TARSA
(Teaching Automation, Robotics and Services to Architects)

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Abstract

Today's innovations increasingly occur in the frontier engineering domains between disciplines. Traditional occupations may rejuvenate by absorbing emerging technologies. Having compiled a quarter century experience of research, development and deployment in construction automation and robotics, this article outlines the planned education of architects in this new crossdisciplinary domain. The chair for building realization and robotics at the faculty of architecture of the TU Munich teaches advanced construction and building management and design focusing on construction automation, robotics and services. In history new tools required new methods. The notion of robot oriented design, first published in 1988, paved the way for more than 20 automated building construction sites till today. Recent and future challenges by demography, ecology and globalization ask for innovation leaps in architecture, engineering and construction and its educational methodology.

Keywords: automation, architecture, robotics, services, innovation, construction

TARSA
(Обучение Архитекторов Автоматизации, Робототехнике и Обслуживанию)

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Аннотация

Сегодняшние новшества все более и более происходят на границе технических областей между дисциплинами. Традиционные занятия могут обновляться, поглощая появляющиеся технологии. Собрав опыт четверти столетия исследований, усовершенствований и развертывания строительной автоматизации и робототехники, статья выделяет запланированное обучение архитекторов в этой новой междисциплинарной области. Кафедра технологии строительства и робототехники архитектурного факультета ТУ Мюнхена преподает передовое строительство и управление строительством и проектированием, сосредотачиваясь на строительной автоматизации, робототехнике и услугах. Исторически новые инструменты требовали новых методов. Идея проектирования, ориентированного на робота, впервые опубликованная в 1988 году, проложила на сегодня путь для более чем 20 автоматизированных участков строительства зданий. Современные и будущие вызовы демографии, экологии и глобализации требуют инновационных скачков в архитектуре, проектировании и строительстве и их методологии обучения.

Ключевые слова: автоматизация, архитектура, робототехника, услуги, инновация, строительство

1. Master of Science in Advanced Construction and Building Technology

The Master of Science in advanced construction and building technology is tailored to offer solutions to globalization, sustainable resource utilization, transformation of technological potentials, environmental and demographic challenges. The future construction sector will expand to new business fields by absorbing advanced technologies from various disciplines. Its success will depend on its innovation leap ability of the complete value chain of the artefactual engineering and built environment by embedding ict, automation, robotics and services. This approach will create new markets, qualifications, skills and professions.

Even though architecture and construction are the focal points of this master course, it crosslinks considerably to other disciplines and faculties such as potential psycho-social health transformation of future societies and incubates it into augmented skill formation for socio-technical qualifications of next generation engineers.

Future socio-ecologic engineers will be prepared to tackle yet unknown challenges by designing solutions for future technology, economy, ecology and society. They apply frontier science competence and define cross-disciplinary domains permanently. The master course of advanced construction and building technology can be considered as an incubator for strategic design and development of continuous improvement and innovation for life long learning.

1.1. Topics of the Master Course

The topics of this course aim at expanding the professional core competence in construction while responding to changing technological, social and ecological circumstances:

1.1.1. New technologies, processes and strategies for designing and producing of buildings

Faster return on investment through implementation of rapid project delivery and zero defect construction by robot oriented design and automated construction systems. The students who take the master course in advanced construction and building technology acquire a complementary knowledge in design, production, assembly, logistics and management emphasizing on information, communication, automation, robotics, mechatronics and service technologies.

1.1.2. Integration of intelligent systems in daily life and environments

Microsystems and microelectronics increasingly form a part of our everyday's life. Its miniaturization allows its incorporation in domestic systems and appliances. Simultaneously we want to deal with a standardized and compatible network of synergetic subsystems rather than detached island solutions. On top of conventional construction planning, engineering and management, these new technologies require an even more complex project management capacity for interfacing the various frontier science disciplines. In order to incorporate microsystems technologies in intelligent living environments the student acquires basic knowledge of these advanced ict.

1.1.3. Life cycle management, value engineering and design, innovation

The master course follows a holistic approach: the deployment of new technologies is considered in each phase of life cycle originating in marketing and project development till re-use and disassembly. Due to the elementary approach of open systems and subsystems, the life cycle of a building can be extended by upgrading or repairing one element without destroying the whole system. This approach is common in aero space industries and in construction industry secondary resource utilization helps increasing the total resource efficiency of building performance. (While taking into account its total effect.)

The course students learn management of technology, processes and projects, its technological interdependencies and socio-economical boundary constraints. By studying intercultural cases in design, production and management the student gets acquainted to cross-cultural experiences for future professional international career.

1.2. Positioning for Future Job Market Opportunities

This master course is in tune with actual professional requirements. It responds to a major shift of the professional mainstream away from the traditional core competences (of architects). (For example as far as architecture is concerned less architects work in their domain and more civil engineers, economists, lawyers and others take over former architect's work load,) Conventional competences transform into border competences such as life support systems, mechatronics, ict and microsystem technology embedded ambience (environments) sustainable energy design and engineering, real time controlling, innovation (project) management, facility transformation management etc. To achieve this, the course expands into disciplines such as economy, management, mechanical and electrical engineering, computer science, sociology and medicine by synchronizing these fields with innovative ambient (construction) technology (of the built environment). Future graduates from this course will be trained for cross disciplinary thinking and acting and therefore will be very flexible to adjust to changing professional environments.

2. Course Cycles

A wide-spread theoretical basic knowledge (theory), the impartation of methods and „tools" for problem solution and project realization (methodology) and the possibility to acquire problem- / interest-specific knowledge (specialization) is the foundation of the Master Course.

2.1. During the first Semester

Basic knowledge is increasingly imparted. The basic knowledge is contentwise wide-spread and ranges from construction-systematic basics (P 03 ARC) over logistics and manufacturing-/ construction-processes (P 03 ARC, P 05 FEM) to life-cycle-relevant technologies and assistive systems in buildings (P 03 ARC, P 04 BSP). Basics in innovation development (P 04 BSP, P 07 MOI) and socio-technological aspects (P 04 BSP, P 05 FEM) are also imparted. A small preproject is supposed to introduce the students to the project work and to help them to realize their strengths and weaknesses at an early stage.

2.2. During the 2nd and 3rd Semester

The project work is given priority. The tasks are set in a way that the students are able to use their learnt basic knowledge and to develop them further so they become personal approaches. The problem-oriented approach shall motivate the students to acquire specific knowledge through the elective subjects. Interdisciplinary basics are also imparted in an integrated way by „learning by doing".

The elective subjects are the second focus in the 2nd and 3rd semester. Through these the students can „line" their projects and bring their personal tendencies in their studies.
In addition further obligatory subjects are deepened concerning the thematic fields of industrialization strategies (P 07 MOI), life-cycle-relevant technologies and assistive systems in buildings (P 08 USE) as well as innovation development (P 11 Inc).

2.3. In the Master Thesis

The learnt basic and specific knowledge as well as the learnt skills and methods are flowing together. According to interests and skills of the students the task can equally involve aspects of theory, methodology / project and specialization or it can focus on one topic. The elaboration of the Master Thesis can take place as a pure project or as a pure scientific-theoretical discourse,

which are the two „extreme cases“ in the spread of possible configurations. Usually a balance is aspired in order to fulfill the principle of the equally wide-spread and varied education.

Fig. 1. Structure of the Master Course

3. Cross-disciplinary Course Coaching

Since the Master Course is mostly characterized by being interdisciplinary, the knowledge is primarily imparting knowledge in respect of the handling with complex issues. On the hand it offers a multi-option, but on the other hand it also requires problem-oriented work for the projects. This is why it is so important to offer several reference points and a clearly regulated course coaching to the students.

The Master Course relies on a course coaching, in which advisors from two categories are allocated to each student: Mentors and international consultants. They assist the students during their studies as well as during the elaboration of the Master Thesis.

3.1. Interdisciplinary Mentors

The Mentors are the main reference persons and consultants during the whole length of study, concerning the professional as well as the organizational matters. A mentor is allocated to each student. The mentors offer support in choosing elective subjects and projects and supervise the projects also contentwise, just as the Master Thesis. Besides that, they give advice concerning the choice of international consultants. For respective technical discussions the students should make use of not only face-to-face-meetings, but also telephone conferences, skype-conferences et cetera. If necessary, mentors can participate in field trips or organize intermediate and final presentations for the individual credits.

3.2. International Consultants

International consultants take on the consulting of the students concerning technical issues in the project phases and during the Master Thesis. Thereby they are imagined to be an addition to the mentors. The international consultants ensure the contact to the professional world on the one hand and they are important reference persons to international students on the other hand. The individual communication can, according to the circumstances, take place in conferences, research travelling, telephone conferences, skype-conferences or email.

4. Learning by Researching

The Master Course *Advanced Construction and Building Technology* is of high relevance to the involved Chairs, to the faculty as well as to the TUM and it offers a chance to expand existent first-class positions. Basically two important fields can be distinguished:

4.1. Roboterization and Automatization in Building and Construction Industry

Robotics and Automation in the building and construction industry is a research field, which is internationally established for around 30 years now. Numerous international conferences (for example the ISARC International Symposium on Automation and Robotics in Construction), CIB-workgroups (TG 57 Industrialization; W 104 Open Building Implementation, W 96 Architectural Management), but also exhibitions (New York MoMA: Home Delivery, 2008; Pinakothek der Moderne: Wendepunkt(e) im Bauen, 2010) and initiatives (Zukunft Bau, BMBF; Bayern Innovative) emphasize the importance of this research field. The expertise at the Chair for Building Realization and Building Robotics in this field is pertinent. The research experience in the field of building robotics dates back over a quarter century. The chair holder is considered to be one of the co-founders of IAARC and is among others director of the „International Association for Automation and Robotics in Construction“ . The chair holder has more than 300 publications, predominantly in this field. The term „Robot Oriented Design“ was initially published by the chair holder in May 1988 in Tokyo, since then his work was the foundation for more than 50 building-robotic-systems, 25 automatized building sites and several service-robotic-systems. Prof. Bock is a member of prestigious editorial boards like „Robotic“, Cambridge University Press, „Automation in Construction“, “Academia” of the Russian Academy of Architecture and Building Sciences and many more.

Since architecture is also increasingly the nucleus of crystallization for Embedded-Technologies in built life-surroundings, the thematic fields of „intelligent surroundings“ and „interaction with intelligent surroundings“ are another focus in the science and research of the Chair for Building Realization and Building Robotics. The special contentwise positioning of the Chair lies in the combination of architecture, informatics, robotics and integrated system technology.

4.2. Demographic Change, Ambient Assisted Living, High-Tech-Assistive Systems

The demographic change with its sum of effects is undoubted to be an over-all-social assignment to the Scientific Community as well as it will unavoidably be a focus of political responsibility of the next generation. The TUM, the Faculty of Architecture and the Chair for Building Realization and Building Robotics deeply committed to these research fields.

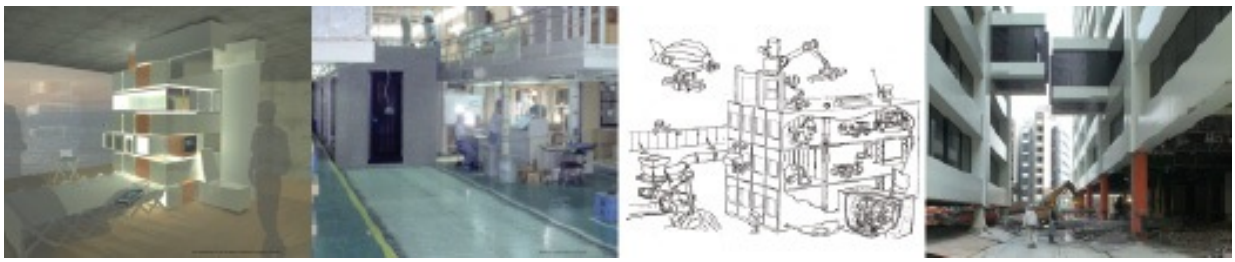
The Master Course *Advanced Construction and Building Technology* lines up in a list of efforts to take up the relevance and potential of this topic. It particularly wants to go towards promoting the integration of assistive systems into the life- and work-surroundings of private and public spaces.

The holder of the Chair for Building Realization and Building Robotics is, since the incurrence of the innovation field of „Ambient Assisted Living“ (kurz: AAL), member of the programcommittee of the same-titled initiative of the „Bundesministeriums für Bildung und Forschung“ (BMBF) and was represented on all german AAL-congresses with his own sessions.

The Chair and the Chair-comprehensive project group TUM AIR (Ambient Innovation Robotics) take up the topic of demographic change and try to utilize new (at the TUM developed) technologies for the support of the activities in daily life in the domestic surrounding. Several AIR-project-teams developed concepts and solutions for intelligent and adjustable life-surroundings. Among the cooperation-partners of the AIR-group are seven faculties such as the Chair for Applied Informatics / Cooperative Systems (Prof. Schlichter), the Chair for Medicine Technology (Prof. Steinbach, Prof. Kranz; „Ubiquitous Computing“, „Human-Machine-Interfaces“), the Chair for Medical Electronics (Prof. Wolf, Dr. Friedrich), the Chair for Human-

Machine-Communication (Prof. Rigoll) as well the Chair for Robotics and Embedded Systems (Prof. Knoll).

The Master Course wants to play a part in contributing the concentrated study of highly qualified national and international students on the above mentioned research topics over the period of four semesters. Since the Master Course equally addresses equally students from different areas of studies, an enrichment of the whole architecture- and construction-oriented research area is to be expected, which is able to deal with the increasing complexity of interdisciplinary research challenges.



a) b) c) d)

Fig. 2(a-d): a) Ambient Innovation; b) Industrialization; c) Site Automation; d) Robotic Deconstruction

5. International Relations

The Master Course equally addresses national and international students. As an approved High-Tech-Country and a prestigious university location Germany – and especially Munich – traditionally attracts an international public. For the mutual interexchange with universities of other industrial countries plays a big part for that purpose, whereby the Chair for Building Realization and Building Robotics makes an attractive contribution towards that:

In context of the ICI ECP „AUSMIP“ (Industrialized Countries Instrument Education Cooperation Program „Architecture and Urbanism Student Mobility International Program“) scholarships for a eight monthly stay at 8 international universities. In the context of the first round (AUSMIP, 2003/2007) the organizing professor-consortium received an award as a „Best Practice“-example. A core topic of the extended, 3rd cooperation is „demographic change, assistant living and assistive technologies“. To Russia with Euler and from Russia with Lomonosow scholarships. To Germany from Asia and the Americas with DAAD and other scholarships.

5.1. IAARC: *International Certificate for Automation and Robotics in Construction*

The union of IAARC (*International Association for Automation and Robotics in Construction*) initiated the construction of the „IAARC Academy“ in June 2010, which shall offer an international professional certificate. The module structure will be similar to the structure of the here introduced Master Course. Thereby it should be possible for students of the M. Sc. *Advanced Construction and Building Technology* study at a partner university for one semester, which also offers such a certificate, while international students participate in a semester of the M. Sc. *Advanced Construction and Building Technology* in return.

Until the complete realization of the international Master Course planned by the IAARC the certified advanced training offer *„International Certificate for Automation and Robotics in Construction“* shall be realized, which will also be compatible to the Master Course *Advanced Construction and Building Technology.*

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