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

Project Practical Course

(Human Centered Robotics)

Procedure:

The practical course (PP) will take place under the guidance of a supervisor with a team of maximum 3 students. The students have to plan tasks, document their progress and present results regarding the assigned topic. The PP includes the following events:

1. Kick-off Meeting: presentation of topics and description of time schedule for PP.
2. Project plan presentations: presentation and discussion of the project plan (after 2 weeks of kick off meeting)
3. Project progress meetings: presentation of project progress (after 6 weeks)
4. Final Deadline: Final report and presentation submission (approximately 2 weeks before end of lectures).
5. Final presentations: each participant presents the result of his PP.

Participation in **all** of the above events is a requirement for successful completion of PP. Participation of students will be documented by means of an attendance lists.

Final Deadline:

A printed copy of the report and a CD should be submitted to (Room 5007@Karlstr.45). The CD should 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 should be made by using LaTeX or word. The supervisor should give you the template for the presentation and the report. The second page of the report should contain the assigned topic sheet. The report should only be stapled two times on the left side (no spiral or adhesive binding).

To evaluate the contribution of each student it is important to ensure that authors of each section is clearly evident. The report is supposed to provide an orderly description of the objective, the methods used, developed algorithms and discussion of results. The documentation should help the reader to understand the experimental setup, usage of the software and the hardware. The readers should be able to reproduce the experiment after reading the report. A comprehensive description of the topic is desirable, however, you should avoid lengthy statements. Experimental protocols, computer print outs etc. should be arranged clearly and attached in Appendix.

The written copy should preferably be available to the supervisor at least 1 week before the deadline of the final submission.

Final presentation:

The duration of the final presentation is 10 minutes. After the presentation, a 5 minutes discussion session will take place in which the students should actively participate. The contribution of each student in the discussion session is included in the grading.

Since the audience might contain people who are not familiar with your work, a clear and comprehensive outline of your ideas and presentation is essential. Explain the problem and the results in detail. The following presentation sequence is recommended:

- 2-3 slides for introduction and explanation of task,

- 4-6 slides for the work conducted,
- 2-3 slides for the results.

Grading:

The final evaluation is based on the attached template. It includes different criterion regarding the preparation of the project description, the final presentations, report and participation in the discussion.

I. Preparation phase

No.	Criteria	Grade
1	**Introduction:** understanding and overview given the difficulty of the task	
2	**Organization:** organization, time management, persistence and diligence	

II. Results (Theory, Software, Hardware)

3	**Goal:** to what extent was the goal achieved considering the requirements/expectations	
4	**Applicability of results:** Generalizability of theory and methodology, functionality of the hardware and the software	

III. Written report (Documentation)

5	**Formatting:** structure, completeness and resources	
6	**Writing content:** style, expression and comprehension of discussion / evaluation of results	

VI. Final presentation

7	**Technical content:** scientific content, classification and evaluation	
8	**Presentation:** presentation style, time management, slides and videos etc.	

Role of supervisors:

The supervisor is your reference person incase of any inquiries. The supervisor supports you in technical matters, introduces you to the required tasks, final report and presentation of the results. In addition to answering your inquiries he helps you with procurement of software and hardware, work orders from the work shop and working on the weekends. The initiative should be taken from the student side.

Project resources:

At the beginning of the project you should have a rough time plan for the milestones. You should constantly update your time schedule and talk about this with your supervisor to avoid unnecessary waste of time. The literature related to your topic is a major help during the beginning. The literature search can be carried out at the central library of TUM or also at the library of the available department.

You are free to carry out work on your private computer or the institution computer. For working at the institute's computer a working account is necessary. All the data should be stored in your home directory.

Absence:

There are strict regulations against unexcused absence during the practical course. Unexcused absence in any of the practical course events will lead to failure in the course. In case of illness a medical certificate must be presented. Overlap with other courses in 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	19.10.2018	09:30 – 11:00 (2026@2906)
Project plan presentations	08.11.2018	10:30 – 12:30 (5016@2906)
Project progress presentations	06.12.2018	10:30 – 12:30 (5016@2906)
Final report submission	14.01.2019	12:00 (5006@2906)
Final presentations	17.01.2019	10:30-12:00 (5016@2906)

* 5015@2906 is a seminar room (5016) on the fifth floor in Karlstr. 45, München.

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I have read and acknowledge the above information and guidelines of the practical course:

Matriculation number: ____________________

First name, Last name: ______________________________

Date: ____________________

Signatures: ______________________________

TECHNISCHE UNIVERSITÄT MÜNCHEN
HUMAN-CENTERED ASSISTIVE ROBOTICS
UNIV.-PROF. DONGHEUI LEE

September 28, 2018

PRACTICAL COURSE
for
xxx, Mat.-Nr. xxx

Learning Control Policies for In-Hand Manipulation using a Kinematic Hand Model and Model-based Reinforcement Learning

Problem description:

In-hand manipulation, which consists in modifying the pose of a grasped object using only finger movements, in an interesting open problem in robotics. Indeed, analytically deriving a model for an in-hand manipulation task is not trivial, due to the complexity introduced by physical contacts and under-actuated fingers. For this reason, reinforcement learning approaches [1] are promising in learning in-hand manipulation tasks, but not fully exploited so far.

In this Practical Course work the student has to implement the learning algorithm in [2] and apply the approach to learn in-hand manipulation tasks. A kinematic model of a five-fingered, under-actuated robotic hand will be used as an approximate model. The approach will be tested in a simulated environment.

Tasks:

- Implementation of the approach in [2] in Matlab/Simulink.
- Evaluation in a simulated environment.
- Experimental evaluation on the ADA Hand (optional).

Bibliography:

[1] J. Kober, D. Bagnell, and J. Peters. Reinforcement learning in robotics: a survey, in *IJRR*, 2013.
[2] M. Saveriano, Y. Yin, P. Falco, and D. Lee. Data-Efficient Control Policy Search using Residual Dynamics Learning, in *IROS*, 2017.

Supervisor: M. Sc. Matteo Saveriano

(D. Lee)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
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October 4, 2018

PRACTICAL COURSE

Role of the knee joint during running using a SLIP model

Problem description:

Lower limb recruits the hip , knee and ankle during running. Ankle torque provides the highest torque followed by the knee and then the hip joint. Spring Loaded Inverted Pendulum are state of the art models used to understand human walking dynamics as they are computationally inexpensive. Geyer et al.[1] showed similarity in dynamics of reproduced through a SLIP model with human walking data Rao et al. [2] showed the dynamics of a knee joint added to a hip-actuated SLIP. The knee joint decreased stability of the SLIP model but similar energetic cost of locomotion. In order to better understand role of the knee joint, the task of this project are the following:

Tasks:

- Simulate a knee based conservative SLIP model.
- Evaluating ground reaction forces, COM trajectory and change in mechanical energies.

Bibliography:

[1] Geyer H., Seyfarth A., and Blickhan R. Compliant leg behaviour explains basic dynamics of walking and running. *Proceedings Of The Royal Society B*, 273(1603):2861–2867, 2006.

[2] Rao N., Shen Z., and Seipel J. Comparing legged locomotion with a sprung-knee and telescoping-spring when hip torque is applied. *ASME 2013 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, 7A, 2013.

Supervisor: M. Sc. Karna Potwar

(D. Lee)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
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October 18

PRACTICAL COURSE
for
– , Mat.-Nr. –

Hand pose estimation using point cloud

Problem description:

Hand pose estimation plays an important role in human-robot interaction tasks, such as gesture recognition and learning grasping capability by human demonstration. Since emergence of consumer level depth sensing device, a lot of depth image based hand pose estimation methods appeared.
State-of-the-arts methods are all using depth image as input, which provides the conveniences to use the well developed convolutional neural networks or residual networks. However, 2D CNNs that take 2D images as input cannot fully utilize 3D spatial information in the depth image, therefore a different network structure for 3D input data is needed. Recently, novel deep learning structure such as PointNet [1] for unordered point cloud has emerged. The main novelty of PointNet is individual processing of each point and a final permutation invariant max-pooling layer.
In this Projektpraktikum, the student should use PointNet as learning structure to regress hand pose from depth images. For training and testing, the ICVL dataset will be used [2]. In addition, a different final permutation invariant layer for the PointNet should be implemented and the performance should be compared to the original max-pooling layer.

Tasks:

- Literature study
- Pre-processing of ICVL dataset for PointNet
- Implementation of the PointNet and the modification
- Evaluation of the implementation

Bibliography:

[1] Charles R Qi, Hao Su, Kaichun Mo, and Leonidas J Guibas. Pointnet: Deep learning on point sets for 3d classification and segmentation. *Proc. Computer Vision and Pattern Recognition (CVPR), IEEE*, 1(2):4, 2017.

[2] Danhang Tang, Hyung Jin Chang, Alykhan Tejani, and Tae-Kyun Kim. Latent regression forest: Structured estimation of 3d articulated hand posture. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pages 3786–3793, 2014.

Supervisor: M. Sc. Shile Li

(D. Lee)
Univ.-Professor

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October 4, 2018

PRACTICAL COURSE

Classification of physical robot contacts

Problem description:

In state of the art approaches, robots are able to learn a variety of contact-based tasks from human demonstrations, e.g. [1]. Although a learned behavior might work well in a specific scenario, it is not optimal in the current situation. Further, it is not clear to the demonstrator which forces and torques will be applied during execution. E.g. sliding along a surface should be achieved with a constant force, while the demonstration might consist of a varying force profile, which is not optimal for reproduction. Another example is slightly touching the environment during demonstration, where we can assume that the robot shall explore its surrounding.

With the inference of an interaction class, we are able to generate more appropriate robot skills than with a simple replay of the demonstrated force. Additionally, with the predicted class, we can extract meaningful parameters assigned to the class, which could be further adapted without requiring additional demonstrations from the operator, e.g. a desired pressing force on the tool.

We can start with the predefined interaction classes: sliding, pressing, touching, force profile (other) A variety of demonstrations need be collected then for each class, in order to have enough training samples for the classification.

You should have programming skills in C++ for robot control and in Matlab or Python for the data processing as well as an interest in machine learning techniques.

Tasks:

- Learn how to record data with the KUKA LWR and an external force-torque sensor
- Preprocess the data such that we obtain the pure contact force at the end effector
- Collect a dataset of robot contact demonstrations
- Define features over the collected demonstrations (duration, forces, torques, motion)
- Test a classifier (e.g. logistic regression, SVM) on your dataset and report the results

Bibliography:

[1] Mattia Racca, Joni Pajarinen, Alberto Montebelli, and Ville Kyrki. Learning in-contact control strategies from demonstration. In *Intelligent Robots and Systems (IROS), 2016 IEEE/RSJ International Conference on*, pages 688–695. IEEE, 2016.

Supervisor: M. Sc. Thomas Eiband

(D. Lee)
Univ.-Professor