TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
Prof. Dr. Dongheui Lee

Advanced Seminar Autonomous System

Procedure:

The advanced seminar consists of the following events, which will be announced on TUM-online:

1. Kick-Off Meeting: presentation of individual topics and description of the schedule for the advanced seminar.
2. Midterm Presentation: presentation of in-depth introduction of one paper.
3. Report submission: submission of the final report, presentation and electronic copies of all publications read during the advanced seminar.
4. Final presentation: each participant has to present the results of his advanced seminar.

Participation in all events is a requirement for successful completion of the advanced seminar. Participation will be documented by means of an attendance list.

Final report submission:

A printed copy of the report with a CD sticked to the last page has to be submitted (Room 5007@Karlstr.45). The CD must contain the presentation, report and all relevant scientific material. Thus, the presentation must be finished by the deadline. The report should be about 10 pages (title page, table of contents and bibliography excluded) and must be written using LaTeX. The supervisor should give you the template for the presentation and the report. The second page of the report has to contain the assigned topic sheet. The report should only be stapled two times on the left side (no spiral or adhesive binding).

The CD should be composed of two directories: Documents and Presentation. In the documents directory, either a Microsoft word document or all Latex files (including images) should be present as a zip file. In addition, a pdf copy of the report should also be present in this directory. The presentation directory should contain a PowerPoint presentation or a pdf version. All relevant (electronic) references have to be saved on the CD as a zip file entitled „references“.

Presentations:

The duration of the presentation is 10 minutes. The presentation format/style can be based on obtained from the supervisor. After the presentation, a 5 minutes discussion will take place in which everyone should actively participate. The contribution to the discussion is included in the final grade. It is compulsory to attend all presentations.

Grading:

The grading of the advanced seminar is based on the template attached below. In the assessment contains various criterion related to the preparation of the advanced seminar, the final report, presentation and participation during the discussion session.

I. Preperation phase

Nr.	Criteria	Grade
1	**Introduction:** understanding and overview given the difficulty of the task	
2	**Own Contribution:** creativity, Richness of ideas, initiative,	

	self organization and decisiveness	
3	**Organization:** organization, time management, persistence and Diligence	
4	**Scientific Work:** rigor, systematic approach, analysis of results	

II. Written report (Documentation)

5	**Formatting:** structure, completeness, sources Formatting and graphic design	
6	**Didactics:** style, expression, comprehension, conciseness of pictures and diagrams	
7	**Scientific Content:** technical correctness, discussion and evaluation of results	

III. Participation

8	**Active participation:** Discussion during presentations	

IV. Final presentation

9	**Technical content:** scientific content, classification and evaluation, discussion	
10	**Presentation:** presentation style, time discipline, slides and videos etc.	

Role of Supervisors:

The supervisor is the reference person in case of any inquiries. Together with the supervisor you agree on the specifics of the topic and the expectations. The supervisor supports you in technical matters, final report and presentation of the results. If desired students can give their presentations prior to the final presentations in order to get some feedback concerning style and content. Your supervisor also shows you the workstations available for students and can introduce you to the computer programs required to complete the seminar.

It is necessary that the written report and the final presentation be submitted to the supervisor at least 1 week before the deadline.

Literature research:

The literature review should be carried out independently. Your supervisor will support you by providing appropriate reference books and scientific papers. In order to facilitate your introduction to the topic, your supervisor also provides a list of introductory articles.

Regulations for absence:

There are strict regulations concerning unexcused absence from the advanced seminar. Unexcused absence in any of the advanced seminar events will lead to failure in the course. In case of illness, a doctor’s certificate must be presented. Overlap with other courses is not a sufficient excuse, because in this case a decision must be made in favor of one course at the beginning of the semester.

Timetable:

Events	Date	Time
Kick-off meeting	18.10.2019	15:30 – 16:30 (2026@2906)
Midterm presentation	13.12.2019	15:30 – 16:30 (2001@2906)
Report submission	27.01.2020	12:00 (5007@2906)
Final presentation	31.01.2020	15:30 – 16:30 (2001@2906)

* 2001@2906 is a seminar room (2001) on the second floor in Karlstr. 45, München.

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I have read and acknowledge the above information and guidelines for the advanced seminar:

Matriculation number: ____________________

First Name, Last Name: ______________________________

Date: ____________________

Signature: ______________________________

TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR.-ING. DONGHEUI LEE

October 01

A D V A N C E D   S E M I N A R

Self-supervised hand pose estimation

Problem description:

Deep learning has significantly advanced state-of-the-art for 3D hand pose estimation. The success of learning-based methods can be attributed to two factors: choices in network design, and increased amounts of labelled data. However, annotating 3D hand pose labels can be extremely difficult.
A recent trend in hand pose estimation is to combine the advantage of learning-based approaches with model-based tracking methods [2, 3, 1]. Relying on the energy terms designed for model-based tracking, self-supervised learning can be trained on large amount of unllabeld data, which are easy to capture.
In this semniar work, the student will conduct a literature survey on self-supervised learning methods for hand-pose estimation. The student should understand the main concepts of the state-of-the-art methods and compare their advantages and disadvantages.

- Literature survey
- Description and comparison of different methods
- Propose own ideas for future research
- Writing report

Bibliography:

[1] Yujin Chen, Zhigang Tu, Liuhao Ge, Dejun Zhang, Ruizhi Chen, and Junsong Yuan. So-handnet: Self-organizing network for 3d hand pose estimation with semi-supervised learning. In *Proceedings of the IEEE International Conference on Computer Vision*, 2019.

[2] Chengde Wan, Thomas Probst, Luc Van Gool, and Angela Yao. Self-supervised 3d hand pose estimation through training by fitting. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 10853–10862, 2019.

[3] Chengde Wan, Thomas Probst, Luc Van Gool, and Angela Yao. Dual grid net: hand mesh vertex regression from single depth maps. *arXiv preprint arXiv:1907.10695*, 2019.

Supervisor: M. Sc. Shile Li

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TECHNISCHE UNIVERSITÄT MÜNCHEN
Human-centered Assistive Robotics
UNIV.-PROF. DR.-ING. DONGHEUI LEE

September 30, 2019

ADVANCED SEMINAR

Contact-based Robot Skills Learned from Demonstration

Problem description:

With current compliant robots, more and more physical force-based interactions with the environment are solvable, for instance industrial tasks where the robot executes force-based assembly operations, deburring, polishing, peg-in-hole, planing etc. Some examples are given in [1, 3, 4].
At the same time, Learning from Demonstration (LfD) is an appealing method to ease the programming process of a complex tasks [2]. As LfD can be also used to program contact-based tasks, it is particularly interesting which behaviors can be exactly transferred by this technique looking at the state of the art.

In detail, do a literature survey and consider these research questions in your advanced seminar:

- Which force-based behaviors (or skills) can be transferred to a robot by LfD?
- How are these skills represented (and how is force and motion encoded)?
- Are these skills rather predefined or directly learned by demonstration?
- Is there an ontology / categorization over force-based skills you can find?

Bibliography:

[1] Fares J Abu-Dakka, Leonel Rozo, and Darwin G Caldwell. Force-based learning of variable impedance skills for robotic manipulation. In *2018 IEEE-RAS 18th International Conference on Humanoid Robots (Humanoids)*, pages 1–9. IEEE, 2018.

[2] S. Calinon and D. Lee. Learning control. In P. Vadakkepat and A. Goswami, editors, *Humanoid Robotics: a Reference*. Springer, 2018.

[3] Alberto Montebelli, Franz Steinmetz, and Ville Kyrki. On handing down our tools to robots: Single-phase kinesthetic teaching for dynamic in-contact tasks. In *IEEE International Conference on Robotics and Automation (ICRA)*, pages 5628–5634. IEEE, 2015.

[4] Ludovic Righetti, Mrinal Kalakrishnan, Peter Pastor, Jonathan Binney, Jonathan Kelly, Randolph C Voorhies, Gaurav S Sukhatme, and Stefan Schaal. An autonomous manipulation system based on force control and optimization. *Autonomous Robots*, 36(1-2):11–30, 2014.

Supervisor: M. Sc. Thomas Eiband

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September 30, 2019

ADVANCED SEMINAR

Interactive Teaching and Active Learning in Programming by Demonstration

Problem description:

Learning from Demonstration (LfD) of robotic tasks, also known as Programming by Demonstration, is in the focus of research since many years. There are two open challenges. First, the behaviors are often demonstrated in a non optimal way, which leads to a non optimal robotic reproduction. Second, the robot is restricted to the learned behavior and does not know how to cope with novel situations. Active learning strategies can alleviate this problems, as the robot is able to incrementally gain knowledge from the user or environment. Therefore, the user provides further demonstrations in an interactive manner. Hereby, both robot and user can decide when new information should be provided, which combines active learning with an interactive teaching strategy.
Your baseline should be a system which is programmed by demonstration. Evaluate active learning approaches which are able to improve the robotic task outcome and how such systems are programmed by the user, e.g [1, 2, 3].
You can follow these research guidelines:

- Find and group active learning approaches in the context of LfD
- Which approaches could be useful for intuitive PbD?
- How do the approaches detect novelties and errors during execution?
- Compare the approaches and find their advantages and drawbacks

Bibliography:

[1] Andrea Bajcsy, Dylan P Losey, Marcia K O'Malley, and Anca D Dragan. Learning robot objectives from physical human interaction. *Proceedings of Machine Learning Research*, 78:217–226, 2017.

[2] Guilherme Maeda, Marco Ewerton, Takayuki Osa, Baptiste Busch, and Jan Peters. Active incremental learning of robot movement primitives. In *CoRL 2017-1st Annual Conference on Robot Learning*, pages 37–46, 2017.

[3] Mattia Racca and Ville Kyrki. Active robot learning for temporal task models. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, pages 123–131. ACM, 2018.

Supervisor: M. Sc. Thomas Eiband

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October 4, 2019

ADVANCED SEMINAR

Interaction control via Hybrid force/impedance control

Problem description:

The huge progress both in mechanical and control design has allowed robot technology to reach a breakthrough in the past decade. Robots nowadays are expected to share their workspace with humans, and operate in uncertain environments. In this regard, the field of interaction control has recieved special intrest and is a current topic of research in the robotics community. Interaction control can be generally classified into indirect and direct force control. For indirect interaction, the framework of impedance control [1] has been the most popular and aims at achieving a specific dynamic behavior between the robot and the environment for stable interaction control. On the other hand, direct force control aims at explicity controlling the contact force by closing a feedback loop around the measured external forces. Most notably, the framework of hybrid force/position control [2] which divides the task space into force and position controlled subspaces. Recently however, approaches unifying impedance and force control [3] has been suggested which aim at gaining the best of all: the robustness of of impedance control and the ability to regulate forces in hybrid force-position control. In this seminar, it is expected to

- Carry out a literature review on the hybrid force/impedance control with a specific focus on applications to unkown enviroments
- Identify the limitations of the current state of the art

Bibliography:

[1] N. Hogan. Impedance control: An approach to manipulation. In *1984 American Control Conference*, pages 304–313, June 1984.
[2] M. H. Raibert and J. J. Craig. Hybrid Position/Force Control of Manipulators. *Journal of Dynamic Systems, Measurement, and Control*, 103(2):126–133, 06 1981.
[3] C. Schindlbeck and S. Haddadin. Unified passivity-based cartesian force/impedance control for rigid and flexible joint robots via task-energy tanks. In *2015 IEEE International Conference on Robotics and Automation (ICRA)*, pages 440–447, May 2015.

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