Detection of ADHD based on Eye Movements during Natural Viewing

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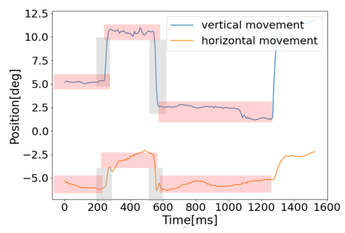
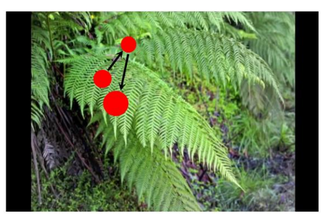
Motivation

- Attention-deficit/hyperactivity disorder (ADHD) is a prevalent (about 5-13% of age cohort) neurodevelopmental disorder.
- Diagnosis: Clinical assessment by specialists.
  - ➢ time-consuming & expensive. ☹
- SWAN rating scale: Commonly used screening tool based on self- and informant reports.
  - ➢ potentially biased & arbitrary cut-off value. ☹
- Viewing behavior provides non-invasive and rich indices of brain function, attention and cognition.





Idea: Develop a fully automatic ADHD screening tool based on eye movements.

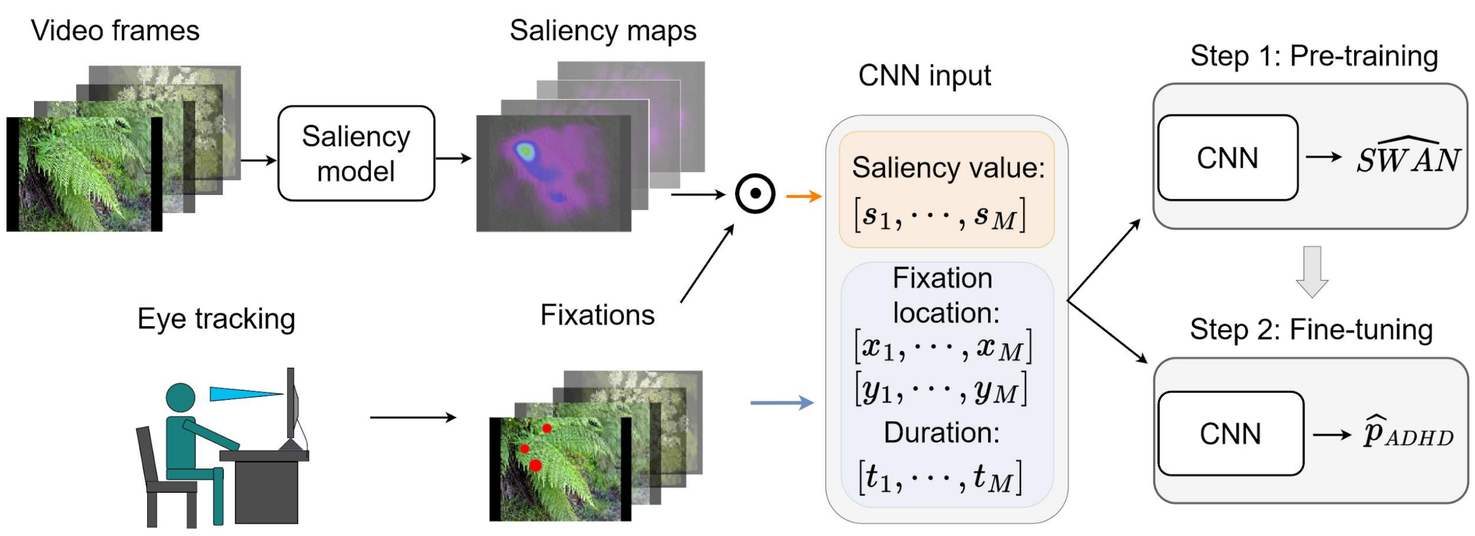
Summary

- Our model improves upon state-of-the-art performance for ADHD classification based on eye gaze on a video stimulus.
- The differences in eye gaze between individuals with and without ADHD are most pronounced in a less engaging video.
- We demonstrate the advantages of pre-training the model on a related task, which bears the potential to alleviate the data scarcity problem in eye-tracking research.

Problem Setting

Goal: Find a model that maps tuple of eye-tracking data and video input to the target label.

End-to-End Deep Sequence Model



- Integrates a video clip with the corresponding gaze sequence.
- Pre-trained on SWAN score regression.
  - Use additional data obtained from individuals diagnosed with other neurodevelopmental disorders.
  - Promote the model to detect ADHD-related patterns in eye movements.

Dataset

- Healthy Brain Network (HBN) Dataset [1]:
  - Eye tracking data (60/120Hz).
  - Stimuli: different types of videos with varying degrees of the excitement of content or educational content.
  - Labels: clinical assessments of a broad range of diseases (ADHD, Autism spectrum disorder, etc.).
  - Age of participants: 6-21 years.

Number of individuals in the data

Video	ADHD classif.	SWAN pred.
Fun with Fractals	67 (48 A, 19 C)	276
The Present	159 (111 A, 48 C)	444
Despicable Me	315 (187 A, 128 C)	656
Diary of a Wimpy Kid	340 (202 A, 138 C)	736
Total	384 (232 A, 152 C)	862

Experiments

Results

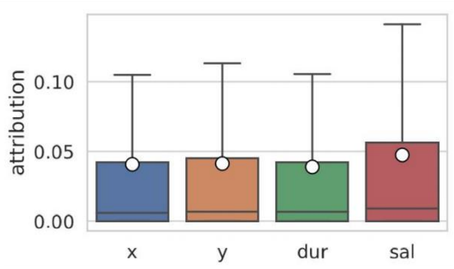
- Evaluation:
  - 5-fold cross-validation, tested on unseen individuals.
  - Metric: AUC ± standard error.

Method \ Video	Fun with Fractals	The Present	Despicable Me	Diary of a Wimpy Kid
CNN@Scratch	0.583 ± 0.026*	0.553 ± 0.017*	0.55 ± 0.01*	0.486 ± 0.01
CNN@Pre-tr.	**0.646 ± 0.025***	**0.554 ± 0.016***	0.544 ± 0.01*	0.503 ± 0.01
Galgani *et al.*	0.33 ± 0.022	0.526 ± 0.017	0.523 ± 0.012*	**0.515 ± 0.01**
Tseng *et al.*	0.608 ± 0.023*	0.418 ± 0.015	**0.561 ± 0.011***	0.465 ± 0.01

- Our model outperforms baselines.
- Models' performance differs in relation to the content of the video.

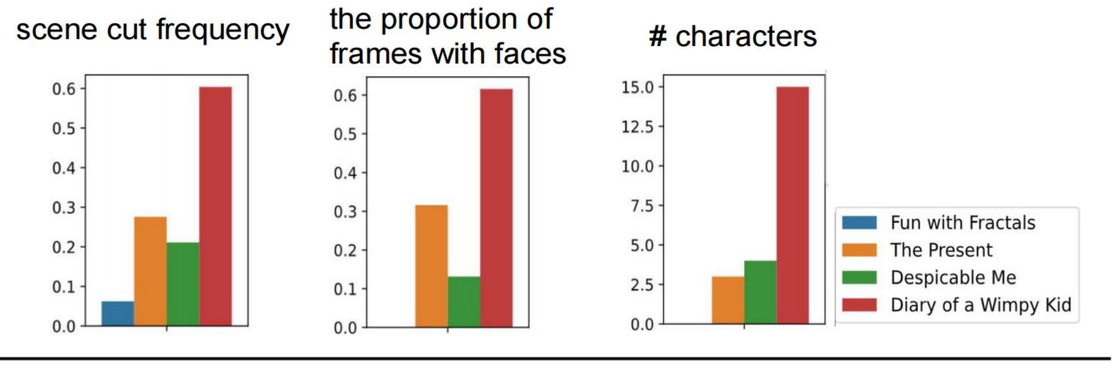
Feature Importance

- All the input channels add valuable information.



Impact of Video Characteristics on Model Performance

- We quantify the video's degree of excitement of content using content-related features.



Video	Fun with Fractals	The Present	Despicable Me	Diary of a Wimpy Kid
Type of video	Educational video	Animation	Animation	Trailer
Level of excitement of content	Low	Middle	Middle	High
CNN@Pre-tr.	0.646 ± 0.025	0.554 ± 0.016	0.544 ± 0.01	0.503 ± 0.01

- Eye movements of individuals with ADHD display more distinctive information for the video with low levels of excitement of content.

[1] Alexander, L.M., Escalera, J., Ai, L., Andreotti, C., Febre, K., Mangone, A., Vega-Potler, N., Langer, N., Alexander, A., Kovacs, M., et al.: An open resource for transdiagnostic research in pediatric mental health and learning disorders. Scientific Data 4(1), 1–26 (2017)

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