Recognizing the traffic situation: Rule-based reasoning and ontology representation

Dr. Evangelia Portouli
Institute of Communication and Computer Systems
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Situation Matching objectives

• Several traffic scenarios that may need an interaction between the AV and other TPs have been selected
• These scenarios have to be recognised by the AV whenever encountered
• Situation Matching:
  • Based on models of traffic scenarios (ontology)
  • Matches in real time the traffic situation, perceived by the AV's sensors, with a traffic scenario from the ontology
Communication and Cooperation Planning Unit (CCPU) architecture

- Perception → Situation Awareness
- Situation Matching → Interaction Planning
- Interaction Planning → Trajectory Planning
- Trajectory Planning → Safety Layer
- Enablers:
  - Scenarios Ontology
  - Interaction Strategies Ontology
- HMI
- Control

Recognizing the traffic situation
CCPU overview

Recognizing the traffic situation

Δv
Δv

Crossing paths → conflict area

Initial situation
- conflict (s) detected for a near-future time window

Interaction planning:
- Decision to re-act (yield, not yield)
- Select AV strategy / Communicate intent

Aftermath
- conflict no longer exists/ AV proceeds with last goal

(pre-requisites)
- AV, TPs predicted paths
- AV, TPs kinematics + position
- Road topology + Traffic rules

interACT Use Case  (description of the sequence of events)

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Scenarios selected and pre-processing

- Traffic conflict detection via indicators suitable for all users and for non-collision + collision courses, i.e.
  - Time Advantage ($|t_1 - t_2|$ time needed for each actor to reach the conflict point)
  - Time_of_the_latest, expected time for the second (latest) road user to arrive at the conflict point
- Deadlock situation detection
React to a single pedestrian who intends to cross, possibly intersecting with the direction of the AV at a crossing without traffic lights with a crossing distance from pavement to pavement 3m-10m. The road is a two-directional road and the pedestrian is detected (un-obscured) close to the crossing on the right side of the driver.

**Example Properties:**
- AV has the right-of-way
- Pedestrian still on the right at 9 m dist.
- AV small deceleration, Vel = 20km/h

**Example Relations:**
- AV-TP cross paths
- AV has the right-of-way
- Pedestrian on the right at 9 m dist
- AV small deceleration

**Example Road properties:**
- No traffic lights
- No zebra crossing
- Two directional
The ontology

- The domain of knowledge consists of road and traffic related elements, TPs and their relations

- Scenarios ontology consists of:
  - Hierarchical taxonomy of classes
  - Properties and relations
  - Rules

\[
\begin{align*}
\text{approaches}(av, RS) & \land \\
\text{crossing}(RS) & \land \\
\text{noTrafficLights}(RS) & \land \\
\text{detected}(TP) & \land \\
\text{nonMotorised}(TP) & \land \\
\text{wantsToCross}(TP, RS) \\
\end{align*}
\]

\[\Rightarrow \text{encountered (scenario1)}\]
The Situation Matching process

Scenarios ontology (created offline)

- Scenarios abstraction
- Ontology building (elements/relations of elements)
- Rules’ construction incorporating paths/objects uncertainties

Realtime execution

- Perception data pre-processing for traffic conflict identification relevant actors’ relations
- Rule Engine performs real-time fuzzy scenario recognition based on available knowledge

Recognizing the traffic situation
Some thoughts

• Our approach: Rule-based reasoning in combination with Ontology representation

• Advantages:
  • Model complex situations with a reasonable amount of rules
  • Flexibility on insertion of new knowledge or modification of current knowledge
  • New rules can be easily inserted without need for software programming

• Disadvantages:
  • High computational complexity (runtime constraints) ... so >
    • Limit expressivity
    • Avoid inequality relations in the rules (instead levels or true-false relations using pre-processed thresholds)
Future work

Abstraction, Ontology elements

Testing with real data and time optimisation

Recognizing the traffic situation

Rules creation

Offline testing with data

Concept testing

Evaluation on real scenarios

Scenarios
Thank you!

https://www.interact-roadautomation.eu/

v.portouli@iccs.gr