Courses

<table>
<thead>
<tr>
<th></th>
<th>Bachelor PG</th>
<th>Master</th>
<th>Master</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lab + Seminar</td>
<td>Lab</td>
<td>Seminar</td>
</tr>
<tr>
<td>ECTS points</td>
<td>6 + 3</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Workload</td>
<td>180 h + 90 h</td>
<td>270 h</td>
<td>120 h</td>
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</table>

- **Seminar**: Presentation and discussion of relevant scientific work
- **Lab**: Programming project on robot simulation software
- **Project Group**: Lab (2/3) + Seminar (1/3)
- Experiments can be performed on physical robots if the covid situation improves during the semester.
Changes due to Covid-19

- All communications will take place electronically until further notice.
- Using simulations instead of actual robot hardware.
- Software requirements on website.
- Presentations over video conference.
- Return to normalcy possible during semester.
MA-INF 4213 Seminar
Seminar Overview

- **Presentation and discussion** of relevant scientific work (conference/journal papers)
- What is the new contribution of the work? How does the technique work? What are the strengths and the weaknesses of the approach?
- **MSc students**: **Summary and discussion** of the work (7 pages not counting figures, LaTeX template provided on web page)
Seminar Overview

- Prepare during the semester (at home)
  - Understand the paper
  - Write summary (MSc)
  - Prepare your presentation
- Seminar Day at the end of the semester
  - Everybody has to present
  - Everybody has to be present
  - It’s a full day event!
  - (Possibly) present over video conference
  - Presentations in person if covid situation improves.
Seminar Grade

BSc Students:
- Presentation: 100%

MSc Students:
- Presentation: 70%
- Summary and discussion: 30%
Seminar Papers
1. Terrain Segmentation and Roughness Estimation using RGB Data
V. Suryamurthy, ..., and D. Kanoulas, IEEE-RAS Int. Conf. on Humanoid Robots, 2019, Supervisor: Maren Bennewitz

- Perceptual understanding of terrain necessary to decide on control/planning strategies
- Fast method for predicting pixel-wise labels of terrain and estimate roughness
- Train a RGB-based deep neural network
- Application to a wheeled-legged robot
Training in Task Space to Speed Up and Guide Reinforcement Learning
Guillaume Bellegarda and Katie Byl
IROS 2019, Supervisor: Christopher Gebauer

- Reinforcement learning based locomotion
- Reduce complexity by simplified model of the system
- Integration of forward and inverse kinematics
Robot Learning via Human Adversarial Games
Jiali Duan et al.
IROS 2019, Supervisor: Christopher Gebauer

- Generative adversarial based learning
- Human gives adversarial feedback
- Improved robustness due to domain knowledge of human
Gradient-Driven Online Learning of Bipedal Push Recovery
Marcell Missura, Sven Behnke
IROS 2015, Supervisor: Marcell Missura

- Online learning of push recovery on a real robot
- Fast learning algorithm with LWPR
- Simple physical model computes policy gradient
Basin of Attraction of the Simplest Walking Model
A. L. Schwab, M. Wisse
DETC 2008, Supervisor: Marcell Missura

- Simplest possible model of walking
- Irreducible equations of motion
- Analysis of the basin of attraction
Minimal Construct: Efficient Shortest Path Finding for Mobile Robots in Polygonal Maps
Marcell Missura, Daniel D. Lee, Maren Bennewitz
IROS 2018, Supervisor: Marcell Missura

- Computes the shortest path in a polygonal scene
- Discovers only a small portion of the Visibility Graph
- Delays collision checks until the last moment
Goal: Find path for UAV to fully cover target structure at minimal cost.

Method: sample points around targets, generate path primitives for close points.

Construct graph from path primitives, find path to minimize travel distance for desired coverage area.
Autonomous 3D Reconstruction

- Goal: Find viewpoints for robotic arm to reconstruct unknown environment
- Evaluate candidates based on two metrics
  - Hand-crafted metric based on built map of the environment
  - Learned metric using current depth image as input for CNN
- Combine metrics to select next pose
Traversable Region Estimation for Mobile Robots in an Outdoor Image


- Estimate appropriate traversable regions from an outdoor scene image.
- Generate an estimation function from user instructed paths.
- Score function determines traversability.

(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)
Pwc-net: Cnns for optical flow using pyramid, warping, and cost volume

Sun et al.: IEEE Conference on Computer Vision and Pattern Recognition, 2018, Supervisor: Arindam Roychoudhury

- Effective CNN model for optical flow.
- Pyramidal processing, warping, and the use of a partial cost volume.
- Reduced model size and faster.
MA-INF 4214 Lab
Programming Projects

- Small groups of 2-3 people
- Work with robot simulation software at home
- Work with the Nao humanoids (in the lab) if Covid situation improves
- Individual projects involving perception and action generation
- Presentation and written documentation at the end of the semester
- Presentations over video conference unless situation improves.
Lab Grade

- Depends on participation during the semester, performance of the system in the final demonstration, and the final presentation.
- Individual grade for each group member
- **Satisfying documentation is a precondition!**
Lab Projects
Soccer

- Score a penalty kick
- Detect goal and ball, walk up to the ball, and kick the ball into the goal
Turtlebot

- Program a mobile robot to avoid obstacles and to find an object in a labyrinth
Robot Arm

- Program a robot arm to sort objects into a cup
Lab Rules

*In case they open up
1. Rule

- The lab closes at 6pm. If you are the last to leave the lab, please ask one of the supervisors to lock up.
2. Rule

- To open or to close the windows, please ask one of the supervisors.
3. Rule

- When you are not using the Nao, please set it into the rest mode by double pressing the button on the chest.
4. Rule

- Please use the harness during walking!
5. Rule

- Clean up after yourself.
Registration
Next Steps

- Two separate registrations are necessary!

1. Registration on our web site (first-come-first-serve!) until Tuesday, April 28th

2. Topic and group assignment: Wednesday April 29th 12:00 (notification via e-mail)

3. Registration in BASIS until Thursday, April 30th
After the first lab meeting, the participants can arrange their working schedule individually after consultation with their supervisor.

Registration

In order to take part in this course you have to complete two separate registrations:

1. Complete the registration form including the selection of topics at the link below until Friday, October 28 at noon:

   [Registration form]

2. Register for the exam in BASIS until Monday, October 31.

Only students who completed both registrations will be allowed to take part.

Topics:

- **Soccer:**
  We place a ball in front of a goal. The robot has to detect the goal and the ball with its camera, walk to the ball, and kick the ball into the goal.
  Focus: image analysis, computer vision, motion planning, navigation

- **Roll the Dice:**
  Implement a dice game that the Nao robot can play against a human, for example "21" (blackjack with dice), "Snakes and Ladders", "Mensch ärgere dich nicht", or a similar game. The robot has to roll a large foam dice, read the points on the dice, play the game according to the rules, and interact with the human opponent.
  Focus: image analysis and computer vision, navigation, human-robot interaction

- **Autonomous Life:**
  Implement a comprehensive state machine to simulate autonomous behavior. The Nao robot will respond to different types of sensors (tactile, visible, sound) and interact with a human in a natural and random way. You will implement multiple behaviors that can be mixed and combined to create different interactions.
  Focus: autonomous behavior, sensor integration, human-robot interaction
Registration for Humanoid Robots Lab Course

Questions marked with (*) are mandatory.

Name (*)

E-Mail address (*)

Study program (*)
- M.Sc. Computer Science (Bonn)
- M.Sc. Media Informatics (Aachen)
- Other: (please specify)

Experience (*)
Please tell us whether you are already experienced with the following technologies. Note that these technologies are not requirements for taking the course. Your answers will only be used to prepare the course materials.

<table>
<thead>
<tr>
<th>Technology</th>
<th>No experience</th>
<th>Basic knowledge</th>
<th>Advanced knowledge</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linux</td>
<td></td>
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<tr>
<td>C++</td>
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<tr>
<td>Python</td>
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<tr>
<td>ROS (Robot Operating System)</td>
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<td>Nao framework (Choregraphe, NaoQI)</td>
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<td>Computer vision (e.g., OpenCV)</td>
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Topics

Please choose four topics and rank them from 1 = highest priority to 4 = lowest priority.

<table>
<thead>
<tr>
<th>#</th>
<th>Topic</th>
<th>Priority (1-4)</th>
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<tbody>
<tr>
<td>1</td>
<td>Generating Legible Motion</td>
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<tr>
<td>2</td>
<td>Considering Avoidance and Consistency in Motion Planning for Human-Robot Manipulation in a Shared Workspace</td>
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<tr>
<td>3</td>
<td>Omnidirectional Bipedal Walking with Direct Fused Angle Feedback Mechanisms</td>
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<tr>
<td>4</td>
<td>Trajectory Free Linear Model Predictive Control for Stable Walking in the Presence of Strong Perturbations</td>
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<tr>
<td>5</td>
<td>Bipedal Walking Control Based on Capture Point Dynamics</td>
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<tr>
<td>6</td>
<td>Robust Physics-Based Locomotion Using Low-Dimensional Planning</td>
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<tr>
<td>7</td>
<td>Optimizing Energy Consumption and Preventing Slips at the Footstep Planning Level</td>
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<tr>
<td>8</td>
<td>Cooperative SLAM-Based Object Transportation by Two Humanoid Robots in a Cluttered Environment</td>
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Apply for Exam in BASIS

Apply for Exams

Please choose the exam from the structure given below. Click on the identifiers.

Master of Science Computer Science 2007

- 2000 Konto: Algorithmics
- 3000 Konto: Graphics, Vision and Audio
- 4000 Konto: Information and communication Management
  - 612103101 Modul MA MA-INF 3101 High Performance Networking
    - Prüfung Modul 3101
      - Date: 08.02.2010, Examiner: Martini, Peter, Date: 01, Room: , Start: Prüfung anmelden
  - 612103102 Modul MA MA-INF 3102 Information Systems Engineering
  - 612103201 Modul MA MA-INF 3201 Network Security
  - 612103202 Modul MA MA-INF 3201 Mobile Communication
  - 612103203 Modul MA MA-INF 3203 Intelligent Information Systems
  - 612103204 Modul MA MA-INF 3204 Distributed and Mobile Information System
## Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>BSc Project Group</th>
<th>MSc Lab Course</th>
<th>MSc Seminar</th>
</tr>
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<tbody>
<tr>
<td>Tue Apr 28</td>
<td>Registration deadline and topic assignment</td>
<td></td>
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<tr>
<td>Thu Apr 30</td>
<td>BASIS registration deadline</td>
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<tr>
<td></td>
<td>Supervised lab course during the whole semester</td>
<td></td>
<td>Individual supervision</td>
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<tr>
<td>Thu Sep 24</td>
<td>Seminar presentation</td>
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<tr>
<td>Fri Sep 25</td>
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<td></td>
<td>Seminar presentation</td>
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<td>Deadline for the summary</td>
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<tr>
<td>Mon Sep 28</td>
<td>Lab demonstration</td>
<td>Lab demonstration</td>
<td></td>
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Questions?