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Knowledge in Health

July 11th - July 13th

BIOMEDICAL ENGINEERING CONGRESS 2022

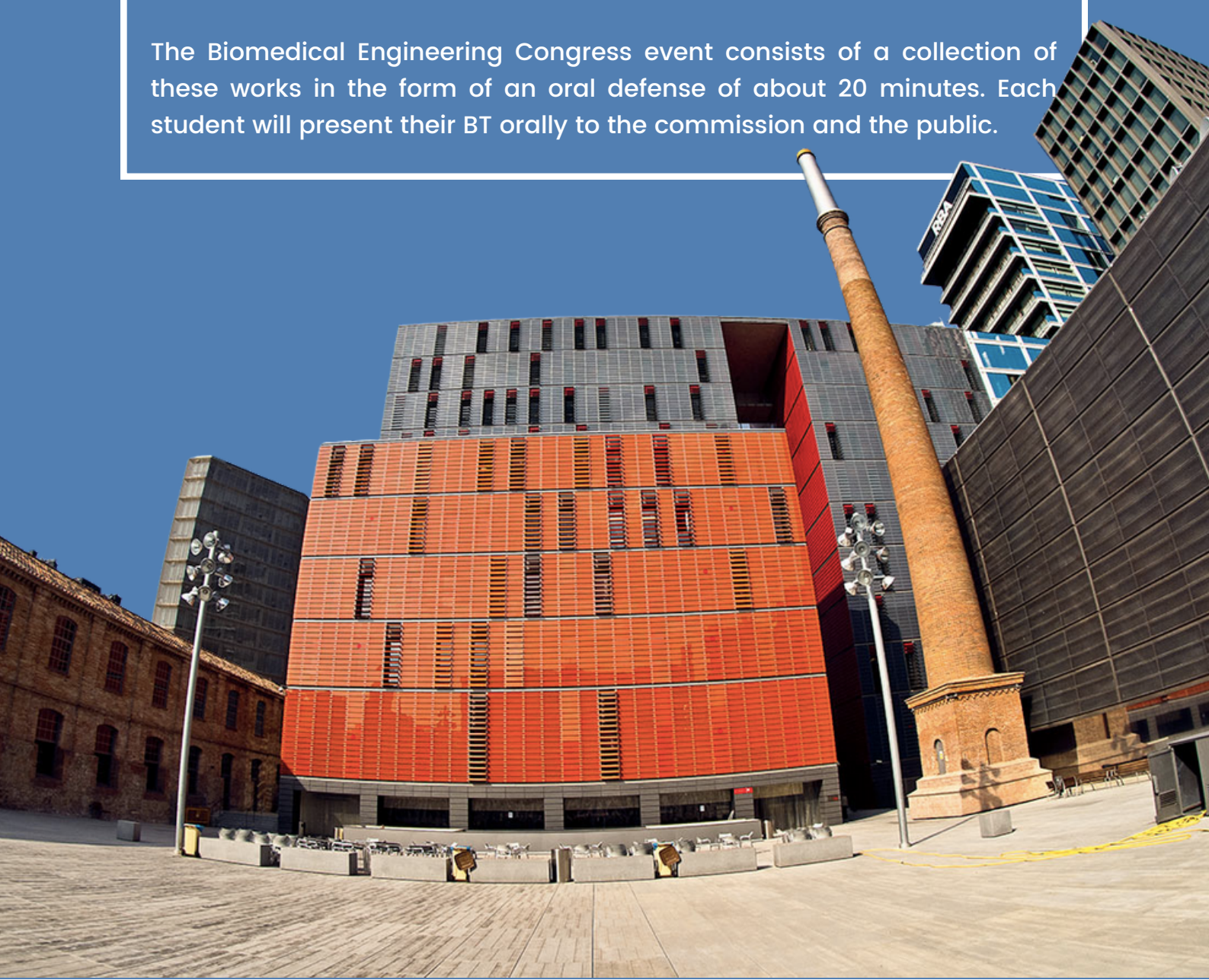
upf. Universitat Pompeu Fabra Barcelona

Index

THE CONGRESS

In this event, **Biomedical Engineering** degree students from Pompeu Fabra University (UPF) about to graduate are due to present and defend their Bachelor's Thesis (BT). Whether professionally – or research-oriented, these works cover a wide range of topics from biomechanics, computational modeling, medical devices, and biomedical image analysis to synthetic biology, competencies acquired during the degree.

The Biomedical Engineering Congress event consists of a collection of these works in the form of an oral defense of about 20 minutes. Each student will present their BT orally to the commission and the public.



CONGRESS SCHEDULE

JULY 11TH

SESSION 1 - Chair: Pilar Rivera Gil		
9:00	Integra Therapeutics. Gene writing technology transfer at UPF	Avencia Sánchez-Mejías (Co-founder & CEO Integra Therapeutics)
9:40	QMENTA - from academia to entrepreneurship: the challenges, learnings, and rewards	Vesna Prchkovska (Co-founder & CEO of QMENTA) and Paulo Rodrigues (CTO & Board Member of QMENTA)
10:20	QUAES foundation roundtable on Osteoporosis	
SESSION 2 - Neuroengineering - Chair: Miguel Ángel González Ballester		
11:30	In vitro neuronal cultures and network analysis to build a proof-of-concept biological computing AI device	Auba Fuster
12:00	Multilayer network analysis of Alzheimer's Disease links clinical features to the phenotype	Angela Pantebre
12:30	Modelling brain growth in early development using meshless techniques	Francesc Carandell
13:00	Alzheimer's Disease Cerebrospinal Fluid Biomarkers	Jan Pinyol

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JULY 11TH

SESSION 3 - Biomechanics I - Chair: Javier Macía		
15:00	Osteoporosis pharmacological treatments evaluation through biomechanical parameter using DXA-based finite elements modelling	Marina Montserrat Pérez
15:30	Multiscale simulation of intervertebral disc multiphysics adaptations and protein turnover in astronauts	Paula Garcia
16:00	Numerical exploration of collagen type I and II changes within lumbar intervertebral disc	Carla Flores
16:30	Development of an advanced force measurement bench for in vivo studies with injectable intramuscular microstimulators	Ferran Camps
17:00	Inverse calculation of multiscale bone composition and mechanical properties out of DXA images	Javier Giráldez
17:30	Determination of biomechanical parameters from dual X-ray absorptiometry measurements	Liliana Stephania Ruiz

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15:30	Study of the propensity to suffer an osteoporotic hip fracture based on biomechanical parameters and the automatic selection of the region of interest	Berta Mateu
16:00	Dynamic analysis of gait motion in osteoarthritic women patients	Judith Torras
16:30	Exploration of articular cartilage biomechanical response during gait of patients with knee osteoarthritis	Marina Giménez
17:00	Evaluation of the Influence of intervertebral disc cartilage endplate composition gradient through advance finite element modelling	Raquel Andrés
17:30	Mechanoregulation study for tissue engineering using fluid-structure computational models	Laia Moliner

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15:30	Super-Resolution of Magnetic Resonance Fetal Images Using Progressive Sequential Generative Adversarial Networks	Manuel Obelleiro
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SESSION 8 - Artificial Intelligence applied to Healthcare - Chair: Baldo Oliva		
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16:30	A multi-paradigm AI and simulation system to tackle lung cancer	Joel Romero
17:00	Continuous Lip Reading in Spanish	Yadira Paola Ronquillo
17:30	Identification and localization of Septal Flash by the means of Time Distributed Networks and Class Activation Maps	Isaac Capallera
18:00	Use of Text Mining techniques for the selection of cohorts in a clinical trial: Classifying patients into potential subjects for a clinical trial according to selection criteria by analyzing medical records	Ricard Cambray

CONGRESS SCHEDULE

JULY 13TH

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10:30	Random Number Generator based on intramuscular electromyography to secure wireless networks of electronic implants	Dante Adami
11:00	Design and implementation of a relay-based switching system for allowing bioimpedance measurements during pulsed field ablation	Felipe Gaitan
11:30	Integrated magnetophoretic transfer of functionalized superparamagnetic beads in microfluidic chip and application to portable diagnostic instruments	Celia Mansilla
12:00	Closed-loop control of a network of intra-muscular electrical microstimulators aiming for precise gestures: preliminary assays in New Zealand white rabbits	Álvaro Martínez
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CONGRESS SCHEDULE

JULY 13TH

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15:30	Analysis of the exploration-exploitation trade-off in the Koa Foundations app usage	Laura Sánchez
16:00	An EEG and ECG based biofeedback system for enhancing music therapy sessions with terminally ill cancer patients	Ava Shamlou
16:30	Development of a Software based on a Mathematical Model of the Renal System for Computer Physiology Practices for Biomedical studies	Paula Serra
17:00	Development of Skeletal Muscle Contraction Computer Physiology Practices for Human Biology, Medicine and Biomedical Engineering	Karina Karenik

CONGRESS SCHEDULE

JULY 13TH

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15:00	Process validation for additive manufacturing (SLA) of customised surgical guides	Clara Sanchez
15:30	Boreas ultra low temperature freezers. New product innovation based on medical device certification	Mariona Fernández
16:00	Study of the purchasing dynamics of medical technology in Spanish hospitals, and particularization for a postpartum hemorrhage detector	Olivia Genova
16:30	Business Plan for introducing to the market correcting sleep posture medical device	David Agulló
17:00	Business plan of VIDAA	Rosa Ana García

STREAMING GUIDELINES

- There is no need to install any software nor register, the link can be opened in a normal web browser

- Two Twitch Channels will be at your disposition to follow live any presentation:

  Talks at Auditorium:
  https://www.twitch.tv/upfbiomedicalengineering

  Talks at Sala Nau:
  https://www.twitch.tv/upfbiomedicengineering2

- These channels are per session and are at the congress web ("Schedule" tab)

- Each student has a Discussion Room. Evaluators are highly encouraged to ask further questions beyond the students' talks

- The Discussion Room is available up until 30 min after the end of the session

- A QR code will be also available to enter in each student's discussion room

session 1
INVITED SPEAKERS

July 11th
Auditorium Campus Poblenou

Chair: Pilar Rivera Gil

9:00	Integra Therapeutics. Gene writing technology transfer at UPF	Avencia Sánchez-Mejías (Co-founder & CEO Integra Therapeutics)
9:40	QMENTA - from academia to entrepreneurship: the challenges, learnings, and rewards	Vesna Prchkovska (Co-founder & CEO of QMENTA) and Paulo Rodrigues (CTO & Board Member of QMENTA)
10:20	QUAES foundation roundtable on Osteoporosis	Remedios Martín Álvarez (SemFYC board secretary - MODERATOR), Renaud Winzenrieth (CEO of 3D-SHAPER, Medical SL of Galgo Medical), Luis del Rio (Cetir Grup Mèdic), Dr. Jordi Monfort (Head of rheumatology at Hospital del Mar, Paldor Global SL), and Jérôme Noailly (UPF)

session 2
NEUROENGINEERING

July 11th
Auditorium Campus Poblenou

Chair: Miguel Ángel González Ballester

Evaluators: Fernándo Giráldez, Magí Andorrà, Jerome Noailly and Andy Luis Olivares

11:30	In vitro neuronal cultures and network analysis to build a proof-of-concept biological computing AI device	Auba Fuster
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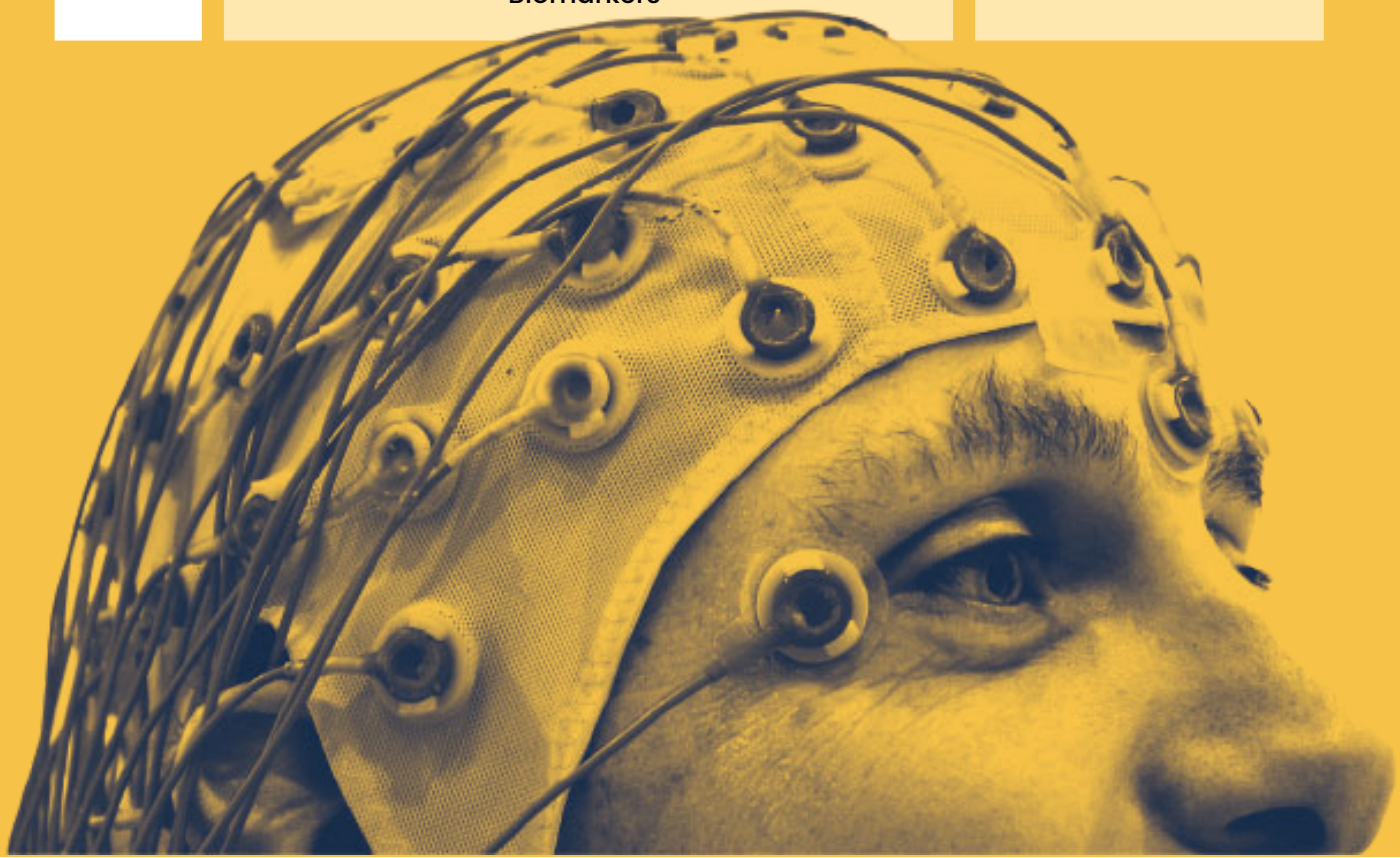

Link for questions

Auditorium

IN VITRO NEURONAL CULTURES AND NETWORK ANALYSIS TO BUILD A PROOF-OF-CONCEPT BIOLOGICAL COMPUTING AI DEVICE

Auba Fuster Palà

SUPERVISOR: Jordi Soriano, Daniel Tornero and Javier Macià

EVALUATORS: Fernándo Giráldez and Guillermo Nevot

The limitations of current computation and artificial intelligence approaches have led to the emergence of biological computation, which is being studied in the last years as an alternative to traditional computation methods. The NeuChiP European project aims to develop a proof-of-concept for a biological computing AI device.

The first step towards biological computation is generating in vitro neuronal cultures with the appropriate characteristics for using them as new AI systems. This thesis aimed to study different culture setups using both primary cultures and hiPSC-derived cortical neurons. Also, the cultures were recorded using calcium imaging and the results were analyzed from a network point of view to study both the activity and the connectivity of the cultures.

The results suggested that it is possible to configure the culture functional connectivity by using physical constraints, chemical agents interfering in synapses and mechanical agents like a random cut. Those have a direct effect on the activity and connectivity of the network and can be used to modulate it. However, with some time the culture is able to adapt to the external changes thanks to the inherent plasticity of biological neuronal networks, which highlights the necessity of finding an effective and durable stimulation method. As expected, the reproducibility of primary culture results with hiPSC-derived cortical neurons is tedious and difficult due to the novelty of the protocol. To conclude, this thesis will be a start point for future studies in the biological computing research field.

Keywords: Biological computation, Artificial intelligence, In vitro neuronal cultures, Network analysis, HiPSC

Link for questions

Auditorium

MULTILAYER NETWORK ANALYSIS OF ALZHEIMER'S DISEASE LINKS CLINICAL FEATURES TO THE PHENOTYPE

Angela Pantebre Pedrosa

SUPERVISOR: Pablo Villoslada and Jordi Garcia Ojalvo

EVALUATORS: Magí Andorrà and Francisco José Muñoz

Alzheimer Disease (AD) is a neurodegenerative disorder involving gradually progressive cognitive and functional depletion as well as behavioral changes and is associated with accumulation of protein depositions in the brain. In complex neurological disorders such as Alzheimer's, a wide range of biological scales are involved, from genes and proteins to cells and tissues, making the symptoms present in the whole body system. Nonetheless, the way in which all these features interact with one another, how this endotype ends up defining the phenotype is yet to be fully understood. This thesis aims to tackle the relationship and correlation of Alzheimer's features and its pathways to comprehend the mechanisms of such outcome. Focusing on a systems biology approach based on multilayer network analysis, through the use of multi-omics techniques, which offer an understanding of the flow of information between layers (genomics, proteomics, metabolomics...) as well as the use of brain imaging and clinical data obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) cohort. A longitudinal multicenter study designed with the goal of the early detection and tracking of Alzheimer's disease, collected laboratory, imaging, clinical, cognitive, and genetic data on patients between the ages of 55 and 90 for over a decade. The specific networks used for the multilayer network analysis are constructed using mutual information a nonlinear measure of correlation, at each layer and between layers. Through the structural and dynamical networks as well as the correlation analysis via Boolean simulations, pathways are identified within the layers through which dynamic information is transmitted. Showing indeed that integrating the flow of information across biological scales reveals relevant pathways for complex diseases such as AD, giving the possibility of new therapeutic targets.

Keywords: Alzheimer's Disease (AD), Neurodegenerative disorders, Multilayer network analysis, Multi-omics, Biological scales

Link for questions

Auditorium

MODELLING BRAIN GROWTH IN EARLY DEVELOPMENT USING MESHLESS TECHNIQUES

Francesc Carandell Verdaguer

SUPERVISOR: Oscar Camara and Mireia Alenya

EVALUATORS: Jerome Noailly and Konstantinos A. Mountris

How the brain develops from a smooth surface at early weeks of gestation to a folded surface with sulci and gyri at the neonatal stage is still one question to be solved. Despite the hypotheses proposed by several theories, the lack of large data at different developmental stages and limitations in computational resources have made difficult to develop mechanical models of brain growth to better understand which mechanisms control the cortical folding process and test different hypothesis about the most relevant factors guiding this phenomenon. An additional challenge is to work with finite-element meshes (FEM) in this application due to the large deformations undergone in brain development that can generate overlapping elements which hamper obtaining the correct solutions and prevent the simulation's to convergence. Thus, meshless modelling techniques could give a solution to that issue and could be tools to be tested in order to obtain even more realistic results. The main goal of this TFG is to adapt a meshless mechanical model developed for cardiac applications to simulate brain development and make a compare them with the current FEM-based implementations.

Keywords: Brain development, Mechanical model, Gyrification, Meshless

Link for questions

Auditorium

ALZHEIMER'S DISEASE CEREBROSPINAL FLUID BIOMARKERS

Jan Pinyol Pont

SUPERVISOR: Oscar Cámara and Carlos Albors

EVALUATORS: Andy Luis Olivares and Mireia Alenyà Sistané

The most prevalent form of dementia is Alzheimer's disease (AD), accounting for 60% to 80% of all cases. It was placed on the 6th leading cause of death in the United States (US) in 2012, but recent studies estimate that this disease may rank third on the list, behind cardiovascular diseases and cancer. The presence of two abnormal buildups are a direct consequence of brain damage and the destruction of synapses in charge of memory and cognition, whose elimination is suspected to be through the cerebrospinal fluid. Computational fluid dynamics (CFD) is a process to mathematically solve problems involving fluid flow.

Keywords: Computational Fluid Dynamics, Cerebrospinal Fluid, Alzheimer's Disease, Arterial Pulsatility, Amyloid Beta

session 3
BIOMECHANICS I

July 11th
Auditorium Campus Poblenou

Chair: Javier Macía
Evaluators: Simone Tassani, Miguel A. González, Morteza Rasouligandomani, Anaïs Espinoso, Andy Luis Olivares and Gemma Piella

15:00	Osteoporosis pharmacological treatments evaluation through biomechanical parameter using DXA-based finite elements modelling.	Marina Montserrat Pérez
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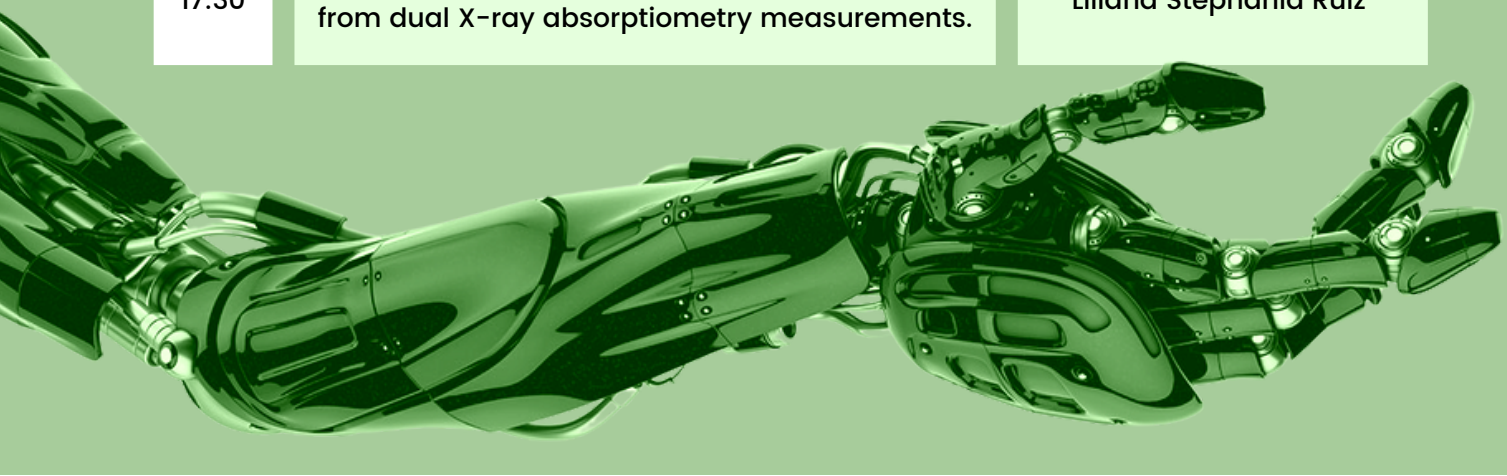


Link for questions

Auditorium

OSTEOPOROSIS PHARMACOLOGICAL TREATMENTS EVALUATION THROUGH BIOMECHANICAL PARAMETER USING DXA-BASED FINITE ELEMENTS MODELLING

Marina Montserrat Pérez

SUPERVISOR: Carlos Ruiz

EVALUATORS: Simone Tassani and Andy Olivares

Osteoporosis is a systemic skeletal disorder that causes bone mass loss increasing its fragility. It is a sanitary problem worldwide and the first cause of hip fractures, which risk is preeminent for the elderly. Such fractures are one of the most severe an individual can suffer due to its high mortality rate. Luckily, there are pharmacological treatments that help to increase bone density, such as Alendronate (AL), Denosumab (DMAB), and Teriparatide (PTH). Depending on their mechanism of action, they can mainly improve the volumetric bone mineral density (vBMD) of either the cortical or the trabecular bone, which can be measured with Dual-Energy X-ray absorptiometry (DXA), a 2D image technique used to diagnose osteoporosis. Several studies combine Finite Element Models (FEM) with DXA images to assess fracture prediction. Still, there is no evidence of using those methods together to study drug effectiveness. Thus, this study aims to evaluate the implementation of a 3D FEM DXA-based to study the effectiveness of different pharmacological treatments for osteoporosis. A cohort of 155 osteoporotic patients were divided into four groups AL (n=54), DMAB (n=33), PTH (n=31), and a control group named NAÏVE (n=37). They provided two DXA images before and after 1-2 years of taking the medication. Then, 310 side-fall simulations with a patient-specific force were implemented where the distal bone and the trochanter were constrained in the direction of the force. Results were analyzed by tissue (cortical or trabecular), zone (neck or trochanter), and by its combination. It showed that the strain decreases when vBMD increases, indicating that the bone deforms less due to the reinforcement of its structure. DMAB had the highest outcomes, while the trabecular bone and the trochanter area were the most reinforced. Overall, this study suggests that DXA 3D finite element models might be a valuable tool in clinical practice for evaluating pharmacological treatment for

Keywords: osteoporosis, finite element model, drug efficacy, DXA, hip fracture

Link for questions

Auditorium

MULTISCALE SIMULATION OF INTERVERTEBRAL DISC MULTIPHYSICS ADAPTATIONS AND PROTEIN TURNOVER IN ASTRONAUTS

Paula Garcia Hernández

SUPERVISOR: Jeróme Noailly and Laura Baumgartner

EVALUATORS: Miguel A. González and Andy Luis Olivares

During spaceflight, many astronauts experience moderate to severe lumbar pain, which might originate from intervertebral disc (IVD) swelling triggered by the lack of compressive loads in microgravity. IVD swelling alters nutrition diffusion in the largely avascular IVD, thereby affecting cell activity. However, to date, it is still unclear how unloading due to microgravity affects IVD multiphysics and consequent protein turnover. To shed light on this topic, a multiscale approach was used. Finite Element (FE) simulations with an L4-L5 mechanotransport IVD model simulated mechanically coupled nutrient diffusion in a normal gravitational environment and during five days and six months of space flight. Mechanotransport simulations provided local changes in pressure and nutrient concentrations within the IVD. Such information was subsequently used to feed an Agent-Based (AB) model that simulated a 1mm3 volume of 4000 cells in the central tissue of the IVD: the Nucleus Pulposus. The AB model allowed to assess the cell activity regarding tissue structural protein and protease mRNA expressions.

Keywords: Low back pain, microgravity, intervertebral disc, Finite Element mechanotransport simulations, Agent-Based modelling

Link for questions

Auditorium

NUMERICAL EXPLORATION OF COLLAGEN TYPE I AND II CHANGES WITHIN LUMBAR INTERVERTEBRAL DISC

Carla Flores Bertó

SUPERVISOR: Carlos Ruiz

EVALUATORS: Laura Baumgartner and Morteza Rasouligandomani

Intervertebral disc (IVD) degeneration is one of the main causes of low back pain syndrome, which affects between 80% and 85% of the general population at least once in their lives, generating large economic costs. Disc degeneration might be related to a deficit in metabolite transport. As a consequence, cells start a series of catabolic cascades that degrades the extracellular matrix; which compromises the ability of the disc to resist compressive loads. As an attempt to recover this resistance, during degeneration, collagen starts to proliferate and grow. Such changes in collagen are hard to study experimentally. Finite element (FE) models of the IVD rise as a tool to explore mechanics and metabolic transport of the disc, however, none of such models include the expression of collagen I and II. The aim of this project is to evaluate the expression of type I and II collagen during disc degeneration through 3D FE models. A mechano-transport 3D model of L4-L5 IVD was used and collagen expression rates for both type I and II were included. Two tissue conditions were evaluated: a) healthy (GI) disc, and b) degenerated one (GIII) during one day of physiological load and three days of nutrient transport. Results have shown that there is an activation in the expression of collagen in both GI and GIII. In the case of GI, this activation is too low to affect the ECM. Interestingly, there is a considerable activation of collagen expression in the case of GIII. Therefore, results point that this activity might facilitate the generation of fibrotic tissue in later stages of disc degeneration. This study represents an advance for the future development of personalised therapies aimed to slowing the fibrillation of disc tissue. Further studies would be necessary to develop novel therapies to treat patients with low back pain.

Keywords: Intervertebral disc, low back pain, collagen, metabolite transport, mechano-transport model

Link for questions

Auditorium

DEVELOPMENT OF AN ADVANCED FORCE MEASUREMENT BENCH FOR IN VIVO STUDIES WITH INJECTABLE INTRAMUSCULAR MICROSTIMULATORS

Ferran Camps Carré

SUPERVISOR: Toni Ivorra and Albert Comerma

EVALUATORS: Anaïs Espinoso and Laura Becerra

Muscular paralysis is the disruption of signal pathways between the brain and the muscles which causes disability to make voluntary muscle movement on subjects suffering from it. In the framework of the eAXON Project, the Biomedical Electronics Research Group (BERG) is exploring an innovative method for performing intramuscular electrical stimulation aimed at functional movement restoration in paralysis patients. In this method, injectable flexible devices with a diameter below 1mm named eAXONs (for electronic axon), perform neuromuscular stimulation in rabbits hindlimbs by rectifying volume conducted high frequency current bursts supplied by external textile electrodes, hence acting as addressable microstimulators. The stimulation of the muscles generated by these smart implants produces specific force patterns (plantarflexion and dorsiflexion movements) that were currently measured through a provisional setup in a hardly reproductible manner. Hence, this project consists of the development and engineering of an advanced version of the force measurement bench now in use by BERG by means of using mechanical components and designing 3D printed parts according to the rabbit's biomechanical features while including the electronic circuitry comprising the sensor, the DAQ and computer connection; while improving the quality of the measurements through signal conditioning. The filtering consisted of smoothing the signal using a circular buffer filter designed with the Window-Sinc Method and tuned according to the data measurement ranges (0-10N). As a result, a robust yet accessible system (80mmx70mm, 6kg) was designed to measure the isometric unidimensional forces generated by a rabbit's hindlimb in an efficient, reproducible, and non-invasive manner by means of fixating the limb towards the sensor while preventing the structure from causing noise to the measurement. The project is expected to evolve to bigger animals (lamb) as the latter aim is to test eAXONs in humans.

Keywords: isometric force measurement, isometric, rabbit, 3D printing, digital filter

Link for questions

Auditorium

INVERSE CALCULATION OF MULTISCALE BONE COMPOSITION AND MECHANICAL PROPERTIES OUT OF DXA IMAGES

Javier Giráldez Suárez

SUPERVISOR: Jerome Noailly and Carlos Ruiz

EVALUATORS: Maria Segarra and Andy Luis Olivares

Osteoporosis is a disease that affects a large number of people worldwide. It results in a degradation of bone structures, causing tissue weakening and increased fracture risk. It does not only provoke a worsening of the quality of life of the patient, but also an excess of mortality.

Early detection and follow-up of osteoporosis are vital to mitigate the effects of the disease. Dual-energy absorptiometry (DXA) is used as a diagnostic tool. However, clinical images cannot quantify the relative effects of bone properties at different scales, leading to limited capacity to predict fragile fracture. Multiscale homogenization theories allow to exploit the universality of bone properties at the nanoscale and the hierarchical structure of bone, to extrapolate the extracellular and macroscale tissue properties out of the composition. In this study, a reverse engineering method is proposed to obtain descriptors of the multiscale composition of bone out of DXA information. Using a genetic algorithm to optimise the vascular porosity, lacunar porosity, extracellular density and the volume fractions of hydroxyapatite, water, and organic matter.

A study with patient specific information extracted from 3D-Shaper® has been carried out to test the results of this method. A subsequent process of multiscale calculation allowed to obtain the mechanical properties of the bones where stiffness tensors depend on the multiscale composition we assessed whether the multiscale properties of bone can be used as predictors of the risk of bone fractures and to monitor treatments against osteoporosis.

Keywords: Osteoporosis, Genetic algorithm, Bone composition, Volume fractions, Stiffness Matrix, Multiscale Continuum Mechanics

Link for questions

Auditorium

DETERMINATION OF BIOMECHANICAL PARAMETERS FROM DUAL X-RAY ABSORPTIOMETRY MEASUREMENTS

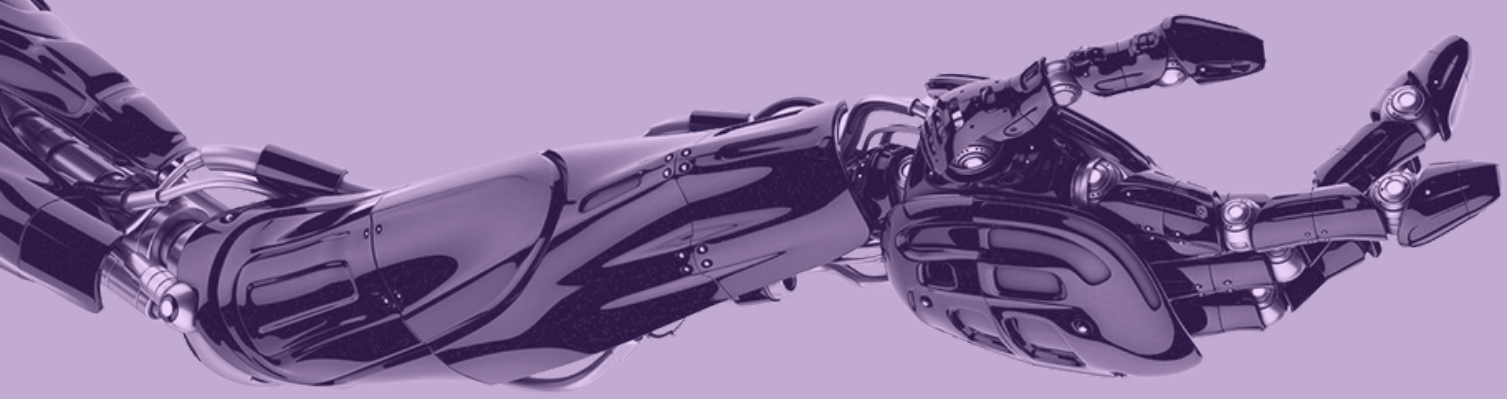
Liliana Stephania Ruiz

SUPERVISOR: Carlos Ruiz and Simone Tassani

EVALUATORS: Gemma Piella and Maria Segarra

Osteoporotic hip fractures represent a high risk for people over 60 years of age, with a reduction in life expectancy of 20% and a reduction in functional capacity of 50%. Currently, dual X-ray absorptiometry (DXA) is the gold standard for the diagnosis of osteoporosis, although it has a low prediction capacity of bone fracture. Likewise, we can find other techniques such as quantitative computed tomography measurements with a better prediction of bone fracture, although limited in practice due to their high radiation doses. On the other hand, finite element models (FEM) represent a tool that provides complementary information, such as strength and stress, which can be better predictors of hip fractures. Thus, the combination of advanced DXA images with FEM allowed a better discrimination of fracture and non-fracture cases with high accuracy. However, the application of these models in clinical practice is complicated due to the computational time and data processing. Therefore, it would be of interest to find an alternative way to calculate such parameters in a shorter time without the need to perform such FEM simulations. With this in mind, the aim of this project is to explore statistical methods to correlate DXA measurements and mechanical stress and strain parameters obtained by FEM simulations. To carry out the study we initially started from a database of 111 patients including DXA measurements and mechanical parameters derived from previous FEM simulations, which were subsequently expanded to balance the number of patients between males and females. Afterwards, correlation analysis was performed to extract the minimum significant DXA parameters for the prediction of mechanical parameters. It was done using a SSPS statistical program. Likewise, a comparison between men and women was made, as well as an iteration analysis between the different parameters and a comparison considering the type of hip fracture (distinguishing between neck and trochanter).

Keywords: Osteoporotic, DXA, hip fracture, Multiple regression, ANOVA, statistical analysis



session 4
BIOMECHANICS II

July 11th
Sala Nau Campus Poblenou

Chair: Bart Bijens

Evaluators: Laura Baumgartner, Marina Estevez, Carlos Ruiz, Maria Segarra and Xabier Morales

15:00	Generation of personalized finite element models of knee joint in a cohort of osteoarthritis patients	Clara Ricci
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Link for questions

Sala Nau

GENERATION OF PERSONALIZED FINITE ELEMENT MODELS OF KNEE JOINT IN A COHORT OF OSTEOARTHRITIS PATIENTS

Clara Ricci Elizalde

SUPERVISOR: Jérôme Noailly

EVALUATORS: Laura Baumgartner and Simone Tassani

Osteoarthritis (OA) is a highly multifactorial disorder that largely lacks information for proper patient stratification. Its most prevalent form is knee OA. The core pathophysiology of the disorder consists in a disregulation of articular chondrocyte activity. The later becomes catabolic and contributes to the destruction of the articular cartilage, which eventually generates chronic pain, stiffness and loss of mobility. Mechanical loads are suspected to participate in the evolution of OA or at least in the evolution of the symptoms. Therefore, detailed descriptions of these loads in the knee joints might be useful to support the objective design of for both prevention and treatment strategies. Arguably, these load cannot be measured in situ but Finite Element (FE) models are valuable tools to create patient-specific models and simulate joint mechanics, at both the organ and tissue levels.

Unfortunately, patient-specific modeling of knee joints remains an unmet challenge, mainly because of the complexity of the joint structure and shape, especially in patients affected by OA. Accordingly, the work consists in the generation and analysis of personalised FE models of the knee joints in a clinical cohort of 80 patients acquired in collaboration with the Rheumatology Service of the Hospital del Mar.

An existing Bayesian Coherent Point Drift (BCPD) algorithm was applied to create a personalized 3D FE models of the knee joints of the patients, based on point set registration between a knee joint FE reference model that incorporates a structural mesh with all the tissues found in a healthy joint, and degenerated knee geometries reconstructed out of MRI. The quality of the mesh of the registered source, i.e., morphed, was determined and used to define a multistep morphing pipeline and adjust the BCPD algorithm parameters.

Keywords: Osteoarthritis, Knee, Finite Element Modelling, Mesh Morphing, Biomechanics

Link for questions

Sala Nau

STUDY OF THE PROPENSITY TO SUFFER AN OSTEOPOROTIC HIP FRACTURE BASED ON BIOMECHANICAL PARAMETERS AND THE AUTOMATIC SELECTION OF THE REGION OF INTEREST

Berta Mateu Yus

SUPERVISOR: Carlos Ruiz and Simone Tassani

EVALUATORS: Andy Luis Olivares and Marina Estevez

Osteoporotic hip fractures represent a high social and economic burden. As such, the identification of the fracture risk for a patient is of high interest to clinicians. Femur finite elements 3D models based on advanced DXA imaging allowed us to discriminate between fracture and non-fracture cases. However, the effectiveness of such methods is very sensible to the selection of the analysis region. This project aims to evaluate the power of classification of biomechanical parameters obtained through those models, focused on automatized ROI selection using advanced statistical methods. A cohort of 180 patients, 90 control and 90 fracture, were used, considering an equal balance between men and women. Proximal femur 3D models were obtained from advanced DXA acquisitions; having the same correspondence of nodes and elements. Lateral fall was simulated by the application of a patient-specific force at the top of the femoral head, the trochanter was fixed in the direction of the force and the distal area was fully constrained. Five parameters were evaluated: volumetric bone mineral density, máximum principal stress/strain and major principal stress/strain. The critical areas were selected by using a statistical parametric map based on random field theory to evaluate the power of classification of the parameters.

Keywords: Hip,Osteoporosis, fracture, ML, random field theory

Link for questions

Sala Nau

DYNAMIC ANALYSIS OF GAIT MOTION IN OSTEOARTHRITIC WOMEN PATIENTS

Judith Torras Piedehierro

SUPERVISOR: Simone Tassani and Espinoso, Anaïs

EVALUATORS: Carlos Ruiz Wills and Bastian Pietras

Over 300 million people around the world, mainly women, suffer from Osteoarthritis (OA), a multifactorial disease affecting joints. It occurs most frequently in hands, hips, and knees. The most common solution is having a total knee replacement (TKR) placing a prosthesis on the patient. In the majority of these cases the decision of placing the prosthesis is based not only on objective radiographic measures but also on the pain felt by the patient and its perception, making this decision subjective.

Nowadays, studies of human motion dynamics have been frequently applied with biomechanical and computational models that use kinematic and kinetic parameters in order to help clinicians in treatment decision. Some dynamic approach to gait analysis was also presented, but they were never performed over OA subjects.

Nonlinear time series analysis forms a group of algorithms and measures used to extract dynamical features underlying measured signals. It allows to describe dynamical systems where nonlinearities lead to complex time evolution. Unlike deterministic models that produce the same results for a particular set of inputs, stochastic models predict outcomes that account for certain levels of unpredictability or randomness. Using the nonlinear prediction error and some simple irregularity analysis measures we study how predictable the gait will be in the next steps.

In this study, human gait recordings of 13 women between 60 to 67 years old that suffer from OA will be analysed from which 6 subjects were referred to take a TKR while the others take a conservative treatment. We want to see differences in the predictability of the underlying dynamics and its irregularity between TKR and conservative patients. Our results show that patients with TKR are more resilient and maintain more coherence compared to conservative patients who seem to present a more stochastic behaviour. Doing so, a quantitative analysis can help clinicians in the treatment decision.

Keywords: Osteoarthritis, conservative, knee replacement, irregularity, predictability

Link for questions

Sala Nau

EXPLORATION OF ARTICULAR CARTILAGE BIOMECHANICAL RESPONSE DURING GAIT OF PATIENTS WITH KNEE OSTEOARTHRITIS

Marina Giménez Lozano

SUPERVISOR: Carlos Ruiz

EVALUATORS: Simone Tassani and Maria Segarra Queralt

Knee osteoarthritis (OA) is one of the most prevalent forms of arthritis and one of the leading causes of disability. The pathological traits consist of articular cartilage degradation and bone thickening, among other factors. Since evaluating the changes in the cartilage is difficult to accomplish via medical tests, finite element (FE) models are arising as an alternative. However, they are too simple and do not consider changes through the gait cycle. Thus, the aim of this project is to evaluate the articular cartilage response of knee osteoarthritic patients during gait cycle through a FE model, using data from real patients.

Three knee condition were evaluated: 1) healthy, 2) with OA referred to conservative treatment, and 3) with OA referred to surgery. For each condition, knee reaction force, rotation angles and time of full gait cycle was obtained from data of real patients. The biomechanical response was addressed by using a 3D knee FE model that considers the femur and tibia as rigid bodies, and the cartilages and menisci as composition-based materials. Two gait simulations were performed: a) full extension, and b) with angles of rotation. Emphasis is placed on contact pressure and water and proteoglycan content at cartilage zones most affected by OA according to clinical observations.

Lateral articular cartilage receives significantly more contact pressure than the medial in all conditions. Nonetheless, an average pressure difference between both cartilages changes from 36.86% to 4.92% when cases 1) and 3) are compared. Similar outcomes were observed water and proteoglycans content. When rotation is considered, OA patients showed cartilage-cartilage contact, aspect not seen for healthy condition..

Overall, this study provides valuable information for clinician in OA treatment decision making. Moreover, the effect of the biomechanical environment found in this study on cartilages cells need to be further study, to develop novel strategies to face knee OA.

Keywords: Finite Element Model, Knee Osteoarthritis, Articular Cartilage, Gait Cycle

Link for questions

Sala Nau

EVALUATION OF THE INFLUENCE OF INTERVERTEBRAL DISC CARTILAGE ENDPLATE COMPOSITION GRADIENT THROUGH ADVANCE FINITE ELEMENT MODELLING

Raquel Andrés Abad

SUPERVISOR: Carlos Ruiz

EVALUATORS: Laura Baumgartner and Morteza Rasouligandomani

Intervertebral disc (IVD) degeneration is one of the leading causes of Low Back Pain (LBP), a main cause of disability affecting 7.5% of global population. IVD degeneration has been directly related to alterations in the nutrition of the IVD. The main nutrition pathways are diffusion through the cartilage endplates (CEPs) and the capillaries surrounding the disc rim. Nevertheless, the role of the CEPs in IVD degeneration is unclear. Experimental models showed a change in composition through the CEP, influencing its biochemical and transport properties. Numerical models can complement these results addressing the study of IVD degeneration. A previous 2D study showed that CEP gradient of permeability had influence in the mass exchange, however, the exploration of the influence of such gradient in a 3D model remains unexplored. Hence, the aim of this project is to study the influence of CEP composition gradient on IVD degeneration using a 3D Finite Element IVD mechano-transport model. Two composition gradients were used, defined on a 2-layer CEP and a 4-layer CEP of elements, in two conditions Grade I (GI) and Grade III (GIII) of degeneration. On the one hand, fluid velocity and mass flow were studied by simulating a daily cycle activity. On the other hand, solutes concentrations and cell viability were explored during three days. Results showed a reduction in 24,60% of mass flow at the boundary CEP-Nucleus when using CEP composition gradient on GI and 11,98% on GIII. Glucose concentration decreased 29,76% and 8,40% on GI and GIII, respectively, inducing cell death at the anterior zone of the disc. The results suggest that it is important to consider the CEP composition gradient as it might act as a barrier in the solutes transport. Next step would be to implement the gradient on a patient-specific IVD cohort for better understanding IVD degeneration. Such knowledge might contribute to generate personalised treatment to enhance the quality of life of patient with LBP.

Keywords: Finite element analysis, cartilage endplates, intervertebral disc degeneration

Link for questions

Sala Nau

MECHANOREGULATION STUDY FOR TISSUE ENGINEERING USING FLUID-STRUCTURE COMPUTATIONAL MODELS

Laia Moliner Carrillo

SUPERVISOR: Carlos Ruiz and Andy Luis Olivares

EVALUATORS: Xabier Morales and Albert Espona

When the bone defect area exceeds a range above two centimeters, it cannot be repaired or restored. In these situations, a surgical procedure is needed using transplanted bone to repair and rebuild the damaged bone. Although graft surgery is broadly used, there are existing limitations regarding autologous (i.e., from the patient) and allogeneic (i.e., from other individuals) bones, such as insufficient bone source, immune rejection, secondary surgery, or cross-infection. Therefore, bone tissue engineering (BTE) has arisen as an alternative approach to solve this problem. BTE attempt to introduce new functional bone regeneration via the cooperative combination of biomaterials, cells, and factor therapy.

The present work aims to develop an in-silico study of bone tissue differentiation in different scaffold designs using fluid-structure interaction. The interactions between scaffold strain deformation and fluid mechanical stimuli at the micro-level are evaluated. The ultimate goal is to find the optimal configuration that leads to cell differentiation conditions to develop bone tissue.

This study uses computational approaches to analyze six different scaffolds at 60, 70 and 80% of porosity with sphere and cylinder porous. Results showed that higher porosity promotes cell differentiation into bone tissue. Contrarily, decreased scaffold porosity leads to more cartilage tissue differentiation.

The methodology developed in this study can serve to test and design new scaffolds. With a better scaffold, tissue engineering could be implanted in a regular clinic in the near future.

Keywords: Tissue engineering, Mesenchymal cells, Mechanoregulation and Scaffold design

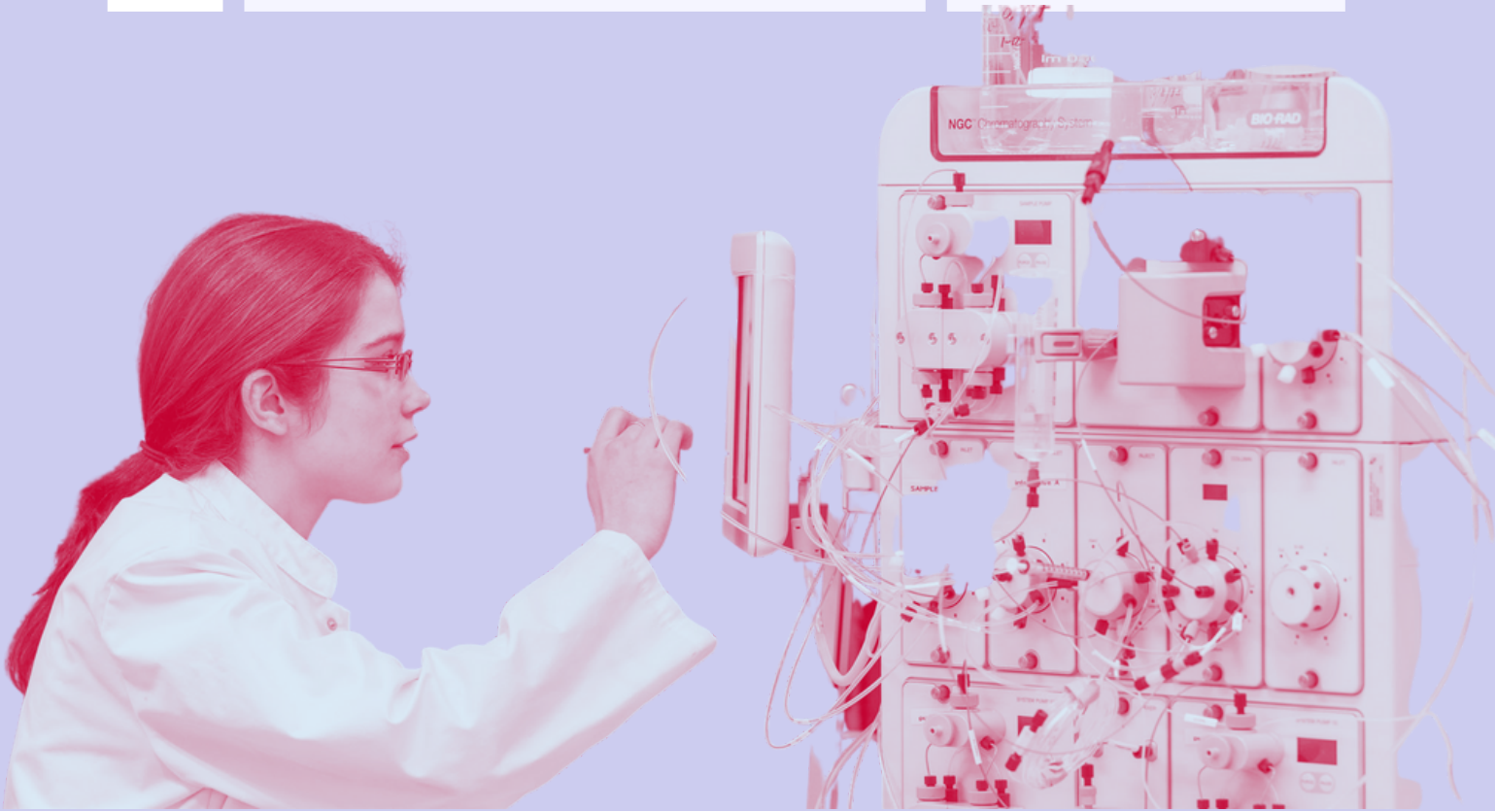
session 5
SYSTEMS BIOLOGY

July 12th
Auditorium Campus Poblenou

Chair: Óscar Cámara

Evaluators: Guim Aguadé, Amal Rahmeh, Marta Guerra and Marc Güell

9:00	Cancer differentiation therapy dynamics on hybrid model of avascular tumor growth	Marc Borràs
9:30	Development and optimization of Cutibacterium Acnes cell-free system for phages production	Anna Comas
10:00	New sealing system as a surgical technique to prevent premature rupture of fetal membranes after minimally invasive surgeries	Victoria Ibeas
10:30	Engineering bioactive bacterial celular tissues for biomedical aplications.	Aina Llovera



Link for questions

Auditorium

CANCER DIFFERENTIATION THERAPY DYNAMICS ON HYBRID MODEL OF AVASCULAR TUMOR GROWTH

Marc Borràs Sánchez

SUPERVISOR: Ricard Solé

EVALUATORS: Guim Aguadé Gorgorió and Joaquim Fort Viader

Cancer is a disease that can take many forms, making it very difficult to successfully develop treatments that effectively end it. Yet, a very promising approach still underdeveloped is differentiation therapy (DTH). As it has long been demonstrated, most tumors are conformed by a cell population a great part of which are poorly differentiated, exhibiting a loss of communication and tissue homeostasis among other things. As a result, they can achieve several hallmarks essential to their identity and chances of success. DTH has been proposed to be an efficient therapy and can be combined with cytotoxic-based therapies, and has already proven to be an efficient treatment for diseases such as acute promyelocytic leukemia (APL). Nonetheless, many challenges need to be overcome to successfully treat solid tumors, and that is due to many reasons, one being the high degree of intra-tumoral heterogeneity. As a result, models are needed to assess the effect of differentiation therapy in said tumors. Here we propose a computational study starting from an already designed model of an avascular tumor to assess differentiation therapy dynamics. The behavior seen and results obtained are in accordance to what has been observed and theorized in research, obtaining some interesting behaviors that can be exploited, further providing a relevant insight into the potential design of therapy.

Keywords: Cancer, Hallmark, Heterogeneity, Differentiation therapy, Competition

Link for questions

Auditorium

DEVELOPMENT AND OPTIMIZATION OF CUTIBACTERIUM ACNES CELL-FREE SYSTEM FOR PHAGES PRODUCTION

Anna Comas Fenoll

SUPERVISOR: Maria José Fábrega and Lorena Viviana Toloza

EVALUATORS: Amal Rahmeh and Guillermo Nevot

Acne vulgaris is a skin disease that affects most teenagers worldwide, causing psychological and emotional impacts in the most severe cases. Despite being considered a multifactorial disorder, the anaerobe skin commensal bacterium Cutibacterium Acnes (C. acnes) is related to its development.

C. acnes mainly resides on pilosebaceous units located on different oily areas across human skin, mainly on the face, back and chest. More specifically, acne-prone skins have a higher pathogenic density or type I (A1) C. acnes strains than non-pathogenic ones. Solutions to treat acne vulgaris include antibiotics, hormones or other drugs such as isotretinoin (Accutane®), all associated with severe side effects. Therefore, more natural, effective, and safe approaches are needed. Phage therapy is a promising treatment for combating acne since bacteriophages are host-specific and overcome antibiotic resistance issues. As their host, C. acnes phages are essential members of the human skin microbiome and are highly present in lipid-rich areas.

The current project presents the first approach to generating engineered C. acnes phages using a C. acnes in vitro cell-free system platform (CFS) as a potential tool for acne phage therapy. Propagation and isolation of two key C. acnes phages (PAD8 and PAD20) were optimized as well as DNA extraction to obtain their genetic material in good quality and concentration. In parallel, lysates of the A1 C. acnes strain were adjusted to ensure a functional CFS able to express the luciferase reporter gene as a control. Finally, CFS reactions with both the optimized phage genetic material and cell-crude extract were assembled in different incubation and components conditions to establish the optimal conditions for phage production.

Keywords: Acne vulgaris, Skin microbiome, Cutibacterium Acnes, Cell-free system (CFS), Phage production

Link for questions

Auditorium

NEW SEALING SYSTEM AS A SURGICAL TECHNIQUE TO PREVENT PREMATURE RUPTURE OF FETAL MEMBRANES AFTER MINIMALLY INVASIVE SURGERIES

Victoria Ibeas Agraz

SUPERVISOR: Germán Febas and Carlos Ruiz

EVALUATORS: Marta Guerra Rebollo and Jose Rodrigo Magana

It is estimated that one in every 33 babies is born with a birth defect, but thanks to the improvement of imaging techniques for foetal diagnosis, the detection of foetal anomalies has increased, making it possible to act on them before the birth of the baby. The use of fetoscopy has allowed for less invasive foetal surgeries in recent years. This kind of intervention consists of a technique that utilizes a small camera or scope to examine and perform procedures on the foetus during pregnancy. One of the issues with foetal procedures is that the opening in the chorioamniotic membrane remains after the trocar is removed. The presence of the orifice, especially in the initial hours following surgery, can result in a variety of complications, including oligohydramnios, chorioamnionitis, foetal pulmonary hypoplasia, and chorioamniotic membrane rupture, which can result in foetal mortality. This rupture of the membrane is called iatrogenic preterm preterm premature rupture of membranes (iPPROM) and is one of the most common complications during pregnancy.

The current bachelor thesis aims to carry out the next steps proposed on the doctoral thesis: “New sealing system as a surgical technique to avoid the iatrogenic Preterm Premature Rupture of foetal Membranes (iPPROM)”, a medical device consisting of a patch that significantly reduces the leakage of amniotic liquid and the risk of chorioamniotic membrane rupture during the first days after fetoscopy. The project is part of a multidisciplinary collaboration between the Materials Engineering Group (GEMAT) of IQS School of Engineering, and the BCNatal - Fetal Medicine Research Center, the Hospital Sant Joan de Déu and the Hospital Clínic de Barcelona.

The main points covered at the present bachelor thesis are twofold: improve the strength and adhesion time of the bioadhesive and study the benefits of adding an internal mesh to the patch in order to add robustness from a mechanical point of view.

Keywords: Fetus, fetoscopy, fetal membrane, sealing system, chorioamniotic membrane

Link for questions

Auditorium

ENGINEERING BIOACTIVE BACTERIAL CELULAR TISSUES FOR BIOMEDICAL APLICATIONS

Aina LLovera Espriu

SUPERVISOR: Javier Macià

EVALUATORS: Marc Güell and Miguel Sabariego

Bioactive materials represent a new generation of biomaterials, which are distinguished from the bio-inert biomaterials. The term bioactive material refers to all biomaterials which have the capability to induce and conduct the response to the biological system upon interacting. The aim of this project is to obtain a new bioactive biomaterial developed from bacterial cellulose that can also be applied in different fields such as biomedical, industrial, pharmacological, or cosmetic. The idea is that the final product is obtained from a co-culture where the production of bacterial cellulose is combined with the production of the protein of interest that will give a specific function to the biomaterial.

In this project we have focused on a specific objective, which is the inhibition of bacterial QS. For this, and as a result, we have developed a biomaterial that contains enzymes capable of inhibiting this type of bacterial communication. This is one of the many applications that can be given to this biomaterial, since once the general system by which any protein can adhere to cellulose is obtained, it can be applied in any situation of interest. This gives us the possibility of making this biomaterial flexible and applicable in different fields of research.

Keywords: Cellulose, Proteins, Membrane, Adherence, Bioactive

session 6

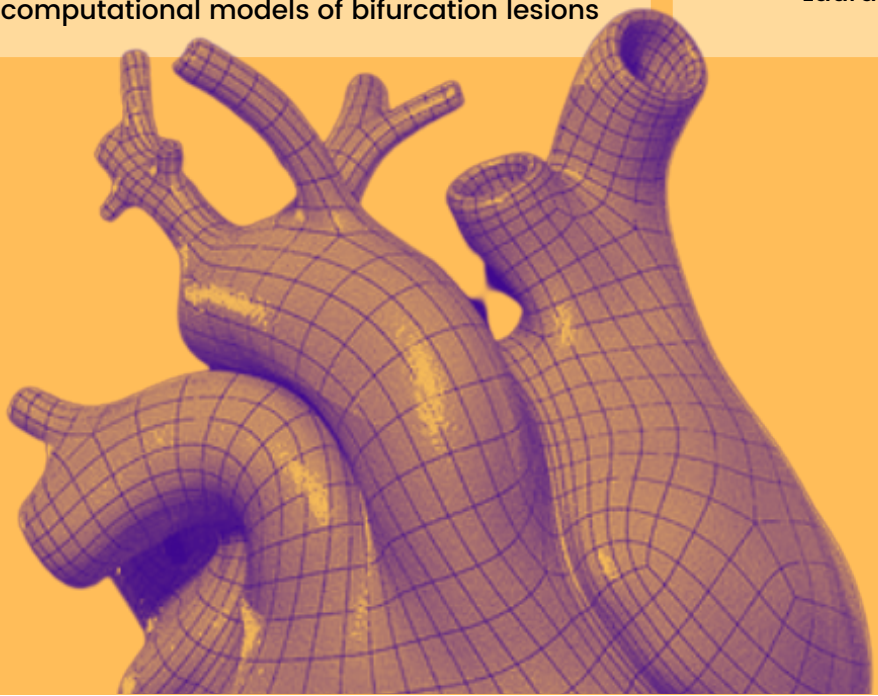
COMPUTATIONAL SYSTEMS MODELLING

July 12th
Auditorium Campus Poblenou

Chair: Gemma Piella

Evaluators: Xabier Morales, Carlos Ruiz, Álvaro Bocanegra and Carlos Albors

11:30	In-silico study of the device-related thrombosis after the transcatheter aortic valve implantation	Monica Font
12:00	Multi-scale modelling of thrombus formation in left atrial appendage	Marta Peña
12:30	Electrophysiological model of the left ventricle: prediction of reentry circuits with fast simulations based on cellular automata applying clinical stimulation protocols	Paula Franco
13:00	Coronary artery disease evaluation using computational models of bifurcation lesions	Laura Ortiz



Link for questions

Auditorium

IN-SILICO STUDY OF THE DEVICE-RELATED THROMBOSIS AFTER THE TRANSCATHETER AORTIC VALVE IMPLANTATION

Mònica Font Murillo

SUPERVISOR: Andy Luis Olivares and Jordi Mill

EVALUATORS: Xabier Morales and Alfonso Santiago

Transcatheter aortic valve implantation (TAVI) is a minimally invasive heart procedure that consists of replacing a thickened aortic valve that can not fully open, with a prosthetic valve. This technique has emerged as a safe and effective treatment for patients with symptomatic aortic stenosis. Despite all the advances that have been made since the first implantation in 2006, there remain important challenges to improve patient outcomes, such as device-related thrombosis (DRT). As the causes for which this happens are not yet well known, computational tools could provide more information to understand why this happens, because numerical simulations allow obtaining predictive information about the behavior of a medical device and understanding the interaction with the anatomical structures. The objective was to develop a computational workflow to evaluate TAVI thrombosis risk under patient-specific condition. The process involved the (i) segmentation and reconstruction of computed tomography (CT) images, (ii) interaction between the device and the anatomy, (iii) discretization of all TAVI components, the material properties and boundary conditions in fluid dynamic simulation. The study has been carried out in collaboration with Montreal Heart Institute (Montreal, Canada) and the results obtained can be included in the protocols to reduce the risk to DRT after TAVI.

Keywords: Transcatheter aortic valve implantation(TAVI), Transcatheter aortic valve replacement (TAVR), computational fluid dynamics(CFD), device-realted thrombosis(DRT)

Link for questions

Auditorium

MULTI-SCALE MODELLING OF THROMBUS FORMATION IN LEFT ATRIAL APPENDAGE

Marta Peña González

SUPERVISOR: Andy Luis Olivares

EVALUATORS: Carlos Wills Ruiz and Mireia Alenyà Sistané

Atrial fibrillation (AF) is a supraventricular arrhythmia associated with an increasing risk of clot formation. When this occurs, the left atrial appendage loses its contractile capacity, increasing the probability of thrombosis. If oral anticoagulation is contraindicated for AF patients, left atrial appendage occlusion (LAAO) presents an alternative to prevent the thrombus. However, it is linked to a risk of generating thrombus at the surface near the device, called device related thrombosis (DRT), that depends on the device configuration. Thrombus formation is a complex biological process involving a larger number of phenomena related to the endothelial injury, stasis of blood and hypercoagulability. In-silico modeling can help us to predict the risk of thrombosis and therefore, improve the assessment of the device configuration. The current work aims to determine the fundamental parameters, both chemical and dynamic, that affect the process of thrombus formation. To do so, a fluid simulation of a thrombus, together with a discrete phase model was implemented, giving a multi-scale model of thrombus formation. A sensitivity analysis, using a simpler model of the LAA, was used to analyze the influence of different parameters to both blood flow patterns and platelet adhesion. The effect of viscosity, the implementation of Newtonian and non-Newtonian blood models, and the addition of chemical reactions involved in thrombosis were studied. The risk of DRT in patient-specific geometries was analyzed, as well as the effect of blood viscosity on the result.

Keywords: CFD, Multi-scale modelling, Haemodynamics, Thrombus simulation

Link for questions

Auditorium

ELECTROPHYSIOLOGICAL MODEL OF THE LEFT VENTRICLE: PREDICTION OF REENTRY CIRCUITS WITH FAST SIMULATIONS BASED ON CELLULAR AUTOMATA APPLYING CLINICAL STIMULATION PROTOCOLS

Paula Franco Ocaña

SUPERVISOR: Oscar Camara

EVALUATORS: Álvaro Bocanegra Pérez and Daniel Romero García

Myocardial infarction is a frequent cardiovascular disease associated with an increased risk of developing ventricular arrhythmias and consequently, sudden cardiac death. This event causes irreversible damage to the myocardium, resulting in the formation of scar tissue in the left ventricle, thus preventing the proper propagation of the electrical impulse. Reentry arrhythmias appear when this phenomenon happens, causing re-excitation in previously depolarized areas and generating an alternative propagation circuit.

Patient-specific computer simulations are used for risk stratification by potentially predicting ventricular tachycardia (VT) events in patients who have suffered a myocardial infarction. Cellular Automata (CA) electrophysiological models allow to reproduce VT from clinical data while performing the simulations near real-time, overcoming the computational burden limitations of biophysical models.

The aim of the present study was to create fifteen computational cardiac models from real patient-specific data to determine if these patients were VT inducible by applying a real clinical stimulation protocol using a novel CA-based solver. The clinical data was provided by Centro Médico Teknon and consisted on cardiac magnetic resonance images (MRI) and the stimulation protocol they apply in the electrophysiological procedures. The project was also carried out with Universitat de Valencia, since the CA-based solver was provided by them.

Keywords: Cardiac computational simulation, Ventricular tachycardia, Myocardial infarction, Cellular automata

Link for questions

Auditorium

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CORONARY ARTERY DISEASE EVALUATION USING COMPUTATIONAL MODELS OF BIFURCATION LESIONS

Laura Ortiz Mengual

SUPERVISOR: Constantine Butakoff, Jazmín Aguado-Sierra and Oscar Camara

EVALUATORS: Carlos Albors Lucas and Jerome Noailly

Coronary Artery Disease (CAD) is one of the leading causes of death worldwide. Bifurcation lesions result in a considerable clinically demanding challenge due to its complex anatomy being critical to treat properly for optimal patient outcomes. Computational Fluid Dynamics (CFD) simulations of coronary artery disease can guide a deeper understanding of the risk, detection, and progression of the disease. Nowadays, Fractional Flow Reserve (FFR) and instantaneous Free Ratio (iFR) are the invasive methods of choice in the clinic which indicate the functional severity of stenosis and are intended to reduce the amount of unnecessary stenting. The challenge in evaluating FFR and iFR is when they show up in parallel or serial stenosis. Those configurations can result in over stenting, and better outcomes are showed when only treating the lesions that meet the criteria for treatment. Therefore, the utility of computationally simulate a platform with accurate coronary biophysical properties can aid in guiding best practices when interferences occur. However, there is still a knowledge gap when in understanding basic pathophysiology. Given this circumstance, the primary objective of this study is to develop a foundation of the disease states that occur clinically in bifurcation lesions and evaluate these lesions computationally in order to create a more optimized anatomical model for future research in evaluating treatment strategies. An exhaustive analysis was conducted by creating computational models with distinct Medina configuration, involving not only proximal and distal main branch but also side branch. Proximal main branch was simulated at 50% of plaque burden and both distal main branch and side branch were simulated at 25%, 50% and 75% plaque burden. Special attention was given to haemodynamics parameters, such as FFR and iFR.

Keywords: Coronary artery disease, Bifurcation lesions, stents, Computational fluid dynamics, Medina classification, FFR, iFR

session 7

INNOVATION IN MEDICAL IMAGING

July 12th
Auditorium Campus Poblenou

Chair: Jérôme Noailly
Evaluators: Benjamin Lalande, Valentin Compte, Mireia Masias, Gloria Haro, Oscar Cámara and Gerard Martí

15:00	Beyond exponential fitting: Deep Learning approach for robust and accurate estimation of myocardial T1	Pau Altur
15:30	Super-Resolution of Magnetic Resonance Fetal Images Using Progressive Sequential Generative Adversarial Networks	Manuel Obelleiro
16:00	Deep Learning applications for discriminating diagnosis of Schizophrenia and Bipolar Disorder based on anatomical MR imaging	Edgar Fabregat
16:30	The face as a window to the brain	Alba Puyuelo
17:00	New insights into the neurovascular coupling with magnetic resonance imaging biomarkers. A study in patients with migraine.	Raquel González
17:30	Cerebral maturation measures on autism spectrum disorder and attention deficit/hyperactivity disorder patients based on MRI scans	Maria Pujol Gil
18:00	Computational detection of interhippocampal demyelination in the early diagnosis of Alzheimer's Disease	Natalia Castillo

Link for questions

Auditorium

BEYOND EXPONENTIAL FITTING: DEEP LEARNING APPROACH FOR ROBUST AND ACCURATE ESTIMATION OF MYOCARDIAL T1

Pau Altur Pastor

SUPERVISOR: Gaspar Delso and Oscar Camara

EVALUATORS: CBenjamin Lalande and Gemma Piella

T1 parametric maps of the myocardium are a recent development in cardiac MRI. They can be used to characterize the composition of the heart and identify alterations in it that can be indicative of a pathology. A common method of T1 estimation involves pixel-wise non-linear curve fitting from Modified Look-Locker Inversion Recovery (MOLLI) series. Said method, whilst relatively accurate presents several drawbacks. Firstly, it assumes magnetization recovery to be a purely exponential process dependent on T1, thus neglecting other parameters such as T2 and B1 that can interfere in the process. Secondly, it does not consider that each acquisition during an inversion recovery experiment inverts the magnetization vector a given angle and thus delays the recovery. Finally, since it considers each pixel individually, it neglects spatial information and is sensitive to image quality. Additionally, since non-linear curve fitting is an iterative algorithm, it is computationally expensive and time-consuming. To address these issues a deep learning neural network(DeepBLESS) and two spatially aware variants of it, were trained to predict T1, T2, and B1 with a dataset of MOLLI series simulated from experimental data. The simulation was performed using Bloch Simulations. Thus, a dataset could be generated without relying on exponential fitting for ground-truth generation. It was shown that the Deep Learning approaches displayed less bias and were more robust to noise than non-linear curve fitting for myocardial T1 estimation, whilst being significantly faster.

Keywords: Cardiac MRI, Deep Learning, T1 mapping, MOLLI Series, Bloch Simulation

Link for questions

Auditorium

SUPER-RESOLUTION OF MAGNETIC RESONANCE FETAL IMAGES USING PROGRESSIVE SEQUENTIAL GENERATIVE ADVERSARIAL NETWORKS

Manuel Obelleiro Liz

SUPERVISOR: Benjamin Lalande

EVALUATORS: Valentin Comte and Jose Manuel Taboada Varela

Magnetic Resonance imaging is a really important imaging technique characterized by the lack of ionizing radiation, great soft-tissue contrast and remarkable resolution. One of the main drawbacks of performing an MRI scan is the time consumption; a complete exam can take up to 90 minutes in which the patient must lie still, avoiding movement, as it would result in image distortion and the need to repeat the imaging process.

This is the reason why an algorithm able to convert low-resolution images, obtained from faster scans, to super resolution images (comparable to full-time scans) could be very useful in the clinical setting.

Generative Adversarial Networks (GANs) have the ability to generate new content, mainly images and data distributions. This kind of network can be divided into 2 units, a generator and a discriminator. The generator is a neural network that will learn a transform function. Thus, its main role will be to try and fool the discriminator by generating images that are as close as possible to real data. This second network is trained to distinguish and classify true and generated data and will give feedback to the generator allowing for the training process.

Super-resolution is a clear application field for these networks, they are given an input an image with low resolution (LR) and they generate a super-resolution version (SR). The discriminator will compare the SR image against its high-res (HR) counterpart. The generator tries to transform the LR making them resemble as much as possible the given HR reference, fooling the discriminator in the process.

In this project the chosen structure is a progressive sequential GAN applied to fetal MRI images after being trained on brain MRI images. Once trained, SR images will be able to be generated from cheaper and faster MRI acquisitions, saving both time and money whilst not conceding on image quality and resolution.

Keywords: MRI, Fetal Images, Super-resolution, Sequential, Progressive GANs

Link for questions

Auditorium

DEEP LEARNING APPLICATIONS FOR DISCRIMINATING DIAGNOSIS OF SCHIZOPHRENIA AND BIPOLAR DISORDER BASED ON ANATOMICAL MR IMAGING

Edgar Fabregat Calbet

SUPERVISOR: Benjamin Lalande

EVALUATORS: Mireia Masias and Ralph Gregor Andrzejak

Mental illnesses such as bipolar disorder and schizophrenia break the proper mental health equilibrium and disrupt the interaction of oneself with the environment. The diagnosis of these two mental disorders is limited to the appearance of clinical manifestations. An early categorization of psychiatric disorders is problematic due to the scarce of prolongated symptoms, episodes, and outbreak in initial stages of the mental illnesses. The present bachelor's thesis aims to develop an automated diagnosis pipeline to discriminate patients with schizophrenia or bipolar disorder from healthy subjects, based on the analysis of brain subcortical structures. Brain T1 MRI data is considered to develop the comparison of patients and control brain morphology. A first convolutional neural network is trained with adult brain atlases developed by A. Hammers, which includes 30 subjects and 95 subcortical regions. A second classification network is trained with 138 healthy control individuals, 58 schizophrenia patients and 49 bipolar disorder patients, from UCLA Consortium for Neuropsychiatric Phenomics database. This project's purpose is to demonstrate the possibility of developing alternative diagnosis tools to differentiate schizophrenia and bipolar disorder patients from healthy controls, based on morphology analysis of brain MR images.

Keywords: Deep Learning, schizophrenia, bipolar disorder, MR imaging, automatic diagnosis

Link for questions

Auditorium

THE FACE AS A WINDOW TO THE BRAIN

Alba Puyuelo Citoler

SUPERVISOR: Gemma Piella and Federico Sukno

EVALUATORS: Gloria Haro and Maria Araceli Morales

The biological evidence that links facial and brain development gave rise to the long-standing hypothesis on the relation between facial geometry and some neuropsychiatric disorders. However, the existence of studies directly comparing face and brain data is still scarce. To enhance this situation, this study was part of a research project from the Dublin City University that aimed to detect whether geometric brain abnormalities linked to schizophrenia may also be related to facial abnormalities. To achieve this, a novel database of Magnetic Resonance scans of the head of schizophrenia and control patients is explored.

The role of this study in the project was to develop the pipeline to extract meaningful facial characteristics. Twenty head scans were processed, ten of which were considered outliers due to their high percentage of noise. Consequently, the project focused on eliminating the noise present in the volumes without losing detail. The pipeline is formed by an initial pre-processing of the scans to segment the facial region through several pixel intensity-based methods. Secondly, as noise remained in some cases, two public 3D Morphable Head Models were employed to deform a source head mesh to the target heads obtained in the pre-processing.
This study presents the different methods applied in the pre-processing step and the parameters tested in the two statistical methods, all with their corresponding results. Finally, it outlines the ones that gave results with enough quality for the extraction of facial features. Thereby, this approach could be employed as an initial step in the research project's goal to detect the possible facial dysmorphogenesis linked to brain abnormalities and schizophrenia.

Keywords: 3D Head MRI, Schizophrenia, Segmentation methods, Denoising methods, Statistical modeling

Link for questions

Auditorium

NEW INSIGHTS INTO THE NEUROVASCULAR COUPLING WITH MAGNETIC RESONANCE IMAGING BIOMARKERS. A STUDY IN PATIENTS WITH MIGRAINE

Raquel González López

SUPERVISOR: Deborah Pareto and Gemma Piella

EVALUATORS: Mireia Masias and Martí Gerard

Background and purpose: Migraine is a recurrent and incapacitating disorder, characterized by attacks of severe headache. Neurovascular coupling abnormalities have been described for migraine. Despite its prevalence, the physiology and underlying mechanism of migraine are poorly understood. In this context, new biomarkers from magnetic resonance imaging (MRI) are needed to bring new knowledge into the field. This study aims to determine vein density in patients with migraine from Susceptibility Weighted Imaging (SWI), compare it with healthy controls, and whether it relates to Resting-State functional MRI (RS-fMRI) measurements.

Materials and methods: The cohort included 30 healthy controls and 70 patients with migraine who were undergoing brain 3.0 T MRI at Vall d'Hebron University Hospital. Clinical and baseline characteristics were also collected. Vein density was determined based on a Mamdani Fuzzy-Type Rule-Based System (FRBS). RS-fMRI images were analyzed with the CONN to generate the Amplitude of Low-Frequency Fluctuations (ALFF). Vein density and ALFF measurements were parcellated in different brain gray (GM) and white matter (WM) regions.

Results: Significant decreases in vein density were observed in migraine in some WM regions. WM vein density in either frontal, temporal or cingulate regions was associated with clinical variables, such as headache days, disability scores, and cognitive impairment (r between 0.25-0.41; $p<0.05$). Strong significant associations between vein density and ALFF measures were obtained in most GM for the healthy subjects (r between 0.50-0.67; $p<0.05$) and in WM (r between 0.30-0.55; $p<0.05$) for the migraine patients.

Conclusions: Quantitative MRI indicators in migraine might be an interesting target that may contribute to its comprehension. A loss of association between vein density and ALFF may support the idea of abnormalities in the neurovascular coupling.

Keywords: Migraine, Susceptibility Weighted Imaging (SWI), Resting-State functional MRI (RS-fMRI), Mamdani Fuzzy-Type Rule-Based System, Amplitude of Low-Frequency Fluctuations

Link for questions

Auditorium

CEREBRAL MATURATION MEASURES ON AUTISM SPECTRUM DISORDER AND ATTENTION DEFICIT/HYPERACTIVITY DISORDER PATIENTS BASED ON MRI SCANS

Maria Pujol Gil

SUPERVISOR: Deborah Pareto and Gemma Piella

EVALUATORS: Oscar Camara and Mireia Masias

Two of the most common childhood-onset disorders are Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD). ASD is a neurodevelopmental disorder characterized by deficits in social communication and the presence of restricted interests and repetitive behaviors. ADHD is a prevalent and debilitating disorder diagnosed on the basis of persistent and developmentally-inappropriate levels of overactivity, inattention and impulsivity. Nowadays diagnosing ASD and ADHD can be difficult because there is no medical test to diagnose these disorders. Therefore, there is a need to find quantitative biomarkers that can diagnose neurodevelopmental disorders like ASD and ADHD, and this can be done by means of medical imaging techniques.

Keywords: ASD, ADHD, image analysis, maturity index, MRI

Link for questions

Auditorium

COMPUTATIONAL DETECTION OF INTERHIPPOCAMPAL DEMYELINATION IN THE EARLY DIAGNOSIS OF ALZHEIMER'S DISEASE

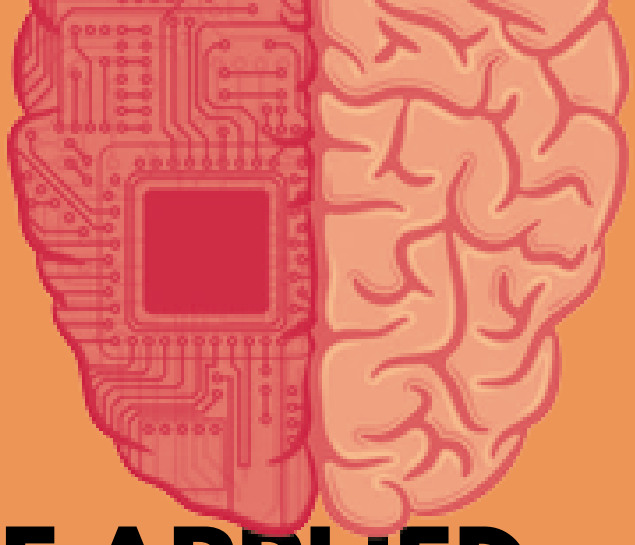
Natalia Castillo Dutor

SUPERVISOR: Jose Luís León Guijarro and Gemma Piella

EVALUATORS: Miguel Ángel González and Gerard Marti

Alzheimer's Disease (AD) is an incurable neurodegenerative disease that causes progressive degeneration of the brain and cognitive function. Detecting the disease in its early stages is the key to a more effective treatment. Recent studies have shown that one of the structural alterations is the loss of myelin in the hippocampal commissure. On the other hand, the Subventricular Zone (SVZ) is studied since has been identified as a key area in the supply of new remyelinating oligodendrocytes. Previous studies in Alzheimer transgenic mice, have shown that this area thickens early, as migratory cells accumulate there and are unable to reach their destination. Despite the complexity, its study is addressed to identify whether these structural alterations can identify AD early on.In the present research, Magnetic Resonance Imaging (MRI) is used to assess structural neurodegeneration of 16 subjects at 3 different stages: healthy controls, patients with Mild Cognitive Impairment (MCI) who are at risk for developing AD and patients with AD. From this technique, the SVZ thickening is detected by manual segmentation. Therefore, this alteration could be related to the values from the MR parameters, which reveal a myelin deficiency in the hippocampal commissure.After imaging process, a statistical analysis is carried out to select the most discriminating variables between groups. The resulting parameters are processed by Multiple Kernel Learning (MKL) algorithm. The evaluation revealed that classification of subjects into stages is possible using 9 variables. In contrast, only 3 are necessary to achieve the division into control and unhealthy, the most significant being the volume of SVZ. The results reveal that accumulation of cells in the SVZ could be responsible for remyelination, leading to a lack of myelin in the hippocampus. This finding helps to select the biomarkers that are relevant in the development of dementia.

Keywords: Magnetic Resonance Imaging (MRI), Machine Learning (ML), Alzheimer's Disease (AD), Subventricular Zone (SVZ)



session 8

ARTIFICIAL INTELLIGENCE APPLIED TO HEALTHCARE

July 12th
Sala Nau Campus Poblenou

Chair: Baldo Oliva

Evaluators: Pablo-Miki Martí, Maria Lucia Rossi, Miguel A. González, Gutiérrez Páez, Benjamín Lalande and Alex Bravo

15:00	Unsupervised Multiple Kernel Learning to Improve Prenatal Diagnosis of Aortic Coarctation	Sara Moya
15:30	Prediction of cardiovascular deterioration in pediatric cancer patients by means of Artificial Intelligence	Ona Grau
16:00	Optic nerve evaluation of multiple sclerosis patients using deep learning techniques on MRI	Marcos Frias
16:30	A multi-paradigm AI and simulation system to tackle lung cancer	Joel Romero
17:00	Continuous Lip Reading in Spanish	Yadira Paola Ronquillo
17:30	Identification and localization of Septal Flash by the means of Time Distributed Networks and Class Activation Maps	Isaac Capallera
18:00	Use of Text Mining techniques for the selection of cohorts in a clinical trial: Classifying patients into potential subjects for a clinical trial according to selection criteria by analyzing medical records.	Ricard Cambray

Link for questions

Sala Nau

UNSUPERVISED MULTIPLE KERNEL LEARNING TO IMPROVE PRENATAL DIAGNOSIS OF AORTIC COARCTATION

Sara Moya Tur

SUPERVISOR: Patricia Garcia-Cañadilla, Bart Bijnens, Inma Villanueva

EVALUATORS: Pablo-Miki Martí and Fatima Crispi

Aortic coarctation (AoC) is one of the most difficult cardiac defects to diagnose before birth, accounting for 6-8% of all congenital heart diseases (CHD). It consists of a narrowing of a portion of the aortic arch, most commonly affecting the aortic isthmus. An AoI Z-score of less than -2 and a reduced AoI-to-ductus arteriosus (DA) diameter ratio are examples of red flags for AoC, but there are still clinical and imaging data that could be exploited.

AoC can occur as an isolated defect, but it can also be associated with other cardiac abnormalities such as ventricular septal defect (VSD), aortic arch hypoplasia, and Shone's syndrome. It is a challenging prenatal diagnosis since the fetal circulation usually allows to preserve cardiac function. Moreover, the narrowing might only appear or aggravate after birth. The response to the coarctation is a left-to-right flow redistribution that results in a ventricle imbalance with right dominant cavities. However, there is also a physiological right dominance during the third trimester, which is the leading cause of false-positive diagnoses.

Given the above, this study aimed to apply machine learning (ML) tools to gain insight into the prenatal diagnosis of AoC, particularly focusing on how hemodynamics can aid in discerning between true coarctations and physiological right dominant cases.

To that end, clinical variables and Doppler velocity traces were used together as input features to an unsupervised multiple kernel learning (U-MKL) algorithm, which allows to reduce the dimensionality of the data and represents patients by similarity. Then, multiscale kernel regression (MKR) was applied in order to analyze the variability encoded in each output dimension. Finally, a generalized linear model (GLM) was trained based on the output coordinates of the MKL space as predictor variables for diagnosis.

Although no significant differences were found between true coarctations and low-risk right dominances, a larger-scale and longitudinal study that integrates other interesting velocity profiles needs to be performed.

Keywords: Aortic coarctation, prenatal diagnosis, unsupervised multiple kernel learning, multiscale kernel regression

Link for questions

Sala Nau

PREDICTION OF CARDIOVASCULAR DETERIORATION IN PEDIATRIC CANCER PATIENTS BY MEANS OF ARTIFICIAL INTELLIGENCE

Ona Grau Sivera

SUPERVISOR: Patricia Garcia-Cañadilla and Oscar Camara

EVALUATORS: Maria Lucia Rossi and Bart Bijnens

Cancer is the main cause of mortality in the pediatric age. Thanks to recent advances in cancer treatment, patient survival has increased, but sometimes at the expense of increased morbidity and mortality from cardiovascular diseases due to the toxicity of treatments. Cardiotoxicity is a condition when there is damage to the heart muscle due to cancer treatments. Cardiovascular follow-up of these patients is essential to be able to detect and treat cardiovascular deterioration. However, there are no clinical guidelines to assess cardiotoxicity in pediatric patients, as its current evaluation is based on guidelines derived from adult population.

Currently, cardiovascular deterioration secondary to cancer treatment is often detected once it has been established, implying treatment suspension and a worsening of the child's quality of life. Therefore, there is a need to identify patients that are in risk of suffering from cardiotoxicity due to oncohematological treatments, even before clinical manifestations are shown.

For this reason, this work aims to use machine learning algorithms to integrate complex and heterogeneous data from different natures such as electrocardiogram signals, echocardiographic as well as clinical parameters to identify the relevant parameters for assessment of cardiotoxicity. Specifically, we will use Unsupervised Multiple Kernel Learning to capture patients' heterogeneity and overcome a "one size fits all" approach, allowing the exploration and clinical interpretation of the data, thus helping to improve prevention and optimize treatments of pediatric cancer patients.

Keywords: Cardiotoxicity, Pediatric cancer patients, Unsupervised Machine Learning, Multiple Kernel Leaning, Kernel Regression

Link for questions

Sala Nau

POPTIC NERVE EVALUATION OF MULTIPLE SCLEROSIS PATIENTS USING DEEP LEARNING TECHNIQUES ON MRI

Marcos Frías Nestares

SUPERVISOR: Deborah Pareto, Gerard Martí and Gemma Piella

EVALUATORS: Miguel Ángel González and Coloma Ballester

Optic neuritis is a condition in which the optic nerve is lesioned, provoking visual loss, and it is one of the first manifestations of multiple sclerosis. A correct evaluation of the nerve could help in the diagnosis of the disease. The increasing prevalence of multiple sclerosis together with the improvement of deep learning techniques in the healthcare field creates a huge motivation for developing automatic tools for optic nerve assessment.

Therefore, the aim of this thesis is to develop two convolutional networks: a first 3D architecture for classifying axial T2-weighted fat-saturated MRI images between lesioned or non lesioned nerves and a second 2D one that automatically segments the optic nerves for longitudinal studies. Two datasets have been used for validating the system (N=107 and 62) and the labels and the ground truth masks have been manually created by analyzing all the scans and their clinical records. Saliency maps have been applied for a better interpretation of the network's performance.

Both models showed good performance: the classification algorithm has an accuracy of 69.68%, which generalizes to unseen data (68.21%), and the segmentation algorithm has a dice score of 85.61%. The saliency maps showed that it is possible to demonstrate that the first network focuses its attention on the areas that correspond to lesions in the optic nerve.

The two methods showed robustness and, when using only imaging data, their performance is comparable to trained radiologists. Given its speed and performance, the developed methodologies could be translated into a clinical setting.

Keywords: Multiple sclerosis, optic nerve, deep learning, CNN, MRI

Link for questions

Sala Nau

A MULTI-PARADIGM AI AND SIMULATION SYSTEM TO TACKLE LUNG CANCER

Joel Romero Hernandez

SUPERVISOR: Oscar Camara and Ricard Solé

EVALUATORS: Miguel Ángel González and Blai Vidiella Rocamora

Complex diseases are one of the gravest sources of suffering and death. Their multifactorial nature and multi-scalar effects induce high uncertainty, often leading to a profound physiological failure that compromises the patient's health and life. In this context, the present project focuses on the design and construction of a modular, multi-purpose system that integrates data analysis, computational simulations and Deep Learning to help patients. Its mission: to optimise the treatment by allowing an efficient exploration of the intricate search space associated with diagnostic and therapy

On the one hand, the various general-purpose modules that make up the end-to-end pipeline are developed and integrated. The first is the Case Analysis Module (Cam), which processes multimodal biomedical patient data directly from the hospital equipment to achieve a spatial and functional approximation of the disease. Second, the Simulation Platform for Adaptive Complex Environments (Space) uses this information to generate several instances of a 3D dynamic representation of the patient's physiopathology, built upon methods like cellular automata, diffusion-reaction and population modelling. Third, the AI Unit for Therapy Optimization (Auto) interacts with these patient-specific simulations and uses Deep Reinforcement Learning to search for strategies that improve therapeutic efficacy, based on metrics defined by the clinicians themselves.

On the other hand, the prototype is tested for lung cancer, a highly prevalent and deathly condition, and a quintessential example of what a complex disease is. Thus, data from actual patients is used to study whether the system can consistently reconstruct the disease-therapy process and to compare the strategies generated with those applied in reality.

With this, the ultimate goal of the project is to lay the first stone of a paradigm that could empower clinicians and help them save more lives by combining the best of humans and machines.

Keywords: Complex Diseases, Computational Physiology, Deep Learning, Reinforcement Learning in Healthcare, Lung Cancer.

Link for questions

Sala Nau

CONTINUOUS LIP READING IN SPANISH

Yadira Paola Ronquillo

SUPERVISOR: Federico Sukno and Ardriana Fernández

EVALUATORS: Nicolás Gutiérrez Páez and Gloria Haro Ortega

Lip reading, also known as visual speech recognition, is the task of decoding text from lip movement, which involves analyzing the change of the speaker's lip shape. It has a wide application in the fields of security, assisted driving systems, virtual reality, speech transcription for cases where audio is not available, and communication of people who are hearing-impaired. For the last case, it can also be an extremely helpful tool for this people to communicate through video calls or to understand what the other person is speaking. It can also be used to enhance some already existing speech recognition models, especially if the audio is noisy. For such reasons, lip-reading has been the subject of a vast research effort over the last few decades. Currently, deep learning is being used to deal with this task. However, the training of the lip-reading model relies on a large amount of data. Therefore, lip reading has limited its applicability to English since this is the only language with large-scale datasets. In this work, we used a new audio-visual dataset in the Spanish language, which has been built from a subset of the RTVE database. This is the largest publicly available sentence-level lip reading dataset to date in the Spanish language and it consists of over 13 hours of video, extracted from Canal 24 horas. We used it to develop an Automatic Lip-Reading (ALR) system for continuous speech recognition in Spanish. For this purpose, we employed Audio-Visual Hidden Unit BERT (AV-HuBERT) model, based on transformer network. The system obtained can differentiate some words but not all the words in the sentence. On the other hand, we demonstrate the advantages of fine tuning over learning from scratch.

Keywords: Lip Reading, Deep Learning, Automatic Speech Recognition, Fine-tuning.

Link for questions

Sala Nau

IDENTIFICATION AND LOCALIZATION OF SEPTAL FLASH BY THE MEANS OF TIME DISTRIBUTED NETWORKS AND CLASS ACTIVATION MAPS

Isaac Capallera Guirado

SUPERVISOR: Oscar Camara

EVALUATORS: Benjamin Lalande and Brais Martínez

Cardiac resynchronization therapy (CRT) has been a significant step forward in the treatment of patients with arrhythmias leading to heart failure. However, it still presents two main issues. Firstly, the criteria to be a candidate for CRT are too simplistic, based on basic indices. Second, the therapy still has a 30% failure rate. Several studies have concluded that specific myocardial motion patterns, mainly the septal flash (SF), are related to a higher success rate of CRT. In prior articles identifying SF in left bundle branch block (LBBB) patients, a dyssynchrony abnormal pattern was present in 45% of the total patients. Its proper identification could serve both as a predictor of CRT success and as a more accurate condition to look for in CRT candidates.

Most approaches to distinguish abnormal conditions rely on medical data. Therefore, machine learning and, concretely, neural networks can be key to revealing new patterns of deformation and improving the characterization and quantification of myocardial motion problems. SF, in particular, is being detected manually by experienced clinicians these days, leading to high inter-observer variability. These facts make SF identification a great subject of study for neural networks, thus potentially impacting clinical practice. However, septal flash occurs at a very specific point of time-space during the cardiac cycle. While neural networks have been demonstrated to be extremely accurate at finding such patterns, they have a huge lack of interpretability, a mandatory feature for clinical applications. In this study, I propose a method to analyze 2D ultrasound video sequences of cardiac motion and automatically characterize septal flash in an interpretable way by defining a time-distributed neural network with an attention system based on gradient class activation maps. The system identifies the most critical frames on the sequence where SF appears and marks the spatial region where the deformation takes place.

Keywords: Cardiac Resynchronization Therapy, Septal Flash, Predictor, Time Distributed Neural Networks, Class Activation Maps

Link for questions

Sala Nau

USE OF TEXT MINING TECHNIQUES FOR THE SELECTION OF COHORTS IN A CLINICAL TRIAL: CLASSIFYING PATIENTS INTO POTENTIAL SUBJECTS FOR A CLINICAL TRIAL ACCORDING TO SELECTION CRITERIA BY ANALYZING MEDICAL RECORDS

Ricard Cambray Alvarez

SUPERVISOR: Horacio Saggion

EVALUATORS: Alex Bravo and Francesco Rozano

DData and its analysis have fostered the development of different fields of knowledge, including clinical medicine. The advancement of this branch of technology has made it possible to increase the efficiency of diagnosing diseases using images and has made it possible to optimize hospital resources and management.

The use of data in the context of hospitals has been based on the analysis of structured or unstructured data such as medical images (X-rays, magnetic resonance, etc.), leaving aside the most abundant data, which are texts (radiology reports, medical history, etc.). The analysis of this type of data is crucial, since it constitutes 80% of the data handled by health professionals.

Text mining and NLP are the combination of multiple techniques and tools that allow preprocessing and extraction of information and knowledge from textual data.

One of the most tedious and time-consuming tasks in clinical trials is the subject selection process. The information of the patients susceptible to inclusion in the study

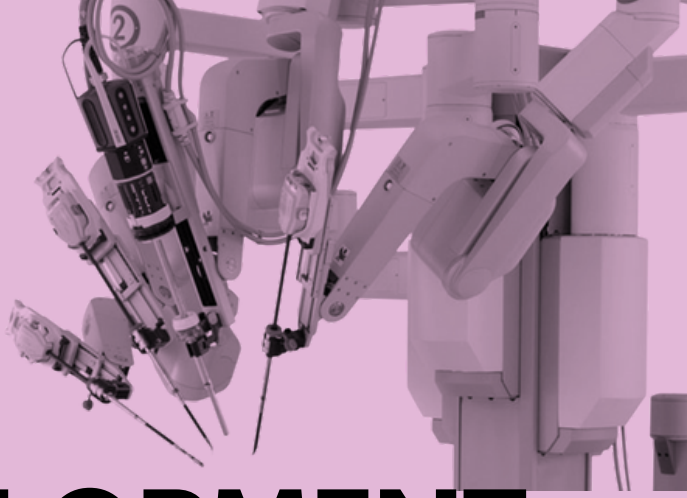
must be consulted manually to check if they meet the defined selection criteria.

The objective of this project is to build an automatic subject selection system for clinical trials from longitudinal medical records of patients using Natural Language Processing (NLP) techniques.

In this way, the time spent in subject selection stage as well as the selection errors would be reduced. In short, speed up the process of selecting the participants of a clinical trial.

This work follows the goals of the 2018 National NLP Clinical Challenges (n2c2) Cohort Selection for Clinical Trials Shared Task and Workshop.

Keywords: Text Mining, NLP, clinical reports, Machine learning, Classification



session 9
MEDICAL DEVICE DEVELOPMENT

July 13th
Auditorium Campus Poblenou

Chair: Ferran Sanz

Evaluators: Rafa Pous, Albert Comerma, Gregorio Boccalero, Anaïs Espinoso, Marc Tudela and Carlos Ruiz

10:00	Communication interface development for an open-source, wireless and implantable vagus nerve stimulator for preclinical studies in mice	Guillem Budia
10:30	Random Number Generator based on intramuscular electromyography to secure wireless networks of electronic implants	Dante Adami
11:00	Design and implementation of a relay-based switching system for allowing bioimpedance measurements during pulsed field ablation	Felipe Gaitan
11:30	Integrated magnetophoretic transfer of functionalized superparamagnetic beads in microfluidic chip and application to portable diagnostic instruments	Celia Mansilla
12:00	Closed-loop control of a network of intra-muscular electrical microstimulators aiming for precise gestures: preliminary assays in New Zealand white rabbits	Álvaro Martínez
12:30	Design and development of a prototype for an intermediate middleware device for medical diagnostic sensors integration	Paula Yuste
13:00	Design and development of capsule and electrode-anchoring system for an implantable intravascular pressure sensor	Nerea Álavarez

Link for questions

Auditorium

COMMUNICATION INTERFACE DEVELOPMENT FOR AN OPEN-SOURCE, WIRELESS AND IMPLANTABLE VAGUS NERVE STIMULATOR FOR PRECLINICAL STUDIES IN MICE

Guillem Budia Vendrell

SUPERVISOR: Laura Becerra

EVALUATORS: Rafa Pous and Albert Comerma

Vagus nerve electric stimulation is a promising neuromodulation technique that has already been approved for depression and epilepsy. The vagus nerve is an intriguing target for this type of stimulation because it is widely known that it is involved in many inflammatory pathways, and the number of diseases linked to inflammation is enormous. With all of this in mind, it's easy to see why functional long-lasting vagus nerve stimulators are in such high demand for pre-clinical research in rodent models. In addition, the current lack of this type of commercial stimulators (none of them open source) in the market makes this work more essential. As a third step of a series of bachelor thesis (BT), following two prior BTs that proposed the development and optimization of a device aimed to be open-source and fully implantable and wireless, this BT aims to add a communication interface to this device to allow the user to interact with it. Hence, the objective is to be able to perform communication functions such as switching ON/OFF magnetically the device in order to increase considerably the battery lifespan and controlling the parameters of the stimulation through IR light. To accomplish this, two state of the art sensors were selected following the small size and current consumption requirements for such implant which were a Hall Effect sensor for the magnetic switch (the Texas Instruments DRV5032) and an IR photodiode for the IR communication (the Wurth Electronik 1540801EEA300). Furthermore, both sensors were connected to a microcontroller (the Nexperia MKL03Z32) in order to prove that they could be correctly implemented in the device.

Keywords: Neurostimulation, vagus nerve, implant, communication interface, sensors.

Link for questions

Auditorium

RANDOM NUMBER GENERATOR BASED ON INTRAMUSCULAR ELECTROMYOGRAPHY TO SECURE WIRELESS NETWORKS OF ELECTRONIC IMPLANTS

Dante Adami Peracchia

SUPERVISOR: Jesús Minguillón and Toni Ivorra

EVALUATORS: Albert Comerma and Anaïs Espinoso

Miniaturization is one of the biggest challenges faced by researchers and engineers working on wireless electronic implants. In this context, the Biomedical Electronics Research Group (BERG) of the Pompeu Fabra University (UPF) works on a new method to perform intramuscular electrical stimulation and electromyography (EMG) through distributed wireless networks of miniaturized implants that bidirectionally communicate with wearable external units. In the future, the communications between the wireless networks of devices and the wearable external units will have to be encrypted to prevent attacks that may jeopardize the health and data of the users. Nowadays, random sequences of bits known as keys are used to encrypt and decrypt signals. These keys are typically generated with Pseudo Random Number Generators (PRNG) which use as sources of entropy combinations of the states and processes of the hardware. In the envisioned scenario, the limited hardware resources hamper the generation of secure and random sequences. Several authors have proposed the use of different biosignals as effective sources of entropy to generate True Random Number Generators (TRNG). In this work, a TRNG based on intramuscular EMG is proposed, hypothesizing that it will generate more random seeds with higher efficiency than a PRNG of a device with limited hardware resources. Furthermore, the effect of different contraction levels and neuromuscular diseases on the EMG and the generated seeds is studied to analyze all the scenarios where such TRNG can be implemented. Results show the capability of the proposed algorithm to generate high-performance random sequences of bits from intramuscular EMG with less computational cost than a PRNG of an electronic device with limited hardware. The performance of the TRNG is not affected by the used muscle as source of EMG or its level of effort. However, results show differences in performance when using data from patients suffering from neuropathic diseases.

Keywords: Implant network security, Key Generation, Electromyography, Pseudo Random Number Generator, True Random Number Generator

Link for questions

Auditorium

DESIGN AND IMPLEMENTATION OF A RELAY-BASED SWITCHING SYSTEM FOR ALLOWING BIOIMPEDANCE MEASUREMENTS DURING PULSED FIELD ABLATION

Felipe Gaitan Conde

SUPERVISOR: Tomás García and Toni Ivorra

EVALUATORS: Albert Comerma and Gerard Amorós

Catheter ablation can be applied for the treatment of atrial fibrillation. Ablation using thermal energies such as radiofrequency or cryotherapy may result in discontinuous lesions and nontargeted tissue injury. Pulsed field ablation (PFA) —also referred to irreversible electroporation (IRE)—, a novel ablation modality, uses short high electric pulses which result in cell death at target tissue by irreversibly permeabilizing the cell membrane. Faster tissue regeneration, tissue specificity and non-thermal damage, are among the benefits claimed for PFA, which may result in a wide therapeutic range and improved safety profile during the procedure.

It is widely known that the phenomenon of electroporation leads to a change in the electrical properties of the tissue. Consequently, some studies on IRE have assayed the use of impedance measurements to monitor the effect of electroporation —such studies were focused on the use of IRE for tumor eradication—. The switching mechanism between both systems (the high-voltage electroporation system and the small-signal impedance measuring system) plays an important role in the overall process, since ideally, measurements before, in between, and after the pulses need to be carried out without interruption. The most common approach is the use of electromechanical relays controlled by a master controller software. However, the design and architecture of the circuit is key in the pursuit of a fail-safe system, since if a high-voltage signal is leaked and reaches the measuring system it could get damaged or even break down.

The present thesis describes the design, implementation, and assay of a robust switching system based on reed relays capable of rapidly switching between the high voltage pulses needed to electroporate the tissue and the impedance measuring system, useful to quantify the level of the lesion. The relays are under the control of a master software run on a microcontroller board (Arduino).

Keywords: Irreversible electroporation, pulsed field ablation, bioimpedance, cardiac arrythmia, switching system, relay

Link for questions

Auditorium

INTEGRATED MAGNETOPHORETIC TRANSFER OF FUNCTIONALIZED SUPERPARAMAGNETIC BEADS IN MICROFLUIDIC CHIP AND APPLICATION TO PORTABLE DIAGNOSTIC INSTRUMENTS

Celia Mansilla Usero

SUPERVISOR: Orphée Cugat and Franz Brukert and Toni Ivorra

EVALUATORS: Gregorio Boccalero and Martial Defoort

Lab-on-chip technologies have demonstrated to be advantageous in terms of analysis time, sample size, portability, etc. With the aim of achieving these features, the startup MagIA diagnostics I am collaborating with was born to came up with magnetic immunological tests done in single-use microfluidic lab-on-chip cartridges. The objective of the project is based on going one step further and trying to minimize and reduce, to lab-on-chip technology, laboratory processes where different steps and reagents are needed. Two important tasks are being developed to achieve the goal. First, performing magnetophoresis in which magnetic beads can be moved from one section to the other on the cartridge. It has been tested with different magnetic nanoparticles, for being sure that it is reproductible and different beads can be displaced. One of the desired processes to be simplified is PCR, so the displacement of magnetic particles that capture DNA has been tested and the result has been satisfactory. Second, microfluidic cartridge design is important when the aim is moving the magnetic particles through the various liquids without mixing the reagents in the different sections. This last step is being exploited since different fluids and geometries are being tested.

Keywords: SPN, lab-on-chip, microfluidics, magnetic field, PCR

Link for questions

Auditorium

CLOSED-LOOP CONTROL OF A NETWORK OF INTRA-MUSCULAR ELECTRICAL MICROSTIMULATORS AIMING FOR PRECISE GESTURES: PRELIMINARY ASSAYS IN NEW ZEALAND WHITE RABBITS

Álvaro Martínez Marco

SUPERVISOR: Jesús Minguillón and Toni Ivorra

EVALUATORS: Anaïs Espinoso Palacín and Albert Comerma Montells

Functional electrical stimulation consists in the delivery of electrical pulses aimed to restore functional movements in paralytic individuals. Its level of applicability is still highly dependent on the invasiveness of the systems required to perform multi-site stimulation. In this framework, one of the most promising approaches is based on the deployment of wireless networks of intra-muscular microstimulators. However, up to date, this approach has been limited by the size of currently available microstimulators.

The Biomedical Electronics Research Group (BERG) at University Pompeu Fabra is pioneering the development of intra-muscular microstimulators with unprecedented features regarding minimal invasiveness. These devices have a diameter below 1 mm and most of their body consist of flexible materials.

The injectable flexible devices developed by BERG, known as eAXONs, evoke neuromuscular stimulation by the rectification of volume conducted high frequency (HF) current pulses supplied by an external unit. Several of these independent eAXONs microstimulators can form a network to be implanted and, ultimately, digitally controlled. Until now, BERG has manufactured and validated its first functional prototypes.

In order to find an appropriate deployment of them in a living organism, secondary goals for the Thesis were established:

1) A preditive musculoskeletal model in OpenSim allowing for an in silico understanding of evoked muscular forces, gestures and stretchings.

2) A mechanical platform where to lay the animal under study.

3) A proper aconditioning of the electronic system and its set-up .

Nonetheless, their applicability to induce precise movements has still not been demonstrated. In this context is where the current Bachelor Thesis has its core value proposal: to prove that by means of a closed-loop controller and a network of eAXONs it is possible to control certain precise muscular movements in a New Zealand anesthetized rabbit.

Keywords: Functional electrical stimulation, muscular restoration, closed-loop controller, electronic injectable device, rabbit.

Link for questions

Auditorium

DESIGN AND DEVELOPMENT OF A PROTOTYPE FOR AN INTERMEDIATE MIDDLEWARE DEVICE FOR MEDICAL DIAGNOSTIC SENSORS INTEGRATION

Paula Yuste Barraquer

SUPERVISOR: Borja Gómez López and Laura Becerra

EVALUATORS: Marc Tudela Pi and Ignacio Gómez Pérez

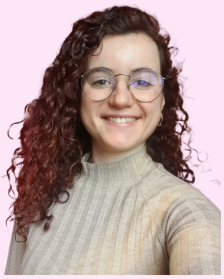
Advances in medicine are constant thanks to the growing and important role of technology in medical care. In the case of telemedicine, it is possible to access medical services and information difficult to achieve in the past. This offers solutions to today's challenges, such as the growing demand for health services, the ageing of the population or the need to manage large amounts of information. This Bachelor Thesis proposes the design and development of a telemedicine middleware device aimed to integrate the information collected from different medical diagnostic sensors, with automatic sending to a cloud-based centralized patient's clinical data software. The most common issue regarding this kind of technology is the ease of use, especially in older adults. An intermediate service is necessary to eliminate the need of a software platform which technological use is not trivial. The operation of the proposed device is a stand-alone solution, not requiring any laptop, phone, or tablet as adapted devices for continuous measurement of patient vital signs (e.g., temperature, weight, blood pressure, and oxygen saturation). To accomplish this, it has been proposed the device's control unit to be based on a Raspberry PI 4 computer board with integrated WIFI and Bluetooth, which would allow the connection to different medical sensors (e.g., thermometers, tensiometers, and pulsioximeters). The device is composed of an external protective structure of the Raspberry PI and its accessories such as visual indicators (LEDs), microphone, speaker, and push buttons. The capacity and quality of the handling of the data received from the sensors by the device has been measured. Moreover, the potential acceptability and perceived usefulness of the prototype has been evaluated with an interview to participants of the target groups. The development of this project has been carried out in collaboration with Kerox Technology (Madrid, Spain), a health sector tech-based company.

Keywords: Telemedicine, Proprietary intermediate device, Bluetooth, WIFI, Smart medical devices, Diagnostic sensors, Wireless, Raspberry PI 4, Bleak library, Ionic

Link for questions

Auditorium

DESIGN AND DEVELOPMENT OF CAPSULE AND ELECTRODE-ANCHORING SYSTEM FOR AN IMPLANTABLE INTRAVASCULAR PRESSURE SENSOR



Nerea Álvarez de Eulate Llano

SUPERVISOR: Laura Becerra and Toni Ivorra

EVALUATORS: Carlos Ruiz Wills and Gerard Amorós

Heart failure (HF) is a major health and economic challenge in both developing and developed countries. Being a chronic condition characterized by a heart that does not pump enough blood to the body, the existing HF monitoring strategies, based on the tracking of symptoms, weight and biomarkers, are inadequate as they occur late. Current efforts towards continuous remote monitoring of physiological variables that change early in HF, present a promising path for improved care delivery and clinical outcomes. In this context, the Senso-eAXON project proposes an implantable intravascular pressure sensor for wireless HF monitoring. This device is currently under development by the Biomedical Electronics Research Group (BERG) at the Universitat Pompeu Fabra (UPF). The Senso-eAXON implant is characterized by being wirelessly powered and interrogated by volume conduction, a method that makes use of the conductive properties of tissues enabling the transfer of current bursts applied epidermically to implants within the body. This bachelor thesis proposes the design and evaluation of a hermetic biocompatible capsule and an electrode-anchoring system for the intravascular pressure sensor proposed. Bearing in mind that the capsule is responsible for the transmission of the external blood pressure to the intracavity space for its sensing, analytical and computational models were implemented to drive towards an optimized capsule design. Two pressure sensing strategies are analyzed. Additionally, a study on the interactions of materials with tissues and organs was performed attempting to design a hemocompatible implant. The functionality of the implants was assessed using the developed test benches. The models, test benches and results presented in this work lay the foundation for the characterization, design and development of the intravascular pressure sensor and serve as a proof-of-concept of the Senso-eAXON implant.

Keywords: Implantable biomedical sensor, heart failure, pressure sensing, finite element analysis, numerical models

session 10

DATA ANALYSIS

July 13th
Auditorium Campus Poblenou

Chair: Marta Ibáñez
Evaluators: Jaume Bertranpetit, Jyoti Narang, José Manuel Fernández and Rubén Vicente

15:00	Analysis of the Breadth-Depth Dilemma through the Users of Koa Foundations, a Mental Well-being App	Maria Pujol Torrens
15:30	Analysis of the exploration-exploitation trade-off in the Koa Foundations app usage	Laura Sánchez
16:00	An EEG and ECG based biofeedback system for enhancing music therapy sessions with terminally ill cancer patients	Ava Shamlou
16:30	Development of a Software based on a Mathematical Model of the Renal System for Computer Physiology Practices for Biomedical studies	Paula Serra
17:00	Development of Skeletal Muscle Contraction Computer Physiology Practices for Human Biology, Medicine and Biomedical Engineering	Karina Karenik

Link for questions

Auditorium

ANALYSIS OF THE BREADTH-DEPTH DILEMMA THROUGH THE USERS OF KOA FOUNDATIONS, A MENTAL WELL-BEING APP

Maria Pujol Torrens

SUPERVISOR: Rubén Moreno

EVALUATORS: Jaume Bertranpetit and Chiara Mastroqiuseppe

In our daily lives, we are constantly facing multi-alternative decision-making tasks. When the options are not familiar to us, we need to extract information from them in advance to make a good choice. Nevertheless, sometimes the decision-maker has limited resources, meaning that, for instance, they do not have enough time to completely learn from all the alternatives, especially if there are many of them. This is the problem that the users of Koa Foundations, a mental well-being app, face at the beginning. Foundations offers a wide range of science-based programmes and activities for the treatment of sub-clinical stress, anxiety, and depression. These activities are divided into different modules, groups of activities that share some features. For example, in the module of 'Relaxation techniques', we can find the activities of watching a video on 'Deep diaphragmatic breath' or listening to an audio on 'Progressive muscular relaxation'. In this work, we analyse how users explore the app through the breadth-depth dilemma. Given that the sampling capacity is finite, the goal is to optimise the search to guarantee that the best alternative is selected. In our context, this would be translated into finding the module that fits the best for a specific user. The dilemma, then, focuses on whether it is better to examine as many alternatives as possible (i.e., to follow a breadth search) or to invest all the sampling in a few options (i.e., to use a depth approach). Since capacity seems to be a determinant factor, we will try to find the most appropriate way to quantify it and see how it influences the trade-off. With this, we will compute how theoretically optimal each user behaves and determine if this translates into a higher engagement with the app.

Keywords: Data analysis, decision-making, breadth-depth dilemma

Link for questions

Auditorium

ANALYSIS OF THE EXPLORATION-EXPLOITATION TRADE-OFF IN THE KOA FOUNDATIONS APP USAGE

Laura Sánchez Ruiz

SUPERVISOR: Rubén Moreno

EVALUATORS: Jaume Bertranpetit and Chiara Mastroqiuseppe

Decision-making is a fundamental human behaviour. In our day-to-day lives, we are constantly coming across the problem of choosing among multiple options, which we aim to solve by maximizing the outcomes. To achieve this, the process of making a decision involves the selection of a course of action among all the possibilities in order to stumble upon the best alternative, which becomes especially critical when the decision-maker's resources are limited. In such cases, the usage of optimal strategies for evaluating the options becomes key for the agent to succeed with the task. The decision of the path to take is usually not straightforward and involves dilemmas such as the exploration-exploitation trade-off, in which the decision-maker agent is faced with deciding whether to sample new options to gain new knowledge (exploration) or instead choose options already sampled and known to perform well (exploitation).

A specific case of study in which such aforementioned tasks take place is in the users' utilization of the Foundations application. This mental-health mobile app offers a wide catalogue of activities, grouped into modules, and does not initially provide users with any explicit guidance or recommendations. In this work, data generated by users using the app has been analyzed by tackling the exploration-exploitation strategy framework, ultimately aiming at relating it to users' engagement. This is done under the premise that they aspire to find the activities and modules that work best for them. To that end, in the beginning, they tend to explore the app more, but then, as their time on the app goes by, a balance between exploration and exploitation appears. As part of the objectives, an optimal strategy balancing the two behaviours correlating to the users' engagement with Foundations has been sought.

Keywords: Data analysis, decision-making, exploration-exploitation dilemma

Link for questions

Auditorium

AN EEG AND ECG BASED BIOFEEDBACK SYSTEM FOR ENHANCING MUSIC THERAPY SESSIONS WITH TERMINALLY ILL CANCER PATIENTS

Ava Shamlou Monzavi

SUPERVISOR: Rafael Ramirez

EVALUATORS: Jyoti Narang and Enric Peig

The present study evaluates, based on data from electroencephalography (EEG) and electrocardiography (ECG), the emotional response of patients with end-stage cancer to a music therapy (MT) intervention in a randomized self-monitoring clinical trial. Following the inclusion criteria, a sample of 20 participants will be recruited from the palliative care unit of the Hospital del Mar in Barcelona. Each participant will act with their own control being subject to a session of music therapy with biofeedback and one without biofeedback. The order of the two interventions will be random. Based on our previous work on EEG-based emotion detection, instantaneous emotional indicators will be extracted in the form of a coordinate in the arousal-valence plane. Emotional indicators will be analyzed in order to quantify (1) the global emotional effect of TM on patients, and (2) the relative effect of biofeedback during each session. In addition to the EEG and ECG data, other data will be collected through a pre and post intervention questionnaire.

Keywords: Cancer, palliative care, EEG, ECG, music therapy, biofeedback, emotion analysis

Link for questions

Auditorium

DEVELOPMENT OF A SOFTWARE BASED ON A MATHEMATICAL MODEL OF THE RENAL SYSTEM FOR COMPUTER PHYSIOLOGY PRACTICES FOR BIOMEDICAL STUDIES

Paula Serra Robres

SUPERVISOR: Rubén Vicente

EVALUATORS: José Manuel Fernández and Gerard Ill-Raga

A complete understanding of human organs and systems cannot be achieved only by theoretical classes. Practical lessons are also part of the curriculum of courses like Molecular Biology or Physiology. The great majority of vital processes and structures studied in these courses are not easy to reach and therefore, there is a need to develop realistic simulators based on mathematical models to work with.

One of these unreachable systems is the Renal System. The purpose of the present study is to program and develop an Open Source software intended to be used as a support tool in the study of the Renal System functioning of Medicine, Human Biology and Biomedical Engineering students. The software is developed in Python programming language and it includes a user-friendly interface created by Qt, a cross-platform software.

The Renal System regulates extracellular liquid volume, blood pressure or osmolarity, among others. The software focuses on the processes performed by the nephrons, the functional units of the kidneys: filtration, reabsorption and secretion. The program simulates different scenarios and shows how important parameters such as the single-nephron glomerular filtration rate (SNGFR), which refers to the volume of plasma filtered per unit of time in each nephron, or the Glomerular Pressure affect the renal function.

Keywords: Software, Mathematical Model, Renal System, Nephron, SNGFR, Glomerular Pressure

Link for questions

Auditorium

DEVELOPMENT OF SKELETAL MUSCLE CONTRACTION COMPUTER PHYSIOLOGY PRACTICES FOR HUMAN BIOLOGY, MEDICINE AND BIOMEDICAL ENGINEERING

Karina Karenik

SUPERVISOR: José Manuel Fernández and Patricia Carbajo

EVALUATORS: Rubén Vicente Garía and Selma Angélica Serra

Development of Skeletal Muscle Contraction practices. Simulation of skeletal muscle contraction in response to electrical stimulation of the motor nerve in order to explain the following concepts: - Recruitment or summation of motor units in response to a single electrical stimulus of increasing amplitude. - Temporal and sequential representation of electrical stimulation of the motor nerve, action potential in the muscle and muscle contraction. - Summation of contraction waves and tetanization as a consequence of the application of high amplitude stimuli at increasing frequencies. - Relationship between the length of a skeletal muscle and its contractile capacity after tetanus stimulation.

Keywords: Physiology, Software Practices, Skeletal Muscle Contraction

session 11
BUSINESS DEVELOPMENT

July 13th
Sala Nau Campus Poblenou

Chair: Nuria Brunet
Evaluators: Diego Torres, Víctor Lázaro, Rafael Manzanera and Albert Domingo

15:00	Process validation for additive manufacturing (SLA) of customised surgical guides	Clara Sanchez
15:30	Boreas ultra low temperature freezers. New product innovation based on medical device certification	Mariona Fernández
16:00	Study of the purchasing dynamics of medical technology in Spanish hospitals, and particularization for a postpartum hemorrhage detector	Olivia Genova
16:30	Business Plan for introducing to the market correcting sleep posture medical device	David Agulló
17:00	Business plan of VIDAA	Rosa Ana García

Link for questions

Sala Nau

PROCESS VALIDATION FOR ADDITIVE MANUFACTURING (SLA) OF CUSTOMISED SURGICAL GUIDES

Clara Sanchez Pedemonte

SUPERVISOR: Cristina Artieda Guzmán and Simone Tassani

EVALUATORS: Diego Torres Garrido and Èlia Vidal Girona

Customised surgical guides are medical devices that assist surgeons in cutting and drilling of bone structures as their use has shown to increase accuracy in surgical treatments. These devices are obtained from medical images and fabricated with 3D printing. Selective laser sintering with poliamide 12 is the standard technology for this purpose, but there are other promising options such as Stereolithography with acrlylic resin. Until 2018, small part of its production was outsourced, but as a new "in-house" regulation is present in Royal Decree draft, it is believed that trend will be outsourcing. After a market study, AMES Medical considers the implementation of Stereolitography manufacturing of customised surgical guides a priority. By means of company's own design and development methodology, it is demonstrated that final process meets all applicable requirements.

However, this layer-by-layer production results in anisotropy, so there can be differences in physical properties when changing printing orientation. To ensure a good performance of the guide, customisation to patient and dimensional accuracy are essential, that can also be affected by orientation. A dimensional study is performed to analyse accuracy of 9 different orientations and to find out which one results in highest and most robust accuracy. Tensile, flexural, impact and hardness properties in 5 different orientations are also analysed to know orientation effects and whether final device meets market standards.

Dimensional results determines that highest accuracy is obtained at 0° in XY plane and at 45° of inclination, although studies on other variables are needed. Mechanical results show competitiveness of device and significant differences between samples manufactured at 0° and 90° of inclination, which is consistent with anisotropy. So after developing a verification methodology for cusomised surgical guides, orientation effect on final dimensions and physical properties is demonstrated.

Keywords: Custom-made medical devices, Surgical Guides,3D printing, Stereolitopgraphy, Validation

Link for questions

Sala Nau

BOREAS ULTRA LOW TEMPERATURE FREEZERS. NEW PRODUCT INNOVATION BASED ON MEDICAL DEVICE CERTIFICATION

Mariona Fernández Salmerón

SUPERVISOR: Lema, Leticia and Rafael Manzanera

EVALUATORS: Víctor Lázaro and Jordi Valls

High-quality storage practices of biological samples are critical to achieve reliable and reproducible results whichever biomedical application. Biospecimens may degrade or lose their integrity over time if subjected to erroneous preservation temperature. Billions of biological samples such as deoxyribonucleic acid (DNA), ribonucleic acid (RNA), endocrine molecules, and sensitive stem cells are long-term stashed away in ultra-low temperature (ULT) freezers.

ULT freezers are refrigerators suitable for preserving contents at temperatures between -55ºC and -86ºC. Nowadays, research institutes, hospitals and pharmaceutical and biotechnology enterprises can lay out a widespread ULT freezer portfolio, manufactured by worldwide companies.

Technology increases at an ever-increasing rate. More than ever, business call for product upgrades to stand apart from the competition. In ULT freezers case, features like energy consumption, screen and software can be enhanced.

This thesis presents a case study focused on the improvement of Boreas ULT freezers, from Azbil Telstar Technologies, a subsidiary of Azbil Japanese corporation. Azbil Telstar Technologies offers ULT freezers that stand out for using environmentally friendly refrigerants and furnishing a large and optimized storage capacity. Albeit the product is mainly sold to biomedical research institutes, it is not yet certified as a medical device. Accordingly, this study will describe and develop the regulatory requirements needed to certify ULT freezers as Class I and Class IIa medical devices under the European Medical Device Regulation 2017/745, deeming stored biospecimens' usage and new market niches.

Keywords: Product innovation, Medical devices, Medical device regulation, Ultra-low temperature freezer, Biospecimens

Link for questions

Sala Nau

STUDY OF THE PURCHASING PROCEDURES FOR MEDICAL TECHNOLOGIES IN SPANISH HOSPITALS: PARTICULARIZATION FOR A POSTPARTUM HEMORRHAGE DETECTOR

Olivia Genova Blanch

SUPERVISOR: Toni Ivorra

EVALUATORS: Rafael Manzanera and Marc Tudela

The World Health Organization defines a medical device as any instrument, machine, implant, software, or material intended to be used for a medical purpose. Medical devices can treat, prevent, detect and diagnose diseases. Examples of medical devices are glucose monitors and pacemakers. The medical device industry in Spain currently accounts for 7,417 million euros, with an increase of close to 42% in the last six years. Developing a new medical device takes an average of 4.6 years. It can cost tens of millions of euros since it must be registered and pass many controls, regulations, and certifications, such as the CE mark. Unfortunately, the procedures to commercially introduce a medical device can be different and unclear in hospitals, depending on the type of technology, the amount, the use, etc. It is beneficial to understand these procedures in order to plan the best strategy for patenting and regulating a new medical technology before marketing it. This study describes the purchasing procedures for medical technologies in Spanish hospitals. The ultimate goal is to provide a guide for the process of introducing a new medical device in Spanish healthcare to facilitate the launch of new medical technology for entrepreneurs. To achieve the objectives of the project, structured and semi-structured interviews have been conducted with professionals from the medical sector and medical technology companies about the introduction of medical technology in hospitals. Twenty-seven interviews were conducted both orally and written. The differences in this process depend on the type of technology and the people involved. As a case study, the description of the purchase procedures is particularized for a hypothetical postpartum hemorrhage detector, an innovative medical device without direct competition.

Keywords: Medical devices, Spanish hospitals, Acquisition, Launching, Postpartum hemorrhage

Link for questions

Sala Nau

BUSINESS PLAN FOR INTRODUCING TO THE MARKET CORRECTING SLEEP POSTURE MEDICAL DEVICE

David Agulló González

SUPERVISOR: Carlos Pachá

EVALUATORS: Rafael Manzanera and Laura Becerra

HThere are hard lenses that are placed at night when sleeping and allow myopia or other eye diseases to be corrected for the rest of the day. The problem that exist is the sleeping position because a face down position make these lenses unuseful.

The idea is to create a device would be able to know the position in which the person is lying down while sleeping and in the event that the patient is not in the desired position, it would emit a vibration or noise that would make the patient not feel comfortable returning to the correct sleep position. At first it would be shocking for the user since they would constantly run into the temptation to sleep with their usual posture, but this discomfort caused by the device in this position would make them adopt the correct one over time.There are two ways to know what position the person is in.

The first and most technological would be to do it by implanting in the device a compass similar to those found in mobile phones with the option of length that measures the angle of twist or deviation from a straight surface, which in this case would be face up. From this origin, everything that the patient is turned over above a set threshold will begin to vibrate the device.

The other option is to create a cavity inside the device where a ball can circulate freely with a kind of hole where a pressure sensor is located and when sleeping face down this ball falls into the hole by pressing on the sensor and causing the passage of current in the circuit and therefore causing the device to vibrate.

Keywords: Orthokeratology, medical device, sleep posture,wireless, multifunctional

Link for questions

Sala Nau

BUSINESS PLAN OF VIDAA

Rosa Ana García García

SUPERVISOR: Andy Luis Olivares and Jordi Mill

EVALUATORS: Albert Domingo

Virtual Implantation and Device selection in left Atrial Appendages, so-called VIDAA, is a web-based platform intended to optimize Atrial Fibrillation (AF) therapies. Patients with contraindications to anticoagulant oral treatments are often implanted a left atrial appendage occluder (LAAO)so as to prevent the blood flow entering the LAA. Currently, VIDAA platform is under clinical trial and has been proven to perfectly select the most appropriate LAAO configuration (type of device, size, landing zone) for a patient-specific LAA morphology. The aim of this thesis is to study and develop the commercialization of VIDAA. For that purpose, firstly the regulatory process of the mentioned platform device must be done, which consists in the development of VIDAA technical documentation following the European Union requirements for its CE. Consequently, the economical and financial viability will be coherently done and therefore all the relevant steps (market analysis, competitors, among others)to conform a robust business plan if possible.

Keywords: left atrial appendage occluder implantation, web-based platform therapy, commercialization, regulatory process, economical and financial viability

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