Design Document

Project Name
Project Theia
Purpose
Develop an in-clinic software that allows patients to track and manage their therapy using the Microsoft Kinect to help guide their movements. (We will focus on parkinson's initially but will design the software to allow other exercises to be "plugged in".)

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Revision History

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1.0	10/22/12	Robert Romore	Table of Contents
1.1	10/23/12	Mitchell Ehlers	Structured Document
1.2	10/23/12	Mitchell Ehlers	Intro and Design Overview
1.3	10/24/12	Robert Romore	Database Architecture
1.4	10/25/2012	Joseph Groenenboom	Assumptions and Constraints
1.5	10/25/12	Mitchell Ehlers	Application Architecture
1.6	10/26/12	Mitchell, Brian, Deven, Robert, Joseph	Added Standards Section
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2.0	12/1/12	Mitchell Ehlers	Updated document title
2.1	12/1/12	Brian Kraus	Updated Application Architecture
3.0	4/25/13	Brian Kraus	First Update for Final submission

Team: May1304

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Design Document

Introduction

Purpose

The purpose of this document is to outline the different technologies and systems we will use to create a Parkinson's Therapeutic Game with the Microsoft Kinect. If you are reading this document hoping to learn the major goals of the project, refer to the project plan document as it will give you all the initial project definitions. This document is an expansion of the project plan (see Appendix for project plan).

Scope

In this design document we will highlight lower level detail on what technologies we will use to store user data, provide a web interface to therapy clinic, programming languages that will be used to develop the game and interface, and what the system flow will be like from a high level user point of view.

Document Organization

Audience

This document will be used by our team to help formulate a more exact process of implementing this project. It will also be used by next year's senior design team as they prepare to add more theory games to our interface or improve our parkinson game. Our advisor and professor will also be reviewing this document.

Requirements

Our client has given the following functional requirements:
1. The system shall track moving objects to see if the patient hit them.
2. The cognitive load placed on the patient during an exercise must be low.
3. The system must provide performance based feedback to the patient.

The following are additional requirements that we believe will aid in the completion of the project:
1. The system will provide patient data to the client.
2. Exercise data will be transmitted to a database.
3. The system will include a web interface for data delivery to researchers.

Our non-functional requirements follow:
1. The patient data must be stored securely.
2. The system needs to remain stable throughout an exercise session.
3. The exercise system needs to be extensible.

Design Overview

This system will comprise of four main areas ….
1. The game
2. Client interface
3. Caregiver web interface
4. Data repository.

The game

The game will be programmed using the Microsoft Kinect to track patients movements. To do this we will be using the following.

- Microsoft Kinects for Windows SDK
  - Hardware requirements for PC:
    - 32 bit (x86) or 64 bit (x64) processor
    - Dual-core 2.66-GHz or faster processor
    - Dedicated USB 2.0 bus
    - 2 GB RAM
- XNA Game Studio 4.0
- Microsoft Visual Studio 2010

- Maybe adding to this as we begin development.

This game's goal is to be used a therapeutic exercise of parkinson's patients. For it to be effective we will have users make quick movement to grab falling objects (this according to our client for the project Dr. Smiley-Oyen). The user will score points for grabbing or catching these falling objects. The falling objects will not fall randomly as this will allows researchers of parkinson's to easily observe if a patient's movements are improving by viewing that data for multiple attempts the patient had.

Patient interface

The client interface is where the game will be plugged into. It will also contain other options such as a planner in which a caregiver can plan what games the user is to play on certain days. The objective of the client interface is to make the system modular, so in the future other teams with this project can add more games easily.

Caregiver web interface

The mission of this web interface is to allow a caregiver of a patient to be able to log into the system from anywhere and look at game data for their patients. This web interface will pull the patient data back from the data repository. The caregiver will also be able to schedule game sessions on a patients calendar. We also assume that our users with parkinson's will be elderly and most likely won't have a electronic calendar so we will provide a feature to print that calendar out for the patient to take home with them. This interface will really be used as a tool for the therapy to track patient game information.

Data repository

The data repository will host all user data. This will include personal information, game tracking data from kinect, and other user account data. So the schema of this database will be very important in order to provide quick retrieval. The security of this database will also be a top priority as we cannot allow unauthorized people to view patients confidential data. So will have be following the Data Encryption Standard to ensure this.

Figure 1
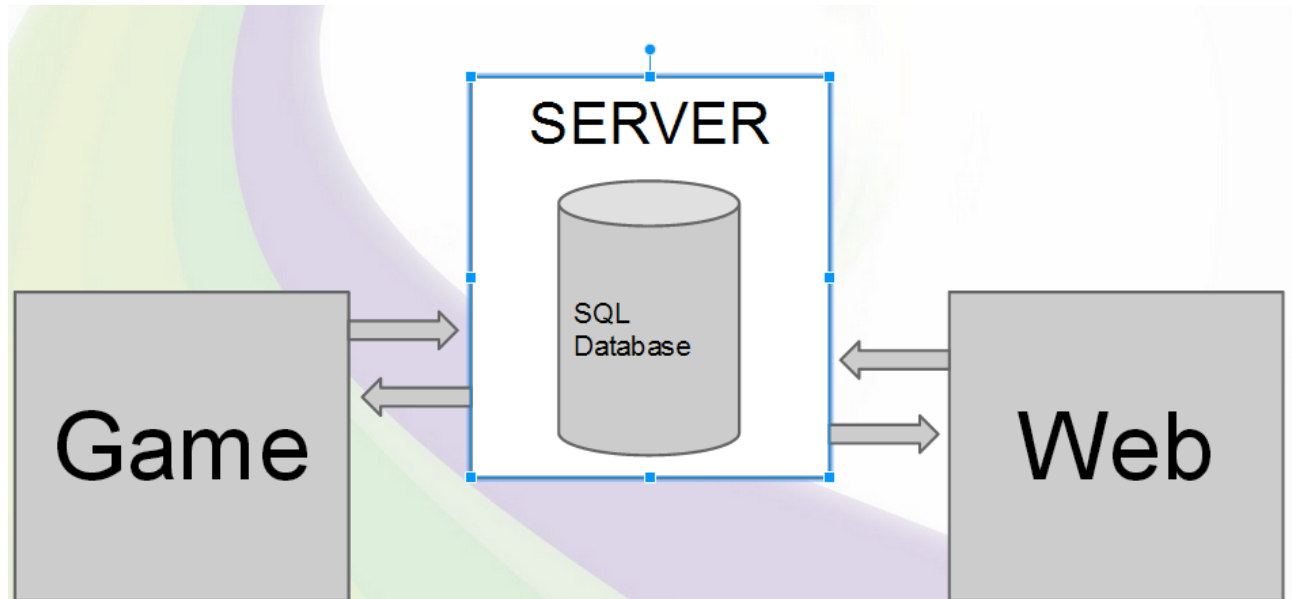
Standards

When the software is finalized it will no doubt have the ability to produce a kind of portfolio for the patient's clinic. Because such sensitive information is at risk it is important to establish a standard for protecting that data between the recording (when the patient is active with the software) and accessing (when the patient's clinic needs to view the data).

Such standards involved in the protection of an individual's physical or mental health records (referred to as protected health information or PHI) are the HIPAA and HITECH standards. The records which get involved with the software could include anything from health progress to name and address or even social security numbers. It will be important to secure this information that follows a well known standard to not only keep the patients records safe, but help in supporting security claims for the software.

From the HIPAA and HITECH documentaiton provided by Amazon Web Services (http://d36cz9buwru1tt.cloudfront.net/AWS_HIPAA_Whitepaper_Final.pdf): "HIPAA's Privacy Rule restricts uses and disclosures of PHI, creates individual rights with respect to their PHI, and mandates administrative requirements. Among other requirements, the privacy rule requires a covered entity to reasonably safeguard PHI from any intentional or unintentional use or disclosure that is in violation of the requirements of HIPAA." Even if the software becomes

internal within the clinic it is designed for, there is still the importance of establishing rights between the client and patient. Who will be accessing this information and how the information will be accessed are also important topics. In short, while the software (the actual user interface, hardware used, etc) may not necessarily follow any standards, it is important to consider the data that will be generated from the software. The HIPAA and HITECH standards are such that can be followed to protect a patient's data.

We will also be using "Standards for the Practice of Therapeutic Recreation" provided by The American Therapeutic Recreation Association. (http://atra-online.com/displaycommon.cfm?an=1&subarticlenbr=42) These standards are designed to deliver quality therapeutic recreation. Through processes such as assessments and treatment planning.

Application Architecture

This section will define the various components and their interactions within the context of the whole system. The components this section will outline are the game, patient application, caregiver web interface, and data repository.
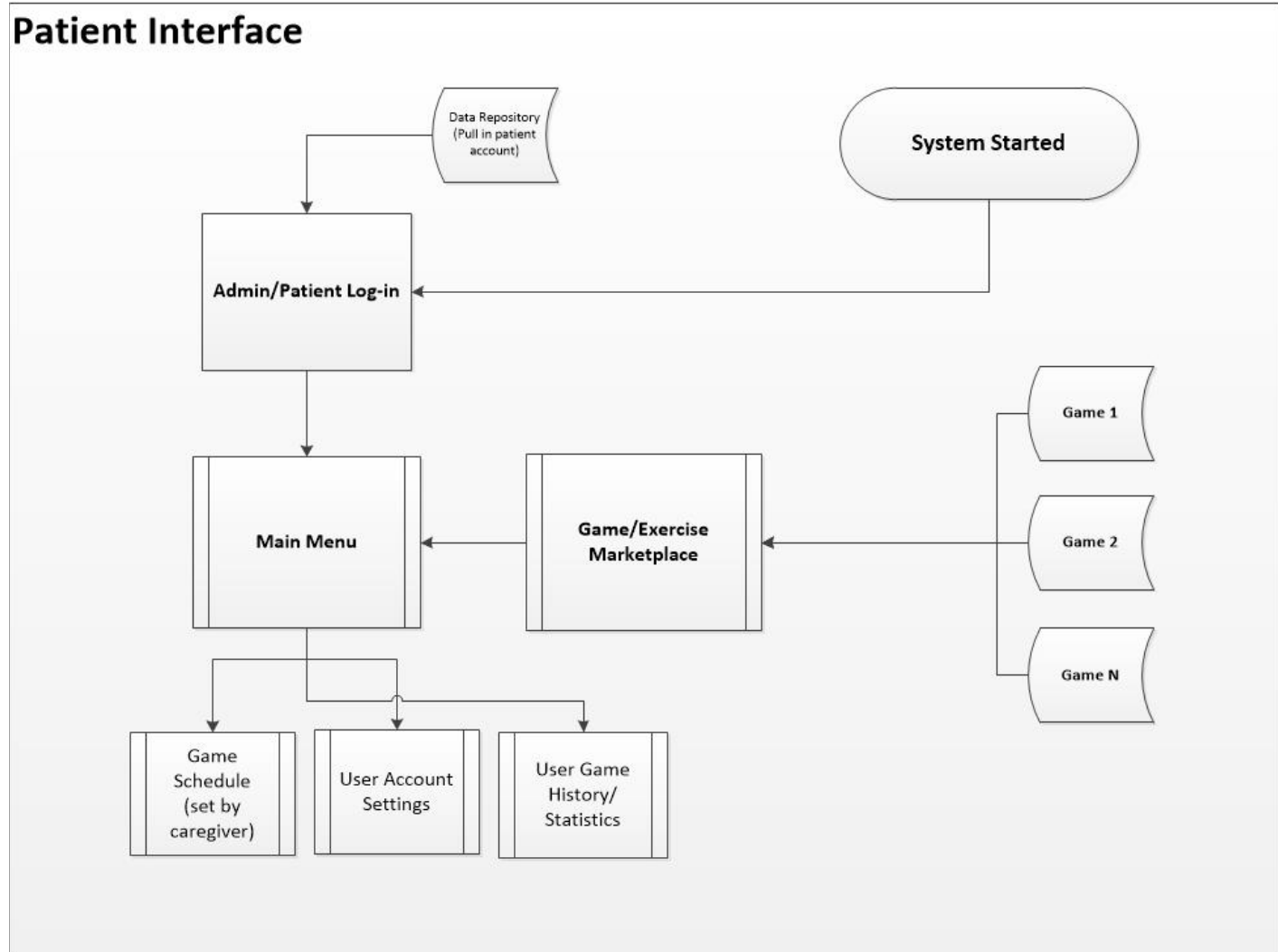
The Game (Figure 2)
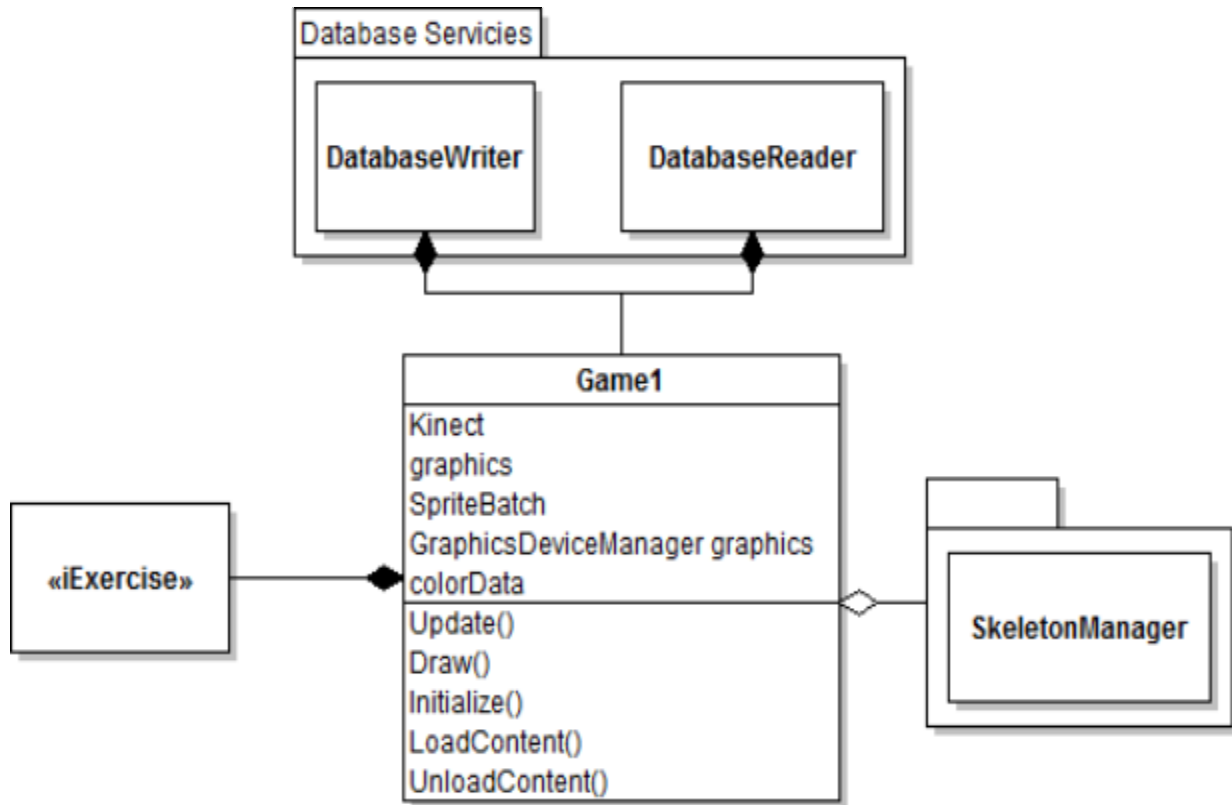
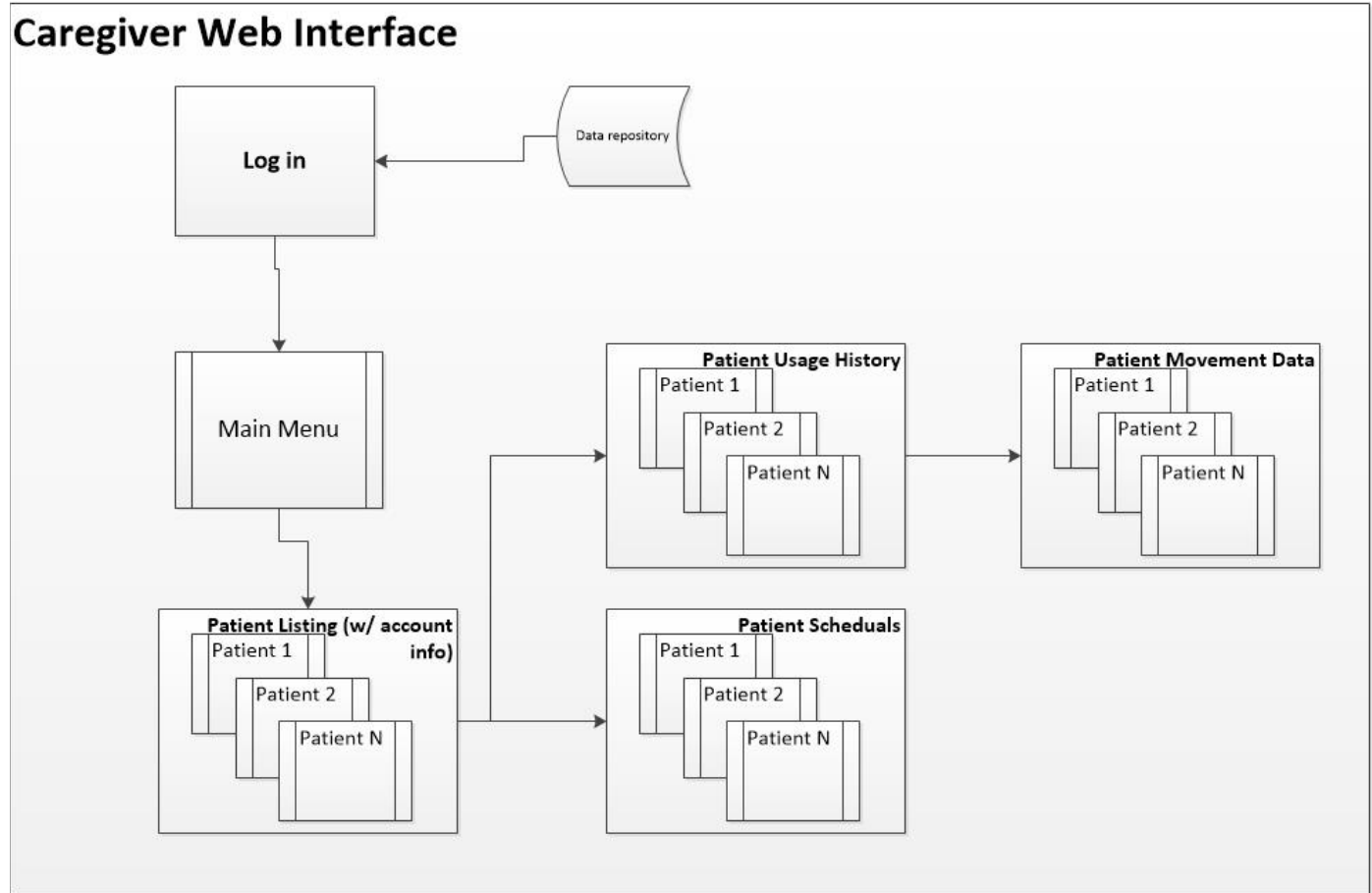**Patient Interface (Figure 3)**

(Figure 3: Caregiver Web Interface above)

Data Repository

For detail on the data repository refer to the "Database Architecture" section.

Summary

If we put these three components together we see a overall flow that is shown in figure 1 in the design overview section.

Application Implementation

Server

We will be using this server to host our web interface and central database. Our server will be running Windows Server 2012. The server will also host our central database. The database will be using SQL.

Web Interface

This is the portal for researchers to view the data we have collected. The site will be built using HTML5, jQuery, and Ajax. We will also be using the ASP.NET MVC 4 framework and C# to build the web applications. We will be using Visual Studio 2010 when building this.

Application:

The application itself will be built using the XNA game development framework. We will be getting input from the Kinect via the Natural User Interface (NUI) API that is provided with the Kinect SDK. We will be building the application using Visual Studio 2010 and C#.
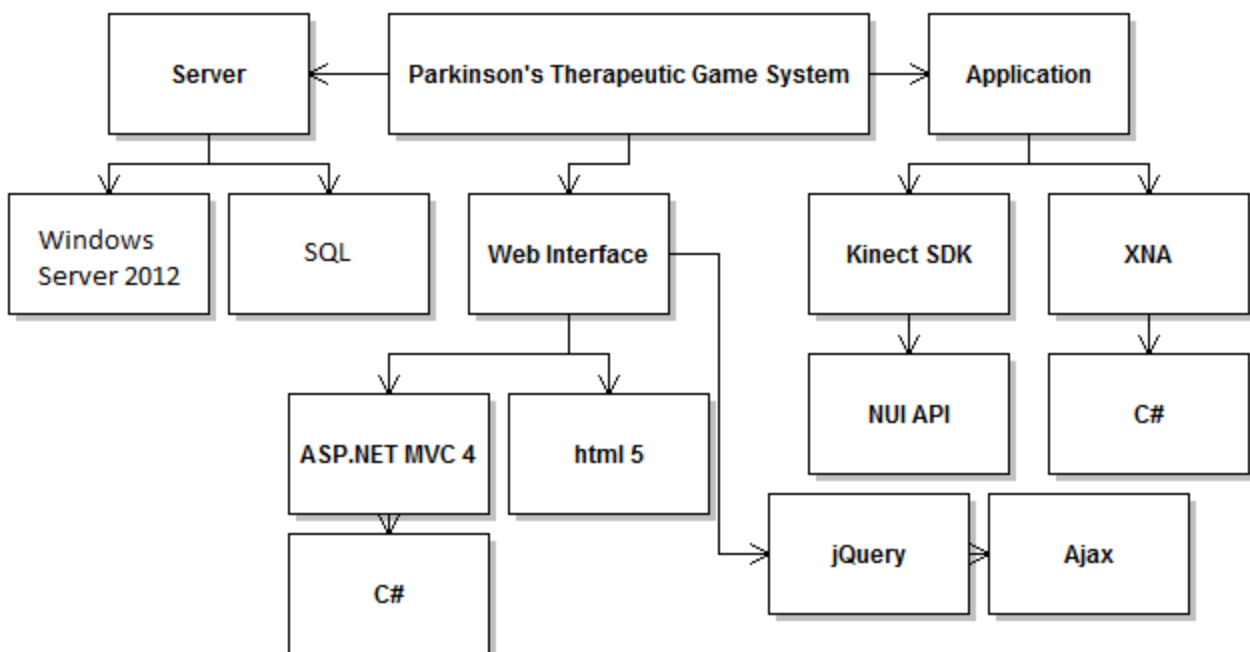
Database Architecture

The project will use a database to store patient information, exercise data tracking information, a schedule of exercises as determined by the physician, and exercise results for future review by physical therapists. Other information that needs to be stored will be discussed with the client(s) at a later date. As such, this database architecture design is not final.

For the database backend, the project will use MySQL.

Data Model
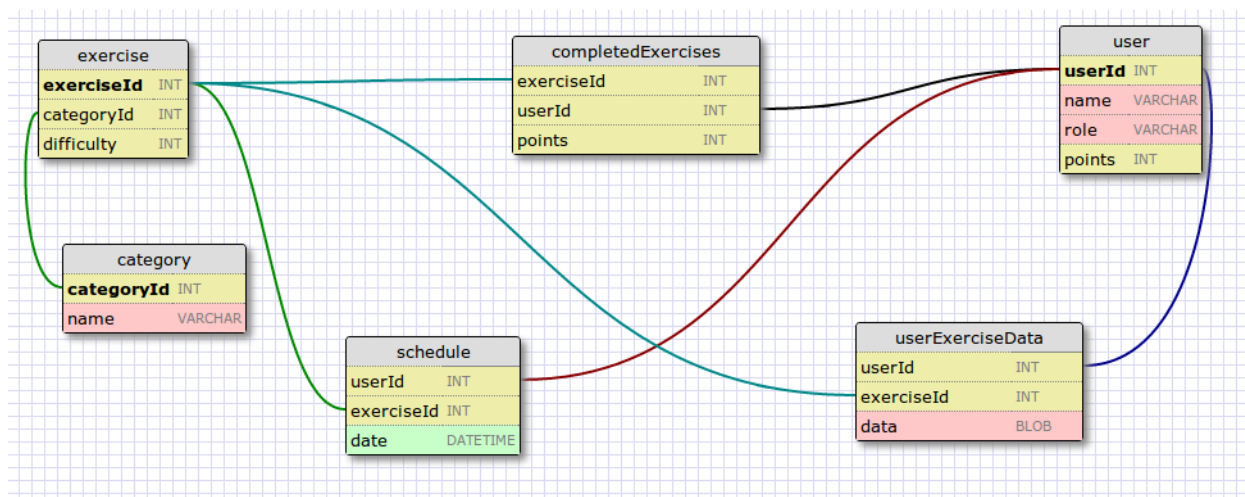
Data Model Explained

Exercises will be stored in the 'exercise' table, each with a unique identifier. Exercises will be associated with a category, stored in the 'category' table, which identifies which exercise category each exercise will belong to.

Users will be stored in the 'user' table, each with a unique identifier, a name, a role (either a patient or a caregiver), and the amount of points they have collected. A user's exercise data for each exercise will be stored in the 'userExerciseData' table, each with a userId associated with the user, an 'exerciseId' associated with the exercise, and the data representing a set of points the user generated throughout the exercise. This set of points will allow caregivers to resimulate the patient's movements throughout the exercise in order to more effectively study and draw conclusions concerning the patient.

Caregivers will also have the ability to schedule exercises for their patients, stored in the 'schedule' table. Each scheduled exercise is identified by a unique user and exercise identifier, as well as a date on which the exercise needs to be completed.

Team: May1304

Assumptions and Constraints

In the construction of this project we have made the following assumptions:
- Both Kinect for XBox and Kinect for PC will work with the code base.
- Kinect technology will be commonplace for the lifetime of the project.
- The Kinect will give accurate enough data to be useful in research.

These assumptions will impact the feasibility and longevity of the project. The ability of clients to use the project depends on the availability of the Kinect. Additionally, the Kinect comes in two varieties. The Kinect for XBox is much more common as of this point. The most critical assumption is the last one. One of the focuses of the client is gathering research data. The system has yet to be tested in a clinic and we assume that the system will function in the intended installation setting.

Additionally we have to operate under the following constraints:
- The software must have a low learning curve.
- The software must be able to be installed in a variety of locations.
- The cost must be kept low relative to standard therapeutic supplies.
- Data gathering requires an internet connection.

As stipulated by the client, the software must be able to be used by people experiencing different stages of Parkinson's disease. As such, the exercises must have a low level of complexity and must not require remembering large amounts of information. The goal of this project is to increase the availability of therapy for Parkinson's disease and provide more data for researchers to use. For this to happen the project must be able to be installed in a variety of locations for wide distribution. Also related to distribution the cost must be kept low so it is more accessible to clinics and possibly individuals (at some point in the future). Lastly any user of the project must have an internet connection for automated data gathering.

Appendix

Project Plan

Project Name
Project Theia
Purpose
Develop an in clinic software that allows patients to track and manage their therapy using the Microsoft Kinect to help guide their movements. (We will focus on parkinson's initially but will design the software to allow other exercises to be "plugged in".)

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Prepared by:
- Robert Romore
- Joseph Groenenboom
- Mitchell Ehlers
- Deven Starn
- Brain Kraus

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- 09/28/2012

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Revision History

Version	Date	Author(s)	Revision Notes
1.0	9/24/12	Mitchell Ehlers	Started first draft
1.1	9/25/12	Mitchell Ehlers	Edited first draft
1.2	9/27/12	Joseph Groenenboom	Edited assumptions
1.3	9/27/12	Deven Starn	Edited assumptions
1.4	9/28/12	Mitchell Ehlers, Joseph Groenenboom, Deven Starn, Brian Kraus	Revised draft
1.5	12/1/12	Mitchell Ehlers	Updated project name
1.6	4/25/12	Mitchell Ehlers	Finalized document

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Project Plan

Project Overview and Product Description

The goal of this project is to design a software solution that allows therapists, researchers, doctors and caregivers to track patients therapeutic exercises by using the Microsoft Kinect for Windows. Using the Kinect we will turn the therapeutic exercises into games that encourage the patient through their exercises. We will focus on a game for Parkinson's disease with the desire to be able to plug in games for other therapies/illness in the future.

We will not only add to the Exsolvo (Phase 1) of this project but to re-imagine how this project will be use by patients leading to a commercially useable product.

Exsolvo reference links:
- http://exsolvo.wordpress.com/
- http://www.youtube.com/watch?v=rOwwA-nFZVk&feature=youtu.be

The Kinect will encourage the patient as they play their therapeutic game, tracking how the patient moves and share that information with their caregiver. The physician can set a weekly schedule to help patient keep on track with their therapy.

Initially we will focus just on Parkinsons diseases for now, but the software will be designed in a manner to allow other therapeutic games for other therapies to be added (think of these games like apps we all download to our mobile devices).

Project Theia website:
- http://seniord.ece.iastate.edu/may1304/

Current State and Business Case

We will build off the Exsolvo project from the last senior design team to create a commercially useable product. So far we have met with our advisors and client to gather requirements for the project. The requirements for the therapeutic game as of 9/25/12 are …

- Game allows for quick movements, such as grabbing falling objects.
- Use a point system to encourage the patient.
- Make sure game uses simple, safe movements for the patient.
- Record patient game scores/data back to caregiver/researchers.

These requirements are very high level but do give us an idea of what the therapeutic game should be like to accommodate parkinson's patients.

The business case here is once this software is fully developed, it could be made commercially available for clinics to purchase and have available at a relatively cheap cost to have available for their patients.

Objectives - Desired Future State

We hope by the end of our teams time with this project we have created a commercial grade software that allows patients to do therapeutic exercises. As we pass it over to the next senior design team we hope that they can investigate other therapeutic games that would be useful in the marketplace.

Scope and Domain

The project will support parkinson's disease patients. It will have a therapeutic game that tracks movement and then share that information automatically with the patient's caregiver, via a web interface.

Out of Scope

We hope next year's senior design team can design a variety of exercise/therapeutic "apps" that can be plugged into our interface. This would most likely require next years team to design a marketplace for users to browse for other exercise/therapeutic apps for them to download.

Assumptions, Dependencies and Constraints

Assumptions:
- We assume that we can reuse code from the Exsolvo project.
- We assume that the Exsolvo project will work with both Kinect for PC and Kinect for Xbox 360

Dependencies:
- Dependent on the capabilities of the Kinetics systems for recording movement data.

Constraints:

- We are limited by the capabilities of the Kinetic's system. Kinect for PC has the following recommended setup.
    - Windows 7 or higher.
    - 32 bit or 64 bit
    - Dual-core 2.66-GHz or faster processor
    - Dedicated USB 2.0 bus
    - 2 GB RAM

Project Members Roles

The Team:

- Robert Romore : User Interface Design, Advisor to Dr. Smiley-Oyen
- Joseph Groenenboom: Data Analysis, Project Manager
- Mitchell Ehlers: Game Design, Advisor to Dr. Rover
- Deven Starn: Web Design, Webmaster (of team site)
- Brain Kraus: Game Design, Advisor to Shawn Hanson

Advisors:

- Shawn Hanson (Microsoft)
- Professor Diane Rover (Iowa State University, Computer Engineering)

Client:

- Dr. Smiley-Oyen (Iowa State University, Kinesiology)

Project Organization

Timeline:
1. Obtain workspace in Senior Design Lab. - 10/1/2012
2. Experiment with the Exsolvo product to determine what code we want to use from this phase 1 of the project. - 10/12/2012
3. Refine project charter to reflect observations from experiments with Exsolvo. - 10/19/2012
4. Work on a high level design document that reflect what systems we want to use and how they will communicate with each other. - 10/26/2012
5. Review design document with client and refine to reflect clients thoughts. - 11/5/2012
6. Work on a low level design document. - 11/9/2012
7. Begin implement the main interface of the software. - 12/14/2012
8. Move into Spring 2013 semester, CprE 492. - 1/7/2012

9. Falling ball exercise fully implemented. (task assigned to Brain and Mitchell). - 4/22/13
10. Web interface implemented. (task assigned to Deven). - 4/1/13
11. User Interface implemented. (task assigned to Robert). - 4/22/13
12. Data score screen implemented. (task assigned to Joseph) - 4/22/13
13. Update all documentation for next project iteration. - 5/3/13
14. Prepare presentation for Industry Review Board. - 5/3/13

Design
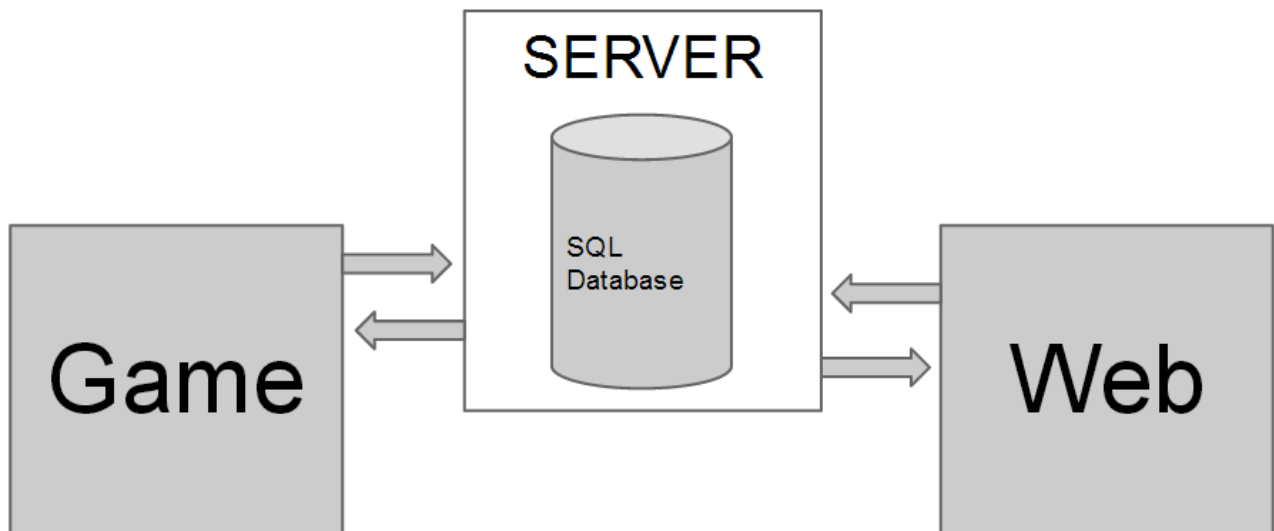
Major Deliverables (High Level Requirements)

- A software interface that allows for a Parkinson's therapeutic game to be plugged in. The intentend for this interface is to allow other exercises/games to be added at a later date.
- Documentation that clearly states how to add exercises/games to our software interface.
- A web interface that allows caregivers to log in and view data (game scores) for their patients from a central repository.

Estimated Cost, Effort and Duration

Cost:
- Kinects (2-3) at $109.99 (at bestbuy.com) for Xbox Kinect or $250 for the Kinect for Windows
- For financial support we have our Microsoft contact Shawn Hanson and our Iowa State

advisor Dr. Diane Rover.

Effort and Duration:
- We expect in order for this project to be successful it will require great dedication and organization. It will be important to stick to our timeline in order to meet our objectives.
- The project will encompass the 2012-2013 Iowa State school year.

Future Work

As this project moves forward we would expect a number of features to be added and some existing to be refined. This section will first quickly outline what was accomplished from 2012-2013, then discuss what the future work.

2012-2013 Accomplishments:
- Game UI completed.
- Falling ball exercise complete (speech recognition exercise integrated into exercise).
- Web Interface completed.
- Virtual server and database built.

Future Work:
- Calibration exercise: This exercise would initialize the Kinect to it could calibrate to the specific person playing the game. The patient would be sitting or standing in front of the Kinect. Next they would attempt to extend their arms fully. Based on that extension the Falling ball exercise (or another exercise) could adjust the difficulty of the exercise base on the Calibration exercise.
- Create stretching exercise: A stretching exercise would test the patients ability to hold a position. For example we would like to challenge the patient to reach for a stationary target and hold that stretched out position of 20-30 seconds then move on to another target.
- Fine tune speech recognition capabilities: Our client, Dr. Smiley-Oyen, would like the speech recognition part of the Falling ball exercise to be a separate exercise. Along with that, in user testing we observed that the speech capabilities of the Kinect and Microsoft Speech Platform weren't good with Parkinson's patients, as they have trouble speaking loudly and clearly. Solutions to fix this issue need to be researched. We suggesting more work needs to be done to make the Microsoft Speech Platform to be more sensitive or may the use of a another microphone to clip on the shirt of the patient.
- Add exercise settings control from Theia Web: From Theia Web settings and exercises controls should be able to be set. This allows caregivers to control the settings for their patients using the system.

- Add user accounts: User accounts should be added. This will allows caregivers to manage their patients and control the settings for their exercise settings (this will be discussed below). The goal of user accounts is to provide a easy way to monitor and control exercise patient data for caregivers.

Approvals

_____   _____   _____
Name   **Title**   **Date**

_____   _____   _____
Name   **Title**   **Date**