Towards Autism Screening through Emotion-guided Eye Gaze Response

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Background

- **Autism Spectrum Disorder (ASD)**
  - Neurodevelopmental disorder \[^1, 2\]
  - Significantly impaired social interaction \[^3, 4\]
  - Limits communication abilities

- **ASD symptom manifestations**
  - Facial expression \[^5\]
  - Atypical gaze response $\rightarrow$ fixate less \[^6\]

- **Automated approaches for screening ASD**
  - Pupil diameter correlates with ASD

Require expert involvement, computationally-complex, and often time-consuming
Research Question

- Emotion \( \rightarrow \) integral component in communication
  - Influence facial expression \(^7\)
  - Influence eye gaze responses \(^8\)

- Possibility to explore the role of emotion
  - For ASD subjects

Can we leverage eye gaze responses based on the emotional stimuli to screen ASD?
Field Study & Dataset

- **Experiment Apparatus**
  - VR-based social interaction platform
    - Avatar narrates story related to social situations
    - Avatar expresses 3 types of emotions (angry, happy, neutral)
    - Avatar asks questions after the story
      - Participants respond with menu-driven interface
    - During interaction participant’s eye gaze data collected

- **Dataset details**

<table>
<thead>
<tr>
<th>TABLE I: Details of the eye gaze dataset used</th>
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<tbody>
<tr>
<td>Number of subjects</td>
</tr>
<tr>
<td>Total (short) sessions</td>
</tr>
<tr>
<td>Average session duration</td>
</tr>
<tr>
<td>ASD sessions</td>
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<tr>
<td>TD sessions</td>
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Data collection setup in a VR-based social interaction platform
Data Analysis

- Pupil diameter, fixation duration, and fixation location
  - Vary significantly ($p<0.001$) between two types of sessions

- Not normal distribution
- Unpaired Mann-Whitney Test
Methodology

- **Session Representation**
  - A set of eye gaze parameters
  - At every time step ‘t’
    - Pupil diameter
    - Fixation duration
    - Fixation location

- **LSTM cells**

- **Dropout layer**

- **Dense layer**
  - Sigmoid function
  - Binary classification (ASD / TD)

LSTM-based model for ASD screening
Evaluation

● Baseline
  ○ RF-based
  ○ Features extracted from sessions
    ■ (mean, median) of pupil diameter
    ■ (mean, median) of fixation duration
    ■ mode of fixation location

● Ablation Study
  ○ Fixation location is the most discriminating

● Emotion Stimuli’s Influence
  ○ Angry, happy stimuli are better

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<table>
<thead>
<tr>
<th>Model</th>
<th>Accuracy (in %)</th>
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<tbody>
<tr>
<td>RF Baseline</td>
<td>67.8 ± 8.7</td>
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<tr>
<td>LSTM (proposed)</td>
<td>77.3 ± 3.5</td>
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</tbody>
</table>

**Ablation**

| LSTM-pupil dia      | 59.1 ± 6.3      |
| LSTM-fix dur        | 54.8 ± 12.5     |
| LSTM-fix loc        | 69.9 ± 7.9      |
| LSTM w/o pupil dia  | 72.2 ± 6.5      |
| LSTM w/o fix dur    | 76.4 ± 6.4      |
| LSTM w/o fix loc    | 61.9 ± 9.7      |

**TABLE II: ASD screening results**

Stimuli-wise ASD screening performance
Conclusion

- Emotion-guided eye gaze response for ASD screening
  - Proposed an LSTM-based classification model
    - Leverages eye gaze parameters (pupil diameter, fixation duration, fixation location) for the screening
    - Returns an average F-score of 77%
  - Angry, and happy emotion stimuli are found more effective in screening ASD
References


Thank You!!

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