MECHATRONICS EDUCATION AND RESEARCH ACTIVITIES AT BRNO UNIVERSITY OF TECHNOLOGY, FACULTY OF MECHANICAL ENGINEERING

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11th International Workshop on Research and Education in Mechatronics - REM 2010
Ostrava, Czech Republic, 9-10 September 2010

Faculty of Mechanical Engineering (FME)
Brno University of Technology
Czech Republic
Faculty in brief

- founded in 1900 - **110th anniversary**
- second largest BUT faculty – 3860 students, 495 doctoral students, 508 employees, **34 branches** in Bachelor`s and follow-up Master`s study programmes (all accredited in Czech and English), 16 doctoral study branches
- outstanding students results in Czech and international competitions (Airbus Fly Challenge, Design 2009, AV Awards 2009, Electrolux Design Laboratory, Maurice Godet Awards)
- joint degree / double degree study programmes (TU Chemnitz - Germany; ENSAM Cluny – France; Universita l`Aquila – Italy; KTH Stockholm – Sweden; Hogeschool Rotterdam – The Netherlands)
- close cooperation with Academy of Science of the Czech Republic
- cooperation agreements with nearly 60 universities all over the world
- cooperation with companies in education and research
Structured type of study

- **Doctoral study programme**
  - 4 years (Ph.D.)

- **Master's study programme**
  - 2 years (Ing.) – 120 credits

- **Bachelor's study programme**
  - 3 years (Bc.) – 180 credits

- **Secondary school**

**ECTS (European Credit Transfer System)**
- students evaluation
- courses in Czech and English
- studies finished with Bachelor's / Master's theses and final examination
- Diploma Supplement to each graduate
- over 800 graduates each year – good career prospects

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Mechatronic concept used

- Methodical guideline: VDI 2206 "Design methodology for mechatronic systems" (VDI Guidelines, Beuth Verlag, 2004)
- Design iteration through different areas of physics and technical disciplines (to achieve a synergic effect) based on
  - design cycle at macro level (V-cycle)
  - design cycle at micro level
- Highest attention is paid to:
  - The early stage of designing process
  - Shared modelling of technical systems and the processes occurring therein
  - Work in an interdisciplinary team
• Special accent is given to areas:
  o **Design** with searching for and mastering of appropriate level of abstract tools and their interconnections, whereas these tools have to be able to appropriately conceive the tasks from mechanics, electrical engineering, electronics, control and data processing
  o **Production** with evaluation of product design in terms of its manufacturability under the respective conditions, namely with respect to mechanical and electrical components
  o **Quality and reliability** with development of methods and tools to ensure the quality and to predict reliability and implementation of these methods and tools into the process of product designing
  o **Education** with breaking through the barriers between a traditional conception of mechanical engineering, electrical engineering and a control including IT (both in tertiary and secondary education)
• Shared modelling is a necessary condition for the work of interdisciplinary team:
  o A designer is provided with a possibility of virtual presentation of problem solving
  o A shared model enables us to explain the core of the solution to the other fellow workers, and if needed by the management, also to other workers from manufacturing and marketing departments. It is also important that this model can be used in further stages of designing process
  o A shared model is a condition that enables the designer to concentrate on the solutions to the problems that are decisive for the respective stage of designing process
  o A shared model also allows an easy verification of completeness and quality of problem solving
Mechatronics at Brno University of Technology

- FME BUT – the first university in Czech Republic offering the mechatronic education (1992/93)
- Nowadays the study of mechatronics involves cooperation between:
  - Faculty of Mechanical Engineering
  - Faculty of Electrical Engineering and Communication
  - Institute of Thermo-mechanics (Academy of Sciences of Czech Republic)
  - Experts from other universities and industry
- During past seventeen years graduated at BUT at mechatronics and related fields of study:
  - 253 Bachelors
  - 256 Masters
  - 47 Ph.D.
Mechatronic Team

- Faculty of Mechanical Engineering
  - Institute of Automation and Computer Science
  - Institute of Production Machines, Systems and Robotics
  - Institute of Solid Mechanics, Mechatronics and Biomechanics
  - Energy Institute - Victor Kaplan Department of Fluid Engineering
- Faculty of Electrical Engineering and Communications
  - Department of Power Electrical and Electronic Engineering

Activities

- Focused on further development of the existing interdisciplinary team
- Research and development of modern mechatronic systems
- Education of research staff, postgraduate students and talented undergraduate
  - Internships at partner universities and research institutions
  - Lectures delivered by experts invited to BUT
- Participating and holding of conferences and workshops
Student’s activities
Support of Mechatronic Team

- The mechatronic team at BUT is mainly supported from:
  - CZ.1.07/2.3.00/09.0162 “Knowledge and Skills in Mechatronics - Innovations Transfer to Practice”
  - CZ.1.07/2.2.00/07.0406 “Introduction of Problem Based Learning to Mechanical Engineering Curricula”
  - DE/08/LLP-LDV/TOI/145110 “Minos**“
  - MSM 0021630518 “Simulation modelling of mechatronic systems”

- and recently finished
  - KONTAKT 1P05ME789 “Simulation of Mechanical Function of Selected Elements of Human Body”
MINOS++

... innovative concept of integrated in-service education of mechatronic in European Union

Project duration: 29.09.2008 to 30.08.2010
MINOS++

... Minos project

MINOS (2005-2007) and MINOS** (2008-2010) is a project supported by the European Union as part of the “Leonardo da Vinci” EU action programme for professional education:

“European concept for the additional qualification mechatronic of skilled personnel in the globalised industrial production”

Homepage of this project is (http://www.minos-mechatronic.eu/).

MINOS is a multi-lingual modular teaching and study concept in the area of mechatronics, which will achieve comparable levels in mechatronics studies and will be open to additional partners.
Knowledge and Skills in Mechatronics
Innovations Transfer to Practice

CZ.1.07/2.3.00/09.0162

Operational Programme
OP Education for Competitiveness

Priority
No. 2 Tertiary Education, Research and Development

Beneficiary
Faculty of Mechanical Engineering, Brno University of Technology

Duration of Project
01/08/2009 - 31/07/2012

The project is co-financed by the European Social Fund and the state budget of the Czech Republic.
Brief Description of Project

- The project is focused on further development of the existing interdisciplinary team that is involved in the research and development of modern mechatronic systems.
- Great emphasis is placed on education of scientific and research staff, Ph.D. students and talented undergraduates.
- Thanks to the interdisciplinary concept, the project can offer a wide knowledge base for innovation potential ensured by research and education activities in different fields forming modern mechatronics. Such approach will facilitate sustainable development, primarily in the area of energy and feedstock saving, and minimization of ecologic and safety risks.
- The aim of the project will be achieved especially by means of support provided to the knowledge transfer.
Key Activities of Project

1. Integration to the international research community
   • Active participation on international conferences

2. Support for professional education of mechatronic team
   • Special lectures
   • Research fellowships
   • Education of team
   • Own education

3. Talented students support
   • Robotic competitions
   • Summer school
   • R&D activity of talented students

4. Conferences, workshops and lectures
   • Organization of workshops
   • Ph.D. conference "Mechatronic"
   • International conferences (e.g. IAHR, Mechatronics)
   • Meetings of teachers
Target Groups

- Research and Development Staff
- Ph.D. Students
- Talented Students

The project is co-financed by the European Social Fund and the state budget of the Czech Republic.
Activities of Mechatronic Team - Conference Mechatronics 2009

• The 8th International Conference “Mechatronics 2009” was organized by BUT mechatronic team, held on November 18–20, 2009, in Luhačovice, Czech Republic

• History of the conference:
  o From 1994 annually and alternately as “Mechatronics, Robotics and Biomechanics” in Czech Republic / “Mechatronics” in Poland
  o After 2005 every 2nd year as Mechatronics (with Polish conf. numbering), alternately in Czech Republic / Poland

• Topics of the conference:
  o Modelling and Simulation
  o Metrology & Diagnostics
  o Sensorics & Photonics
  o Control & Robotics
  o MEMS Design & Mechatronic Products
  o Production Machines and Biomechanics
Activities of Mechatronic Team – Participated Conferences

- Mechatronics Systems and Materials 2009, Vilnius, Lithuania
- CIRP January Meetings Paris
- The 15th IEEE Mediterranean Electrotechnical Conference, Melecon 2010 Valletta, Malta
- SME 2010, Ustron, Poland
- CIRP General Assembly, Pisa
- EPE-PEMC 2010, Ohrid, Macedonia
- SCHUNK International Expert Days 2010
- ISIE 2010, Bari, Italia
- Automatica Munich 2010
Activities of Mechatronic Team - Trainings and Research Fellowships

Research internships on international and professional training programs, e.g.:

- Delft University of Technology, Nederland
- TU Chemnitz, Germany
- Fraunhofer IWU, Germany
- ACRO - KHLim Technologiecentrum, Wetenschapspark, Diepenbeek, Belgium
- Advanced TRIZ Program: Technology and Engineering, Utrecht, Nederland
- PULSE, Denmark
- NI LabView
- MSC.ADAMS
- ANSYS
- Maxon
Activities of Mechatronic Team - Talented Students

Support activities of students in all study programmes, e.g:

- Robotic Competition (Robocup German Open 2010)
- Summer Scholl of Mechatronics:
  - Mobile robotics
  - Industrial robotics
  - Virtual prototyping and simulation modelling of mechatronic systems
- R&D activity of talented students
Activities of Mechatronic Team – Research and Development of Modern Mechatronic systems

- Device for cord implants testing
  - its movements are as close as possible to the real physiological movements and loads
  - mechatronic design results on PKM (Stewart Platform - hexapod) hardware
• The simulation modelling includes iteration between
  o state-space model of mechanics and state-space controllers design
  o model of mechanics with uncertainties and H-infinity controllers design
Design specification and definition of requirements

Feasibility study

Kinematic and dynamic model

CAD model development

Controller algorithm development

Controller algorithm verification

Requirements verification

System integration

System validation

Requirements verification

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Energy harvesting from vibrations

- Energy harvesting systems
  - Electromechanical energy conversion
  - Autonomous electrical energy source for wireless applications exploiting ambient vibrations
- The device contains
  - Precise mechanics
  - Electro-mechanical converter
  - Power electronics
Development of Vibration Energy Harvester with Mechatronics Approach

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BLDC Motor

- BLDC Motor Control for Critical Application
Mobile Robots

- Bender II
  - Outdoor environment
  - Long distance travelling
  - Moving object detection
  - Collision avoidance
- Onboard electronics
  - Maxon motors
  - Laser range finder
  - Vision system
  - 3D Compass / GPS
Autonomous mobile robot development

Requirements
- Outdoor environment
- Long distance travelling
- Moving objects detection
- Collision avoidance

Navigation algorithms development

Mobile robot

System integration

Simulation experiments

Test on real conditions

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Other Successful Examples of Faculty Projects: Aeroplanes

- Ultralight aeroplane KP-2U
  Sova type in Luxor

- Single engine airplane for air traveling and pilot training
  VUT 100 Cobra

- OK-VUT Marabu
Development of turning machines

C Axis for Multifunction Turning Centre
Conclusions

- Consistent V-model application
- Inspiration by mechatronic methodology usage in another branches (sp. machine construction)
- Methodologies based on successful R&D realizations are developed for education
- Accent placed on state linear models with uncertainties and connected robust control (if possible)
- Inclusion of additional aspects into early stages of design (reliability, maintenance, risk management)
- Ranking the best students into mechatronic team (VaVpl)
- So V-model is used also in education process shaping
Thank you for your attention!