



Project Practical Course (Human Centered Robotics)

Procedure:

The practical course (PP) will take place under the guidance of a supervisor individually, or 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@Karlst.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 in case 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 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	26.04.2019	15:30 – 16:30 (2026@2906)
Project plan presentations	10.05.2019	15:30 – 17:00 (5016@2906)
Project progress presentations	14.06.2019	15:30 – 17:00 (5016@2906)
Final report submission	15.07.2019	12:00 (5007@2906)
Final presentations	19.07.2019	15:30 – 17:00 (5016@2906)

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

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

Matriculation number:

First name, Last name:

Date:

Signatures:



April 16, 2019

PRACTICAL COURSE
for
N.N., Mat.-Nr. XXXXXXXX

Motion Control using Reinforcement Learning

Problem description:

Reinforcement learning (RL) algorithms [2] are an appealing alternative to classical control mechanisms for controlling simple actuators. These algorithms permit learning control strategies automatically, without the need of knowing the actuator's dynamics and avoiding the fine tuning of controllers parameters. However, RL algorithms requires that every possible situation is experienced several times in order to learn a (sub-) optimal control policy. This is clearly a limitation in continuous environments, typical of motion control problems, where experiencing all the possible situations is unfeasible. To overcome this limitation, RL approaches are complemented with function approximation methods that permits inferring the consequences of actions in unexperienced situations from the experienced ones (generalization) [1]. This project comprises the combination of function approximation and RL methods for the control of simple actuators.

Tasks:

- Literature research.
- Task 1: Implementation of a simulator for an underactuated inverted-pendulum.
- Task 2: Implementation of a function approximation method based on variable resolution.
- Task 3: Combination of the variable resolution approach with Q-learning.
- Task 4: Control of an underactuated inverted-pendulum using variable resolution and Q-learning.

Bibliography:

- [1] Alejandro Agostini and Enric Celaya. Online reinforcement learning using a probability density estimation. *Neural computation*, 29(1):220–246, 2017.
- [2] Richard S Sutton, Andrew G Barto, et al. *Introduction to reinforcement learning*, volume 135. MIT press Cambridge, 1998.

Supervisor: Dr. Alejandro Agostini

(D. Lee)
Univ.-Professor



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

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April 15

PRACTICAL COURSE

Hand pose refinement using particle swarm optimization

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 use deep learning to detect hand pose frame by frame. However, detecting hand pose for each frame individually ignores the temporal consistency of the hand pose, which results in "jittering" effect in hand pose. In this project, the student will combine temporal tracking method with the frame-based deep learning method [1] to remove the "jittering" effect of hand pose. Particle swarm optimization [2] will be used to refine the pose from learning based detection method.

Tasks:

- Literature study
- familiarization with previous implementations
- Implementation of the swarm optimization method
- Evaluation of the implementation with real scenario

Bibliography:

- [1] Shile Li and Dongheui Lee. Point-to-pose voting based hand pose estimation using residual permutation equivariant layer. *arXiv preprint arXiv:1812.02050*, 2018.
- [2] Chen Qian, Xiao Sun, Yichen Wei, Xiaou Tang, and Jian Sun. Realtime and robust hand tracking from depth. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pages 1106–1113, 2014.

Supervisor: M. Sc. Shile Li

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April 11, 2019

PRACTICAL COURSE

Development of a Kinesthetic Teaching Interface

Problem description:

The current research trend on robot programming lies on learning from demonstration (LfD), also known as programming by demonstration (PbD). When using kinesthetic teaching, which is guiding the robot physically around, a number of commands is required during the teaching procedure. These commands could be given by a teaching interface attached to the end effector of the robot, equipped with buttons and feedback of the system state.

Your task is to develop such a device, which is used as handle and interface during the teaching phase. The following requirements should be fulfilled: Control buttons to start/stop the teaching phase, to trigger another demonstration, to open/close the gripper and further buttons to give additional input. There should be also feedback about the system state, e.g. lights indicate if the teaching phase is running, if there are errors present etc.

The electronic interface board is already available and can be interfaced with python. Further control elements need to be selected during the project. Additionally, two teaching handles need to be designed for different robot flanges.



Figure 1: Current solution without teaching handle.

Tasks:

- Define requirements and collect ideas from existing solutions
- Design a teaching handle using a simple CAD designer (e.g. FreeCAD)
- 3D print your design
- Integrate electronics for user control interface and feedback about system state
- Implement an interface between teaching handle and ROS using Python programming language

Supervisor: M. Sc. Thomas Eiband

(D. Lee)
 Univ.-Professor



April 11, 2019

P R A C T I C A L C O U R S E
for
N.N., Mat.-Nr. XXXXXXXX

Evaluating the effect of biomimetic light touch contact on postural balance

Problem description:

Light touch contact (Force $< 1\text{N}$) with a stationary surface reduces body sway improving the postural balance control [1]. This contact is not sufficient to support the body mechanically, and thus the reduction can be attributed to improved sensory feedback through light touch cues. In contrast, light touch with a human partner [2] or a moving reference [3] leads to sway entrainment effects. In this Projektpraktikum, the student shall investigate the effects on human balance when the contact receiver is exposed to light touch feedback provided by a robotic manipulator that mimics the biological sway properties of a human.

Tasks:

- Set-up the sensor system for recording body sway and control of the robotic manipulator.
- Perform pilot testing with human participants.
- Collect and analyze the data.

Bibliography:

- [1] James R. Lackner, Ely Rabin, and Paul DiZio. Stabilization of posture by precision touch of the index finger with rigid and flexible filaments. *Experimental Brain Research*, 139:454–464, 2001.
- [2] Raymond F. Reynolds and Callum J. Osler. Mechanisms of interpersonal sway synchrony and stability. *Journal of The Royal Society Interface*, 11(101):20140751, 2014.
- [3] Alan M. Wing, Leif Johannsen, and Satoshi Endo. Light touch for balance: influence of a time-varying external driving signal. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1581):3133–3141, 2011.

Supervisor: M. Sc. Youssef Michel

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