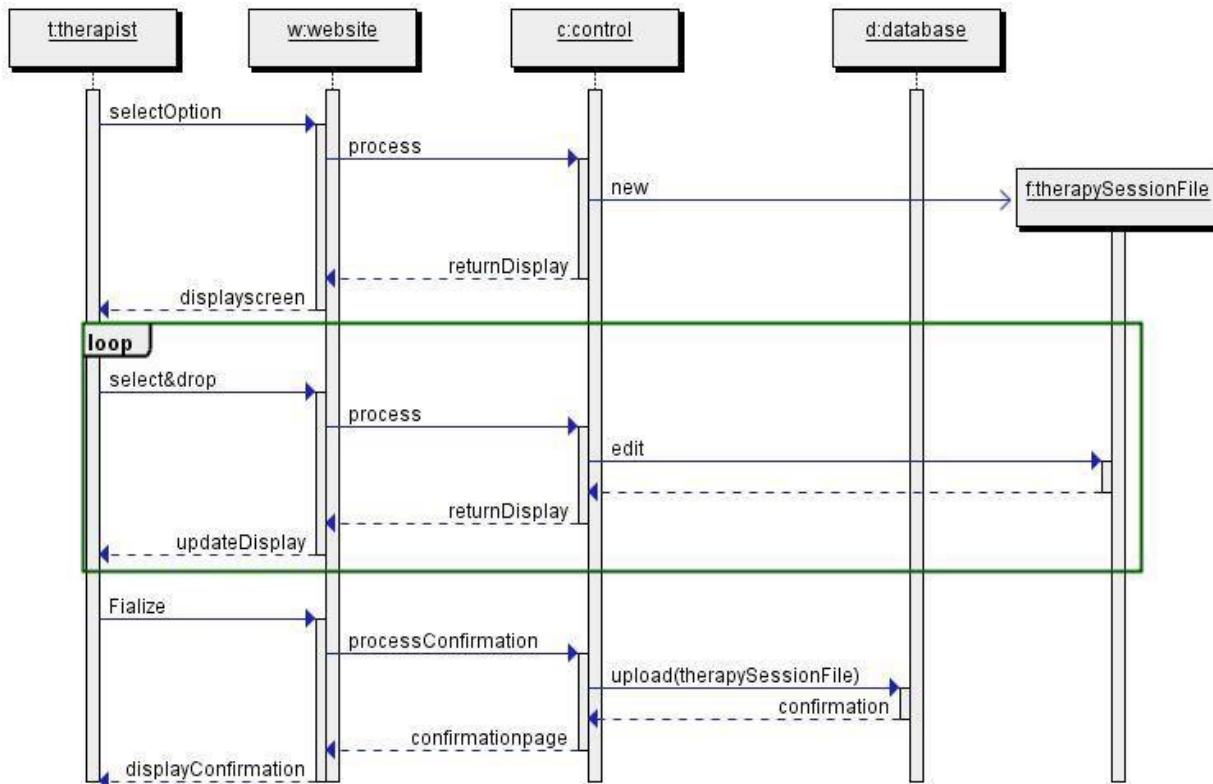


Therapist login**Therapist creates new patient**

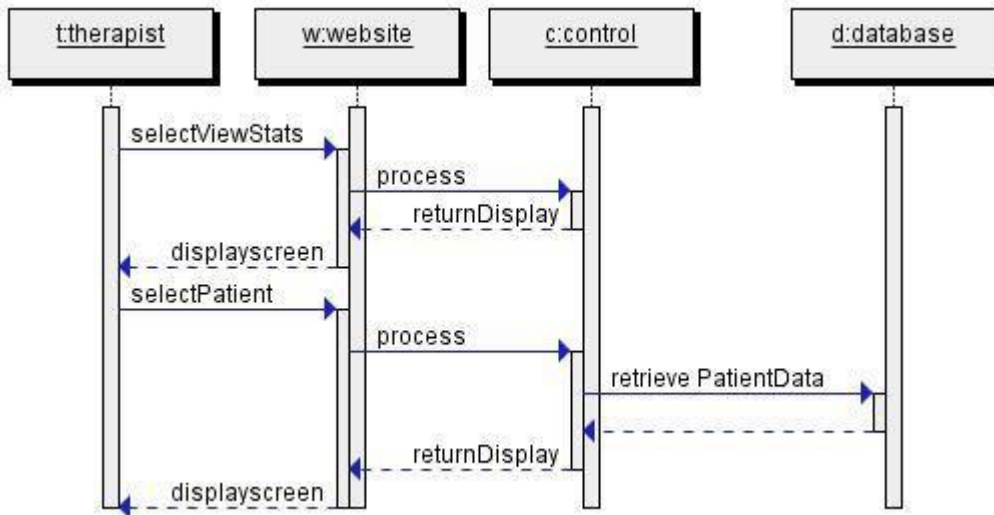
Therapist uploads new exercises



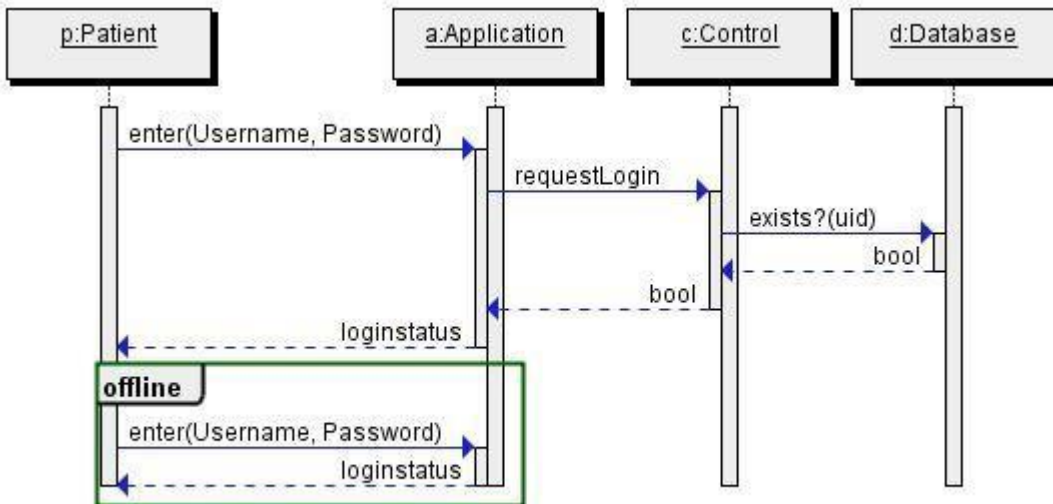
Therapist assigns therapy sessions



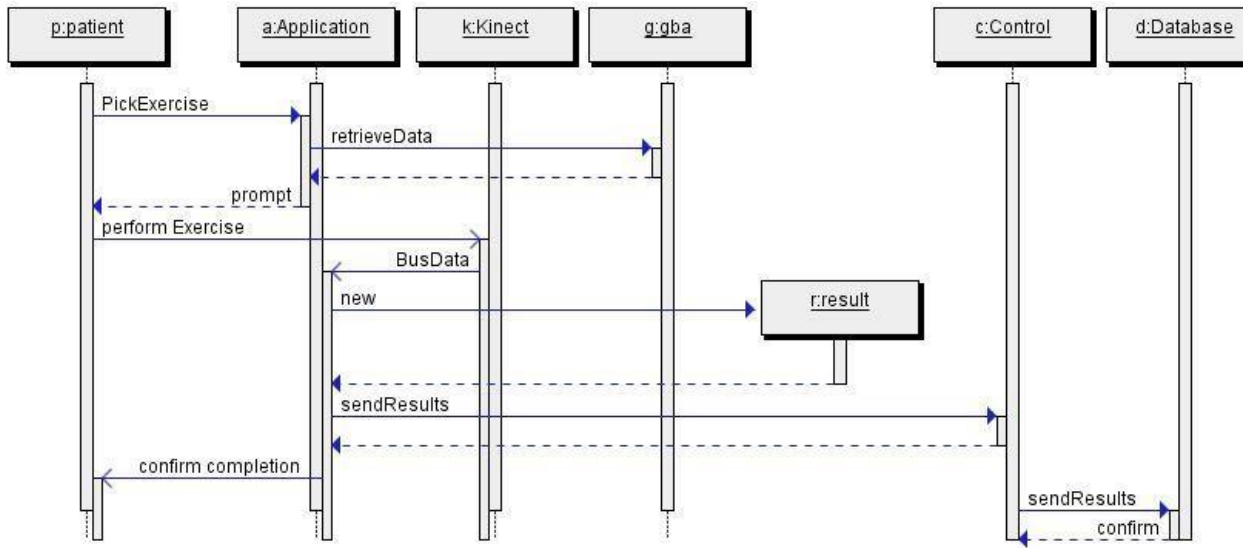
Therapist views patient stats



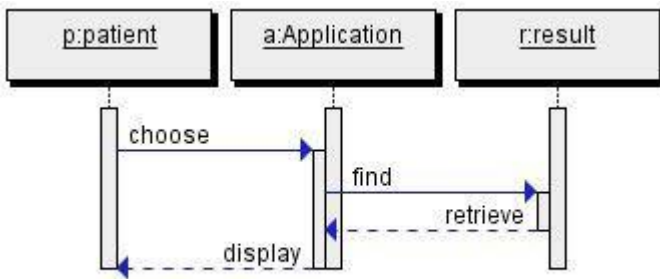
Patient login Kinect App



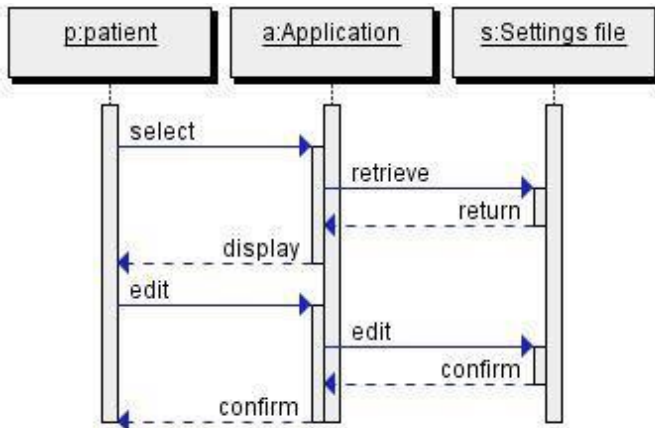
Patient completes therapy session



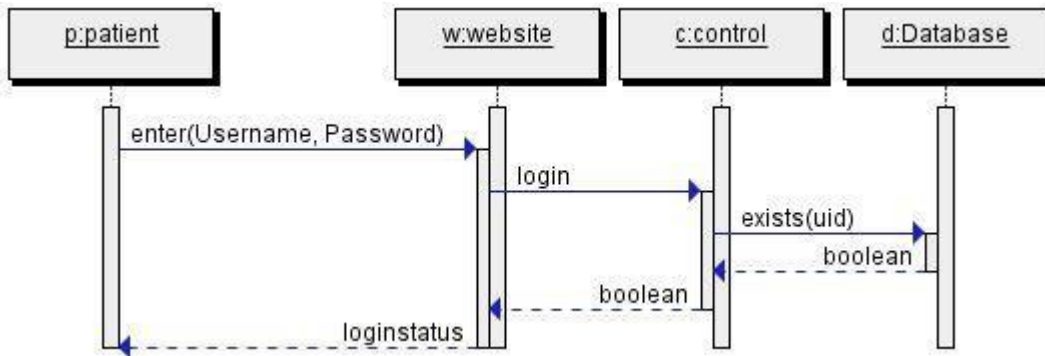
Patient views results

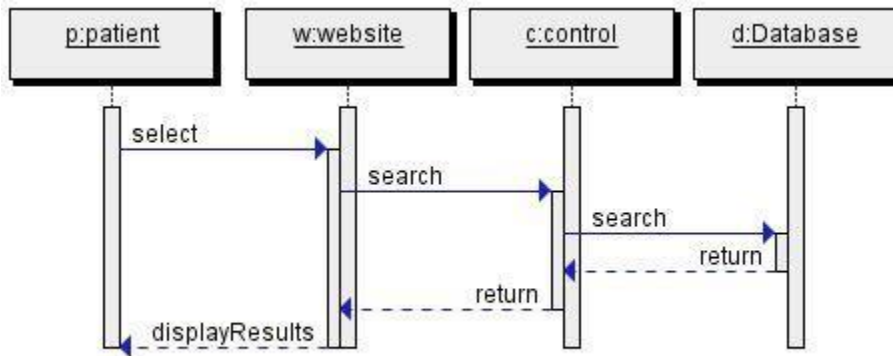


Patient personalizes settings



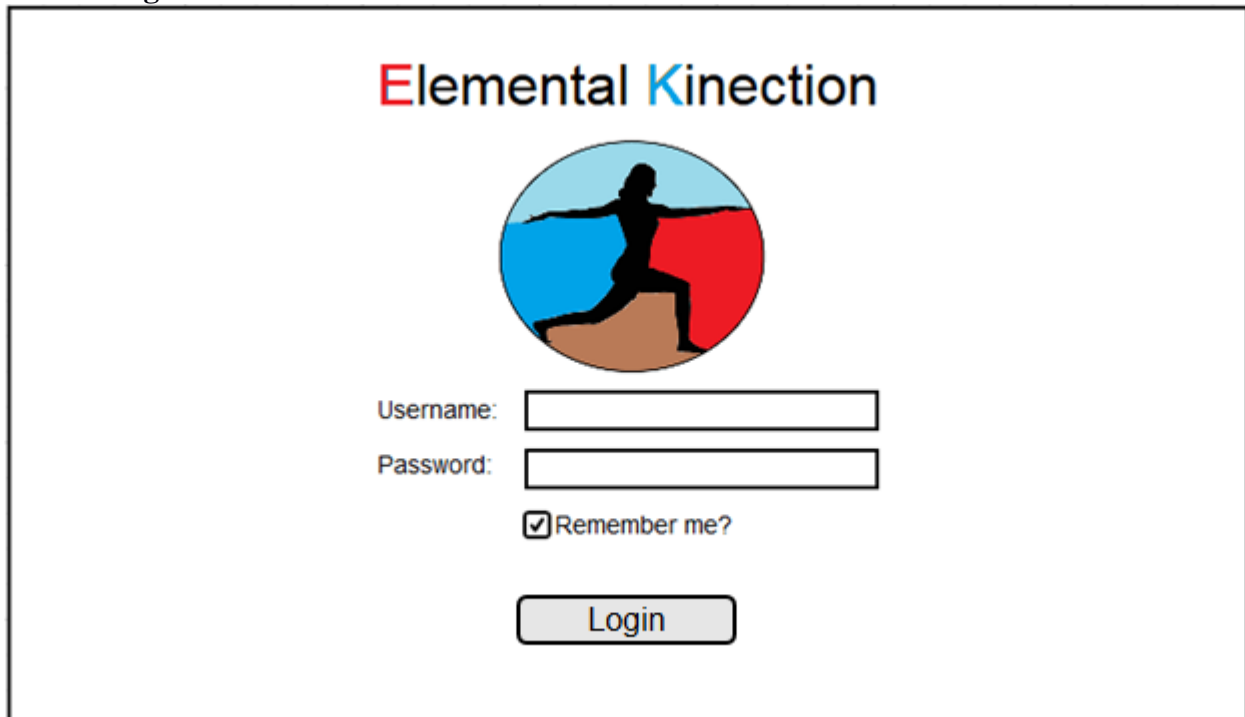
Patient login Web App



Patient views result on Web App

6 User Interface

Web Application Prototypes Admin Login Screen



The image shows a web application prototype for an admin login screen. At the top, the text "Elemental Kinection" is displayed in a red and blue font. Below the text is a circular logo featuring a silhouette of a person in a dynamic pose, with a blue and red background. Underneath the logo are two input fields: "Username:" and "Password:". Below the password field is a checkbox labeled "Remember me?". At the bottom of the form is a "Login" button.

Login Button

For admin → Admin Home Page

Admin Homepage



Welcome Admin XYZ



Add a Therapist



Add an Admin

Admin – Create a Therapist

Add a Therapist

Username:

Password:

First Name:

Last Name:

Workplace:

Create a Therapist → Add therapist to database

Admin – Create an Admin

Add an Admin

Username:

Password:


First Name:

Last Name:

Create an Admin → Add admin to database

Login Screen

Elemental Kinection



Username:

Password:

Remember me?

Login Button

For Patients → Patient Home Page
For Therapists → Therapist Home Page

Therapist Home Page

Patients:		
▼ Username	▼ Start Date	▼ Completion Date
johnson	Nov. 03 2015	Mar. 03 2015

[Add a Patient](#) [Manage Exercises](#)

Manage Exercises → Exercise List
Add a Patient → New Patient

Exercise List

All Exercises:

Shoulder Touches
Reverse Flies
Left Arm Pendulum
Right Arm Pendulum
Left Hip Abduction
Right Hip Abduction

[Add a new Exercise](#)

Name:

Category:

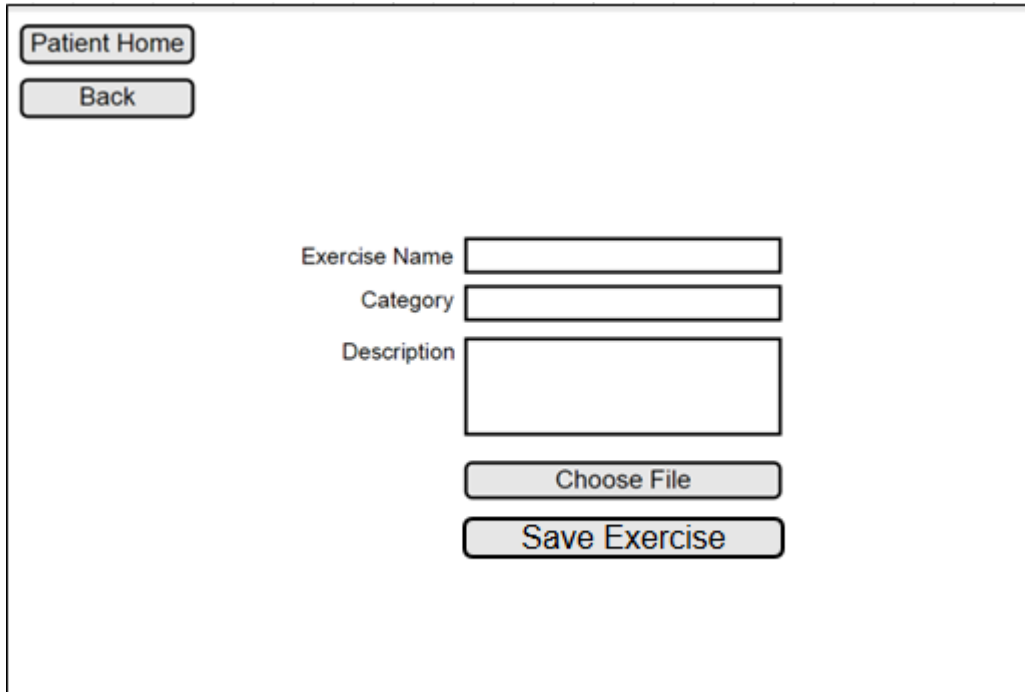
Added By:

Date:

Description:

[Add Exercise](#) → [Go to New Exercise](#)

New Exercise



The form is contained within a rectangular border. In the top-left corner, there are two buttons: "Patient Home" and "Back". In the center, there are three input fields: "Exercise Name", "Category", and "Description". Below the "Description" field are two buttons: "Choose File" and "Save Exercise".

- Patient Home → Go to Patient List
- Back → Go to Exercise List
- Choose File → Upload .gbd file

Add New Patient

[Exercises](#)

[Back](#)

Username

Password Password Strength

Confirm Password

Expected Start Date

Expected End Date

[Create](#)

- Back → Patient List
- Create → Generate new patient account.

View Patient

[Patient Name]'s Exercises

- Shoulder Touches
- Reverse Flies
- Left Arm Pendulums

Sessions

Patient List

[Patient Name]'s Results

Month: August

The graph displays two data series. The first series (black line) starts at a low point, rises to a peak, falls to a low point, rises to a medium peak, and then falls. The second series (grey line) starts at a low point, rises to a medium peak, falls to a low point, rises to a high peak, and then falls.

Return → Patient List
Assign Session → Assign Session

Assign Session

Welcome to Session Assignment

November 23, 2015

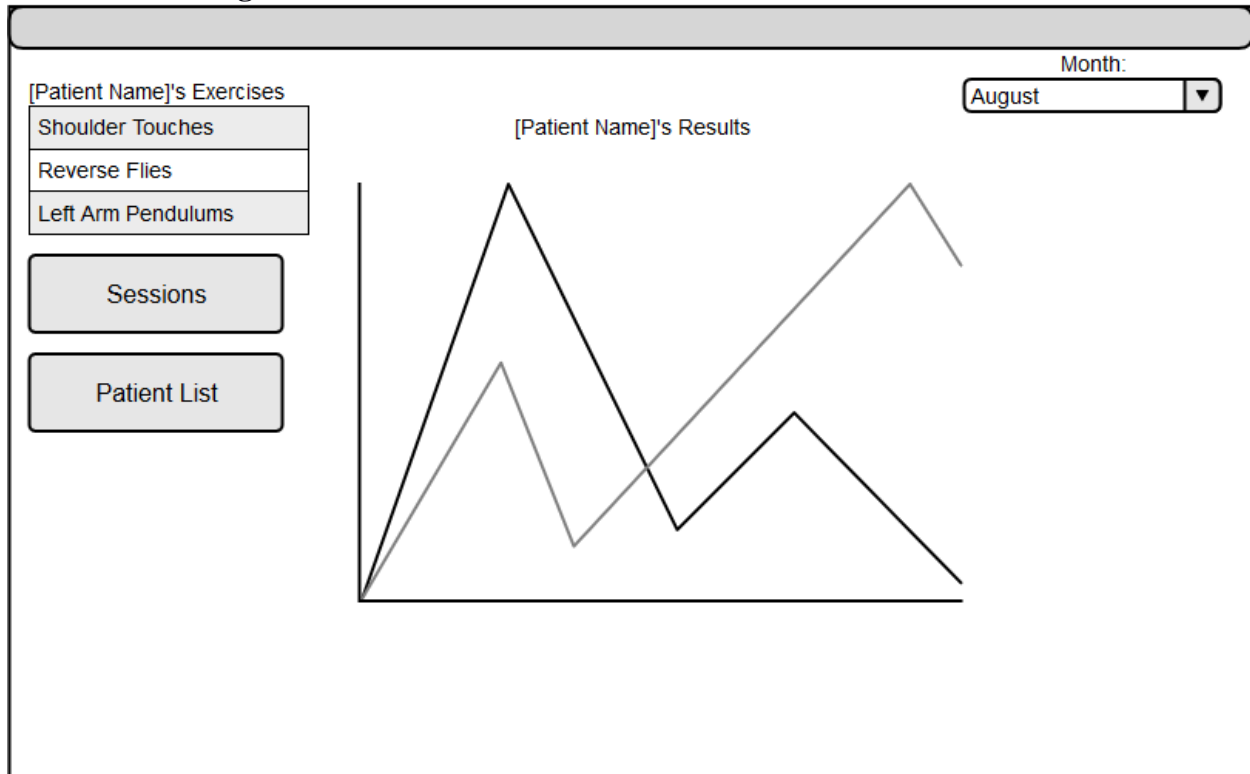
Shoulder Touches	10 reps	1:00
Reverse Flies	15 Reps	2:00

November 22, 2015

Shoulder Touches	15 reps	1:00
Reverse Flies	20 Reps	2:00

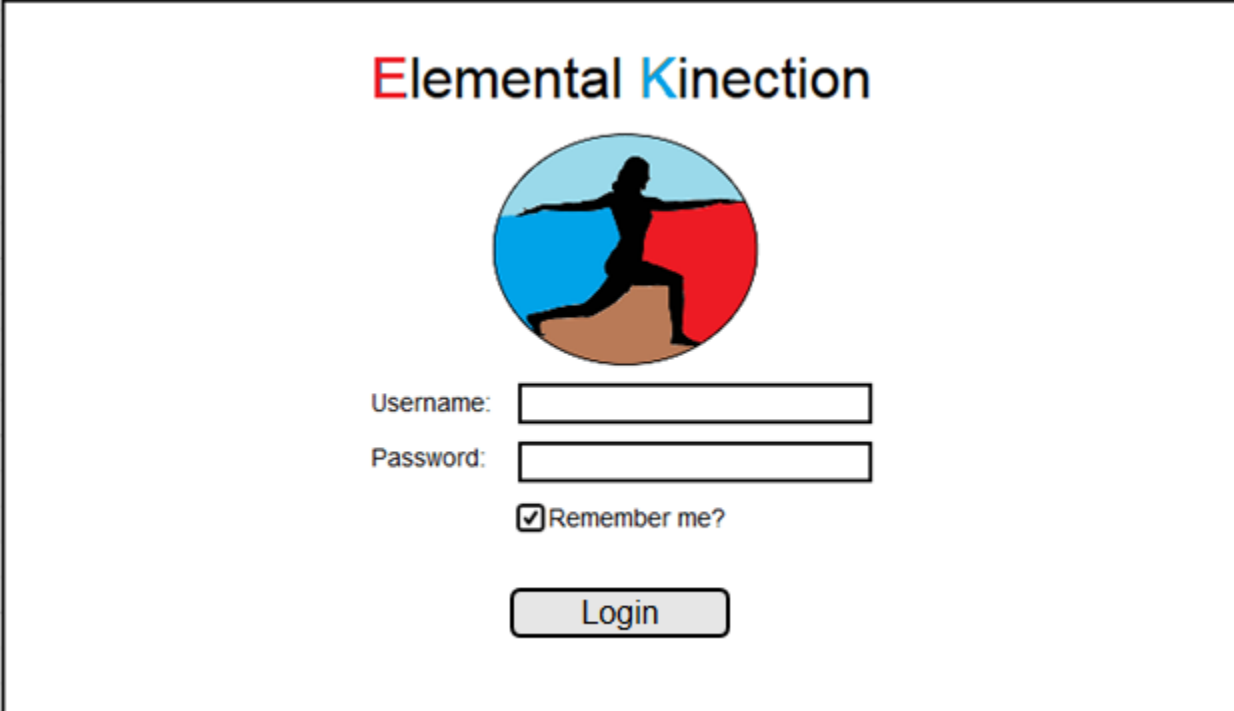
Create a SessionBack to Results

Patient Home Page



- Reps → Show reps performed over time.
- Time → Show time for exercises to be performed over time.
- Score → Show score over time.

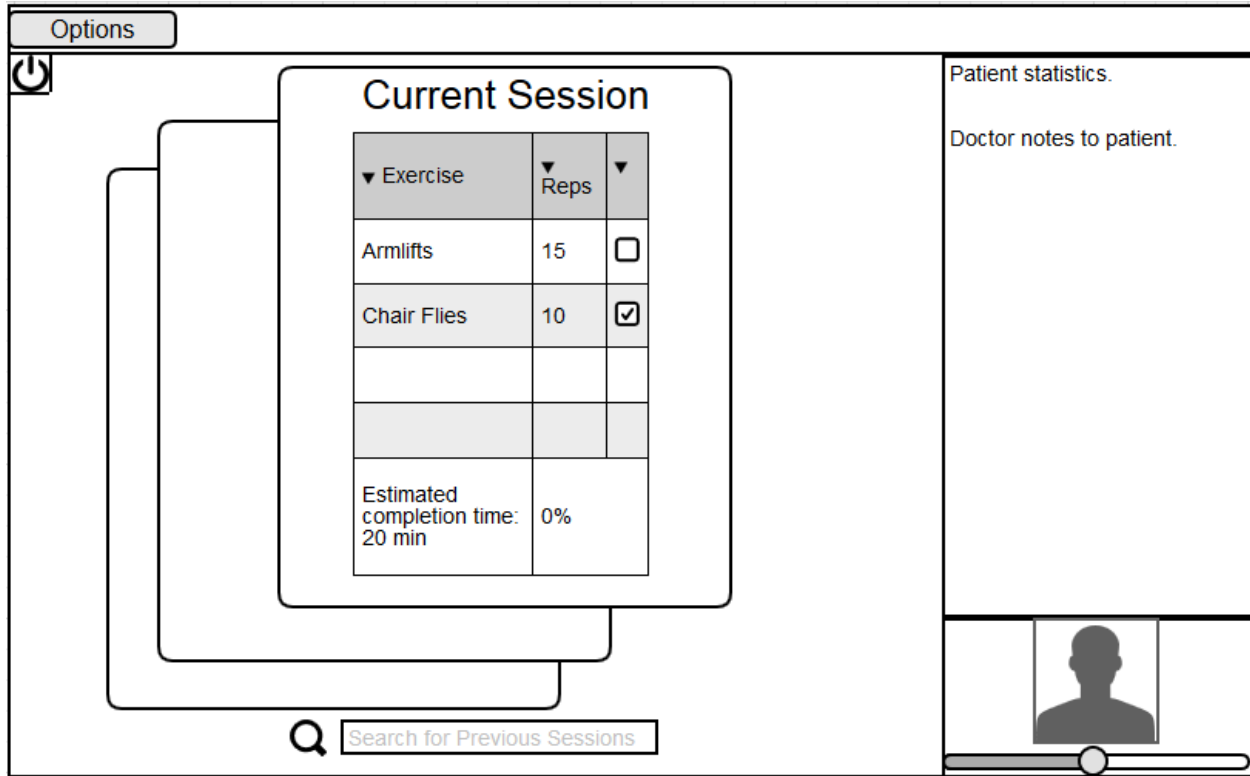
Kinect Application Prototypes
Login Screen



The login screen features the title "Elemental Kinection" at the top center, with "Elemental" in red and "Kinection" in blue. Below the title is a circular logo containing a black silhouette of a person in a dynamic pose, set against a background of blue, red, and brown. Underneath the logo are two input fields: "Username:" followed by a white rectangular box, and "Password:" followed by another white rectangular box. Below the password field is a checkbox labeled "Remember me?". At the bottom center is a rounded rectangular button with the text "Login".

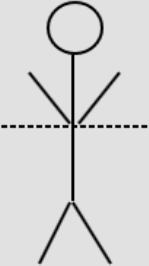
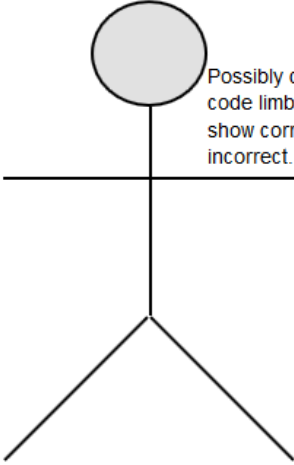

If connected to internet, goto main screen.

Kinect Main Screen

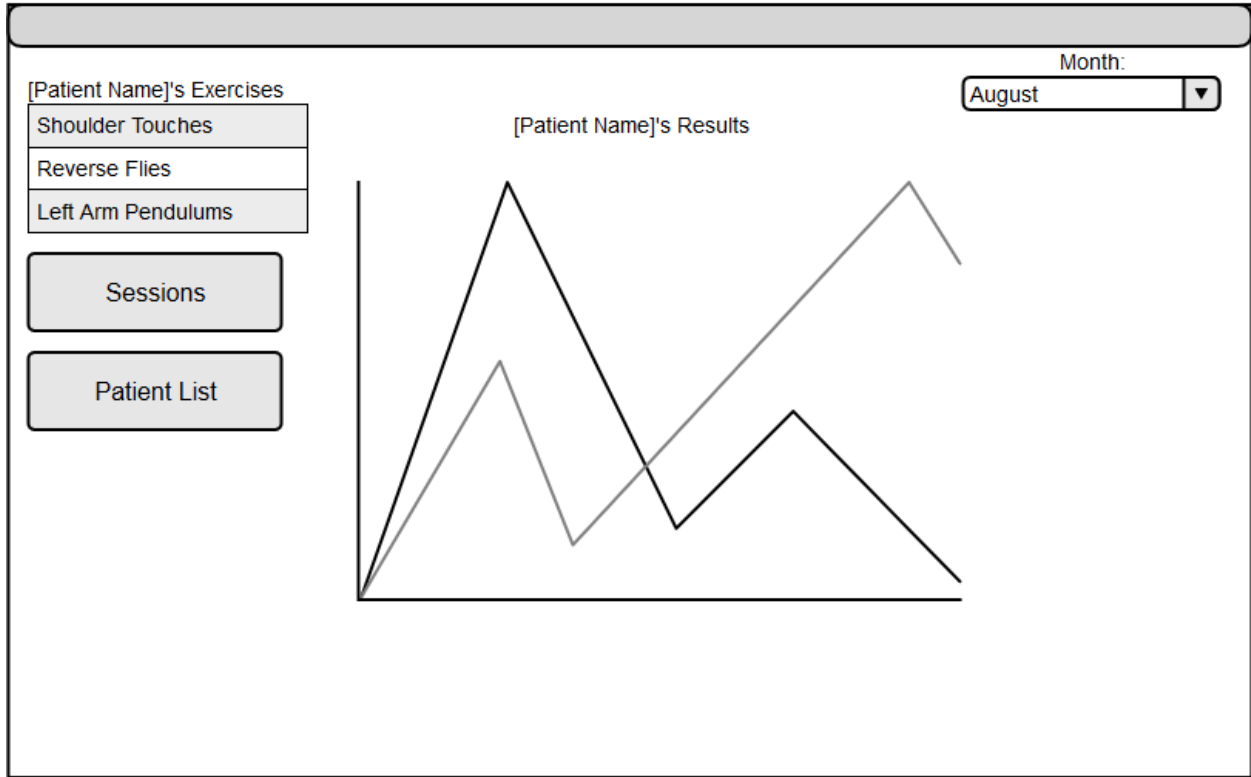


Options → Go to View Settings
 Clicking on a previous card goes to view statistics.

Kinect Exercise Screen

	 <p>Possibly color code limbs to show correct or incorrect.</p>	 <p>Reps remaining: 1</p>
		<p>Total Reps: 15</p>
<p>🔊) Directions for the exercise.</p>		<p>Time Elapsed: 14:12</p>
		<p>Return to main screen</p>

View Statistics



7 Glossary of Terms

Amazon Web Services – A secure cloud services platform for compute power, database storage and content delivery.

Django - Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design.

Kinect Studio – Kinect Studio is a utility application that you can use to preview Kinect sensor array data, record and play eXtended Event File (XEF) files, control the timeline position, and select 2D or 3D views. Kinect Studio APIs enable you to develop custom tools, to record and play back body data using XEF files.

Kinect v2 - A motion sensing input devices by Microsoft for PCs. Based around a webcam-style add-on peripheral, it enables users to control and interact with their console/computer without the need for a game controller, through a natural user interface using gestures

Kinect for Windows SDK 2.0 – A set of developer tools, tutorials, and an API reference put out by Microsoft for the development of Kinect v2 on Windows 8, 8.1 and Windows 10.

MySQL – A popular Open Source SQL database management system, developed, distributed, and supported by Oracle Corporation

Nginx - A free, open-source, high-performance HTTP server and reverse proxy, as well as an IMAP/POP3 proxy server. It provides load-balancing, security controls and other monitoring tools.

Slack – A collaboration tool that allows for instant messaging, file sharing and other customizable plug-ins.

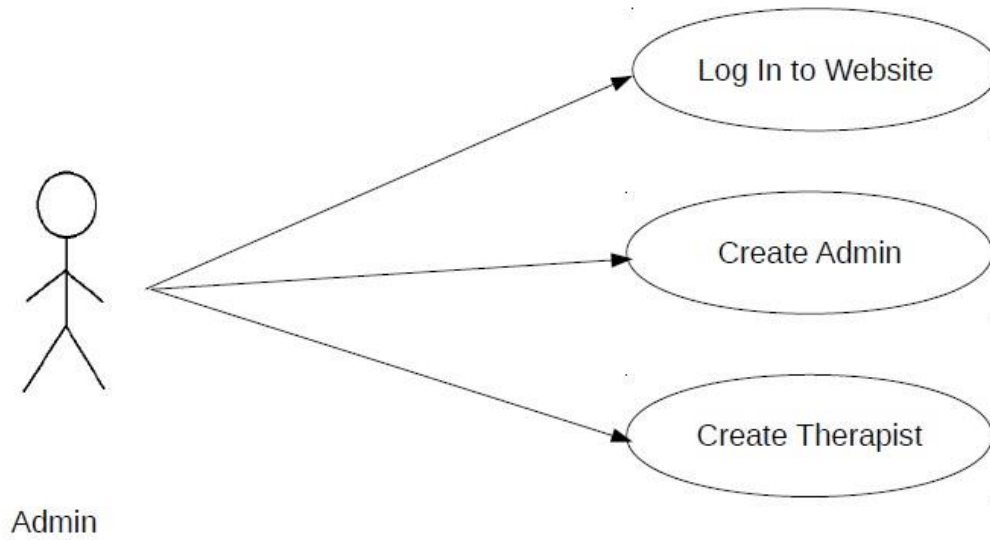
Telerehabilitation- the delivery of rehabilitation services over telecommunication networks and the internet.

Unity - a cross-platform game engine developed by Unity Technologies and used to develop video games for PC, consoles, mobile devices and websites.

USB 3.0 - The third major version of the Universal Serial Bus (USB) standard for interfacing computers and electronic devices. Among other improvements, USB 3.0 adds the new transfer rate referred to as *SuperSpeed USB* (SS) that can transfer data at up to 5 Gbit/s (625 MB/s), which is about ten times as fast as the USB 2.0 standard.

Visual Gesture Builder - Visual Gesture Builder (VGB) generates data that applications use to perform gesture detection at run time. By using a data-driven model, VGB shifts the emphasis from writing code to building gesture detection that is testable, repeatable, configurable, and database-driven.

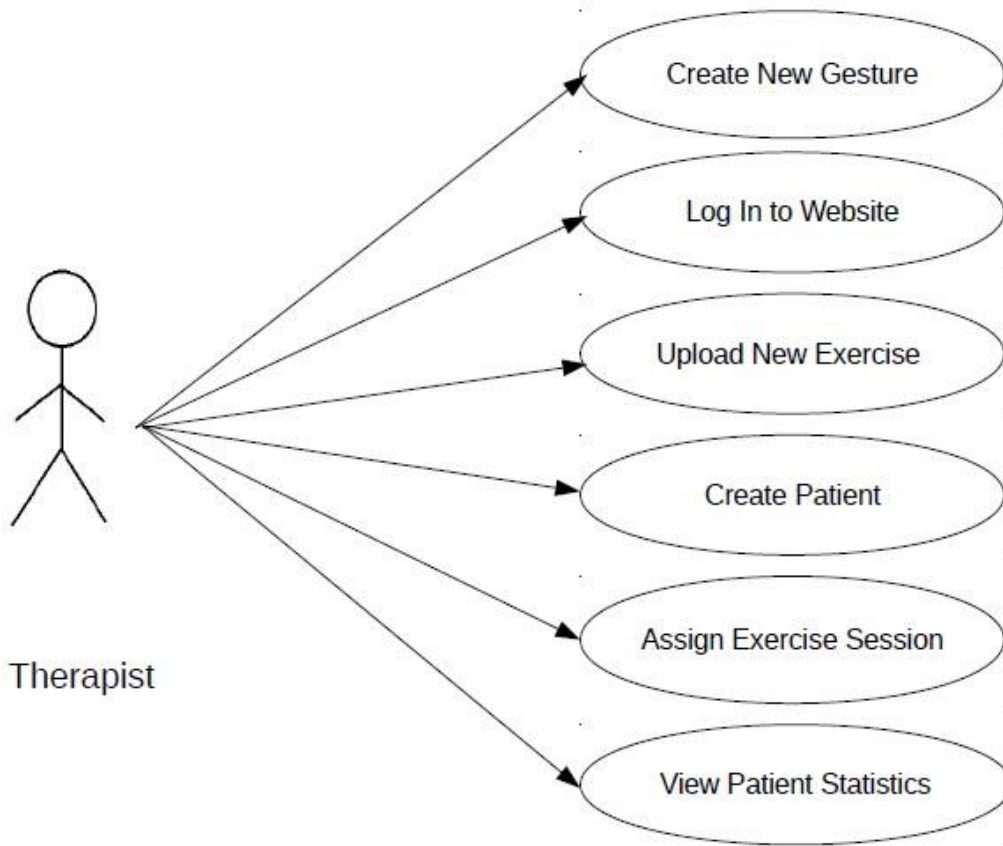
Appendix A: Use Cases



Use Case	Log In to Website
Actors	Admin
Description	Admin provides authentication to the website.
Data	Admin user name and password
Precondition	<ul style="list-style-type: none">• Admin has an account registered and is connected to the internet
Stimulus	Admin enters the EK URL
Response	<ul style="list-style-type: none">• Enter username and password• Press “login”• Username and password are compared to what is in the database• If valid, user is taken to the home page• If invalid, prompted for data again
Comments	

Use Case	Create admin
Actors	Admin
Description	Admin creates a new admin account.
Data	New account's information
Precondition	<ul style="list-style-type: none">• The admin must be logged in
Stimulus	Admin selects "add an admin" on the admin homepage
Response	<ul style="list-style-type: none">• Admin enters the information for the new admin account• The new account's username and password are saved to the database
Comments	

Use Case	Create therapist
Actors	Admin
Description	Administrator creates a therapist account, allowing them to create patient accounts, update/upload exercises, and assign sessions
Data	Therapist information
Precondition	<ul style="list-style-type: none">• Admin must be logged in
Stimulus	Admin selects “add a therapist” on admin homepage
Response	<ul style="list-style-type: none">• Admin inputs the necessary therapist information• Admin selects “create a therapist”• New therapist account information is saved to the database.
Comments	



Use Case	Create New Gesture
Actors	Therapist
Description	The therapists defines new exercises for storage in the database.
Data	.gbd (gesture build file)
Precondition	<ul style="list-style-type: none">• Therapist has Visual Gesture Builder, Kinect SDK, and Microsoft Kinect
Stimulus	Therapist runs Gesture Builder
Response	<ul style="list-style-type: none">• The therapist performs the gesture in front of the Kinect• The therapist selects, in Visual Gesture Builder, which points in the recorded movements show the correct gesture• The therapist saves the clips and builds the .gbd file• The .gbd file is saved to the therapist's computer
Comments	

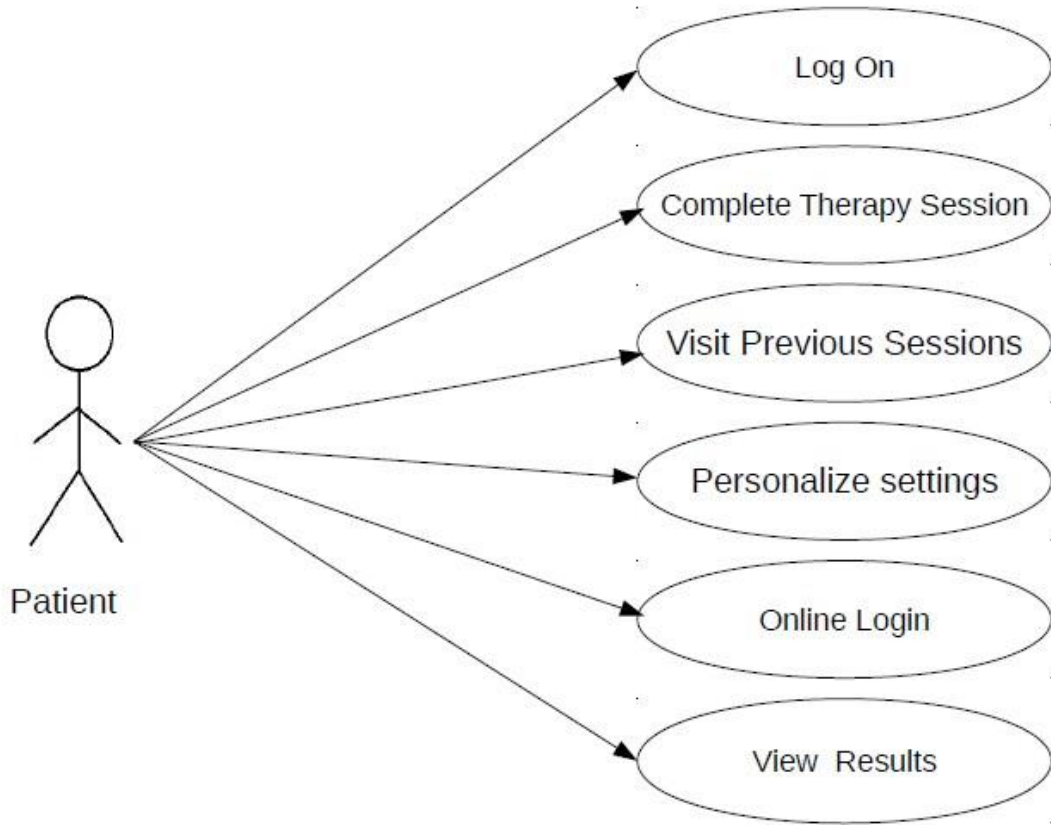
Use Case	Log In to Website
Actors	Therapist
Description	Therapist provides authentication to the website.
Data	User name, Password
Precondition	<ul style="list-style-type: none">• Therapist has an account registered and is connected to the internet
Stimulus	Therapist enters EK URL and navigates to the website
Response	<ul style="list-style-type: none">• Enter username and password• Press “login”• Username and password are compared to what is in the database.• If valid, user is taken to the home page• If invalid, prompted for data again
Comments	

Use Case	Upload New Exercise
Actors	Therapist
Description	Therapist selects type of exercise to upload and selects .gbd file to upload
Data	.gbd file
Precondition	<ul style="list-style-type: none">• Therapist is logged in• Therapist has created a gesture using gesture builder, and has the .gbd file stored locally on their computer• Therapist is on Exercise list screen
Stimulus	Therapist clicks on Add Exercise
Response	<ul style="list-style-type: none">• Therapist enters exercise name, category and a short description• Therapist clicks on “choose file” and selects .gbd file• Therapist clicks “save exercise”• File is saved to the website
Comments	

Use Case	Create Patient
Actors	Therapist
Description	Therapist defines patient account parameters, enabling a patient to log in to their account from the application or website
Data	Patient username and password
Precondition	<ul style="list-style-type: none">• Therapist is logged in and has a patient in contact.
Stimulus	Therapist navigates to Patient List screen and hits account create button
Response	<ul style="list-style-type: none">• Therapist enters username and password for patient.• Therapist shall enter the expected start and end date of the patient's therapy.• Patient account data is saved to the database
Comments	

Use Case	Assign Exercise Session
Actors	Therapist
Description	Therapist assigns a selection of exercises to be performed by patient. These are saved in the database and downloaded by the patients application
Data	Therapy sessions
Precondition	<ul style="list-style-type: none"> • Therapist has a patient • There is at least one exercise in the database • Therapist is on the View Session screen
Stimulus	Therapist clicks assign session
Response	<ul style="list-style-type: none"> • Therapist is brought to the Assign Session screen • Therapist enters information for each exercise and adds them to the session • Therapist enters session due date • Therapist can link certain sequences of exercises together • Patient therapy session is saved to the database
Comments	

Use Case	View Patient Statistics
Actors	Therapist
Description	Therapist selects a patient from Patient List page and sees session stats. Patient's results file is pulled and graphs created from this data
Data	.txt results file
Precondition	<ul style="list-style-type: none">• Therapist is logged in• Therapist is on the patient list page• Therapist has a patient who has completed at least one exercise
Stimulus	Therapist selects a patient on the Patient List page
Response	<ul style="list-style-type: none">• View Patient page is opened• Webpage shows patients therapy results• Results can be sorted using dates and exercises• Results are shown according to reps completion and time taken to finish exercises
Comments	



Use Case	Log on
Actors	Patient
Description	The application authenticates the patient and proceeds to the main screen after synchronizing with the main database.
Data	User name, Password
Preconditions	<ul style="list-style-type: none"> • Kinect application installed on computer. • Patient has registered a username and password with therapist. • Patient has a computer capable of running the Kinect application. • Patient has a Kinect.
Stimulus	Patient starts the Kinect application.
Response	<ul style="list-style-type: none"> • Patient inputs a username and password. • The application checks the internet connection. • If there is internet connection, the application checks the username and password against the hash stored in the online database. • If the username and password is correct, according to the online database, the application syncs results and therapy sessions with the main database and directs the patient to the main page of the application. • Else, the patient is prompted to enter a correct username and password and the application remains on the logon page.
Comments	

Use Case	Complete Therapy Session
Actors	Patient
Description	Patient selects and performs exercises in the currently assigned therapy session.
Data	.gbd exercise files, online database session table
Preconditions	<ul style="list-style-type: none"> • Patient is successfully logged into the application and is present on the session select screen.
Stimulus	Patient logs in successfully.
Response	<ul style="list-style-type: none"> • Application displays a screen with the current, active session. • If this is either already completed or not available, the application will inform the patient that all current sessions are either complete or expired. • Application checks the local list of .gbd files against the current active session. If a .gbd file is found in the session that is not present in the local list, the application attempts to connect to the database of exercises and download the required .gbd file. • Patient selects an exercise from the current, active session. • Application displays the exercise screen. • Patient performs the exercise. • Application tracks each rep that the patient performs. • When the patient completes the exercise, how quickly the exercise was performed is recorded.
Comments	

Use Case	View Statistics
Actors	Patient
Description	Patient views overall progress by month in terms of repetitions completed and time take to complete exercises.
Data	Online database results table
Preconditions	<ul style="list-style-type: none"> • Patient is successfully logged into the application and is present on the session select screen. • Patient has completed at least one session on this computer. <ul style="list-style-type: none"> • AND • Application has synced with the online database
Stimulus	<p>Patient clicks on the Stats button, selects month, type of result and exercise.</p> <p style="text-align: center;">OR</p> <p>Patient inputs a date into the search bar.</p>
Response	<ul style="list-style-type: none"> • Application selects all exercise results that match the selection for that month • Application displays the graph with the y-column being number of reps performed, or time taken for completion, and the x-column being the due dates of therapy sessions. • Application displays time taken in seconds or completed reps out of total reps over each point in the graph
Comments	

Use Case	Online Login
Actors	Patient
Description	Patient accesses therapy results via the website.
Data	Username, Password
Preconditions	<ul style="list-style-type: none">• Patient has registered a username and password with therapist.• Patient has internet access.
Stimulus	Patient navigates to the website URL.
Response	<ul style="list-style-type: none">• Patient inputs username and password.• The website checks these against the online database.• If the username and password are correct, the patient is redirected to the patient page.• If the username and password are incorrect, the patient is prompted to input a valid username and password.
Comments	

Use Case	View Results
Actors	Patient
Description	Patient views selected therapy results on the website.
Data	Online Database
Preconditions	<ul style="list-style-type: none"> • Patient is successfully logged into the website.
Stimulus	Patient logs into the website.
Response	<ul style="list-style-type: none"> • Website selects all therapy session results stored in the database that is tagged with that patient's id and plots a graph. • If there are no sessions in the database, the website simply displays a blank graph and informs the patient that no sessions have been saved in the database. • Website displays the graph with the y-column being number of reps performed, time taken for completion and the x-column being the dates of therapy sessions completed. By default, the graph loads displaying reps. • Website highlights the specified month on the graph and highlights the number of reps performed, time, or score, depending on the setting the patient has chosen.
Comments	