One Step Ahead

Detecting Unusual Human Motions for QualityMinds

Introduction

The ability to predict human movements accurately is becoming increasingly crucial as we witness the rise of human-robot interaction and autonomous systems in various domains, such as autonomous vehicles, industrial robots, and public surveillance. As part of our project with the Data Science consultancy "QualityMinds", we had the opportunity to delve into the fascinating world of human motion prediction.

Understanding Human Motion Prediction

Human motion prediction involves predicting future human movements based on a given body position and most recent motions. QualityMinds uses advanced Deep Neural Networks to predict a person's actions, looking ahead into the future for one second. Sometimes the prediction fails and this is where our project starts.

Our Key Task and Approach

Our primary goal was to quantify anomalies in human motions, as these unusual movements pose challenges for the prediction models of QualityMinds. To achieve this, we used the Human 3.6m public dataset, which contains 3.6 million human poses.
We restructured the dataset into 180,000 motion sequences, each sequence of 35 frames. The pose of the human body in each frame is represented by the position of 32 joints in 3D space. To prepare the dataset for our models, we performed dimensionality reduction and scaling.


Then we used four distinct outlier detection models, each provided a unique perspective on identifying outlying motions. To validate our findings, we compared the prediction errors from QualityMinds' human motion prediction models with the outliers we identified. With this we proved the direct connection between outliers and failed motion predictions.

Results and Tools

There were three main results from our project, each designed to empower QualityMinds in improving their motion prediction capabilities:

Outlier Detection App

This tool presents motion sequences as data points on a scatter plot, with outliers represented as green triangles and inliers as gray circles. Users can interactively explore specific data points, accessing detailed information, such as the motion's index and underlying action for further analysis. The app offers flexible analysis scenarios, allowing users to adjust the decision score threshold to define outliers. It also facilitates comparisons of outliers and inliers across different actions, providing comprehensive insights into unusual motions.
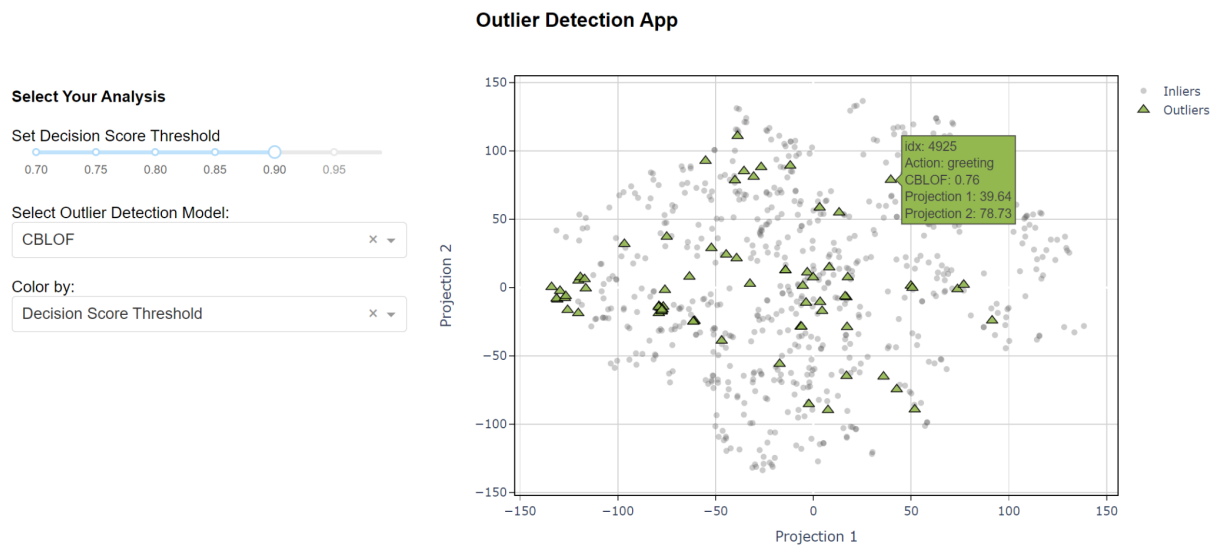

Outlier Validation App

Our second interactive plot demonstrates the correlation between a motion sequence's anomaly degree (precision score) and its prediction error. The positive correlation confirms that motions with higher decision scores are more likely to have higher prediction errors. This validates that the outliers we found indeed contribute to higher prediction errors, which was the task of our project. The app enables QualityMinds to explore specific outliers, choose different analysis scenarios, and efficiently compare precision and recall metrics.

Kinematic Comparison Toolkit

The toolkit allows QualityMinds to compare and visualize inliers and outliers for specific actions, such as walking, based on kinematic key characteristics, like joint velocity and acceleration. Understanding these nuances offers valuable insights for understanding, why observations are detected as outliers.
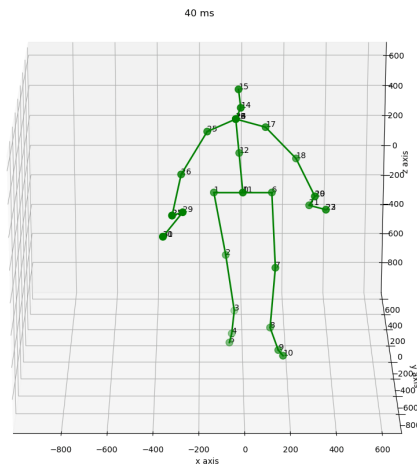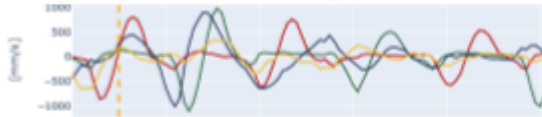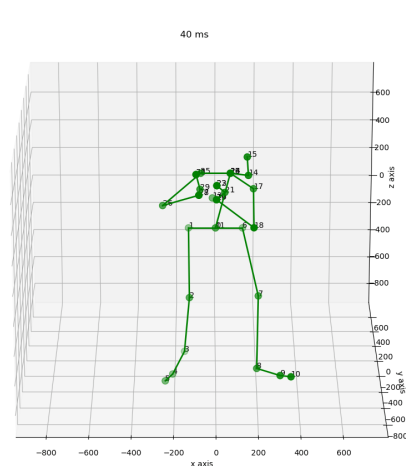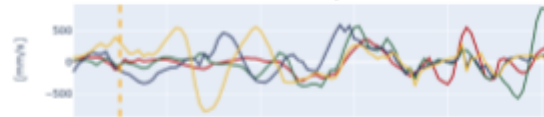
Conclusion and Outlook

In conclusion, our collaboration with QualityMinds has equipped them with tools to improve human motion prediction for autonomous driving and other applications. Moving forward, we aim to expand our insights by generalizing them to other public datasets. By incorporating information on identified outliers, QualityMinds can improve motion prediction models used for human-robot interaction and autonomous systems, ensuring a safer and more efficient future for everyone. We are proud to have been part of this project and are excited to witness the impact of our work in the field of autonomous technology.

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