Home Exercise Coach

CS 489 Human Augmentics - Final Project

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MOTIVATION

The goal of this project was to create an at-home exercise system that would track the user’s movements and provide feedback if they were performing the exercises incorrectly. There is tremendous demand for at-home physical exercise systems. The home gym is a staple in many American households. However, it is also almost a cliche punchline that these gyms often fall into disuse. Sustaining the motivation to complete an exercise program is beyond the capabilities of the self-control for many. To address this, the industry of personal training has arisen. People like having the immediate feedback, external motivation, and an objective accountability that a personal trainer provides. However, many can’t afford the exorbitant fees associated with hiring a personal trainer.

Our system attempts to combine the best of both worlds in an approachable package. We aim to provide real time feedback, motivation, and accountability at an affordable price to a user within the comfort of their own home.

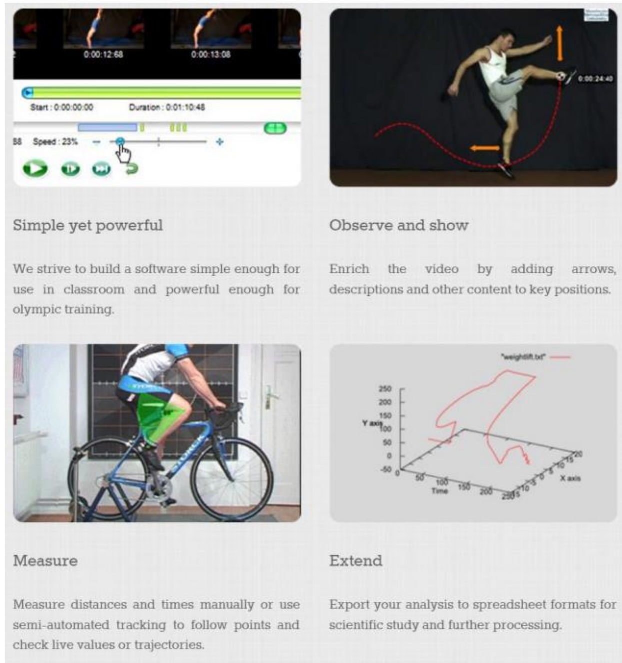
LITERATURE REVIEW

Beyond physical exercise, there is a medical motivation for this solution as well. Physical therapy compliance is an issue that has plagued physical therapists since the inception of the profession. In a 1993 study examining why patients fail to comply with their prescribed physical therapy regimens, researchers found that there were two major factors patients reported. The first was about the barriers that the patient perceives. Specifically, lack of time and access was seen as the largest barriers. The other factor patients most commonly complained about was the lack of positive feedback.

So what has worked in this space? A 2013 study examined the motivation associated with a home-based Wii Fit exercise routine. They found that the interactivity and immersion that the Wii provided contributed to enjoyment being the most prevalent theme for the participants.

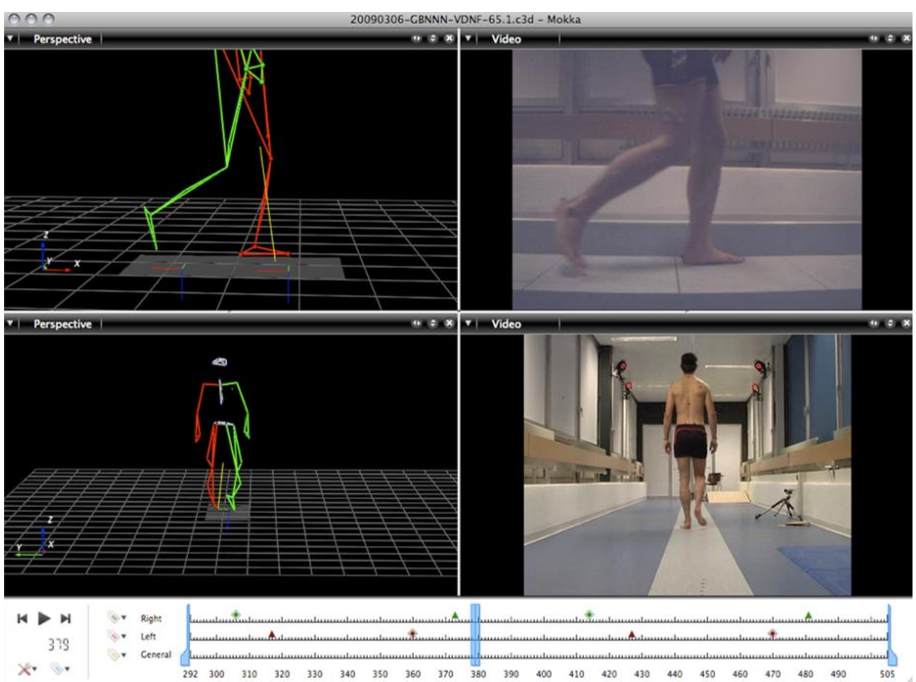
At first, we wanted to keep the system free from additional equipment and run the application on the user’s smartphone or laptop. However, we were unable to find any software systems that could track a human subject in real time through these cameras. The different software applications we tried were Mokka, Kinovea, and SkillSpectors. Mokka requires a C3D file, which is an industry standard and difficult to obtain. Obviously, because it requires a specific filetype, it is also not able to provide real time analysis. Kinovea looked very attractive at the beginning, but ultimately would only work with XML video files which also means that it wasn’t able to provide real time analysis. SkillSpector was just another software application that analyzed video.

Kinovea



Mokka

Motion kinematic & kinetic analyzer

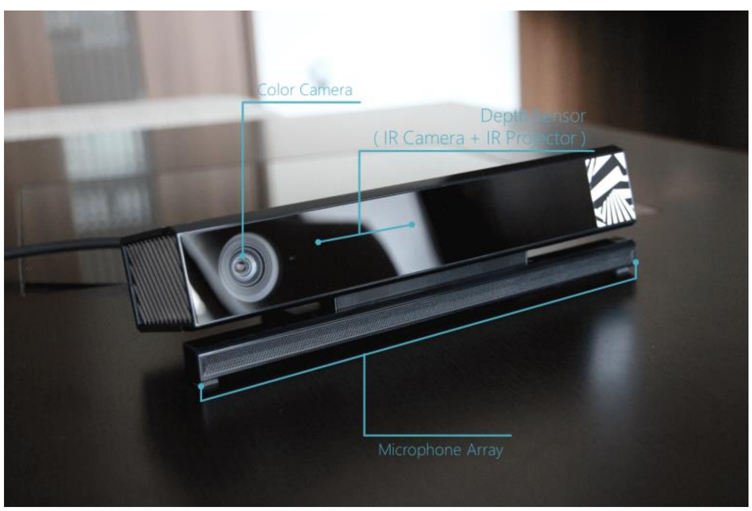


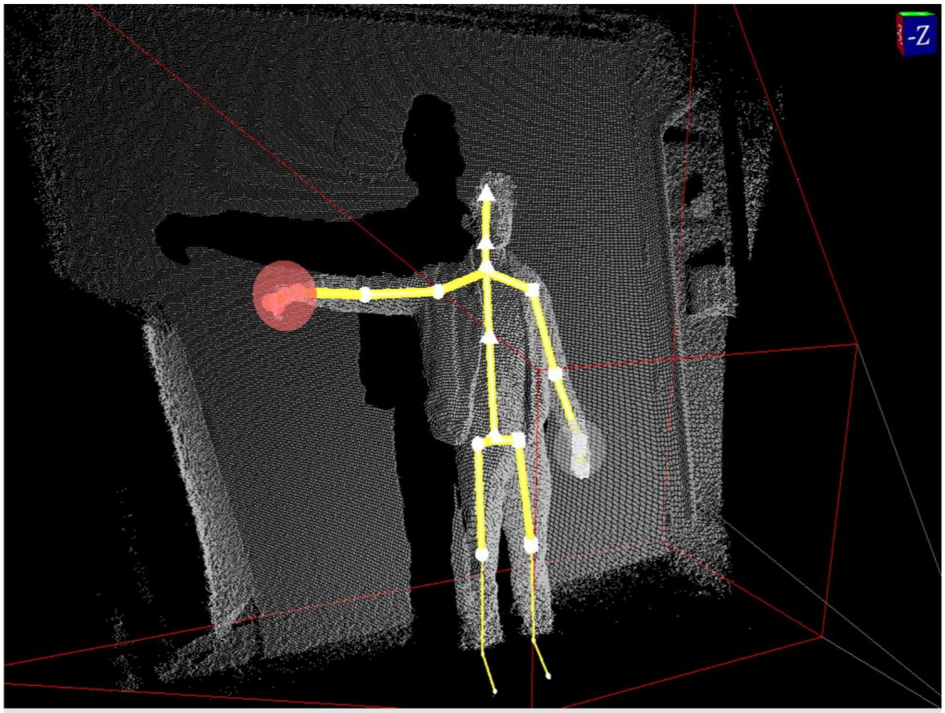
DESIGN CONSIDERATIONS

Due to these restraints, we decided to incorporate an Xbox Kinect into our solution. The Kinect comes with many developer tools that can track specific joints and limb positions in real time and in three dimensional space. While the real time analysis was the main reason we decided to pivot to the Kinect platform, the three dimensional tracking was a tremendous asset to have access to as well.

The first decision we made was to pick an exercise to use as our proof-of-concept. We wanted to keep it to a single movement of a single limb to keep things as simple as possible. We also wanted it to be a large, gross movement instead of something more delicate such as minute finger manipulations. Finally, we wanted to have it grounded on a medical necessity. For all of these reasons, we decided to start by tracking scapular plane elevation, also known as scaption. Scaption is a rehabilitation exercise for rotator cuff strain, which is one of the most common conditions afflicting the shoulder. By checking the coordinates of the shoulder and the wrist, we were able to program the Kinect to output a beep when the shoulder and wrist were at the same height (i.e. the arm is straight and at a 90°). Later, we wanted add an additional exercise and wanted to stick close to our previous constraints, but with enough changes to ensure that we were verifying the efficacy of the bounds of our product.

Initially we were working with Kinect v1 but eventually we have adopted Kinect v2 in our project. The main reason behind this decision is robust and accurate skeleton tracking of v2 compared to v1. There are also some advanced features like face recognition and dense depth estimation which could be leveraged by our application to decrease false positives and to increase the productivity.

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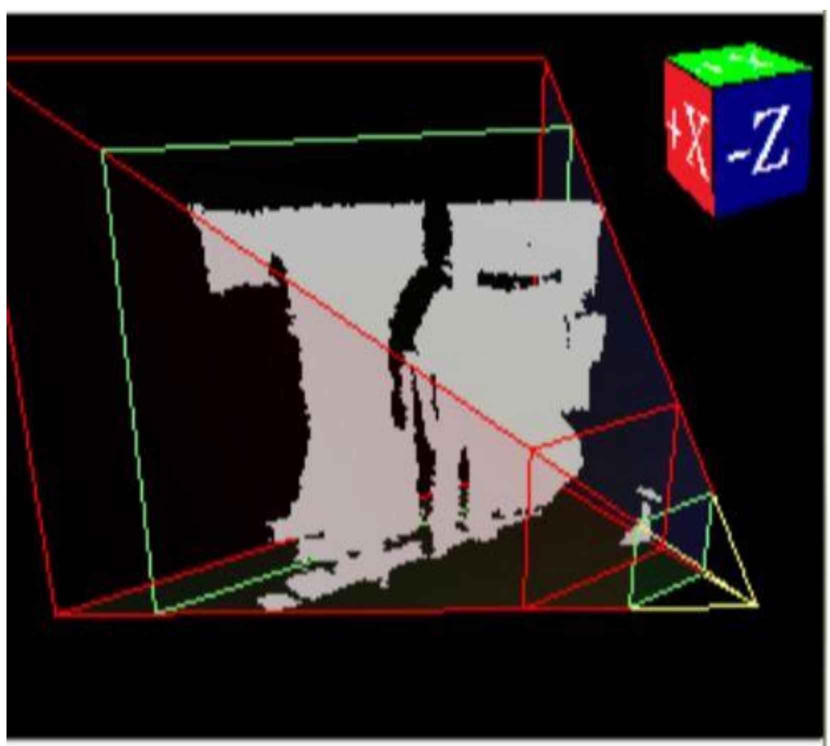
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IMPLEMENTATION

Overview

C# / .Net was used as the backend framework in this project. Already existing open source code base (Body basics) was used to build our application. Our application tracks the body motions of the user and determines whether the user is appropriately doing the selected exercise from the user interface.

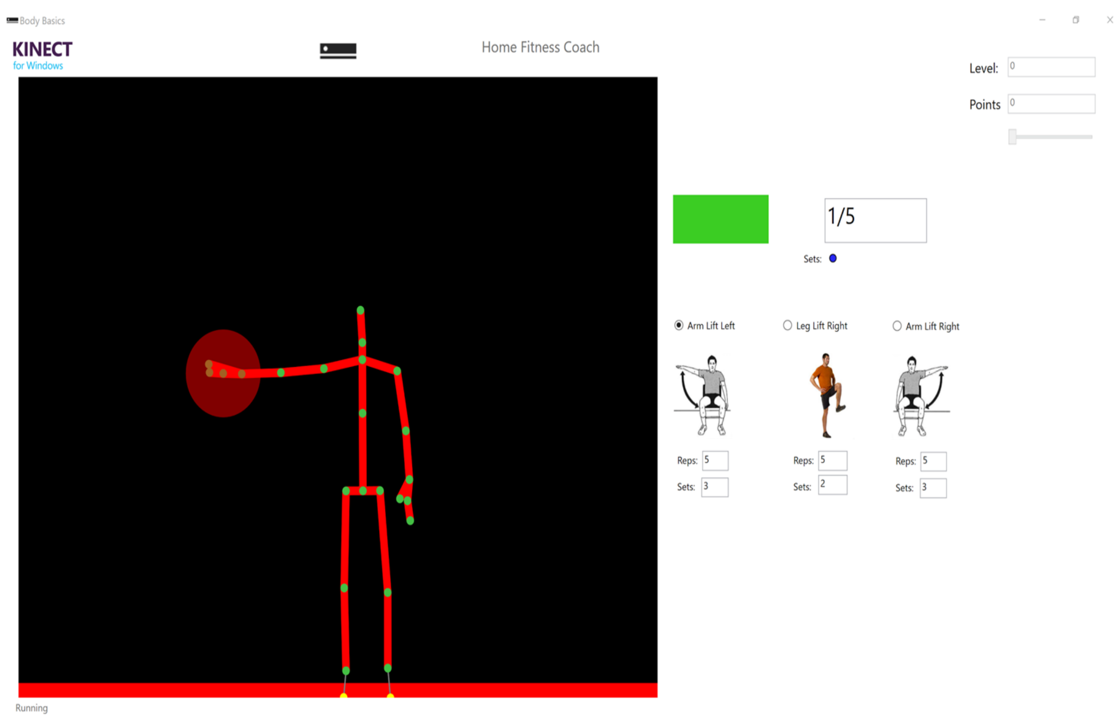
As mentioned, the application was built on the preexisting open source implementation called BodyBasics, where input data is fed via Kinect and a skeleton image was generated as the output. Source code from bodybasics was modified accordingly to calculate joint angles and the thresholds to make sure that the selected exercises are done precisely.

Underlying implementation of Bodybasics has a Joint object defined for each physical joint and there are a predefined 26 joint objects for 26 joints of human body, for example, the code has a right arm joint object which corresponds to the right arm of the user.

Each joint object has several attributes like the x,y,z direction of the corresponding physical joint, which can be used to calculate the appropriate angles of body parts and this information is fed into the program to check whether the posture made by the user is a valid posture or not and based on this information the user profile is updated

Graphical User Interface Overview

User interface mainly consists of a list of exercises from which the user can select from. User can manually set the reps and sets counter. It also displays the current level and points of the user.



Generic Algorithm Overview

- Find the appropriate joints for each exercise
- Calculate the appropriate angles based on the joint object
- Based on the selected exercise check whether the appropriate joint angles are within a certain range.
- Based on the check, the user gets a feedback (both audio and visual) whether or not the exercise was done correctly.
- If the exercise was done correctly increment the reps counter, once the rep counter reaches a certain threshold increment the set counter.
- This continues until a certain predetermined number of times (user defined) and then an achievement is unlocked.

FUTURE WORK

- Generate a user profile associated by the face (by recognizing the face) for each user and coach so that the coach could see and set the required exercises.
- Unlocking different avatars based on the user profile ratings.
- Make the experience more interesting by introducing gamification, by incorporating games in to normal exercise routines (for example the user can play hole in the wall game where the holes that we display are specific to an exercise routine that the user has selected).
- Unlocking licensed exercise routines by collaborating with expert coaches in that discipline.

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