ADHD Prediction Through Analysis of Eye Movements with Graph Convolution Network

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ABSTRACT

Adolescents with ADHD have difficulty processing speech with background noise due to reduced inhibitory control and working memory capacity.

In this study,

- We utilize eye-tracking measures collected during Audiovisual Speech-In-Noise (SIN) task from young adults with ADHD and generate graphs using eye-tracking features and connection among trials in terms of subject, background noise, and sentence.
- Since Graph Convolutional Networks (GCN) can use both graph and node feature information to capture the neighborhood information from graphs by incorporating node features into these embeddings, we apply GCN to classify our nodes (each trial of the experiment) into ADHD or Non-ADHD category.

DATASET

Participants: 5 ADHD participants & 6 Non-ADHD

Eye Tracker: Tobii Pro X2-60

Task: Each participant has been told to watch a computer screen where a female speaks sentences out loud as levels of background noise varies and asked to repeat the sentences exactly as they heard them.

Background Noise Levels: 0, 5, 10, 15, 20, 25 dB

Trials: Each participants completed audiovisual SIN task accompanied by one of the six background noise levels and one of the sentences out of nine sentences. There were 830 such trials in this study.

Figure 1: Speaker's face as viewed by the participants during the audiovisual SIN task, and sample scan-path with fixations.

METHODOLOGY

Eye-tracking Features

We generated following eight eye-tracking features for each trial:

- Fixation count
- Average, Total, and Standard Deviation of Fixation duration
- Min, Average, and Standard Deviation of Saccade Amplitude
- Max Saccade Peak Velocity

Graph Construction

We formed graphs utilizing the eye-tracking features and connection among trials in terms of subject, background noise, and sentence. We created multiple un-directed multi graphs, each with 830 nodes which corresponds to a trial.

Nodes: Defined by a participant, background noise-level, and the sentence.

Node Features: For each node we created a feature matrix utilizing the eye-tracking features.

Edges: We introduced 6 different types of edge categories:

1. Same Background Noise Level,
2. Same Subject,
3. Same Sentence,
4. Same Background Noise Level and Same Subject,
5. Same Subject and Same Sentence,
6. Same Background Noise Level and Same Sentence

Target of each Node: Binary value (0 and 1)

- Non-ADHD participant's trial/node's target is 0
- ADHD participant's trial/node's target is 1

Graph Convolutional Network (GCN model using Stellargraph

Stellargraph has its own graph data structure and is required to work with their API. We transformed our data into StellarGraph by providing the node features and edges (one at a time) to the StellarGraph function.

We used StellarGraph to generate Undirected multigraphs for all the edge categories.

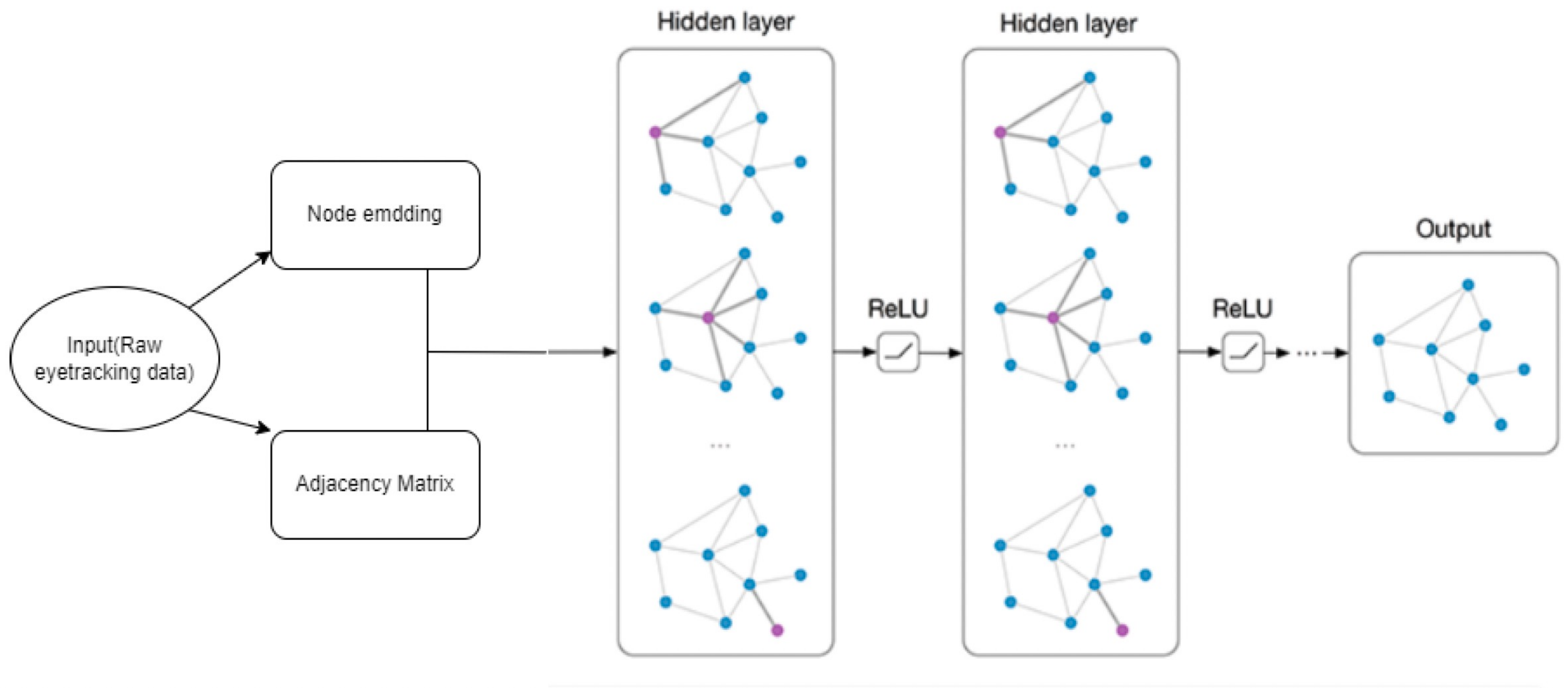

Figure 2: Proposed method diagram, our eye tracking raw data is converted into node embedding of features and adjacency matrix that will be used as input of the convolutions layer. The layers output is concatenated into dense layer followed by output layer that contains SoftMax function

RESULTS

Edge Category	AUC	Precision	F1
Same Background Noise Level	0.50	0.23	0.39
Same Subject	0.50	0.23	0.39
Same Sentence	0.50	0.36	0.00
Same Background Noise Level and Same Subject	**0.53**	**0.54**	0.00
Same Background Noise Level and Same Sentence	0.50	0.50	**0.66**
Same Subject and Same Sentence	0.19	0.24	0.00

Table 1: Performance of models corresponding to each edge category

We obtained around 0.5 ROC AUC score with 750 labelled trials, which indicates that our model does not learn a proper separation among ADHD and Non-ADHD trials from the neighbors.

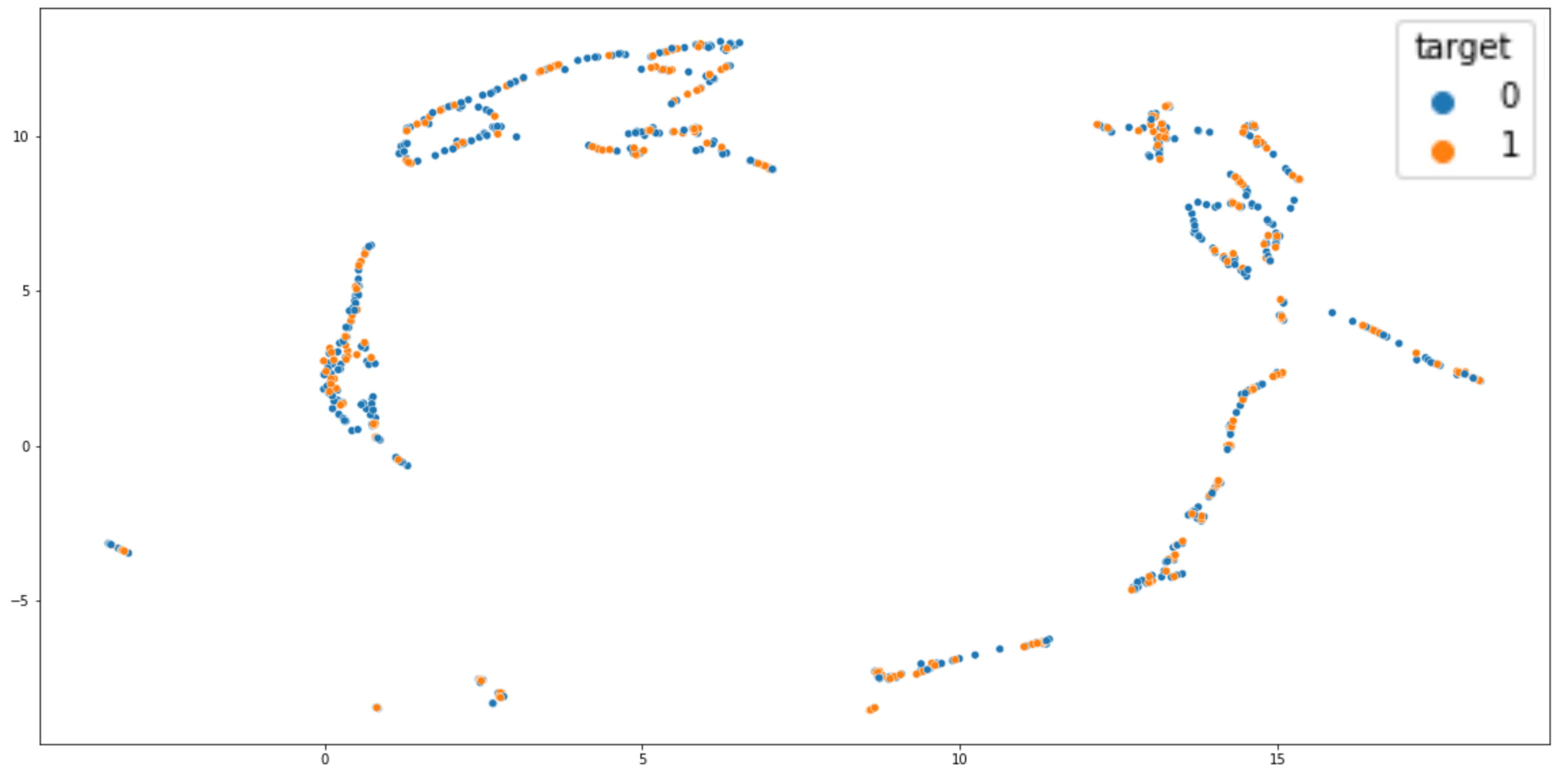

Figure 3: Embeddings from Edge Category: Same Background Noise Level and Same Sentence, before the classification layer.

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Contact Email: hjaya001@odu.edu | This work was supported in part by NSF CAREER 2045523. Any opinions, findings and conclusions or recommendations expressed in this material are the author(s) and do not necessarily reflect those of the sponsors.