Interpretable Machine Learning for Predicting the Likelihood of Autism from Infant ECG Recordings

Deepa Tilwani[1] , Christian O'Reilly[1,2], Jessica Bradshaw[2], Amit Sheth[1]

1) AI Institue UofSC, 2) IMB UofSC

Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder defined by difficulties with social interaction and communication, restricted interests, and repetitive behaviors.

Motivation

- Difficult to diagnose until 3 years of age.
- Prevalence is increasing, 1 out of 44 children[3] .
- Behavioral assessments and tests are very time consuming.
- No standardized assessment tools available to identify individual strengths, weaknesses, and needs.
- Understanding behavioral and neurological developments at early age is becoming crucial.

What is the aim of Machine Learning in ASD?

There is a need of automated pipeline which can pre-process, analyse, and predict the the likelihood of ASD at young (3-6 mo) age.
Impact: Reduce waiting times for access to therapy and treatment and to reach underserved populations better.

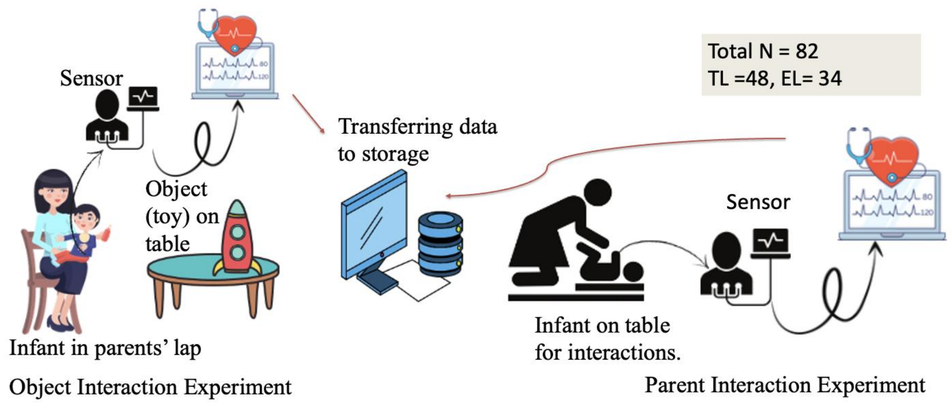
To identify specific patterns or features in ECG signals that are associated with infant ASD.
Impact: Provides incremental information about attentional engagement beyond looking behaviours alone [4].

To study the differences in the autonomic nervous system (ANS) function in individuals with ASD.
Impact: Better treatment for regulation of behaviours during social interaction.

Motivating Research Questions

- Can Machine Learning algorithms be used to develop a predictive model for ASD likelihood prediction using ECG recordings?
- Can Machine Learning algorithms be used to monitor changes in cardiac function in individuals with ASD?
- Is there any potential for ECG and HRV as biomarkers for ASD?

Data Collection



Proposed Approach

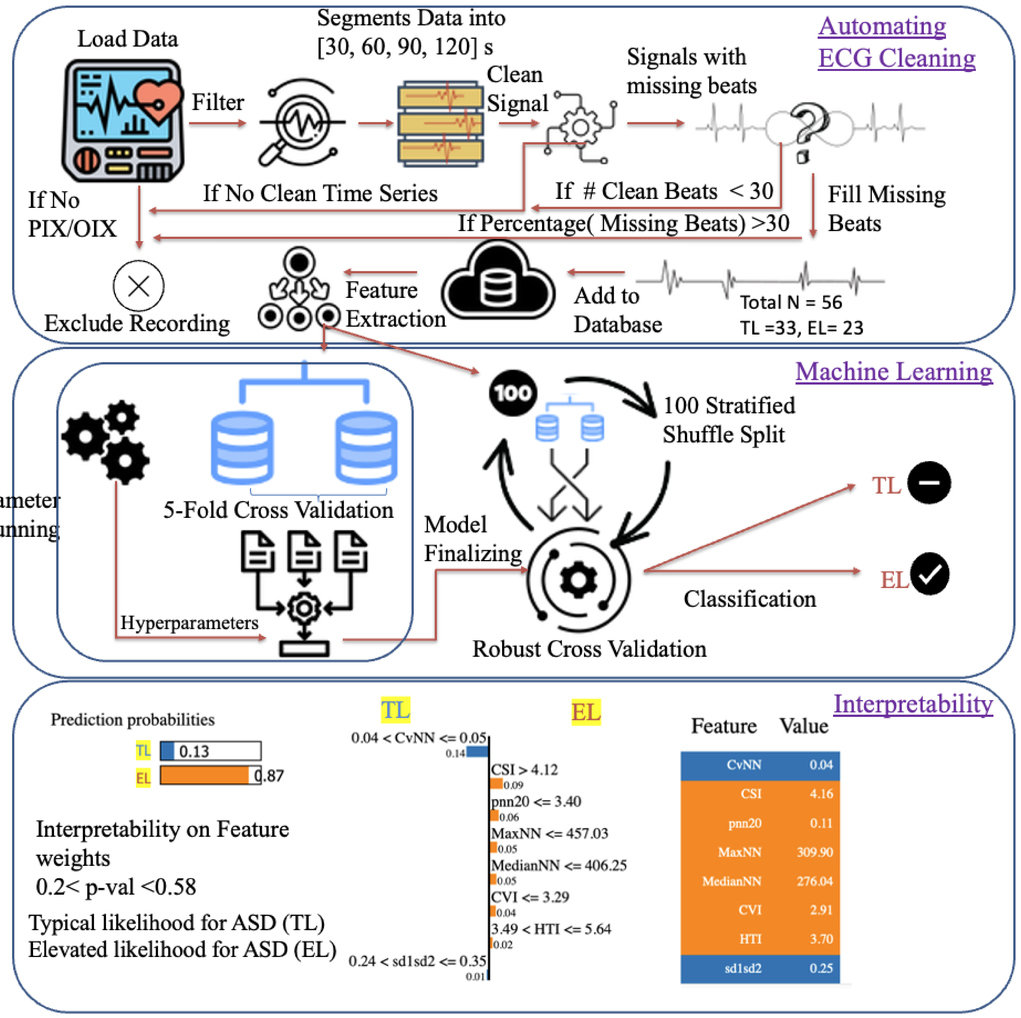


Figure: Pipeline to identify best Model out of 8 on metrics (Accuracy (p-val <0.00), Precision, Recall, F1-Score, ROC (p-val <0.06)).

RESULTS

Methodology	Precision	Recall	ROC	Accuracy	F1-Score
Ensemble [1]	-	-	-	**0.75 (avg)**	-
XGB (Highest performing model) [2]	**0.57**	**0.59**	**0.88**	**0.59**	-
90 s XGB with Robust Cross Validation (ours)	0.74 ± 0. 14	0.72 ± 0.12	0.72 ± 0.12 (p-val <0.06)	0.73 ± 0.12 (p-val <0.00)	0.72± 0.13

CONCLUSIONS

Outcome

- We developed an automated pipeline which can pre-process, analyse, and predict the likelihood of ASD at young (3-6 mo) age.
- HRV is a useful measure to study ANS, and our results indicate that ECG signals contain information about ASD likelihood in infants and show potential for biomarker development.

Future Work

- We plan to explore other approaches for interpretability (e.g SHAP) .
- Further explore HRV features and combination of HRV features as potential biomarkers of ASD in infancy and replicate these results in a larger sample that includes infants and children.

REFRENCES

1. Y.-C. Cheng,et al. Heart rate variability in individuals with autism spectrum disorders: a meta- analysis. Neurosci. Biobehav Rev, 118, 08 2020.
2. M. Frasch, et al Can a composite heart rate variability biomarker shed new insights about autism spectrum disorder in school-age children? J *Autism Dev Disord*, 51, 05 2020.
3. M. Maenner, et al. Prevalence and characteristics of autism spectrum disorder among children aged 8 years autism and developmental disabilities monitoring network, 11 sites, united states, 2018. *MMWR Surveillance Summaries*, 70(11):1–16, Dec. 2021.
4. Tonnsen, Bridgette & Richards, John & Roberts, Jane. (2018). Heart rate-defined sustained attention in infants at risk for autism. Journal of Neurodevelopmental Disorders. 10. 10.1186/s11689-018-9224-2.

ACKNOWLEDGEMENTS

I am thankful to **JAYANA CLERK** fellowship in supporting my research at AIISC during my internship. Also, I am thankful to **Dr. Jessica Bradshaw**, **Dr. Christian O'Reilly**, and **Dr. Amit Sheth** for supporting my research and valuable feedback on the project.

CONTACT

Deepa Tilwani,
Phd Student,
AIISC
dtilwani@mailbox.sc.edu