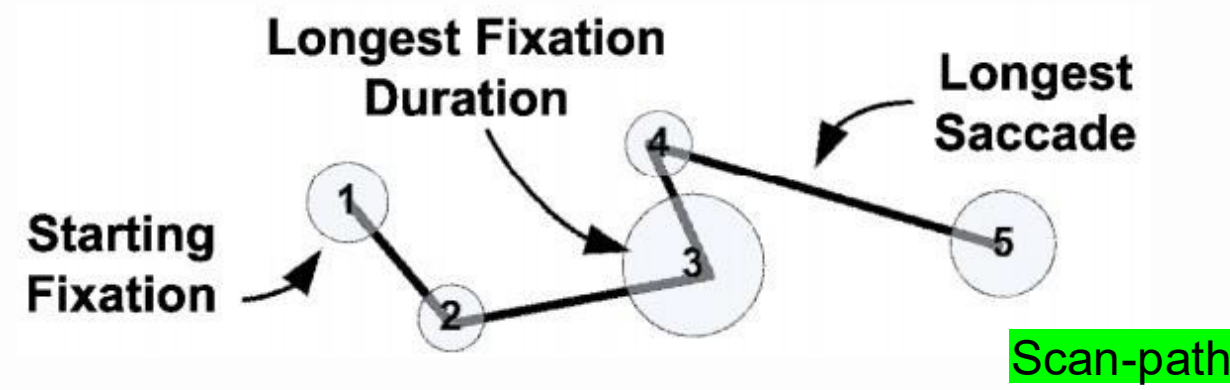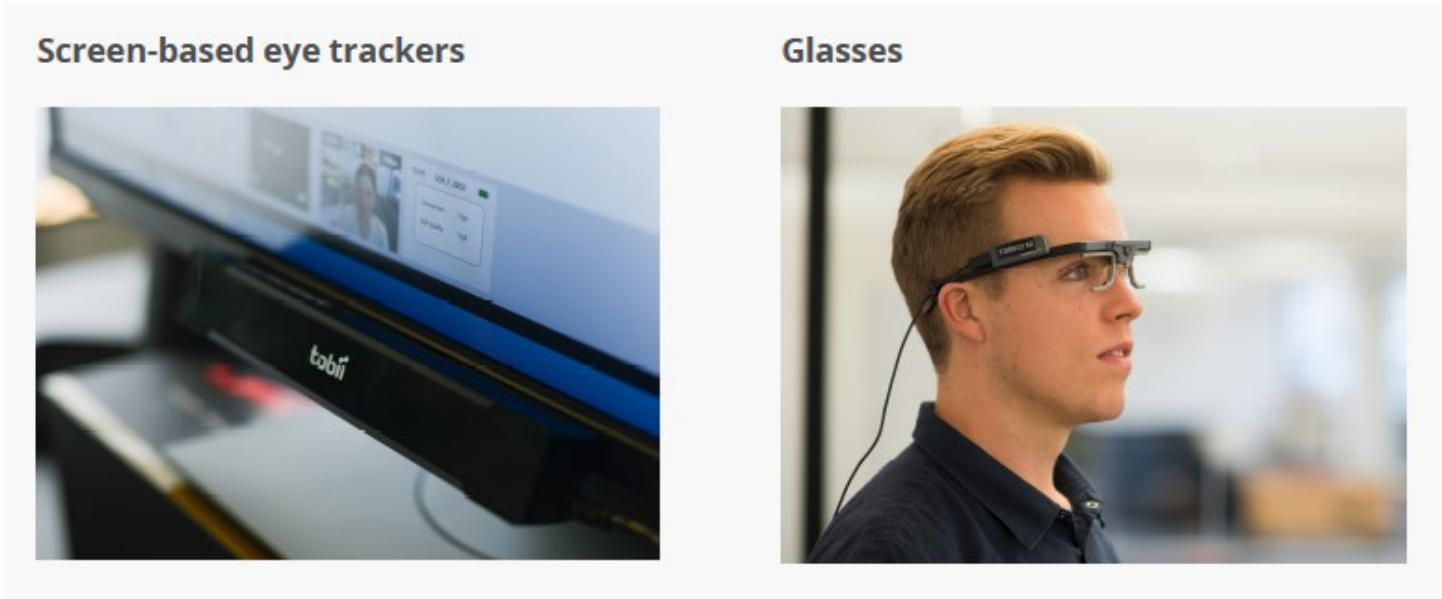# Generative Modeling of Synthetic Eye-Tracking Data: NLP-Based Approach with Recurrent Neural Networks

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Background: Eye-Tracking Technology

Screen-based eye trackers

Glasses

Longest Fixation Duration

Longest Saccade

Starting Fixation

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

Challenge:

• The lack or difficulty of acquiring eye-tracking datasets presents a key challenge for eye-tracking studies.

Possible Solution:

• Generating synthetic eye-tracking data.

RELATED WORK

- Hand-crafted algorithmic methods, such as:
  - (Ma and Deng, 2009).
  - (Le, Ma, and Deng, 2012).
  - (Duchowski et al. 2016)

- Machine Learning approaches, such as:
  - (Assens et al. 2018), using convolutional-recurrent architecture
  - (Zemblys, Niehorster, and Holmqvist, 2019), using sequence-to-sequence LSTM-based architecture
  - (Fuhl, 2020), using variational autoencoder

Our Approach: Key Ideas

- Considering Eye-tracking records as textual sequences.

- Applying methods from the Natural Language Processing (NLP) domain to transform and model eye-tracking sequences.

- Using a long short-term memory (LSTM) model for the generative modeling task.

Data Description

Number of Participants (ASD, TD)	59 (29, 30)
Gender Distribution (M, F)	38 ($\approx$ 64%), 21 ($\approx$ 36%)
Age (Mean, Median) years	7.88, 8.1

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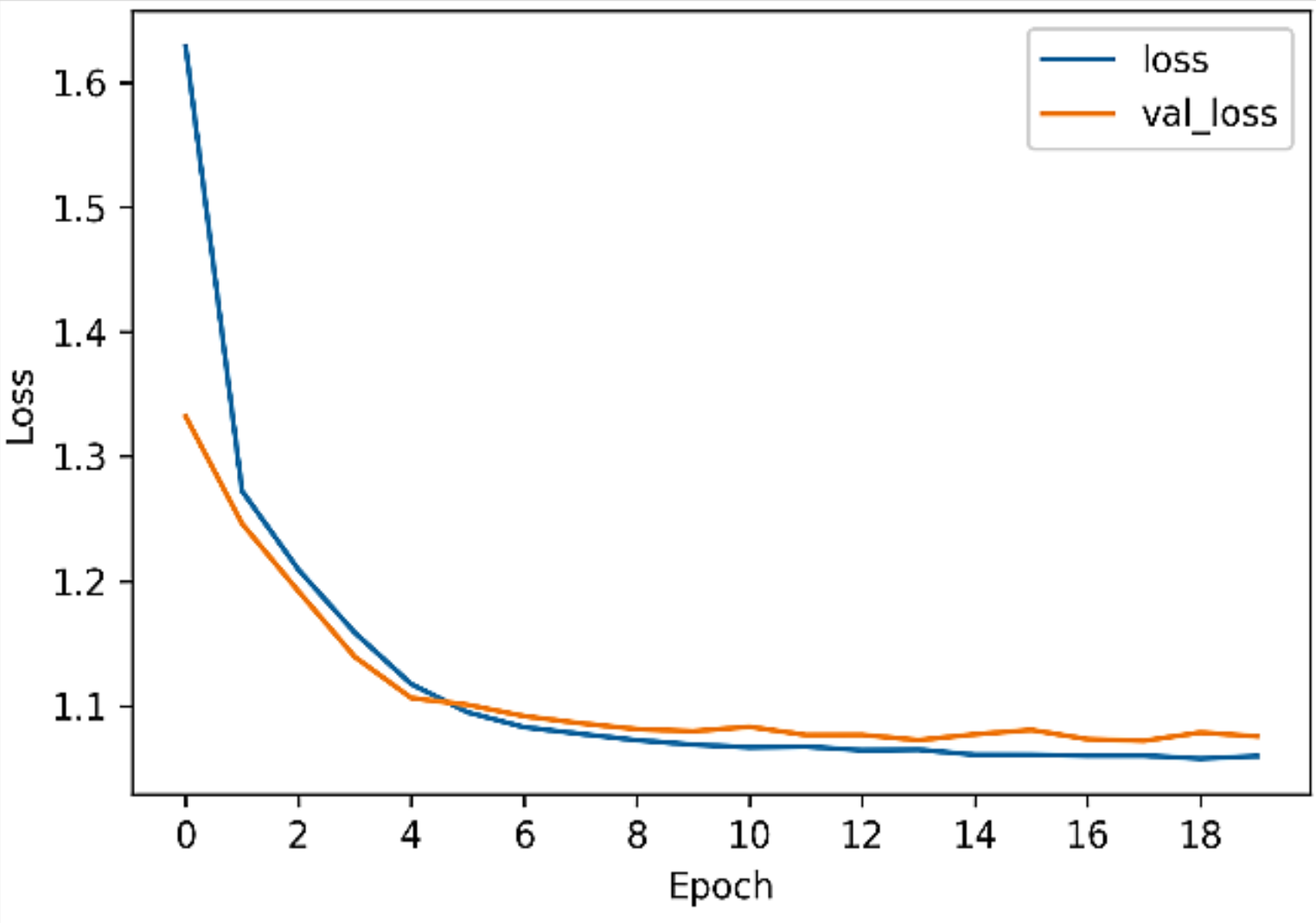
Data Transformation
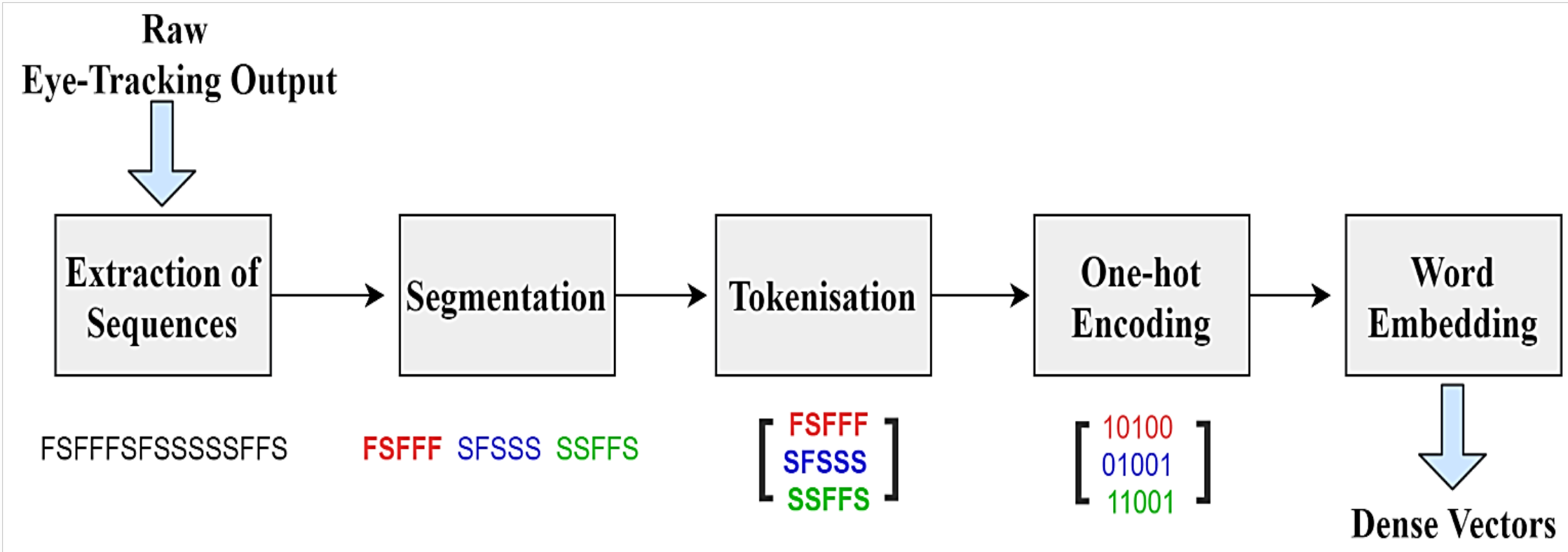
Segmentation of sequences was partly inspired by the *K-mer* representation, widely used in Genomics.

Generative Model Architecture
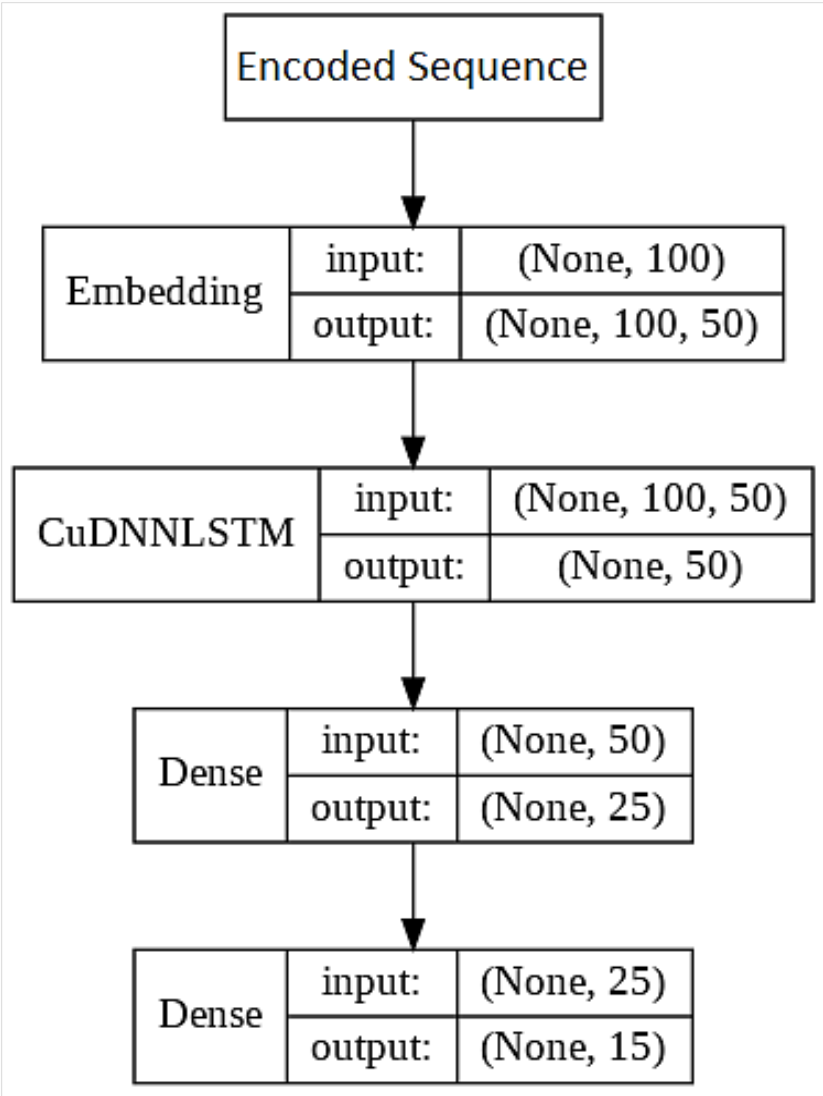
Experimental Results

≈ 75% accuracy of prediction

Summary

- We presented an NLP-based approach for generating synthetic eye-tracking data.

- Using a sequence-based representation of the saccadic eye movement, eye-tracking records could be modelled as textual strings with an LSTM model.

- The lack of open-access eye-tracking datasets could make our approach attractive for further studies.

- For instance, the generative model can serve as an alternative method for data augmentation in a wide range of eye-tracking applications.

Thank You!