**Summary of Research Papers**

**1. Applying Pose Estimation to Predict Amateur Golf Swing Performance Using Edge Processing**

* Contains information about setting up the camera and the shot. “Down the line” angle view.
* Used TensorFlow’s PoseNet
* No formulae mentioned
* The varying methods of capture resulted in swing pose accuracies from 20% to 81.1%.
* Limitations of a bad dataset causing high inaccuracies (low lighting conditions and lack of data to identify ‘bad swings’)

The general process for collecting the data and analysing the results are:

1. Video data of a swing from a down range camera position is collected

2. Video is converted to individual frames

3. PoseNet machine learning model is run on the frames on the TPU

4. Frame-by-frame pose positions are collected

5. Data is smoothed using a Savitzky-Golay Filter to help minimize sudden changes caused by PoseNet inaccuracies

6. Critical points in the swing and their associated frames are found using the feature table below

**Golf Swing Actions:**

\_ P1- Address

\_ P2- Club shaft parallel with ground on takeaway

\_ P3- Lead arm parallel with ground

\_ P4- Top of backswing

\_ P5- Lead arm parallel with ground on downswing

\_ P6- Club shaft parallel with ground on downswing

\_ P7- Impact

\_ P8- Club shaft parallel with ground on follow-through

\_ P9- Trail arm parallel with ground on follow-through

\_ P10- Finish

**2. Accurate and Efficient 3D Human Pose Estimation Algorithm using Single Depth Images for Pose Analysis in Golf** (Unrelated to our needs)

-Uses Kinect and Vicon motion capture systems, not mobile phone cameras

-7 Swing Actions

-Uses Decision Trees

**3. How Can I Swing Like Pro? Golf Swing Analysis Tool for Self Training**

-Uses 2 Videos:

* An expert’s swing
* A beginner’s swing

Compares the two to find differences.

Summarized:

* Easier for us as we have an expert’s swing being analyzed by the machine and not us as ‘outsiders to golf’
* The frames are synchronized using TCC (Temporal Cycle-Consistency) as the 2 videos can have different timings for the swings
* Uses the difference between latent vectors to calculate how close the swings are to each other
* Pearson’s correlation value is calculated for the elbow, shoulder, neck, head, wrist, spine, knee, foot, hip, and the whole body.
* HRNet and simple linear network with Procrustes to allow users to visually recognize the difference in motion between them and the expert   
  -**Database** used: GolfDB which contains 1400 vids of experienced swingers.
* The pose of the golf club is also considered for the swings

**4. Golf Swing Correction Based on Deep Learning Body Posture Recognition** (Best suited to our needs)

* Uses OpenPose to detect key points and calculates arm angle, wrist distance, hand distance, displacement of the nose, leg angle and spine line features.
* Most of these use simple formulae utilizing Euclidean distance alongside the change in coordinates with an interval of a few frames.
* All the formulae used are included in the report.
* There are a few formulae to fix misdetections too.
* The accuracy is at 98.7% without misdetection fixes, with a sample size of 25,000 and with the misdetection fixes, the accuracy is at 99.9%.

**Golf Swing Actions:** setup frame, back-swing frame, top frame, release frame, hit frame, foreswing frame, and closing frame

**5. Human Pose Estimation for Training Assistance: A Systematic Literature Review**A general context of HPE usage for Exercising.

* Motion blur, ambiguity between the poses and loose fitting clothing can cause misdetections
* Uses Belief Propagation algorithm to estimate pose samples
* Applied trained randomized decision trees to associate each pixel with a particular bone segment for labelling.
* Shape Context is used to extract features and compare query images against the dataset samples.
* Human Mesh Recovery to reconstruct a full 3D mesh of a human body