Autonomous Driving Technologies
for Advanced Driver Assist System

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Contents

1. Definition of automated driving.

2. Effect of automated driving.

3. TOYOTA Automated Highway Driving Assist.

4. TOYOTA autonomous vehicle and developing philosophy.

5. JAPAN Auto Pilot System.
Definition of automated driving

- **Driver in the loop**
  - Driver must drive, watch system, and intervene as necessary

- **Driver out of the loop**
  - Driver is unnecessary

**Automated ratio**
- **Continuous Operation**
  - Necessary
  - Mix (necessary - unnecessary)
  - Unnecessary

**Scene coverage**
- Full self-driving car
- Platooning on specific road
- Auto drive in factory

**NHTSA definition Level**
- 1
- 2
- 3
- 4

Automated

Autonomous

2013/10/21
Safety

Decrease of recognition / judgment ability after driving for a long time.

Poor operation in unfamiliar environments or at high-speeds.

Traffic Accident: Highway

Single Rear Collision

Risk avoidance

Automated Driving

Warning

Stop avoid

FCW: Forward Collision Warning

FCA: Forward Collision Avoidance

FCW

FCA

PCS

LDW

LDP

PCF : Pre-Crash System

LDW : Lane Departure Warning

LDP : Lane Departure Prevention

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Environment

① Vehicle density becomes high.
② Speeds slow down at uphill of sag area.
③ Deceleration wave spreads and amplifies.

Loss time

Min

0  5  10  15  20  25  30

ACC vehicle penetration ratio

0%  3%  5%  10%  30%  50%  70%  100%

Reduction by half

ACC vehicle penetration ratio
Moving Assist

Harmonized increase of road safety and decrease of driving work load

Most effective

For the elderly

Driving license numbers according to age in JAPAN
Other Effect

Automated vehicle and technologies positively affect our lives.

- Industrial development by investment in technologies such as onboard devices and infrastructure.

- Economic development by improving the movement of the people.

- Revolution of logistics.

- Change of the urban planning.

...
TOYOTA’s System

Driver in the loop
- Driver must drive, watch system and intervene as necessary

Driver out of the loop
- Driver is unnecessary

Automated ratio

LKA
ACC
AHDA

ABS

Continuous Operation

Necessary
Mix (necessary - unnecessary)
Unnecessary

AHDA : Automated Highway Driving Assist

Full self-driving car
Platooning on specific road
Auto drive in factory
Scene coverage
LTC : Lane Trace Control

- Recognize lane markers by onboard camera and calculate estimated track
- Control steering wheel and vehicle velocity along calculated track

Lane Detection ➔ Road-shape & Vehicle-motion Estimator ➔ FF Controller ➔ Steering Angle Controller ➔ FB Controller
Cooperative - ACC

- V2V 760MHz ITS exclusive frequency
- Transmitting acceleration data to mitigate delay of onboard ranging sensor (e.g., radar)

ACC

C-ACC
TOYOTA Autonomous Vehicle

Front Camera

360° LIDAR

GPS System

Speed Sensor

Side Radar

Side Camera

Front Radar

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TOYOTA Autonomous Vehicle
Philosophy

Autonomous vehicle technologies enable every driver to drive like expert safety driver.

- Technologies produced by developing an autonomous vehicle are then realized in various Advanced Driver Assist Systems.
JAPAN Auto Pilot System

For the time being, automated driving is focus area of advanced driver support systems.

Diagram:
- **Automatic Driving**
- **Driver support system**
  - *Driver drives, watch systems*
- **Driverless**
  - **Full driverless**

Legend:
- Single ACC, PCS, LKA
- Complex ACC + LKA
- Advanced (to aim at for the time being by this study meeting)

System involvement ratio:
- 0% (driver)
- 100% (system)

Technical level:
- Improvement
Image of Auto Pilot System

- Auto Pilot System works on expressways from enter to exit.
Vehicle Issues

① Continuous driving on a lane
- Vehicle cannot define own position at areas with no GPS signal (e.g., tunnel)

② Lane change
- Vehicle cannot have enough margin at lane-changing without forward regulation.
  - Vehicle cannot drive smoothly at sharp curve or steep slope, etc.

③ Optimal driving at merge, branch, and traffic jam area.
- Vehicle cannot detect other vehicles on main lane at merge, and cannot get forward traffic condition especially at branch.
- Vehicle cannot drive optimally for smoothing the flow at traffic jam area.
Infrastructure Support

① Continuous driving on a lane
  • Provide position information at tunnel.
  • Provide road structure data as curvature, slope, etc.

② Lane change
  • Provide forward traffic regulations data.

③ Optimal driving at merge, branch, and traffic jam area
  • Provide other vehicle position on main lane.
  • Provide forward traffic condition at branch.
  • Provide optimal speed, gap, and recommended lane for traffic jam area.
In future & Conclusion

■ TOYOTA announced to launch in mid-2010s Advanced Driving Assist System Using Autonomous Driving Technologies.

■ TOYOTA’s Advanced Driving Assist System is for safer highway driving, reduced environmental effects and driver workload.

■ TOYOTA is thinking Autonomous driving technologies are to realize Advanced Driver Assist System.

■ TOYOTA is developing various Advanced Driver Assist System using not only Autonomous Driving Technologies but Cooperative systems with various governments.