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Annual Report 2010

Master of Science in Biomedical Engineering

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Introduction

2010 in Retrospect

Despite the fact that medical technology is a particularly well established and highly successful industry sector in Switzerland, there is only a limited number of corresponding education programs available. In March 2006, 23 students coming from various fields of studies gathered in a lecture hall to commence the new specialized master study course "Master of Science in Biomedical Engineering". To date, a unique initiative between the University of Bern and the Bern University of Applied Sciences as collaborating partner has opened up the exciting interdisciplinary field at the interface between medicine and engineering to about 250 students from more than 20 countries.

Since the start of the specialized master course the constant effort to improve the quality of our curriculum has resulted in substantial changes of the course structure and its content over the past four years. The four semester program is now grouped into well-defined modules, where the major modules represent the focus areas, available to the students for their final specialization. To date, these are musculoskeletal system, electronic implants, and image guided therapy, with more to come in the next years.

The biomedical engineering program draws on the expertise of over 60 lecturers, offering almost 50 courses. They are faculty members of the University of Bern, Bern University of Applied Sciences, and recently of the University of Basel, or bring their expertise from the medical technology industry. This unique team covers a wide variety of aspects of biomedical engineering and promotes a high level of interaction between disciplines to assure a constantly evolving study program.

In 2010, five new courses, namely Fluid Dynamics, Technology and Diabetes Management, Rehabilitation Technology, Cardiovascular Signal Analysis and Modelling, and Medical Robotics were introduced. Most of the respective lecturers had recently joined the ARTORG Center for Biomedical Engineering Research of the University of Bern as junior faculty members. By this, our curriculum comprises a wide variety of highly specialized courses, which are also of particular interest for the medical technology industry as part of their continuing education activities and programs.

In 2010, 24 students graduated as biomedical engineers of the University of Bern. 69% of the corresponding master theses were advised at the University of Bern and Bern University of Applied Sciences, 20% at collaborating Swiss Schools, namely the ETHZ, EPFL, and other Universities of Applied Sciences, while 11% of the advisors came directly from the medical technology industry. This close collaboration is promoted through our annual Biomedical Engineering Day. It offers Swiss and international companies from the medical technological field an excellent opportunity to meet our highly qualified and motivated students face to face and to present themselves as attractive employers.

We hereby introduce to you our first annual report of the biomedical engineering master course, which presents the educational activities and the progress made in 2010.

Lutz P. Nolte
Program Director

Organization

Master of Science Biomedical Engineering

L. P. Nolte
Program Director

U. Jakob-Burger
Study Coordinator

S. J. Ferguson
Master Thesis Coordinator

V. M. Koch
Deputy Director

A. Neuenschwander
Study Coordinator

J. Spyra
Study Coordinator

BME First Year Students 2010, Alter Hörsaal der Anatomie, University of Bern

Course Structure of the Master Program

The Curriculum
Since the start of the Master Course Biomedical Engineering in March 2006, the constant effort to improve the quality of our curriculum has resulted in substantial changes of the course structure over the past years.
The first curriculum consisted of a number of individual courses which were either mandatory or elective, but their coherence with regards to contents was in most cases not expressed by a defined structure. However, two major modules (formerly called "focus areas") already existed.
As of the fall semester 2009, all courses were grouped in a strictly modular way in order to enhance both the clarity and the complexity of the curricular structure.
A main idea was to guide the students through their studies in a better way by adding a thematically related elective part to the major modules, which formerly had consisted exclusively of mandatory courses. Furthermore, the curriculum was expanded by a number of new specialized courses as well as an additional major module called "Image-Guided Therapy".
The initial concept included another module called "Complementary" which contained a range of elective courses. Although the system was quite sophisticated, the calculation of the required ECTS points turned out to be too complicated. To facilitate the system, the decision was made during the last year to integrate all elective courses from the master program into the major modules (see below) and to ensure a consistent selection of courses, not so much by formal regulations, but rather by giving recommendations.
The study course takes 4 semesters which corresponds to 120 ECTS points, one ECTS point being defined as 25-30 hours of student workload. It can be extended to a maximum of 6 semesters.

Basic Modules
The basic modules provide the students with the necessary background to be able to fully understand the highly complex subject matter in the specialized courses. All students with an engineering background (for all other students, individual study plans are set up which may contain certain variations) have to complete all courses in the Basic Modules Biomedical Engineering, Human Medicine, Engineering Mechanics, and Applied Mathematics. In the first semester, all courses belong to this group, whereas in the second and third semester, the courses from the basic modules make up 25-30%.

Major Modules
The choice of one of three major modules, Musculoskeletal System, Electronic Implants, or Image-Guided Therapy, after the first semester constitutes the first opportunity for specialization. Approximately one third of the major modules consist of mandatory courses. In the elective part of the major module, the student is allowed to select any course from the list of courses in the master program, giving rise to a high degree of diversity and flexibility and allowing for an almost infinite number of course combinations. However, this freedom makes it somewhat difficult for the student to make reasonable choices regarding professional prospects.
This is why the responsible lecturers developed a recommended study plan to guide the students through the course selection process and to avoid organizational problems such as overlapping courses. If a student follows the recommended path, he or she can be sure to establish a sound professional profile.

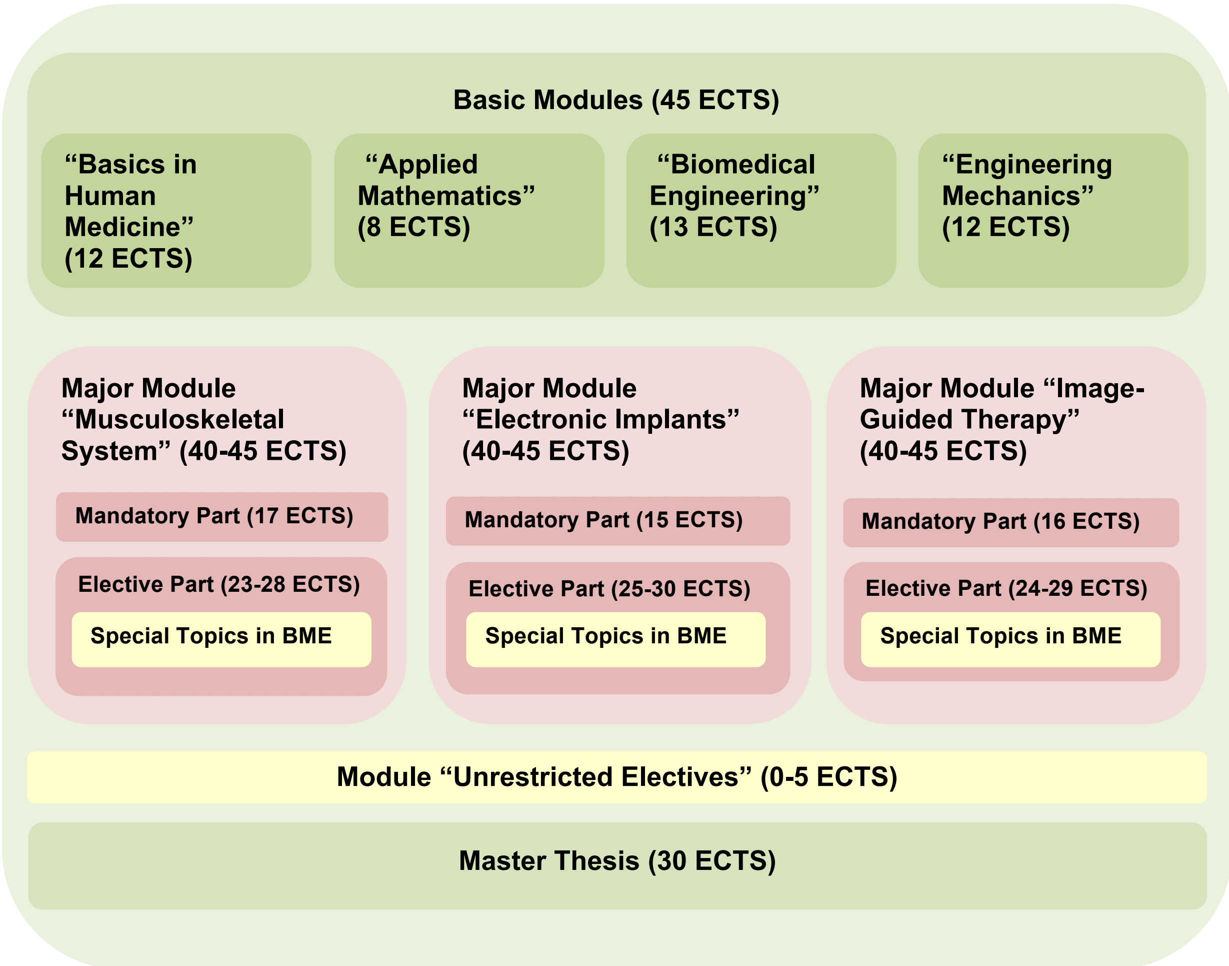
Module "Special Topics in Biomedical Engineering"
In order to meet an increasing demand for continuing education in the medical technology industry, the Special Topics in Biomedical Engineering have been developed. Scientists from institutions affiliated to the Medical Faculty of the University of Bern - the Artificial Organ (ARTORG) Center for Biomedical Engineering Research as well as the Institute of Surgical Technology & Biomechanics (ISTB) – established the course curricula in close collaboration with representatives from the leading medical technology companies in Switzerland. Courses have been designed to convey state-of-the-art knowledge in many future-oriented areas at the interface between applied scientific research and industrial research and development on a high level. Apart from contributing a hands-on aspect to the studies, thus complementing the theoretical foundation which is laid in the basic modules, these courses provide an excellent opportunity for industry professionals to deepen and expand their knowledge in selected areas of Biomedical Engineering. The course list is continuously expanded. Formally, this module has been integrated into the elective parts of the major modules.

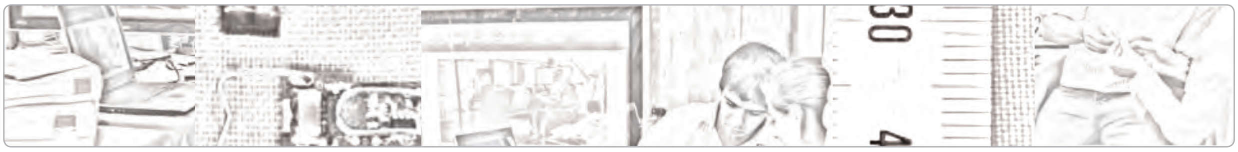
Module "Unrestricted Electives"

Unrestricted electives can be freely chosen by the student from the entire curriculum of the University of Bern and the Bern University of Applied Sciences, Department of Engineering and Information Technology. Of these courses, a maximum of 5 ECTS points are credited. It is advisable to select courses which fit into the context of the student's study plan, either to make up for missing knowledge or to add new and interesting aspects to the individual study program.

Master Thesis

The last semester is dedicated to a master thesis project on an individually suited topic in a research group or, in many cases, in an industrial environment. As a rule, all 90 ECTS points from the course program have to be completed, thus ensuring that the student is able to fully concentrate on the challenges imposed by exciting research activities. The master thesis includes the thesis paper, a thesis defense as well as a one-page abstract for publication in the Annual Report of the master course.





Major Modules

Electronic Implants

V. M. Koch

Electronic implants are devices like cardiac pacemakers and cochlear implants. Due to miniaturization and other developments, many new applications become feasible and this exciting area is growing rapidly. For example, cochlear implants provide already approximately 200’000 people a sense of sound. These people were previously profoundly deaf or severely hard of hearing. Recently, researchers demonstrated that electronic retinal implants allow the blind to read large words.

There are many more applications for electronic implants beyond treating heart problems, hearing loss or blindness. For example, there are electronic implants that treat obesity, depression, incontinence, hydrocephalus, pain, paraplegia, and joint diseases.

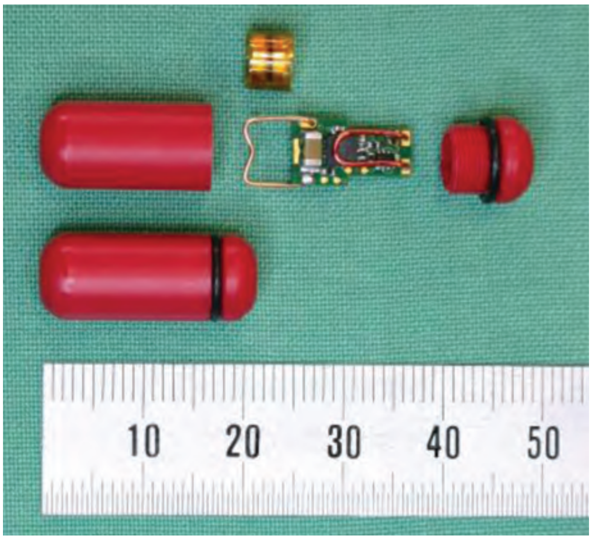
In this module, students will learn about the basics of electronic implants. This includes: sensor and measurement technology, signal processing and analysis, microcontroller programming, actuator technology, and miniaturization of micro-electro-mechanical systems.

Collaboration across various disciplines is important when developing electronic implants: Markus Lempen, research assistant of Prof. Dr. Volker M. Koch, explains the temperature capsule.

Application-oriented topics are also taught, e.g., cardiovascular technology and biomedical acoustics.

Since the development and manufacturing of electronic implants is highly complex and since it involves many different disciplines, it is not the goal of this major that students are able to develop an electronic implant on their own but rather to be able to work successfully in a project team that develops electronic implants.

Students may already apply their knowledge as a part-time assistant in a laboratory and/or during their master’s projects. After finishing the degree program, a wide variety of career paths are available, ranging from research and development to project and product management. Many well-known companies in Switzerland work in this field, e.g., Codman and Phonak Acoustic Implants. This list is, of course, not complete. For example, many „traditional“ implants manufacturers have recently become interested in electronic implants, e.g., to measure forces in knee implants.



Capsules with built-in temperature sensor and radio frequency transmitter.

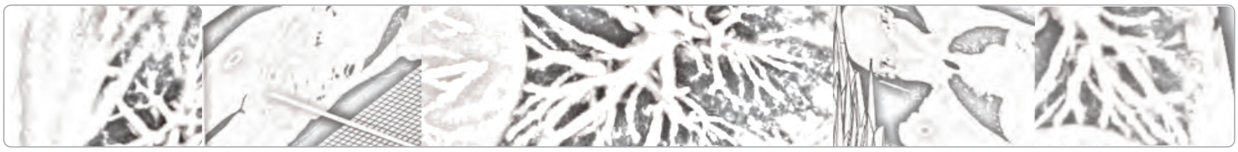


Image-Guided Therapy

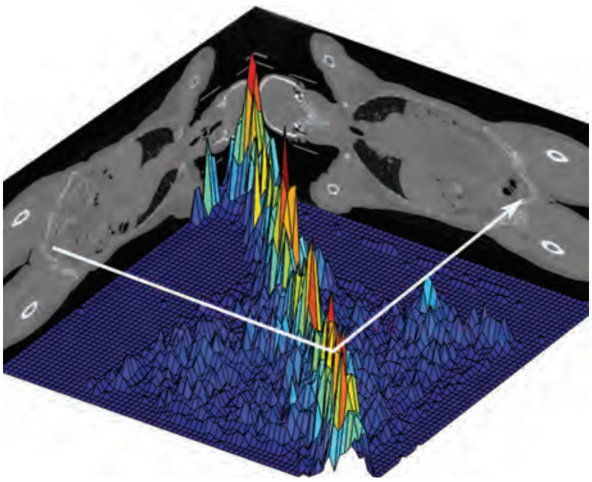
Ph. Cattin
Originally medical imaging was only applied during diagnosis. Later, X-ray systems were introduced in operating rooms to help localising anatomical structures, pathologic lesions, as well as surgical instruments in order to find the optimal access path to the target site.

Recently, fluoroscopes and the more cost-effective and non-ionising ultrasound devices became the predominant imaging modalities used in Image-Guided Therapy.

Today's developments furthermore try to integrate computed tomography and magnetic resonance imaging systems in the operating room to support intraoperative navigation. All these developments aim at improving the surgical outcome in various aspects.

In particular complications, morbidity and surgical time should be minimised whilst improving the predictability of the surgical outcome through the use of advanced intraoperative navigation techniques.

In the Image-Guided Therapy module, the students will gain a comprehensive understanding of all technical fundamentals required to understand, improve and to successfully develop Image-Guided Therapy systems.



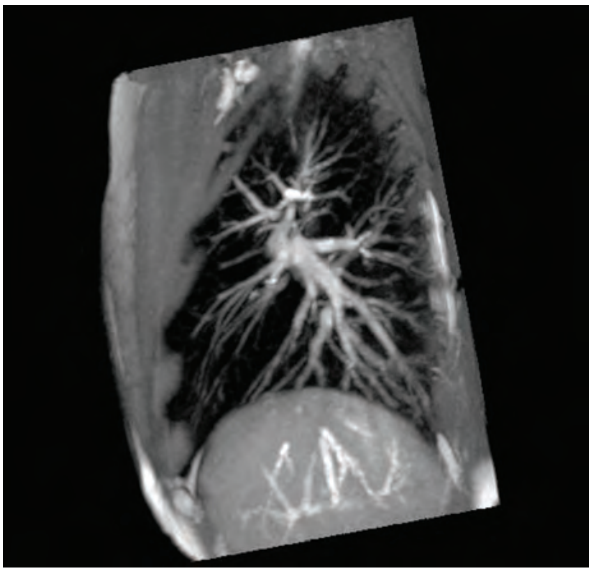
Anatomically similar locations can be automatically found in 2D or even 3D data sets.

In the mandatory courses of this module the fundamentals of Image-Guided Therapy systems are taught. In particular an Introduction to Signal- and Image-Processing where the fundamentl algorithms commonly used in image analysis as well as the required mathematical foundations are shown.

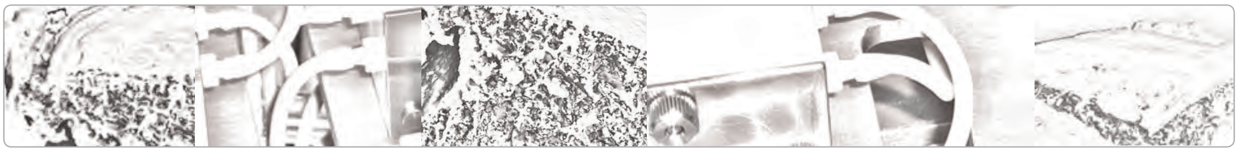
In the continuative lecture entitled Medical Image Analysis higher level algorithms are explained that are mainly specifically trailered towards the medical application. For example a nice mathematical framework is presented to seamlessly include anatomical knowledge into many different algorithms such as for the delineation of organ boundaries or the prediction of breathing organ motion.

In the last mandatory course the foundations of computer assisted surgeries such as the optical tracking system and their calibration is explained.

In the elective part students can specialise in various subtopics such as computer graphics, simulation using FE models, pattern recognition and machine learning.



Using our mathematical models we predict the exact position of organs, e.g. the lung, for improved targeting in tumor therapy.



Major Modules

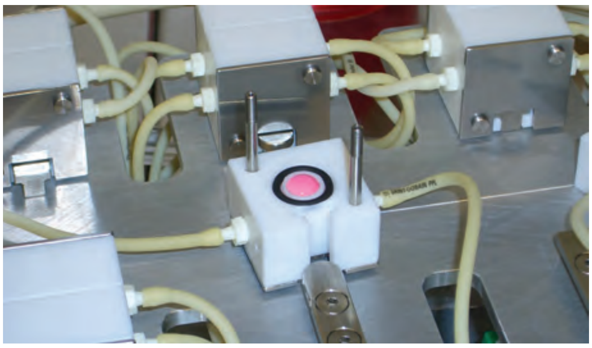
Musculoskeletal System

S. J. Ferguson

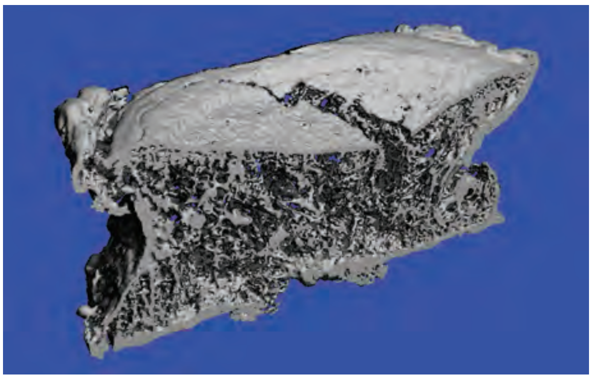
The musculoskeletal system is the structural basis for human locomotion and, as such, the health of this system has a profound influence on our quality of life. Injuries and pathologies of the musculoskeletal system are the most costly ailments facing our society, both in terms of direct medical costs and the ensuing compensation payments related to loss-of-work. In this module, students will gain a comprehensive understanding of the multi-scale characteristics and response of the musculoskeletal system, combining knowledge at the body, organ, tissue and cell level. They will learn to apply engineering, medical and biological theory and methods to the solution of complex biomechanical and mechanobiological problems. Students will learn to draw logical connections between musculoskeletal tissue composition and mechanical response, and vice versa. Students will gain the required expertise to apply their knowledge in relevant, practice-oriented problem solving in the fields of e.g. rehabilitation, sports science and orthopaedics.

The mandatory courses in this module provide the student with fundamental knowledge of functional anatomy, kinematics and kinetics, tissue biomechanics and tissue engineering. This provides a comprehensive understanding of the functional adaptation of the musculoskeletal system to the demands of daily living, and the potential for its repair and regeneration. This major module demands a fundamental knowledge of mechanics, numerical methods and related engineering sciences, as many of the mandatory and elective courses build upon this foundation. However, students with a background in the medical and natural sciences or computer science have also demonstrated their ability to quickly adapt and consolidate this information, which is complemented by their own unique background knowledge. Elective courses allow the students to extend their competence in a chosen direction, gaining knowledge in analytical methodology, medical device design, rehabilitation and orthopaedics or biological sciences. Furthermore, the elective courses provide the practical application of core knowledge to problems related to regenerative medicine. Knowledge gained during the coursework highlights the multidisciplinary nature of this study focus area, encompassing the cell to body, the idea to application and the lab bench top to the hospital bedside. This knowledge is applied during the final thesis project, a project often with a direct link to a final therapeutic application.

Examples of past thesis projects include the development of radiographic imaging methods for measuring three-dimensional bone kinematics, the evaluation of novel biomaterials for the reinforcement of fragile osteoporotic bone and the study of the link between mechanical loading and tissue metabolism. Career prospects are numerous. Many students proceed to further post-graduate education and research, pursuing doctoral research in the fields of biomechanics, tissue engineering, biomaterials development, or in cross-over disciplines such as systems biology. Most of the major companies in the fields of orthopaedics, rehabilitation engineering and pharmaceuticals are strongly represented within the Swiss Medical Technology industry and continue to experience strong growth, therefore driving a demand for graduates of this major module. At the interface between biomedical sciences and clinical applications, graduates may also pursue careers related to the evaluation and validation of modern health technology.



Perfusion chamber for the culture of intervertebral disc cells enhances tissue growth through increased solute transport.



MicroCT image of an osteoporotic vertebra highlights the mechanics of fragility fractures.

Faculty

The Biomedical Engineering Program at the University of Bern draws on the expertise of over 60 lecturers, with an unprecedented breadth and depth of knowledge. Lecturers are faculty members of the University of Bern, Bern University of Applied Sciences and University of Basel, or bring their expertise from the medical technology industry. Faculty members cover all aspects of Biomedical Engineering, from the cell to the whole body, from basic science to medical product development. A strength of the BME program is the high level of interaction between the faculty members, promoting an interdisciplinary and constantly evolving study program. To foster this interaction, faculty members met in January 2010 for an Apéro at the Institute for History of Medicine at the University of Bern. As the main focus of the BME program is on building bridges and establishing connections between different disciplines and expertises, namely biology, engineering, and clinical practice, with the aim to develop novel therapies and treatments, a study of how treatments have evolved over time was a perfect topic to explore. Professor Urs Boschung, the Director of the Institute, guided the faculty first through the library, with its unique collection of hand-written scripts and ancient manuscripts and the collection of ancient herbal preparations. The ensuing lecture took the faculty through the history of medicine in Switzerland, with an emphasis on the rapid, yet often unscientific development of „medical technology" in the Bern region. A memorable occasion, and one which will be repeated to further promote dialogue within our faculty.

Lecturers meet for the annual New Year's apéro in the Alter Hörsaal der Anatomie, University of Bern.

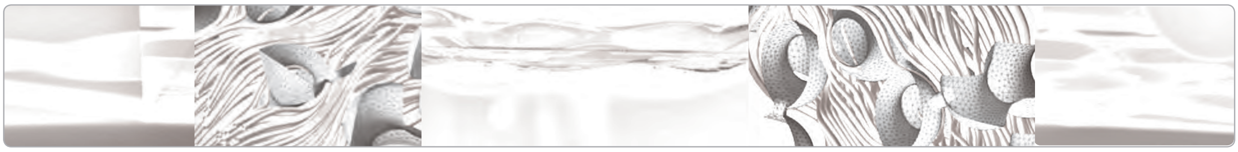
Acikgöz Ersoy Dr., Bernur
Albrecht Prof. Dr., Christiane
Altmann Dr., Martin
Andres Prof. Dr., Anne-Catherine
Baum PD Dr., Oliver
Bieri Dr., Oliver
Büchler Dr., Philippe
Bunke Prof. Dr., Horst
Burger PD Dr., Jürgen
Busato Prof. Dr., André
Cattin Prof. Dr., Philippe
Caversaccio Prof. Dr., Marco-Domenico
Czerwinska Prof. Dr.-Ing., Justyna
Daniels Prof. Dr., Dan
Debrunner Prof., Daniel
Delfosse Dr. sc. techn., Daniel
Dommann Prof. Dr., Alex
Egger PD Dr., Marcel
Erdmann, Raimund
Ferguson PD Dr., Stephen
Firouzi Prof. Dr., Elham
Frenz Prof. Dr., Martin
Gantenbein Prof. Dr., Benjamin
Geiser Kamber Prof. Dr., Marianne
Götte Prof. Dr., Josef
Hedbom Dr., Erik
Hofer Dr., Ulrich
Hofstetter Prof. Dr., Wilhelm
Hoppeler Prof. Dr., Hans-Heinrich
Hunt Prof. Dr., Kenneth
Hüsler Prof. Dr., Jürg
Ilgenstein Dr., Bernd
Jacomet Prof. Dr., Marcel
Jaeger Prof. Dr., Kurt
Jensen Prof. Dr., Björn
Jungo Dr., Markus
Keppner Prof. Dr., Herbert
Koch Prof. Dr., Volker
Kompis Prof. Dr., Martin
Kowal Prof. Dr., Jens
Kucera PD Dr., Jan
Lechmann, Beat
Lüscher Prof. Dr., Hans-Rudolf
Mack Dr., Alexander
Moser Dr., Walter
Mougiakakou Prof. Dr., Stavroula
Müller Prof. Dr., Bert
Mussard Prof., Yves

Faculty

Nesic PD Dr., Dobrila
Nef Prof. Dr., Tobias
Nevian Prof. Dr., Thomas
Niggli Prof. Dr., Ernst
Nolte Prof. Dr., Lutz-Peter
Reyes Dr., Mauricio
Schäfer PD Dr., Birgit
Schittny Prof. Dr., Johannes
Schwieger Dr., Karsten
Senn Prof. Dr., Walter Martin
Stahel Prof. Dr., Andreas
Sterchi Prof. Dr., Erwin
Stieger Prof. Dr., Christof
Stoyanov Dr., Jivko
Streit Prof. Dr., Jürg
Tschanz Dr., Stefan
Vandenberghe Prof. Dr., Stijn
Vetter Prof. Dr., Thomas
Vogel Prof. Dr., Rolf
Weber Prof. Dr.-Ing., Stefan
Zeilhofer, Prof. Dr. Dr., Hans-Florian
Zheng PD Dr., Guoyan
Zwicker Prof. Dr., Matthias

List of Courses

Biological Principles of Human Medicine
Biomedical Acoustics
Biomedical Instrumentation
Biomedical Laser Applications
Biomedical Signal Processing and Analysis
Cardiovascular Medicine and Engineering
Cardiovascular Signal Analysis and Modeling
Computer Assisted Surgery
Computer Graphics
Design of Biomechanical Systems
Electrical Engineering
Engineering Design
Engineering Mechanics I
Engineering Mechanics II
Finite Element Analysis I
Finite Element Analysis II
Functional Anatomy and Histology
Functional Anatomy of the Locomotor Apparatus
Health Technology Assessment
Intelligent Implants and Surgical Instruments
Introduction to Medical Statistics
Introduction to Signal and Image Processing
Machine Learning for Vision Applications
Management
Materials and Technologies in Dentistry
Materials Science and Biomaterials
Medical Image Analysis
Medical Robotics
Medical Terminology
Microelectronics
Microsystems Engineering
Molecular Biology
Numerical Methods
Osteology
Pattern Recognition I
Pattern Recognition II
Physiology
Practical Course in Tissue Engineering
Principles of Medical Imaging
Programming of Microcontrollers
Regulatory Affairs and Patents
Rehabilitation Technology
Reliability of MEMS for Medical Applications
Spine Biomechanics
Technology and Diabetes Management
Tissue Biomechanics
Tissue Engineering



New Courses

Fluid Dynamics

J. Czerwinska

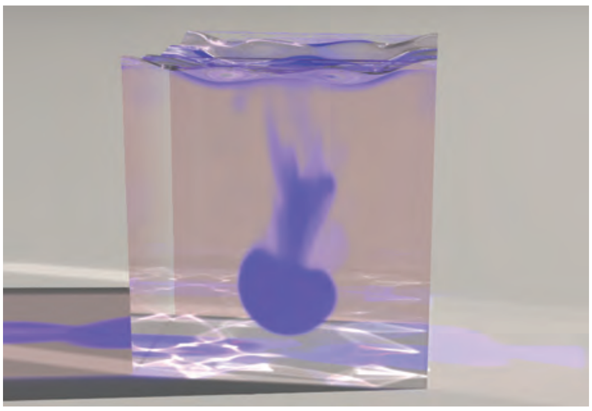
Fluid Dynamics is a field describing properties of fluids in motion. Most of the matter in the universe and in everyday living environment is in the fluid state. Basic laws of fluid motion remain the same regardless of the dimension scale.
Fluids in motion are particularly relevant for many aspects of biomedical engineering. Clear applications are in the cardiovascular field, drug delivery, or the lubrication of prosthetic joints. However, micro-scale fluid motion also governs the deformation of the tissues of the musculoskeletal system and has a profound effect on even cell metabolism.

For the relevant scale estimation non-dimensional parameters are used, such as Reynolds number relating viscous and inertia effects, or Mach number correlating speed of sound with the local velocity of the fluid.

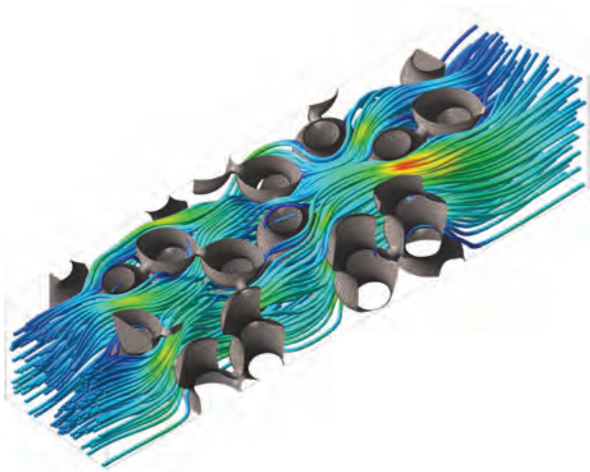
The basic equations of fluid dynamics, the Navier-Stokes equations, are non-linear second order partial differential equations with time and space dependency.

There are very few analytical solutions of these equations and the numerical approach is a very challenging task as well. Therefore, many simplified approaches are developed to describe specific fluids, such as inviscous or viscous assumption, equations for the jump on the shock wave, vortex dynamics, turbulence models etc.

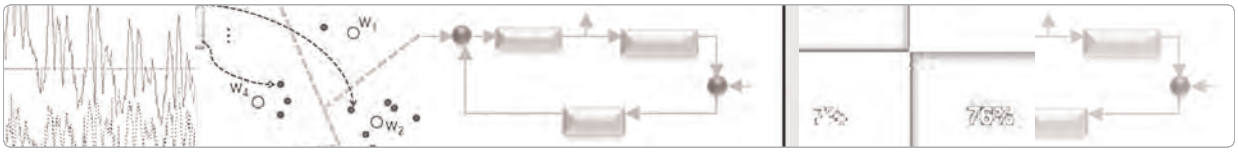
This course gives a short introduction to the many basic models of fluids motion.



Fluid flows at the micro- and macro-scale are governed by a unified set of governing equations.



Pore-scale computer simulations of biomaterial flow through trabecaular bone (R. Widmer).



New Courses

Technology and Diabetes Management

S. Mougiakakou

Diabetes mellitus is a chronic metabolic disease resulting from insufficient secretion or action of insulin. Diabetes mellitus patients are mainly classified into Type 1, which are characterized by an absence of insulin secretion due to destruction of the ß-cells of pancreas, Type 2, which are characterized by reduced action of insulin, and gestational diabetes, which is usually diagnosed during pregnancy.

The absent or reduced action of insulin results in short-term complications (hypoglycaemia, hyperglycaemia) and long-term complications (e.g. neuropathies, nephropathy, retinopathy, heart and stroke). Intensive glycaemic control has been shown to reduce short- and long-term complications.

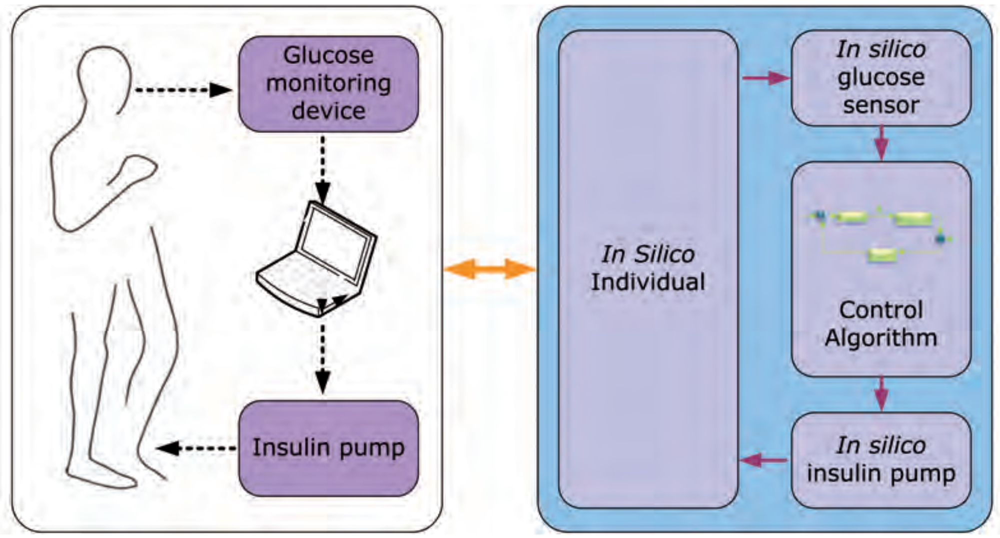
Intensive glycaemic control refers to (1) regular self-monitoring of glucose levels, and (2) insulin therapy. The appropriate insulin dose has to be carefully adjusted, since blood glucose profile is rapidly and non predictably changing due to its dependence not only on the internal mechanism of glucose-insulin metabolism, but also on a great number of life style factors.

The scope of the course is therefore to introduce students to i) basics of physiology, etiology and treatment of diabetes mellitus, and ii) latest scientific and technological achievements in order to enhance the quality of life and independence of people with diabetes mellitus and reduce the risk for life-threatening complications.

Emphasis is given on technologies used for:

- Novel glucose monitoring systems
- Insulin delivery devices
- Modeling and simulation of glucose metabolism
- Design and development of control algorithms to be used by an artificial pancreas
- eHealth solutions for comprehensive diabetes management
- Advanced analysis of diabetes data and provision of personalized treatment

The course is comprised of a series of lecturers given by the instructors and invited speakers from the industry, together with a series of laboratory exercises in topics related to modeling and control of the glucose regulatory system.



External artificial pancreas and evaluation in an in-silico environment.

Rehabilitation Technology

T. Nef, K. Hunt
Rehabilitation engineering is the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply and distribute technological solutions to problems faced by individuals with disabilities. This covers functional areas such as mobility, communications, hearing, vision and cognition, and activities associated with employment, independent living, education and integration into the community.

In this lecture series, we will focus on the human sensory-motor system and technologies to rehabilitate individuals with neurological impairment.

Prof. Hunt is a recognized expert in the field of Functional Electrical Stimulation and Cardiopulmonary Rehabilitation. Prof. Nef is internationally known for being the inventor of the robotic arm therapy system ARMin. Both researchers are very active in the field of Rehabilitation Technology and students profit from state-of-the-art information.

Case-studies of successful rehabilitation systems will be presented and discussed. After completion of this class, students will be able to critically analyze rehabilitation systems and their application in the clinics.

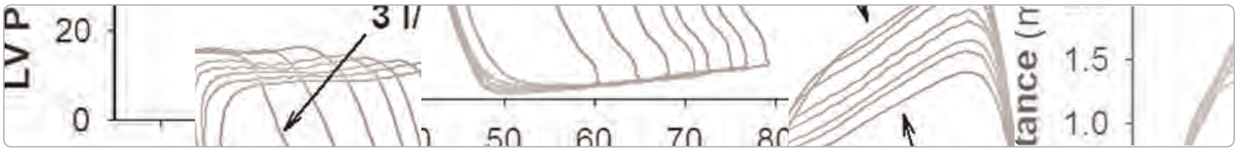
Half of the lectures are dedicated to make the students familiar with background knowledge necessary to understand the application of new technology in rehabilitation. Thus, the human sensory-motor system and different motor pathologies will be introduced.

Multimodal sensors and actuators that are used in rehabilitation systems are presented and discussed in class. The basic classes are followed by case-studies of robotic gait therapy, robotic arm therapy, and functional electrical stimulation.

The link to current research is made in the focus lectures Cardiopulmonary Rehabilitation (Prof. Hunt) and Assistive Technology in Dementia Care (Prof. Nef).

Case-study of a technical device to measure wrist rigor (University of Berne & Lutz Medical Engineering GmbH).

Case-study of the robotic arm therapy system ARMin (T. Nef, M. Guidali, R. Riener, Applied Bionics and Biomechanics, 2009).



New Courses

Cardiovascular Signal Analysis and Modeling

S. Vandenberghe

The cardiovascular system is a complex entity that is regulated by many factors: chemical, biological, and mechanical. To have a better understanding of the interactions between these factors, a thorough analysis is necessary of all possible data that can be collected. In the "Cardiovascular Signal Analysis and Modeling" course, the focus is on the mechanical behavior and hemodynamics of the cardiovascular system.

Topics included basic anatomy and physiology of heart and vessels. Important parameters are stressed and methods to measure them are discussed and at the end of the course demonstrated in the lab. Also calibration methods and frequent errors in performing measurements on the cardiovascular system are discussed.

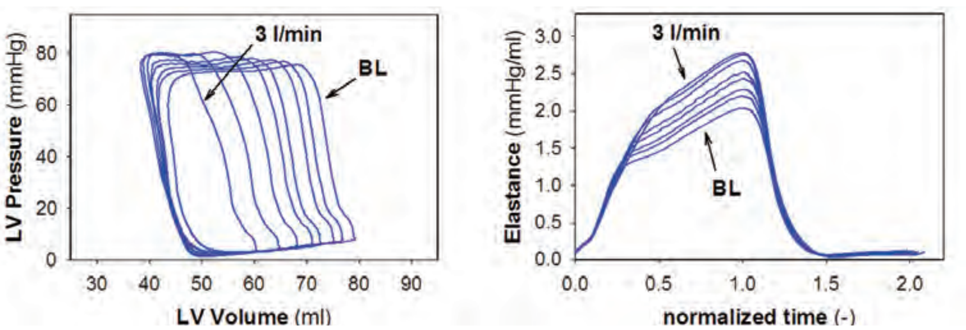
Data resulting from measurements need to be analyzed and a series of methods and indices are discussed to evaluate the performance of the heart, and properties of the blood vessels, such as compliance and resistance. The details of wave intensity analysis in coronary arteries are taught by Dr. S. DeMarchi from the cardiology department.

Another part of the course entailed modeling the cardiovascular system so the above mentioned parameters can be retrieved from simulations, either in vitro or by mathematical models that resemble electronic circuits. An overview of modeling methods at different levels of complexity is given and hands on experience with lumped parameter models is gained with real data obtained from in vivo experiments.

The hands-on experience is mostly obtained through homework, where the students are asked to process given data and perform specific calculations and construct informative graphs. Most students perform their tasks with Matlab software, but also LabView and Excel are used.

In order to learn more about the engineering side of devices that are typically used in diagnosis or treatment of cardiovascular disease, the students are asked to present and critically evaluate a patent of a medical device. In addition, diagnosis and treatment of vascular problems in the brain are demonstrated by a team of the neuroradiology department (Dr. P. Mordasini and colleagues) where students are given a sneak peek in the clinical use and possible complications of vascular devices.
Another didactic tool employed in this course is a Lab session where the pumping capacity of the left ventricle is demonstrated with an isolated rat heart. This is performed in two groups where the students themselves perform specific tasks such as flow measurement, gas analysis of perfusate, and heart rate and pressure monitoring.

These data are later processed during the take-home exam, which also includes other analysis and modeling tasks that the students can perform at home (2-3 days of work) and then present in a 30 min. oral exam session.



PV-loops and elastance curves obtained in a sheep found to vary by ramping up the flow of a rotary blood pump from baseline (BL, 0 l/min) to 3 l/min.

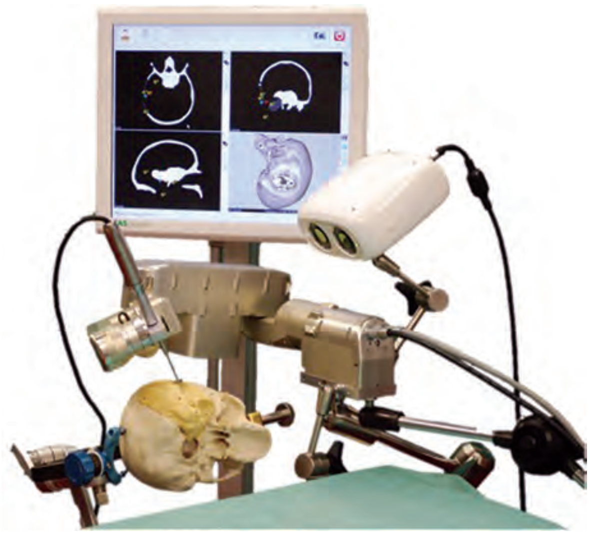
Medical Robotics

S. Weber, B. Jensen
Robotic systems play an ever-increasing role in medicine, such as in surgery and in rehabilitation. Together with the general technological development of robotics during the past decades, its application to the field of medicine has attracted both the research community and the medical technology industry.

The course Medical Robotics focuses on robotic applications specifically dedicated to medical applications, the history of this specialty and its developments within various clinical disciplines. Besides an introduction of existing application concepts such as intelligent instrument holding, tele-manipulation and automated systems, focus is also placed on related concepts such as Navigated Control. The lecture further discusses legal and regulatory implications of robotics in medicine. The course will also provide the students with fundamental knowledge on the underlying engineering and technical aspects such as control theory, robot kinematics and dynamics as well as path planning. Throughout the lecture, various examples of medical robotic systems, together with their application area, clinical impacts, benefits and drawbacks are introduced both in a theoretical manner and using practical training videos.

A more practical part of the course work is strongly linked to an ongoing surgical robotic development for application in the delicate area of hearing aid implantation. The aim of the project is the realization of a computer and robot based support for microsurgery in the area, which requires unprecedented accuracy. The project highlights the practical aspects of medical robotics developments through hands-on demos. Furthermore, during a hands-on lecture and visit of the „daVinci" system at the Inselspital in Bern, students have a chance to see and operate a real-world surgical robot system.

The course is dedicated to students with initial knowledge of complimentary technologies such as stereotactic image guidance and computer aided surgery.



Current research towards a surgical robotic system for computer assisted microsurgery hearing aid implantation is used to introduce students to development aspects of medical robotics.

BME Students visit the daVinci surgical robot system at the Inselspital Bern.

Master Theses 2010

Bernasconi Michael
Functional Clustering of EEG in Epilepsy
Dr. Christian Rummel, University of Bern

Bösch Lukas
Cardiac Virtual Biopsy by Optical Coherence Tomography
Christoph Meier, BFH-TI

Charmet Jérôme
Stabilising Self-Assembled Structures using the SOLID Process
Prof. Dr. Marcus Textor, ETH Zurich

Coigny Florian
MEMS-Based Laser Projection System for Computer Guided Surgery
Prof. Dr. Erik Schkommodau, FHNW

Graf Benjamin
SOLID-based microfluidics components
Dr. Alexandra Homsy, EPFL

Hofmann Simon
Liver Surface Marker Tracking
Dr. Matthias Peterhans, University of Bern

Jäger Michael
Spinal Muscle Volume and PCSA in the elderly population
PD Dr. Stephen Ferguson, University of Bern

Jaggi Gerhard
Bestimmung der Insulinkonzentration im subkutanen Gewebe
James Leuenberger, Roche Diagnostics

Jungo Michael
E2 corder (Esophageal ECG recorder) Anchoring System
Thomas Niederhauser, University of Bern

Klein Alycia
Creating in vitro models of blood vessels
PD Dr. Stefanos Demertzis, University of Bern

Lam Willy Huy
Development of Device to Perform Steam Penetration to Validate Sterilization Cycles
Nicolas Gehrig, Odus Technologies SA

Landtwing Helen
Dynamic Evaluation of Vascular Cannulas
Prof. Dr. Stijn Vandenberghe, University of Bern

Léchot Christophe
Intracoronary Flow Rate Probe
Prof. Dr. Rolf Vogel, University of Bern

Lindenmann Philippe
Finite Element Analysis of a prototype disc prosthesis
Jayr Bass, Synthes GmbH

Meister Dominik
Angepasste Optik für AMD Sehhilfe
Prof. Dr. Jörn Justiz, BFH-TI

Mirsaidi Ali
Differentiation of Mesenchymal Stem Cells on Elastic Matrices
Dr. Rainer Egli, University of Bern

Ortiz Franyuti Daniela
T-Cells and Substrate Rigidity: Possible roles of integrins ß1, ß2 and ß3 in T-Cell adhesion and Distal PoleComplex Formation
Prof. Dr. Viola Vogel, ETH Zurich

Ramseyer Roman
Reduction of metal artifacts caused by OR-table using C-arm tracking
Prof. Dr. Erik Schkommodau, FHNW

Rüegsegger Michael
Statistical modeling of the retina to develop new diagnostic methods using automatic image segmentationstrategies for optical coherence tomography
PD. Dr. Guoyan Zheng, University of Bern

Seif Maryam
Numerical Simulation of the Cornea Capillary Forces Caused by Tear Film Surface Tension
Dr. Philippe Büchler, University of Bern

Steiner Thomas
Comparing a Stochastic Loading Pattern to Cyclic Loading in an in vitro Testing of Rabbit flexor digitorumprofundus Tendons
Prof. Dr. Benjamin Gantenbein, University of Bern

Stirnimann Patrik
Determinants of the mechanical response of trabecular bone-cement composite
Dr. Benedikt Helgason, University of Bern

von Waldkirch Bernhard
Real-Time Eye Motion Tracker for Computer Assisted Retinal Laser Photocoagulation System
Prof. Dr. Jens Kowal, University of Bern

Weber Doris
The Effects of Tensile Strain on the Development of Mesenchymal Progenitor Cells
Prof. Dr. Beat Trueb, University of Bern

Wüthrich Adrian
Evaluation of an Ultrasonic Deflector
Dr. Philippe Büchler, University of Bern

Zurbuchen Adrian
Intracorporeal Energy Harvesting from the Beating Heart
Prof. Dr. Stijn Vandenberghe, University of Bern

Graduation Ceremony, Kultur Casino Bern

At the end of March, the Faculty of Medicine of the University Bern organized the annual diploma- and graduation ceremony for the new alumni and alumnae in the Kultur Casino Bern.

After the opening piece by the Medical Orchestra, Professor Dr. Peter Eggli, Dean of the Medical Faculty, welcomed the graduates and their families. Then, Professor Dr. Thomas Zeltner held a speech titled "The Checklist". He addressed the fresh alumni and asked them to deal with their new rights and obligations in a responsible and deliberate way.

Besides continuous education in expert knowledge, the human factor also plays a key role in daily work, he emphasized. This held especially true in the field of health care. And, therefore, the prospective doctors and scientists should investigate in these skills.

In the end, each graduate was handed his or her diploma. The biomedical engineers received them from Professor Dr.-Ing. Nolte. After the best graduates of the Medical Faculty, one of them a straight 6.0 student, were honored, the lecturer of the year was nominated: Professor Dr. med. Christian Seiler.

After about two solemn hours, the ceremony ended with a jolly apéro for all guests.

From top to bottom, left to right: P. Lindenmann, L. Bösch, P. Stirnimann, B. Graf, M. Seif, L.-P. Nolte (Program Director), T. Steiner, B. von Waldkirch.

Biomedical Engineering Day 2010

At the BME Day, the Biomedical Engineering community of the University of Bern opens its doors to university members, professionals, and students. This year's participants included Biomedical Engineering faculty and students (both graduate and undergraduate), other students from the University community, corporate members, and various guest speakers from within the profession.

The BME Day aims at offering networking opportunities and allowing undergraduates and graduates to explore career options in the field.

The Second Annual Biomedical Engineering Day took place on Friday, June 4, 2010 in the Auditorium Rossi at the University Hospital (Inselspital) in Bern. The BME Day kicked off with a welcome note by Prof. Dr. Lutz Nolte.

Thierry Carrel: Director Clinic of Cardiovascular Surgery, University Hospital, Bern

Eleven companies from Germany and Switzerland presented themselves to an audience of approximately 230 participants. The coffee and the lunch breaks offered the opportunity to visit the posters and medical company booths displaying their products ranging from diagnostic instruments to medical implants.

Fifteen biomedical engineering undergraduates and graduates presented posters focusing on the research they had conducted during their master thesis and doctoral work. In addition, the ARTORG research groups impressed the event's visitors with demonstrations from the fields of artificial hearing aids, computer-aided surgery, diabetes technology, gerontology and rehabilitation, and ophthalmic technology. Faculty members judged the posters to choose the Co-Me poster award winner.

The Keynote lecture 'Polymers in cardiovascular surgery' by Prof. Dr. med. Thierry Carrel from the University Hospital Bern was the highlight of the day. In his stimulating lecture he gave a comprehensive overview of the great challenges for biomedical engineering in cardiovascular surgery and the application of plastics in the cardiovascular sector.

The much awaited Medical Cluster Award ceremony was moderated by Dr. Stephen J. Ferguson. Andreas Wüthrich was granted the award for the best master thesis „Osteointegration of Model Implants with Anti-bacterial Surfaces" and Dr. Flurin Pfiffner for the best Ph.D. thesis „Optimizing the Benefit of Bone Anchored Hearing Aids". Dr. Rubino Mordasini, President of the Medical Cluster, presented the awards to the winners.

The Co-Me Poster Award was given to V. Oliva, B. Bell, S. Stankowsky, M. Caversaccio, C. Stieger, S. Weber in recognition of the outstanding poster presentation „Advanced Surgical Instrumentation for ORL and CMF Applications".

The BME Day Lottery prize – an iPad sponsored by Ypsomed AG, was given to a lucky master student. The day closed with a well deserved apéro followed by the BME club's annual general assembly.

Andreas Wüthrich, Medical Cluster Award winner 2010, Master thesis „Osteointegration of Model Implants with Anti-bacterial Coatings". A. Wüthrich receives the Medical Cluster Award from S. J. Ferguson (ISTB, University of Bern) and R. Mordasini (President of the Medical Cluster).

Flurin Pfiffner, Medical Cluster Award winner 2010, PhD thesis „Optimizing the Benefit of Bone-Anchored Hearing Aids".

Vidina Oliva Rodriguez receives the CO-ME Poster Award for „Advanced Surgical Instrumentation for ORL and CMF Applications".

The Biomedical Engineering Club

The BME Club and Its Mission

The BME Club is an alumni club whose mandate is to promote networking among the biomedical engineers. The BME Club of the University of Bern connects you to a growing network of biomedical engineers, scientists, past and present students and medical technology corporate with a desire to bring together engineering principles, biology, and clinical medicine. This is accomplished by hosting events such as information sessions on the latest cutting-edge research in the fields of biomedical engineering; attending international conferences in related areas; and touring various industrial plants, hospitals, and laboratories. The club is run by an executive committee following the dictates of our constitution, and is recognized as an official alumni association of the University of Bern under the umbrella organization – Alumni UniBe.

We are an enthusiastic and versatile group with diverse activities:

- bi-monthly meetings in a local restaurant to network, brainstorm or simply socialize (“Stammtisch”)
- visits to medical and engineering companies
- providing information on career opportunities
- annual welcome event for “New Students”
- annual BME day (co-organized with Master Study Coordination)
- annual lecturers’ event (collaboration with Master Study Coordination)
- bi-annual BME Newsletter
- access to the Medical Cluster events
- joint membership with SSBE (Swiss Society for Biomedical Engineering)
- providing updated list of MedTech events

In short, the BME club represents a unique platform for professional lifelong communication and networking.

Executive Committee for 2009-2011

President: Prabitha Urwyler
Vice President: Sébastien Barré
Secretary: Julia Spyra
Treasurer: Christian Güder
Webmaster: Frank Langlotz
Faculty Representative: Dobrila Nesic
Master Students Representative: Rosablanca Paez
Alumni Representative: Lukas Bosch
PhD Students Representative: Christoph Reutlinger
Industry & Job Market Manager: Rudolf Sidler
Auditor: Lutz Nolte
Auditor: Patrick Roth

History Behind the Motivation and Vision for the BME Club

The idea for the BME Club arose in Spring 2009 at a discussion on keeping tuned to the whereabouts of the former students. Research had started on tracking the old master students, PhD students, postdocs. We realized that only an organization could muscle enough persuasion - and so the BME Club was born. The BME Club quickly took off. The official inaugural meeting of the BME Club took place on 12th August 2009 at the Restaurant Beaulieu in Bern. An interim executive board represented the club until the first general assembly in 2010. During our first year, there were quiet some activities and membership was less than 100 people. We initiated the concept of the Stammtisch in order to network with the broad spectrum of members. Having the backbone of an organization, we were able to bring in great events. For further details look up our website for an acitivity report of the first year at http://www.bme-club.ch. The size of the club allowed us to join hands with the Master Study Coordination for annual events such as the Biomedical Engineering Day (BME Day), and the lecturers’ event. The momentum ball just kept on rolling. We formed alliances with the Swiss Society of Biomedical Engineering (SSBE) offering joint memberships to our regular members. Another feather in our cap is our friendly tie-up with the Medical Cluster Bern which opened up opportunities for our members to the Medical cluster events like the “Morning talk”. Thus we were able to extend our events and activities in addition to our membership base.

How to Join

Becoming a member is easy! Simply sign up at any BME Club event or visit us at http://www.bmeclub.ch. By signing up you will be regularly informed of BME events happening across Switzerland held by organizations other than the BME Club as well. On sign up, you can also indicate your wish to have a joint membership with the SSBE. BME alumni who join us will automatically become a member of Alumni UniBe, the alumni association of the University of Bern. Among other benefits this includes receiving a lifelong UniBe email address.

BME Excursion to MEDICA

The Biomedical Engineering Program offers not only a traditional lecture environment, but also places an emphasis on practical learning opportunities. These include not only the laboratories, project work and related assignments, but also learning experiences outside the walls of the university.

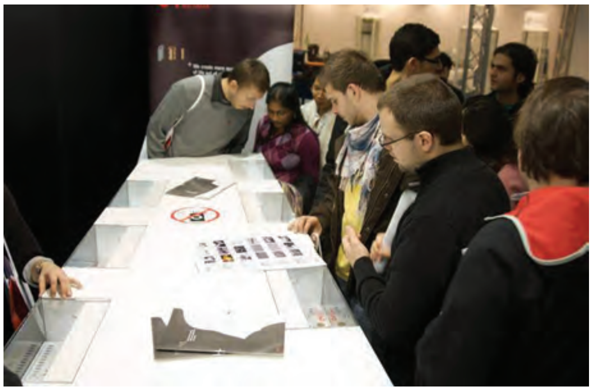
In 2010, for the first time, the BME Club organized a field trip for current students and BME alumni to the MEDICA World Forum for Medicine in Düsseldorf. The MEDICA Forum, and the parallel COMPAMED trade show, is an annual event, attracting over 130'000 visitors and more than 4'000 exhibitors presenting everything from medical technology prototypes to manufacturing methods to an audience of healthcare professionals, biomedical engineers, scientists and patients.

The interests of the students were particularly well covered by the exhibits, with technology on display with a direct relevance for each of the master program major modules.

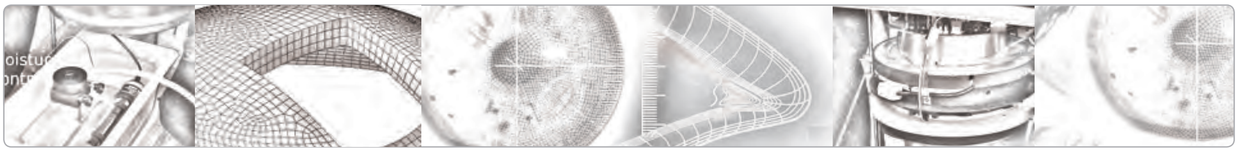
For the Image Guided Therapy students, the latest methods and equipment for medical imaging and analysis, surgical navigation and virtual surgery simulation were on display.

The orthopaedic and rehabilitation technology industries presented fitness and physiotherapy equipment, biomaterials, implants and instruments to students of the Musculoskeletal System.

Electronic Implants were well represented by state-of-the-art sensors and devices for diagnosis and treatment of e.g. diabetes or cardiac ailments.



Although it was only a short visit to such an extensive exhibition, the students were left with the lasting impression of many companies succeeding on the foundation of innovation, research and technical development. The visit to MEDICA also provided an important overview of the many opportunities awaiting the graduates of the Biomedical Engineering Program.



Graduate Profile

Harald Studer, M.Sc.

The Biomedical Engineering program at the University of Bern is growing from year to year. We take the opportunity in this year's Annual Report to catch up with a graduate of the first class of our program, Harald Studer, to gain some insight into his motivation to pursue the BME program, and where his studies have taken him since.

BME: What was your academic and professional background prior to your BME studies?

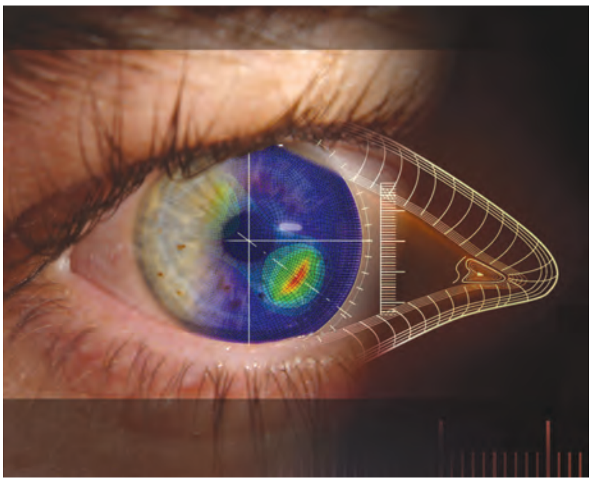
HS: I initially completed a four-year apprenticeship as a metal constructions designer in the structural steelwork industry. This was followed by a one-year university entrance diploma study, with a focus on technical courses, to gain admission to the FH Biel. At the FH, I studied six semesters of computer science, with a one-year leave after the fourth semester. During this internship, I developed software for a small company in the „Silicon Valley" in California. After completing my degree, I started as a scientific co-worker at the image-processing lab of Roger Cattin at the FH Biel, which, through an industry project in the field of ophthalmologic medical technology, lead to a new position at ISS AG - Integrated Scientific Services (by Ziemer Ophthalmology, Port, Switzerland).

BME: Why did you choose to pursue your Master's studies at the University of Bern?

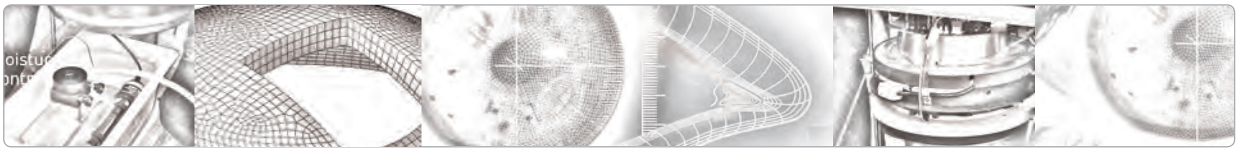
HS: The above mentioned industry project was in the field of medical technology. The goal was to develop image-processing algorithms to detect the cornea and the crystalline lens in „Scheimpflug" images. At that time, the first announcement was made for the Biomedical Engineering Master Program in Bern. I have always been convinced that certain goals can only be reached with a qualified education and I was very keen to enter the medical technology field. My decision for the MSc in Bern was based on the interesting details in that first announcement, the acceptance of the FH degree as a pre-requisite, and the excellent timing.
My chosen focus area, the Musculoskeletal System, was clear from the beginning. I wanted to attend the human anatomy course and also extend my own knowledge beyond programming and software development.

BME: You continued to work during your studies. How was this experience?

HS: When I accepted the offer at ISS AG in Port, being able to work part-time and thus follow the MSc was a major precondition. I worked for 60% during the first three semesters and 40% during my master thesis. My job was developing software for a device that optically measures the anterior section of the human eye. Maintaining a good work/life balance was a challenge with the heavy load, but in the end I was convinced that finishing all courses in three semesters was the right choice for me. Having a flexible employer was of key importance.

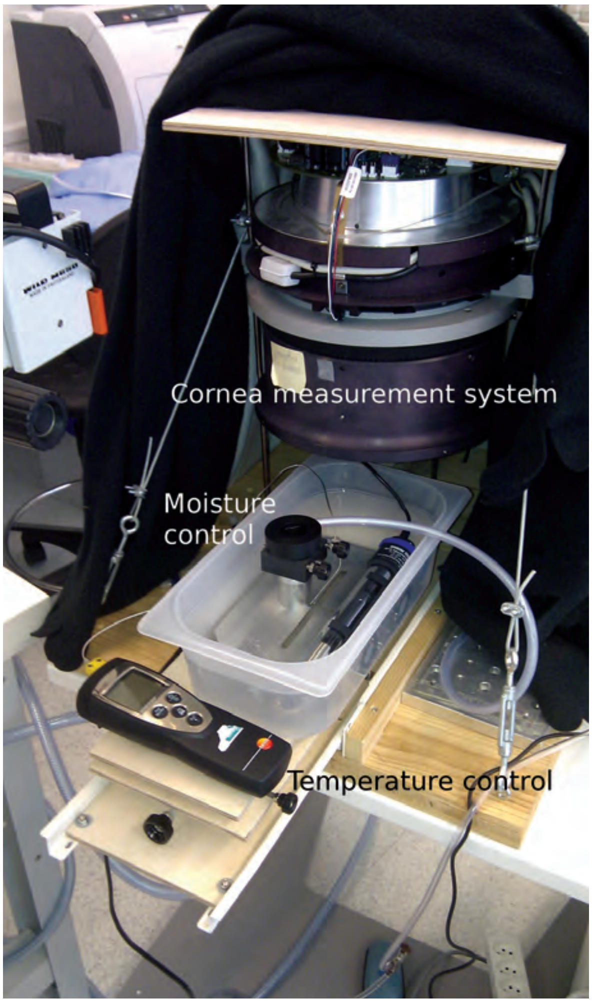


Numerical simulation allows the prediction of the patient-specific outcome of corneal surgery.



BME: What are you doing now and how is this related to biomedical engineering?

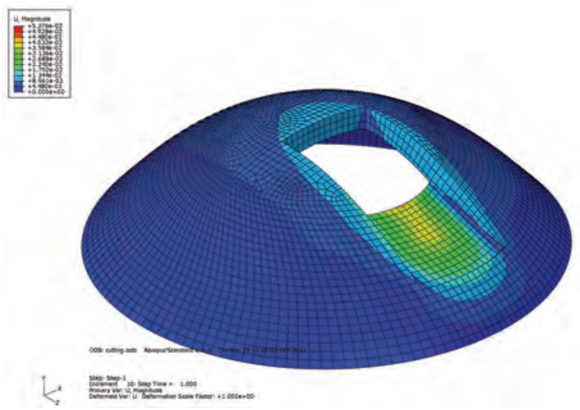
HS: After my master thesis defense, I started as a full-time PhD candidate in the Computational Bioengineering group of Dr. Philippe Büchler at the Institute for Surgical Technology and Biomechanics, University of Bern. I am working on numerical models of the biomechanical behavior of the human cornea. The goal is to predict the patient specific outcome for different surgical procedures, such as LASIK, or cataract surgery. I am planning to submit my thesis by the end of this year. After specifying my project, I realized that I have now headed down a very specialized path.
During my MSc studies, I attended many course with a particular relevance for my current work, such as Tissue Biomechanics, Finite Element Analysis and also the basic courses in Mechanics. Furthermore, courses like Cell Biology and Physiology help me to understand the metabolic processes in my target tissue, the cornea. The design of the MSc program put me in contact with journal papers, scientific writing, and the whole academic world, with its many unique aspects compared to industry.



The experimental setup for some pre- and post interventional measurements with cadaver corneas includes temperature- and moisture control for the tissue as well as the actual cornea measurement system.

BME: What is your career plan after completing your PhD?

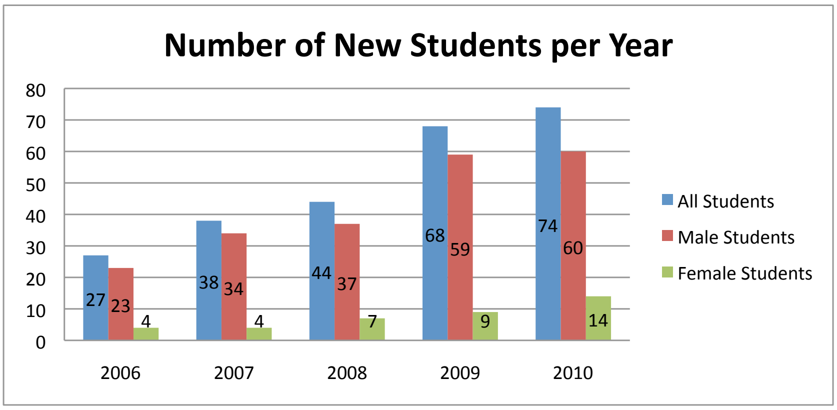
HS: I am torn between the academic and industrial world. They both have their pros and cons. Currently, the more likely choice is to go back to industry, where I will most likely be able to follow up on my current project, translating it to practice.

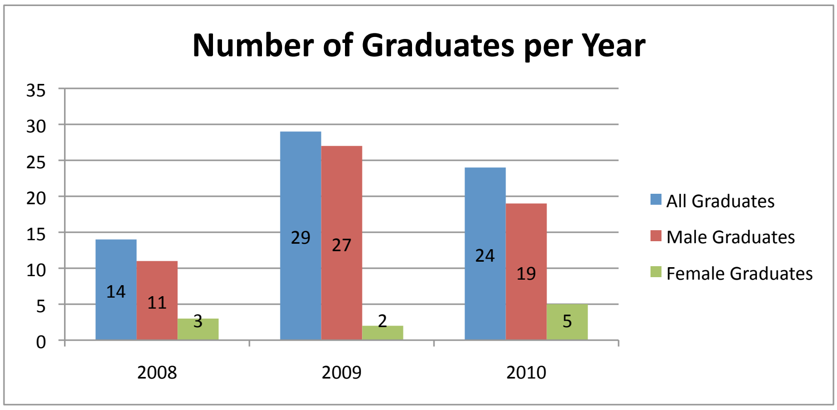


Finite element simulation of cataract surgical intervention. Some elements are removed to unveil the planar cut interface of the cataract tunnel incision done by the surgeon.

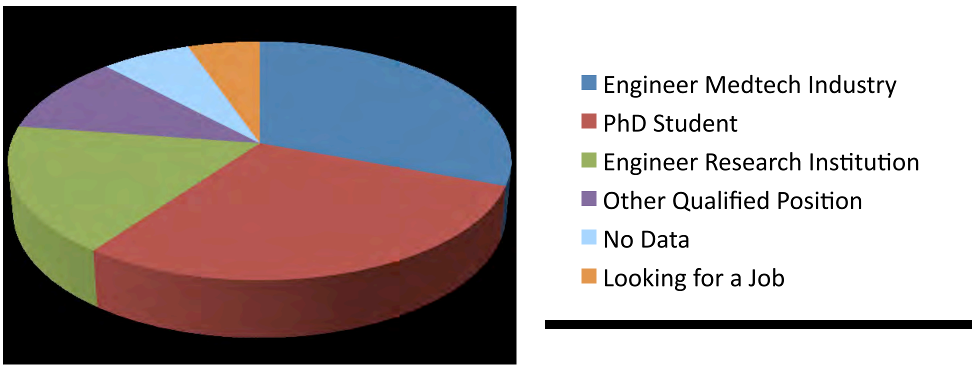
Statistics

Number of students per year





BME Alumni: Career Directions
Profession after Graduation



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