Intelligent Vehicles: Communication, Sensing and Perception

Automotive Bachelors Mini-program

Offered by:	Department of Electrical Engineering
Language:	English
Primarily interesting for:	AU and EE
Prerequisites:	Basic knowledge of vector and matrix calculations
Contact person:	Gijs Dubbelman (G.Dubbelman@tue.nl)

Content and composition

Figure 1, Boss intelligent vehicle; winner of the DARPA urban Challenge (image courtesy of Field Robotics Center, USA).

A major automotive innovation in the coming decades will come from intelligent communication, sensing and perception technologies that enable autonomous (self driving) vehicles. This development has already started with the first generations of Advanced Driver Assistance Systems (ADAS) that are currently being put on the market. Such systems enable automatic pedestrian/cyclist detection, automatic traffic sign detection, and automatic parking. These technologies will be extended to semi-autonomous vehicles in the near future and to fully autonomous vehicles within a few decades.

In this mini-program, students will be introduced to the fundamental communication, sensing and perception technologies for intelligent vehicles. It consists of 3 courses given by experts from TU/e and from the automotive industry. These courses include lab experiments, to give students hands-on experience with state-of-the-art technology. Students following this mini program, furthermore have the opportunity to do their final bachelor project in this context, so as to obtain real-world immersion in the subject matter.

1. 5XSJ0 Automotive Sensing
- RADAR, LIDAR
- Stereo vision, thermal vision
- 3D vision (passive, active)
- GPS, INS

2. 5ETA0 Intro Telecommunications
- Baseband data communication
- Carrier modulation and reception techniques
- Modulation in time and frequency domain

3. 5XSK0 Data fusion & Semantic interpretation
- Data fusion principles
- 3D pattern recognition principles
- Pedestrian detection, lane detection, etc.
- Relation to intelligent vehicle control loop

Figure 2, Composition of 3-course mini-program on intelligent vehicles.

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Course descriptions

In Figure 2, an overview of the content of the 3 courses in this mini-program is provided. The first course "Automotive Sensing" discusses the fundamental sensor principles that allow vehicles to sense their environment. The second course "Intro Telecommunications" treats the basic principles of the telecommunication techniques that are used between vehicles and infrastructure. The third course "Data fusion & Semantic interpretation" deals with technologies that combine and interpret data from different sensors, to allow vehicles to drive autonomously. The third course primarily builds on the content of the first course and hence must be followed chronologically. For the second course "Intro Telecommunications" there are no such restrictions. More detailed information on these 3 courses is provided below.

Course code	Course name	Level	Year-Quartile
5XSJ0	Automotive Sensing	3 Advanced	Year 2 (or 3) - Q1
5ETA0	Intro Telecommunications	2 In-depth	Year 2 - Q3
5XSK0	Data fusion & Semantic interpretation	3 Advanced	Year 3 - Q3

Depending on your major, the mini-program consists of two or three courses (10 or 15 ECTS). For EE students, the mini-program is 10 ECTS: only the courses Automotive Sensing (5XSJ0) and Data Fusion & Semantic Interpretation (5XSK0), since Intro Telecommunications (5ETA0) is already part of the EE major. For AU and other students, the mini-program is the full 15 ECTS, meaning all three courses listed in the table above. **We recommend students to start this Mini-program with 5XSJ0 Automotive Sensing.**

1. Automotive Sensing (5XSJ0)

Sensing the environment around the vehicle is one of the most important aspects of autonomous driving. In this course, we introduce the most important sensor modalities, i.e. RADAR, LIDAR, thermal and stereo vision, active 3D vision, GPS(-INS), and ultrasound. For each sensor modality the students are taught: (1) the use of the sensor in automotive applications, (2) the physical principles underlying the sensor, (3) the mathematical models describing these physical principles, (4) how to derive first-order probabilistic models describing the accuracy of the sensor, (5) the fundamental pro's and con's of the sensor, (6) the recent advances in improving the sensor. The lectures will be given by TUE researchers as well as by experts from industry. The course includes extensive lab experiments with real sensors.

2. Intro Telecommunications (5ETA0)

Digital communication between vehicles as well as between vehicles and infrastructure is crucial for proper vehicle functioning, navigation and driver safety. This course provides a basic introduction to the fundamental principles of wired and wireless digital communication, along with lab experiments that provide students with hands-on experience with this technology. For more information on this course visit http://oase.tue.nl/

3. Data fusion & Semantic interpretation (5XSK0)

Sensing the environment around the vehicle requires giving real-world significance to sensory signals. We call this "semantic interpretation". For example, the vehicle must be able to decide whether a pixel in an image belongs to a tree or to a pedestrian. This semantic interpretation is done by advanced pattern recognition software, of which the principles are taught in this course.

For intelligent vehicles to be safe, the interpretation of sensory signals must be done extremely reliably in a wide variety of environmental conditions. This is achieved by fusing signals from multiple and, most importantly, from different sensor modalities, as this allows mitigating the pro's and con's of different sensors. Sensor fusion is performed by probabilistic filtering techniques, of which the most well-known is

the Kalman filter. This and other more advanced filtering techniques, such as particle filtering, will be taught in this course. Besides lectures, the course also incorporates programming assignments in which students will develop a pedestrian detection system.

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