Estimation of Clinical Tremor using ST-AAE

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Background

• Clinical Tremor
  • Rhythmic, involuntary oscillatory movement
  • Diagnostic feature of multiple central system disorders
    • Parkinson’s disease
    • essential tremor,
    • medication side effect
• Monitor across diverse population with limited mobility
• Clear value in automated methods for remote assessments
Why Spatio-Temporal Adversarial AutoEncoder?

- Limitation of hand detection and tracking
  - Bounded by accuracy and robustness of underlying detection
  - Motion blurring, occlusions, and/or complex hand poses
  - End-to-end training frameworks should be more suitable
- Challenge of data collection
  - Very large amount data requires major effort, or not possible
  - Intra- or inter- observer variability
- Spatio-temporal adversarial autoencoder (ST-AAE)
  - Integrates spatial and temporal information
  - Adversarial generative model boosts learning
  - 3D Optical extracts only motion
Spatio-Temporal AAE for Tremor
Optical Flows at Different Frequencies

- **x-y**
  - 0Hz
  - 4Hz
  - 10Hz

- **x-t**
  - 0Hz
  - 4Hz
  - 10Hz

- **y-t**
  - 0Hz
  - 4Hz
  - 10Hz
Volunteer Data Collection

- Simulate tremor using an electronic pulse massager
  - Deliver electrical stimulus to hand via two 2x2 electrodes
- 3 frequencies
  - 0 Hz (no stimulus), 4 Hz, and 10 Hz
- 3068 video segments of 53 videos from 28 subjects
  - each segment of 2 seconds
Validation on Volunteer Data

- Videos from selected 8 subjects were used to perform ablation study
  - Basic
  - Basic + Weight Initialization
  - Basic + Weight Initialization + Image Augment
  - Basic + Weight Initialization + Image Augment + AutoEncoder (w/o adversarial discriminator)
  - Basic + Weight Initialization + Image Augment + AAE Generator
Results

Movement Model Validation: Volunteer Data

Prediction Accuracy (%)
Volunteer Data Results

- Leave-one-out cross validation:
  - Testing video segments from one subject
  - Videos from 3-4 subjects in the other subjects were selected as validation data
  - Videos from the remaining subjects were training data
Validation on Clinical Data

- 33 clinical videos from 9 essential tremor patients
  - Left / right hand
  - Hand forward position
- Clinical videos were coupled with clinical TETRAS scores

<table>
<thead>
<tr>
<th>Hand</th>
<th>0</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-forward</td>
<td>none</td>
<td>barely visible</td>
<td>&lt;1 cm</td>
<td>1- &lt;3 cm</td>
<td>3- &lt;5 cm</td>
<td>5- &lt;10 cm</td>
<td>10-20 cm</td>
<td>&gt;20 cm</td>
</tr>
<tr>
<td>L-forward</td>
<td>none</td>
<td>barely visible</td>
<td>&lt;1 cm</td>
<td>1- &lt;3 cm</td>
<td>3- &lt;5 cm</td>
<td>5- &lt;10 cm</td>
<td>10-20 cm</td>
<td>&gt;20 cm</td>
</tr>
</tbody>
</table>
Results of Clinical Validation
Conclusion

- ST-AAE can be trained with limited data
- Can be used for a data-driven paradigm of healthcare applications, limiting the raters’ impact on reliability and accuracy of assessment

Thank you!