



UNIVERSITÄT BERN

Master Biomedical Engineering

Annual Report 2015



MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

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Introduction

For the first time this year, all mandatory courses of our BME master's program were taught in English: this represents the ultimate stage towards internationality and I would like to acknowledge the Director of the Institute of Anatomy, Prof. Valentin Djonov, and the Dean of the Medical Faculty, Prof. Peter Eggli, who supported this process throughout the past years.

Internationality becomes an important hallmark of our curriculum and may well attract further students from other regions of the world. In this spirit, our program organized a trip to MEDICA, the world forum for medicine in Düsseldorf to give an opportunity to our students to discover the latest trends of the medical industry and network across borders.

In a more regional context, the Biomedical Engineering Day 2015 held again all its promises with almost 300 participants, 10 companies and 3 research institutes reunited around a live cataract surgery, a keynote lecture, several company presentations and numerous awards. I would like to take the opportunity to thank here our faithful partners who supported us over the years as well as Mrs Julia Spyra for her efficient and friendly coordination of this rather unique event.

In the coming years, our Medical Faculty will face some major challenges with the expectations of 100 additional

medical students and the potential emergence of a Center for Translational Medicine and Entrepreneurship (SITEM) with planned chairs in additive manufacturing in medicine as well as in translational medicine. These initiatives will make the environment of our master's program even more attractive.

Finally, I would like to express my appreciation to the teachers of the program, who deliver week after week the core of our added value, knowledge, skills and enthusiasm in biomedical engineering. I wish also to emphasize the essential contribution of the study coordination, Mrs Ulla Jakob and Alexandra Neuenschwander in maintaining a high level of service to both students and lecturers. I am very glad to present our achievements in this report and hope you will enjoy it.

Philippe Zysset Program Director



Organization

Management



Ph. Zysset Program Director



V. M. Koch Deputy Program Director

Administration



U. Jakob-Burger Study Coordinator



A. Neuenschwander Salazar Study Coordinator



J. Spyra Study Coordinator



M. Reyes Master Thesis Coordinator

Structure of Courses in the Master's Program

The Curriculum

Since the start of the Master's Program 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 that 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 Fall Semester 2009, all courses were grouped in a strictly modular way in order to enhance the clarity and reduce the complexity of the curricular structure. A main idea was to guide the students through their studies in a better way by adding an elective part to the major modules, which formerly had consisted exclusively of mandatory courses. Besides, the curriculum was expanded by a number of new specialized courses as well as an additional major module called "Image-Guided Therapy".

Adaptations in the legal framework of the master's program are now offering more flexibility in the design of courses and modules, thus providing the basis for a second fundamental restructuration of the curriculum as of Fall Semester 2013. In particular, a new module called "Complementary Skills" is replacing the former module "Unrestricted Electives". In addition, the list of mandatory courses in both basic and major modules was revised.

Duration of Studies and Part-Time Professional Occupation

The full-time study program 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. When a student decides to complete the studies in parallel to a part-time professional occupation, further extension is possible on request. To support regular part-time work, mandatory courses take place (with rare exceptions) on only 3 days per week.

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 Human Medicine, Applied Mathematics, and Biomedical Engineering. 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 for approximately 30%.

Major Modules

The choice of one of three major modules Biomechanical Systems, Electronic Implants, or Image-Guided Therapy after the first semester constitutes the first opportunity for specialization. The former major module "Musculoskeletal System" has been adapted and renamed "Biomechanical Systems".

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 every course from the list of courses in the master's program, giving rise to a high degree of diversity and flexibility and allowing for numerous 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 "Complementary Skills"

Apart from the rapid development of technology itself, today's biomedical engineers are increasingly challenged by complementary issues like ethical aspects, project planning, quality assurance and product safety, legal regulations and intellectual property rights, as well as marketing aspects. Language competence in English is of paramount importance both in an industrial and academic environment. This situation has been accounted for by the introduction of a new module called "Complementary Skills" where students are required to complete two mandatory courses (Innovation Management; Regulatory Affairs and Patents) as well as 2 ECTS from the electives courses (Ethics in Biomedical Engineering; Scientific Writing in Biomedical Engineering; Introduction to Epidemiology and Health Technology Assessment). If a student selects more than 2 ECTS from the elective part, the additional points can be credited in the student's major module.

Master's Thesis

The last semester is dedicated to a master's thesis project on an individually suited topic in an academic research group at the University of Bern or the Bern University of Applied Sciences or, for particular cases, in an industrial research and development 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's thesis includes the thesis paper, a thesis presentation and defense as well as a one-page abstract for publication in the Annual Report of the master's program.



List of Courses

- Applied Biomaterials
- Basics of Applied Molecular Biology
- Basics in Physiology for Biomedical Engineering
- Biological Principles of Human Medicine
- Biomaterials
- Biomedical Sensors
- Biomedical Acoustics
- Biomedical Instrumentation
- Biomedical Laser Applications
- Biomedical Signal Processing and Analysis
- BioMicrofluidics
- C++ Programming I
- C++ Programming II
- Cardiovascular Technology
- Clinical Applications of Image-Guided Therapy
- Computer Assisted Surgery
- Computer Graphics
- Computer Vision
- Continuum Mechanics
- Cutting Edge Microscopy
- Design of Biomechanical Systems
- Engineering Mechanics
- Ethics in Biomedical Engineering
- Finite Element Analysis I
- Finite Element Analysis II
- Fluid Mechanics
- Functional Anatomy of the Locomotor Apparatus
- Image-Guided Therapy Lab
- Innovation Management
- Intelligent Implants and Surgical Instruments

- Introduction to Clinical Epidemiology and Health Technology Assessment
- Introduction to Digital Logic
- Introduction to Medical Statistics
- Introduction to Signal and Image Processing
- Introductory Anatomy and Histology for Biomedical Engineers
- Low Power Microelectronics
- Machine Learning
- Measurement Technologies in Biomechanics
- Medical Image Analysis
- Medical Image Analysis Lab
- Medical Robotics
- Microsystems Engineering
- Modeling and Simulation
- Molecular and Cellular Biology Practical
- Numerical Methods
- Ophthalmic Technologies
- Osteology
- Principles of Medical Imaging
- Programming of Microcontrollers
- Regenerative Dentistry for Biomedical Engineering
- Regulatory Affairs and Patents
- Rehabilitation Technology
- Scientific Writing in Biomedical Engineering
- Technology and Diabetes Management
- Tissue Biomechanics
- Tissue Biomechanics Lab
- Tissue Engineering
- Tissue Engineering Practical Course
- Wireless Communication for Medical Devices

Major Modules

Biomechanical Systems



Prof. Dr. Philippe Zysset

The cardiovascular and musculoskeletal systems are the transport and structural bases for our physical activities and their health have a profound influence on our quality of life. Cardiovascular diseases, musculoskeletal injuries and pathologies are the most costly ailments facing our health care systems, both in terms of direct medical costs and compensation payments related to loss-of-work.

In this module, students will gain a comprehensive understanding of the multi-scale organisation of the cardiovascular and musculoskeletal systems, combining knowledge from the cell, tissue, organ to the body level. They will learn how to apply engineering, biological and medical theory and methods to resolve complex problems in biomechanics and mechano-biology. Students will learn to draw connections between tissue morphology and mechanical response, and vice versa. Students will also gain the required expertise to apply their knowledge in relevant, practice-oriented problem solving in the fields of cardiology, vessel surgery, orthopaedics, dentistry, rehabilitation and sports sciences.

The mandatory courses in this module provide the student with fundamental knowledge of fluid and solid mechanics, tissue engineering, tissue biomechanics and finite element analysis. This provides an overview of the functional adaptation of the cardiovascular or musculoskeletal system to the demands of daily living, and the necessary conditions for its repair and regeneration. This major module requires a prior knowledge of mechanics, numerical methods and related engineering sciences, as many of the mandatory and elective courses build upon these foundations. Elective courses allow the students to extend their competence in a chosen direction, gaining knowledge in analytical methodologies, medical device design, minimally invasive surgery or rehabilitation.

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 link to a final diagnostic or therapeutic application. Examples of recent master thesis projects include the design of a portal to regulate venous flow during liver surgery, the intra-operative prediction of dental implant stability or the investigation of the potential of specific biomolecules for cartilage repair.

Career prospects are numerous. Many students proceed to further post-graduate education and research, pursuing doctoral research in the fields of biomechanics, tissue engineering or development of biomaterials. Most of the major companies in the fields of cardiovascular engineering, orthopaedics, dentistry, rehabilitation engineering and pharmaceuticals are strongly represented within the Swiss Medical Technology industry and, despite the strong Swiss franc, have an ongoing demand for graduates of this major module. At the interface between biomedical engineering and clinical applications, graduates may also pursue careers related to the evaluation and validation of contemporary health technology, a cornerstone for future policies on the adoption of these new methods in the highly competitive health care domain.



Finite element models of a proximal femur (left) and a vertebral body (right) with the applied boundary conditions for prediction of fracture risk. BV/TV is the bone volume fraction.

Major Modules

Electronic Implants



Prof. Dr. Volker 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 more than 320'000 people worldwide 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: signal processing and analysis, low-power microelectronics, wireless communications, and MEMS technology. Application-oriented elective courses are also taught, e.g., diabetes management, bio-medical acoustics, and biomedical sensors.

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 parttime 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 companies in Switzerland work in this field and "traditional" implants manufacturers have recently become interested in electronic implants, e.g., to measure forces in knee implants.



The figure shows the technological development and miniaturization of artificial cardiac pacemakers. Left: a fixed-rate pacemaker from the 60s; Center: a typical pacemaker used today with the ability to pace adaptively on-demand and to treat atrioventricular blocks; Right: a novel leadless pacemaker, which is able to stimulate on-demand. However, usage is restricted to single-chamber ventricular pacing. Photo: Martin Grambone.

Image-Guided Therapy



Prof. Dr. Stefan Weber

Image-Guided Therapy refers to the concept of guiding medical procedures and interventions through perceiving and viewing of medical image data, possibly extended by using stereotactic tracking systems. Medical imaging typically relates to a great variety of modalities ranging from 2D fluoroscopy and ultrasound to 3D computed tomography and magnet-resonance imaging, possibly extended to complex 4D time series and enhanced with functional information (PET, SPECT). Guidance is realized by various means of determination of the spatial instrument-to-patient relationship and by suitable visualizations. Image guidance is very often accompanied by other surgical technologies such as surgical robotics, sensor enhanced instrument systems as well as information and communication technology.

Students of the IGT module will be introduced to the fundamentals of the above-mentioned clinical and technical aspects of image-guided therapy. They will receive an overview of currently applied clinical standards as well as an overview of latest advancements in research (check out the recently introduced course on Clinical applications of IGT as well as the IGT Lab). Successful students will be able to develop novel clinic-technological applications for complex medical procedures as well as improve existing approaches to IGT. This will enable further careers both in the industrial and academic sector.

Mandatory courses of this module are concerned with the fundamentals of Signal and Image Processing and Medical Image Analysis. Furthermore, fundamental aspects of stereotactic image guidance, tracking, patient-to-image registration and basic clinical applications are taught in the course Computer-Assisted Surgery. Recent trends and fundamental aspects in surgical robot technology, minimally invasive procedures and its applications with-in IGT are introduced in the course "Medical Robotics". Additional elective courses extend students competencies in related areas such as computer graphics, pattern recognition, machine learning, and regulatory affairs.



Image-guidance in clinical use for ablation of liver tumors (Photo © ARTORG Center Bern and Inselspital Bern).

New Courses

Introduction to Medical Statistics



Prof. Dr. Jasmin Wandel

In a broad sense, statistics involves collecting, summarising, presenting, analysing and interpreting data. It allows the researcher to make inference about a population of interest whilst accounting for sources of variation (uncertainty). Statistics plays a key role in every medical study from the very beginning (study plan) to the very end (interpretation). As such, it is a prime example of an interdisciplinary science and offers a communication bridge between clinicians and engineers.



Principle of statistical analysis.

For a biomedical engineer faced with statistics, common sense is of greater importance than a strong mathematical background. Most importantly, he should always critically appraise statistical analyses he is confronted with.

In this module, the students will learn the basic concepts of medical statistics relevant for biomedical engineers. The goal is to equip the students with the necessary skills and know-how for their future career. Namely, a biomedical engineer should be able to actively join the planning phase of a scientific study and perform simple statistical analyses using appropriate software, such as R. Further, he should have an understanding of the most common statistical methods in the scientific literature. By the end of the course, the student will be capable to read more advanced texts on statistics and correctly interpret statistical analyses used in the biomedical engineering field.

During the course, the focus is set on the context in which statistical methods are required and the related principles involved. These will be illustrated using examples from the medical literature and hands-on computer exercises. The emphasis is on the application of statistics, the assumptions underlying inferential methods and the errors often committed in using statistical analysis.



Example of survival analysis.

Measurement Technologies in Biomechanical Engineering



Dr. Daniel Baumgartner, Prof. Dr. Heiner Baur, Dr. Mathias Bonmarin, Prof. Dr. Philippe Büchler, Prof. Dr. Bernd Heinlein, Dr. Lukas Lichtensteiger, Dr. Ghislain Maquer, Dr. Yves Pauchard, Marc Stadelmann, Benjamin Voumard, Prof. Dr. Philippe Zysset.

Acquisition of geometrical and biomechanical data of the human body is an indispensable task to improve our understanding of musculoskeletal disorders and help design improved prevention, diagnostic, therapeutic and rehabilitation strategies. These data cover multiple scales from air/blood flow in alveoli/capillaries, through mechanical properties of tissues up to gait analysis and involve a broad range of sensors and technologies.



Experimental set-up reproducing muscle forces to investigate the biomechanical behaviour of the human lumbar spine.

The long standing collaboration with the BME Master Program and the complementary technological competences of the University of Applied Sciences in Zürich (ZHAW) motivated the introduction of this new course in measurement technologies in biomechanical engineering.

This course exposes the biomedical background, the underlying physical principles and the applications of contemporary technologies used to measure displacements, forces, temperatures or electromagnetic activation signals in living or artificial biomechanical systems.

The lecture series starts with a presentation of the sensors and actuators available to measure, respectively control displacements, strains, forces or pressures. The application of sensors and actuators is then discussed in the field of robot assisted neuro rehabilitation. Mechanical testing of implants and organs in vitro is exposed with the requirements for their accreditation. Experimental set-ups to assess joint loads and/or moments in the shoulder and the spine are then explained. A multi-axial spinal testing machine using a motion capture system to assess intervertebral kinematics is demonstrated. At smaller dimensions, examples of dental implant tests are reviewed. Mechanical testing of tissues in vitro follows with applications to bone at the micro-scale. The ongoing improvement of biomedical imaging allows for extraction of organ geometries and material properties of tissues in order to generate linear or non-linear finite element models of the musculoskeletal system with increasing accuracy. Prototypes for in vivo and intraoperative biomechanical measurements of the human spine are shown in the frame of clinical applications. Motion capture with multiple video cameras and simultaneous measurement of floor reaction forces demonstrate the potential of a gait lab. The alternative motion capture approach of fluoroscopy is introduced with its advantages and limitations. The major breakthrough of instrumented joint prostheses is outlined with a focus on the total knee. An introduction to musculoskeletal modelling from the side of inverse dynamics is then given without leaving out the important notion of validation. Finally, the recent technology of thermal imaging is presented.



Motion capture during stair descent to detect dynamic dysfunctions of the foot related to flattening of the arch (pes planovalgus).

The main learning outcomes are

• Understand and describe the physical principles underlying the presented measurement technologies in biomechanical engineering

• Know the key characteristics of the presented technologies and in particular their limitations and potential synergies

• Interpret and process correctly the retrieved data and evaluate the contribution of these technologies to biomechanical engineering and their potential in future health care

New Courses

Molecular and Cellular Biology Practical



Prof. Dr. Roch-Philippe Charles

Molecular cloning is an important part of what is known as biotechnology. Many techniques are used to manipulate DNA. They can result in the medical applications like the recombinant insulin production or project us in what could be the world of tomorrow with the possibility of engineering tissue or even whole organisms to repair damaged genome. Biomedical engineering also comprises DNA alteration for building new tools like models of disease that are required for accelerating pre-clinical science.



Prototypic genetic engineering.

In this practical course, the aim is to initiate students to the basic techniques used in molecular and cellular biology labs. The course consists in two days of theoretical courses presenting the background required to get indepth understanding of the practical part. This theoretical study is then followed by five days in a molecular biology lab. There, the students perform a plasmid cloning and its transformation into a bacteria, an extraction of genomic DNA to perform a PCR and finally a Western blot.

Plasmid cloning is the most widely used technique to engineer DNA sequences prior to re-expression into human cells. Here students are familiarized with the enzymes used to cut and paste DNA sequences in order to generate modified genes. This is crucial to isolate and clone new genes, but also to express them in a different host cell system. This exogenous expression can then result in further studies in terms of function or structure of the protein. Polymerase chain reaction (or PCR) has become the most commonly used technique in biology. The application based on the PCR principle are numerous. Whether it is the early detection of a mutation, the sequencing of a gene (or even a whole genome of an person), determination of the relationship of two species (phylogeny) PCRbased techniques are bringing fast and robust answers. Students are also taught major techniques of DNA isolation that are required for obtaining good results with PCR. These techniques are used in a practical to perform the genotyping of several animal samples.

The main effectors in cells are the proteins. All cellular functions are regulated by protein expression or short term modifications of these proteins. Therefore, it is necessary to be able to witness either protein expression or these modifications (phosphorylation, cleavage or degradation). To investigate protein status, we perform Western blots. This technique based on the separation of proteins on a gel based on their electro motility and then transfer on a membrane allows the detection of very small amounts of proteins using antibodies. The students here perform a Western blot using proteins extracted from human cell lines treated with drugs to assay the effects of the drugs on cellular pathways.



Dual color western blot detection for P-S6.

Evaluation of Courses in the Academic Year 2014/2015

Like in the previous years, a centralized evaluation was performed in the Master's program in Fall Semester 2014 and Spring Semester 2015 according to the guidelines of the University of Bern. Both semesters were considered which led to 43 course evaluations involving more than 1000 forms in total. The results regarding all forms (see below) reveal that the students are very satisfied with the course program and that the courses are interesting and demanding at the same time.



Professor Koch teaching at the venerable Alter Hörsaal at the Institute of Anatomy. Photo: Adrian Moser.



1: very poor 2: poor 3: good 4: excellent



1: far too narrow/narrow 3: just right 5: far too high/wide

Faculty

Ahmad Dr., Sufian S. Albrecht Prof. Dr., Christiane Baier Prof. Dr., Norman Urs Baumann Dr., Tommy Baumgartner Dr., Daniel Baur Prof. Dr., Heiner Bohlius PD Dr., Julia Bohner Dr., Marc Bonmarin Dr., Mathias Bosshardt Prof. Dr., Dieter Büchler Prof. Dr., Philippe Burger PD Dr., Jürgen Cattin Prof. Dr., Philippe Caversaccio Prof. Dr., Marco-Domenico Cazzoli Dr., Dario Chappuis Dr., Vivianne Charles Prof. Dr., Roch-Philippe Cianfoni Dr., Alessandro da Costa Dr., Bruno de Haller Dr., Emmanuel Debrunner Prof., Daniel Diehm Prof. Dr., Nicolas Alexander Diem Prof. Dr., Peter Döbelin Dr., Nicola Dommann Dr., Alex Dutoit Prof. Dr., Bertrand Egger Prof. Dr., Marcel Eglin Dr., David Erlanger Dr., Tobias Eschbach Dr., Lukas Favaro Prof. Dr., Paolo Fichtner Dr., Jens Fix PD Dr., Michael Flury Dr., Simon Frenz Prof. Dr., Martin Fudalej PD Dr., Pjotr Gantenbein Prof. Dr., Benjamin Gerber Dr., Nicolas Gerber Dr., Kate Gicquel Dr., Pierre-Yves Giraud PD Dr., Marie-Noëlle Götte Prof. Dr., Josef Gruber Prof. Dr., Reinhard Guenat Prof. Dr., Olivier Häberlin Dr., Andreas Haschtmann Dr., Daniel Heinlein Prof. Dr., Bernd Heuberger Dr., Roman Hofer Dr., Ulrich Hofstetter Prof. Dr., Wilhelm Hunt Prof. Dr., Kenneth James Imwinkelried Dr., Thomas Jacomet Prof. Dr., Marcel Jensen Prof. Dr., Björn Joda Dr., Tim Justiz Prof. Dr., Jörn Katsoulis PD Dr., Joannis Keppner Prof. Dr., Herbert Kluter Prof Dr., Theo Koch Prof. Dr., Volker M. Kompis Prof. Dr., Martin Kopp, Doris

Kowal PD Dr., Jens H. Kucera Prof. Dr., Jan Kucera Prof., Martin Laederach Prof. Dr., Kurt Lechmann, Beat Lerf Dr., Reto Lichtensteiger Dr., Lukas Lu Dr., Huanxiang Luginbühl Dr., Reto Lurman Dr., Glenn Mack Dr., Alexander Maguy Dr., Ange Maquer Dr., Ghislain Meier Prof., Christoph Milligan Dr., Simon Minder, Beatrice Moser Dr., Walter Mougiakakou PD Dr., Stavroula Nef Prof. Dr., Tobias Nesic PD Dr., Dobrila Nevian Prof. Dr., Thomas Niederhauser Dr., Thomas Niggli Prof. Dr., Ernst Nolte Prof. Dr., Lutz Nydegger, Michael Nyffeler PD Dr., Richard Obrist Prof. Dr., Dominik Pauchard Dr., Yves Peterhans Dr., Matthias Pilgrim Prof. Dr., Thomas Porz Dr., Rouven Räber PD Dr. Lorenz Ramseier Dr., Christoph Andreas Reyes Prof. Dr., Mauricio Roggo PD Dr., Antoine Rothen-Rutishauser Prof. Dr., Barbara Saads Carvalho Dr., Thiago Sague Dr., Jorge Schäfer PD Dr., Birgit Schenk, Samuel Schumann Dr., Steffen Schwarzenbach Prof., Heinrich Schwenkglenks PD Dr., Matthias Senn Prof. Dr., Walter Martin Seyed Hosseini Dr., Hadi Stadelmann, Marc Stahel Prof. Dr., Andreas Stovanov Dr., Jivko Streit Prof. Dr., Jürg Sznitman Dr., Raphael Täschler, Dominik Tekari Dr., Adel Tschanz Dr., Stefan Andreas Vogt PD Dr.,, Jürgen Von Garnier, Prof. Dr. Christophe Wandel Prof. Dr., Jasmin Weber Prof. Dr., Stefan Weber Dr., André Zheng Prof. Dr., Guoyan Zwicker Prof. Dr., Matthias Zysset Prof. Dr., Philippe

Statistics

Number of New Students and Graduates per Year



BME Alumni: Career Directions

Profession after Graduation



Profession 5 Years after Graduation



- PhD Student or Postdoc
- Engineer Research Institution
- Engineer Medtech Industry
- Other Qualified Position
- No Data
- Looking for a Job
- Military or Civil Service

Biomedical Engineering Day 2015

The industry, medical doctors, and engineers met for the Biomedical Engineering Day at the Inselspital in Bern with great success.

On May 29, 2015, the seventh Biomedical Engineering Day took at the Inselspital in Bern. The event was organized by the Master in Biomedical Engineering program of the University of Bern.



Participants in the auditorium. Photo: Tom de Bruyne

The event is an efficient platform in Switzerland for networking of Master and PhD graduates and Swiss and international medical technology companies. This year's companies introduced themselves through oral presentations and gave insight into their commercial activities and their company philosophies as well as showed their demands on junior employees. Students thus had the opportunity to get to know potential future employers and contact them directly. This was made possible between the sessions in personal conversations and at the exhibitors' booths.



Networking time during the breaks. Photo: Carlos Ciller

The BME Day offered great opportunities for the Bernese biomedical researchers, too. The ARTORG Center for Biomedical Engineering Research and the Institute for Surgical Technologies and Biomechanics as well as the Bern University of Applied Sciences, a partner within the Master's program, used the possibility of presenting current research projects to more than 250 participants. Interestingly, Master and PhD students play an important role in many of these projects. Thereby, this event was a demonstration of scientific achievements, too.



Ping Lu, PhD student at the ISTB, and Aarati Chacko, BME Master student, discuss a poster. Photo: Tom de Bruyne

Besides company representatives, scientists, researchers, and young academics, many medical doctors participated in this year's event as they had the chance for intensive communication with the biomedical engineers.

One highlight of the day was the successful live eye surgery by Beatrice Früh, Department of Ophthalmology, Inselspital Bern. In the auditorium, Martin Zinkernagel from the respective department gave illustrative explanations.



Flurin Feuerstein shows his master thesis project to Vanessa Vallejo, PhD student at the ARTORG Center. Photo: Tom de Bruyne

At the end of the day, four awards for excellent academic achievements in the field of Biomedical Engineering at the University of Bern were presented.

Yves Mermoud received the SICAS Award 2015 for the best Master thesis for his work "On-Chip Impedance Analysis to Monitor Epithelial Barrier Integrity".

The SICAS Award 2015 for the best PhD thesis was given to Johann Jakob Schwiedrzik for his work "Experimental, theoretical and numerical investigation of the nonlinear micro- mechanical properties of bone".



Yves Mermoud receives the SICAS Award for the best Master Thesis from Ruth Steinmann (SICAS Foundation) and Mauricio Reyes (ISTB, University of Bern). Photo: Carlos Ciller



Ruth Steinmann (SICAS Foundation) and Mauricio Reyes (ISTB, University of Bern) hand Johann Jakob Schwiedrzik the SICAS Award for the best PhD Thesis. Photo: Carlos Ciller

We thank our sponsors and exhibitors

- Biotronik AG
- BME Club
- Haag-Streit AG
- Icotec AG
- Johnson & Johnson AG
- Maxon Motor AG
- Medtronic (Schweiz) AG
- RMS Foundation
- Scanco Medical AG
- SICAS Swiss Institute for Computer Assisted Surgery
- Stryker Trauma AG
- Symbios Orthopédie SA

The BME Club Poster Award 2015 was given to Tom Williamson and his team. His poster "High accuracy surface matching and navigation on the lateral skull base" convinced the jury.

Manuel Jonas Bracher and Andreas Dünki shared the BME Club Award 2015 for the best Master Thesis Abstract for their works "Wireless Functional Electrical Stimulation" and "Experimental Validation of an HR-pQCT-based Homogenized Finite Element Analysis of Human Distal Radius Sections".



Prabitha Urwyler and Andreas Stahel congratulate Manuel Bracher and Andreas Dünki on the BME Club Abstract Award. Photo: Carlos Ciller



Christoph Rathgeb collecs the BME Club Poster Award for the team of Tom Williamson. Photo: Carlos Ciller



The Biomedical Engineering Club

The BME Club and Its Mission

The BME Club is an alumni club with the mission to provide and promote networking among its interdisciplinary members. We are a constantly growing group of biomedical engineers, scientists, past and present students and medical technology corporates eager to bring together the principles of engineering, biology, and clinical medicine. BME club accomplishes these goals by hosting events such as information sessions on the latest cutting-edge research in different fields of biomedical engineering, attendance of international conferences and organizing visits of various industrial plants and laboratories. BME club is recognized as an official alumni association of the University of Bern under the umbrella organization – Alumni UniBe. A dedicated executive committee follows the principles of our constitution.

We are an enthusiastic and versatile group with diverse activities:

• bi-monthly "Stammtisch" in a local restaurant as an amiable platform to exchange, discuss, brainstorm or simply chat

- visits to Swiss medical and engineering companies
- organization of the annual MEDICA trip

• information on career opportunities (including job offers)

• organization of the annual welcome event for new students of the BME Master program

• organization of an annual alumni gathering

• sponsorship of the poster and abstract awards at the annual BME day

- sponsorship of Travel award
- publish annual BME club Newsletter
- provide access to the Medical Cluster events

• offer joint membership with SSBE (Swiss Society for Biomedical Engineering)

In short, the BME club represents a unique platform for professional, lifelong communication and networking. For further details look up our website at http://www.bmeclub.ch.

How to Join

Becoming a member is easy! Simply sign up at any BME Club event or visit us at http://www.bmeclub.ch. We are looking forward to welcome you!



Andrea Nienhaus, Prabitha Urwyler and Christian Güder represent the Club at the BME Day 2015. Photo: Carlos Ciller

The BME Club Board in 2015



Prabitha Urwyler President



Tom de Bruyne Vice President



Julia Spyra Back Office



Christian Güder Public Relations



Juan Anso PhD Students



Tobias Imfeld Webmaster



Carlos Ciller Treasurer



Dobrila Nesic Faculty



Andrea Nienhaus Master Students



Fatih Toy Alumni

Trip to Medica 2015

One week before the fall semester started I got an e-mail from Andrea, the student representative of the BME Club that registration is open for the trip to Medica. You might think now what is Medica?

Medica is the largest professional trade fair of the medical technology sector. Every year around 130'000 visitors travel to Düsseldorf in Germany to discover Medica and to trade and discuss the very latest in health technology. The exhibiting companies are specialised in electro-medicine & medical-technology, diagnostics & lab equipment, physiotherapy & orthopaedics, commodities & consumables, IT & communication technologies to name a few. COMPAMED - a trade fair for suppliers of the med-tech sector - takes place on the same grounds, in parallel with Medica. Here the new materials and technologies that will one day change the way we live and practice medicine are presented.

Given that every biomedical engineer wants to promote health and save lives, I was very happy to have the opportunity to see one of the biggest medTech exhibitions in Europe. I even had this tingling feeling in my stomach before we even started our trip! Students who had been there before told us it is advisable to have a plan which companies or technology fields we would be interested in and we wanted to see. The trade fair is so large that we would not be able to see everything in two days.

At the evening of departure we met for dinner at the Restaurant Tramway. We enjoyed their specialty -a large Cordon-Bleu - which I highly recommend if you are really hungry. After this huge dinner our group of approximately thirty people boarded the bus in front of Kunstmuseum in Bern and we were off on our overnight journey to Köln.

Still a bit sleepy from the bus ride we arrived in the early morning in the youth hostel where we were to spend the night from Wednesday to Thursday. After refreshments we went by train from Köln to Düsseldorf. At ten o' clock in the morning, after a coffee and a Bretzel, I was ready to discover Medica. I checked my plan and looked where I can find my companies of interest: DePuy Synthes, Hall 07a, Striker, Hall 13 and, Hocoma, Hall 04.

In small groups we started to explore the world of med-Tech. As we had interesting discussions with companies' representatives and saw demonstrations the time went by very fast. And YES, Medica is really huge!

In the evening - before dinner - we went back to Köln and made an obligatory selfie with the impressive cathedral of Köln. After some battery recharging in the hostel we ended the day with the sightseeing "Köln by night" while enjoying some of Köln's famous beers.

In the morning of our second day - all well rested and with recommended companies in the luggage whichever were discovered the evening before- we started again an unforgettable day at Medica. In the early evening we went for shopping in Düsseldorf and later our small group met the whole group at the famous brewery Füchschen for our last dinner. The brewery was a recommendation of a PhD student of the ISTB who grew up in Düsseldorf. After some marvelous traditional food like Haxen or Schnitzel we were ready for our overnight bus trip back to Bern.

I want to thank the BME Club and the organizer who allowed us such an unforgettable and amazing trip. I can only recommend to future students to participate; I would love to come again next year. It is a chance to ask a million questions and gain insights which you will otherwise never have. You get in touch with parts of the Biomedical Engineering field you have never heard of and would perhaps, never come to know or think of. It is just a dream for every Biomedical Engineer.

Stephan Moreno Gerber



From left to right: 1. The BME Club travel group 2015 ready to discover MEDICA; 2. Dinner at Restaurant Tramway before departure in Bern; 3. Denis Schenk about to attack his Haxe at the famous Füchschen brewery in Düsseldorf.

Graduation Ceremony

On a sunny Saturday, March 14th, 2015, the day on which spring was nearly coming and flowers were ready to bloom, our graduation ceremony as new graduates from the Master of Science in Biomedical Engineering program took place. This annual traditional ceremony was also organised for students who completed their studies from March 2014 - February 2015 in other medical programs which are part of the Faculty of Medicine, University of Bern. We were delightedly gathered at the "Kultur Casino Bern" and accompanied by our families and/or friends to witness and proudly celebrate our achievement.

At 17 o'clock in a beautiful late Baroque, Neoclassical interior-designed Grosser Saal (Great Hall) of the Kultur Casino Bern, the ceremony was opened by enchanting music from the Mediziner-Orchester followed by a greeting from Professor Dr. Peter Eggli, Dean of the Faculty of Medicine. Later, a speech by Mr. Walter Inäbnit, CEO of Haag-Streit Holding AG was given to the audience under the topic of "Mediziner, Arzt, Heilsbringer oder Unternehmer(in)".

The key message to take home was that we should use "observation and networking" in order to obtain knowledge and to create a product or an organization valuable to the society. As an example, Mr. Inäbnit asked the audience to cover their watches and then describe their watches such as what they looked like, whether numbers are Roman or Arabic, what the labelling looked like, is there a sweeping second hand or what else, and so on. With this task, we quickly noticed that we look at our watches many times a day or since we have them but we don't observe well enough to tell what they look like. In conclusion, a careful observation actually brings us knowledge. Another example was about a story how the first intraocular lens was invented with involvement of observation and networking. A doctor treated patients who were pilots during the World War II having pieces of shattered canopies in their eyes. The material of those tiny debris was polymethylmethacrylate from the plane's cockpit window. However, neither an inflammation nor negative interaction was noticed in the patients' eyes by the doctor. So he observed, understood and started networking with others and finally this led him to the idea of the intraocular lens. This story was to emphasise the importance of observation and networking in daily life.

After the thought-provoking speech, it was time for handing over the diplomas to the new graduates. The diploma of MSc in Biomedical Engineering was pleasantly conferred by Professor Dr. Philippe Zysset, the BME program director to each of us whom attended the ceremony on that day. This year, the RMS Master Award of 1,000 CHF was granted by Dr. Beat Gasser, CEO of RMS foundation to Michael Nydegger for the most outstanding GPA. The whole ceremony took approximately 2.5 hours, followed by an Apèro. We also made some group photographs together with Professor Zysset after the ceremony.

To me as a foreign student from Thailand, this graduation ceremony was very lively and quite impressive. I could feel the happiness of everyone from the smiles on their faces. At this point, I would like to take an advantage for all of us to thank every professor and lecturer for their efforts in teaching us and for sharing their knowledge and experience. We also would like to thank the study-coordinator team for their dedication to coordinate and administer activities in this master program of Biomedical Engineering. I am sure that the days we endeavoured with the studying and exams until the moment we were awarded the diploma to our hands, these become and will always be one of our vivid memorable pictures for all time.

Issarawan Taoyuwapan



Our alumni 2015

Bottom (from left to right): Alejandro Juarez Robles, Issarawan Toyuwapan, Jonas Fabech, Denise Baumann, Theresa Senti, Lukas Bereuter, Etienne de Coulon, Manuel Bracher, Simon Bosshard, Thomas Kranz, Mohammed Adagunodo. Top (from left to right):

Hilippe Zysset (Progam Director), Boris Brun, Michael Nydegger, Adyl El Guamra, Daniel Bär, Christian Geissberger, Martin Heller, Marcel Schweizer, Raphael Schertenleib, Marco Matulic, Andreas Renggli, Marcel Büchler.

RMS Award



The RMS Award stands for the Robert Mathys Foundation Award that honors the student with the best grade average over the two year master program with a prize of 1000 CHF.

The study direction wishes to thank Dr. Beat Gasser and the executive board of the Robert Mathys Foundation for this contribution to the excellence and visibility of our biomedical engineering field.

RMS Award 2015 Michael Nydegger receives the Award from Beat Gasser, RMS Foundation.

Graduation Profile



Denise Baumann

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

A: I did a Bachelor's degree in Life Science Technologies with a major in Biomedical Engineering at the Fachhochschule Nordwestschweiz in Muttenz. Besides my studies I was also working as a research laboratory technician in a microbiological & plant science laboratory of an agrochemical company, where I had previously gone through a very interesting and inspiring apprenticeship. I also continued with this work in the first year of my master's before switching to a position as scientific assistant at the ARTORG Image Guided Therapy group.

Q: Why did you choose to pursue your Master's studies at the University of Bern / Bern University of Applied Sciences?

A: After the bachelor's degree I was still eager to deepen my knowledge in certain disciplines. Although I had the option to pursue a Master's accompanying work at the Fachhochschule this was not an option to me. I wanted to see something new, to get to know different people and in this sense also to broaden my knowledge and network.

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

A: For me working besides studies is key: I wouldn't have studied without having the option to work also besides it. I always want to apply my knowledge in reality. Realizing interesting projects inspires me. With the motivation of knowing why I am learning something learning goes much easier for me.

Q: What was your career plan after the completion of your degree?

A: After the completion of my degree I wanted to see

the real application of our developments, so going to the "field", which means in our case the clinics, and go more into clinical research, which is needed to make our developments applicable to patients.

I started to work as a clinical application specialist for surgical navigation systems, which means I help doctors choosing the right navigation method, train and help them on how to use a navigation device and I support and partially coordinate relevant clinical studies or development projects.

But I also want to start my own business with several ideas I have, all concerning the visualization of medical image data. I am at the moment in the phase of formulating exactly what I want to offer and to which conditions. My position as a clinical application specialist helps me finding contacts in the field of course.

Q: What is the benefit of the Master studies with regard to your current professional activity?

A: On the one hand I of course obtained additional valuable knowledge, in my case for instance in computer graphics and programming of 3D visualizations. On the other hand I also got to know many of the important projects and contacts in the field in which I am working right know.

Q: You have been nominated for the "Burgdorfer Innopreis 2014". What kind of award is this and which project did you get the nomination for?

A: This price shall fascinate people for the studies at the Berner Fachhochschule and support creativity and innovation. I got the nomination for my Master's project about the development of an entirely mobile application for surgical planning and the viewing of 2D and 3D medical image data.



Please visit our website at http://www.bme.master.unibe.ch for an online version with full page Master Thesis Summaries

Sven Achenbach

Supervisors: Prof. Dr. Oriver Guents and Janick Studie Institutors: University of Ben, ARTORG Contex, Organs-On-Chip Technologies Examiners: Prof. Dr. Oliver Guents and Prof. Dr. mod. Thomas Gaiset

Introduction

In-vitor models of the lung parenchyma are often using rigid or flexible membranes to mimic the basal alveolar membrane. However, these membranes are arthreal and do not reproduce the specificity of the thin basal membrane that consists of collagen and deskin. To best, mimic this membrane, we developed a thin flexible and bioartificial membrane of collagen and elastin.



A contractive of decellularized collagen flocs. Automotive decellularized collagen flocs. Automotive sets a headar process. AE = alveolar entrance). Right: SEM image of continened, decellularized elastin fibers. (Arrow heads = alveolar elastin fibers. V = blood vessels) [1]. enchyma. Left: SEM

Materials and Methods

or several days. The membrane was characterized in terms of thickness, deflection and cell culture membrane was vaporized for 48h at RT, after gelation thor 2h in the incubator. The deflection properties were measured after 2h incubation with DMEM+ on the wet (DMEM) membrane. For cell culture experiments, the cells were seeded with a seeding density of 250'000 cells/cm² and cultured Collagen type I rat tail, filter-sterilized (0.2um) bovine elastin, dH₂0 and NaOH were mixed and covalently bonded on a support system. The apabilities.

Results

reproduce the respiratory movements of the lung. A thin membrane (8.8µg each) was found to be more A bioartificial membrane was successfully produced on a support system with a 1:1 ratio of collagen and elastin. The membrane has a minimal thickness of 3.3μm ± 0.7μm (8.8μg each). Further, the collagenflexible than a thick membrane (17.5µg each). Further, a monolayer with 16-HBE14o- cells could be achieved on the collagen-elastin membrane. elastin membrane could be cyclically stretched to





Fig. 2 Load deflection curve of two different membranes with a 1:1 weight ratio of collagen and elastin (8.8µg each vs. 17.5µg each).



7.5µg collagen elastin each.

Fig. 4 Slice of the collagen-elastin membrane covering a 250µm hole, measured by a confocal microscopy (8.6µg each).

A new bloartificial membrane was fabricated with a minimal thickness of $3.3 \mu \pm 0.7 \mu m$. Its composition is similar to that of the basal membrane In the lung alveol. The collagen-elastin ratio used is identical to the ratio found in in-vivo. The membrane can be cyclically deflected and calls (16HEE14o-) were successfully grown in a monolayer. This new bioartificial membrane is a further step towards better modelling in-vivo conditions in-vitro. Discussion

References

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Advanced Interaction and Visualization Concepts for Medical Image Data on Mobile Devices

Denise Baumann

Supervisors: Dr. Thomas Winklehner and Prof. Dr. Stefan Weber Institutions: ARTORG Center, Chair for image Guided Therapy, Universität Bem Examiners: Prof. Dr. Stefan Weber and Dr. Thomas Winklehner

Introduction

Rapid development in the area of mobile computing would allow for data access outside this immed environment. Increasing accustomization of medical doctors to mobile computing devices supports the It, such as surgical planning, are currently limited incough restricted data access, for the fact that therefore commonly specialized software and dedicated workstations in hospitals have to be used feasibility of using the later for the viewing of medical image data and for the performance of Viewing of medical image data and tasks based on planning tasks.

doctors, graphical and computational capacity and the suitability of design of radiological image data (1). The application is developed using the cross platform game-engine luthy and inbound C# scripts Three-dimensional anatomical models and the representative (Mo-dimensional images were surgical planning on mobile devices is developed. The iPad was identified as the most appropriate viewing and and threemobile device, due to its high acceptance among representative two-dimensional images we received from MeVis Medical Solutions (Bremen). An application for coherent two-dimensional medical image data



performing or planning liver surgeries. In addition, the feasibility of the established data pipeline was evaluated. Furthermore, functions for liver resection and ablation planning were developed, but not yet medical image data was tested in a usability study with 11 test users, thereof 3 medical doctors The developed application for viewing of planar



Materials and Methods



Fig. 1 Screenshot DICOM images.

tested.



Viewing of medical image data and planning tasks can be realized on a mobile device. Usability of the developed application for viewing of planar medical image data has reached a SUS (system usability scale) score of 865 points, which is a very high usability score compared to other usability studies (normalized ranking of 98%, [2]). For more representative results further tests with medical doctors who perform or plan liver interveritions. doctors who perform or should be conducted. Results and Discussion



the computed through Fig. 2 Resection proposal o developed application on an iPad. The established data processing pipeline has shown to be feasible for transfer of large medical image data sets, data can be downloaded from a webserver with a download speed of up to 0.5s / MB in 3G network. Tools for surgical planning have been developed and implemented, but have to be improved and tested with users

Conclusion

two- and three-dimensional image data and performance of surgical planning tasks could be The capability of mobile devices for visualization of shown.

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Master's Thesis in Biomedical Engineering

Novel Implant Design for a Long-term Esophageal ECG Recorder

Jan Beerstecher

Supervisors: Dr. phil. Thomas Nicolenhauser, Dr.med. & phil. Andreas Haberlin, Institute of Human Convected Engineering, IACE-microteck, Ben: University of Applied Sciences Institute of Chard ords. The Biomatical Engineering Research, University of Ben. Department of Chard ords. The Repistal, Ben University Hospital and University of Ben. Examiness: PHOT Dr., Josef Casta and Dr. Rep. Lugibulki

Introduction

(\$ECG) devices have been used to diagnose arrhythmias but manifest problems such as poor atrial signal quality and skin irritations for long-term monitoring. Esophageal ECG (eECG) has been proven to feature better signal quality. However, due to the lack of a dedicated recorder, borg-term Heart rhythm disorders (arrhythmias) affect an ever growing number of people due to the aging population. These disorders may present symptoms like syncope, light-headedness, shortness of breath, and chest pain. Historically Holter surface ECG eECG is not often used in daily clinical practice. In this thesis, the design of a miniaturized long-time eECG recorder placed and fixated in the nasal

hatent was developed Special paid to wearing comfort, aesthetic impart impairment, safety against inhalation and dropping out, conformation to the human nose anatomy, and cavity of the patient attention was paid mechanical properties. biocompatibility.

Materials and Methods

final design (Fig. 1), containing all the necessary components was produced using a Wacker Silpuran 2440 biocompatible silicone, and tested in 8 individuals, during 138 hours in the daytime and 40.5 hours at night-time. The subjects were asked to assess the wearing comfort and aesthetical impact on their daily life. The devices' mechanical Design ideas were adopted from commercially available nasal anti-snoring clips, incorporated into a basal design, and then iteratively improved. The properties were investigated in a tensile test according to the standard EN1618.



Fig. 1 CAD rendering of the final design, containing A10 constructions as nose tools (i), the AND memory only aborg the als of the nose (ii), the ASIC (iii) FFID components (iv), the adjustable titanium frame (v) components (vi), the adjustable titanium frame (v) multi-turmer catheter (viai). Wacker Signara 2440 silicone shown in gray is the translucent encapsulation.



Results The result of the study is a shape which conforms well to most nasal anatomies, containing betteries (i), memory (ii), RFID antenna and controller chip (iv), and electronics for data processing(ii). The device incorporates important features such as: adaptability to various nasal geometries (titanium frame (v)), compatibility with the read out apparatus nostril design) and slipping out (elongated shape, battery filled nose-locks), and secure fixation of the (centering tubes (vi)), security against inhalation (bicatheter (vii)

Fig. 2 shows the results of the comfort test, on a score from 1 (lowest) to 10 (highest): a mean value of 7.25 (SD = 1.16), 7.5 (SD = 1.6), 7.75 (SD = 1.58) was recorded for the comfort, the breathing, and the aesthetics, respectively. No drop-out was

reported by the subjects revealed a mean maximum tendenmed traction tests revealed a mean maximum tensile force at break of 17.22N (SD = 504) for the catheter to device connection, which manifests the weakest element of the device.



Fig. 2 Context test results for the general context $(\vec{x} = 7.5, SD = 1.16)$, the string $(\vec{x} = 7.5, SD = 1.6)$, and aesthetics $(\vec{x}=8.0, SD = 1.56)$ categories (scale 1 worst to 10 best)

Discussion

The proposed design was verified with a comfort assessment and mechanical strength test. Results slightly impairs daily life activities. Limitations are the small sample size and lack of female subjects. The force was not significantly over 15N, necessitating further development to be in suggest that the obtained shape fits well and only accordance with ISO1618.

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are Acknowledgements All members of the HuCE microLab, Biel thankfully acknowledged.



Introduction

Body modeling is the process of describing the real human body by a physical model, which in turn can

different motion capture systems. The output of the model consists of the internal forces and torques of generated. To facilitate the extension of the mode inverse dynamics calculation



Fig. 1 Display of the body model in Simulink's mechanics explorer using 3D-CAD-models for the representation of the bones.

Results

Implementation and Validation of an Inverse-Dynamic Rigid-**Body Model for Human Motion Analysis**

Pierrick Bersier

Supervisor: Dr. Ralf Kredel Institution: Institute of Sport Science, Universität Bem Examiners: Prof. Dr. Philippe Zysset and Dr. Ralf Kredel

be used to analyze the body motion and the internal forces in the joints. This analysis can be pursued in two different directions: forward dynamics compute the motion of the human body by the application of entertainment industry and Sport Science. The aim entertainment industry and Sport Science. The aim body modeling tool that allows to compute inverse dynamics simulation with a reasonable set-up time. already suggests, use the measured kinematics to compute the implied forces. Human body modeling known forces while inverse dynamics, as the name is used in several fields such as rehabilitation, the

Materials and Methods

The body model is implemented in the MATLAB simuluk environment To enable at faster set up time of the model, to encourage its use and to make it easily adaptable, the model is dynamically every joint. In order to validate the model, several motions (jumping, walking) were recorded using a Vicon T25s system with 2 AMTI force plates. Residual forces and torques at the not segment of the model were used to quantify the errors of the in the future, the program is written in object oriented programming style. The model comports several interfaces to make it compatible with



The program allows good possibilities to display the motion recorded by the Vicon motion capturing



and torques still suffer from high relative errors (up to 15%), which are supposed to mainly arise from the mathematical human body model of Hanavan, that was used to compute the inertial parameters of the different body segments for the validation study. system by using three dimensional CAD-files (Fig1). In addition, the model can estimate the resulting forces and torques in the joints. However, the forces 0.25



Fig. 2 Relative errors of the external forces computed on the root segment of the body model while walking.

Discussion The

into the mechanics of human motion, especially as its workflow is very streamlined for an efficient application of the model in various analysis tasks. verification of the calculation steps and a further validation of the model using individual body segment parameters (e.g. via Body Scanning) is developed body modeling tool in Matlab/ Simulink provides a valuable tool for deeper insights However, as relative errors are still high, a careful recommended, before it is used in practice

E. P. Hanavan Jr. A mathematical model of the numan body. Technical report, DTIC Documents, References 964 ш

Acknowledgements

The main contributor of this project was the behiung IV of the Institute of Sport Science under the supervision of Dr. Ralf Kredel. Prof. Dr. Ernst-Joachim Hossner and the entire team are gratefulls. acknowledged.



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Master's Thesis in Biomedical Engineering

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Master's Thesis in Biomedical Engineering

Novel Preservative and Uninterrupted Suction Device for the Heart Lung Machine

Mirko Betto

Supervisors: Msc. Martin Walls Institutions: MrCPGC cerric (University of Berri), R&D Healthcare (Maedia AG), Examiners: Prof. Dr. Dominik Obrist and Msc. Martin Vahl

Introduction

surgeries requiring a cardiopulmonary bypass. Significant proceedings have been achieved in the recent past regarding bio-compatibility of the used to the blood. Nevertheless, the quality of suction blood is remaining an issue and compromises cardiotomy suction, very high pressure and shear forces can occur which cause several side-effects such as increased hemolysis and platelet activation. In this project a prototype of a novel suction device Heart lung machines are established devices for patient outcome. When using roller-pumps for comparative set-up with materials and reduction of foreign surface exposed developed which is promising a superior performance in a conventional devices. SBW

Materials and Methods

A Graphical User Interface (GUI) has been developed with Matlab as front-end for the controller. Comprising Simulink Desktop Realtime and a data acquisition board the controller and GUI were integrated on an x64 computer platform for A Simulink model of the device has been created in order to evolve and tune a control system.



Fig. 1 GUI of the Preservative Heart Lung Machine Suction (PHLMS) prototype showing suction and release pressure and how.

developed by means of processing pressure differences on the aspirator providing optimized Flow measurement was implemented by processing measured liquid level. A fluid-detection has been blood air contact performance.

Results

suction (maximum range 19.5kPa to 20.6 kPa in a 20kPa setting). Yet the device was not able to provide the required maximum flow-rate of 2L/min in The sequence control with two underlying pressure controller enabled the device with uninterrupted a given worst-case-scenario set-up (cardiotomy



aspirator and tubing, maximum suction pressure 20kPa, glycerol 58%).

Detection of liquid at the aspirator was possible readily (< 0.28), change from liquid to air was also detected within 0.28, though the prevention of mixture of air and liquid was not effective in this setting.



Fig. 2 Uninterrupted suction with afternating pressures in two carristers.



Fig. 3 Detection of liquid and following detection of air at

the aspirator's tip.

since it does not effectively prevent blood and air mixture yet. Regarding the unmet flowrate A novel prototype has been developed suitable for a comparative study against a conventional device. The fluid detection mechanism has to be improved exceeding damaging pressure levels in the blood. Discussion

Acknowledgements

The project was supported by Medela AG.

Novel, Fast Digital Filtering of Electrocardiogram Records

Sandro Burn

Superviseurs: Prod. Dr. Marcel Jacomet and Dr. med. Reto Wittmaber Institutions: Instatute In-Intram Continetar Egiptereng, ILCE-introduals, Bern University of Applied Sciences Examines: Prod. Dr. Josef Cette and Dr. Thomas Holcerhubert

sampled data by using uniform voltage steps. An additional compression is done with a cubic polynomial [1]. arrhythmias) occur spontaneously and can last for only a short time. Such episodes require a continuous long-term Electrocardiogram (ECG) for weeks. To save storage space and to lower the energy consumption leading to a smaller battery size, a new ALD-conversion algorithm has been developed [1]. The algorithm creates asynchronous necessitates dedicated post-processing However, wearable and smart ECG recorders don't provide the space for the electronics to store and process the uncompressed data recorded over days or detection and diagnosis. Baseline wander arising from electrode motion as well as high frequency noise might impede the signal analysis and, thus, (cardiad disorders rhythm heart Paroxysmal Introduction



Fig. 1 The asynchronous uniform voltage steps signal creates many samples during long-term recording (synthetic high frequency noise added). A compression algorithm is applied for reducing the amount of data [1], creates many samples durin (synthetic high frequency noise

filtering asynchronous uniform voltage steps and the compressed data. However, conventional finite impulse response (FIR) or infinite impulse response (IIR) filters process equidistant samples, thus the compressed data has first to be converted. This necessitates algorithm which acts directly on the compressed betweer 4 difference resources. and time-consuming the considerable hardware shows data is desired. -<u>w</u> Figure step

Materials and Methods

The novel non-uniform algorithm is based on a linear analogue system. Therefore the input as well as the output signal are represented by a polynomial. The differential equation defining the filter can be solved analytically and describes a continuous system. By taking the linear combination of the input polynomial with the filtering polynomial, we get an output polynomial. Afterwards the output



polynomial must be solved numerically to find the zero crossings. Defined level-crossings are then used for coding the output signal back mito mutiorm volgege steps. To improve the accuracy of the algorithm, initially applied piecewise constant interpolation was replaced by a cubic polynomial interpolation

coursey (RMSE = 14.5) compared to the pocowise constant interpolation (RMSE = 22.2) on the non-uniform compressed input samples (Figure 2). Moreover, the Newfor's method is used to find the zero of the non-linear equation Figure 2 shows a real ECG signal superimosed with synthetic high frequency components. The first order low pass filter designed with the non-uniform algorithm, The fitthering algorithm was developed and verified in MATLAB (Mathworks, Inc.), based on synthetic input signals. A simulated time response of a linear time-invariant filter served as reference signal. The cubic polynomial interpolation shows a much higher attenuates the high frequency components. Results



Fig. 2 Real ECG signal with high frequency components. After filtering with the novel fast non-uniform filtering algorithm the high frequency components are attenuated.

Discussion

MATLAB^{III} by using synthetic ECG signals. This filtering algorithm will require less hardware resources and lower computational burden if mplemented on a real-time system compared to The novel filtering algorithm based on a linear analogue system that directly acts on asynchronous data has successfully been developed and tested in conventional approaches.

References

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Master's Thesis in Biomedical Engineering

Jonas Egger

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Prof. Dr. Kenneth J. Hunt Institute for Rehabilitation and Performance Technology of BFH-TI, University of Bern Prof. Dr. Kanneth J. Hunt and Prof. Dr. Volker M. Koch Supervisors: Institutions: Examinens:

ntroduction

The maintenance and development of cactorespiratory fitness (CRF) is becoming more and more important with regard to prevention and treatment of chronic diseases and it is related to a number of heath benefix [1]. The ILPUT in Burgoof arms to guide the intensity of exercise during treadmill running using feedback control of the heart variability in the very low frequency (VLF) many at variability in the very low frequency (VLF) range at about 0.01 Hz. This variability of the heart rate causes the feedback system to sociale and leads to poor performance of the heart rate control. The aim of the thesis was to systematically investigate and describe the VLF-HRV during treadmill ate. Spectral analysis of the heart rate measurement showed systematic heart rate exercise.

Materials and Methods 21 able-bodied subjects were recruited. Each subject performed 2 tests, running on a treadmill at different constant speeds v1 and v2 v1 was chosen to be a moderate intensity, was chosen v2 v2 vas chosen vigorous intensity. In order to get a baseline for both tests, a resting ECG measurement was carried out. During the running exercises the heart rate was measured by a wrieless ECG device. The recorded signals are further processed in MATLAB. A spectral analysis using Fast Fourier Transform (FFT) was done, to analyze the frequency components of the measured heart rate.

Results

heart rate signals showed resonances at different requencies, ranging from 0002 to 003 Hz at both intensity leves. The results of some subjects showed resonances around 001 Hz. The most The results of 16 subjects were included in the data processing. The spectral analysis of the measured esonances were found around 0.004-0.0049 Hz,



moderate and including both testing conditions, vigorous intensity levels.



Fig. 1 Example single sided amplitude spectrum of a heart rate measurement, which was recorded during moderate intensity running on a treadmill.

Discussion

IRPT. Furthermore, the results suggest resonances around 0.004 Hz, which might be the basis for developing new feedback control systems. No similarities or differences within the different The observed resonances around 0.01 Hz support the findings which were previously seen at the subjects and the testing conditions moderate and vigorous could be detected.

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Acknowledgements I would like to thank Prof. Dr. Kenneth J. Hunt, Dr. Jittma Sengsuwan (ND) and the whole team of the Institute for Rehabilitation and Performance Technology for their support.

application to Biosensing of Metabolites and Pharmacological Test and Optimization of pH sensors on Microelectrodes for Adyl-Michaël El Guamra Compounds

Supervisor: Prof. Dr. Herbert Keppner Institution : EPFL ST1 LSI2 Examinens: Prof. Dr. Herbert Keppner and Prof. Dr. Sandro Carrara

Introduction

processes underlying the electrochemical depositon of indium oxide and optimize the parameters to improve the sensitivity. One example of parameter is the required blue color (9). This sensor is located on a chip which is part of an implant, that imtegrates bisensions for personal integration, fragility as well as temperature and pressure of use. One promising terchology is the metaf/metal oxide sensitive element. The indium oxide is of particular interest as its integration on small surface is possible, it is corrosion resistant, biocompatible and highly sensitive to pH. The aim of this work is to gain insight on the physico-chemical liquid solutions and it is estimated that several millions of pH sensors are currently in service worldwide. The glass electrode is almost the only measurement is essential in industries using available technique for acidity measurement in solution. But in recent years, an increasing interest is focused on emerging technologies to overcome the limitations of the glass electrode in terms of medical therapy purpose. he pH

Materials and Methods

(EIS) analysis which permits the identification of an electroal ciorum minisking the behavior of interface phenomena. The second one is the Hull cell technique, its configuration enables the application of a current density gradenet on the actinode for plating purpose, which gives the opportunity to visually observe the effect of current density charges to quickly examine and evaluate the process. An *ad hoc* Hull cell was designed and fabricated of fit the implant's chip. Two complementary electrochemical techniques were used to characterize the oxide layer. The first one is the electrochemical impedance spectroscopy



Fig.1 Up) Equivalent circuit. Down) Data and curves fitting

An electrical equivalent circuit of the interface of three inclum oxide layers was found by EIS analysis. The three layers were deposited at three analysis. The equivalent circuit is presented in figure 1 (Up). It is composed of an electrolyte resistance R₄ and capacitance C₄₁ a charge transfer resistance R₄ and a constant phase element 0. The circuit simulation are reported in figure 1 (Down) The identification of the bright range of the indium layer was achieved with the Hull cell technique. Figure 2 reports a oxide, as well as profile and arithmetic rugosity (Ra) measurement. An analytical model was used to find the current density range corresponding to the (continuous line) fits the experimental data, the plots picture of a platinum electrode coated with indium bright blue range Results



Fig.2 Electrodeposition with a current density gradient.

Discussion and Conclusion

Comparative analysis of sensitivity plots and detricted equivation transmeters confirmed that the element is most likely a sign of roughness at the interface oxide/metal (pack contact) reducing the eventivity and that the current density range corresponding to the blight region (front contact), 1.38 ± 0.08 mJAcm', is exactly in the current transe or the place of the highest Ra and the thickest layer are located in the blight region. Thus the ensitivity of the sensor is optimized if the surface area at the back contact is minimized and the surface area at the fourties maximized.

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Master's Thesis in Biomedical Engineering

Biological Evaluation of a Long-term Esophageal ECG Recorder

Barbara M Esch

Dr. Thomas Niederhauser and Prof. Dr. Benjamin Gantenbein Institute för Human Centered Engineening, Bein University of Applied Sciences Institute för Surgeal Technology & Biomechanics, University of Bein Prof. Dr. Benjamin Gantenbern and Prof. Dr. Josef Gote Supervisors: Institutions: Examiners:

ntroduction

Medical devices have to meet high quality indicards to guarantee function and safety. An important quality issue of medical devices having direct or indirect contact with the body lissue is biocompatibility, tested along ISO 10993 standards

The research project "E2conder" aims to develop an implantable esophageal sensor dedicated to ECG recording for duration up to 30 days and with direct and stable contact with the esophageal mucosa. The prodype was constructed in a old moding process and mainly composed of polymers, namely polyurethane polydimethylsiloxane (PDMS) and pol (PU) and several platinum electrodes (Pt). The objectives of this master's thesis w through in vitro tests.

The objectives of this master's thesis were (i) to outline the milestones for the device to be marketed, (ii) to evaluate the biocompatibility of the esophagus, and (iii) to develop a suitable in vitro test system. medium/long-term use in the device for the



Fig. 1: AB /K-violet test of the materials Pu, PDMS, PC, K and Pt in the first experiment compared to reference values of Pu+ (= positive control), P- (= negative control) and MG 132 (= experimental control). Since the set of the and MG 132 (= experimental control). Significar from one-way-ANOVA test. Black line. Pu+ value.

Materials and Methods

10,000 3T3 mice fibroblasts per well were exposed to substances extracted from fur, pIMS, FC, Silver-Epoxy Glue (K) and Pt on 96-well microtite plates. The off unablity reaction to the extracts was measured with change in fluorescence of Resazurin Sodium Sait Metabolic Cell Activity Assay (MB) and



content measurement). The new normalized test parameter AB / X-violet was calculated. in a second step stained with x- violet (indirect DNA

after the treatment with pepsin, pancreas-enzymes and a control group without enzyme treatment in a third test, we compared Pu with a thermoplastic Polyurethane (TPU) that could also be used for the In a second test, we treated 3x9 material probes with 10mMol HCI and compared Pu, PDMS and PC E2corder.

Results

In the first cytotoxicity tests, extracts from PDIMS, PC and Pt showed a moderate to weak influence on the cell activity. Pu- in the form used in the first results under treatment with pepsin differed significantly from the other two groups with less suppression of the cell activity in the pepsin group. In contrast to Pu, the TPU showed significant less prototype of the E2corder- and K appeared inappropriate from their toxicological profile. The cell viability suppression.

Discussion

The new in vitro test seems valid, but the method meeds further evaluation. The different results among the polymets could be explained by toxic ingredients that release and hydrokyze according to the chemical composition of the polymet (e.g. MDA in case of all Pu's), from residues from the manufacturing process (THF is needed in the cold molding of Pu, not in TPU) or from increased release in an acidic environment. Materials for devices in the gastrofinestinal tract rave to be carefully selected (polymets with less oil and plastocare or TPUs) for minimum hoxicly. Further detailed chemical and physical testing is required to establish the biocompatibility of the E2corder.

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Increasing Safety of Liver Surgery by Regulation of Portal Venous Flow

Rico Fausch

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chamber to detect the corresponding flow rate values is highly dependent on the geometry of the occluder. Concerning hemodynamics, the diameter of the thin-walled collapsible tube has to be reduced dramatically before an adjustment of portal venous vein as well as a difference between zero and maximum flow. The sensitivity of the pressure tada a major liker resection is the devices way to improve survival. A small termant liver volume has a high risk of total liver failure caused by small-loc-size syndrome (SFSS), which may lead to fatal outcome. SFSS includes a wide range of liver resection-related diseases like portal hyper-perision Recent studies showed evidence that the increased portal venous blood flow normalized to the remnant liver volume is a cause of SFSS. No devices are commercially available and hemodynamics concerning a reduced portal behave blood flow are not understood. Therefore, a device

Liver resection is the only curative therapy for hepatic tumors. In patients with high hepatic tumor

Introduction



An adjustable portal venous blood flow regulation device was designed as well as an in vitro set-up to reduce the impact of animal trials. Three feasible

to adjust portal venous blood flow is desirable.

Materials and Methods

concepts in a different category of motion were designed and built to evaluate the most suitable technique and the impact of the device geometry on

the measurement.

Fig. 2 The hydrostatic change is detectable in the pressure volume diagram of the occluder chamber.

Discussion

These results show the feasibility of a device to restrict portal venous blood flow simultaneously. The built device should be assessed on a porcine model to validate the in vitro set-up.

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portal vein banding device could prevent post-operative liver failure - artificial control of portal venous flow is the key to a new threapeutic world. Medical hypotheses, 73(5): 640–650, 2008.

Variation in flow rate and hydrostatic pressure are detectable inside the occluder pressure chamber. The pressure volume curve of the occluder pressure

Results

chamber exhibits several differences upon a change

of hydrostatic pressure inside the portal

rigid support, an inflatable pressure chamber made out of silicone and a hose connecting the pressure chamber allowing an inflation with a syringe.

consists of three parts such as a

Fig. 1 A circular

3 occluder

Acknowledgements The whole CVE group from ARTORG especially Dominik Obrist and Sabrina Fery as well as Andreas Kohler are gratefully acknowledged.

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Development and Comparison of Simulated Driving Setups

Flurin Feuerstein

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ntroduction

Due to the increase of the average age of the popu-lation, the age of the average driver is also increas-ing. Therefore the driving safety of elderly drivers needs to be verified. For this purpose, driving simu-lators were developed. The existing approaches of driving simulation are either abstract tests of indi-vidual skills needed for driving or high-fidelity simu-lators that are often immobile and cause high costs. The goal of this master's thesis is to develop a driv-ing simulator used in combination with a perimeter sevice. Perimeter devices feature hemispherical surfaces suitable for coverage of the full visual field.

Materials and Methods

For the first step, a steering wheel was constructed as a human machine interface for the simulator. steering movement to a computer were chosen and implemented. Third, the software for the driving Second, the electronics for the transmission of the simulation and for hemispherical projection was mplemented. All the developed components were mproved over time to grant the best possible expelience.



Fig. 1 Sketch of some first ideas for the implementation

developed solution was compared to an existing solution of the corresponding component. After the individual tests the complete system was evaluated After full implementation and first improvements, the single components were tested. Wherever possible in terms of usability and simulator sickness. the

mentations. The developed steering wheel showed The results showed positive results for most imple-Results and Discussion

performance comparable to an existing consumer



grade steering wheel in usability (Developed solution 82.69 \pm 31.83, consumer 86.54 \pm 33.83, (112) = 0.0192, p = 0.370) and driving errors made (Developed solution 20.23 \pm 37.63, consumer 50.8 \pm 165.4, (112) = 1.560, p = 0.145). Nevertheless, there was a significant difference in time needed (Developed solution 86.38 \pm 24.75, consumer 53.23 \pm 18.32, (112) = 4.165; p = 0.001). The implemented hemispherical projection algorithm was appreciated by the testers for its accuracy and ability to project natural images. Most testers criticized the low resolution of the projector whereas its luminance was sufficient for darkreat coom projection. The full system evaluation showed, that most subjects did not feel any difference in symptoms of simulator sickness when comparing before to after testing Before 16.32 ± 8.92, after 18.36 ± 11.44, t(10) = -0.747; p = 0.473). The usability of the whole system was rated as high by the testers (85.23 ± 8.95). sickness



Fig. 2 Developed simulator setup with steering wheel and bernispherical screen and setup used for comparison

Conclusion

The development task was implemented quite suc-cessful. The implementation of the steering wheel, the electronics and the software implementation in the scope of functions of the simulation software and the used projector. Additionally, eye and head tracking systems could be added to the system. worked well. Possible improvements can be made

Musculoskeletal modeling of the shoulder to analyze the effects of scapular anatomy on the development of rotator cuff tears and osteoarthritis

Marc Grepper

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Introduction

Different studies on the shoulder hypothesized that an increased upward in or the glenoid carby is associated with increased risk of supraspinatus tendon tears, while an increased retroversion of the glenoid fossa is associated with anterior cult tears. Radiological studies concluded the direct relation between the lateral extension of the acromion with the occurrence of the actual to the lateral and osteoarthmits. The actual amount of knowledge about these disorders is mainly based or visual information on mechanical variables such as actual joint reaction forces or translation of the humeral head on the glenoid surface. The aim of this study was to assess the influence of the anatomy of the scapula on the glenohumeral joint biomechanics in order to better understand how anatomical precise parameters affect degenerative joint disorders.[1][2] without investigations radiological

Materials and Methods

Musculoskeletal modeling systems, AnyBody and OpenSim, were used to evaluate the effect of various bone anatomical variations and calculate First results obtained with both software were compared for simple motions. In a second step, published results obtained with instrumented implants were used to verify the accuracy of each the forces acting in the shoulder joint and muscles model prediction.[3][4]



Fig. 1 OpenSim (right) and AnyBody (left) shoulder models performing a right arm abduction. Once verified, an accurate model was used to evaluate the effect of anatomical variations on the joint contact force, muscle recruitment pattern and magnitude of the muscle forces.

Results

The validation results showed that joint reaction forces calculated during aboutcion by OpenSim were generally lower than those calculated by AnyBody. The forces predicted by AnyBody were also lower than the values recorded in-vivo using instrumented imparts. [3][4] However, when the second the forces calculated with AnyBody reached realistic forces calculated with AnyBody reached realistic

and accurate values considering joint reaction forces, while the error increased with OperSin. (Fig. 2) Results of the simulations including a change in scapular antomy showed that a larger extension of the arcomon induced a decease of the reaction the forces produced by the rotator cuff muscles. While a smaller extension of the acromon resulted in tigher joint reaction forces but in lower forces produced by the rotator cuff muscles. forces in the glenohumeral joint but an increase in



Fig. 2 The drage shows the shall point reaction frace (hack) in the glennineral joint as well as it X(red). Y(klue) and Z(grean) components, plotted against the Orthocoar data (storii itee). AnyBooy (staure) and OpenSim (hample). For a 30° humerus abduction.

Discussion

AnyBody was used to analyze the effects of changing seatular anatomy. The results of the simulation showed that the contract force increases by more than 5% when the acronicin length is shortneed with in hhysiological limits. This observation agrees with the radiological imfinitys indicating that a shorte acromion is a factor that contellation between the effects induced by the osteoarthritis is not trivial. In addition, the orientation of the glenoid surface has not been considered in this study. Due to its importance in affecting the vertical translation of the joint, it will be the topic of during abduction using the Anybody model, once the shoulder rhythm was included. For this reason, change of the lateral extension of the acromion and Accurate joint reaction forces could be predicted further investigations.

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ntroduction

diseases of the eve as early as possible. The slit tamp bio-microscope, as a means to directly inspect the anterior and posterior parts of the eye, is commonly available and used on a daily basis in clinical practice. However, photo documentation of slit lamp examinations is difficult due to a complex focus and illumination situation. An intelligent autobous system could meet these challenges by detecting regions of interest. A robust iris and publi detection, even under bed illumination or in off-Human vision plays a crucial role in most aspects of life. This is why it is important to diagnose and treat angle situations, is a major building block of such a

a morphological approach was thorough evaluation [1] The was compared to established segmentation methods (John Daugman, IDO). In a second step, a classifier was designed to identify During the thesis, a state of the art analysis was performed, and a morphological approach chosen after thorough evaluation [1]. naccurate segmentation results. implementation

Methods

Using elementary mathematical operations a robust iris and pupil detector was implemented. A filtering is performed by a geodesic reconstruction and with the help of a general distance function (GDF) the center of the pupil is extracted.



Fig. 1 The image shows the gradient values of the polar representation of an eye. It builds the base for the antection of the two required borders. First, the pupil border appears (from the fit to right) and rext the limbic boundary shows up (value 100 on the X-axis).

Transforming the image to the polar space, (Fig. 1) let the pupil border as well as the limbic boundary become nearly a straight line. To gain reliability, a binary classification excludes the inaccurate segmentation results. The feature vector to take the decision, is based on a template region, consisting



of the extracted iris region. Binned gradient orientations values result from the template region and are finally transformed into the feature vector. To train the classifier, a Support Vector Machine (SVM) in combination with a linear kernel is used.

recorded data from volunteers and analyzed by two different error values. Based on these results, the algorithm worked for challenging situations (Fig. 2). In deal cases the results were good as well and could confirm the behavior from the first trial. Looking at the classification, the ROC curve shows. features. These are supported by the resulting average certainty of ~84% across the entire cross segmentation performance was tested on a reasonable performance based on the chosen validation process of volunteers. Results The seg



2 Results of the segmentation algorithm in various benging situations (illumination, blur, off-angle, Fig. 2 Results of the segmentation algo challenging situations (#ummation, specular reflections, eye lids, eye lashes)

Discussion

The thesis shows, that the imprementance in a reliable handles a variety of non-ideal images in a reliable manner. Concerning the possible improvements, to meet the high expectations. In combination with the classification, the current implementation suppresses the outliers and the images without a with respect to the computational speed, the simplicity of the mathematical operations will allow risible iris.

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Pressure Measurements in Micro-Channels

Alexander Grundmann



Introduction

than can be provided by the vessel of interest. In the present work, the concept of an analog Servo Nulling Pressue Measuring System (SNPMS) is enhanced, by using novel software based control. This improved system allows to measure the pressure in the small vessels of the microcirculation measurement of fluid pressure in microfluidics is challenging. Conventional pressure measurement devices require more liquid to fill the transducer, (sizes of 7µm). Pe

on the 7.5µm channel. The pressure (~5mmHg) induced flow in Fig.2 (t=0-0.55) is suppressed as soon as the control is enabled (t=0.55-1.29).

results are obtained testing the SNPMS

Conclusive

Results

Materials and Methods

Due to an overpressure *P*_u, fluid exhausts the punctured capillary during a measurement. This pertor and the set of th



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Fig. 1: Bench test setup for the SNPMS (details in the text)

The unknown pressure *P*_o generated by a reservoir, contraining physiological *D*(*Astinola*: a sime (white), is inducing an interface deflection *x* in the micropipette (blue) prefiled with *2molar* saline test-solution (green). By varying the ratio of the two fluids, the resistance in the micropipette undergoes a change, which is recorded with a sensing circuit (V) via electrodes (yellow). The interface deflection *x*, representing the controller error is reduced with a counter pressure $P_{\text{paragraphic}}$ are derived by the pump. This pump is triggered in a software based closed-loop control (LabVIEW, National Instruments, USA) using a PID or a MPC control algorithm. If the shifted interface is moved back to the initial position and hold, the error is reduced and the equilibrium is set. At equilibrium $P_{\text{paragraphic}}$ and the pump (T) with a pressure is then recorded on the pump (T) with a (straight channel with 7.5µm x 7.5µm cross-section) is placed in series between the micropipette and the reservoir to survey the flow with a microscope, by conventional pressure transducer. A microdevice reservoir to survey the flow with a microscope, tracking particles (RBCs) contained in the liquid.



to controll ontrolled 0.37 0.55-0.74-0.92 -111 0.18-1.29ŝ

Fig. 2: Stacked frames (Δt^{ue0} . (85s) showing an example of the control by the SNPMS: a RBC moving from left to right is stopped by the counter pressure (P_{more}), and pushed provends initial position.

Discussion

While first measurements with the SNPMS show promising results, further improvements has to be done to allow effective accurate measurements in the smallest channels (*7µm*) and microcapillaries *in* vivo (pressure range (*2µ0mHq*). The proof of concept, as well as first bench test, are successfully done. The SNPMS, once fully developed will enable deeper insights of microfludic phenomena and allow pressure measurements in small vessels of microcirculations.

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The project was supported by the Cardiovascular Engineering Group of the ARTORG Center for Biomedical Engineering Research, Universität Bern.

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Master's Thesis in Biomedical Engineering

Prof. Dr. Philippe C. Cattin Medical Image Analysis Center, University of Basel Prof. Dr. Philippe C. Cattin and Dr. Christoph Jud Supervisors: Institutions: Examiners:

Introduction (Arial 9pt, bold)

Basel cuts bone with 200 µm to 500 µm groove with and is tracked by a 3D optical tracking system with 200 µm to 300 µm resolution. After an interruption the accuracy is not high enough to Cutting bone with a laser-based osteotome requires accurate guidance during the intervention. The laser-osteotome developed at the University of reposition the osteotome to continue the cutting at

the previous location. In this thesis a method was investigated to find the previously cut groove with an on-board camera on the low contrast surface of bone.

Materials and Methods

For creating contrast artificially on the otherwise smooth bore, the sample was illuminated with LEDs arranged around the camera at two spots to cast shadows on the grooves from different directions. Considering the later applicable environment the optimal light position was investigated with a geometric simulation for high visible to the camera maximising the shadow length visible to the camera analysed for the optimal shapes to find the groove intensity correspondence with the physical geometry of the groove for a stable and simple localisation. To reach subpixel accuracy the intensity profiles are interpolated with lanczos4 filter. The groove location and orientation is estimated from eleven points distributed over its length to Then the intensity profile across the groove was compensate for the not perfectly machined cut.



Fig. 1 Estimation of edge location (black) from intensity profiles overlaid with original image drawn at mid-plane of 3D plot.



Performance measures include precision and accuracy evaluation by placing the sample on a micro stage and performing known motions

Results

that results in a reduced groove location precision over a 3d interval of 14.1 µm positional and 0.6° directional deviation. Accuracy measurement shows dependency on image noise also due to the ringing artefacts produced by the lanczos4 interpolation estimation shows a relatively high a positional error 3o interval of 18.7 µm. he edge



Fig. 2 Relative accuracy measurement errors from multiple locations over 1600 µm with more samples at centre each location sampled 5 times, showing blob forming.

Discussion

and the noise dependency is higher than in current subpixel edge detectors. The accuracy measurements show an indication for systematic error introduced during the measurement which increases the interval size and underestimates the Achieved accuracy is lower than initially targeted real accuracy.

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Acknowledgements My sincerest thanks to Prof. Dr. Philippe Cattin and Stefan Wyder for their support and guidance.

Application for the Therapy of Brain-Injured Patients with Development and Evaluation of a New Tablet Computer Aphasia

Silvan Januth

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by a user management system into a patient interface and a therapist interface. Both interfaces were evaluated using the SUS (Subject Usability Scale). The patient interface was tested by 15 healty contois and 5 patients. For the patients, we also collected tracking data for further analysis. The therapist interface was evaluated by 5 speech The application has two parts which are separated therapists

Larguage is the most important mean of communication and plays a central role in our everyddy life. Brain damage (e.g. stoke) can lead to acquired disorders di anguage affecting the four linguistic modalities (i.e. reading, miting speech production and comprehension) in different

Introduction

production and comprehension) in different combinations and levels of severity. Every year, more than 5000 people (Aphasie Suisse) are affected by aphasia in Switzerland alone. Since

aphasia is highly individual, the level of difficulty and the content of tasks have to be adapted continuously by the speech therapists. Computer-based assignments allow patients to train independently at home and thus increasing the frequency of therapy. Recent developments in tablet computers have opened new opportunities to use these devices for rehabilitation purposes. Especially





Materials and Methods The aim of this project was to develop an application that emables patients to train language related tasks autonomously and, on the other hand, allows speech therapists to assign exercises to the patients and to track their results online. Seven

older people, who have no prior experience with

computers, can benefit from the new technologies.

Fig. 2 Screenshot of a picture-word matching task Results

were

with various types of tasks

implemented.

categories

The SUS scores are $\overline{x}_{pointet} = 98$ and $\overline{x}_{hasthy} = 92.7$ (median = 96, SD = 7, 95% CI (88.8, 96.6)) in case of the patient interface and $\overline{x}_{hystocits} = 68$ in case of the therapist interface.

Conclusion

to the patient interface, but is still considered as "good" and "usable". The user tracking system and the interviews revealed that there is room for improvements and inspired new ideas for future Both, the patients and the healthy subjects, attested high SUS scores to the patient interface. These scores are considered as *itest imaginable*. The therapist interface got a lower SUS score compared versions.

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Fig. 1 Screenshot of a word ordering task



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Master's Thesis in Biomedical Engineering

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Master's Thesis in Biomedical Engineering

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Development of Electrospun Hollow-core Fibers for Drug Release and other Applications

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Prof. Dr. Herbert Keppner and PD Dr. Järgen Burger Institue of Appied Microtechnedgeser, Haule Ecole Arc Ingénierle, La Chaux-de-Fonds PD Dr., Jürgen Burger and Port, Dr. Herbert Keppner Supervisor Institutions: I Examinens: I

ntroduction

Drug release is an old field, which has been relicovered in the last three decades. New technodoges, but also increasing difficulties to accover new pharmoeutical molecules had repectusors in the way currently existing drugs needed to be defivered [1]. More specific, more targeted ways emerged, also to correspond to another rising field - tissue engineering. While different means of transmission in the body exist in a tailored polymer membrane. Those membranes are produced by creating template fibers by electrospinning, coating them with Parylene – a biocompatible polymer – and finally dissolving the this work is based on diffusion controlled drug delivery, and more specifically encapsulating a drug template fibers.

Materials and Methods

more critical to produce and needed 1.3-1.4 Vcm⁻¹ Substances such as indoarmine B (RhoB) were incorporated to act as markers for later diffusion measurements. The coaling with Parylene was performed following the Gorham process [2] Diffusion measurements were implemented with Fibers made of a fluoropolymer (THV) and gelatine (a collagen derivative) were produced with a setup consisting of a non-beveled syringe needle of 0.8mm acting as spinneret, and aluminum foil or slicon as collector. THV fibers were obtained from a THV/acetone mix (5g:50 ml ratio) with voltage to distance ratios between 1.3 and 1.7 Vcm⁻¹. Gelatine tibers, made of a solution of 19% gelatine w/v with acetic acid (97%) and dimethyl suffoxide (3%), were spectroscopic measurements.

Results

Fibers were successfully produced, with a smooth single. The following coating with Parylene did not modify the shape of the fibers (Fig.1). The RhoB marker included in the gelatine matrix slightly changed the electrospinning parameters, but did integrate nicely in the gelatine. To characterize the diffusion rate of Parylene coaded gelatin fibers, the samples were placed in ultrapure water. UV-Vis spectroscopy was used to analyze this water and measurements were taken at specific points in time (Fig. 2). The intensity of the peak increased with time spent in the water, indicating a gradual dissolution of the temolate fibers. letect a RhoB absorbance peak at 553nm. Those





Fig.1: SEM picture of gelatine fibers deposited at 1.4Vcm² and coated with 150nm of Parylene. Fibers are smooth and unfused.



UV-Vis the wate s concentration increases over time, until saturation. RhoB spectrometer.

Discussion and conclusion

Fibers of the desired shape and composition were created, Parvlene-coord, and removed to create ubbes. The diffusion measurements are promising, and a powerful platform is now in place with spectroscopt certifiques. This will be the starting point for more work on Parylene functionalization.

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Visual Detection of Surgical Instruments During Retinal Microsurgery

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Introduction

assistance to the surgern. Computer Vision and Machine Learning techniques have demonstrated to be effective methods for visual detection in computer-assisted interventions. The goal of this thesis was to detect and to accurately locate surgical instruments on images obtained from the microscopic camera with these techniques. The oblenges of this method lie in the quality of the video frames as well as in the estimation of the instruments' pose and position at any given time. opening, the patient recovers more quickly than with conventional surgery. One limitation of MIS is the reduced field of view of the operating site that is only visible with the endoscope. Real-time knowledge of the instruments pose and position during surgical procedures can therefore provide Minimally invasive surgery (MIS) has gained popular acceptance in the past years. Since only small indisions are performed, instead of one large





Fig 1 Example image with identified instrument parts to detect and final response map, obtained from the sliding window procedure. Materials and Methods An integral part of this thesis focuses on Machine Learning methods. These methods learn a hypo-



position estimation. Feature representations of these response maps have been trained with regression trees to predict the position of the instrument parts. background. It is essential to adopt a feasible classifier and to extract representative features, object detection procedure. The response maps obtained from this procedure can be used for the on new testing data. The objects of interest to be detected are classified and trained against the which can then be integrated into the sliding window thesis from training data and perform a prediction



Fig. 2 Example of a response map showing a forceps with overlaid true positions (dots) and predictions (crosses).

Regulto

Both the intensity and the gradient information turned out to be viable features and the Gradient

Boosting framework emerged to be an efficient classifier. All the tool parsould be classified with accuracy higher than 0.98. With the siding window procedure, we obtained adequate response maps (Fig.1) that we could then use to estimate the position of the surgical instrument. Despite promising results for pose estimation (Fig. 2), further research must be performed.

It became apparent that Extra-Trees with multiple outputs is a powerful tool to predict dependent

Discussion

variables. However, the pose estimation remains a problem to be solved in future research

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Acknowledgements I offer my special thank to Dr. Raphael Sznitman and the members of the OTL group for their advice and support.

10



ALL COLUMN u^{b}

32

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Introduction

During certain clinical procedures, it is necessary to use high-speed cutting tools, such as saws or drill bits. The generated heat is concentrated around or simulate a proper surgical procedure, where menerature can be monitored and controlled; so potential itssue damage can be diminished. The aim of this study was to design, manufacture and make damage to the bone or soft tissue. Knowing the thermal properties of bone will help to plan, optimize preliminary test of an experimental set-up to determine the thermal conductivity of cortical and tools, which may cause an irreversible rabecular bone. these

Materials and Methods

conductivity, was used in a serial configuration to identify the temperature drop across the bone sample, which was necessary to quantify the bone instrument was developed. The experimental device is able to generate a constant and well-controlled heat flux in one direction. A sample made of a thermal Based on the steady-state method, a parallel-plate hermal conductivity based on Fourier's law a known material with reference



Fig. 1 Cross-sectional view of the experimental set-up: (1) Cooling system, (2 and 10) petiter modules, (3 and 9) aluminum plates, (5) PE-foam insulation, (5) cylindrical holder and (7) thermocouples. A set of measurements was first performed with a commercial device. The Hot Disk® system utilizes a transient method that allows quick measurements of the thermal conductivity, thermal diffusivity and specific heat capacity of a vast number of materials. Pilot tests on bovine and human bone samples were then realized with the developed parallel-plate astrument



The thermal conductivity measured with the Hot Disk® system was 0.6±0.01 W/mK for cortical bone and 0.32±0.02 W/mK for trabecular bone. The of trabecular bone. Results





observed difference is statistically significant (Fig. 2). Preliminary measurements on thermal conductivity with the experimental sectury, showed much higher values and these proved to be identical for human and bovine concilat hone. A significant difference between contrat and trabecular hone was also found, and thermal instorpay of trabecular bone was confirmed. Surprisingly, no relationship was found between thermal conductivity and BV/TV



Fig. 2 Measurements of contical and trabecular bovine bone with the Hot Disk® system.

Discussion

unexpectedly high. However, similar absolute differences between the medians were observed in both contical and trabecular bone for the two systems. Based on this observation, a possible explanation for the discretancy of these results could be a substantial heat loss at the lateral surfaces of the samples due to a high length/diameter ratio, causing a higher temperature drop than expected between the relerence and bone samples. Modifications of the experimental system have to be undertaken in order to obtain an Disk® system match well those found in the literature (0.56±0.04 W/mK), but absolute values The thermal conductivities obtained with the Hot measured with the developed set-up were accurate value of the thermal conductivity of bone

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Multi-Modal Matching of 2-Dimensional Images with 3-**Dimensional Data**

Nadieh Khalili

Prof. Dr. Philippe C. Catifine and Natalia Chickerova Medical image analysis corter, Basel University Prof. Philippe C. Catifine and Prof. Dr. Guoyan Zheng Supervisors. F Institutions 1 Examiners. 1

Introduction

we dreat image modalities is always desired to gain the maximum information. The first step to fuse images is to register them in a common reference farm. Although many studies have been carried with the goal of correct registration, yet multi-modal registration is highly changing and nontrivial. The present work is confinuation of a previous study in prevent work is confinuation of a previous study in the present work is confinuation of a previous study of the present work is confinuation of a previous study of previous study a fully automatic method for registration of 2D histology on 3D µCT dataset has been proposed (see Figure 1). The algorithm used SURF as feature descriptor whrease SURF feature detector and descriptor whrease substration, in this master thesis, we address this issue based on the similarity of small image patches with its different Combining of images obtained from neighboring region.



Figure Tpipeline of the algorithm: Feature matching or JCJ cate and histological image, (middle) 3D point cloud of matched points, (right) optimized RAINSAC plane fitting [1].

Materials and Methods

quantized to m^2 angular bins and m radial bins. When each keypoint is rotation the descriptors based on degree of rotation are shifted. We employ this property to enable keypoints of entation invariant and for scale invariance the scale of each For each keypoint the self-similarity descriptor is periated by taking a small image path and comparing it to a larger surrounding image region using sum of square difference (SSD). The similarity measurements are converted from Cartesian coordinates into log-polar coordinate system and scale approximated SURF keypoint detector

Results

We implement our algorithm in two pipelines, in the first pipeline the keypoints are extracted densely



descriptors are extracted from the scaled keypoints. The results of both pipelines are compared with the manually registered results and the previous study from every second pixel of the image. In the second pipeline the keypoints are extracted using SURF feature detector and afterward self-similarity in our group [1].



Figure 2 The left graph is showing the number of matching points from self-similarity (green). SURF (burb) and SIFF (red) along the µc/S tikes in the first dataset (the verical black lines shows the corresponding slices from manual registration). The right graph is showing the number of matching points from dense self-similarity algorithm along the points from dense self-similarity is along the points from dense self-similarity along the points from dense self self self self se corresponding slices from manual registration).

Discussion

information from structure of image in multi-modal dataset. Moreover we found that the LoG and its approximation "DoG" do not supply stable keypoints robust feature points are not describing the exact same location. multi-modal dataset, which means that the enables to extract more Self-similarity 5

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Acknowledgements I would like to thank Prof. Dr. Philippe C. Cattine. Natalia Chicherova and the whole team of the Medical image Analysis Center for their support

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Master's Thesis in Biomedical Engineering

Augmented Reality for Radio-guided Surgery

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Superviscors: Prof. Dr. Ph. Cattin Institutions: Department of Blomedical Engineering, Universität Basel Examiners: Prof. Dr. Ph. Cattin, PD PhD Mauricio Reves

ntroduction

procedures show limited accuracy and other options surgery Radio-guided surgery using a gamma probe is an established practice in SNB It provides the surgeon. The major drawback of the method is the limitation of only displaying the count rate based sentinel lymph node and enhanced capabilities for Diagnosis, planning and staging is for any cancer nust be considered like the sentinel node biopsy on the local activity concentration which makes it difficult for the surgeon to identify the anatomical patient of utmost importance. Different staging (SNB). SNB is considered to be the standard procedures are used to exclude any regional metastases radiological and clinical staging staging procedure for melanoma and breast advantages like accurate identification of the egion at the surgical site.

Materials and Methods

The aim of this work is to develop the hard- and software for an intraoperative mobile optical navigated SPECT camera for radio- guided surgery with augmented reality. To compensate the different leveloped which enables the mapping between the reconstructed in 3D. A structured light scanner ins implementened in order to obrain the depth projection geometries the surgical site must be information. A calibration method should be detector and the camera image.



"eg. 1 Concept drawing of the mobile optical navigated SPECT camera

The developed mechanical design of the prototype allows first measurements and comprises the hardware in one integrated system. Results





Fig. 2 In- vivo experiment and recorded activity image

The first collimator design showed limitations in its resolution. Two new collimator designs were evaluated for the specific purpose. The developed reprojection error of 55 mm. The acquired depth map with the structured light scanner showed a reasonable depth information to augment the between the detector and the camera images calibration method is able to map the points theoretically. First experiments showed a camera images with an activity image



Fig. 3 Augmented image and artificial activity image

A first prototype was developed for radio- guided augmented surgery. The hardware must be optimised for its pupose and the gained experience through the first experiment showed adjustments must be carried out in order to have an high performance device. The performance of the two experiment. Summarising, the concept works and new collimator designs must be tested in a next the prototype reached a next stage. Discussion

Intraoperative gamma cameras for radioguided ugery: Technical characteristics, performance parameters, and clinical applications. Department of Oral and Maxillofacial Radiology Nigata Hayama. Kazuhide References

Acknowledgements

The important contribution of Haerle Stephan and the University Hospital of Basel for the experimental set-up is gratefully acknowledged.

Detection and Segmentation of Anatomical and Pathological Structures in Fundus Images

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Introduction

and treatment planning of a vast number of retinal diseases. Among the most threatening diseases for the loss of vision are diabetic retinopathy and retinoblastoma. Even though both diseases greatly differ in their origin, if left untreated, they lead to visual impairment and ultimately to blindness. To help prevent vision loss of millions of patients, automated fundus image processing may assist in diagnosis and treatment planning by detection and segmentation of anatomical and pathological Retinal fundus imaging is essential for diagnosis segmentation of anatomical a structures visible in fundus images.

Materials and Methods

Four different aspects of fundus image processing in the scope of diabetic retinopathy and retinoblastoma are proposed.

retinopathy is considered to be the most proliferative form of the disease. Detection of blood vessels in the retina is essential for the evaluation of neovascularization. A per-pixel supervised method for segmentation of blood vessels using a random forest with a set of 56 features is proposed. The optic disc is a dominant landmark in fundus Neovascularization of the retina due to diabetic

<u>u</u> images. Detection and segmentation of the optic disc is required for the evaluation of various aspects of diabetic retinopathy. A multi-stage pipeline for segmentation and subsequent detection pesodouc

Indicators for capillary leakage in the retina are hard exudates, which appear as bright yellow regions in fundus images. As they are an early sign for their early detection and segmentation is of great importance. For this purpose, a novel multi-stream retinopathy. convolutional neural network segmentation method advanced non-proliferative diabetic s proposed.

Retinoblastomas are turnours growing from the retina in young oflidiern. For treatment planning of radiotherapy, precise localization of the turnour is important. To increase precision, multiple imaging modatiles are tused. For registration, proper segmentation of the turnour in fundus imaging is required. A supervised method for the segmentation of the tumour in fundus images is proposed.

Results

The methods are evaluated on numerous databases Blood vessel segmentation is evaluated using a 20 image test set and shows a mean areaunder-the-curve (AUC) performance of 0.975.



and shows very good generalization with a mean AUC of 0.985 Optic disc performance is evaluated twofold. The localization method finds the optic disc previous the evaluated the evaluated the evaluated the rease. The mean Dice coefficient of the segmentation was evaluated at 0.914. In 34% of the segmentation was evaluated at 0.914. Dice > 0.9). Evaluation of hard evudates was performed on Further, the model is evaluated on a second test set a per image and per pixel base. Image based evaluation shows an AUC of 0.96. Pixel based



Fig. 1 Automated segmentation results of a fundus image with diabetic retinopathy. Vessels are colored green, the optic disc border blue and hard exudate regions cyan.

Segmentation of retinoblastoma shows good results on images where the patient has not been treated. In images with prior treatment, the method requires further improvements in the future.

Discussion

The results show state-of-the art performance for blood vessel and hard exudate segmentation. Optic disc and retinoblastoma segmentation show promising results for future research.

Acknowledgements I would like to thank everyone from the OTL group for their support. A special thanks goes to my supervisors Dr. Sandro De Zanet and Dr. Raphale Sznitman

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articular Introduction esions in

classical chondrogenic markers collagen type II and aggrecan by high osmolarity and BMP4 in de-differentiated HAC in monolayer results in an increase of their redifferentiation potential in micromass pellet cultures. spontaneously, and if left untreated lead to osteoarthritis. Autologous chondrocyte implantation cartilage lesions in the knee, still yields inconsistent clinical outcomes due to human articular chondrocytes (HAC) loss of chondrogenic potential during monolayer expansion (de-differentiation). S100 proteins were previously identified as markers of di ARC chordrogenic (redifferentiation) potential (Di aARC chordrogenic) (redifferentiation) potential (Diaz Romano, et al., 2014). The aim of this study was to determine whether the induction of S100 and cartilage do not heal ACI), considered as the most promising therapy for

monolayer up to 5 weeks with weekly passaging. At passages 5 (P3), 4 H2, and 5 (P5), HAC were incubated in high samolarity (550mCsm) serum free medium (SFC5) ± 100ng/mL of BMP4. Cells were harvised after one week. analyzed for thordrogenic gene and protein expression, and Materials and Methods HAC were obtained from 3 donors and expanded in micromass pellets were prepared. Neochondro-genesis was assessed after 3 weeks by gene expression, GAG/DNA content, histology and mmunohistochemistry.



Fig. 1 Upregulation of chondrogenic genes in HAC induced to redifferentiate in monolayer culture by SFOS and BMP4



Results

aggrecan RNA levels increased only in response to BINP4 (Fig. 1) A gradual loss of responseness to both treatments from P3 to P5 was noted in all genes except aggrecan. At the protein level, the percentage of 5100A1 and 5100B positive cells increased in response to SFOS and BMP4 KGN had no effect. Analysis of pellets revealed induction By contrast, collagen type II and expression.



1 cm

deposition of collagen type II and proteoglycans.

chondrogenic potential.

Discussion this study further confirms S100 as a chondrogenic marker for HAC in monolayer and pellet cultures. The BMP4 induction of HAC redifferentiation in monolayer resulting in their improved chondro-genesis in pellets lends hope for tuture ACI treatments: de-differentiated HAC could be induced towards redifferentiation prior implantation in the damaged knee.

In monolayer, regardless of the HAC de-differentiation level, high osmolarity and BMP4 induced an increase of \$100A1 and \$100B RNA



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Fig. 2 Macroscopical overview and proteoglycan staining of peliets prepared from P3, P4 and P5 HAC incubated in FCS medium, SFOS and BMP4 in monolayer

HAC incubated in BMP4 regardless of the passage, yet most pronounced in P3 (Fig. 2). Expression of \$100A1 and to a lesser extent \$100B paralleled the of proteoglycan and collagen type II deposition from

Biochemical analysis of pellets showed higher amounts of profeogybrans (GAD) relative to cellularity (DNA) in least de-officientiated P3 HAC incubated with BMP4 suggesting their improved

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Tracking Morphological Changes of the Choroid and Sclera

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mean error of 10.9 μm was found between short-time consecutive follow-up scans. A comparison between identical accans consisting of 16 and 100 averaged B-scans showed a mean error of 4.7 μm maps were created with the segmented information to compare consecutive follow-up scans and identical scans with different signal-to-noise ratio. A

The choroid is a supporting structure in the wall of the evebal. It is essentially responsible for blood supply of retinal structures and lies therefore behind the retina. It is surrounded by the outer kyer of the wall (scolera) and consists of two types of

Introduction



vasculature and intersitial issue filing the gaps. The change in chronoidal hitckness is assumed to be a factor which correlates with the progression of myopia, also known as short-Inear-sightedness. A filing prevalence in developed countries urges to further research on chronoidal changes to further research on chronoidal changes to coherence transgraphy is an advanced imaging modely which is able to scan retinal and chronoidal structures. Volume scans (C-Scan) or these issues, consisting of multiple sign images (B-Scan), thickness. This cultured is of multiple sign.

thickness. This demands for automated segmentation algorithms to efficiently support future

studies.

Cife 1. Commonstration of examine threitomess may overlaid of a fundric image. A B-Scan in the middle of the associated C-Scan is extrated and placed at the bottom associated C-Scan is extrated and placed at the bottom of the flight. This scan reveals the result of both wavefendth measurements. The dashed black time athous the position of this single scan. The dashed while cycle depicts the position of the mecula.

Materials and Methods A staged algorithm has been developed which serves as foundation for retinal and choordial layer segmentations. It was used to segment the inner limiting membrane (LUM) the bluck's membrane (BM) and the choroid-solera interface (CSI). By parametric adaptation of each individual stage, an optimal reliability of the segmentation is achieved. Every stage consists of image transformation, pre-filtering, graphout and post-fitting.

Discussion

The algorithm showed to be stable and yields an adequate precision for future research on choroidal thickness changes. There are still many optimizations possible which allow augmenting its performance. The usage of a dual-wavelength OCT system opens new possibilities towards befer OCT visibility.

A preceding segmentation of the optical nerve, by usage of fundus images, allowed introducing a special treatment of the appearing interruptions at these locations. Distorting geometrical

transformations allow matching the coordinate

References

system of the resulting image with preferential profiles. Adaptive intensity transformations and simple edge detection kernels were used as fittering operators. A 3D-graphout method ensures the segmented layers to be on the same plane. Cubic spines allow fitting the different layers with a defined flexibility.

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Acknowledgements

The main contributor to this project was the HuCE -probled BUAS) under the guidance of Prof. Christoph Meier. The support of the entire team and Prof. Dr. Boris Považay are gratefully acknowledged.

A verification by professional ophthalmologists was conducted which yielded an absolute mean segmentation error of 1.5 µm and a relative mean segmentation error of 0.55 %. Choroidal thickness

Results

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ADDRESS AND u^b

Master's Thesis in Biomedical Engineering

Marco Matulic

Supervisors: Dr. Brett Bell and Prof. Daniel Debrunner Institutions: ARTORG Center for Biomedical Research – IGT Lab Examiners: Prof. Dr.-Ing. Stefan Weber and Dr. Brett Bell

Introduction

access for implantation of cochiea electrodes has been developed at the ARTOR5 center for Biomedical Engineering. The system has been successfully tested on cadave heads, however, a design reside on cadave heads, however, a accuracy is required for the production of a A robotic manipulator for minimally invasive cochlea design review for improved system accuracy is required for the produc commercial version of the system.

Materials and Methods

The main output of the risk analysis of the current tobolic prototype and the resulting new safety concept is that absolute rotary position data at the axis level is required it is additionally hypothesized that the use of absolute position data for motion control could embarce the positioning accuracy and proposed position sensor, was designed in order to perform. The axis can be controlled by both the current and proposed motion controllers to compare repeatability of the robot. A single axis test bench, which emulates the mechanical structure of the first axis of the current robotic system, but with the the positioning performance, which is measured with the high resolution position sensor RESA at the axis. the ъ output



Fig. 1 Single Axis Test Bench: Consisting of the molor unit rimotor, Yake, encoder), Hammolic Unive gear, RESA absolute rotary encoder (226 incremments resolution), distortion harmer, current used molicon controller EPOS 362, new motion controller DC Gold Bell (DCGB) and the control lox with a Reacyboard 3010 for the Linux system.

The comparison of the positioning showed clearly that the steady-state position arror could be reduced by more than 99 % with the new control concept. The measured steady-state error, with the axis perpendicular to gravity (wast case) was found to be: $Epos: \mu \neq \sigma(m) = 3.86F + 2.45$ fs Results



The new control structure was also shown to impose the distortion behavior of the system, since the axis could return to its start position after a heavy mechanical shock by a 1 kg metal hammer talling on the axis. Generally, the measurements showed that the new motion controller can position the axis within the resolution of the absolute rotary DCGB : $\mu \pm \sigma$ (inc) = 8.07E-2 ± 1.12E-1 sensor, since $\mu < 1$ inc.



Fig. 2 Hammer Test: Distortion response of the Epos 36/2 and the device under test DC Gold Bell to a mechanical shock of the axis, positioned perpendicular to the gravity.

Discussion

The dual teedback control structure, with an intermential encoder at the motor, to measure the velocity, and a high resolution absolute rotary position sensor at the output of the gear, promises a developed in the future. The sensor can achieve an developed in the future. The axis is calibrated with a alser measurement system and a corresponding error mapping, implemented directly on the motion significant improvement of the positioning performance. A calibration procedure has to be The dual feedback control structure, with controller. [1]

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Acknowledgements Special thanks goes to Dr. B. Bell and T. Williamson for the graceful support during the project.

The Heart's Butterfly – Intracardiac Energy Harvesting using a Microstructure Driven Generator

Sören Miethke

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Introduction

Nowaddy, all implanted pacemaker are battery powered Although advances in battery technology, ted to the reduction in size and an increased storage capacity, the lifetime of batteries is shill limited. Therefore energy harvesting has been a Pacemaker and defibrillators have been developed to treat patients, who suffer from a disorder of or cardiac dysrhythmia. stimulus conduction

without a battery is very attractive for implanted biomedical devices. Powering pacemaker with an energy harvesting device would avoid repeated focus in research for many years. The concept of driving low-power electronic devices conventionally associated limited battery lifetime. interventions, surgical with

Materials and Methods

In the present work we first investigated the capability of intracardiac energy harvesting in the right ventricle by myocardial contraction, blood flow and blood pressure changes. Due to the detected contraction pattern in the right ventricle, we rejected the initial idea of a butterfly like energy harvesting device. The main objective of this thesis is the development of a novel bistable micro generator. prototypes are described and experimental results are presented. A fast acting modified micro switch constitutes the core element of both prototypes. The which can be triggered by the intracardiac blood flow and generates sufficient energy to power between two air-filled coils and attached to a micro switch. The second prototype is built up by a coll, modern cardiac pacemaker. Two micro generator aligned a magnet, to, consists generator tell



micro switch. Triggering the mechanisms leads to an oscillation of the coil between the magnet array. Fig. 1 Experimental set-up: Coil attached to a modified



attached to a modified micro switch and surrounded

by four magnets. Results

Due to a high acceleration of the micro switch we could generate a maximum output energy of 1.74µJ at an oscillation frequency of w=653Hz for the first prototype. For the optimized generator we observed a maximum output energy of 16.55µJ per snap action cycle at an oscillation frequency of action cycle at an w=1230Hz.

Discussion

The generated output energy is sufficient to drive modern pacemakers. Furthermore, we reduced the overall size of the second generator prototype to fit



Fig. 2 Typical output signal of a complete bistable snap action cycle of the second generator prototype (R. as = 12003).

5 0 with a volume acceptable for prospective implantation into the right ventricle. would be a a cylindrical which 0.48cm² into

Bebby, Steve P., et al. "A micro electromagnetic generator for vibration energy harvesting." *Journal* of *Micromechanics and microengineering* 17.7 of Micromechanics and (2007): 1257.

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Acknowledgements

acknowledged. Special thank goes to Adrian Zurbuchen and Dr. Andreas Häberlin for their enriching advices. All members of the Cardiovascular Engineering group of the ARTORG Center in Bern are gratefully



AND ADDRESS OF u^b

Master's Thesis in Biomedical Engineering

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ntroduction

involves interactions that are still elusive. The aim of this master project was to estabilish a cyclically stretchable in vitro microvasculature that enables the investigation of the effects of cyclic distension on the microvasculat development. An existing microfludic platform allowing the formation of 3D Mechanical ventilation is a lifesaving tool to support patients with respiratory failure. However, this intervention exposes lungs to high tidal volume and can induce higher alveolar strain than during normal breathing. Ventilator-induced lung injury (VLI) is characterized by lung inflammation, increased vascular permeability and alveolar edema. The role 2 of the lung microvasculature in the process of VILI perfusable microvasculatures embedded in fibrin gel was adapted by integrating a system to mechanically cyclically stress the microvasculature.

Materials and Methods

A Stretchable Vasculogenesis (SV) chip was designed and microfabricated by soft lithography and rapid prototyping technique. The 100µm high microvasculature chamber was sandwiched between two thin circular membranes of 1.5mm Ø. 3D imaging of the microvasculature chamber filled with fluorescent fibrin gel, at rest and stretched, enabled optimal fabrication parameters to be parameters to be

established. established and on chip, the breathing started on day 7, it consisted of a cyclic deflection generated by a home-made "breather" enabling the deflection of the microvasculature at a frequency of anisotropy of endothelial cells (primary C) was assessed by immunostaining (phalloidin) with the FibriTool plugin in Fiji. Three sub-regions per chip were selected and the plugin returned corresponding values (0 to 1), 1 being the 12/min with a negative pressure of 22kPa. The actin maximal anisotropy. HUVEC) fiber



Fig. 1 SV Chip: 110p layer 2 vasculogenasis ayer, including the top membrane 3.Bottom membrane 4.Actuation ayer 5 class such 5 connection for breather 7. Tokie (Chiltorovasculates Chamber (Chi) forum kramites for medium (SC)Side chambers for periciple culture.



The microvasculature chamber with 7 supporting pillars (Ø 100µm, 1 in the middle and 6 located around it) was sandwiched between two thin Results

microvasculature was measured to be 7% of linear distension. Anisotropy of actin filaments in the stretched chip was 0.18 ± 0.04 , and 0.11 ± 0.01 in The amplitude of the mechanical strain of the the static chip (p=0.086) nembranes.



Fig. 2 (A) Microvasculature after 24h-cyclic actuation. (B) Control microvasculature. (Red bai) Direction and langth of the Bar represent the crientation and the arisotropy level in the sub-region.

Discussion

stretched microvasculature, confirming data from the literature. The amount of measurements should be increased to corroborate the results. enabling the investigation of the effects of omnidirectional cyclic stretch on 3D microvascular network. We observed a tendency towards higher alignment/anisotropy of actin cytoskeleton in the new platform was designed and produced

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team of Lung the ARTORG, team Acknowledgements Great thanks to the whole t Regeneration Technologies at especially Colette A. Bichsel.

[1D based on Multiple Physiological Parameters and Real Time Detection of Hypo-/Hyperglycemic Events in Individuals with Adaptive Data-Driven Models

Samuel W. Mosimann

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Introduction

(EVNS) proved itself to have great promise. The aim of this study is to augment the EVNS by incorporating not only glucose and insulin data, but also food and sercisting information, the key element being potential improvement of early Prompt recognition of imminent hypoglycemic and hyperglycemic events is crucial in preventing the onset of pathologies caused by abnormal blood diabetes care technologies allow the user to obtain regular suboutaneous glucose readings with consistent dose assessments. However, an alarm predicting abnormal glucose levels prematurely would be more beneficial. The early warning system Currently, advanced glucose concentration to individuals with type 1 diabetes mellitus (T1D). Currently, advanced detection of abnormal metabolic stages.



Fig. 1 Flowchart of the early warning system (EWS). First linear and nonlinear prediction models estimate blood glucose level up to 45 minutes ahead. Fusion of the glucose level up to 45 minutes ahead. Fusion of the predictions is performed as second slage. A decision agorithm utilimately elicit appropriate alarms

Materials and Methods

With the aim to improve the reliability of linear and normear dista-driven models, experiences on 10 virtual and six real individuals with T1D were conducted (MATLAB R2014b). *In silico* data of continuous glucose monitoring (CGM) reading, insulin injections, and food intake were produced by the FDA accepted UVa/Padova T1DMS simulator under different meal scenarios. Real data of sensor glucose, insulin pump, food intake, and physical activity were collected from six individuals with T1D pump (SAP) therapy trial register NTR02068635). Prediction horizons of 15, 30, and 45 minutes were investigated with augmented adaptive online linear autoregressive models with output correction module (cARX) or/and Kalman filtering (ARXK and cARXK) as well as nonlinear Elman recurrent neural (age 22-29 years, HbA1c 6.83 \pm 0.75 %, body mass index 24.79 \pm 4.71 kg/m³) under sensor augmented network (ERNN) with unscented Kalman filtering (UKF) learning algorithm. To efficiently combine



approaches while following the inter- and intra-subject variation, online adaptive fusion through particle filtering was proposed. Finally, an already developed extreme learning machine (ELM) module has been added on the fused predictions to further complementary advantages of linear and nonlinear improve results.

incorporating all available physiological information. Coupled to an ELM, the EWS is capable of preciding the cocurrence of a giveenic event 20 minutes in advance with a detection sensitivity of 100% and one daily false alarm. Results The most satisfactory performances in terms of accuracy and detection time are obtained through a hybrid system based on an online adaptive association of the cARX with the ERNN

Discussion

patients thanks to early glycemic detection. Since the prediction horizon exceeds 15 minutes, an abnormal glycemic event can easily be avoided by appropriate insulin injections or restinctions. While future research will include the integration of the EWS into a control algorithm for an antificial pancreas, the models and nature of the fusion should be further investigated and critically The new dynamic hybrid system provides a powerful clagnostic tool with the potential of drastically reducing the pathological trends in evaluated on more real individuals

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Acknowledgements

The important contribution of the department of endocrinology and volunteers with T1D of Bern University Hospital "Inselspital" is gratefully acknowledged.

11

AN INCOME. u^b

Integrating Quantitative EEG Analysis Algorithms into Simultaneous EEG-fMRI Studies in Epilepsy Patients

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interictal spikes. Currently it requires visual analysis of EEG signals by clinical experts. Automation of this step is desired to objectify the procedure and Epilepsy is a serious neurological disease affecting about 1% of the general population. Diagnostics (EEG). Localization of brain areas involved in epileptic activity helps to characterize the underlying syndromes and is a crucial step to evaluate the potential of surgical treatment. The seizure onset zone (SOZ) is best determined using peri-seizure magnetic resonance imaging (IMRI) enables delineation of the irritative zone (IZ) causing relies in a large part on electroencephalography Simultaneous recording of scalp EEG and functional EEG as recorded from intracranial electrodes enable analysis of large data sets. Introduction

Materials and Methods

A variety of quantitative analysis methods to reveal properties of intracranial EEG (IEEG) data has been developed at the Inselspital in the past fifteen years. The task of this thesis was to evaluate, wheter these algorithms can be applied on scalp EEG to complement visual analysis. Indicators of epileptic activity (predictors) were calculated from a variety of algorithms and correlated with regional changes in cerebral blood oxygenation as measured by fMRI. Results were compared to predictors that are currently in clinical use and to the literature.



Fig. 1 The default mode network (DMN) with its core nodes medial pretrontal cortex, precuraeus and interior parelal cortex, deachrated during interictal epileptic decomposi in idopathic generalized activity. (Visualization in radiological convention).



the functionality of the algorithms. The threachold in SNR limiting the avplanatory power of the measures lies between the documented SNR values of scalp and intracratial EEG. When applied on scalp EEG, the examined agorithms could not indicate epideptic activity reliably and stable. Various attempts to improve the procedures remained ineffective. Main differences properly were considered and the influences of parameter for to intracranial EEG where all tested algorithms work crucial properties were investigated in numerical simulations. The signal to noise ratio (SNR) of the EEG data turned out as the critical Results



Fig. 2 Power of one tested quantilative EEG measure to discriminate between interactal and class signals in dependence of the SWR and the used signal length (1) in seconds. Discrimination is approximately possible for values above 3 (z - pvalue 0.001). The SWR of iEEG is documented to be always >2 and that of scalp EEG to be 0.6 or considerably before.

Discussion

Crucial criterion is apparently the fundamental difference in SNR between these work years of EEC. This finding precludes the examined methods from randysis of scape EEC recordings and thus their intended use to complement the current analysis pipeline for simultaneous EEC-MMR of epilepsy developed and successfully tested on IEEG signals have severe difficulties when applied to scalp EEG. Quantitative EEG analysis algorithms that were patients.

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Guidance System for Surgical Interventions in the Ear High Accuracy, General Purpose Stereotactic

Christoph Rathgeb

Supervisors Prof. Dr.-Ing. Stefan Weber, Tem Williamson Institutions: Artorg Center, Universitat Bern Examiners: Prof. Dr.-Ing. Stefan Weber

Introduction

of the temporal bone, the field of otologic surgery is ideally suited for IGSN. However the very small anatomic structures in the ear typically mean that ctologic IGSN systems require submillimetric coursey, furthermore the size of such a system should somehow reflect the narrow and small workspace. The aim of this work was the workspace. The aim of this work was the development of a navigation system that enables high accuracy navigation and straightforward OR integration for surgery on the lateral skull base. Image-guided surgical navigation (IGSN) can provide a number of advantages over traditional surgical techniques in a variety of surgical fields and for a variety of procedures. Given the rigid structure

Materials and Methods

the position data is further transmitted to a tablet by Bluetooth (the hardware components of the system are shown in Figure 1). The software pipeline is responsible for preprocessing virtual patient data, guide the user through the registration setup and The navigation system is based on a hardware and software pipeline. The hardware pipeline processes the real world position data of a surgical tool acquired by a tracking camera. A tracking controller calculates and compresses the position data. Finally finally enable real time tracking.



Fig. 1 Components of the navigation system: a high accuracy tracking camera, tracking controller, a tablet, markers, a pointing device and cables.

inspection / navigation and registration view. Both a fiducial based registration and a surface matching based registration are supported. After the system A preprocessing software converts and optimizes the planning data from a custom surgical planning software [1] for further use on the tablet. The actual navigation software is implemented with Unity3d. The application consist of a data import, data



is successfully setup, real time tracking in 2d and 3d of surgical tools relative to a patient reference marker is enabled. The developed user interface is shown in Figure 2.



Fig. 2 Real time tracking in 2d and 3d using the navigation software.

Results and Discussion

components of the system can be carried in a suitcase and intra-operative set up requires less than 5 minutes. The accuracy of the fiducial based accuracy of 0.1mm ± 0.04 mm in a ground truth phantom truth/12/1 me eo fno.ncm.mastve surface registration produces less accurate results and needs to be further developed and optimized. of the art systems. Furthermore, the hardware configuration simplifies the intraoperative set up and removes many of the integration problems associated with existing devices. The major The major E Future work will focus on the development of non-invasive registration techniques and the clinical evaluation of the system in the OR. The developed navigation system demonstrates higher accuracy and lower noise than existing state demonstrated registration has previously

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Acknowledgements Thanks to the IGT group at the ARTORG Center, Thanks to the IGT group at the and assistance and Cigla Dirr for elinical advice and assistance and Mazic Gaverscotic for higher level input into the system and setup. Special thanks also go to my supervisors Prof. Dr.Ing. Statan Weber and Tom Williamson

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Validation of a novel in vitro bone resorption assay

Lorenz Rordorf

Supervisons: Prof. Dr. phil. nat. Willy Hofstetter Institutions: Group of Store & Rody Dispertment of Clinical Research. University Bern Examiners: Prof. Dr. phil. nat. Willy Hofstetter and Dr. Rete. Usgrbuhl

Introduction

To assess the resorptive activity of osteoclasts in vitro, in the past, several experimental systems were described [1]. These methods are limited by changes in bone resorption to osteoclass development or activity, the considerable intra- and inter-assay variations and the limitation of a 2D assessment of a 3D process. The aim of this study different factors, such as the impossibility to assign changes in bone resorption to osteoclast is to separate the formation of osteoclasts from the resorption phase and to provide osteoclasts with a homogenous substrate to improve reproducibility of the results.

Materials and Methods

of the cells by decreasing the temperature. For this purpose, PCF were cultured for 5 days and after phosphate substrate (CaP) for resorption. To assess CaP dissolution, Ca³⁵ was included as a trace. Subsequently, Ca⁴¹ were induced as a trace. Subsequently, and the meeting during resorption was quantitated. To investigate the modulation of osteoclast activity, inhibitors of bone resorption like resorption phase, osteoclast progenitor cells (OPC) were grown on culture dishes that allow the release To separate development of osteoclasts from the Ibandronate) and calcitonin (CT) were used in the Alendronate (Chlodronate, bisphosphonates resorption assay.

SEW For the histological characterization of active osteoclasts, the formation of actin rings assessed



Fig. 1: Actin and Hoochst staining: Mature actoclasts were transferred onto calcum phosphate and resorption was salowed to proceed for 24 hours. Threetife, the exits were stained for actin and nuclei were visualized with Hoechst 33342.

by investigating the gene expression of differentiating cells. For this purpose, the expression of transcripts encoding the osteoclastic enzymes Osteoclast development was further characterized



cathepsin K and TRAP was quantitated Further genes included in this part of the study were DC-STAMP, OC-STAMP and OSCAR. Results

bioxed by CT. The novel resorption assay allowed the characterization of the potency of the bisphospharaterization of the potency of the Alendronates tested so far (Ibandronate > Alendronates CTRAP activity in cell tysates was increased in cells that were inactivated TRAP activity in cell lysates, and therefore the number of osteolcasts, was not increased during the 24h resorption phase. The release of Ca45 was inhibited by bisphosphonates and was completely was was found that the number of active osteoclasts. Lastly, was found that the number of actin rings wa correlated to the release of Ca⁴⁵



Discussion In this study, a novel in vitro resorption assay, based on the release of Ca¹⁵ from spiked CaP layers, was characterized. The validity of the assay was demonstrate bisphosphonates

References

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Fig. 2: Card release with coaled and added bisphos-prionales during 24 hours or resorption. Osteocrists are seeded on Car Prasted on one hand with osteorini an on the other hand, with different bisphosthonates ((1=6))

demonstrated by the inhibitory effects of topphonates and CT. The potency of the bisphosphonates was in agreement with previous data (lbandhate-Allentionates-Allentionates)[2], Furthermore, a correlation of actin ring formation and osteoclastic activity was shown.

resorption activity using calcium phosphate coating combined with tabled polyanion. Analytical Biochemie 410 (2011) 7-12 [2] Rogers et al. (2000) Cellular and Miecular Mechanisms of Action of Bisphosphonates, Cancet. Jun 15;86(12 Supp):2961-78

Assessing Sleeping Disorders through Measurement of Sleeping Quality

Kevin Schwab

Supervisor Prof. Martin Kucera Imatutions: Instantie for Humon Centered Engineering, Bern University of Applied Sciences Examines: Prof. Martin Kucera and Prof. Dr. Volker Koch.

Introduction

well-being. However, there are numerous sleep disorders witch affect the quality of sleep. One of the sleep blocders is beep apriva is characterised by a complete or partial obstruction of the upper ainways cuming sleep. This obstruction is due to the relaxation of the muscles of the tongue behaviours using this method can be performed at home, where most people have the best sleep. Furthermore, they allow to reduce the medical A healthy sleep is important for the health and the 2] A method to diagnose sleep apnea are portable monitoring systems. The analysis of sleep root which leads to a deoxygenation of the body [1 costs.

Materials and Methods

prototype system have been developed to demonstrate the feasibility of using the wretess technology to detect sleep prova. This portable monitoring system consists of three small sensors Hardware and software of a portable monitoring which allow to measure the subject's breathing and oxygen level. An Android tablet is used to record between the sensors and the tablet is wireless using the Bluetooth low energy (BLE) standard (Figure 1). to analyse the data. The communication energy (BLE) standard (Figure 1) and



Fig. 1 The schematic overview of the portable monitoring system shows where the sensors are placed on the body to record the signals.

Results

accurately detected. The pulse oximeter (POX) measures the pulse waves. The pulse waves are used to calculate the modulation ratio R and to respiratory frequency of approximately 7.6 breaths per minute and that it is possible to detect a The results of the thermal sensor (TS) show a breathing interruption (Figure 2). The results of the respiratory inductance plethysmography sensor (RIP) indicate that deflections of 2 cm and more are extract the heart rate (Figure 3).





Fig. 2 The tracing shows a simulated breathing interruption around the point of 80 s. The extracted respiratory frequency is approximately 7.6 breaths per minutes.

" MANY MANY MANY "





Fig. 3 This chart represents a record of the modulation ratio R and the pulse waves. The extracted heart rate is approximately 78 bpm and the modulation ratio R 0.73.

Discussion

The novelty, compared to other portable monitoring systems, is the fact that each sensor is individually connected through a Bluetooth low energy (BLE) can be placed on the body without any sensor cable restrictions. This allows the patient to sleep well so link with the master device. Therefore, the sensors a more realistic evaluation can be obtained

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Acknowledgements

All members of the laboratory in Burgdorf and my supervisor Prof. Martin Kucera are gratefully acknowledged for their advice and support.



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1.

Advanced Intracranial Electrode Localization using Multimodal CT and MR Imaging

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ntroduction

Implanting intracranial electrodes is one of the most widely used procedures to locate the epileptogenic location of the seizure onset zone and its relation with eloquent functional areas is an important prerequisite for the planning of a possible surgery. We propose a new method to automatically localize subdural electrodes (strips and grids) and depth electrodes in a post-operative CT and project them onto the cortical surface extracted from a prezone in patients suffering from epilepsy. The precise operative MRI.

The contact points found are then grouped using a new score-based maximization algorithm. For each contact point, the normal vector is computed Finally, the coordinates of the contact point are Materials and Methods First, CT and MRI are co-registered based on First, CT and MRI are co-registered based on mutual information. Subsequently the contact points of the electrodes are localized in the CT image projected along the vector onto the contrical surface to compensate for post-operative soft tissue deformation. Electrode positions can then be for post-operative soft tissue image using a threshold-based segmentation algorithm a medical processing software such as 3D Slicer. exported and rendered in



Fig. 1 Grid (blue) and strip electrodes (green, krown) projected onto the cortical surface. Without projection, the electrodes would be rendered below the surface. Image rendered in 3D Sker.



Results Both Sensitivity and precision for the electrode Both Sensitivity and precision for the electrode as 98%. Electrode grouping was measured as fully detected (all contact points are correctly assigned to an electrode) and partially detected. Here, we achieved over 70% of fully detected electrodes.



Fig. 2 Example of a patient with 11 electrodes implanted. All are fully detected. Depth electrodes (dark green and purple), all others are strip electrodes.

Discussion

contributes significantly to a reduced workload for clinicians. However, the precision of the electrode projection could not be measured due to a lack of Our proposed method allows rapid and precise localization of different types of electrodes. The approach is fully automated and therefore ground truth data (e.g. intra-operative photographs of the electrodes in place). Additional research and clinical studies are needed to investigate this topic.

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Analysis and Optimization of the Cutting Performance of Surgical Drill Bits for Cortical Bone

Marcel Schweizer

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Introduction

necrosis due to temperature generation. There were three major goals of this project: to generate a standard test plan and method for the industrial cutting performance of state-of-the-art orthopedic drill bits and 3. to create an optimized drill bit design and compare it to the state-of-the-art orthopedic drill surgery. Clinically, it is important that these drill bits require minimal force during the drilling process to Bone drill bits are commonly used in orthopedic allow for precise drilling, remove the bone chips generated during drilling and do not induce bone testing of orthopedic drill bits, 2. to analyze the bits.

Materials and Methods

during drilling in bovine bone and 4 bone substitute materials (SFFE, PUR-40/50, BoneSim1800) to find A test setup was defined to measure axial reaction force, wear influence and temperature development

a more readily available substitute for bone. Additionally, 3 state of the art orthopedic drill bits (Stryker, Zimmer, Synthes) and one other drill bit (Bosch), were compared with regards to the parameters defined above.



Fig. 1 Temperature development in bovine, measured with FLIR IR camera.

Further modified drill bit designs were generated to study the influence of various drill bit parameters on their performance in orthopedic surgery.

because this prevents clogging of the flues with bone chips. However, they were measured with the worst cutting performance in bounce bone. The Synthes drill bit with the sharpest cutting edge and largest relief angle showed the lowest thrust force, but the highest temperatures in bovine. Of all the All tested drill bits showed signs of wear, which increased the thrust force needed to drill. The Zimmer and Bosch drill bits with the largest helix with electropolishing achieved a significantly improved curling performance in bovine bore. The optimized drill bit D2 with a large taper produced the lowest temperatures of all designs which were optimized drill bits, only the surface modification angles showed the lowest temperature development based on the standard Synthes drill bit Results

Discussion

wear or temperature development comparable to could be shown that none of the artificial bone substitute materials showed a cutting performance bovine bone.

The results showed a trade-off exists between cutting performance, temperature development, and the wear rate of a surgical drill bit.

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Acknowledgements The project was supported by DePuy Synthes (Synthes GmbH, Zuchwil).

AND ADDRESS OF u^b



Influence of TAVI stents on valve kinematics and coronary perfusion, tested in a systemic in vitro flow circuit with coronaries

André Schwery

David Hasler ARTORG Center, University of Bem Prof. Dr. Dominik Obrist and Dr. Stefano de Marchi Supervisor. Institutions: Examinens:

ntroduction

The objective of this master thesis was to investigate the influence of transcatheter aortic valve implantation (TAVI) stents on the coronary perfusion and the valve kinematics using an experimental flow circuit with an attached coronary network model. A previous study by Moore et al. achieved a near physiological coronary flow rate using a similar in vitro flow loop with one coronary pranch [1].

piston pump reproduced physiological flow conditions. An acute root with left and right coronary ostium was fabricated by silicone casting using an aortic root negative model as core. The coronary network consisted of a left and a right branch connected to the aortic root. A physiological cornary flow in both branches was set with adjustable resistors and an inframyocardial Materials and Methods A systemic in vitro flow circuit with a connected collapsing capillary in the left branch, contracted by the regulated left ventricular pressure. In the flow circuit a 27 mm Carpentier-Edwards 2625 aortic /alve (Edwards Lifesciences, Irvine CA, USA) was n house produced framework was mounted on the sutured into the annulus (Fig. 1). A long and a short aortic valve to mimic the obstruction of a TAVI stent



Fig. 1 Carpentier-Edwards 2625 aortic valve with the short **FAVI framework mounted**

coronary flow, measurements with both frameworks were compared to a baseline measurement without To quantify the influence of TAVI stents on the ramework. The valve kinematics in all measurements were recorded with a high speed camera.



Results

We achieved a physiological flow in the left and the right coronary branch (Fig. 2). No significant coronary flow rate difference was measured with TAVI frameworks mounted compared to the baseline measurement without framework. However, the frameworks caused the valve to stay open for a longer time and to close faster.



curves and left ventricular and acritic pressure curves of the baseline measurement without TAVI stent. Fig. 2 Physiological left, right and total coronary flow rate

Discussion & Conclusion

perfusion, but the perfusion could be influenced by native leaflest pushed over the coronary octa during TAVI procedure. The varive kinematics were influenced by the TAVI stents, and further investigations are suggested to define the flow phenomena in the aortic root affecting the valve TAVI stents did not decline the coronary closure. The

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Acknowledgements All members of the Cardiovascular Engineering group of the ARTORC center in Barm are gratefully acknowledged Special thank goes to David Hasier and Prof. Dr. Dominik Obrist for their enriching advices

Image-based Intraoperative Evaluation for Minimally Invasive Cochlear Implantation

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Introduction Minimally Invasive Cochlear Implantation (MICI) requires a tunnel to be drilled less than a millimeter from critical anatomical structures such as the facial nerve. An intraperative evaluation system has been developed for the robotically performed, image guided MICI procedure using the system described in [1]. Based on intraperative core beam computed tomography (CBCI) images, the approach provides high accuracy, automated evaluation of the drilling accuracy and of the risk posed to the facial nerve. Addiconally, the approach provides secondary means for the surgeon to evaluate the safety based on the augmented intra-operative image data that is minimally reliant on image registration accuracy.

Materials and Methods

For intraoperative evaluation, the access tunnel to corbie ais planned in two segments. After difiling the first segment (3 mm before the level of facial neve), CBCT scan of draped situs is acquired. The augmented intraoperative images are presented to evaluating surgeon. In case of high drilling error or insufficient distance to the facial nerve, the system segmented facial nerve and intraoperatively segmented drilled tunnel is calculated (Fig. 1) and intraoperative images are segmented and registered to preoperative images using Computer-Aided Design (CAD) models of the rod and screws. The minimum distance between preoperatively warns the surgeon about the risks of damage to the intraoperative facial nerve.



Fg. 1 Intractorrative images acquired during a cadaveric study by using xCAT (XORM, USA). The CAD model of root is matched with segmented tunnel and facial nerve is transformed to intracoperative coordinate system.



studies, allows the drilling path error and safety margin to the facial nerve with a maximum error of 0.13 mm by comparing it to the post-operative analysis using manual segmentation as ground truth (fale 1). The system additionally assists the surgeon in a secondary manual safety evaluation with minimal interference from image registration validated in cadaveric The evaluation method, Results error.

| Distance to Facial Nerve | (postoperative) | (m m) | 1.35 | 0.40 |
|-----------------------------|------------------|-------|------|-------|
| Distance to Facial Nerve | (intraoperative) | (mm) | 1.26 | 70.07 |
| Case | | | - | c |

Table 1 shows the results of cadaveric studies performed with intraoperative evaluation method.

Discussion

complexity of as effects of metallic rod on intraoperative images. In the future, automated evaluation may lead to reduced surgeon suggested that benefits such as improved surgical confidence and better evaluation of drilling accuracy studies are however, required in order to confirm the effect of the evaluation solution on surgical robotic drilling experiments on cadavers demonstrated an accuracy of 0.13 mm and may result from the use of proposed computer Further efficacy Invasive strain and development of better imaging system minimally intraoperative evaluation as well as parameters such as time and assisted automated evaluation. Validation of the system in with reduced artefacts

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Acknowledgements Special thanks goes to Dr. K. Gerber, N. Gerber and T. Williamson for their graceful support during the project.

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Sensor Fusion of Inertial Motion Sensors and Visual Pose

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Prof. Dr. Philippe Cattin Medical Image Analysis Center (MIAC), University Basel Robin Sandkuehler Supervisors: F Institutions: N Examiners: F

wide range of navigational applications. Traditionally, the sensors are used in the navigational field of aircraft, missiles, spaceoraft and ships. Recent improvements in the size and ships. Recent improvements in the size and increased interest to incorporate IMUs in the domains of human motion capture. Fusing the necessary to overcome error characteristics of the IMU. The incorporation of inertial sensors into a visual pose estimation system was evaluated in this nertial motion sensors (IMU) are being used in a nertial data with other input sources is often ntroduction study.

sensors. Sensor fusion was achieved with the Unscretted Kiaman Fitter (UKC). The inertial data was used as control input during the prediction stage of the UKF algorithm. The inertial pose estimation was then updated by the visual measurements in the correction stage. Measured variances were used to determine the reliability of A commercially available Android tablet device was used to fuse the integrated inertial sensors into a visual pose estimation application. Calibration of the IMU was performed to reduce the bias of the inertial he inertial data Methods



Fig. 1 Schematic of the fusion of IMU and carnera pose estimation with the Unscented Kalman Filter.

The accuracy of the inertial sensors and the precision of the fused data was evaluated. For the use case that the visual input signal is lost, the prediction by the inertial pose estimation was compared to the actual pose.



The sensor fusion with the UKF provided a computational efficient and accurate pose estimation. The calibration of the IMU provided higher stability of the inertial readings. Accurate inertial positioning over long time periods remains problematic. Results

Fig. 2 Calityrated accelerometer data and companisated gravity component (green) led to an improved linear acceleration compared to the sensor of the Android nework (blue)

Discussion

Calibration and handling of the IMU data is a delicate task. Small calibration errors can already lead to erroneous data. The type of motion performed influences the sensor reading as well. The inertial pose estimation may be used to reduce the region of interest to visual detection or tracking algorithms. With the LKF, other input sources might be considered to be fused with the existing application.

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Acknowledgements The project was supported by the Medical Image Analysis Center of the University of Basel. Thank goes to Prof. Dr. Philippe Cattin for the assistance and providing me the opportunity to realize this work.

Biphasic hyperelastic model for a particulate bone regeneration material and mechanical strains in augmented vertical dental defects

Niklaus G. Stiefel

Supervisors: PD Dr. Philippe Buchler and PD Dr. Single Schäffer Institutions: Institute for Support Technology & Bonnehamics, Universität Bam Material Discovery Research, Gesclich Pharma AG, Wohlusen Examinens: PD Dr. Philippe Buchler and PD Dr. Bingt Schäfter

Mechanical stimuli are essential for maintenance of human borne tassue. In dentistry, the mechanical loads are transferred to the gaw by the teeth. For this reason, edentulous jaw bone experience The aims of the thesis were to develop a constitutive mechanical model for a particulate bone regeneration material and to assess strains jaws, regeneration of bone is necessary to allow implant placement. Particulate bone regeneration materials, stabilized by titanium meshes, titanium reinforced-PTFE or resorbable polymer membranes, occurring during the early phase of large dental regeneration. Another goal was to evaluate the mechanical stabilization of the regeneration material progressive bone resorption. In severely atrophied provided by a polylactid acid membrane implanted are used as a scaffold to guide bone regeneration around the reconstructed part of the jaw.

A highly porous hydroxyapatite based particulate bone regeneration material uses mixed with simulated blood ofto to reproduce the material used in the clinical setting The mechanical properties of



Fig. 1 Particulate bone regeneration material embedded in a simulated blood clot after mechanical testing and festing after mechanical a simulated blood clot afte uncasing of the sample holder.

providence by approximation mean of a contribution providence of a contribution by the second of the parameter identification was performed using particle swarm minimization algorithm combined with Abaqus mechanical simulators linear leastic models were used to simulate the behavior of the polyacid acid material regeneration bone particulate nembrane.



Introduction

Materials and Methods

the regeneration material were tested experiments using submerged confined creep and step periments at 37 °C. The elastic modulus of a dental polylactici acid membrane was determined under tensile loading at 37 °C.



the t the mechanical behavior To simulate



Finite element models representing typical jaw defect were produced to evaluate the strain occurring during bone regeneration of large occurring during bone regeneral horizontal and vertical dental defects.

Results

A biphasic reduced polynomial compressible hyperelastic model simulated the behavior of the photoclate bone regeneration material and the blood ofd accurately.



Fig. 2 Typical result of FEM simulation of defect.

regeneration material is used alone, it experiences large strains. In stabilized defects, strains are reduced. The resulting strains, hydrostatio pressures and fluid flows were compared to the Simulations of large horizontal and vertical defects at physiological loadings enabled the simultaneous calculation of strains, hydrostatic pressures and fluid flows in the tissues. If the particulate bone values known to enable fracture healing in long bones^[2]

models are behavior of particulate bone regeneration material. This model can be used to better understand the bone Discussion Biphasic compressible hyperelastic suitable to model the mechanical regeneration mechanisms in dentistry

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The project was supported by Geistlich Pharma AG. Acknowledgements

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Master's Thesis in Biomedical Engineering

Tobias Stöckli



Introduction

recording capability and low atrial sensitivity. Long-term esophageai ECS (eECC) might provide a way out, but a dedicated recorder is lacking. A novel eECG is currently developed at the HuCE. This recorder stores up to 30 days of eECG data that has to be react-ut and processed off-line. The goal of this thesis was to design a docking station to get access to the memory inside this recorder. to diagnose AF. To detect paroxysmal AF, i.e. rare episodes of AF, long-tern rhythm monitoring is required. However, the surface ECG has a limited Atrial fibrillation (AF) is the most common sustained it's prevalence constantly increases with the aging. Surface electrocardiogram (ECG) is routinely used arrhythmia, and is associated with significant morbidity and mortality. AF is age-related and, thus

Materials and Methods

The second set of the measurements, on sample that have thickness for on 0.6 to 2.1 mm. The second set of the measurements, on sample that have thickness in fig. 1) was designed using the second set of the set of the second set of set of the second set of the set of the second set of the second set of the set The connection to the memory was realized with sping contracts (connacts) that were subsequently investigated with two set-ups. A set-up consisting of contacts allow to measure how well the contacts were done with five samples of each material.



Fig. 1: CAD rendering of the set-up consisting of (i) spring contacts. (ii) recorder prototype. (iii) the centering pins. (iv) upper and (v) lower guidance.



The centering mechanism and the power supply of the recorder through the pins (iii) were successfully tested on the current docking prototype. The guidance turned out to be precise enough to provide a reliable operation. The forces required to contact the pins were extensively measured (see Fig. 2). I should mention that the force was dependent on the thickness of the layer, as expected, but the force was high in particular. Results



Fig. 2: First contact forces on the two sample types stypard 184 in red (x=0.727, SD = 0.66) and Sturan 2440 in blue (x=0.885, SD = 0.25), in green the contact's spiring force (0.751)

Discussion

The measurements showed that this connection-concept is promising. For the centering of the recorder and its power supply issue, a reliable solution vas found. Unfortunately, the force to prefate the shell is too high for the chosen contacts with a sping force of 0.75 M. The biocompatible silicone (Silipuran) turned out to have an even higher mechanical resistance to the contacts as compared to Sylgard.

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Acknowledgements

All members of the HuCE microlab are gratefully acknowledged. Special thanks are given to Thomas Niederhauser for his great support during the whole thesis.

Comparison of Functional Pressure Indices of Myocardial Ischemia with Electrocardiography

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Supervisors: Dr. med. Minkel Stora and Dr. phil. Thomas Neterland under the Manual Storage Storage and University of Barn. Desamment of Cardology, Bern ARTORO Centre Displayed Equipment of Research University of Parnameter Cardology. Bern Instances Cardonades Equipment Storages Starebard Storages and Dr. mark Stefano de Marchi. Dr. mod. et phil. Andreas Headonfin and Dr. mark Stefano de Marchi. Dr. mod. et phil. Andreas Headonfin and Dr. mark Stefano de Marchi.

Introduction

of death in industrialized countries. In patients with chronic stable CAD, revascularization targets hemodynamically significant stenoses causing inducible myocardial ischemia. Miniaturized sensor-wire technology has enabled Coronary artery disease (CAD) is the leading cause

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Unctional pressure indices

functional assessment during coronary anglography. Commonly, these techniques rely on determination of the pressure gradient across a stenosis to determine its hemodynamic significance. However, pressure indices provide only an indirect assessment of myocardial ischemia an indirect concepts rely on simplified physiologic concepts.

In contrast, the intracoronary electrocardiogram derived from the angioplasty guidewire (icECG) provides an inexpensive, sensitive and direct measure of myocardial ischemia.

the intracoronary ECG during pharmacologic hyperemia with functional pressure indices of The aim of this project was to exploratory compare Materials and Methods myocardial ischemia.

Blood pressure signals (BPW) from patients undergoing invasive functional assessment for chronic stable CAD and simultaneous icECG Key points in the BPW signal were delineated using multiple high order moments (MHOM) to derive the instantaneous wave-free ratio (iFR) and diastolic FFR as functional recording available were retrospectively analyzed. fractional flow reserve (FFR),

pressure indices. The idc.CC before and at the end of 1-minute pharmacologic hyperemia was analyzed using the area-curve-length (ACL) method to determine ST area-curve-length (ACL) mathod the ST segment and T wave magnitude area as ECG markers for myocardial ischemia.

Results

relation between FFR and icECC indices of mycoardia ischemical awas found. However, individually, significant changes in icECG could be observed (figure 1, bottom) FR had excellent agreement, whi FFR as the reference, sensitivity 97%, specificity 92%. 122 coronary arteries underwent invasive functional assessment with simultaneous intracoronary ECG recording. During 1-minute steady-state mia, overall, no significant pharmacologic hyper





Fig. 1 Top Diagram showing functional pressure indices at test and during pharmacologic hyperama. *Publ.* and of distal coronary pressure to antic (effective prehusion) pressure. *FOR*, distablic factional diverse. *FFR*, pressure 2007, distablic factional diverse. *FFR*, factional flow reserve **Bottom** Evolution of IGEC0 indices of sciencia during pharmacologic hyperenta in the same patient.

Discussion

The between Pharmacologic hyperemia must be prolonged to 4 feature IOECG. automatic minutes for adequate comparison functional pressure indices and proposed algorithm offers autor detection for future studies. proposed ŝ

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Intervention of Functionally Nonsgnificant Stenosis, 5 Year Follow-Up of the DEFER Study. Journal of the American College of Cardiology, 49(21):2105– 2111,2007. N. H. J. Pijls et al. Percutaneous Coronary

M. R. Homaeinezhad et al. A high-speed C++/MEX solution for long-duration atterial blood pressure characteristic locations detection. Biomedical Signal Processing and Control, 7(2):151-172, 2012.

Acknowledgements

The project was enabled by the research team of Prof. Christian Seiler, who provided the analyzed dataset.

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Feasibility of Preterm Esophageal Signal Recording and Processing

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Supervisors: Dr. Thomas Niederhauser, Dr. med. Kerstin Jost and Dr. med. et phil. Andreas Häberlin Institutions: Institute for Vinumin Centreal Editation Sciences University Children's Hospital Basel – UKBS Research. University of Ban Examiners: Perio Dr. Josef-Gate and Port Dr. med. Swin Schuldse

ntroduction

respiration. Maturing of this ability serves as crucial indicator to release initials form the neonatal inten-sive care unit and is threafore of great interest. Swallowing and breathing must be recordination parallel to investigate maturing of their coordination. the capability to achieve this through the proximity of the electrodes to the diaphragm and the peris-talitic wave, which manifests as motion signal. To Preterm infants (born before 37 weeks of gestation) suffer from several complications like immature autonomous control which, inter alla, results in the inability to autonomously coordinate swallowing and acquire preliminary data, a single center pilot study luciding 15 preterm infants was search. Ecophageal measurements are done in several sequences during 5 days of inclusion. The ecophageal signals are correlated to the clinical standard data using predefined marks in the simultaneously recorded surface electrocardiogram (ECG) Esophageal biopotential measurements possess

Materials and Methods A dedicated data acquisition setup including a medical certified biopotential amplifier and an developed. Post-processing steps were applied to investigate the feasibility to extract respiration, esophageal peristalsis and ECG data out of the esophageal catheter was defined (Figure 1). Subsequently, a signal library in an adult showing providing morphological signal templates for respiration, esophageal peristalsis and ECG was acquired. Eligible recording software for the clinical data acquisition was developed and thoroughly optimized for clinical use. 6 patients were included in the study and measured so far. Software to display and evaluate the study signals was essential functionality of the acquisition setup and





efforts. These signals correlate well with the clinical standard monitoring data Swallowing and the induced peristaltic wave show a characteristic wander, whereas the corresponding diaphragm electromyogram (EMG) consists of higher frequency Figure 2 exemplarily shows the impact of respiration esophageal biopotential signals. Mechanical components and occurs only during inspirational deviation in the signal that is superimposed by other displacements of the catheter which impede distinct respiration manifests as low frequency baseline identification. Results 5



Fig. 2 Stationary wavelet transform (SWT) reveals dispforegm EMD activity and approximates baseline wantler which corresponds to respiration movement (I-Phase = Inspiration Phase)

Discussion

placements. In future, sophisticated algorithms need to be developed to enable the broad analysis of the diaphragm EMG as well as peristaltic waves can be recorded with dedicated esophageal electrodes. Additional effort is required to separate swallowing esophageal measurements. The preliminary recordhowever, show the potential of esophageal respiration activity and corresponding and peristaltic activities from other catheter disnonitoring to improve neonatal care in the future. Mechanical ngs,

Reference

Stattery et al., "Early sucking and svallowing problems as predictors of neurodevelopmental outcorre in children with neonatal brain injury. a systematic review." Dev. Med. Child Neurol., vol 54, no. 9, pp. 796–806, Sep. 2012.

Thomas Andreas Acknowledgements I would like to thank my supervisors Dr. Niederhauser, Dr. Kerstin Jost and Dr. J Haberlin for their encouraging support.

Development of a Hand Prosthesis Prototype with Tactile Sensory Feedback

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Ozan Ünsal

Supervisors: Prot. Dr. Volker M. Kooh and Dr. Tao U Buraulions: Instrue for Human Centered Egineening, HUCE - BME Lab, Bern University of Applied Sciences Examines: Prof. Dr. John Justiz and Dr. John Farserolu

Introduction

system for commercially available prosthetic hands, aming at rescoring senation of nucl. In order for the user to feel the possiblesis as a part of his or her body, the time delay from sensing pressures on the fingers to the haptic actuators should be less than 70 ms [1]. Commercially available myoelectric prosthetic hands are usually not exuptioned with feedback devices to deliver tactile information to the users. Therefore, amputees need to control the prostheeses with visual feedback, which is inconvenient and is a reason for prosthesis abandonment. We have developed a non-invasive tactile sensory feedback

Materials and Methods

Barometric pressure sensors were covered with salcome in order to measure externity applied forces. The measured pressure values are sent to a computer for real-time data processing via the Bluetooth Low Energy (BLE) protocol. After processing, proper advaton commands are sent to an actuator module via BLE again. Figure 1 shows the first prototype.



Fig. 1 The first prototype. 1, 2, 3 and 4 indicate sensor module, actuator module, microcontroller block and PC, respectively.

The first prototype was tested on amputees in collaboration with Dr. C. Anttolk from the University of Lund. Localization and intensity recognition with three types of stimulation (mechanolaciale, vibrotactile and hybrid) were investigated. Each



The correct answer percentage for stimulus localization was 98.7%. The percentage changed to 83.3% for the case where both stimulus intensity and focation had to be identified correctly. Figure 2 shows a confidential matrix with the answers of the Results



Fig. 2 Hybrid responses are shown in a confidential matrix. M and H mean low, medium and high stimulation intensity, respectively. Columns indicate the given stimulus and rows show the feedback from the subject.

concluded that stimulus point perception can be felt better with mechanotactile feedback. For correct stimulus intensity perception, vibrotactile feedback is a useful choice. In order to detect both stimulation point and intensity correctly, mechanotactile and vibrotactile feedbacks should be combined. Overall, it can be concluded that the developed prototype is answer percentages are quite high. It can also be These results are very promising since the correct able to give useful and distinguishable sensory eedback to an amputee. Discussion

optimal Ш References [1] T. R. Farrell and R. F. Weir, The of controller delay for myoelectric prostheses, I Systems and Rehabilitation Engineering, Fransactions 15.1, 2007.

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Benjamin Voumard

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ntroduction

allow immediate implant loading which requires an optimal surgery resulting in a high pimary implant stability. This necessifiates an evaluation of bone quality, commonly realized by resonance frequency analysis (RFA). The goal of this thesis was to develop an experimental goid standard for assessment of implant stability. annually with a success of 97 %. The desire arises to Over 12 million dental implants are placed worldwide

samples from bovine tible plateau. These 94 samples were machined hito cyrinders of 14 mm diameter and 13 mm length. In parallel, 6 poviurethane (PU) foam (a bone substitute) cyrinders of same dimensions were fabricated for comparison of their fluation properties with bone. After embedding in polymethy-1 methacrylate (PMMA), bone samples were scanned in a µCT scanner at 36 µm spatial resolution to obtain bone volume fraction (BVTV or 0) and anisotropy (fabrid). Samples were assigned to two groups having the same BV/TV distribution. The first group using a protocol for dense bone with a large drilling diameter and the second group using a protocol for soft bone with a small diameter. Implants were placed based on a standard surgical procedure. Controlled drilling was performed at a rate of 1 mm/s rating a CNC milling machine. Dental implants were inserted using an implantation device (Nobel Biocare) with an integrated torque measurement. Skty-seven trabecular bone samples were extracted rom human vertebral bodies and 27 trabecular bone **Aaterials and Methods**



we applied on the key points (ed) of the rew signal. The ultimate force (black) was detarmined using a first derivative condition. The yield point (yan) was calculated with an offset line (magnification). The siftness (black lines) was computed using the secant of the hind cycles. Cyclic damage test for a bovine trabecular bone sample a volume fraction of 38%. A cubic interpolation (green)

Bone-implant compound stability was investigated by low-cycle, large amplitude damage tests (Fig. 1). BV/TV and all variables from the superiar procedure analysed statistically with the experimental bone-implant compound stiffness and strength. RFA (Osstell) mplant stability was assessed by

Result

The degree of anisotropy (DA) was not dependent of BV/TV. Simes, and the uptimale force correlated with BV/TV ($^{1-0}_{-0.94}$ and $r^{1-0}_{-0.75}$, resp.) (Fig. 2.) insertion forque was a good predictor of sittiness ($r^{1-0}_{-0.96}$) and utilimate force $(r^{2-0}_{-0.94})$ RFA assessed byticit the stiftness ($r^{1-0}_{-0.77}$) than the ultimate force bytic the stiftness of the second predictor of sittiness of the second ²=0.74). Damage and accumulation of irreversible eformations were identical for both drilling deformations were identical for both drilling protocols. PU foam did not represent the variability of trabecular bone.



Fig. 2 Stiffness (blue) and bone-tinglant strength compound (green) consideral antilative well with those volume fraction Peareau. The dark and fight obtos reprosent human and confidenting processis respectively. Disks represent human and cicles bovine tradeocatia bone.

As expected, RFA reflects primarily stiffness of the bone-implant compound. The insertion torque is a good surrogate of bone-implant primary stability. However, the most relevant measure of stability for 5 able to assess primary stability for small and large deformations and allowed the evaluation of several intraoperative indicators. conclusion, the proposed experimental system was osseointegration remains to be clarified. Discussion

Acknowledgements

This project was supported by Nobel Blocare.

Optical Coherence Tomography Needle Probe for Robotic Assisted Cochlear Implant Drilling

Felix Wassmer

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Introduction

During the execution of the surgical procedure, a 1.8 mm hole is called through the margood into the cochied arymapic dreat care needs to be taken to avoid damage to the nervis factalis (factal nerve) and choid arymapic (taste) during the driling process. Therefore a method for early detection of these structures is needed. In this thesis it is investigated if Optical Cohenence Trongraphy (OCT) can be used as an image modality for nerve canal detection during cochlear implant drilling. nt (CI) called mastoidectomy. One promising method of intervention developed by the ARTOTG center at the University of Bern, uses a robot guided minimal invasive approach to bypass the mastoidectomy [1]. The current approach for cochlear implant implantation requires a surgical procedure mastoidectomy. One promising methor

Materials and Methods

scanning is enabled with a microelectromechanical miror. The output power of the probe is 9.5 mV/ Using a gradient index based rod lens which is housed in a tubing of 1.2 mm (-4 French) diameter, it is possible to access the 1.8 mm drill canal. viewing have been published, showing its use in minimally invasive surgery and as an image guidance system. To acquire images inside a drilled using state of the art optical design tools (ZEMAX) [Fig.1] as well as CAD software. Measurements were conducted on an acrylic rapid prototype phantom, as well as on a temporal bone sample of a pig. The bulk probe operates using a low coherence swept source laser (Santec) at 1900 nm wavelength with a bandwidth of 100 nm and OCT Various OCT probe designs, both forward and side canal, an OCT needle probe was designed and built



designed of the simulation setup 1 ZEMAX needle probe E.

Results

Calcar we want the acquired. Phantom measurements showed that it is possible to detect a 0.8 mm diameter hole which lies Using the endoscope system, A-, B- and 3D volume

approximately 0.2 mm lateral to the main endoscope canal Also it was observed that the addition of water increases the detection range up to 1 mm lateral of the endoscope canal. Overall OCT penetration was measured in pig trabecular. in a dry, as well as in a moistened sample. A d=0.8 mm bore hole which simulates a nerve canal was imaged through 0.2 mm of trabecular bone [Fig. 2]. bone. It was determined to be at maximum 0.5 mm æ



Fig. 2 COT image tracting transcript backerslow showing a dr08 mm nerve carel like structure (A) taken from the bottom surface of the endotectope canal (B). Longhudnes section (tablet). The acede on the lift sele indicates the optical path length m mm.

probe, operating at a wavelength of 1300 nm was designed. Image quality of the probe is limited by some perturbations which are induced by lens sufface reliections and could not be eliminated, but the source was identified. By adjusting the probe design for a future version, image quality can be A functional first prototype of an endoscopic needle Discussion

herve canal like structures of d=0.8 mm in pig temporal bone is possible. It is estimated that a nerve canal can be detected up to a maximum depth of -0.5 mm in *in vitro* and -0.3-0.4 mm in *in vivo* oconditions. Factors such as bone improved. With the built endoscopic needle probe, detection of mineralization, blood perfusion and probe angle may influence the depth in which nervous structures can be detected

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OCT

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Master's Thesis in Biomedical Engineering

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/alidation of a Batteryless Sunlight-Powered Cardiac Pacemaker

Sebastian Williner

 Lukas Bereuter and Adrian Zurbuchen ARTORG Center for Biomedical Engineering Research, Universität Bern Dr. med. Dr. phil. Andreas Häberlin and Prof. Dr. med. Dr. phil. Rolf Vogel Supervisors: Institutions: A

introduction

Today's pacemakers use a primary battery as a power source. When the battery is depleted, a surgical intervention is needed to replace the lifestyle and weather during different seasons, amongst others, are unexplored factors on the available energy that could be harvested. Therefore, ouilding a solar-powered batteryless cardiac bacemaker. This device would recharge itself using solar energy and prevent the inconvenience of a surgical intervention replacing the device. Research on the topic shows promising results, but an investigation in the long-term feasibility of such a device has not been done yet. The influence of a study will be run in which test subjects will wear loggers over a certain time span at different season. made towards solar-powered batteryless Efforts have been bacemaker. building

Materials and Methods

A portable measurement device (logger) that emultates the solar energy in anx-sering capacity of a solar-powered pacemaker was developed, the device simultaneously measures and stores the output energy of the solar cells. This logger is assembled with optical filters, which simulate the transmission properties of human skin, a solar cell module with electronics of human skin, a solar cell module with electronics of human skin, a solar cell module with electronics the harvest energy, and a pricult, which measures the output power and stores the values on a micro SD memory card. The device is battery provincial the device hardware and designed to have low power consumption. To ensure measurement accuracy the solar logger's power sense circuit was validated powered, WPLP battery software



Fig. 1 Solar logger with optical filter and elastic strap



for every measurement period was computed and visualized in a box plot (Fig. 2). The 35% confidence interval of all logger recordings used in the preliminary study is 83.28µW ± 32.04µW. This corresponds to a power per area of 23.13µW/cm⁺ ± 89µWcm⁺. July and August was performed. The mean power for every measurement period was committed and measurements give an idea of the energy preliminary evaluation of the data collected betwee conditions. lighting different for Example n collected Results



Fig. 2 Boxplot of the mean power values of 16 recordings

study is 25.6µW. This energy would be sufficient to supply a power-efficient pacemaker (~10µW). Due to the increased hours of sunshine during summertime, it can be assumed that the amount of harvestable solar energy during summer is larger than during the remaining seasons. The than during the remaining seasons. The continuation of the study will quantify the influence The lowest mean power value from the preliminary of the seasons on the available solar energy. Discussion

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Acknowledgements The ARTORS Cardiovascular Engineering group and the microtab at BFH Biel are gratefully acknowledged.

Fabrication and Characterisation of Aorta Models with Different Distensibilities

Jessica Wirz

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Introduction

in the snuses during systole and the distensibility of the snus contribute to a stress reduction on the valve leaftest [1]2]. The objective of this master thesis was to investigate the feasibility of creating different aord models over the range of human physiological distensibilities, which can be used to Today there are many different artificial heart valves which have different designs and hemodynamics. But not only the design of the heart values But not only the design of the heart valves influences their performance. The vortices that form investigate the mechanics of artificial heart valves.

Materials and Methods

The study by Jahren et al. [3] describes the valve kinematics of the Edwards Intuity sutureless valve. For the measurements a new experimental set-up was introduced. It contains a transparent aorta model to be able to capture the movement of the valve leaflets during the pressure cycle. In this master thesis several aorta models with the same geometry but varying wall thicknesses were created by applying the slicone (Elassoi IRT 601 AB) in layers to a negative model. To measure the distensibility the internal pressure of the aorta the distensibility was calculated. In order to predict the change in diameter using the wall thickness the actar model was assumed as an infinitely long tube. The thickness of the actar models was measured with an OCT system to investigate the regularity of models was gradually increased while the change in diameter was captured with a camera. From the change in diameter and the corresponding pressure the wall thickness



Fig. 1 The change in diameter of the aoria models at the ascending aoria.

Results

The approximation of the aorta models predicts the change in dameter of the ascending aorta well enough to be used as a guideline for the creation of new aorta models. The results show that the change in diameter is directly proportional to the



throughout the aorta model. Additional models with the same number of silicone layers showed that the overall thickness of the layers vary from layer to pressure change (Figure 1). Figure 1 also shows the increasing exactness of the movement the increasing exactness of the approximation with increasing wall thickness. The OCT measurements showed that the thickness of the silicone is not even

Conclusion

ayer.

of distensibilities by adjusting the wall thickness of the aorta models (Figure 2). However, the fabrication of aorta models with specific specific distensibilities is not possible with the current manufacturing method since the wall thickness can not be controlled with the appropriate accuracy. Fig. 2 Distensibility of the ascending aorta in healthy In conclusion it is possible to span the whole range with models



subjects at different age ranges [4]. The coloured lines show the distensibility of the acrta models at 40mmHg.

Opening and Closing De Paulis el al. References

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Acknowledgements

The project was supported by the ARTORG and the CVE Group. The support of my supervisor Silje Ekroll Jahren and examiner Professor Dominik Obrist is gratefully acknowledged.

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Sarah Zbinden

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ntroduction

Ultra-high resolution optical coherence tomography (UHR-OCT) has proven to be successful in the detection of laser lesions introduced in the retina by the adequate energy SRT only affects the retinal pigmented epithelium (RPE) layer in the outer retina. UHR-OCT might be used to monitor SRT selective retina therapy (SRT). When applied with reatment application if the amount of damage can be assessed automatically.

observer-independent binary classification. The validity of the animal model features was tested on clinical data. n this work, time-resolved point scans (Mscan) of ex-vivo porcine eyes were investigated with the objective of algorithmic detection of RPE lesions. Temporal optical changes in the Mscans were dentified and described to realize an automatic and

Materials and Methods

Experiments on porcine eves were conducted to collect UHR-OCT datasets of different laser energies of simultaneous laser release at the same changes related to laser micro-pulses were characterized according to their occurrence. Features were extracted from the Miscans and the retinal position. Mscans raw data were post-processed using Matlab and temporal intensity derived spectrogram (Fig.1). High variations of intensity pattern were detected by inspection in specific signal regions of depth and time scale.



Fig. 1 Overview of features preparation from the raw UHR-OCT Mscans images and spectrogram.



Results The features identified from the raw data OCT and

spectrogram images led to reliable detection of RPE damages. Ex-vivo porcine eves samples were classified with a performance of 99.616% (AUC of Fig.2).



Fig. 2 Receiver Operating Curve of 153 ex-vivo porcine eyes Mscans 50-fold cross-validation with 70% of the data in training set.

Out of 15 clinical Miscans data 14 were classified right according to the current gold standard assessment. The tests were based on the experimental data.

Discussion

lesions with a high performance (0.996). The high constation with the standard assessment method reinforces the hypothesis that optical changes in the measurement data scale with tissue damage. UHR: OCT time-resolved point scans showed the potential to enable a minimal laser energy. The algorithm was able to detect experimental SRT potential to enable a monitoring of SRT lesions

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Acknowledgements All members of the OTL group of the ARTORG center, Bern are gratefully acknowledged A special thanks goes to Patrick Steiner and Raphael Sznitman.

Pattern Identification of Urinary Bladder Pre-Voiding Activity in Humans

Daniel Zolliker

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Introduction

characterized by urinary urgency often combined with recuent univation with our urgency in the absence of urinary tract infection [1]. Around 17% of people older than 40 in the United States and Europe suffer from OAB. In the costs of OAB in the US was 72.6 billion US dollars in 2000 and is increasing with the aging population. In some cases OAB is associated with diversor overactivity (DO) (an unodynamic diagnosis). Because of its complexity the OAB pathophysiology is still poorly hypotheses that 1) a prediction of the voiding and 2) a differentiation between overactive and normal patients is possible using dedicated frequency understoood and its diagnosis relies mainly on qualitative information. This thesis aims to prove the Overactive bladder (OAB) is a unological disorder analysis of the bladder pressure signal.

Materials and Methods

recordings are analyzed in specified frequency bands in thow ways. Once method is to compute a power spectral density (PSD) and then to integrate the power values in a specific frequency band. The other method is to use a wavelet multi-level decompetibion and compute the power in a (SUI) patients. A second group (DO+) contains patients with proven DD in cystometry (eladoer pressure measurement). The third group (DO-) contains patients with OAB symptorrs that could not be confirmed in the cystometry traces. The last A data base of 72 urodynamic examination divided in four groups was retrospectively analyzed. The control group contrains stress urinary incontinent pathologies (e.g. residual urine) but no symptoms of OAB were present. The power of bladder pressure be confirmed in the cystometry traces. The last group (Other P.) contains patients with different predefined wavelet level.

Results A statistically significant difference in the power signal between the beginning of the bladder filling (first part) and just before the volding (second part) was found in all groups (see Fig. 1) with the FSD approach. With the wavelet approach only a significant difference was found in the DD+ group The power between the two sections decreases in all SUI patients and increases in the other groups



(DO+. DO-, Other P.). In 69% of the pressure signals an algorithm could predict the volding, which could potentially be used to warn the patient to prevent incontinence.



Fig. 1 Normalized Power in the frequency band between 0.04 and 0.08 Hz. The box and the red line depict the interquartile range and the median value, respectively. Outliers are shown as red plus.

The results for the prediction of voiding are promising and, warrant further studies to explore the full potential of frequency analysis in urodynamic examinations Discussion

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Acknowledgements

I would like to thank my supervisors Dr. Francesco Clavica and Dr. Thomas Nederhauser for their continuous support and the whole CVE team for the exchange during the master thesis



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Master's Thesis in Biomedical Engineering

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Imprint

Master's Program Biomedical Engineering Annual Report 2015 Editor: University of Bern, Master's Program Biomedical Engineering Layout: Weimin Yu, ISTB, University of Bern Print: Geiger AG Bern, Habsburgstrasse 19, 3000 Bern 6 Photo Cover: Adrian Moser University of Bern Master's Program Biomedical Engineering Stauffacherstrasse 78 3014 Bern Switzerland

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