Dynamic risk assessment for highly automated vehicles

Lars Svensson, Alexander Gratner, Stefan Annell

Background

Predetermined risk assessment (PRAS)

- Identification of all possible hazards during design time.
- Design the system in such a way that hazards are unlikely enough to lead to accidents.
- Currently regarded as best practice (ISO26262).
- Limitations when applied to highly automated vehicles:

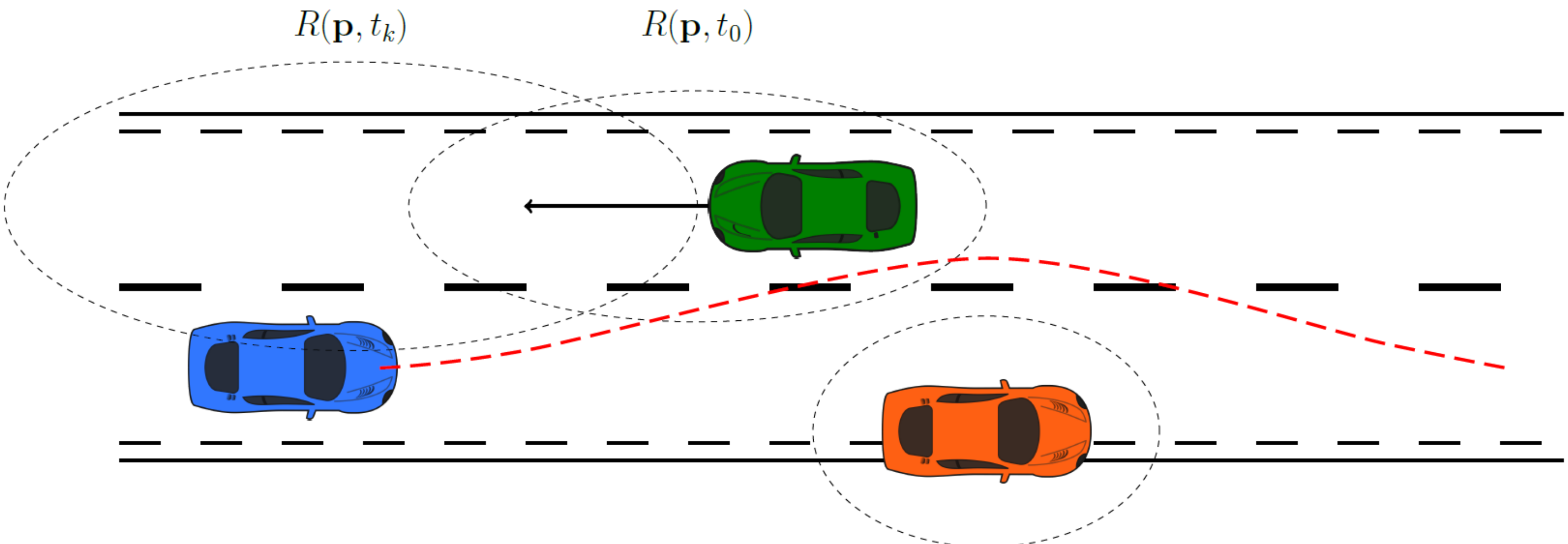
  Inefficiency:
  System must always act in a conservative manner in order to oblige to the rules set in design time

Hypothesis:
Alternative or complementary strategy needed for highly automated vehicles

Background

Dynamic risk assessment (DRAS)

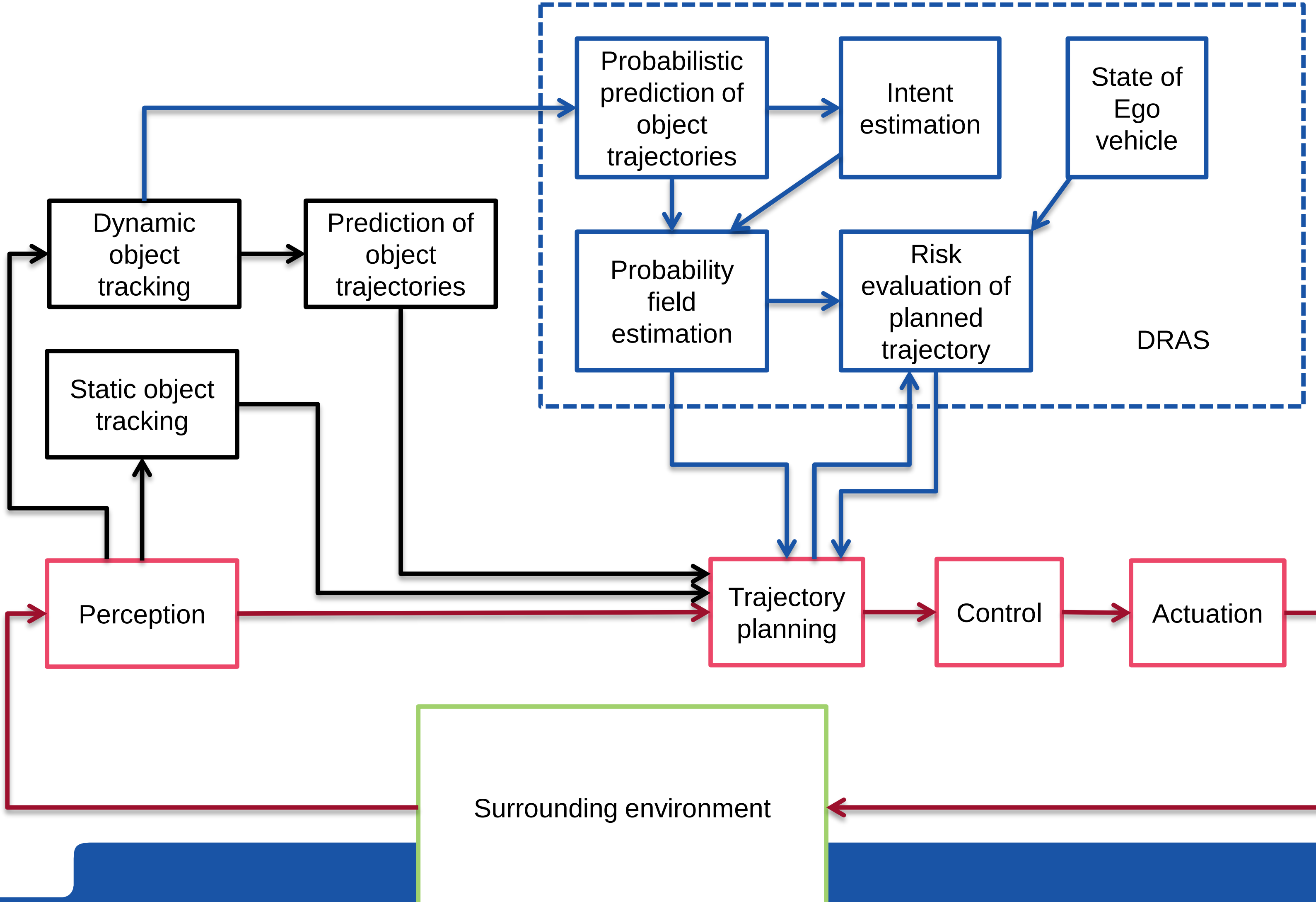
- Run-time estimation of risk in the surrounding traffic environment
- Risk is represented as a function of time and space
- Risk assessment is used in as an decision basis for manoeuvre planning
- Enables the system to optimize traffic flow under risk/safety constraints



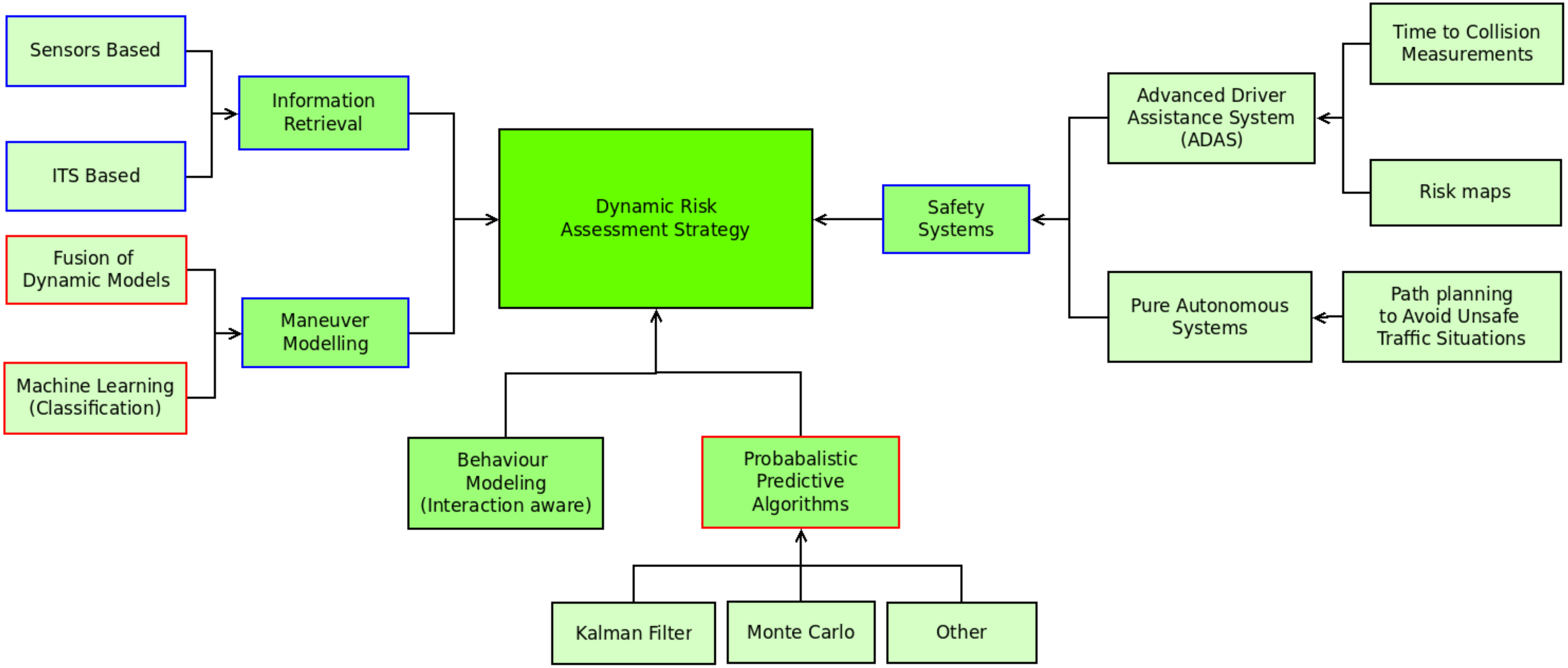
Data sources for DRAS

- Dynamic sensor (fusion) accuracy
  - Confidence in state estimates for dynamic objects
- Traffic statistics
  - e.g likelihood of a vehicle turning at an intersection
- V2X communication
  - Intention of other agents may be communicated
  - Discrepancy between V2X and sensor data, uncertainty
- Vehicle platform status
  - Consider degradation of vehicle platform

Architecture concept



Research areas related to DRAS



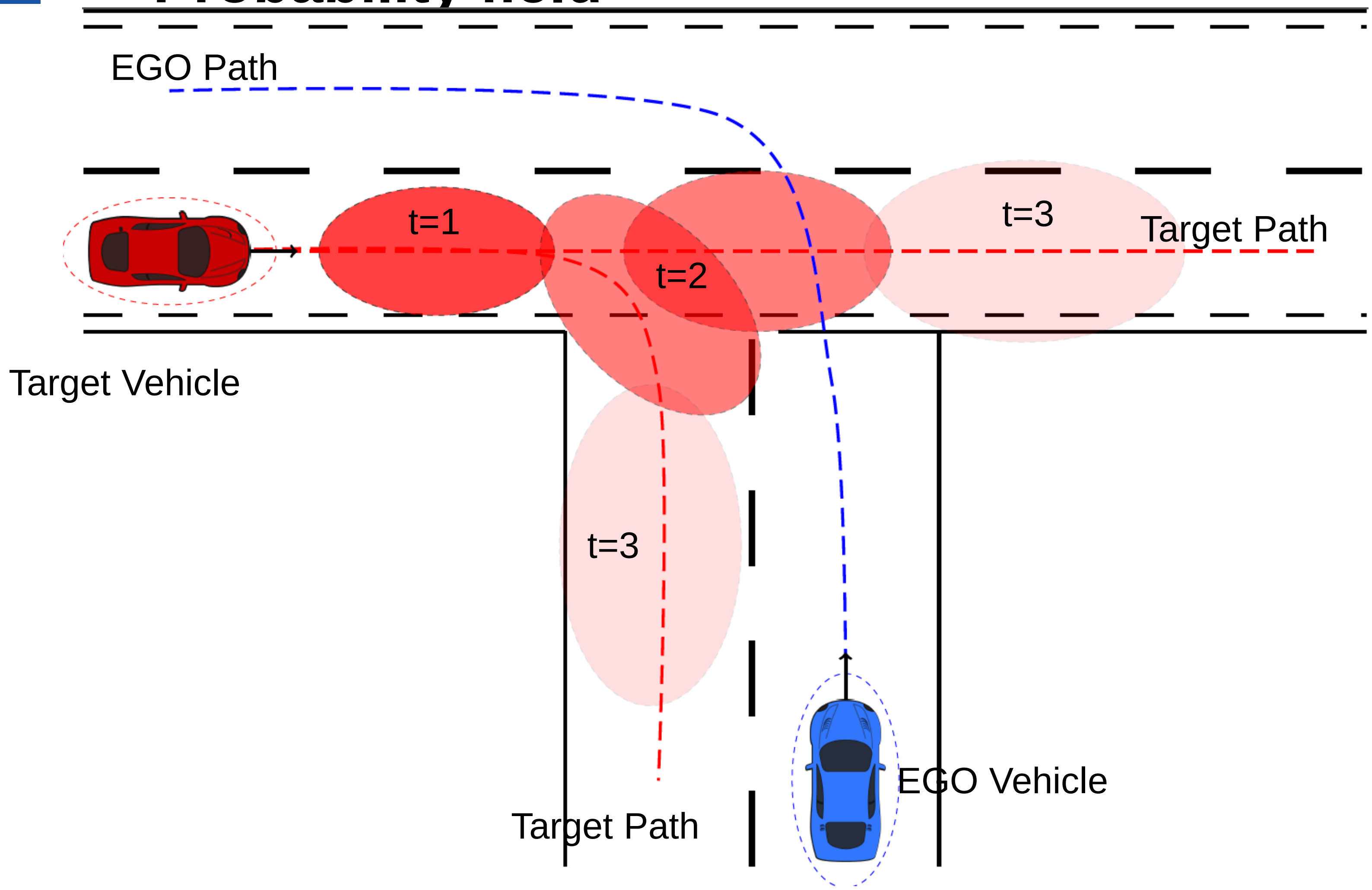
Delimitations of Scope

- Only simulation of concept
- Our case: T-intersection, EGO vehicle and one other vehicle
- Assumes environmental information
- Assumes exteroceptive based sensor tracking system
- No trajectory planning

Concept

- Combination of machine learning, vehicle dynamic model
- Probabilistic long-term prediction (~5s) of target behavior
- Probability Field
- Risk Evaluation
- Evaluation of Trajectory
- Modular system

Probability field



Algorithms

Paths:

Dynamic model + Ideal paths

Probability field prediction:

Extended Kalman Filter

Particle Filter

Risk evaluation:

$$\mathbb{P}_{coll}(v,o) = \iiint_{\mathbb{R}^3} p_v(x,y,\theta) \cdot p_o(x,y,\theta) \cdot dxdyd\theta$$

$$risk_{coll}(v) = p_{coll}(v, o_1...o_n) \cdot speed_v^2$$

Open questions for discussion

How can we evaluate that risk estimates are accurate?

Actions taken by the ego vehicle will affect the behavior of other agents in the situation. Will this need to be handled? How could that be done?