Intelligent vehicles: integration and issues

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Robotics vs. Artificial Intelligence (AI)

Robotics:
science of perceiving and manipulating the physical world through computer-controlled mechanical devices

AI:
any computer program which would be said "intelligent" if the same observed behavior would be so qualified when performed by a human.
Robotics

“Robotics is the science of perceiving and manipulating the physical world through computer-controlled mechanical devices.” [S. Thrun, 2006]
An attempt to define an intelligent robot

- **Ultimate goal: ensure its survival in its environment**
  - Ensure its energy independence
  - Diagnose its own state
  - Evaluate its perception abilities

- **Achieve a mission**
  - React properly to an unknown/abnormal situation
  - Learn from experience
Work in progress with intelligent cars

- **Ultimate goal: ensure its survival in its environment**
  - Ensure its energy independence
  - Diagnose its own state
  - Evaluate its perception abilities

- **Achieve a mission: move safely from a point A to B**
  - React properly to an unknown/abnormal situation
  - Learn from experience
Automation loop

How to introduce intelligence (human behavior) into the driving process?
How do we introduce intelligence into the driving process?

1. Supervision through Software Architectures: a unified framework
2. Dealing with uncertainty
3. Increase the perception using communication
4. Limit the combination explosion
Supervision through software architectures: a unified framework

• reaching a full autonomous driving mode in all situations → impossible
• self-assessment for the vehicle of its own perception abilities

E. Pollard et al., *An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving*
E. Pollard, An Ontology-based Model to Determine the Automation Level of an Automated Vehicle for Co-Driving
Longitudinal control layer

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

Longitudinal control

- Long1: Cruise control
- Long2: Dynamic Set Speed Type
- Long3: Autonomous CC
- Long4: Stop&Go

CLong: Cooperative cruise control

Increasing needs in terms of perception and communication

P1 ⇒ Long1
Long1 & P2 ⇒ Long2
Long2 & P3 ⇒ Long3 & Long4
Long1 & Long2 & Long3 & Long4 ⇒ Long
Dealing with uncertainty
Dealing with uncertainty
Supervision: dealing with real time
Multi-sensor fusion:

- To combine properly data from multiple sensors
- Deal with the problem of track spatial and temporal correlation
Split Covariance Intersection Filter-Information Matrix Filter (SCIF-IMF)

\[ P^{-1} = P_1^{-1} + P_2^{-1} - P_0^{-1} \]
\[ X = P(P_1^{-1}X_1 + P_2^{-1}X_2 - P_0^{-1}X_0) \]

Perception with Transferable Belief Model

Credibilist Simultaneous Localization And Mapping (C-SLAM)

Filling the polar grid map

Impacted cells

m_{gridmap(t,cell)}(Unknown) = 1
m_{gridmap(t,cell)}(Free) = 1
m_{gridmap(t,cell)}(Occupied) = 1

[Trehard 2014] Credibilist simultaneous localization and mapping (C-SLAM) with a lidar
Dealing with uncertainty and building generic architectures

[Image of diagram]

SLAM

Landmark queue

Drift handling

EKF SLAM

Drift estimation

Absolute information (GPS, V2I…)

Loop

Information from another vehicle (V2V)

[Bresson 2013], A General Consistent Decentralized SLAM Solution
Increasing perception using communications

Decorrelated maps

Decentralized map

Send

Receive

Receive

v

Pv

Pb

Pv

Pb

Pv

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Limit the combinatorial explosion: SLAM stretching compacted grid map:

• Dedicated to “open” areas

• Load in memory only the local neighborhood map slots, since the rest of the map is saved on the hard disc

• A coding technique to compact and save the old or non-used far slots
SLAM stretching compacted grid map
Conclusion

• The main issues related to autonomous vehicles can be summarized like this:
  • Deal with integration problems
  • Using redundancy and complementary information to achieve very precise state estimation
  • Using the fact that a vehicle should know that it does not know
  • Imitate human behavior for decision process

More experiment results on: https://team.inria.fr/rits/

Thank you for your attention!