Optimizing Camera Locations for Efficient Human Motion Analysis

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Introduction

Optimizing efficiency, safety, and productivity are the priorities for a better workplace.
This research focuses on the optimization of camera locations for human motion analysis.

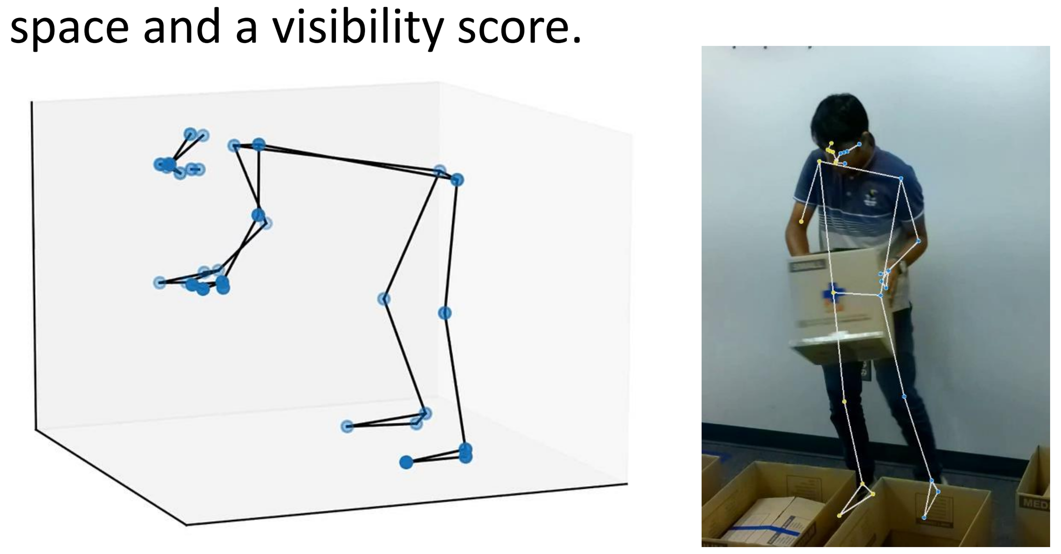
Methods

Extract human pose features from multiple camera angles.
Implement ML models to predict the current motion state.
Analyze ML outcomes and decide the best camera angles.

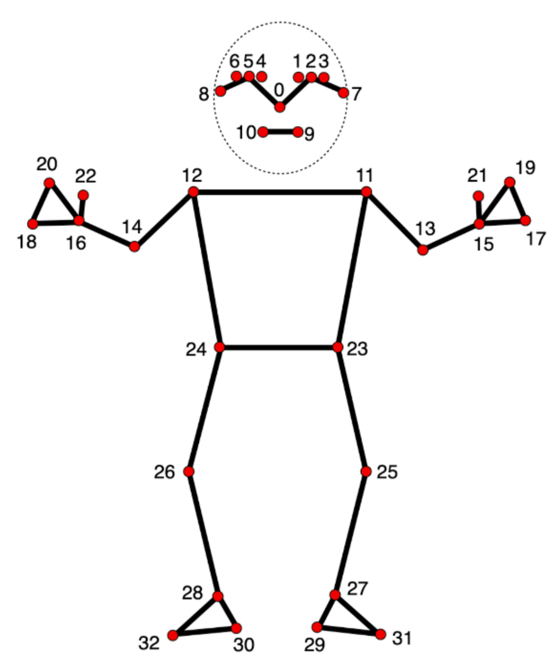
Objective: Analyze and determine which camera angle provides most useful features for ML/DL training process.

Video frames to pose features

General idea: Implement **MediaPipe Landmark** to extract 33 landmark features.
Each landmark feature include (x, y, z) coordinates in the 3D space and a visibility score.



Pose landmark extracted from video frame



List of body landmarks extracted by MediaPipe [3]

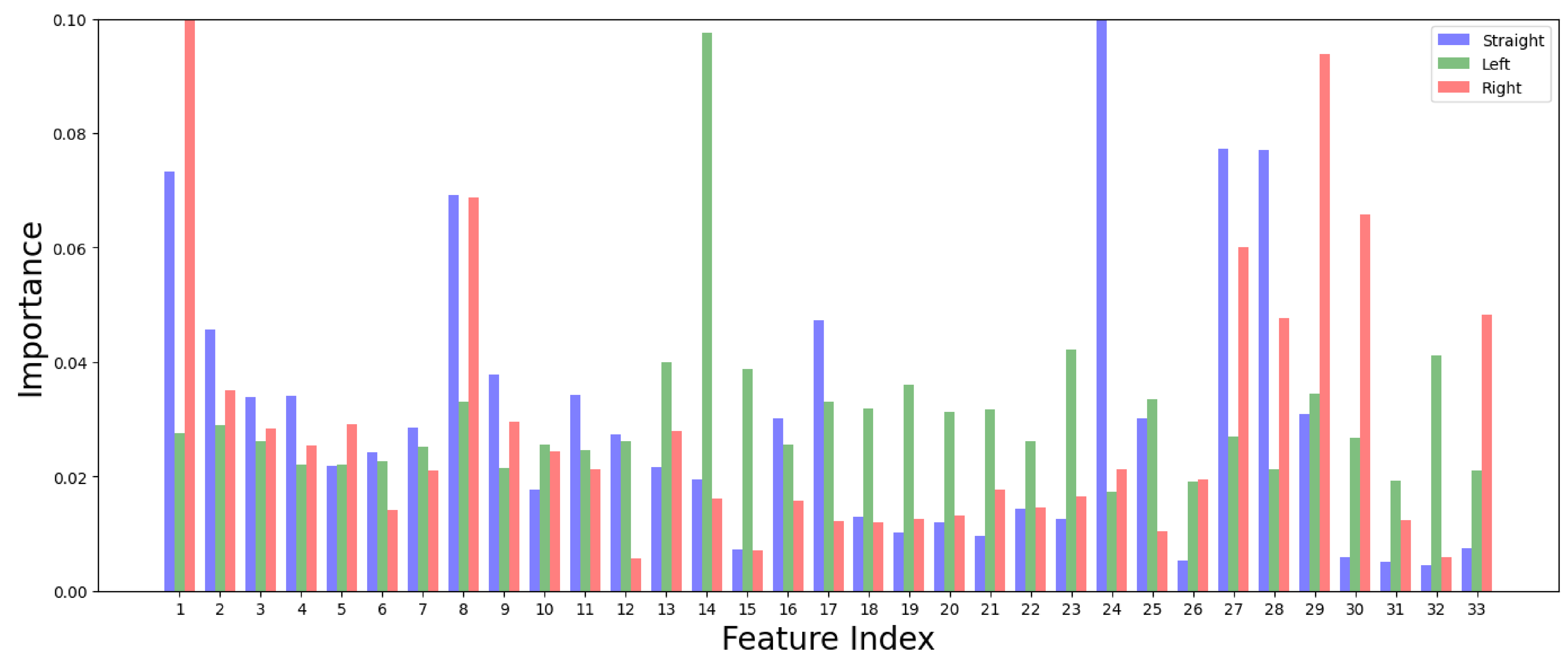
0 - nose
1 - left eye (inner)
2 - left eye
3 - left eye (outer)
4 - right eye (inner)
5 - right eye
6 - right eye (outer)
7 - left ear
8 - right ear
9 - mouth (left)
10 - mouth (right)
11 - left shoulder
12 - right shoulder
13 - left elbow
14 - right elbow
15 - left wrist
16 - right wrist
17 - left pinky
18 - right pinky
19 - left index
20 - right index
21 - left thumb
22 - right thumb
23 - left hip
24 - right hip
25 - left knee
26 - right knee
27 - left ankle
28 - right ankle
29 - left heel
30 - right heel
31 - left foot index
32 - right foot index

Preliminary Result

#	Right		Left		Straight	
training	Train	Test	Train	Test	Train	Test
data	36	36	36	36	37	37
XGBoost	0.9166		0.8611		0.8648	
CatBoost	0.9166		0.8333		0.973	
LGBM	0.5555		0.5		0.5676	
Metric in use: Accuracy (%)						

Result: Our expectation was that training with data from left or right angles would yield superior results due to the greater diversity of features available compared to data from the direct camera angle.
However, our current findings suggest that there is not much of a significant difference in accuracy between these camera angles.

Feature Importance for different Camera Angles



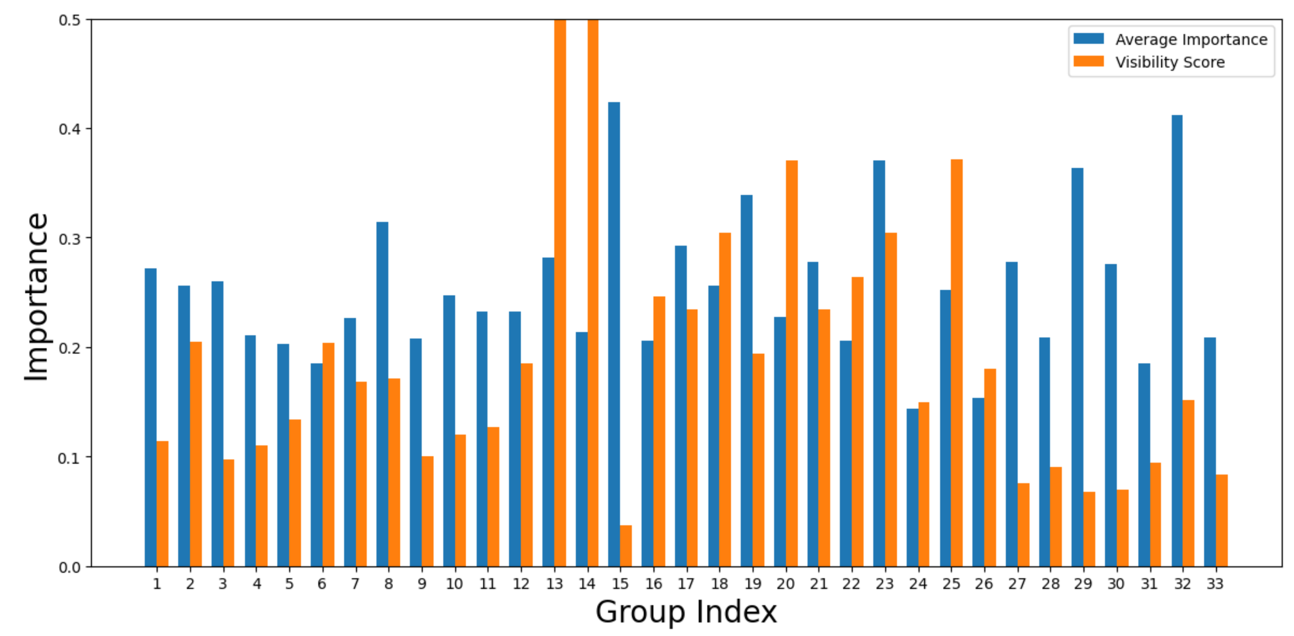
Average Feature Importance across all ML Models [1], [2], [5]

Result: Based on our analysis, some features such as eye, mouth, finger, and heel landmarks seem less significant for our model's task. Removing these features could improve model performance, *which can lay a foundational groundwork for future research in the domain of human motion quantification.*

Data Pipeline

Extract frames from video → Extract pose landmark → Standardize pose data → Construct pose embedding → Evaluate with Machine Learning models

The effect of visibility scores



Feature Importance with Visibility Scores Highlighted

Result: Based on our analysis, visibility scores may not significantly contribute to our model's inference process. Therefore, we may consider excluding them in future iterations to avoid biasing the model's inference results [1], [2], [5].

Discussions

This research provide insight on the impact of pose landmark features across multiple camera angles, ***crucial for optimizing monitoring systems in large working spaces***.
Limited data samples and the ***resource-intensive process of manual labeling*** currently constrain the differentiation between camera angles, underlining the need for further data acquisition and annotation methods.
This study lays the groundwork for enhanced monitoring of human workers, facilitating the quantification of their movements within expansive work environments, thereby improving productivity and safety measures.

Future Work

Develope and train a ***time-series model*** for sequential data analysis.
Ensure generalization of the model through ***feature selection and engineering***.
Extend the feature set by ***incorporating image features***.
Apply ***video processing and quantification methods*** to retrieve appropriate ground truth for ML models [4].

References

[1] E. K. Marsh, "XGBoost feature importance," Medium, https://medium.com/@emilykmarsh/xgboost-feature-importance-233ee27c33a4. (accessed Apr. 8, 2024).
[2] "Feature importances - Key features," CatBoost, https://catboost.ai/en/docs/features/feature-importances-calculation (accessed Apr. 9, 2024).
[3] "Pose landmark detection guide | mediapipe | google for developers," Google, https://developers.google.com/mediapipe/solutions/vision/pose_landmarker (accessed Apr. 7, 2024).
[4] S. Guo, "Manufacturing Digitalization: Video Processing and Analysis for Quality Prediction," Data Analytics & Insights in Manifacturing (DAIM), https://sites.google.com/asu.edu/shenghanguo/home (accessed Apr. 9, 2024).
[5] S. Mazza, "Feature importance in lightgbm," Medium, https://medium.com/@saverio3107/feature-importance-in-lightgbm-102592b2c482 (accessed Apr. 9, 2024).

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