Towards Automated Analysis of Gaze Behavior from Consumer VR Devices for Neurological Diagnosis

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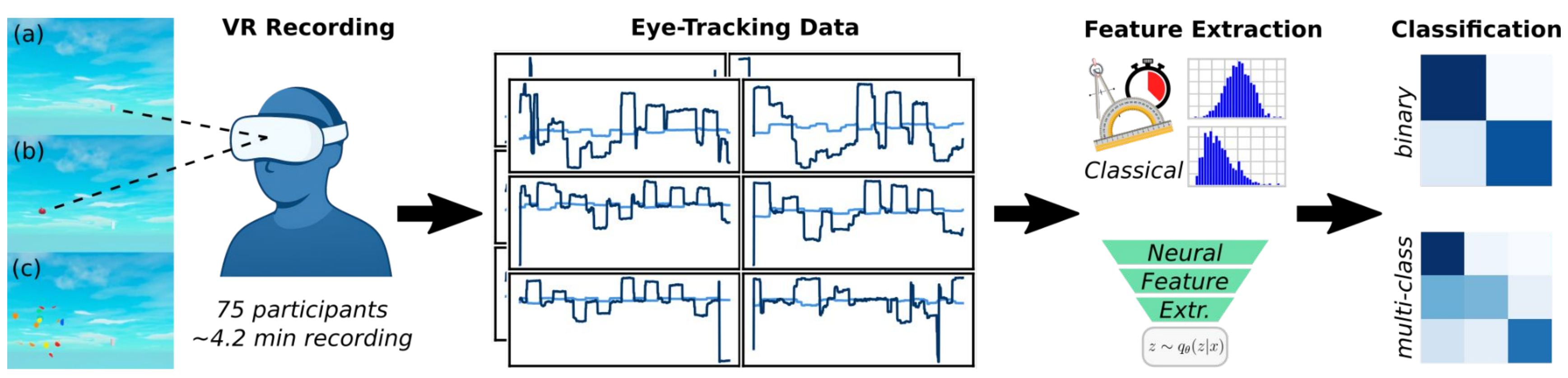
Eye tracking is a promising tool for the detection, classification, and monitoring of neurodegenerative diseases such as Parkinson's Disease (PD). To support early diagnostics and non-invasive symptom monitoring, we design a gamified experiment for disease classification. We evaluate general, task-specific, statistical, and learned features to automate the assessment of neuro-degenerative disease symptoms and improve diagnostic accuracy.

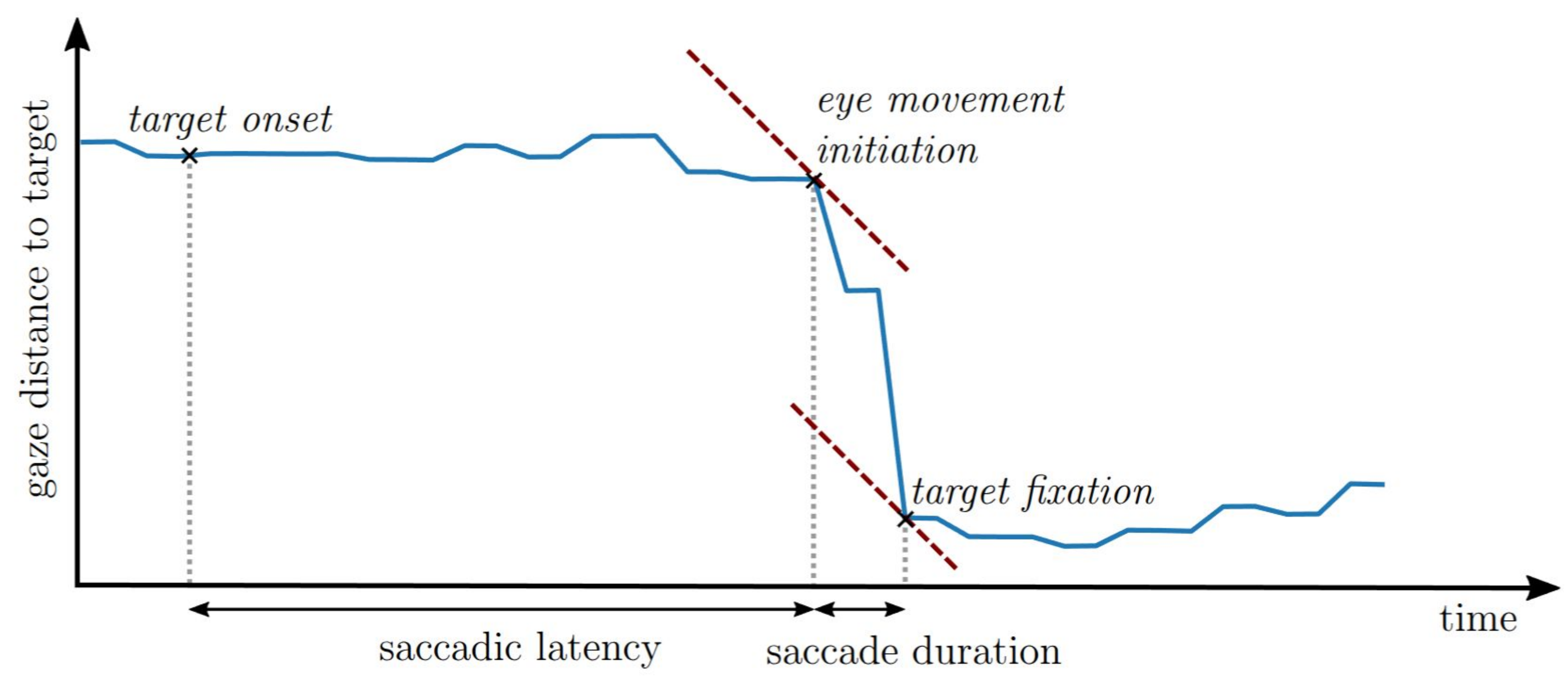


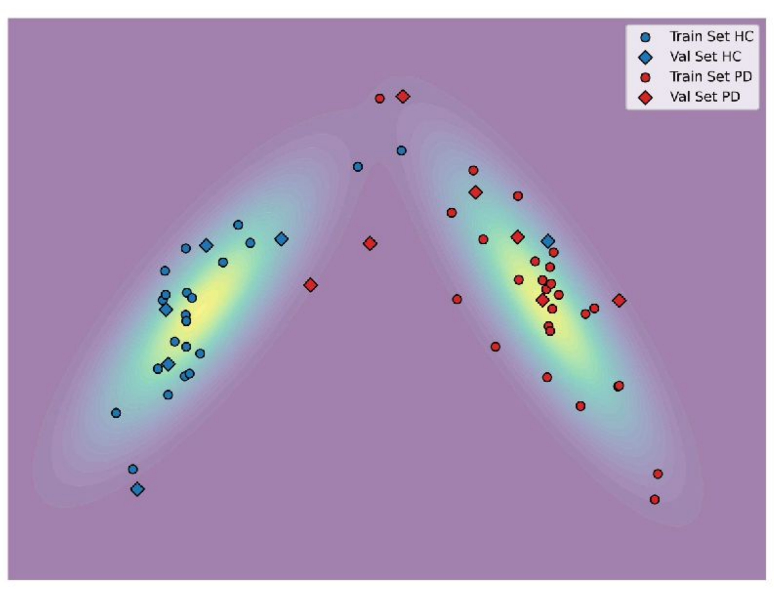
VR-based Gamified Data Collection

We built a simple VR game where participants had to look at continuously appearing fruits. We recorded eye tracking data with a consumer-grade VR headset, the Meta Quest Pro, from 75 participants (Parkinson's Disease: 33, Healthy Control: 27, Ataxia: 15).

Extracting of Generic, Task-evoked, and Learned Features

We extract typical eye tracking features based on saccades and fixations. As demonstrated in the following graphic, we additionally exploit task-specific features by fitting a reference line with a fixed slope to the angular distance between gaze and target object to differentiate between saccadic latency and saccade velocity. We enhance the features by applying statistics such as mean, skew and kurtosis to the sequence of saccades recorded for each patient.

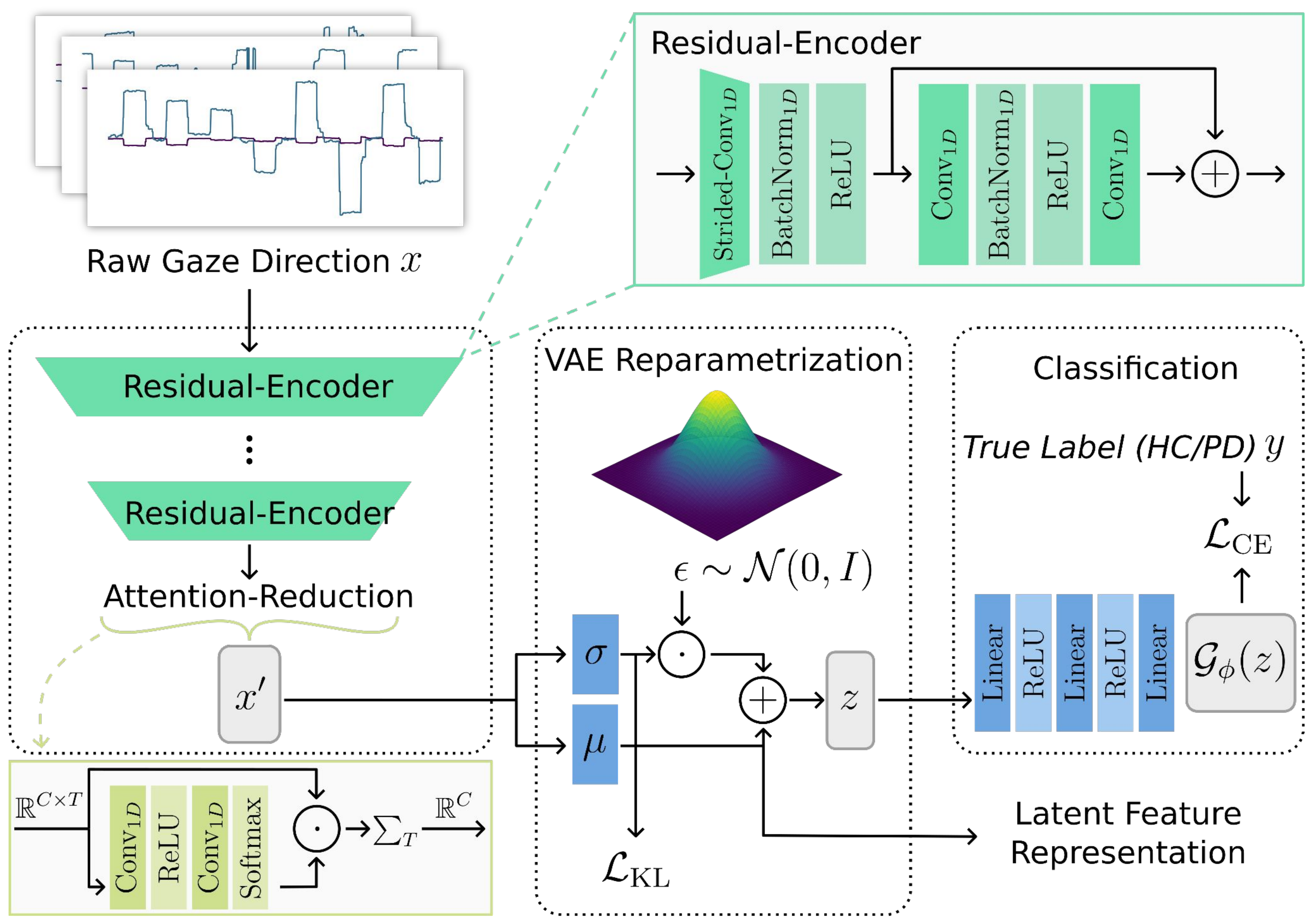




We employ a residual encoder architecture to learn feature embeddings from the raw gaze data. The graphic to the left shows a PCA projection of the learned feature space, demonstrating the clustering of the two groups (Red: Parkinson's Disease. Blue: Healthy Control).

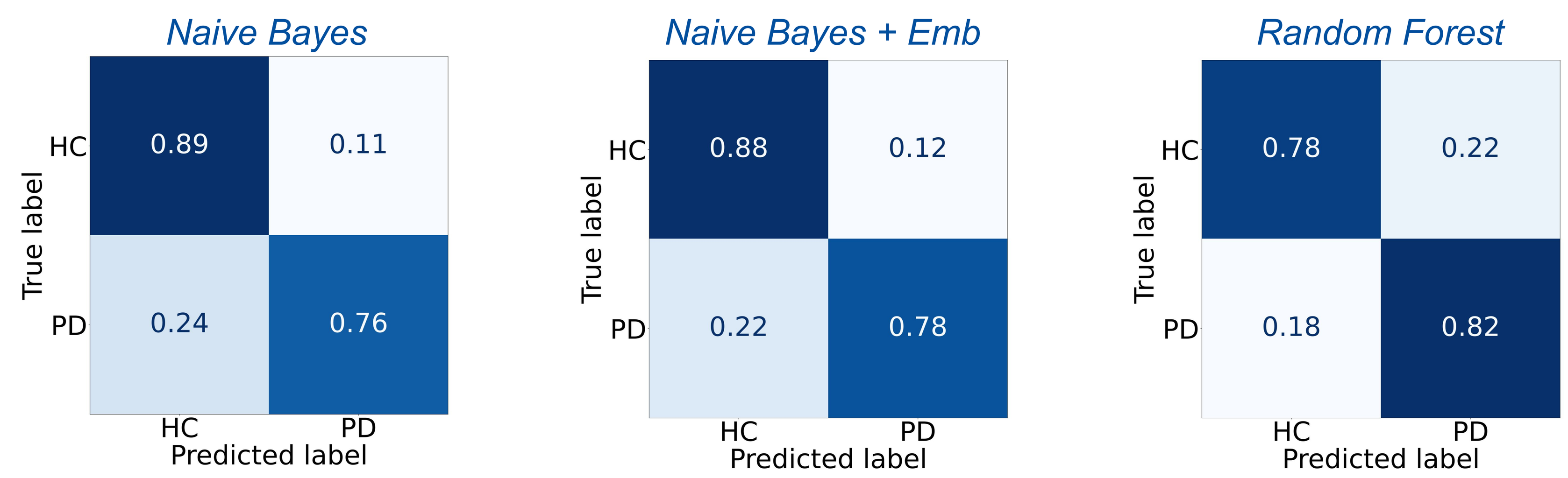
Learned Feature Space Visualization.

This is the model architecture for learning the feature embeddings:

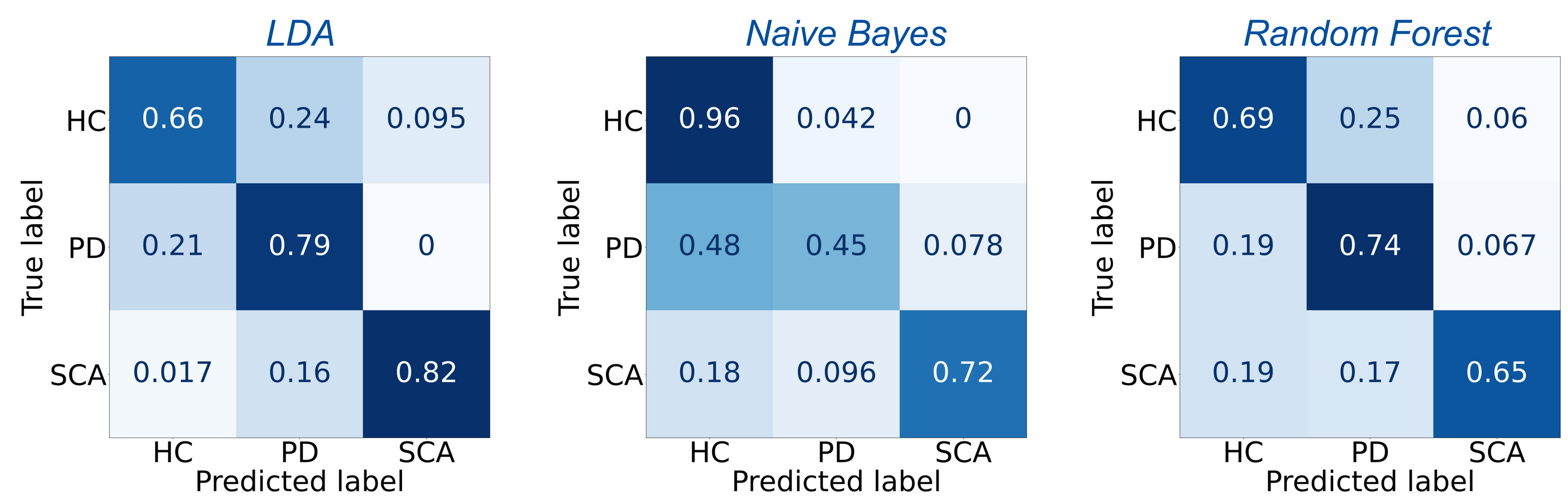


Prediction of Parkinson's Disease - Best Models

	Accuracy	Precision	Recall	F1 Score	ROC AUC
Random Forest	0.804	0.829	0.824	0.818	0.836
Naive Bayes	0.824	0.913	0.756	0.808	0.873
Naive Bayes + Embedding	0.831	0.859	0.821	0.816	0.871



Confusion Matrices showing the likelihood of false positives and negatives when distinguishing Parkinson's Disease patients from a healthy control group.



Multiclass Classification to differentiate between Parkinson's Disease, Spinocerebellar Ataxia and a healthy control group.

Conclusion

VR headset are a promising tool for Parkinson's Disease diagnostics and symptom monitoring, enabling remote and non-invasive assessments. Combining generic, task-evoked and learned features resulted in the best model accuracy overall. Additionally, computing statistic features on the measurements improved classification performance.

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