Predicting Length of Stay For Acute Stroke Patients Using Hemodynamic Features

Zach Murphy,[1,2] Michael Ainsworth,[1] Alex Hepp,[1] Varun Naga,[1] Athena Olszewski,[1] Kirby Gong,[1] Elizabeth Zink,[3] Joseph Greenstein,[4] Raimond Winslow,[4] Mona Bahouth,[5]

[1]Department of Biomedical Engineering, Johns Hopkins University, [2]Johns Hopkins University School of Medicine, [3]Neuroscience Critical Care Unit, Johns Hopkins Medicine
[4]Institute for Computational Medicine, Johns Hopkins University, [5]Department of Neurology, Johns Hopkins University School of Medicine

JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Background

- Stroke is a leading cause of death and disability.
- During the acute stroke period, there is a disruption of the blood-brain barrier and cerebral blood flow autoregulation.
- Hemodynamic variability has been associated with worse outcomes
- Using hemodynamics to predict normal vs abnormal lengths of stay (LOS) may help in risk profiling, care coordination, and resource allocation

Methods

- Combine static and time-series data to feed models
- Predictive models include **Generalized Linear Models**, **Random Forest**, and **XGBoost**
- Output label: patient **length of stay (LOS)**
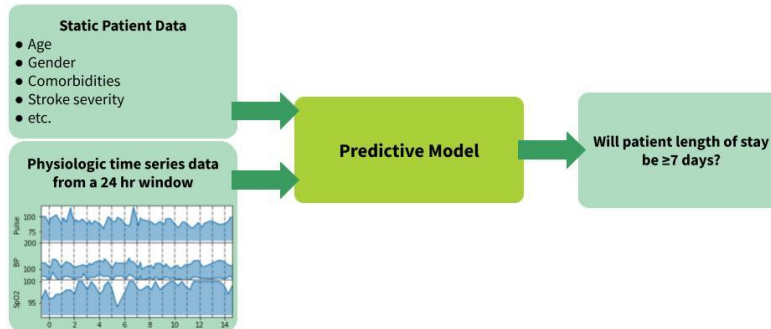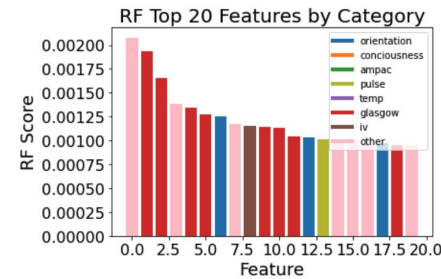- **LOS** converted into a binary label

Figure 1: Design image demonstrating the project pipeline. Data taken from the first 24 hours of admission. Feature space is used to train models to predict patient length of stay

Results

- Included 2,025 patients from Johns Hopkins Stroke Center
- Demographics matched general stroke population well

Feature ranking reduced feature space from **8741 features** to **785 features**

Figure 2: Top 20 features using RF feature ranking. High scoring features were derived from glasgow, orientation, pulse, and IV features.
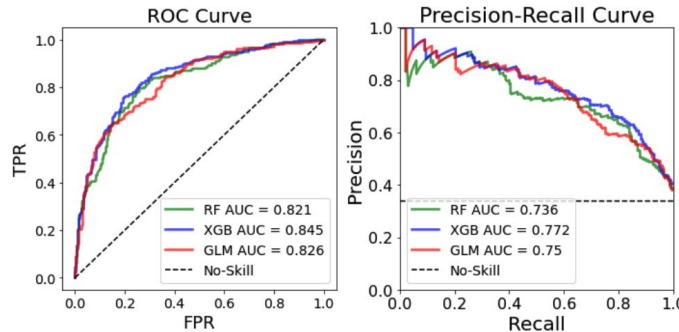

Figure 3: ROC and Precision-Recall curves for final models. XGBoost scored the highest with an AUC of 0.840.

Specificity	Sensitivity	PPV	NPV	F1-score	Accuracy
0.80	0.76	0.70	0.85	0.73	0.79

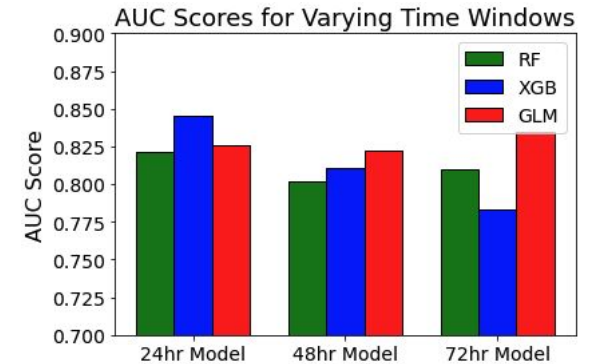Table 1: XGBoost statistics for the optimal operating point

Figure 4: AUC scores for varying time windows. The observation window for time series data was increased to 48 hours and 72 hours. Model AUCs yielded comparable results

Discussion / Conclusion

- Our results enable prediction of LOS $\geq$ 7 days for stroke patients with respectable performance after the first 24 hours of admission, and can be updated at each 24 hours interval.
- Limitations include data coming from a single site as well as inability to capture non-medical factors related to LOS such as insurance plan and social determinants.
- Further work is needed to refine these models, validate in other stroke centers, and implement into clinical practice in order to understand the full impact of such predictions