**Neural Nets and 3D Mapping of Human Motion**

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**Problem Statement:**

For this capstone project, we will be leveraging developments in the fields of computer vision to improve upon current technological developments in the fitness industry (as well as healthcare industry) that make use of motion-sensing technology.

***Natural User Interfaces:*** The goal of a lot of developments in human-computer interaction is make these interactions more intuitive and require less technical training for human users. In other words, developers want to build technology that adapts/learns human behavior rather than the other way around. Due to this goal, there has been several technological developments focused on creating “natural user interfaces” (NUI) – especially in the video/computer game industry. Some of these initial developments focused on a more tactile approach to building NUIs (e.g. Perceptive Pixel, Microsoft PixelSense, and 3D Immersive Touch). These interfaces rely on physical contact between the user and the computer interface. On the other hand, there have been several developments of NUIs which use motion-sensing instead of the tactile approach (e.g., Nintendo’s Wii Remote, Xbox Kinect). Recently, there has been a focus on improving the video/computer gaming experience by using 3D mapping based on video input to incorporate the user’s motions into the action of the game (similar to the concept of virtual reality).

***Developments in 3D Skeletal Mapping***: In the recent decade, computer vision researcher have been working on models which could infer internal skeletal structure (i.e., discerning joint placement and angles to classify poses) from static and active sources (i.e., from pictures and video). Much of this research has been focused on classification tasks. The researchers are either trying to identify the pose or gesture of the subject (i.e., trying to identify what the subject is doing) or identifying a specific subject (e.g., combining facial recognition and gait analysis). Additionally, there has been a focus on the application of neural networks in creating 3D maps of human poses (e.g., DeepPose project at Google).

These technological developments have huge potential impact on increasing access to fitness and health resources. There are many people who do not have the financial situation or the geographic proximity which would enable them to utilize fitness resources such as physical trainers or physical therapists. This access problem has started to be addressed by the creation of video games which are fitness-focused. 3D skeletal mapping has been utilized by some NUIs in the context of fitness programs enabling people exercising at home to determine if they are correctly following the exercise instructions at home in the absence of an in-person instructor. However, these applications require the use of specific equipment containing only a single camera. The requirement of specific equipment drives up the cost of these video fitness programs and the use of the single camera makes it difficult to correctly determine depth (which is crucial for accurate skeletal mapping). These programs also only inform the user of how accurately they are matching the instructor. They do not provide a way for users to measure their progress towards a goal or when they are in danger of injury.

**Research Purpose:**

We plan to build a tool which would extract skeleton position information using a model which incorporates video from multiple sources using generic video cameras. We will then develop a distance metric which would allow us to compare different skeletal positions to determine a person’s distance from the ideal/goal position as well as the rate and degree in change in their gait and posture. Additionally, we would incorporate a warning system that would alert users when they are in danger of injury.

***Use Cases:***

1. A person is undergoing a physical training program. They would decide with a trainer their goal physical shape. They would then use the tool to make sure they are correctly and safely following instructions, as well as, tracking their progress towards their goals. Being able to track their progress will enable them to determine the effectiveness of their training program and enable them to make corrective changes to their program.
2. A person is given a set of exercises to do at home by the physical therapist. Our tool could help people at home make sure that they are performing the exercises correctly. It could also be used to measure level of improvement by the therapist (comparing the patient's distance from their original posture situation to their current posture situation and their current posture situation to the goal posture situation).

**Research Questions/Goals:**

1. Build a deep learning neural net model of a single human which can map posture and gait.
2. What is the best method for combining incoming video streams from multiple cameras? How will the neural net account for differences in angles and depth
3. Which distance metric should be used to compare skeletal positions?
4. How do we best model injury risk situations based on skeletal positions?

**Business development questions:**

1. How large is the target market for skeletal tracking technology?
2. What is the expected valued added for businesses and chiropractic office?
3. What kinds of competing products are already in the market?
4. What is the profit/revenue trajectory of a product like skeletal tracking?
5. What are the expected costs of developing and implementing skeletal tracking technology ?
6. What is the optimal strategy of prototyping, developing, and commercializing skeletal tracking technology?