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. Presentation techniques seminar: participant will be given advice and suggestions regarding final presentations i.e how to give scientific talks.
3. Project plan presentations: presentation and discussion of the project plan (after 2 weeks of kick off meeting)
4. Project progress meetings: presentation of project progress (after 6 weeks)
5. Final Deadline: Final report and presentation submission (approximately 2 weeks before end of lectures).
6. 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 Miss Schneider (Room 5006@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 1-2 weeks 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	19.10.2017	11:30 – 13:00 (5016@2906)
Presentation techniques seminar	23.10.2017	11:30 – 13:30 (N0507)
Project plan presentations	02.11.2017	10:30 – 12:30 (5016@2906)
Project progress presentations	07.12.2017	10:30 – 12:30 (5016@2906)
Final report submission	11.01.2018	12:00 (Ms. Schneider / 5006@2906)
Final presentations	18.01.2018	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

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

22.09.2017

P R A C T I C A L   C O U R S E

Evaluation experiments of Task Parameterized Dynamic Movement Primitives on NAO robot

Problem description:

Dynamic Movement Primitive (DMP) provides a way for encoding motion data [1]. DMP model consists of two dynamical systems with one way parameterized connection such that one system drives the other (acting as a clock). Dynamical system can either form point attractor or limit cycles which make them suitable for imitating single-stroke movements or rhythmic tasks and provide robustness against perturbation. The approach relies on reshaping the attractor landscape by using non-linear regression for imitating demonstrated movement. The original formulation of DMP has the limitation of learning single demonstration at a time. [2] provided an approach of learning multiple demonstrations at a time which they termed Parametric-DMP (PDMP). PDMP has the set of style parameters which can be used for reproducing different motions. [3] has provided a way to encode DMP with a Gaussian Mixture Model (GMM). Gaussian Mixture Regression (GMR) can then be used for reproduction from GMM. For multiple demonstrations performing different tasks, GMM based DMP learning can be used for learning Task parameterized-DMP (TP-DMP) (unpublished).

Tasks:

Experiment: Object grasping

Vision part: Retrieving the objects x-y position using Nao's built in camera.

Control part: Collecting demonstrations for grasping an object with variable position and orientation. The GMM model learned from the demonstrations will be used for online motion generation (using GMR) for the new objects position passed by the vision part.

Bibliography:

[1] Ijspeert, Auke Jan, Jun Nakanishi, and Stefan Schaal. Learning attractor landscapes for learning motor primitives. No. BIOROB-CONF-2002-004. 2002.

[2] Matsubara, Takamitsu, Sang-Ho Hyon, and Jun Morimoto. "Learning parametric dynamic movement primitives from multiple demonstrations." Neural Networks 24.5 (2011): 493-500.

[3] Calinon, Sylvain, Florent Guenter, and Aude Billard. "On learning, representing, and generalizing a task in a humanoid robot." Systems, Man, and Cybernetics, Part B: Cybernetics, IEEE Transactions on 37.2 (2007): 286-298.

Supervisor: M.Sc. Affan Pervez

(D. Lee)
Univ.-Professor

TECHNISCHE UNIVERSITÄT MÜNCHEN
LEHRSTUHL FÜR STEUERUNGS- UND REGELUNGSTECHNIK
ORDINARIUS: UNIV.-PROF. DR.-ING./UNIV. TOKIO MARTIN BUSS

21.09.2017

PRACTICAL COURSE

Developing a Spring-Mass Model for Human Running

During walking or running humans maintain a constant speed of locomotion. The lower limb joint work in tandem to maintain that speed. Each speed has a characteristic gait and parameters such as leg stiffness, leg damping and joint torques etc. Zhang et al. [1] evaluated the leg stiffness and viscous damping of the leg for hopping with an amplitude of 7 mm as 28,500 N/m and 950 Ns/m respectively. To improve our understanding of the mechanics of locomotion several bipedal models have been developed. Spring mass models and inverted pendulum models are the simplest templates that accurately describe human locomotion. Shen et al. [2] showed that an under actuated hip actuated spring mass model showed more stability as compared to conservative spring mass model during running. Geyer et al. [3] showed that at a particular metabolic cost of locomotion humans prefer running at a higher speed than walking at a slower speed.

<u>Tasks:</u>

- Conduct a literature survey of various bipedal models used for terrestrial locomotion by human beings.
- Developing a simple spring mass model which can portray stable running for a set of human locomotion parameters.
- Compare center of mass trajectory and ground reaction forces for these parameter sets.

<u>BIBLIOGRAPHY</u>

[1] L. Zhang, D. Xu, M. Makhsous, and F. Lin, “Stiffness and viscous damping of the human leg,” *… 24Th Annu. Meet. …*, pp. 3–4, 2000.

[2] Z. H. Shen and J. E. Seipel, “A fundamental mechanism of legged locomotion with hip torque and leg damping,” *Bioinspir. Biomim.*, vol. 7, no. 4, p. 046010, 2012.

[3] H. Geyer, A. Seyfarth, and R. Blickhan, “Compliant leg behaviour explains basic dynamics of walking and running.,” *Proc. Biol. Sci.*, vol. 273, no. 1603, pp. 2861–2867, 2006.

SUPERVISOR: M.Sc. Karna Potwar

D.Lee
(Univ. Professor)

TECHNISCHE UNIVERSITÄT MÜNCHEN

HUMAN-CENTERED ASSISTIVE ROBOTICS

UNIV.-PROF. DONGHEUI LEE

22 September 2017

P R A C T I C A L   C O U R S E

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 [2] are promising in learning in-hand manipulation tasks, but not fully exploited so far [1].

In this Practical Course work the student has to implement the learning algorithm in [3] 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 [3] in Matlab/Simulink.
- Evaluation in a simulated environment.
- Experimental evaluation on the ADA Hand (optional).

Bibliography:

[1] H. van Hoof, T. Hermans, G. Neumann, and J. Peters. Learning robot in-hand manipulation with tactile features, in *HUMANOIDS*, 2015.

[2] J. Kober, D. Bagnell, and J. Peters. Reinforcement learning in robotics: a survey, in *IJRR*, 2013.

[3] 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

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TECHNISCHE UNIVERSITÄT MÜNCHEN

Human-centered Assistive Robotics

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

September 21, 2017

P R A C T I C A L   C O U R S E

Kinematic Model of a Low-Cost Prosthetic Hand

Problem description:

A key challenge in modern robotics and biomedical engineering is to design artificial hands able to reproduce human abilities. The difficulty to handle human-like manipulation problems is mainly due to the high number of Degrees of Freedom (DOFs) concentrated in a small volume. As a consequence, control of robotic grasp and manipulation is an interesting challenges for engineers and scientists in the fields of robotics and machine learning. Recently, robotics community is studying hybrid reinforcement learning approaches to handle in-hand manipulation tasks [1]. In such approaches an approximated model is required to learn more quickly and effectively the task. The objective of this project is to derive an approximated hand model for an OPENBIONICS ADA hand using the MATLAB robotics toolbox.

Tasks:

- study the kinematics for robotic systems
- derive an approximated kinematic model for an OPENBIONICS prosthetic hand

Bibliography:

[1] Matteo Saveriano, Yuchao Yin, Pietro Falco, and Dongheui Lee. Data-efficient control policy search using residual dynamics learning. In *IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS*, 2017.

Supervisor: Pietro Falco

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TECHNISCHE UNIVERSITÄT MÜNCHEN

Human-centered Assistive Robotics

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

September 18

P R A C T I C A L   C O U R S E

Evaluating Human Hand Pose

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. One of the hand pose estimation approach relies on the kinematic model of human hand. Regardless of the optimization method, a likelihood function is needed to evaluate the quality of pose estimate given the depth image. This likelihood function needs to be efficient to compute and to be potentially parallelizable.
In this Projektpraktikum, the student should implement the sphere based likelihood function from [1], and evaluate the implementation using a public dataset [2].

Tasks:

- Literature research
- Implementation of sphere based likelihood function
- Evaluation of the implementation

Bibliography:

[1] Chen Qian, Xiao Sun, Yichen Wei, Xiaoou 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.

[2] Jonathan Tompson, Murphy Stein, Yann Lecun, and Ken Perlin. Real-time continuous pose recovery of human hands using convolutional networks. *ACM Transactions on Graphics*, 33, August 2014.

Supervisor: M. Sc. Shile Li

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