DTU

Lazaros Nalpantidis

Introduction to 31392 Perception for Autonomous Systems

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Overview

- 10 ECTS
- Technological Specialization course for the MSc. in Autonomous Systems
- Elective for other DTU MSc programmes

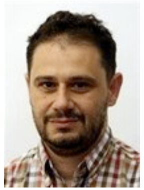
- All course lectures and activities:
  - Mondays 13:00-17:00 and Thursdays 08:30-12:00

- All course activities will be carried out electronically:
  – Lectures and Guest Lectures will be live streamed on Zoom: https://dtudk.zoom.us/j/62024533303?pwd=d3pLNDFmNHBpdW1Ja002RkVmNEh4Zz09
  – Exercises, Weekly Projects and Final Project work will be supported through Discord: https://discord.gg/qEameYuM5Y
  – Communication and Material Sharing will take place through DTU Learn

- Rooms reserved in case we are again allowed to be on campus:
  – 329A-120 (room 120, building 329A),
  – 325-017 (room 017, building 325),
  – 325-025 (room 025, building 325)

Lecturers

- **Lecturers:**
  - Lazaros Nalpantidis, Associate Professor, build. 326, room 018.



  - Evangelos Boukas, Associate Professor, build. 326, room 020.

- **Teaching Assistants:**
  - Rasmus Eckholdt Andersen, build. 326, room 110.

  - Jonathan Binner Becktor, build 326, room 119.

What is “Perception”?

What is an “Autonomous System”?

Why Autonomous Systems need Perception?

General Objectives

- Theory and practical applications of perception for autonomous systems.
- Transform sensory input from a variety of imaging and 3D sensors into more abstract description.
- Allow autonomous systems to perceive their environment and act within it or interact with it.
- Both the mathematical descriptions and programming tools to implement such perception techniques.
  – Open source tools will be used as much as possible, such as Python, OpenCV and Open3D.
- Enable you to use the taught concepts and tools to further develop either embodied (e.g. robotic) or intangible (e.g. software agent) Autonomous Systems.

Learning Objectives

A student who has met the objectives of the course will be able to:

- Describe the steps that lead to 3D reconstruction using multiple views.
- Define commonly used image feature extraction and matching techniques,.
- Discuss characteristics of various ranging sensors and techniques.
- Apply software tools to process 3D point clouds.
- Combine visual and 3D sensory input with state estimation techniques.
- Describe the differences between classical and learning-based object/scene classification techniques.
- Describe the different steps in visual odometry and explain the operation of the related algorithms.
- Combine the taught material to propose and describe possible implementations of further perception applications.

Literature

In this course we will be using 2 books as our main sources. However, topic-specific research papers and other additional material might be distributed in certain classes.

- **Book A:**
  - Richard Szeliski. 2010. Computer Vision: Algorithms and Applications (1st. ed.). Springer-Verlag, Berlin, Heidelberg.

- **Book B:**
  - David A. Forsyth and Jean Ponce. 2002. Computer Vision: A Modern Approach. Prentice Hall Professional Technical Reference.

Course Terminology (1/2)

- **Lectures & Exercises:**
  - As a general rule, Mondays will start with Lectures of new theoretical topics and
  - finish with Exercises applying the topics of the day.
    - » Exercises will be not be accompanied by solutions and it is up to the students to solve them, using the provided material. No hand-in is required for Exercises.

- **Weekly Projects:**
  - Thursdays will be mainly devoted to Weekly Projects. They are small, self-contained assignments where students need to exhibit self-driven behavior, use the taught material but also possibly go beyond that in order to solve them. No report is required for Weekly projects.
    - » No report is required for Weekly projects. In most cases, there are more than one correct ways of dealing with the Weekly Projects. Due to their open nature and to avoid limiting exploratory learning of students, no exact solutions to the Weekly projects will be provided. Instead, an indicative list of abstract steps in the form of hints, will be provided.

- **Mini-Quizzes:**
  - Throughout the course we will be having some Mini-Quizzes. They are short multiple-choice quizzes that will prepare the students for the style of questions expected in the final exam.

Course Terminology (2/2)

- **Guest Lectures:**
  - Towards the end of the course, a number of Guest Lectures are invited, where externals will link the course topics to real applications and industrial needs.

- **Final Project:**
  - The last period of the course is devoted to a Final Project,
  - Students are expected to work in groups of 4 people and solve a bigger assignment that will be given to them.
  - The outcome of the Final Project is a report of 10±2 pages that includes a link to a video demonstrating the group's main achievements.
  - A positive evaluation (pass/fail) of the report is mandatory for the group members to participate in the final exam.

Course Timeline

Calendar Week	F2A (Monday 13:00-17:00)		F2B (Thursday 08:00-12:00)	
5	Mon 1. Feb	• Introduction and Plan • Lecture: Image Processing • Python Environment Setup	Thu 4. Feb	• Group Formation • Weekly Project: Image Processing
6	Mon 08. Feb	• Lecture: Image Feature Description and Matching • Exercises	Thu 11. Feb	• Mini-Quiz • Weekly Project: Image Features
7	Mon 15. Feb	• Lecture: Multiple View Geometry 1 • Exercises	Thu 18. Feb	• Weekly Project: Multiple View Geometry
8	Mon 22. Feb	• Lecture: Multiple View Geometry 2 / Ranging • Exercises	Thu 25. Feb	• Mini-Quiz • Weekly Project: Multiple View Geometry
9	Mon 01. Mar	• Lecture: 3D Point Cloud Processing 1 • Exercises	Thu 04. Mar	• Weekly Project: 3D Point Cloud Processing
10	Mon 08. Mar	• Lecture: 3D Point Cloud Processing 2 • Exercises	Thu 11. Mar	• Mini-Quiz • Weekly Project: 3D Point Cloud Processing
11	Mon 15. Mar	• Lecture: State Estimation • Exercises	Thu 18. Mar	• Weekly Project: State Estimation
12	Mon 22. Mar	• Lecture: Classification • Final Project Description • Exercises	Thu 25. Mar	• Weekly Project: Classification
13	---------	Easter Holiday	---------	Easter Holiday
14	---------	Easter Holiday	Thu 08. Apr	• Final Project • Guest Lecture
15	Mon 12. Apr	• Lecture: Visual Odometry • Exercises	Thu 15. Apr	• Mini-Quiz • Weekly Project: Visual Odometry
16	Mon 19. Apr	• Lecture: SLAM • Final Project	Thu 22. Apr	• Guest Lecture • Final Project
17	Mon 26. Apr	• Guest Lecture • Final Project	Thu 29. Apr	• Guest Lecture • Final Project
18	Mon 03. May	• Final Project	Thu 06. May	• Final Project
19	Mon 10. May	• Final Project • Report Hand-in	--------	

Important Dates

4. February 2021	Deadline for group formation. Students form groups of 4 people to work together on Exercises, Weekly Projects and Final Project.
22. March 2021	Announcement from the teachers of the Final Project description.
10. May 2021	Group report hand-in.
12. May 2021	Information about non-qualification for participating in the exam by email to the members of groups with inadequate reports.
19. May 2021	Exam

Exams / Evaluation

The assessment for this course will take place by evaluating together the group report and the personal final exam score:

- **Report:**
  - Groups of 4 people will submit reports about their Final Project by the end of the course. Submission will take place by uploading on DTU Learn.
  - The report needs to be 10±2 pages and include a link to a video demonstrating the group's main outcomes.
  - Approval of report (based on a pass/fail evaluation) is mandatory for the group members to participate in the exam.
  - The report will account for 10% of the final grade.

- **Exam**
  - The examination type is multiple-choice test with questions and problems on the taught material.
  - The duration of the exam will be 4 hours.
  - The exam score will account for 90% of the final grade.

Summary

- Our goal is to learn a lot and connect theory to real problems.
- We need your feedback during the semester!

- We are looking forward to an exciting course!

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