# NLP-Based Approach to Detect Autism Spectrum Disorder in Saccadic Eye Movement

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# Background: Autism Spectrum Disorder

- Autism Spectrum Disorder (ASD) is a pervasive developmental disorder characterised by a set of impairments including social communication problems.[1]
- ASD has been considered to affect about 1% of the world's population (US Dep. of Health, 2018). [2]
- The hallmark of autism is an impairment of the ability to make and maintain eye contact. [3]

[1] L. Wing, and J. Gould, "Severe Impairments of Social Interaction and Associated Abnormalities in Children: Epidemiology and Classification". Journal of Autism and Developmental Disorders, 9(1), pp.11-29, 1979.

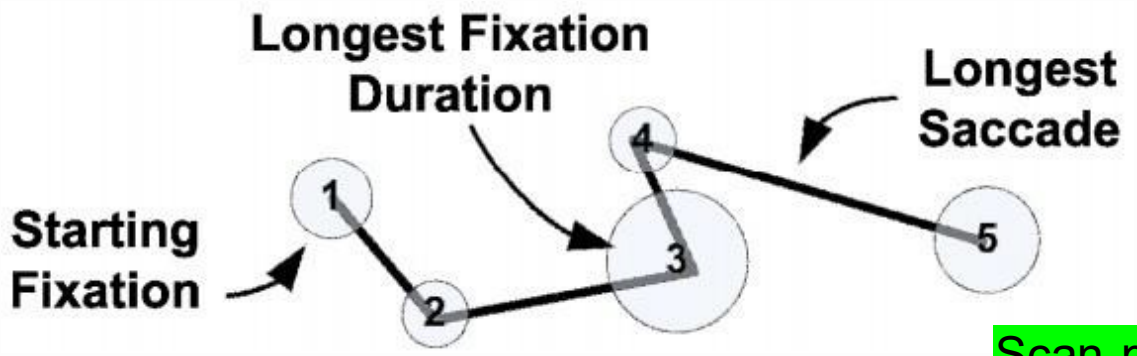
[2] U.S. Department of Health & Human Services. Data and statistics | autism spectrum disorder (asd) | ncbddd | cdc, 2018. URL: https://www.cdc.gov/ncbddd/autism/data.html.

[3] Coonrod, E. E. and Stone, W. L. (2004). Early concerns of parents of children with autistic and nonautistic disorders. Infants & Young Children, 17(3), 258–268.

# Background: Eye-Tracking Technology

Screen-based eye trackers


Glasses




Scan-path

Image Source: https://imotions.com/blog/eye-tracking/

J.H. Goldberg, and J.I. Helfman, “Visual scanpath representation”, In Proceedings of the 2010 Symposium on Eye-Tracking Research & Applications, ACM, 2010, pp. 203-210.

# Motivation

**Our Goal:**

- Detecting ASD-diagnosed individual in eye-tracking data.

**Key Ideas:**

- Eye-tracking records are represented as textual sequences.
- Applying Natural Language Processing (NLP) methods to transform high-dimensional eye-tracking data into an amenable representation for developing ML models.
- As such, the classification task could be approached as sequence learning.

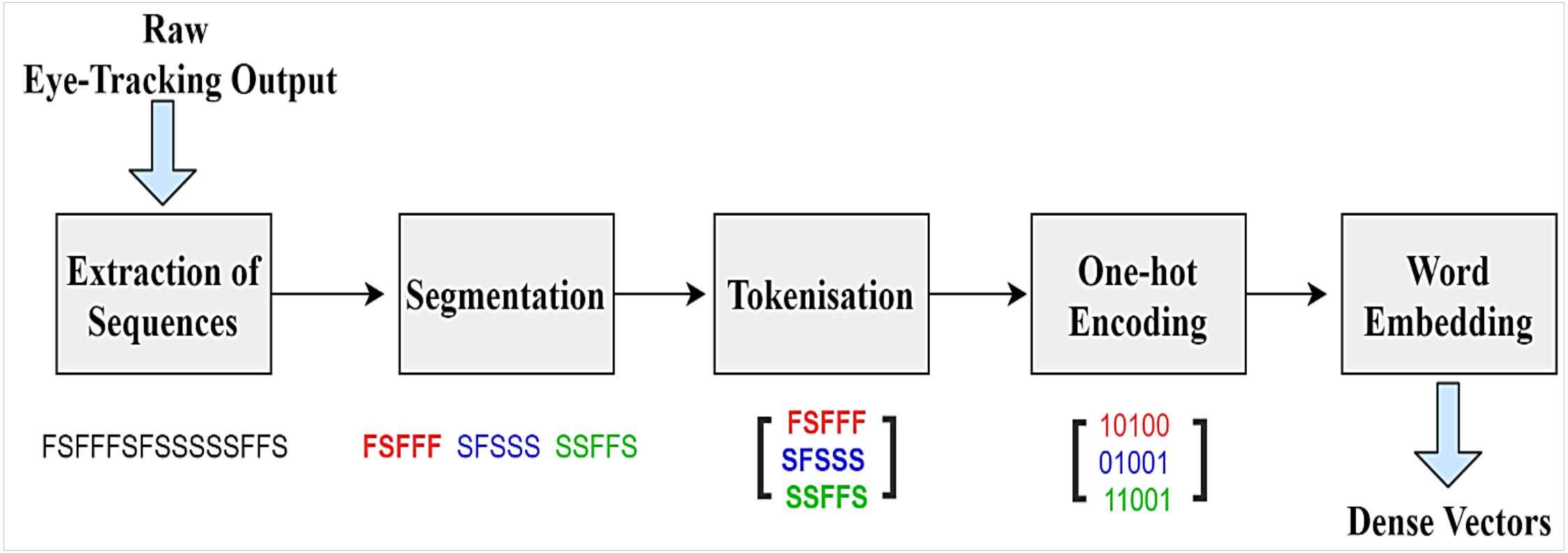
# Data Description

| | |
|---|---|
| Number of Participants (ASD, TD) | 59 (29, 30) |
| Gender Distribution (M, F) | 38 (≈ 64%), 21 (≈ 36%) |
| Age (Mean, Median) years | 7.88, 8.1 |
| CARS Score (Mean, Median) | 32.97, 34.50 |

- The eye-tracking dataset was constructed over 25 sessions.
- More than 2M records stored in structured CSV files.

Carette, R., Elbattah, M., Dequen, G., Guérin, J. L., & Cilia, F. (2018, September). Visualization of eye-tracking patterns in autism spectrum disorder: method and dataset. In *2018 Thirteenth International Conference on Digital Information Management (ICDIM)* (pp. 248-253). IEEE.

# Data Transformation




Segmentation of sequences was partly inspired by the *K-mer* representation, widely used in Genomics.

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# Experimental Datasets

| Parameters | | Output Dataset Size (Number of Sequences) |
|---|---|---|
| Sequence Length (L) | Fragment Length (K) | |
| 100 | 5 | 8,642 |
| 200 | | 4,230 |
| 400 | | 2,018 |
| 500 | | 1,563 |

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# Dataset Splitting (3-Fold Cross-Validation)

The dataset was split using the following stepwise procedures:

1. **Split Participants:** Initially, the group of 59 participants was randomly split into two independent sets (i.e. train and test).
2. **Match Sequences:** Based on the IDs of participants, the sequences were matched and loaded into the train and test sets.
3. **Repeat:** Step #1 and Step #2 would be repeated for each round of the cross-validation process.

# Experimental Results

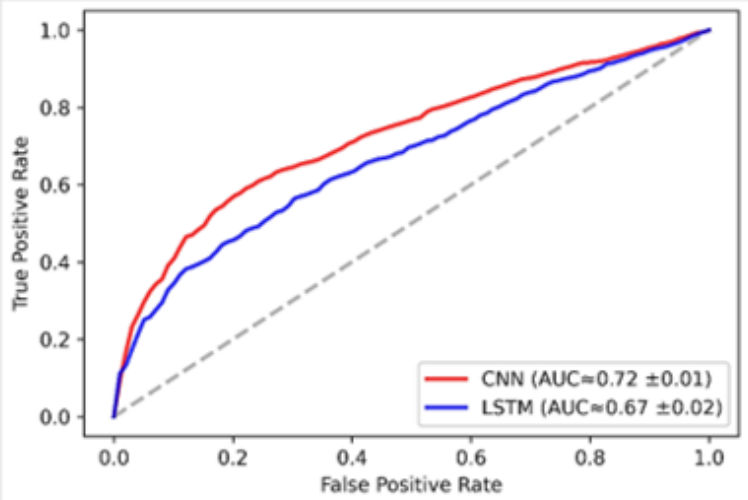


Fig 2. Classification accuracy (L=100, K=5).

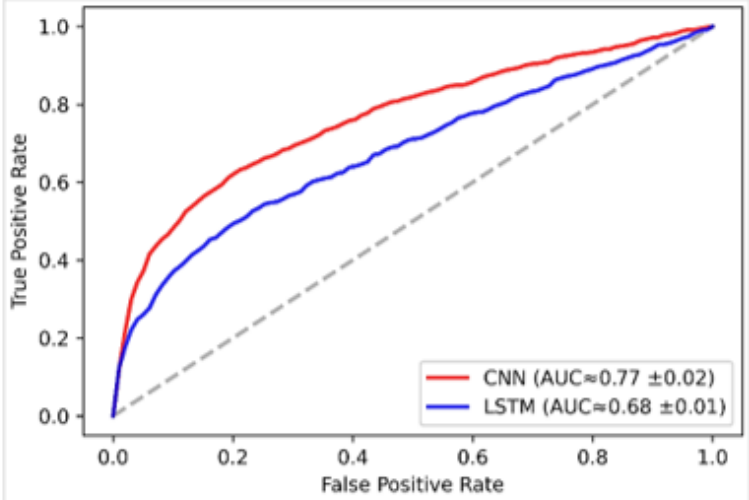


Fig 3. Classification accuracy (L= 200, K=5).

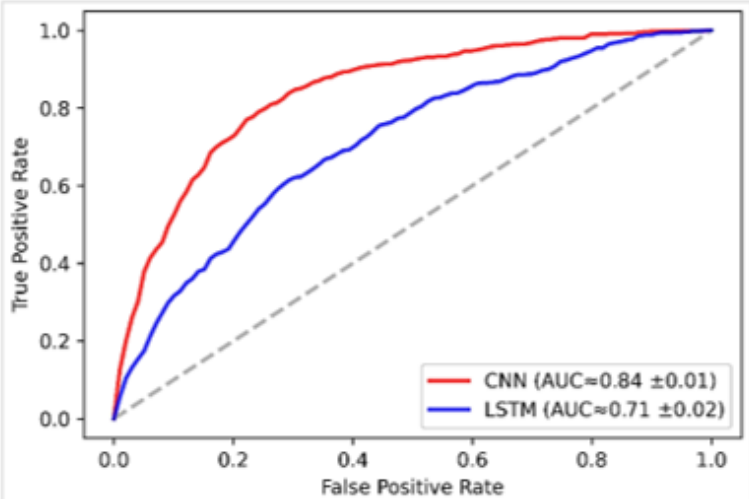


Fig 4. Classification accuracy (L= 400, K=5).

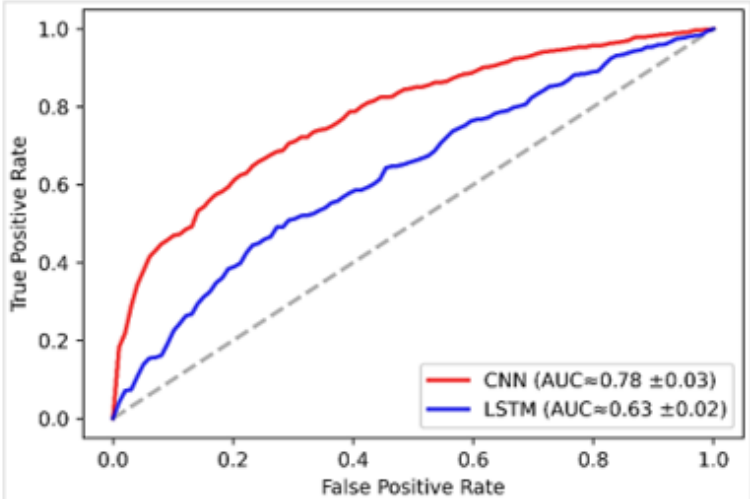


Fig 5. Classification accuracy (L= 500, K=5).

# Experimental Results (cont'd)

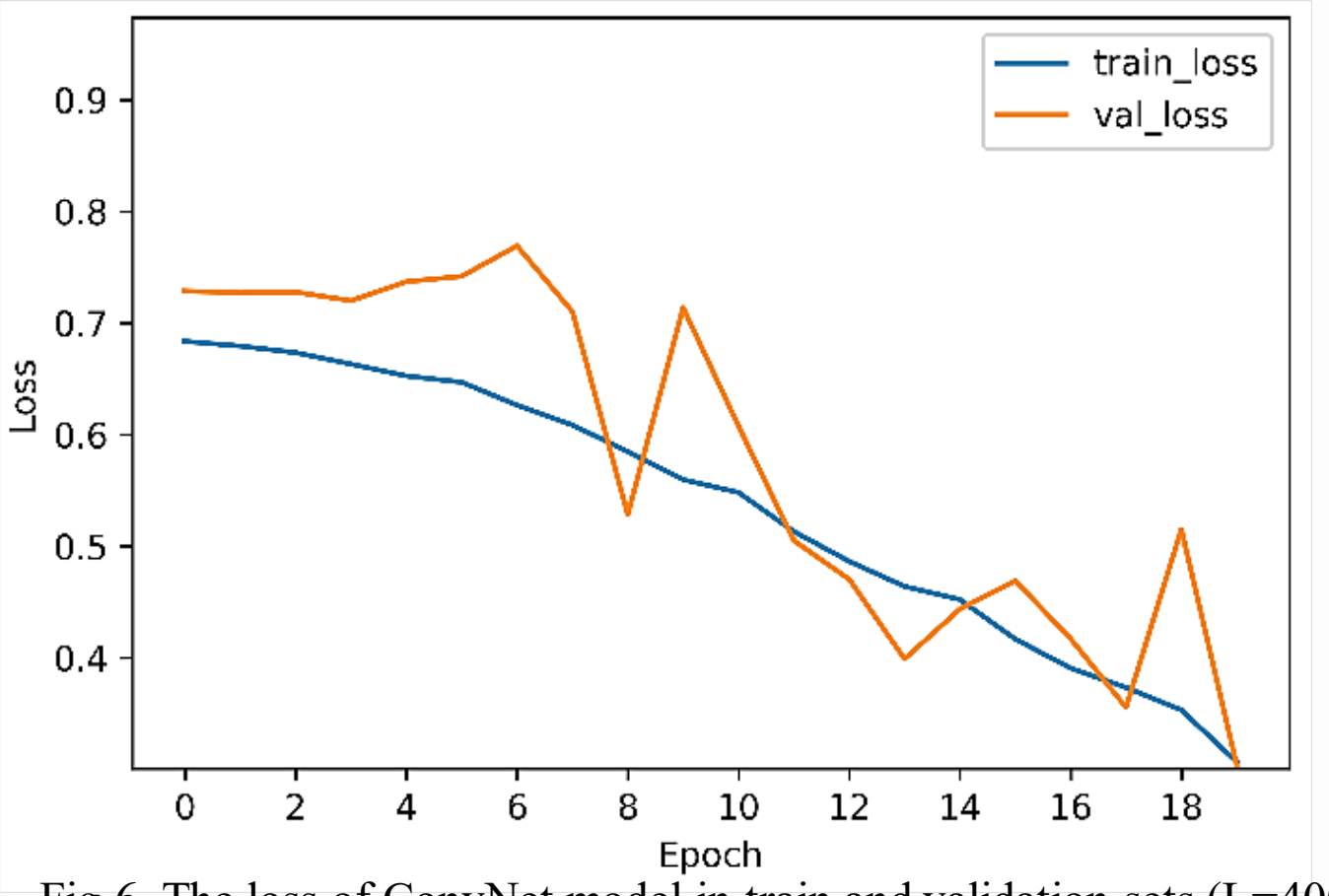


Fig 6. The loss of ConvNet model in train and validation sets (L=400).

# Experimental Results (cont'd)

TABLE . AVERAGE PRECISION-RECALL OF MODELS (L=400).

| | Precision | Recall |
|---|---|---|
| ConvNet Model | 0.79 | 0.71 |
| LSTM Model | 0.72 | 0.48 |

# Conclusions and Limitations

- The promising accuracy indicated that the sequence-based modeling of fixations and saccades could serve as an applicable basis to this end.

- This could open a fruitful avenue for future research of NLP methods for developing diagnostic tools in the autism context or other comparable diagnostic problems.

- However, the lack of a benchmark dataset in the ASD literature makes it difficult to objectively compare our results to other ML approaches.

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# Thank You!