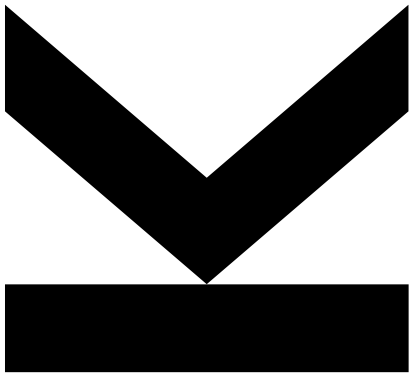
Institute of
Pervasive Computing

Classifying Lifting Movements Based on Height and Weight



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Data Preprocessing & Analysis

- Removed metadata
- Removed columns not crucially important for my classification task
- Labeled each file with which weight and height was used
- Created artificial data for training and tests based on acquired data (using noise)

	Name	Skeleton_25_marker:Head	Skeleton_25_marker:Head	Skeleton_25_marker:Head	Skeleton_25_marker:Head	Skeleton_25_marker:I
		Rotation	Rotation	Rotation	Rotation	Position
Frame	Time (Seconds)	X	Y	Z	W	X
0	0.000000	0.338051	0.701408	-0.261631	0.570349	-96.959770
1	0.008333	0.337889	0.701179	-0.261275	0.570889	-97.037704
2	0.016667	0.337505	0.701169	-0.261027	0.571241	-97.029961
3	0.025000	0.337291	0.700959	-0.260681	0.571784	-97.085304
4	0.033333	0.337045	0.700645	-0.260521	0.572386	-97.044609
5	0.041667	0.336882	0.700365	-0.260233	0.572956	-97.024895
6	0.050000	0.336717	0.700004	-0.260033	0.573584	-96.977043
7	0.058333	0.336602	0.699702	-0.259827	0.574114	-96.878571

Image 1: Example of how the preprocessed data looks like

I made some visualisations of the data gathered to make it clear what I am working with, recognise some patterns and to compare. The next two slides will show two of my visualisations and some comments to them.

- When an uncomfortable way of picking up or incorrect posture/grip then the lines appear to be more chaotic. (ex.: 1,1; 1,4;2,3; 3,1)

- The more comfortable object grip and weight, the less movement detected on different body parts (ex.: 2,2 compare with 3,4 or 1,4 compare with 2,4)

- Heavier objects appear to be more difficult to get a good grip before picking up

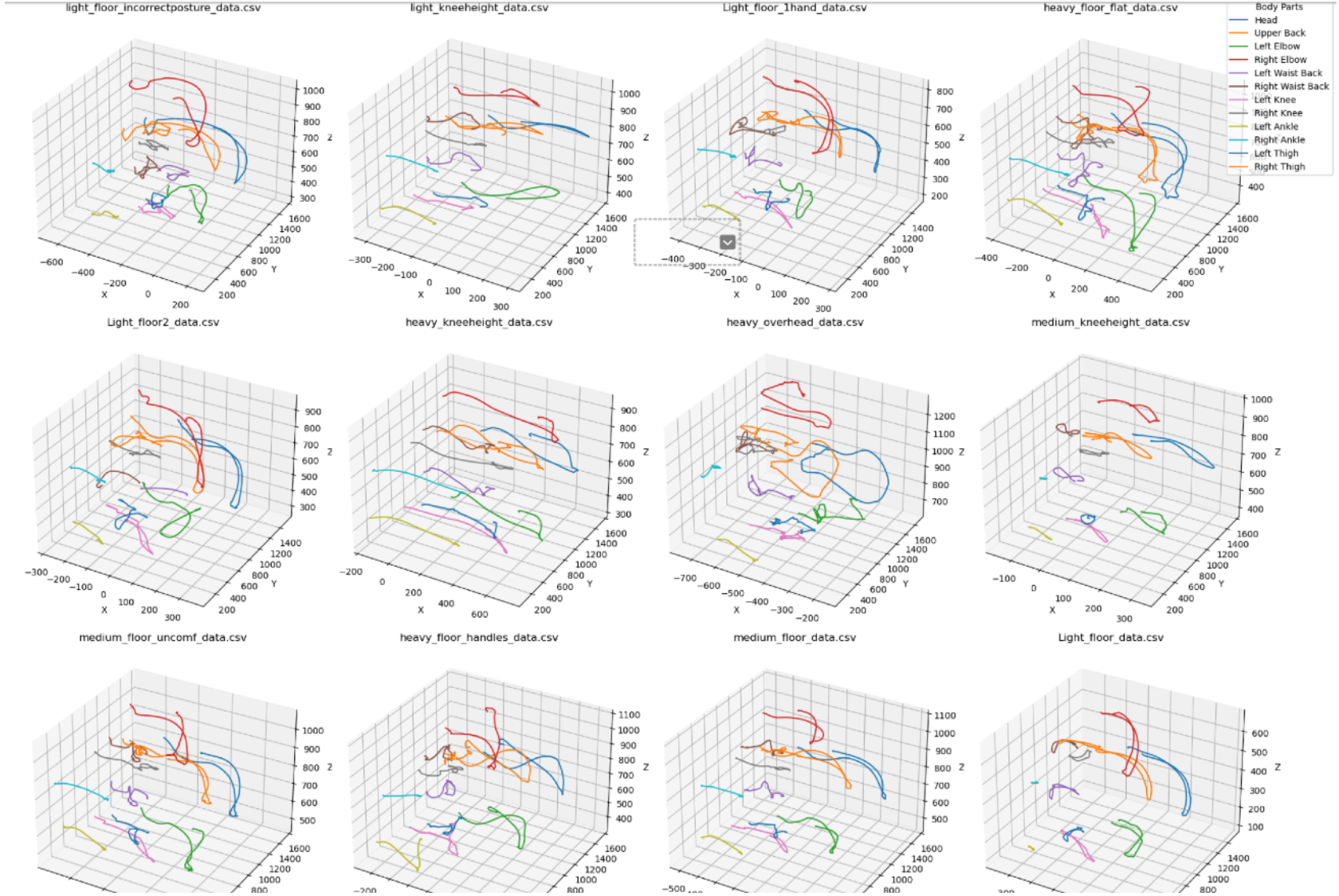

Image 2: Visualisation of marker movements through time

- Heavier objects / objects picked up uncomfortably have longer time under smaller angle
- Start/Stop position 160-170 degrees, pick-up point 90-110 degrees (depending on item size, height where object was placed)
- Angle change not completely smooth. It is jittery because, in my opinion, of micro adjustments throughout the pick-up motion (Heavier objects require more micro adjustments), could be just noise

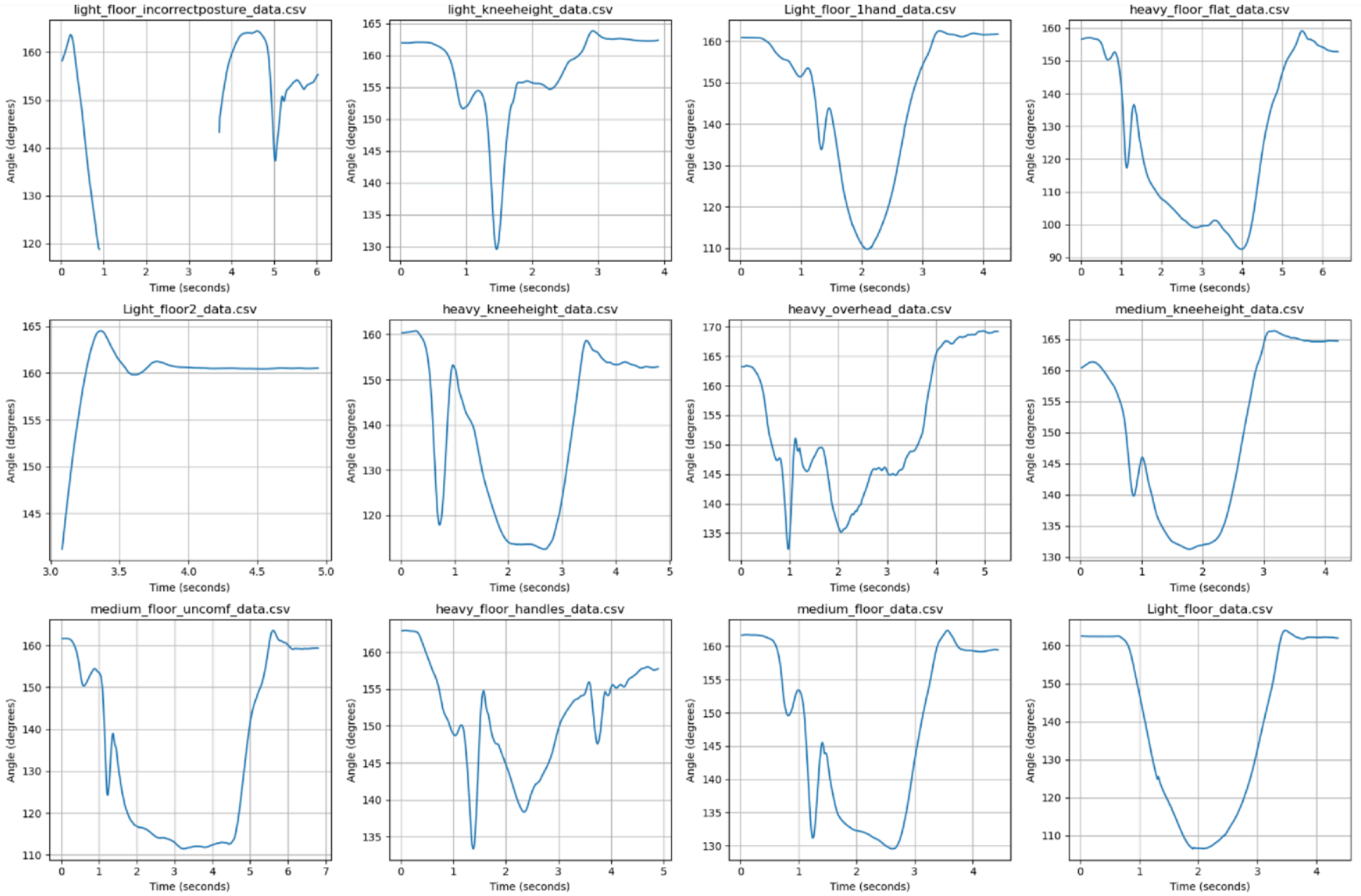

Image 3: Hip-Knee-Ankle angle changes through time

Model Creation & Results

- Created additional data files for training and test sets based on gathered data (48 in total, 12 original, 36 artificial created with noise, used: 10 train and 10 test)
- Random Forest Classifier used: several reasons to this, namely well-suited for high-dimensional data; it is capable of capturing complex, non-linear relationships in the data (ex.: motion data positions can be non-linear); robustness to overfitting
- Changes in angle between Hip, Knee, Ankle was used and the overall changes in the X, Y, Z of each Optitrack marker.
- Force calculation of a body part (in my case knee). Formula for force: $F = m * a$, where $a(t) = \frac{\Delta v}{\Delta t} = \frac{v(t) - v(t-1)}{t - (t-1)}$
- The model performs a classification task, predicting the weight of the object picked up and height of pick-up from the passed on data
- For the test set I got the following results:

```
Weight Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.75      0.86         4
           1       1.00      1.00      1.00         3
           2       0.75      1.00      0.86         3

    accuracy                           0.90        10
   macro avg       0.92      0.92      0.90        10
weighted avg       0.93      0.90      0.90        10

Height Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         7
           1       1.00      1.00      1.00         3

    accuracy                           1.00        10
   macro avg       1.00      1.00      1.00        10
weighted avg       1.00      1.00      1.00        10

Weight Classification Accuracy: 0.9
Height Classification Accuracy: 1.0

Pair Accuracy of Correct Weight and Height Predictions: 0.90
```

File	Predicted Weight	Actual Weight	Weight Correct	Predicted Height	Actual Height	Height Correct
medium_floor_uncomf_data_artificial_3.csv	medium	medium	TRUE	floor	floor	TRUE
heavy_floor_handles_data_artificial_1.csv	heavy	heavy	TRUE	floor	floor	TRUE
heavy_floor_flat_data.csv	medium	heavy	FALSE	floor	floor	TRUE
Light_floor2_data.csv	light	light	TRUE	floor	floor	TRUE
medium_kneeheight_data_artificial_2.csv	medium	medium	TRUE	not_floor	not_floor	TRUE
medium_floor_data_artificial_1.csv	medium	medium	TRUE	floor	floor	TRUE
Light_floor2_data_artificial_1.csv	light	light	TRUE	floor	floor	TRUE
heavy_floor_overhead_data_artificial_1.csv	heavy	heavy	TRUE	floor	floor	TRUE
heavy_kneeheight_data_artificial_2.csv	heavy	heavy	TRUE	not_floor	not_floor	TRUE
light_kneeheight_data_artificial_2.csv	light	light	TRUE	not_floor	not_floor	TRUE

Using the Model

- Model saved to pickle file (.pkl)
- Add raw Optitrack data to specified folder
- Run the code, it will preprocess the file and then make predictions based on the loaded model and output the results
- The result can then be used to provide recommendations based on the size of object and lifting height