Identifying Dementia Patients based on Behavioral Markers in Human-Avatar Interaction

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Early detection of dementia

- Dementia is one of the major causes of disability

Around 50 million people have dementia

- There is no treatment currently available to cure dementia or to alter its progressive course
Dementia detection tools

Neuropsychological tests

- MMSE [Folstein et al. 1975]
  One of the *frequently used tests* for detecting dementia

- WMS-R [Wechsler 1997]
  Designed to measure different memory functions

Medical experts are necessary for these tests
Patients need to go to hospital

Much easier tool is needed

We focus on speech and language of dementia
[Roark et al. 2011], [Aramaki et al. 2016]
Purpose of our study

**Purpose**
- Avatar-based detection
- Language and speech features

**Detection of dementia from Q&A using an avatar system**

- Suspected case of dementia
- Not suspected case of dementia
Question examples (A total of 13 questions)

- What’s your hobby?
- Please tell me about Yujiro Ishihara.

The avatar asks randomly five questions from 13 questions
Diagnosis is based on DSM-IV-TR

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age mean (SD)</th>
<th>MMSE mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-dementia</td>
<td>12</td>
<td>74.5 (4.3)</td>
<td>27.5 (1.8)</td>
</tr>
<tr>
<td>Dementia</td>
<td>12</td>
<td>75.9 (7.6)</td>
<td>21.2 (5.1)</td>
</tr>
</tbody>
</table>

Dementia
- Alzheimer’s disease (AD): 9
- Normal pressure hydrocephalus (NPH): 1
- Mild cognitive impairment (MCI): 1
- AD+NPH: 1
Analysis of the user’s utterances

Feature extraction from five questions

- Speech features:
  - Gap, Pause, Fundamental frequency (f0), Power, Answer time
- Language features:
  - Speech Rate, Tokens, Fillers, Part of Speech
Detection performance

- Normalized the features
  - Mean: 0, SD: 1

- Classification model
  - Linear SVM
  - Logistic regression

- Model evaluation
  - Leave-one-participant-out
  - ROC curve

<table>
<thead>
<tr>
<th></th>
<th>Accuracy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE</td>
<td>83</td>
</tr>
<tr>
<td>Our system</td>
<td>92</td>
</tr>
</tbody>
</table>

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“Gap” is the most important feature

- The dementia group is slow to respond to questions
- There was a significant difference between the two groups
  
  Mann-Whitney’s U test: $p < 0.05$ ($n = 24$)
  Effect size: Cohen's $d = 0.98$
Other important features

- Range of fundamental frequency (= pitch of voice)
  Non-dementia group < Dementia group

- Number of verb usage
  Non-dementia group < Dementia group

- Time between utterances
  Non-dementia group < Dementia group
Purpose

- Avatar-based detection
- Language and speech features

Proposed method

Analysis of multiple features used while asking questions by an avatar system

Evaluation

About 92% detection performance

Future work

Analysis of image features


Easier tool: speech and language

- Previous studies show possibilities of detecting dementia from speech and language features in human-human interaction
  
  [Roark et al. 2011], [Aramaki et al. 2016]

Limitation
- These studies were based on MMSE and WMS-R
- Same interaction patterns and questions
  - Not suitable for daily use
## Feature extraction

### Speech features

- **Answer time, Gap, Power** (mean, SD),
- **Pause** (count, mean time, max time),
- **Fundamental frequency** (f0)
  (coefficient of variation, mean, max, median, min, SD, range)

### Language features

- **Speech rate, Tokens, Fillers,**
- **POS** (noun, verb, adjective, adverb)