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	22.04.2015	09:00 – 10:20 (5016@2906)
Lecture on presentation techniques	30.04.2015	10:00 – 12:00 (N0507)
Registration deadline	06.05.2015	23:59
Final report submission	02.07.2015	12:00 (N2515)
Final presentations	07.07.2015	9:00 – 10:20 (5016@2906)

* 5016@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 for the advanced seminar:

Matriculation number: ____________________

First Name, Last Name: ______________________________

Date: ____________________

Signature: ______________________________

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07.04.2015

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

A review of Deep learning approaches, suitable for robotics applications

Problem description:

It is suggested that for learning complex functions that represent high level abstractions, one may need deep architectures [1]. Deep architectures provide different level of abstractions and require exponentially less number of computational units than a shallow architecture. Multi-Layer Perceptron (MLP) provide one such architecture for learning nonlinear mapping between a set of input data to appropriate outputs. Backpropagation in MLP suffers from problems such as getting into local minima's and slow learning due to vanishing gradients. Learning algorithms such as Deep Belief Networks have been recently proposed to tackle these problems [2]. Deep learning has shown promising results in speech recognition, natural language processing and image recognition.

In this seminar work the student will:

- Review different deep learning approaches.
- Investigate the importance of deep architectures as compared to shallow architectures.
- Identify the deep learning algorithms suitable for robotics applications.

Bibliography:

[1] Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1-127.
[2] Lee, Honglak, et al. "Convolutional deep belief networks for scalable unsupervised learning of hierarchical representations." Proceedings of the 26th Annual International Conference on Machine Learning. ACM, 2009.

Supervisor: Dipl.-Ing. Affan Pervez

(D. Lee)
Univ.-Professor

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10.04.2015

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

Footstep Planning of Biped Robots

Problem description:

Compared with wheeled mobile systems, biped robots provide superior navigation ability especially in the environment constructed for humans. Motion planning of humanoid robots is among the most challenging problems due to the high degree of freedoms. As a prerequisite for navigation a sequence of collision-free footsteps have to be planned from the start posture to the goal posture. Many research works have been done in order to find an optimal solution of this problem such as A * search based methods [1,2]. The student has to do a literature survey in this research topic.

- Literature survey of footstep planning methods.
- Comparison of different approaches.
- Documentation

Bibliography:

[1] Chestnutt, Joel E and Nishiwaki, Koichi and Kuffner, James and Kagami, Satoshi. An adaptive action model for legged navigation planning. In *IEEE-RAS International Conference on Humanoid Robots, 2007*.

[2] Armin Hornung and Andrew Dornbush and Maxim Likhachev and Maren Bennewitz. Anytime Search-Based Footstep Planning with Suboptimality Bounds In *IEEE-RAS International Conference on Humanoid Robots, 2012*.

Supervisor: M.Sc. Kai Hu

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22.04.2015

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

On the Importance of Qualitative Features of Motion and Context in Cognitive Robotics

Problem description:

In the programming by demonstration (PbD) paradigm, multiple action instances are shown to the robot in order to teach an abstract notion of an action. The majority of current attempts to generalize such latent models from many training instances are based on trajectory information [1].
It is apparent that while such generalization at a sensorimotor level encapsulates important information for task reproduction, robustness towards context variation (in terms of adopted objects and their parametrization) can only be achieved at a higher level of abstraction, i.e., by making use of semantic notions and reasoning [2]. In fact, the use of discrete, sequential primitives as basic constituents of actions, which intend to describe a qualitative variation with respect to the previous state of the instance, enable ontological representation and semantic reasoning.
These primitives are generated by a perception segmentation module, and capture information regarding the surrounding scenario, the motion, or the labels attributed to objects involved in the interaction. The focus of this work will be to understand how this information is processed and used, as well as identifying future opportunities. In particular, the student will:

- Investigate the current use of qualitative descriptions of motion in robotic literature
- Understand and critique advantages and drawbacks of qualitative information usage and its implemented segmentation
- Identify (at least two) viable and substantial research gaps which can make use of discrete, qualitative information of motion and context in the cognitive robotics domain
- Document all past steps in a four-page double coloumn report

Bibliography:

[1] A. Billard, S. Calinon, R. Dillmann, and S. Schaal. Robot programming by demonstration. in *Springer handbook of robotics. Springer Berlin Heidelberg*, 2008, pp. 1371-1394

[2] N. Kirk, K. Ramirez, E. Dean, M. Saveriano and G. Cheng. Predicting Modular Robotic Plans via Probabilistic Semantic Reasoning on Context and Sequence. in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Hamburg, Germany [submitted]*, 2015.

Supervisor: Nicholas H. Kirk, M. Sc.

(D. Lee)
Carl-von-Linde Fellow

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April 2, 2015

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

Machine Learning in advanced mobile manipulation systems

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. Such methods include classical control theory, optimal control, machine learning, and perception-based motion planning. The objective of the Principal Seminar is to investigate the literature on learning techniques to execute successfully mobile manipulation tasks in unstructured environments. In particular, starting from [1] and [2], the following tasks are required:

- Review on learning methods for human-like robotic hands
- Review on learning methods applied to robotic manipulators.

Bibliography:

[1] Brenna D Argall, Sonia Chernova, Manuela Veloso, and Brett Browning. A survey of robot learning from demonstration. *Robotics and autonomous systems*, 57(5):469–483, 2009.

[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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April 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

(Ph.D. Dongheui Lee)
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