Technical trends of driver assistance & automated driving

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Traffic Accidents – Global Fatalities

Source: Projections of mortality and causes of death, 2015 and 2030
BASELINE SCENARIO, 20 Leading Causes of Death
World Health Organization (WHO), 2015

2. Direction of Automated Driving Technologies Development

3. Technology Development for Automated Driving on Surface Roads
Towards “Eliminating Fatalities”

Integrated Three Part Initiative

Vehicles

Traffic Environment

People

Three Part Initiative

Pursuit for Vehicle Safety

Accident Investigation & Analysis

Pursuit for “Real-World Safety”

Development & Evaluation

Simulation
Toyota’s Approach to Safety

Integrated Safety Concept

- Optimal support in all driving conditions
- Coordination between individual systems

- Pre-Collision System (PCS)
  - Basic Functions
  - Alert
  - Pre-Collision
  - Brake Assist
  - Pre-Collision Braking

- Types
  - Regular Type: PCS to help prevent rear-end collision
  - Advanced Type: PCS to help prevent collision with pedestrians

- VDIM
- Vehicle Stability Control System (VSC)
- Traction Control (TRC)
- Brake Assist (BA)
- Anti-lock Braking System (ABS)
Toyota Safety Sense

• Combines cameras and radar for outstanding performance and reliability
• Functions chosen for their effectiveness in reducing traffic accidents
Toyota Safety Sense (Laser & Camera)

- First available in EU on AURIS, June ’15 (followed by Avensis, Yaris, Aygo….)
- Passed Euro NCAP and JNCAP assessment with success
Toyota Safety Sense (Radar + Camera)

- First available on Land Cruiser (Japan) in August ’15 (followed in EU by Prius, RAV-4, C-HR …and Lexus)
- Features Radar Cruise Control, Pre-Collision System with pedestrian detection function
We aim to equip Toyota Safety Sense on almost all passenger vehicles in Japan, Europe, and the U.S. by the end of 2017.
Towards Eliminating Traffic Accident Fatalities

Next Step

Active Safety Technology
Passive Safety Technology

2. Direction of Automated Driving Technologies Development

3. Technology Development for Automated Driving on Surface Roads
Our Concept of Automated Driving

1. To provide mobility for all people
2. All drivers can experience the fun of driving, when they want to
3. If driver requests, driver can rely on the automated driving
4. Design based on the Mobility Teammate Concept

Building relation between people and cars that share the same purpose, like close friends who sometimes watch over each other and sometimes help each other out.
Our Goals for Automated Driving

Safety

Freedom

Efficiency

Achieve a society where mobility means safety, efficiency, and freedom
Product Study Vehicle

Structure enabling mass-production, aiming for early product deployment
### Localization technology comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>Accuracy (worst case)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>~50m</td>
</tr>
<tr>
<td>GPS + dead reckoning (Conventional technology)</td>
<td>~30m</td>
</tr>
<tr>
<td>GPS + dead reckoning (Improved by latest software technology, TRCDL)</td>
<td>~10m</td>
</tr>
<tr>
<td>GPS + dead reckoning + Vision + Precise map</td>
<td>Lateral 0.1m, Longitudinal 0.5m</td>
</tr>
</tbody>
</table>

**GPS: Accuracy insufficient for Automated Driving**

Accurate localization only possible by using sensors & maps
Localization Technologies on Highways

1) Current technologies

Lane-keeping by detecting only white lines

【Limitations】
1. Miss/Loss detection
2. Cannot keep away from moving objects

2) Localization by white lines + landmarks + HD map
Using HD Maps for Accurate Localization

Front View

Accumulated image

Matching

Localized

Data Base

Road shape (2D)

Generated road image

Match camera view with road pictures generated from road database

2. Direction of Automated Driving Technologies Development

3. Technology Development for Automated Driving on Surface Roads
Highway

Surface road

Poorly maintained. Various rules and designs.

- No lane markings
- Road condition
- Traffic lights
- Various rules
- Hand signal

Many types of mobility. Moving in various directions.

- Pedestrians
- Various mobility
- Crossroads
- Multiple directions

Decisions for complicated situations are required.

- Giving way/cutting in?
- Instructions not clear?
- Waiting to park?
- Interaction
Importance of Maps

1. Obtain road network data, traffic rules/lights
2. Localization
3. Obstacle detection by matching with sensor data

Enable precise localization and also rich recognition
Automatic Spatial Data Generation

Rear-view camera + Accurate positioning
Accurate positioning technology (PRECISE)

Spatial data

Generate road image
Put together images along the path driven

Integrate road image
Data integration by matching images
High Resolution 3D SPAD LIDAR

※ SPAD: Single Photon Avalanche Diode
LIDAR: Light Detection And Ranging
Recognition Technology using Camera

■ Challenging Conditions; Recognition Not Possible So Far

e.g. Recognition of Partially Visible Pedestrians

■ Various Conditions not Noted in Rules

e.g. Projection of drive behavior based on statistical models

e.g. Detection of Moving Objects that Differ from Surroundings
Deep Learning

CES2016: Automated Vehicles learn to “avoid collisions”

For Deep Learning of automated vehicles, “Chainer”, the Deep Learning development framework by Preferred Networks, in which Toyota has invested, was used. Written in CUDA running on NVIDIA GPU.

In the beginning, automated vehicles had collisions, but as deep learning progressed, collisions were decreasing, vehicles were giving way to each other and what seemed like driving lanes appeared.
Questions?

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