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Cognitive Impairment Detection through Recurrent Neural Networks and Mobile Health Technologies

Melissa Ouellet[1], Clauirton Siebra[2]

[1]Digital Health Cluster, Hasso Plattner Institute, Potsdam, Germany

[2]Informatics Center, Federal University of Paraiba, João Pessoa, Brazil

HASSO PLATTNER INSTITUTE
FEDERAL UNIVERSITY OF PARAIBA

OBJECTIVE

> Investigate the potential of leveraging mobile health technologies and recurrent neural networks (RNNs) to detect cognitive impairment (CI) in individuals

METHODOLOGY

- 2011-2014 National Health and Nutrition Examination Survey
- Cognitive tests: Immediate and Delayed Recall, Animal Fluency, and Digital Symbol Substitution
  - Scores converted to z-scores and summed
  - Cognitive impairment below lowest quartile, cutoff: -2.20
- Accelerometer data aggregated to hourly levels, with features:
  - Triaxial Acceleration (mean, SD, min, max, median, kurtosis, entropy) and day of the week
  - Sleep, Sedentary, Light, Moderate, Vigorous activities
- Machine Learning and Deep Learning models:
  - Logistic, Random Forest, Gradient Boosting
  - Standard RNN, Long Short-Term Memory, Gated Recurrent Unit (GRU)
- Model safeguards:
  - Adjusted for class imbalance
  - Prevented data leakage across uses
  - Evaluated using Monte Carlo cross-validation on a 20% test set

RESULTS

- Sample:
  - 2,559 individuals, aged 60–80
  - 24.6% cognitively impaired
  - 429,912 hourly data points over 7 days
- Top Performing Model:
  - GRU: AUC=0.966 ± 0.002, mean ± std. dev.
- Behavioral patterns:
  - More sleep and less moderate-to-vigorous activity
  - Light and sedentary activity having the greatest impact on AUC, 18.8% and16.8% respectively
- Temporal trends:
  - GRU model preserved hourly patterns
  - Room for improvement in capturing daily and weekly trends

CONCLUSION

- Identified distinct behavioral activity patterns in CI sufferers and their impact on model performance
- Highlighted the potential of wearables and sequence modeling to uncover behavioral patterns linked to CI.
- Findings offer opportunities to enhance predictive models and develop improved intervention strategies.

Model	AUROC	AUPRC	Sensitivity	Specificity
Logistic Regression	0.570 ± 0.014	0.288 ± 0.018	0.624 ± 0.015	0.475 ± 0.008
Random Forest Classifier	0.582 ± 0.016	0.304 ± 0.026	0.574 ± 0.017	0.545 ± 0.007
Gradient Boosting Classifier	0.586 ± 0.016	0.308 ± 0.027	0.541 ± 0.014	0.582 ± 0.011
Standard Recurrent Neural Network	0.776 ± 0.042	0.495 ± 0.044	0.758 ± 0.063	0.671 ± 0.044
Long Short-Term Memory	0.956 ± 0.003	0.874 ± 0.008	0.907 ± 0.033	0.862 ± 0.037
Gated Recurrent Unit	**0.966 ± 0.002**	**0.898 ± 0.002**	**0.922 ± 0.038**	**0.878 ± 0.035**