UAB
Universitat Autònoma de Barcelona

Autonomous Navigation

Code: 106590
ECTS Credits: 6

2025/2026

Degree	Type	Year
Artificial Intelligence	OT	3
Artificial Intelligence	OT	4

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

This subject follows a practical approach. However, it is based on the theoretical foundations taught in previous subjects of UAB's Artificial Intelligence Degree. Some of them are essential and the subjects in which they are taught should be considered a prerequisite for Autonomous Navigation: (1) Fundamentals of Mathematics II; (2) Data Engineering; (3) Neural Networks and Deep Learning; (4) Machine Learning Paradigms; (5) Vision and Learning.

Objectives and Contextualisation

Autonomous navigation refers here to the scientific and technical knowledge associated with the intelligent movement of physical systems. This broad definition encompasses a variety of systems, including small objects moving through the bloodstream to monitor and ensure health, household or industrial robots aiding in tasks requiring mobility, unmanned aerial vehicles monitoring forest areas to prevent fires or perform rescues, unmanned underwater robots exploring the seafloor, autonomous vehicles for delivering goods, and robotaxis or autonomous buses for urban transportation. Each of these systems presents its own unique characteristics and primary challenges. In fact, to capture the main commonalities and differences between multiple systems with autonomous navigation capabilities, we could propose several separate subjects such as body nanobots, underwater autonomous navigation, air autonomous navigation, unstructured land autonomous navigation, and structured land autonomous navigation.

Certainly, all of this knowledge cannot be covered by a single 6-ECTS university subject. Therefore, it is not surprising that, when it was planned as part of the UAB's AI degree, the focus was on autonomous driving technology for vehicles such as cars, trucks, or buses that must transport people and goods in structured land environments. Still, autonomous driving is based on multi-disciplinary knowledge, thus, we have to emphasize certain contents over others depending on the context of the subject. For instance, in the context of a degree in Telecommunications Engineering, Vehicle-to-X cooperative driving would be especially relevant; in the context of a degree in Automation and Industrial Systems Engineering the topics of local planning and control within a classical autonomous driving stack would be core knowledge; in the context of a degree in Physics, the sensors enabling autonomous driving may deserve especial interest. The subject that brings us together is within the UAB's degree in AI. Therefore, we willfocus on scientific and technical knowledge at the intersection of AI and autonomous driving (AD).

As a matter of fact, this field is still broad and continuously evolving, and there will be many topics not covered. We prefer to focus on fewer topics in more depth rather than covering more topics superficially. Considering the experience in this subject gathered in previous courses, we will focus on sensorimotor deep models for autonomous driving (sometimes referred to in the literature as end-to-end AD), where imitation learning plays a key role. Note that this is the "purest" AI and naturalistic paradigm. Therefore, we leave out traditional AD stacks based on explicit modules for semantic perception, local planning and control, HD 3D maps and SLAM, since these stacks arise from the divide-and-conquer approach of classical engineering. Moreover, covering all the paradigms would be only possible in a purely theoretical approach to the subject, while we want practical work to be core.

The teaching methodology will follow a project-based approach. We will review the basic theoretical concepts so that students can grasp the overall picture and delve into the specific aspects needed to solve a project on autonomous driving. The specific project to be solved will depend on the particular computational resources and budget for materials that are assigned to our subject (these do not depend on the teachers and may change every year). However, in general terms, we aim to follow the usual approach we can find in the real world, which involves simulation and real-world developments.

Overall, the objective of this subject is to expose the students, through theory but mainly practice, to the relevant core contents of AD, so that in the future they are ready to tackle new challenges in autonomous navigation. Last but not least, it is crucial to learn how to collaborate in a team to achieve project success effectively.

Competences

Artificial Intelligence

- Analyse and solve problems effectively, generating innovative and creative proposals to achieve objectives.
- Conceive, design, analyse and implement autonomous cyber-physical agents and systems capable of interacting with other agents and/or people in open environments, taking into account collective demands and needs.
- Conceptualize and model alternatives of complex solutions to problems of application of artificial intelligence in different fields and create prototypes that demonstrate the validity of the proposed system.
- Identify, analyse and evaluate the ethical and social impact, the human and cultural context, and the legal implications of the development of artificial intelligence and data manipulation applications in different fields.
- Work cooperatively to achieve common objectives, assuming own responsibility and respecting the role of the different members of the team.

Learning Outcomes

1. Analyse and solve problems effectively, generating innovative and creative proposals to achieve objectives.

2. Design, simulate and evaluate autonomous driving systems.
3. Identify the best solutions for designing autonomous driving systems.
4. Identify the ethical and social impact and legal implications on the development of automated driving systems.
5. Work cooperatively to achieve common objectives, assuming own responsibility and respecting the role of the different members of the team.

Content

We will focus on:
(1) Autonomous driving sensors.
(2) Sensorimotor deep models.
(3) Imitation learning.
(4) Simulation and real-world development.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theoretical classes	10	0.4	3, 4
Type: Supervised			
Practical classes	38	1.52	1, 2, 3, 5
Type: Autonomous			
Study the theoretical content	13	0.52	3, 4
Team project	82	3.28	1, 2, 3, 5

The subject's contents will be deployed as follows:

(1) Theoretical classes will be taught to review key concepts related to autonomous driving, with a special focus on AI. The theoretical part will also include reading scientific articles.
(2) In the practical classes, tools/frameworks related to autonomous driving will be taught. A learning-by-practicing approach will be followed.
(3) A team project will be carried out to train a vehicle to perform autonomous driving maneuvers. Depending on available resources, the work will be carried out in a simulator and/or using a scale car.

In summary, the subject follows a project based learning (PBL) approach.

On the use of tool of generative artificial intelligence (AI). The use of generative AI tools is permitted for completing project tasks. However, it is essential to keep the following in mind:

(1) *Responsibility for Content:* All content generated with the help of AI will be considered as if it were entirely produced by the student(s). Therefore, each student must understand, be able to explain, and defend any part of the submitted work, whether it is design, code, documentation, or any other type of deliverable.
(2) *Defense and Justification:* If asked about any aspect of the project, students must be able to respond precisely and clearly. Answers such as "I don't know, the AI generated it" will not be accepted.

(3) *Active Learning:* The purpose of allowing the use of generative AI is to complement learning, not to replace it. Using these tools responsibly means reviewing, understanding, and adapting the results they provide.

In summary, you may use generative AI, but you must understand and be able to explain any content it generates. The use of AI does not exempt you from responsibility for the submitted content.

Furthermore, the following generic text from the degree applies: *"In this subject, the use of Artificial Intelligence (AI) technologies is permitted as an integral part of the development of the work, provided that the final result reflects a significant contribution from the student in terms of analysis and personal reflection. The student must clearly identify which parts have been generated with this technology, specify the tools used, and include a critical reflection on how these have influenced the process and the final result of the activity. Lack of transparency in the use of AI will be considered academic dishonesty and may result in a penalty in the grade for the activity, or more severe sanctions in serious cases."*

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Pair Evaluation (PE)	0.15	1	0.04	5
Practice Assessment (PrA)	0.2	2	0.08	1, 2, 3, 5
Project Assesment (PjA)	0.35	2	0.08	1, 2, 3, 5
Theory Assessment (TA)	0.3	2	0.08	3, 4

Single assessments are not considered.

The evaluation is continuous and will be based on the following marks:

Theory Assessment (TA): This is an individual assessment based on an exam to evaluate the theoretical knowledge acquired by the students.
Practice Assessment (PrA): Concerning the practices proposed by the lecturers, this is a team assessment based on the released code and documentation.
Project Assessment (PjA): Concerning the single project on autonomous driving proposed by the lecturers, this is a team assessment based on the obtained results, released code, and documentation.
Pair Evaluation (PE): A blind pair evaluation will be conducted to determine the level of active involvement of each student in the project developed by their team.

To pass the subject, all these sections must be passed separately. In other words, TA>=5, PrA>=5, PjA>=5, and PE>=5, where TA, PrA, PjA, and PE are grades out of 10. If this is true, then the final grade, FG, is calculated as:

FG = 0.3 TA + 0.2 PrA + 0.35 PjA + 0.15 PE.

NOTE: In cases where a student consistently fails to complete their work or makes only a minimal contribution (PE<5), the student will suspend the subject.
NOTE: PjA and PE are non-recoverable grades. If PjA<5, then no team member will pass the subject.

NOTE: TA and PrA are recoverable grades if (they are lower than 5) and (0.35 PjA + 0.15 PE>=3.5) and (PE>=5).

If a student fails to pass the subject, then their final garde (FG) will be min(TA,PrA,PjA,PE). It is understood that "Non-Evaluable" students are only those who have not undergone any evaluation/assessment activity.

MF grades (with Honors) will be given according to the UAB rules and considering features such as FG, continued work, relevance within the team, etc.

It should also be noted that students repeating the subject will not receive any special treatment, they must follow the subject as the rest of the students.

Without prejudice to other disciplinary measures deemed appropriate, and following current academic regulations, will be scored with a zero for the irregularities committed by the student that may lead to a variation of the qualification of an evaluation activity. Therefore, plagiarizing, copying, or allowing an assessment to be copied or any other evaluation activity, will involve suspending the activity with a zero so that it cannot be recovered in the same academic year. If this activity has a minimum associated score, then the subject will be suspended.

Bibliography

Autonomous driving is a constantly developing field. As a result, the most relevant literature changes continuously and is mainly available in the form of scientific articles. Therefore, instead of proposing a finalist bibliography when writing this guide, that is, seven months before the start of the subject, we will provide the most relevant literature at the start of the subject. On the other hand, if any student wants to read some materials beforehand, we suggest:

"A Survey of Autonomous Driving: Common Practices and Emerging Technologies" Ekim Yurtsever, Jacob Lambert, Alexander Carballo, Kazuya Takeda.
"A Survey of End-to-End Driving: Architectures and Training Methods", Ardi Tampuu, Maksym Semikin, Naveed Muhammad, Dmytro Fishman, Tambet Matiisen.
"End-to-end Autonomous Driving: Challenges and Frontiers", Li Chen, Penghao Wu, Kashyap Chitta, Bernhard Jaeger, Andreas Geiger and Hongyang Li.

All these articles can be found in arxiv.org, so there is a publicly available version of them. On the other hand, since the literature is constantly advancing, at the beginning of each course we will review the most relevant articles, and those mentioned here may be replaced by others.

Software

The software's requirements will vary depending on the specific practice and project. However, we anticipate a non-exclusive set of "keywords":

The CARLA simulator (carla.org)
The Robotic Operating System (ROS) 2 (https://docs.ros.org/en/foxy/index.html)
SCENIC (https://docs.scenic-lang.org/en/latest/)
Pytorch (https://pytorch.org/)

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	711	English	second semester	morning-mixed
(TE) Theory	71	English	second semester	morning-mixed