Praktikum/Lab Course - Perception and Learning in Robotics and Augmented Reality

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Introduction

- **Computer Vision**
  - High-level image understanding
    - Object recognition
    - Object detection
    - Pose estimation

- **Deep Learning**
  - Learn representations of data
    - Learn from examples
    - Model features relevant for a given task
    - Boost performance in CV problems

- **Application in Robotics**
  - Grasping and Manipulation
  - Navigation
  - Obstacle avoidance

- **Augmented Reality**
  - Render virtual/augmented content on real objects of known shape or pose
Contents

● Theory
  ○ Image matching using keypoints and features
  ○ 3D data representations
  ○ Surface matching via 3D descriptors
  ○ 3D Object detection and pose estimation
  ○ Basics of Convolutional Neural Networks (CNNs)
  ○ Image classification and object detection using deep networks

● Practice
  ○ OpenCV (C++, open source)
  ○ Point Cloud Library (C++, open source)
  ○ Tensorflow (Python, open source)
Goals

- Be familiar with practical aspects of computer vision and deep learning for typical 3D perception tasks such as feature extraction, surface matching, object localization, pose estimation
- Learn to develop code with relevant open source libraries for computer vision, 3D perception and deep learning
- Learn to build up an end-to-end framework for the goal of object detection and pose estimation
- Be ready to challenge your code under unseen (and unpredictable) working conditions
Pre-requisites

- Basic knowledge of Python and C++

Schedule

- Thursday afternoon
- Seminarraum
Structure

- Lectures & Assignments stage:
  - 1 weekly lecture of one hour, for 7 weeks
  - Weekly assignments - to be submitted via GitHub
    (deadline: Thursday morning before every lecture, 9am)

- Challenge stage:
  - Project building with gradual milestones (Challenge I and II)
  - Final project evaluation at the end of the course

- Final challenge and leaderboard (not counted for grading - secret prize for the winning team)
Evaluation criteria

● Weekly assignments (50%)
● Challenges (50%)
Teams

- Students are grouped in pairs and evaluated jointly
- Registered students are requested to communicate with their team before the beginning of the semester
- Unpaired students will be paired randomly

- 6 teams
- Each team will be assigned to a tutor
## Tentative schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Tool</th>
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<tbody>
<tr>
<td>27.04</td>
<td>Computer vision basics</td>
<td>OpenCV (I)</td>
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<tr>
<td>04.05</td>
<td>Feature description and matching</td>
<td>OpenCV (II)</td>
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<td>11.05</td>
<td>3D data representations</td>
<td>PCL (I)</td>
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<td>18.05</td>
<td>3D description and surface matching</td>
<td>PCL (II)</td>
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<td>25.05</td>
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<td>01.06</td>
<td>3D object detection and pose estimation</td>
<td>PCL (III)</td>
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<td>08.06</td>
<td>Fundamentals of CNNs and deep feature learning</td>
<td>TensorFlow (I)</td>
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<td>15.06</td>
<td>Feiertag</td>
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<tr>
<td>22.06</td>
<td>Image classification and object detection with CNNs</td>
<td>TensorFlow (II)</td>
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<td>29.06</td>
<td>Framework building and challenge I</td>
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<tr>
<td>06.07</td>
<td>Framework building and challenge II</td>
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<td>13.07</td>
<td>Project development (no lecture)</td>
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<tr>
<td>17-20.07 (TBD)</td>
<td>Final Challenge and Project Evaluation</td>
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