An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving

Evangeline POLLARD, Philippe MORIGNOT, Fawzi NASHASHIBI

Fusion’13, Istanbul, July 10, 2013
Perception sensors

Intelligent vehicle + low cost production = Data fusion techniques

GPS  laser  camera  radar  exteroceptif
gyrometer  accelerometer  odometer  proprioceptif

E. Pollard, An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving
Situation assessment

- obstacles
- ego-vehicle
- environment
Autonomous driving

90’s: Cybercar concept

97: automatic shuttle at Shilport airport

2007: Junior

2010: Vislab challenge

2013: Link&Go vehicle

E. Pollard, An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving

2013/07/10
**Goal:** Demonstrate the technical feasibility of fully automated driving at speeds below 50km/h on controlled infrastructures

**Means:**
- Lane detection
- Obstacle detection and tracking
- Lane keeping system
- ACC
- ...
The final demonstration of ABV

"Your internet bill is 852.21 euros. Please contact your customer service"
Motivation

Sensors have predefined operating range and are not free of breakdowns

- full automated driving cannot be ensured yet at once in all situations
- self-assessment of the perception abilities
Outline

• Ontology description
• Automation spectrum
• Situation assessment
• Conclusion
Outline

• Ontology description
• Automation spectrum
• Situation assessment
• Conclusion
Ontology description

• Knowledge representation:
  « A specification of conceptualization of a domain knowledge » [Gruber 92]

• A complete semantic network.
  • Classes, individuals, properties.

• Tools embed an inference mechanism.
Outline

• Ontology description
• Automation spectrum
• Situation assessment
• Conclusion
5 automation layers have been defined:

- Longitudinal
- Lateral
- Local planning
- Global planning
- Parking
Longitudinal control layer

Levels of automation in terms of decisions to make about…

0: fully driving

Maintaining the velocity
Adapting the velocity
Starting, stopping

Long1: Cruise control

Long2: Dynamic Set Speed Type

Long3: Autonomous CC

Long4: Stop&Go

CLong: Cooperative cruise control

P1 ⇒ Long1
Long1 & P2 ⇒ Long2
Long2 & P3 ⇒ Long3 & Long4
Long1 & Long2 & Long3 & Long4 ⇒ Long

Increasing needs in terms of perception and communication

P1
Velocity estimation

P2
Estimation of speed limitation

P3
Front obstacle detection and tracking V2V

C1

E. Pollard, An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving

2013/07/10
E. Pollard, An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving

Levels of automation in terms of decisions to make about...

- Long1: Cruise control
- Long2: Dynamic Set Speed Type
- Long3: Autonomous CC
- Long4: Stop&Go
- CLong: Cooperative cruise control
- Lat1: Platooning
- Lat2: Lane following

Local planning:
- Loc1: Changing lane
- Loc2: Overtaking
- Loc3: Obstacle avoidance
  - Clloc1: Emergency stop
  - Clloc2: Cooperative path planning
- Loc4: Deciding into intersections

Global planning:
- Glob1: Dynamic trajectory planning
- Clloc: Cooperative trajectory planning

Parking:
- Park1: parking and pulling out
- Park2: search for parking place
- Park3: valet parking
- CPark: Cooperative parking

Legend:
- Communication layer
- Autonomy layer
- Automation mode
Logical rules for automation spectrum

• Non-communicative vehicles

$$\neg \text{Long} \Rightarrow \neg \text{Lat} \& \neg \text{Loc} \& \neg \text{Glo} \& \neg \text{Park}$$

$$\neg \text{Lat} \Rightarrow \neg \text{Loc} \& \neg \text{Glo} \& \neg \text{Park}$$

$$\neg \text{Loc} \Rightarrow \neg \text{Glo}$$

• Communicative vehicles

$$C1 \& \text{Long1} \& \text{Long2} \& \text{Long3} \& \text{Long4} \Rightarrow C_{\text{Long}}$$
Outline

• Ontology description
• Automation spectrum
• Situation assessment
• Conclusion
Logical rules depending on weather conditions

- snowy $\Rightarrow \tilde{M}_k = 0$
- raining $\Rightarrow \neg P3 \Rightarrow \tilde{M}_k = Long2$
- foggy & $\neg lat\ HP$ & long HP $\Rightarrow \neg P4 \& P2$

Maximum automation level
Front obstacle detection
Ego-lane estimation
Speed limit estimation
Combining with the current driver state

\[(\hat{M}_k < \hat{M}_{k-1}) \& \neg DS \Rightarrow \hat{M}_k = \hat{M}_{k-1}\]

Highest automation mode measured by the system (without driver consideration)  Highest automation mode measured by the system (with driver consideration)

In this case, an alert is given to the driver to give him more control back.
Conclusion

• An ontology on automation layers and an ontology on situation assessment, for co-driving (ITS).
  • Inference rules to infer the former given the latter.

• Implementation:
  • Classes /properties in OWL using PROTEGÉ.
  • 14+3 rules in SWRL using PELLET.

• Future work: better representation of rules (e.g., negation) and individuals (e.g., float numbers); porting on CyberCars (RTMaps and MySQL).
Thank you!

Contacts :
Evangeline POLLARD
Evangeline.pollard@inria.fr

imara.inria.fr