Examining Survey Mouse Movements as Indicators of Individual Cognitive Functioning



Introduction

- **Mild Cognitive Impairment** is a condition in which people have more memory or thinking problems than other people their age [1, 2]
- Mouse Movements in survey could be a window into cognitive processes [3]
- Shapley value, a concept from cooperative game theory, is increasingly used in machine learning to interpret and understand the contributions of individual features in predictive models, offering valuable insights into cognitive processes by quantifying the impact of each inp.

Evaluate Feature Importances in Machine Learning using SHAP







Methodology

- We train a deep neutral network (DNN) to predict either high or low probability of mild cognitive impairment (PCI) using mouse movement features and demographic features which are captured in the 618 Survey of the Understanding America Study Panel (*N* = 754; *p* = 349 features)
- Shapley values of each features from both correctly classified samples and misclassified samples are

evalua	UAS618 - Response Overview	
	Size of selected sample	14588
	Completed the survey	9883
	Started but did not complete the survey	81
	Did not start the survey	4624
	Response rate	67.75%

Training Strategy

- Explored a total of N = 754 instances (575 with low PCI and 179 with high PCI)
- The DNN model with two hidden layers (96 and 32 units), dropout regularization, and Adam optimizer

Overall samples

- Surprisingly, age does not significantly influence the model's predictions. Instead, mouse features play a more dominant role, more so than most demographic features—except for employment status and gender, which remain influential
- Mouse feature names are prefixed by their corresponding screen id/question id. As expected, the model's outputs **do not imply causal** relationships, and its performance isn't flawless due to overlaps between correctly and incorrectly classified samples.





Mouse Features

- **Hovers**: moving within a designated response box or area indicates the choice
- **MD_above/below**: maximum deviation above/ below the ideal trajectory
- Flips: directional changes along the axis of interest
- Idle_time: total time during which there is no movement
- AD: arithmetic mean of all signed pointwise deviations between the trajectory and the ideal trajectory
 Further evaluation
- Compare SHAP Distributions for Correct vs.
 Misclassified Samples: aggregate analysis, feature importance disparities, and directional consistency
- Investigate Disparities Across Demographics: examine differences in feature importance and misclassification rates.

Reference

(learning rate=0.001) is trained on a 70-30 train-test split, with 50% of the test data used for validation, incorporating class weights to handle imbalanced data and early stopping (monitoring validation loss with patience=5) to prevent overfitting while minimizing

	precision	recall	f1-score	support	
0	0.78	0.90	0.84	82	
1	0.58	0.34	0.43	32	
accuracy			0.75	114	
macro avg	0.68	0.62	0.63	114	
weighted avg	0.72	0.75	0.72	114	





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