Using Machine Learning on Naturalistic Driving Data to Predict Mild Cognitive Impairment

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Objective

To implement machine learning models in Python using extracted turning data to seek the answer to this question: does naturalistic driving signature data aid cognitive diagnosis and Alzheimer Disease risk

Background

Due to the lack of FDA-approved medications for controlling Alzheimer's Disease, it would be optimal to treat Mild Cognitive Impairment (MCI) [1]. One promising approach is to collect continuous data from individuals in what is known as "free- living conditions", such as driving [2].

An ASU team in collaborating with TF Health Corp. is developing biosensor array technology to pull biometric data with driving sensors, GPS data to identify markers for Alzheimer's Disease early detection

Feature Engineering- Identifying Turns

- Calculation of peaks in latitude and longitude data

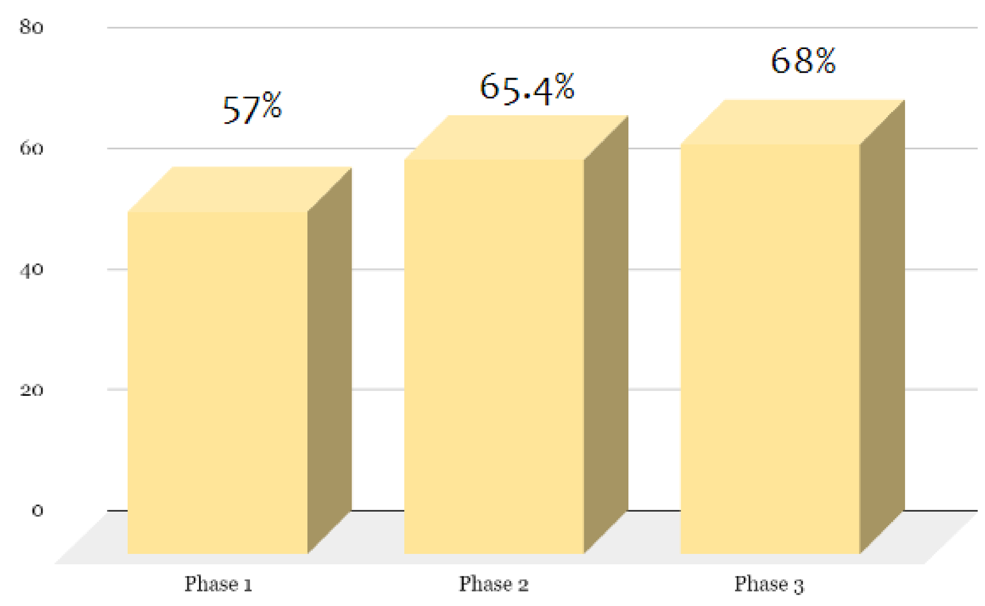
  - Isolated gradients that met a 30° angle threshold
  - Used Numpy and Pandas
- Smoothening accelerometer and gyroscope data during turns:
  - Both sensors ran at 24 Hz, so readings were averaged per sec
  - Calculated radial acceleration: $\frac{\Delta gyro_z}{\Delta t}$
- Final data frame for modeling:
  - Means of each parameter during all turns (Phase II)
  - Max, min, median of each parameter to represent each turn (Phase III)

Ablation Study Results

28 total experiments	I = base: speed, radial acc, gyro: z II: base + acc: x III: base + acc: y	IV: base + acc: x, y V: base + acc: x, y, z VII: base + acc: z VI: base + acc: x, y, z + gyro: x,y,z
	Category 1	**Category 2**
	❑ I_turn, no medians ❑ II_turn, no medians ❑ III_turn, no medians ❑ IV_turn, no medians ❑ V_turn, no medians ❑ VI_turn, no medians ❑ VII_turn, no medians	❑ I_no turn, no medians ❑ II_no turn, no medians ❑ III_no turn, no medians ❑ IV_no turn, no medians ❑ V_no turn, no medians ❑ VI_no turn, no medians ❑ VII_no turn, no medians
Best	**VII: 62%**	**II, III, IV, V, VII: 62%**
	Category 3	**Category 4**
	❑ I_turn, medians ❑ II_turn, medians ❑ III_turn, medians ❑ IV_turn, medians ❑ V_turn, medians ❑ VI_turn, medians ❑ VII_turn, medians	❑ I_no turn, medians ❑ II_no turn, medians ❑ III_no turn, medians ❑ IV_no turn, medians ❑ V_no turn, medians ❑ VI_no turn, medians ❑ VII_no turn, medians
Best	**V: 67%**	**V, VII: 68%**

Top Performing Experiment: V, Cat 4
Increased accuracy by a min of -0.3% to a max of 4.2% with a mean of 0.61% and std of 1.495%

Classifier	Accuracy	Balanced_Accuracy	AUC	Precision	Recall
GaussianNB	62%	55%	56%	45%	27%
GradientBoostingClassifier	43%	44%	50%	31%	38%
LogisticRegression	65%	58%	59%	44%	30%
RandomForestClassifier	56%	54%	45%	33%	**45%**
SVC	**68%**	**59%**	**64%**	**53%**	35%



Phase 1: used summarized statistics of all data

Phase 2: used means of turn data

Phase 3: used summarized statistics of turn data

Conclusion

- Experiment V is the best performing, which includes the accelerometer sensor in the x, y, z direction along with the radial acceleration, speed, and gyroscope in the z direction.
- Utilizing the medians in testing groups positively impacts the prediction, implying that more descriptive statistics help
- Excluding the turn number improved accuracy , showing that driving patterns for prediction are independent of trip progression.

Future Work

- Add descriptive statistics to each parameter: avg, std dev, range, coefficient of variation
  - Test one by one into the models of the best experiments
  - Find combinations that lead to significant results
- Make new conclusions to perform additional experiments
- Honors Thesis: develop my own models using these findings in hopes to attain better results that can help accurate prediction of MCI

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References

[1]Alzheimer's Association: Earlier Diagnosis. https://www.alz.org/alzheimers-dementia/research_progress/earlier-diagnosis
[2]Gauthier, S.; Reisberg, B.; Zaudig, M.; Petersen, R. C.; Ritchie, K.; Broich, K.; Belleville, S.; Brodaty, H.; Bennett, D.; Chertkow, H.; Cummings, J. L.; de Leon, M.; Feldman, H.; Ganguli, M.; Hampel, H.; Scheltens, P.; Tierney, M. C.; Whitehouse, P.; Winblad, B., Mild cognitive impairment (International Psychogeriatric Association Expert Conference on mild cognitive impairment). Lancet 2006, 367 (9518), 1262-1270..

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