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

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 Renner (Room N2515).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. Preperation 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.

Completion of the project:

After completion of the project all keys, rented equipment, surplus components and software etc. should be returned. The confirmation of the return of all borrowed objects should be made on the return form. This form is filled out by Mrs. Renner (Room N2515).

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	22.04.2015	10:30 – 12:00 (5015@2906)
Presentation techniques seminar	30.04.2015	10:00 – 12:00 (N0507)
Registration deadline	06.05.2015	23:59
Project plan presentations	07.05.2015	9:00 – 11:00 (5016@2906)
Project progress presentations	02.06.2015	9:00 – 11:00 (5016@2906)
Final report submission	02.07.2015	12:00 (N2515)
Final presentations	07.07.2015	10:30-12:00 (5016@2906)

* 5015@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: ______________________________

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

PP: Projektpraktikum

07.04.2015

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

C++ implementation of Task Parameterized Dynamic Movement Primitives using mixture of GMMs

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). As a result of this pre-structuring the system is guaranteed to be stable. 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:

- The student will have to translate the existing TP-DMP Matlab code in C++.

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

10.04.2015

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

Kinematic Optimization of Ankle Motion for Biped Locomotion

Problem description:

Biped walking control is among the most challenging tasks of robotics research. In order to have control over both center of mass (COM) and swing leg, biped robots are usually equipped with at least 6 degrees of freedom (DOFs) per leg. The horizontal COM motion pattern is generated according to the robot dynamics in order to ensure the motion stability [1, 2]. Apart from that 4 DOFs are left for the support leg trajectory and 6 DOFs for the swing leg. Trajectory planning of such large number of joints is not a trivial problem. For maximal stability constant hip height and fix body posture are preferred. The swing leg trajectory can be determined arbitrarily under certain constrains. For simplicity the swing leg orientation is usually set to be parallel to the ground for robots with flat feet. The resulted motion is not natural looking and generates unnecessary joint velocity which could limit the robot's mobility. In [3] an offline optimization method is proposed in order to design the swing leg motion to achieve minimal joint velocities. In this practical course the student should follow similar procedure to design an ankle motion considering different objectives and constraints.

Tasks:

- Study the literature of walking pattern planning.
- Implement the kinematic optimization procedure for the ankle motion.
- Test the algorithm in simulation.
- Documentation

Bibliography:

[1] Kajita, S., Kanehiro, F., Kaneko, K., Fujiwara, K., Harada, K., Yokoi, K. and Hirukawa, H. Biped walking pattern generation by using preview control of zero-moment point. In *IEEE/RSJ International Conference on Robotics and Automation, 2003*.

[2] Wieber, P. B. Trajectory free linear model predictive control for stable walking in the presence of strong perturbations. In *IEEE/RSJ International Conference on Humanoid Robots, 2006*.

[3] Kaminaga, Hiroshi and Englsberger, Johannes and Ott, Christian Kinematic optimization and online adaptation of swing foot trajectory for biped locomotion In *IEEE/RSJ International Conference on Humanoid Robots, 2012*.

Supervisor: M.Sc. Kai Hu

(D. Lee)
Univ.-Professor

April 2015

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

Assembly and Control of a Humanoid Torso with Variable Stiffness Actuators

Problem description:

The developed of robots able to operate in unstructured environments and to physically interact with unknown objects requires impedance management. A novel technological trend in robotics focuses on the development of actuators able to change their stiffness with dedicated mechanisms, the so-called variable stiffness actuators (VSA) [1], [2].

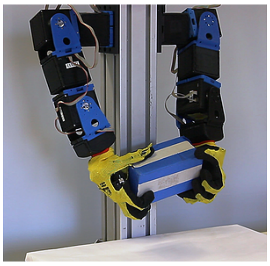

Figure 1: Humanois torso with VSA

In this Practical Course work the student has to assemble a humanoid torso consisting of 12 VSA and a head. The student is also asked to compute forward and inverse kinematics of the arm and to implement the zero deflection control [2] and position control of the two arms in Matlab/Simulink.

Tasks:

- Assembly of the humanoids torso.
- Compute forward and inverse kinematics of the arms.
- Zero deflection control
- Position control in Matlab/Simulink.

Bibliography:

[1] M. G. Catalano, G. Grioli, M. Garabini, F. Bonomo, M. Mancini, N. G. Tsagarakis, A. and Bicchi. VSA - CubeBot. A modular variable stiffness platform for multi degrees of freedom systems, in *International Conference on Robotics and Automation*, 2011.
[2] G. Tonietti, R. Schiavi and A. Bicchi. Design and control of a variable stiffness actuator for safe and fast physical human/robot interaction, in *International Conference on Robotics and Automation*, 2011.

Supervisor: M.S. Matteo Saveriano

(D. Lee)
Univ.-Professor

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

22.04.2015

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

Implementation of a Bayesian Multi-Sensor Fusion Package for Robot Operating System (ROS)

Problem description:

Bayesian formulation, given its intrinsic possibility of relating prior and current probability, is an instrument for inference in sensor information fusion, above all when problems are partially observable and sensors are unreliable [1]. The scope of this project will focus on software development and architecture engineering of a Robot Operating System (ROS) package, implementing a multi-feed Bayesian fusion solution which comprises all parametrizations which are currently used in everyday applications by the industry [2].

Tasks:

- Understand the common parametrization of state-of-the-art Bayesian sensor fusion procedures
- Study ROS documentation, its architecture and functionalities
- Develop a skeleton framework (client and server) for an online, multiple feed Bayesian sensor fusion system, exploiting ROS nodes and topics
- Document all past steps in a four-page double coloumn report, including UML architecture graphs and pseudo algorithmic procedures

Bibliography:

[1] Hackett, Jay K., and Mubarak Shah. Multi-sensor fusion: a perspective. in *IEEE International Conference on Robotics and Automation*, 1990.

[2] Khaleghi, B., Khamis, A., Karray, F. O., and Razavi, S. N. Multisensor data fusion: A review of the state-of-the-art. in *Information Fusion 14.1*, (2013): 28-44.

Supervisor: Nicholas H. Kirk, M. Sc.

(D. Lee)
Carl-von-Linde Fellow

April 2, 2015

PRACTICAL COURSE

Evaluating human grasping tasks for applications in advanced robotic manipulation

Problem description:

A key challenge in modern robotics and biomedical engineering is to design artificial hands able to reproduce human abilities [1]. 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. This makes the observation, the interpretation and the control of human-like manipulation an interesting application for engineers and scientists in the fields of robotics and machine learning. In order to apply reinforcement learning methods to control anthropomorphic hands, techniques are required to evaluate if a grasp is executed successfully and how effectively. Tools have been developed to evaluate grasp by exploiting sensorized objects [3]. The objective of the project is to provide a preliminary method, which does not require a sensorized environment, able to evaluate the outcome of grasping activities performed by humans. The method will rely on the framework developed in [2].

Tasks:

- Literature review on methods to evaluate human and robotic grasping
- Preparing an experimental setup based of the framework developed in [2]
- Defining a vision-based method of grasping evaluation

Bibliography:

[1] Antonio Bicchi. Hands for dexterous manipulation and robust grasping: A difficult road toward simplicity. *Robotics and Automation, IEEE Transactions on*, 16(6):652–662, 2000.
[2] Seongyong Koo, Dongheui Lee, and Dong-Soo Kwon. Incremental object learning and robust tracking of multiple objects from rgb-d point set data. *Journal of Visual Communication and Image Representation*, 25(1):108–121, 2014.
[3] Maximo A Roa, Risto Koiva, and Claudio Castellini. Experimental evaluation of human grasps using a sensorized object. In *Biomedical Robotics and Biomechatronics (BioRob), 2012 4th IEEE RAS & EMBS International Conference on*, pages 1662–1668. IEEE, 2012.

Supervisor: Dr. Pietro Falco

(D. Lee)
Univ.-Professor

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

April, 2015

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

Sphere-Shape Object Tracking with Uncertainty of RGBD Camera

Problem description:

In many robotic applications, it is crucial to measure dynamic object movements to make the robot interactive to the environment and human. The RGBD camera shown in Fig. 1 has grown as an attractive 3D measurement device because of its high price-performance ratio and usability. A simple object detection algorithm was implemented for the sphere-shape objects [2]. However, the performance in terms of the speed and accuracy is limited compared to the high performance motion capture system, so there is large uncertainty in the measured data. So, a survey of uncertainty of the RGBD camera was carried out focused on basic operating principle, source of uncertainty, uncedrtainty modeling and identification, etc [1]. In this practical course, the integration of two previous works are aimed to extract the continuous motion trajectory of the sphere-shape objects with the uncertainty values from the sequence of the RGBD vision data.

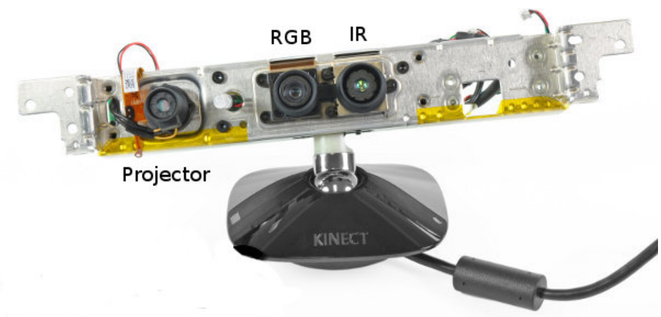

Figure 1: Kinect camera consists of an infrared projector, a RGB camera, and an infrared camera.

Tasks:

- Literature research of object tracking algorithms and uncertainty of the RGBD camera.
- Implementation of an object tracking algorithm with uncertainty for the sphere-shape objects using the RGBD camera.
- Integration of two previous works [1] and [2].

Bibliography:

[1] Marcin Kasperek, Uncertainty of Kinect Camera, In Advanced Seminar, EI, TUM, 2014
[2] Chao Li, Real-Time Obstacle Avoidance Control with KUKA LWR and Kinect Camera (Vision Part), In Practical Course, EI, TUM, 2015

Supervisor: M. Sc. Sang-ik An

(Ph.D. Dongheui Lee)
Univ.-Professor