Identifying Driver’s Cognitive Distraction Using Inductive Logic Programming

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Background

• Next Generation Services in Car
  • Telematics
    • Entune, G-BOOK
  • Services in Cooperation with Smartphone
    • Smartphone NaviCon
  • Common Internet Services

Toyota Entune

Denso NaviCon
Purpose of the Study

• New research topic to Traffic problem
• To detect distracted driving
  Inside car services causes distracted driving, cell phone, media players, navigation
Real time driving experiments

Cognitive Qualitative SIMulation on Eye Movement

- Using QSIM: Qualitative SIMulation
- Analyzing real data
  - Eye Movement
  - Driving Data

Real street experiments: Limits of subjects numbers
Driving Simulator to Collect Experimental Data
Experimental Setting

Participants:

19 drivers (female 9 male 10)

Age: 30 ～ 50s
Experience: 5 ～ over 20 years
Hours/week: 1 ～ 30 hours

Two 15 min. same route drives for each participants

1. First Driving (without mental load)
   - normal driving

2. Second Driving (with mental load)
   - mental arithmetic task (load driving) every 8 seconds
Data Collection

1. Eye movement using EMR-9
   Position of Eye move \((X,Y)\)

2. Driving data using vehicle sensors from Simulator
   - accelerator depression data \((0 \sim 100)\)
   - steering data \((-1 \sim +1)\)
   - braking signal \((0 \text{ or } 1)\)
   - velocity data \((\text{km})\)
   - front vehicle \((0 \text{ or } 1)\)

*Obtain 60 data points per second*
Data Transformation for ILP learning

Transform raw data at constant time intervals to qualitative data

*(About 900 sec: (5 sec) 54,000 times)*

From Eye movement data

*On move direction and distance*

1. the counts of saccade and fixation
2. total eye movement distance

From driving data

1. Data average and standard deviation
2. Add difference attribute values

Example of qualitative data

`bigHigh` `bigMiddle` `bigLow` `average` `smallLow` `smallMiddle` `smallHigh`

Add new information on before event (interval)
## Background knowledge

<table>
<thead>
<tr>
<th>Types</th>
<th>Predicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative value</td>
<td>accele(+ID, #Val), brake(+ID, #Val), velocity(+ID, #Val), steering(+ID, #Val), gazeX(+ID, #Val), gazeY(+ID, #Val), front(+ID, #Val), sacCount(+ID, #Val), fixCount(+ID, #Val), eyeMove(+ID, #Val)</td>
</tr>
<tr>
<td>Qualitative state difference</td>
<td>accele diff(+ID,#Val), brake diff(+ID,#Val), velocity diff(+ID,#Val), steering diff(+ID,,#Val), gazeX diff(+ID,#Val), gazeY diff(+ID,#Val), front diff(+ID,#Time,#Val), sacCount_diff(+ID, #Val), fixCount_diff(+ID, #Val), moveCount_diff(+ID, #Val)</td>
</tr>
<tr>
<td>Information on before event</td>
<td>Before_event(+ID, -ID)</td>
</tr>
</tbody>
</table>

*Mode declaration: + input type   - output type   # constant*
Positive/Negative Examples

Positive examples: mental arithmetic task  
(more half time of driving)

Negative examples: Normal driving  
(only first driving data)

Data example: F01 (female, age 30, experiences 10 years, 5 hours/week)

<table>
<thead>
<tr>
<th>State</th>
<th>Time(sec.)</th>
<th>The number observation of raw data</th>
<th>The number of examples</th>
<th>Positive examples</th>
<th>Negative examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>917</td>
<td>55020</td>
<td>183</td>
<td>0</td>
<td>183</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>934</td>
<td>56220</td>
<td>186</td>
<td>119</td>
<td>0</td>
</tr>
</tbody>
</table>
Obtained ILP Rules

Rule generation by Parallel ILP engine
[Nishiyama & Owada 2015, Owada & Mizoguchi 1999]

- 2sets 6CPU computers
  (Intel(R) Core(TM) i7-5820K CPU @ 3.30GHz 16.0GB 64bit)
- 6sets 4CPU computers
  (Intel(R) Core(TM) i7-4790 CPU @ 3.60GHz 8.0GB 64bit)

Total time: 4615 sec. (1.28 hours)
Rule generations: 22sets
Examples of Rule (driving data F01)

**Driving and Eye movement Rules**

\[
\{23,4\} \text{ class}(A) : - \text{ steering}(A, \text{ straight}), \text{ eyeMove}(A, \text{ average}), \\
\text{ before\_event}(A, B), \text{ front}(B, \text{ notClear}).
\]

\[
\{21,3\} \text{ class}(A) : - \text{ front}(A, \text{ notClear}), \text{ before\_event}(A, B), \\
\text{ steering}(B, \text{ straight}), \text{ eyeMove}(A, \text{ average}).
\]

Each rule means **this driver follows a car in front, going straight and eye-movement is average**

*Checked normal driving video*

*In normal driving: eye-movement is almost high moving*

(No mental arithmetic task)

‘Average eye-movement’ means this driver don’t gather front information

*Not fixation, not saccade*
Conclusions

*Using Driving Simulator, we have obtained cognitive distraction with inductive rules.
*Parallel ILP engine is useful for the identification of distraction.
*The rules verify distraction in terms of eye-movement data, sac and fix.