



Introduction

Squatting is a very popular compound exercise and has a multitude of benefits. However, most people performing a squat do not execute the exercise adequately, hence not optimizing their results whilst risking injury. A 'good squat' can be difficult for an individual to quantify, let alone realize any issues with their squat without an external source. Using computer vision and sensors, we hope to resolve this issue.

Computer Vision

Computer vision enables computers to interpret and understand visual information from the world. It involves the development of algorithms and techniques that allow computers to extract meaningful insights from images and videos.

Computer Vision Elements

- Two camera system
- Individual and stereo calibration of cameras
- Mediapipe landmarks
- Angular and positional calculations
- Feedback and analysis based off angular data calculations from landmarks focusing on:
 - Angle of both knees
 - Both knee's landmark position with respect to the toe's landmark
 - Chest position
- Caters for both squats and split-squats
- Two methods of identifying when a squat has been completed and hence count the quality of squats:
 - Trained Convolutional Neural Network (CNN) model
 - Using angular and positional calculations of landmarks
- Footage from both cameras is recorded
- Angular data saved with timestamps to an Excel file
- Excel to python plotting script developed for further data analysis

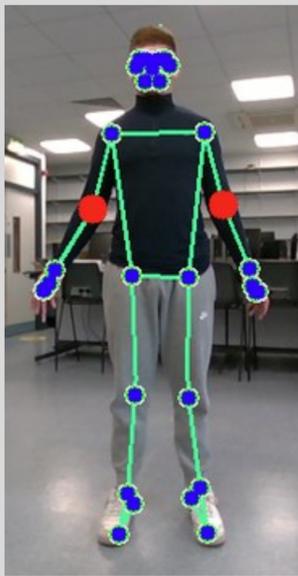


Figure 1.1: Landmarks predicting body parts accurately

Aims

- Investigate the use of two different types of sensing systems in order to determine if a person is doing an unweighted squat exercise correctly.
- Develop a classifier list that will use a machine learning algorithm to detect when a squat exercise is being performed incorrectly and identify where the errors lie.
- Use wireless accelerometer and gyroscopic sensors to measure acceleration and relative angular motion of limbs and joints.

ShimmerIMU

As seen in figure 1.2, this is the device used for collecting data. This device is an inertial measurement unit that contains an accelerometer to measure acceleration and a gyroscope to measure to angular change of limbs and joints. This data is monitored and managed via the Consensys software.



Figure 1.2: ShimmerIMU unit placed on knee

Data Collection

Various tests were conducted to collect data on categorizing a good squat and a bad squat. Four units were placed on the following locations for testing:

- Chest
- Base of back (5th Lumbar)
- Knee
- Ankle

The data categories gathered are as follows:

- Good Squats
- Bad Squats:
 - Knee Flaring Inside and Outside
 - Chest Falling Forward
 - Hip Twisting Left and Right
 - Knee Going Beyond Toe

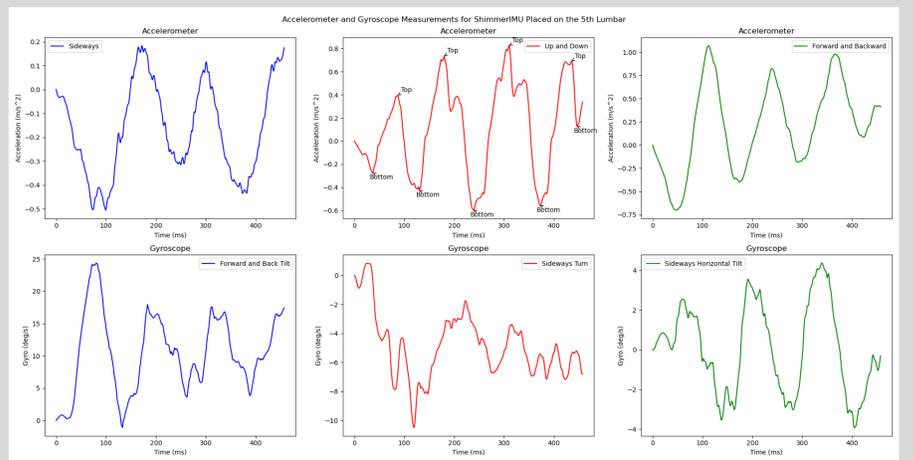


Figure 1.3: Data for a 'good squat' placed on 5th lumbar

Computer Vision Method

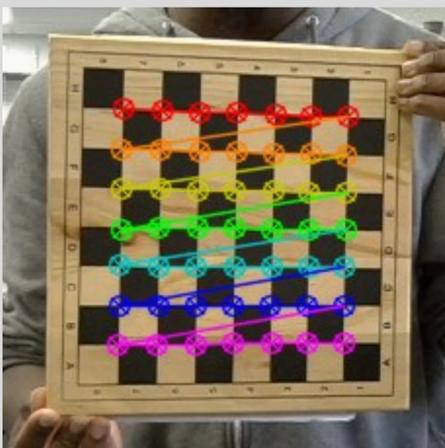


Figure 1.4: Camera Calibration

In figure 1.4, it can be observed how the camera calibration works. Calibrating the cameras allows for a better quality of image and hence a better performance of the computer vision. Both cameras look for patterns to translate the 3D world into a 2D image.



Figure 1.5: Squat Analysis and Feedback

In figure 1.5, the squat analysis and feedback now begins. The landmarks make estimations to points on your body, angular and positional calculations are made and data is exported to an Excel file. This also gives real-time feedback.



Conclusion

- Successfully developed a classifier list using computer vision to identify when a squat has been completed, classify it, give real-time feedback and export data for analysis.
- Obtained valuable data via ShimmerIMU to build a catalogue of good squatting examples and various types of bad squatting examples.
- Developed additional features for the computer vision system for a more enhanced and accurate experience.

Future Work

- Implement the system for other types of exercises and provide additional feedback.
- Train a Recurrent Neural Network (RNN) model to identify when an exercise has been complete for better accuracy.

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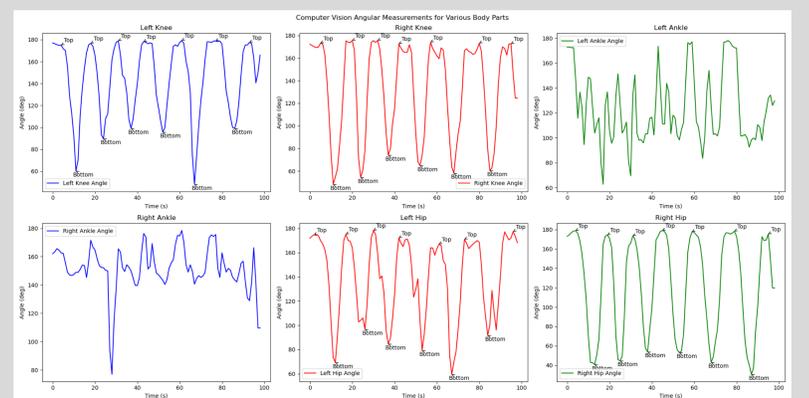


Figure 1.6: Computer Vision Data Graph

Finally, figure 1.6 represents the data obtained through the computer vision angular measurements, using the landmarks.