SOFTWARE AND DATA INFRASTRUCTURE FOR VEHICLE PROJECT

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PROJECT OBJECTIVES

- Investigate open source / commercial driving simulator suitable for the project
- Investigate other data collection modalities
- Experiment with eye tracking machine and packages
- Develop software to collect, timestamp and register data collected
- Software to run experiment process
Driving Simulator Requirements

- Reflect real-life driving conditions
- Presence of pedestrian on road
- Support “left-hand traffic”
- Customizable / configurable traffic conditions
- Realistic physics
- Support for the use of steering wheel
# Driving Simulator Comparison

<table>
<thead>
<tr>
<th>Software</th>
<th>License</th>
<th>Support electronic steering wheel</th>
<th>Pedestrian</th>
<th>Support left-hand traffic</th>
<th>Support automatic/manual car</th>
<th>Traffic condition customization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Theft Auto</td>
<td>Closed Source</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>NA</td>
<td>No</td>
</tr>
<tr>
<td>TORCS</td>
<td>Open Source</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Both</td>
<td>No pre-made function</td>
</tr>
<tr>
<td>SimuRide</td>
<td>Closed Source</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Both (Pro version) Auto (Home Ed)</td>
<td>Yes AI car behavior</td>
</tr>
<tr>
<td>City Car Driving</td>
<td>Closed Source</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Both</td>
<td>Yes AI car behaviour Traffic rate</td>
</tr>
<tr>
<td>Driving Simulator 2012</td>
<td>Closed Source</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Both</td>
<td>Yes AI car behaviour Traffic rate</td>
</tr>
<tr>
<td>OpenDS</td>
<td>Open Source</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Auto</td>
<td>No pre-made function</td>
</tr>
</tbody>
</table>

- Electronic steering wheel: Support or not.
- Pedestrian: Support or not.
- Left-hand traffic: Support or not.
- Automatic/manual car: Support or not.
- Traffic condition customization: Support or not.
Driving Simulator Choice and Settings

City Car Driving 1.2
- Two in-game profiles set to support both keyboard and steering wheel
- 100% pedestrian rate
- 60% traffic density—reflect local traffic condition
- Traffic behavior: fast moving traffic of typical modern megapolis
- Virtual map set to modern district – fast moving traffic with traffic jams forming

(insert image of in-game setting screenshot)
## Data Collection Modalities

<table>
<thead>
<tr>
<th>Modality</th>
<th>Available Equipment</th>
<th>Usage</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye gaze</td>
<td>- FaceLab tracker</td>
<td>• Measure eye movement pattern</td>
<td>• Possible poor gaze accuracy due to internal and external factors</td>
</tr>
<tr>
<td></td>
<td>- EEG headset</td>
<td>• Possible to measure expression</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial Expression</td>
<td>FaceAPI</td>
<td>• Possible to use Facial Action Coding System (FACS) and Action Units (AU) to measure</td>
<td>• No optimal solution achieve high accuracy</td>
</tr>
<tr>
<td></td>
<td>Faceware</td>
<td>• Can be used for emotion recognition</td>
<td></td>
</tr>
<tr>
<td>Galvanic Skin Response (GSR)</td>
<td>GSR sensors</td>
<td>• Possible to measure emotional responses, anxiety and stress level</td>
<td>• Inconsistent result due to affection of temperature and humidity affect</td>
</tr>
<tr>
<td>Heart rate variability (HRV)</td>
<td>EKG sensors</td>
<td></td>
<td>• Possibly disturb driving subject due to too many cables running around</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Inaccurate result due to motion</td>
</tr>
<tr>
<td>Normal images</td>
<td>Normal webcam, camera</td>
<td>• Measure facial expression and emotion</td>
<td>• Human is good in faking emotion</td>
</tr>
<tr>
<td>Thermal images</td>
<td>Thermal camera</td>
<td>• Physiological measurement without skin contact</td>
<td>• Possible false face detection due to image background</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Possible to measure facial expression</td>
<td></td>
</tr>
</tbody>
</table>
EYE TRACKING MACHINES AND PACKAGES

- Evidence suggests a link between eye gaze and emotional behavior
- Eyes data captures using:
  - SeeingMachines Facelab 5.0 eye tracker
    - Provide real-time measurement
    - Gaze direction
    - Eyes movement
  - EyeWorks
    - Records to collect data:
      - Fixations
      - Blinks
      - Pupil size
      - Timing information
      - Audio and video of testing session
      - Head position and rotation
      - Eyelid aperture
SOFTWARE FOR EXPERIMENT

Data timestamp:
- Timestamp within same machine
  - Batch file (.bat) to start multiple programmes at once
  - Mouse recorder software: record mouse and keyboard actions for experiment process
    - Automation of experiment setup
    - Fixed delay time between software
- Timestamp the data collected using multiple machines
  - Manual “flagging” method recorded by multiple camera with audio enabled
  - Desktop activity recorded software: record real-time each software is started
Experiment setup

- City Car Driving 1.2 mirror-flipped using Ultramon 3.2.2
- Eye tracking using SeeingMachines Facelab 5.0 eye tracker and EyeWorks Record
- Galvanic skin response logging using GSR logger sensor NUL-217
- Heart’s activity tracking using electrocardiogram logger sensor NUL-218
- Subject’s body movement captured using front and side cameras
Equipment Integration Testing
Equipment Integration Testing

Experiment setup

- 5 randomly selected subjects

- 20 minutes driving with a 27” monitor:
  - 10 minutes using keyboard
  - 10 minutes using electrical steering wheel
# Experiment Observations and Integration

<table>
<thead>
<tr>
<th>Observation</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laggy driving simulator on flipped screen</td>
<td>• Provide more RAM (from 8GB to 16GB)</td>
</tr>
<tr>
<td></td>
<td>• Disable all other unnecessary programmes to boost performance</td>
</tr>
<tr>
<td>Sequence of programmes to be started up affect the performance of driving</td>
<td>• Sequence of start-up programmes to be followed to optimize performance</td>
</tr>
<tr>
<td>simulator</td>
<td></td>
</tr>
<tr>
<td>Overheat eye-tracking machine leads to poor eye tracking quality</td>
<td>• Schedule the experiment to allow cooling off time</td>
</tr>
</tbody>
</table>
# Experiment Observations and Integration

<table>
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<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neulog GSR sensors tend to get stuck into steering wheel and get loose</td>
<td>• Two cables taped together to increase width</td>
</tr>
<tr>
<td></td>
<td>• Position cables to avoid disturbing subjects during experiment</td>
</tr>
<tr>
<td>EKG sensors are too sensitive towards motions</td>
<td>• Normalize data to reduce noise</td>
</tr>
<tr>
<td></td>
<td>• Perform data cleaning before analysis</td>
</tr>
</tbody>
</table>
CONCLUSION AND FUTURE WORK

Learning Outcomes
- Understand the different data modalities, the purposes and potential usages of each modality
- Experience in conducting complex experiment
- Understand the importance and experience with data register and time-stamping

Future Work
- Improve current methods to optimize data collection process