TECHNISCHE UNIVERSITÄT MÜNCHEN
INSTITUTE OF AUTOMATIC CONTROL ENGINEERING
ORDINARIUS: UNIV.-PROF. DR.-ING./UNIV. TOKIO MARTIN BUSS

Advanced Seminar Autonomous System

Procedure:

The advanced seminar consists of the following events, which will be announced on TUM-online:

1. Kick-Off Meeting: presentation of individual topics and description of the schedule for the advanced seminar.
2. Presentation techniques seminar: participants will be given advice and suggestions on presentation techniques, i.e. how to give scientific talks.
3. Report submission: submission of the final report, presentation and electronic copies of all publications read during the advanced seminar.
4. Final presentation: each participant has to present the results of his advanced seminar.

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

Final report submission:

A printed copy of the report and a CD have to be submitted to Miss Renner (Room N2515). The CD must 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 must be written using LaTeX or word. The supervisor should give you 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 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 a zip file. In addition, a pdf copy of the report should also be present in this directory. The presentation directory should contain a PowerPoint presentation or a pdf version. 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. The presentation format/style can be based on obtained from the supervisor. After a 5 minutes discussion will take place in which every one should actively participate. The contribution to the discussion is included in the final grade. It is compulsory to attend all presentations.

Grading:

The grading of the advanced seminar is based on the template attached below. In the assessment contains various criterion related to the preperation of the advanced seminar, the final report, presentation and participation during the discussion session.

I. Preperation phase

Nr.	Criteria	Grade
1	**Introduction:** understanding and overview given the difficulty of the task	
2	**Own Contribution:** creativity, Richness of ideas, initiative,	

	self organization and decisiveness	
3	**Organization:** organization, time management, persistence and Diligence	
4	**Scientific Work:** rigor, systematic approach, analysis of results	

II. Written 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, dicussion and evaluation of results	

III. Participation

8	**Active participation:** Discussion during presentations	

IV. Final presentation

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

Role of Supervisors:

The supervisor is the reference persion in case of any inquiries. Together with the supervisor you agree on the specifics of the topic and the expectations. The supervisor supports you in technical matters, final report and presentation of the results. If desired students can give their presentations prior to the final presentations in order to get some feedback concerning style and content. Your supervisor also shows you the workstations available for students and can introduce you to the computer programs required to complete the seminar.

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

Literature research:

The literature review should be carried out independently. Your supervisor will support you by providing appropriate refrence books and scientific papers. In order to facilitate your introduction to the topic, your supervisor also provides a list of introductory articles. In addition the central library as well as the institute's library can be used.

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, 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	14.10.2015	09:00 – 10:20 (5016@2906)
Lecture on presentation techniques	22.10.2015	13:00 – 15:00 (N0507)
Registration deadline	27.10.2015	23:59 (TUM Online)
Final report submission	12.01.2016	12:00 (Ms. Renner / N2515)
Final presentations	20.01.2016	9:00 – 10:20 (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 for the advanced seminar:

Matriculation number: ____________________

First Name, Last Name: ______________________________

Date: ____________________

Signature: ______________________________

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14.10.2015

ADVANCED SEMINAR

A literature review of approaches for robot motion trajectories segmentation

Problem description:

Humans are very good at learning and reproducing complex tasks, but it is often tedious and cumbersome to program a robot to perform them. Programming by Demonstration (PbD) alleviates this problem, where a human teaches a skill to a robot through demonstrations. A seemingly complex demonstration can be decomposed into a set of simple primitives, which can be learned efficiently [1]. There are approaches in which one has to manually specify segments (basis functions) in a trajectory [1]. A better way to tackle this problem is by automatically learning the trajectory segmentation [2].

In this seminar work the student will:

- Study and compare existing motion trajectory segmentation approaches.
- Identify problem domains where some motion segmentation approaches are preferable over the others.

Bibliography:

[1] Schaal, Stefan. "Dynamic movement primitives-a framework for motor control in humans and humanoid robotics." Adaptive Motion of Animals and Machines. Springer Tokyo, 2006. 261-280.
[2] Lee, Sang Hyoung, et al. "Autonomous framework for segmenting robot trajectories of manipulation task." Autonomous Robots 38.2 (2015): 107-141.

Supervisor: M.Sc. Affan Pervez

(D. Lee)
Univ.-Professor

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10.10.2015

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

Force Control for Biped Robot Locomotion

Problem description:

The state of the art of biped walking control is based on walking pattern generation and trajectory tracking along the generated pattern based on joint position control [1]. However biped locomotion involves physical interaction between the robot and the environment. A good biped walking control scheme should not only have the ability to following the walking pattern accurately, but also to have a secure and stable footing on the ground. Pure motion control cannot fulfill this requirement and produce footing bouncing during landing since the ground can never be modeled precisely. On the other hand many force control concepts have been developed for interaction tasks [2]. In this advanced seminar the student should do a literature survey on force control applied to biped walking control.

- Study the force control methods of interaction control.
- Literature survey of force control applied to biped walking control.
- 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] Siciliano, Bruno and Khatib, Oussama. Springer handbook of robotics. In *Springer Science & Business Media*.

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12 October 2015

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

On-line Gaussian Processes for Robotics

Problem description:

Gaussian Processes (GP) [1] are statistical modelling tools that has been successfully used in a number of robotics applications, such as imitation [2] and reinforcement learning [3].

In this Advanced Seminar, we aim at investigating on-line, incremental learning algorithms for GP [4]. These algorithms are useful to update the learned parameters according to new incoming data, without considering all the previous data. The advantages and disadvantages of these algorithms will be discussed, as well as possible robotics applications that requires to continuously refine or increase the robot knowledge.

Bibliography:

[1] C. E. Rasmussen and C. K. I. Williams. Gaussian processes for machine learning *MIT Press*, 2006.
[2] K. Kronander, S. M. Khansari Zadeh and A. Billard. Incremental Motion Learning with Locally Modulated Dynamical Systems *Robotics and Autonomous Systems*, 2015.
[3] M. P. Deisenroth and C. E. Rasmussen. PILCO: A Model-based and Data-Efficient Approach to Policy Search, in *International Conference on Machine Learning*, 2011.
[4] L. Csató. Gaussian Processes - Iterative Sparse Approximations *Aston University - PhD dissertation*, 2002.

Supervisor: M. Sc. Matteo Saveriano

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Carl-von-Linde Fellow

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October 11, 2015

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

Model-based Reinforcement Learning in Advanced Robotics

Problem description:

The generation of motion for robots and mobile manipulators in unstructured, dynamic environments has been a key research topic in the last years and an interesting challenge in industrial applications. Nevertheless, due to the high complexity of the problem, a ultimate solution has not been defined and the issue is far to be solved. In order to tackle uncertainties and unexpected events, several methods and diverse scientific communities have contributed to the development of artificial cognitive systems that aim at working in unknown, dynamic environments. In the last few years, reinforcement learning (RL) approaches showed a promising potential to increase the flexibility and autonomy of robotic systems [2]. RL techniques can be classified in model-free and model-based. Model-free methods are more flexible but require a large number of iterations to converge. Model-based techniques have the potential to decrease the number of interactions with the external world but they require a careful choice of the model, that is a key open point in modern robotics. The objective of the Principal Seminar is to investigate the literature on model-based learning techniques to execute successfully mobile manipulation tasks in unstructured environments. In particular, starting from [1], the following tasks are required:

- Literature research on model-based learning methods for robotics in unstructured environment
- Critical analysis and comparison on different model-based RL approach adopted in robotics

Bibliography:

[1] Marc Peter Deisenroth, Gerhard Neumann, Jan Peters, et al. A survey on policy search for robotics. *Foundations and Trends in Robotics*, 2(1-2):1–142, 2013.

[2] Jens Kober, J Andrew Bagnell, and Jan Peters. Reinforcement learning in robotics: A survey. *The Int. Jour. of Rob. Res.*, 2013.

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October 2015

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

Discontinuity of Orthogonalization of Continuous Functions

Problem description:

In the prioritized inverse kinematics problem, orthogonalization is used to decompose a task into the summation of orthogonal vectors, so the inverse solution can be found considering priority between multiple tasks [1]. A primitive step of orthogonalization is the orthogonal projection of a vector or a matrix into the nullspace of previous vectors or matrices. Specifically, given k tasks, there are k Jacobians which are decomposed as

$$\begin{aligned}
\mathbf{J}_1 &= \mathbf{C}_{11}\hat{\mathbf{J}}_1 \\
\mathbf{J}_2 &= \mathbf{C}_{21}\hat{\mathbf{J}}_1 + \mathbf{C}_{22}\hat{\mathbf{J}}_2 \\
&\vdots \\
\mathbf{J}_k &= \mathbf{C}_{k1}\hat{\mathbf{J}}_1 + \mathbf{C}_{k2}\hat{\mathbf{J}}_2 + \cdots + \mathbf{C}_{kk}\hat{\mathbf{J}}_k
\end{aligned}$$

where $\hat{\mathbf{J}}_i\hat{\mathbf{J}}_j^T$ is $\mathbf{0}$ if $i \neq j$ and $\mathbf{I}$ if $i = j$. A problem of this decomposition is that it can be discontinuous even if the Jacobians are all continuous, so the inverse solution can also be discontinuous. This phenomenon has already reported in the constrained optimization problem in which Byrd [2] told that "in general, there is no continuous function that generates the null space basis of all full rank rectangular matrices of a fixed size". This advanced seminar focuses on the literature research related to discontinuity of orthogonalization and the null space basis of continuous matrix functions in both the prioritized inverse kinematics and constrained optimization problems.

Bibliography:

[1] An, S. and Lee, D. Prioritized Inverse Kinematics using QR and Cholesky Decompositions In *IEEE International Conference on Robotics and Automation*, 2014

[2] Byrd, R. and Schnabel, R. Continuity of the Null Space Basis and Constrained Optimization In *Mathematical Programming*, 1986

Supervisor: M. Sc. Sang-ik An

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07.10.2015

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

Motion segmentation and object discovery from image pair

Problem description:

For a dynamic scene without prior knowledge, motion is an important cue to discover unknown objects. Giving image pair or sequence, pixels can be grouped to different objects based on the motion information. Motion segmentation is an essential building block for many applications such as scene understanding, video surveillance, traffic monitoring. Different methods has been developed for motion segmentation task [1, 2, 3]. The student has to do a literature survey in this topic:

- Literature survey of motion segmentation.
- Comparison of different approaches.
- Documentation.

Bibliography:

[1] G. Zhang, J. Jia, and H. Bao. Simultaneous multi-body stereo and segmentation. In Proc. of the IEEE Int. Conf. on Computer Vision (ICCV) , 2011

[2] D. Cremers, S. Soatto. Motion competition: A variational framework for piecewise parametric motion segmentation. International Journal of Computer Vision, 2005

[3] M. Jaimez, M. Souiai, J. Stueckler, J. Gonzalez-Jimenez, D. Cremers. Motion Cooperation: Smooth Piece-Wise Rigid Scene Flow from RGB-D Images, In Proc. of the Int. Conference on 3D Vision, 2015

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