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

October 20, 2021

ADVANCED SEMINAR

Overview of Course

Procedure

The advanced seminar course consists of the following events, which will be announced on TUMonline:

1. *Kick-off Meeting* – presentation of potential individual topics by supervisors and description of the schedule for the advanced seminar.
2. *Report Submission* – submission of the final report, final presentation, and electronic copies of all publications that were read or reviewed during the advanced seminar.
3. *Final Presentation* – each participant will present their findings of their advanced seminar.

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

Timeline

Event	Date	Time & Venue
Kick-off Meeting	29.10.2021	10:00 – 11:00 (Online)
Midterm Presentation	10.12.2021	10:00 – 11:00 (Online)
Submission of Final Report and Materials	07.02.2022	15:00 (Room 5007*)
Final Presentation	11.02.2022	10:00 – 11:30 (Online or Room 2026*)

***** – Rooms 5007 and 2026 are located on the fifth and second floor in Karlstr. 45, 80333 München.

Note: A Zoom link will be provided for online meetings. The final presentation *may* be conducted in person, should the COVID situation allow it.

Final Report: Submission Protocol

As partial fulfillment of the course's requirements, a printed copy of your report and a CD containing required materials have to be submitted by 07.02.2022 (no later than 15:00). Thus, the presentation must be finished by the deadline. These items must be delivered to Room 5007 (fifth floor of Karlstr. 45 building) to the course organizer. The final report should be about 10 pages (excluding the title page, table of contents, and bibliography) and must be written using LaTeX (we recommend using *Overleaf*). Your supervisor will provide you with 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 must contain the following materials: 1) your final presentation, 2) your final report, and 3) any and all relevant scientific material. 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 an archived .ZIP file. In addition, a .PDF copy of your report should be present in this directory. The presentation directory should contain a PowerPoint presentation, which is either in a native PowerPoint format (e.g., .PPT) or a .PDF format. All relevant (electronic) references have to be saved on the CD as a .ZIP file entitled "References".

Final Presentation

The duration of the final presentation is *10 minutes maximum*. You may ask your supervisor or organizer to provide you with a PowerPoint template for your presentation. After the presentation, a 5 minute discussion will take place in which everyone should actively participate. Your contribution to the discussion will be considered for thee final grade. It is compulsory to attend all presentations.

Literature Review

The literature review should be carried out independently. Your supervisor will support you by providing appropriate reference books, scientific papers, and other pertinent materials. To facilitate your introduction to the topic, your supervisor will also provide a list of introductory articles along with a problem definition.

Role of Supervisors

The supervisor is the reference person in case of any inquiries. You and your supervisor should agree on the specifics of the topic and identify expectations. The supervisor will support you in technical matters, final report preparation and proofreading, and presentation of the results. If desired, students can practice their presentations prior to the final presentations in order to get some feedback on presentation style and content. Your supervisor may also provide you with access to the workstations available for students and can introduce you to the computer programs or platforms required to complete the seminar project.

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

Grading

Your grade for the advanced seminar is based on the template attached below. This assessment template contains various criterion related to the preparation of the advanced seminar, the final report, final presentation, and participation during the discussion session that follows each presentation.

Please note the following:

Item	Criteria Description	Grade
	Preparation Phase	
1	**Introduction**: understanding and overview given the difficulty of the task	—
2	**Contribution**: creativity, innovation, initiative, self-organization, decisiveness	—
3	**Organization**: organization, time management, persistence and diligence	—
4	**Scientific Work**: rigor, systematic approach, analysis of results	—
	Final 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	—
	Participation	
8	**Discussion**: active participation in discussion during presentations	—
	Final Presentation	
9	**Technical Content**: scientific content, classification and evaluation, discussion	—
10	**Presentation**: presentation style, adherence to time, clear slides and videos, etc.	—

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, as a decision must be made in favor of one course at the beginning of the semester.

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I have fully read and acknowledge the above information and guidelines for the advanced seminar course.

Matriculation Number: ________________________

Full Name (First Name, Last Name): ________________________

Date, Place: ________________________

Signature: ________________________

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

October 18, 2021

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

Usage of Transformer in Computer Vision: Classification and Detection

Problem description:

A deep neural network structure named Transformer [4], which is based on the multi-headed self-attention mechanism, appeared in four years ago. Since its publication, the number of citation of its paper is around 30k, and now it influences to various research fields such as computer vision [2, 1] or robotics manipulation [3], even its initial objective was to contribute to the natural language processing researches. For example, in the work of image classification, there has been a work named Visual Transformer [2] that suggests to divide the image into 16 by 16 small patches, interpret that image as a sequence of those patches, put this patch sequence into Transformer, and obtain the classification score for the given image. Including this work, in this advanced seminar, the student would be required to conduct a small survey regarding how the Transformer contributed to the computer vision society, especially to the image classification and object detection. Below is the list of tasks that the student needs to achieve.

- Understand the structure of the Transformer and its several variants.
- Survey the usage of Transformers for Image Classification.
- Survey the usage of Transformers for Object Detection.

Bibliography:

[1] Nicolas Carion, Francisco Massa, Gabriel Synnaeve, Nicolas Usunier, Alexander Kirillov, and Sergey Zagoruyko. End-to-end object detection with transformers. In *European Conference on Computer Vision*, pages 213–229. Springer, 2020.

[2] Alexey Dosovitskiy, Lucas Beyer, Alexander Kolesnikov, Dirk Weissenborn, Xiaohua Zhai, Thomas Unterthiner, Mostafa Dehghani, Matthias Minderer, Georg Heigold, Sylvain Gelly, et al. An image is worth 16x16 words: Transformers for image recognition at scale. In *International Conference on Learning Representations*, 2020.

[3] Mohit Shridhar, Lucas Manuelli, and Dieter Fox. Cliport: What and where pathways for robotic manipulation. *arXiv preprint arXiv:2109.12098*, 2021.

[4] Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Łukasz Kaiser, and Illia Polosukhin. Attention is all you need. In *Advances in neural information processing systems*, pages 5998–6008, 2017.

Supervisor: Dr. Hyemin Ahn

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October 20, 2021

A D V A N C E D   S E M I N A R
for
N.N., Mat.-Nr. XXXXXXX

A Survey on Physical Human-Robot Interactions in Collaborative tasks

Problem description:

Human Robot collaboration has witnessed a significant advancement made possible thanks to the emergence of a new generation of compliant and safe robots. This facilitates the presence of robots in domestic environments where humans can receive physical assistance from robots in achieving a number of tasks. In particular, physical collaboration is an interesting research problem since it involves haptic interactions, requiring robots to control not only its motion, but together with its force and impedance to regulate its interactive behavior. For instance, learning from demonstration is exploited in [2] to learn collaborative behaviours in tasks such as transporting an object and furniture assembly, while in [1], a robot assists a human in a sawing task, delivering adaptive assistance based on human fatigue level. In this seminar, your task will be

- Conduct a literature review on Human robot physical collaboration with a focus on tasks involving haptic interactions
- Identify the different collaborative tasks reported in the literature and
- Identify the different control/learning techniques used in such tasks.

Bibliography:

[1] L. Peternel, N. Tsagarakis, D. Caldwell, and A. Ajoudani. Adaptation of robot physical behaviour to human fatigue in human-robot co-manipulation. In *IEEE-RAS International Conference on Humanoid Robots (Humanoids)*, pages 489–494, 2016.

[2] L. Rozo, S. Calinon, D. G. Caldwell, P. Jimnez, and C. Torras. Learning physical collaborative robot behaviors from human demonstrations. *IEEE Transactions on Robotics*, 32(3):513–527, 2016.

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TECHNISCHE UNIVERSITÄT MÜNCHEN
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UNIV.-PROF. DR.-ING. DONGHEUI LEE

October 19, 2021

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

Interpersonal Haptic Interactions in Collaborative Tasks - A Systematic Review

Problem description:

Human-robot collaboration receives increasing attention in research, industry, as well as in the healthcare system. For successful assistance and collaboration, especially in goal-directed tasks, such as transporting or translating an object [1], interpersonal coordination plays a crucial role. Several factors, such as shared mental information and representations [4], as well as similarity of the individual movement dynamics [3], have been observed to facilitate interpersonal coordination. Furthermore, an asymmetric difficulty of the joint task induces leader-follower roles [2]. Not least, the interpersonal interactions can be harmonious (moving together), conflicting (moving in another direction) or neutral (purely following) [1]. To reach human-like human-robot collaborations underlying mechanisms and patterns of interpersonal coordination need to be better understood in human-human interactions. In this seminar, your task will be:

Tasks:

- Conduct a literature review on physical interpersonal collaboration with a focus on tasks involving haptic interactions
- Identify ...
  - ... different collaborative tasks reported in the literature
  - ... different interpersonal coordination patterns as well as the switching behavior
  - ... coordination relevant features
- Document your procedure
- Provide an overview of your findings and discuss your findings with respect to a human-like simulation of one of the partners

Bibliography:

[1] C. E. Madan, A. Kucukyilmaz, T. M. Sezgin, and C. Basdogan. Recognition of haptic interaction patterns in dyadic joint object manipulation. *IEEE Transactions on Haptics*, 8(1):54–66, 2015.
[2] J.C. Skewes, L. Skewes, J. Michael, and I. Konvalinka. Synchronised and complementary coordination mechanisms in an asymmetric joint aiming task. *Exp Brain Res.*, 2015.
[3] P. Sowiski, C. Zhai, F. Alderisio, R. Salesse, M. Gueugnon, L. Marin, B. Bardy, M. Di Bernardo, and K. Tsaneva-Atanasova. Dynamic similarity promotes interpersonal coordination in joint action. *Journal of The Royal Society Interface*, 13:20151093, 03 2016.
[4] C. Vesper, E. Abramova, J. Btepage, F. Ciardo, B. Crossey, A. Effenberg, D. Hristova, A. Karlinsky, L. McEllin, S. R. R. Nijssen, L. Schmitz, and B. Wahn. Joint action: Mental representations, shared information and general mechanisms for coordinating with others. *Frontiers in Psychology*, 7:2039, 2017.

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TECHNISCHE UNIVERSITÄT MÜNCHEN

Human-centered Assistive Robotics

UNIV.-PROF. DR.-ING. DONGHEUI LEE

October 15, 2021

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

for

N.N., Mat.-Nr. XXXXXXX

Review and analysis of robotic skills representation through a structured approach

Problem description:

As every country has its own language, the robotic domain is full of different descriptions for defined robot actions (e.g., Point to Point, Pick, Place, Grasp). Therefore, when experts from different domains try to communicate between each other, misunderstandings may arise. In order to reduce this gap in this advanced seminar, you will delve in the topic and you will try to find a common description for different robot actions or skills. A survey about robot action representations from a neuroscientific perspective was presented in [1]. In contrast, you will focus on robot action representations for the industrial manufacturing domain since it is one of the key pillars of the European Economy [2].

Therefore, in this advanced seminar you will research, analyze and understand which nomenclature is used for representing robot abilities in the industrial domain. This will require you to dive into research papers and code repositories of robotic applications in several areas giving you a wide understanding of the robotics domain which will be fundamental for your research in the field. More precisely, your tasks will be as follows:

- Collaborate with the supervisors to understand the existing review procedure
- Perform a literature research using defined search queries
- Contribute to populate a review table together with the supervisors to identify a robot skill taxonomy
- Summarize the findings on a report

Bibliography:

[1] Zech, P., Renaudo, E., Haller, S., Zhang, X., and Piater, J. (2019). Action representations in robotics: A taxonomy and systematic classification. The International Journal of Robotics Research, 38(5), 518–562. https://doi.org/10.1177/0278364919835020

[2] European Union, "Unleashing the full potential of European SMEs", Publications Office of the European Union, Luxembourg, 2020, ISBN: 978-92-76-16912-3.

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TECHNISCHE UNIVERSITÄT MÜNCHEN
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October 18, 2021

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

Online Anomaly Detection and Skill Transition in Robotic Tasks

Problem description:

One of the main goals of autonomous systems is to robustly achieve a task at hand even in unknown environments or when unmodeled perturbations occur. This is especially challenging during robotic manipulation tasks with complex object interactions. Manually designing rules to determine whether the recorded multi-modal sensor information indicates a valid or invalid skill execution can be very hard or intractable. That is why Learning from Demonstration (LfD) plays an important role, when transferring task knowledge from humans to robots. Current LfD approaches use different strategies to encode the demonstrated task knowledge [4], [3] and rely on an online decision making system to decide when and to which successive behavior to switch in order to recover from an erroneous execution or to initiate a new skill [1], [2]. Online anomaly detection and flexible skill transition are key factors for achieving reliable task performance under challenging conditions and should be further investigated in this seminar:

- Carry out literature research on online anomaly detection and skill transition
- Compare the advantages and drawbacks of different strategies for handling anomalies regarding e.g. their detection mechanisms, generalization capabilities to new environments and underlying task representations
- Develop own ideas for flexibly handling anomalies

Bibliography:

[1] Thomas Eiband, Matteo Saveriano, and Dongheui Lee. Intuitive programming of conditional tasks by demonstration of multiple solutions. *IEEE Robotics and Automation Letters*, 4(4):4483–4490, 2019.

[2] Daniel Kappler, Peter Pastor, Mrinal Kalakrishnan, Manuel Wüthrich, and Stefan Schaal. Data-driven online decision making for autonomous manipulation. In *Robotics: Science and Systems*, 2015.

[3] Scott Niekum, Sarah Osentoski, George Konidaris, Sachin Chitta, Bhaskara Marthi, and Andrew G Barto. Learning grounded finite-state representations from unstructured demonstrations. *The International Journal of Robotics Research*, 34(2):131–157, 2015.

[4] Daehyung Park, Michael Noseworthy, Rohan Paul, Subhro Roy, and Nicholas Roy. Inferring task goals and constraints using bayesian nonparametric inverse reinforcement learning. In *Conference on Robot Learning*, pages 1005–1014, 2020.

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TECHNISCHE UNIVERSITÄT MÜNCHEN

Human-centered Assistive Robotics

UNIV.-PROF. DR.-ING. DONGHEUI LEE

October 21, 2021

A D V A N C E D   S E M I N A R
for
Student's name, Mat.-Nr. XXX

The challenges of identifying and exploiting failure in learning from demonstration

Problem description:

Nowadays robots need to be more adaptable and easily programmed, even by non-expert users, to be used in a large variety of fields such as assistive robotics or collaborative robotics. A way to make programming accessible to all is learning from demonstration methods [1] among which are kinesthetic teaching, tele-manipulation, or visual demonstrations. The tasks to be taught can be difficult to demonstrate, which leads to some failed or ambiguous demonstrations by non-experts users. Recent articles have tried to deal with those difficulties in several ways. First by finding a way to evaluate a demonstration in order to improve it [4]. It is also possible to reduce ambiguities by using interactive programming [2]. Finally some articles have studied the interest of using failed demonstrations as a source of information to improve teaching [3] [5]. During this project your task will be to write a review on the following topics:

- The reasons that demonstrations fail
- The evaluation of a demonstration quality and ways to improve a demonstration
- The system process to ask for new demonstrations interactively to reduce ambiguities and failures
- The use of failed demonstrations as a way to improve teaching

Bibliography:

[1] Sylvain Calinon and Dongheui Lee. *Learning Control*, pages 1261–1312. 01 2019.

[2] Giovanni Franzese, CE Celemin, and Jens Kober. Learning interactively to resolve ambiguity in reference frame selection. In *Conference on Robot Learning (CoRL)*, 2020.

[3] Masashi Hamaya, Felix von Drigalski, Takamitsu Matsubara, Kazutoshi Tanaka, Robert Lee, Chisato Nakashima, Yoshiya Shibata, and Yoshihisa Ijiri. Learning soft robotic assembly strategies from successful and failed demonstrations. 10 2020.

[4] Aran Sena and Matthew Howard. Quantifying teaching behavior in robot learning from demonstration. *The International Journal of Robotics Research*, 39(1):54–72, 2020.

[5] Xu Xie, Changyang Li, Chi Zhang, Yixin Zhu, and Song-Chun Zhu. Learning virtual grasp with failed demonstrations via bayesian inverse reinforcement learning. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019.

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

October 7, 2021

A D V A N C E D   S E M I N A R
for
Student's name, Mat.-Nr. XXXX

Social Interactions for Intention Prediction

Problem description:

As humans, we have developed a common sense that allows us to infer relationships between concepts. An example is understanding Human-Human Interaction (HHI) to recognize social behaviors and boost Human-Robot Collaboration (HRC) approaches in real-world environment [1]. The great advances in Deep Learning have propelled HHI's comprehension work through images and videos. HHI has focused mostly on understanding the deterministic joint actions that two people perform with each other (hugs, high five, pushing) [2, 3]. Even so, there are recent works that deal with the ambiguous nature in the perception of social behaviors [4] or address to Recognize the Activities of a whole social Group (GAR) [5]. Understanding this common sense both as human and social level will create the foundation for the future of Human-Robot Interaction. Robots should be able to predict the intention of the humans [6] to assist them properly. The aim of this seminar is to conduct a survey of computer vision methodologies dealing with HHI and GAR so far in order to discuss the limitations of state-of-the-art and highlight current trends and future directions, always taking into consideration the Human Intention Prediction (HIP) approach.

Bibliography:

[1] Alessandro D'Ausilio, Katrin Lohan, Leonardo Badino, and Alessandra Sciutti. *Studying Human-Human interaction to build the future of Human-Robot interaction*, pages 215–227. 03 2016.
[2] Alexandros Stergiou and Ronald Poppe. Analyzing human–human interactions: A survey. *Computer Vision and Image Understanding*, 188:102799, Nov 2019.
[3] Mauricio Perez, Jun Liu, and Alex C. Kot. Interaction relational network for mutual action recognition, 2021.
[4] Xiangbo Shu, Jinhui Tang, Guo-Jun Qi, Wei Liu, and Jian Yang. Hierarchical long short-term concurrent memory for human interaction recognition, 2018.
[5] Hangjie Yuan, Dong Ni, and Mang Wang. Spatio-temporal dynamic inference network for group activity recognition, 2021.
[6] Junwen Chen, Wentao Bao, and Yu Kong. Group activity prediction with sequential relational anticipation model, 2020.

Supervisor: M. Sc. Esteve Valls

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