LOCALISATION SYSTEMS FOR INTELLIGENT VEHICLES: NEEDS AND CHALLENGES

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OUTLINE

- **Context**
  - The motivation
  - Intelligent Vehicles → Vehicle Navigation

- **Needs & Challenges**
  - Driving Assistance Systems
    - E.g. Road Intersection Warning
  - Cooperative Vehicles
    - E.g. Arrival of an emergency vehicle towards an intersection
  - Autonomous Vehicles
    - E.g. Autonomous valet parking service

- **Challenges & Localisation Systems**
  - Sample Issues
  - Some solutions

- **Conclusions**
INTELLIGENT VEHICLES ➔ VEHICLE NAVIGATION

LOCALISATION
Where am I?
Acknowledging the vehicle pose

DECISION & MOTION
How can I do it?
Generating actions: path planning, vehicle control

MAPPING
Where can I move?
Modelling and understanding the world. Driver & Machine View.

INTERACTION
How do I interact?
The interaction with other road users sharing the same road network.
### Driving Assistance Systems

- Machine Perception → Judgement / Evaluation → Inform / Warn → Operator or machine acts
- Challenges:
  - Perception is a hard problem: Laser Rangers, Radars, Machine Vision
  - Making a numerical model with incomplete information is difficult
  - Understanding a situation to decide under uncertainty a challenge
- Maps:
  - Provide context, a priory information
  - e.g. road geometry for ACC, speed limits, the proximity of an intersection, etc.
- Localisation
  - We need to know the vehicle location and projected to the map
  - Any projection error will imply that any map information is false.
NEEDS: DRIVING ASSISTANCE SYSTEMS: EXAMPLE ROAD INTERSECTION WARNING
**NEEDS: DRIVING ASSISTANCE SYSTEMS: EXAMPLE ROAD INTERSECTION WARNING**

<table>
<thead>
<tr>
<th>Information from Navigation Map</th>
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</thead>
<tbody>
<tr>
<td>Intersection Type</td>
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<tr>
<td>Distance with respect to the nearest intersection</td>
</tr>
<tr>
<td>Velocity Limits</td>
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<tr>
<td>Type of Road</td>
</tr>
<tr>
<td>Number of Lanes</td>
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<tr>
<td>Intersection Geometry</td>
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<tr>
<td>Roundabout</td>
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</tbody>
</table>

If the projection of the vehicle in the map is wrong, the whole strategy is **INVALID**.
NEEDS

- Cooperating Vehicles V2X: Example Road Intersection Warning

Information Sharing
- Enlarges Driver Perception
- Enhanced situational Awareness for all
- Dynamic information

Information
- Facilitates comms. Link
- Enhanced situational Awareness for all
- Dynamic information update

Which Intersection?
- What to Expect?
- Where in the Intersection?
- Vehicle State vs. Position.

Awareness

- Perception System
- Limited FOV
NEEDS

- Cooperating Vehicles V2X: The enabling technologies

- Local Dynamic Map (LDM)

- Localisation (LOC)

- Wireless Connectivity (V2X)
NEEDS

- **Cooperating Vehicles V2X**: e.g. Arrival of an emergency vehicle at an intersection
  
  - An emergency vehicle approaches an intersection.
  - It communicates its presence and direction of motion to neighboring vehicles.
  - Accordingly drivers are warned of its presence.
**NEEDS**

- **Cooperating Vehicles V2X:** e.g. Arrival of an emergency vehicle at an intersection

- **Gateway:** Interface to vehicle CAN-bus
- **Localisation System**
- **Purpose Built Map LDM**
- **Fusion Process**
- **Application Computer**
- **RF Modems 5.9GHz**
CHALLENGES

- **Cooperating Vehicles V2X**: e.g. Arrival of an emergency vehicle at an intersection
NEEDS: AUTONOMOUS VEHICLES

- Context. Intelligent Mobility
  - Technological convergence: Connectivity, Computer Power, Artificial Intelligence

- The trends:
  - Driverless Vehicles
    - New Mobility Services
  - Autonomous Vehicles
    - Traditional Clients
NEEDS: AUTONOMOUS VEHICLES

- A typical Functional Architecture
NEEDS: AUTONOMOUS VEHICLES

- E.g. unmanned valet Parking

  **Purpose:**
  
  To offer an integrated valet service for the use of EVs within the Technocentre Renault a demonstrator platform of autonomous driving technologies.

  **Objectives**
  
  - To provide a System Solution for the use of computer controlled EVs evolving in constrained spaces.
  - To develop safe and reliable systems for autonomous vehicles, using automotive type components
  - To build the technological know-how on: localisation, perception, navigation, control, integrity monitoring
NEEDS: AUTONOMOUS VEHICLES

- E.g. unmanned valet Parking
NEEDS: AUTONOMOUS VEHICLES

- E.g. unmanned valet Parking: Localisation system

Components
- CAN bus Proproceptive Data
- GNSS Rx + MEMS IMU
- Mobileye Camera
- Map of Drivable Area

Output (10Hz)
- Position and Heading
- Velocity
- Confidence Indicators
CHALLENGES: AUTONOMOUS VEHICLES

- The navigation environment can be very complex
  - Urban Canyons, tree canopies,
- Information sources can suffer strong disturbances
CHALLENGES: AUTONOMOUS VEHICLES

Effects on GNSS responses from tree canopies

Errors on GNSS responses even at simple roundabouts.
Effects on GNSS responses due to multipath.

Effects on GNSS responses due to full occlusion as vehicle enters a tunnel.
AUTONOMOUS NAVIGATION: SOURCES OF INFORMATION

- Exteroceptive Sensors
- GNSS Receivers
- Wireless Connectivity
- Navigation Maps
- Proprioceptive Sensors

Exteroceptive Sensors
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AUTONOMOUS NAVIGATION: DIFFERENT SOLUTIONS EXPLORED

Fault Detection and Exclusion through Integrity Monitoring

Exploiting Vehicle information and GNSS data using machine learning methods

- Tropo. noise
- Iono. noise
- Satellite
- Multipaths
- Receiver disturbances

Space level

Correction data
Integrity data

Use / don’t use

Protection levels calculation

Position calculation

FDE

CAN Bus

Receiver level

SBAS

Broadcasted data

- GNSS signal

Multiple-Model EKF

Learned maneuver recognition model

Weights

Vehicle position

GPS NMEA outputs

Exploiting Vehicle information and GNSS data using machine learning methods

DIRECTION R&D
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RENAULT
CONCLUSIONS

- Localisation estimates (position & attitude) are needed for all modern intelligent vehicle applications.
- The limitations of GNSS systems are well understood, new features as those brought by the Galileo constellation should provide better performance.
- Autonomous Vehicles are a major trend: Localisation shall become a safety critical function → work towards high integrity localisation
- Combine different solutions:
  - Augment GNSS estimates via other sensors
  - Combine absolute localisation solutions with those from relative localisation solutions like optical odometry or SLAM
- Major interest by vehicle OEMs, hence our participation in ESCAPE one of the first Galileo centred solutions for Avs.