VILNIUS TECH
Vilnius Gediminas Technical University

OTH REGENSBURG

POLITECHNIKA BIAŁOSTOCKA

Blended Intensive Program (BIP) on "Sensor Driven Modelling for Healthy Living"

Musculoskeletal Simulations, Biosignals and Sensor Data analysis for data-driven solutions for mobility, prevention, diagnosis and rehabilitation

Remote sessions: 05-09 May 2025

On-site sessions: 19-23 May 2025

VILNIUS TECH, Vilnius, Lithuania

BIP on "Sensor Driven Modelling for Healthy Living"

Key areas: Musculoskeletal modelling, Biosignals and predictive modeling

The Department of Biomechanical Engineering (VILNIUS TECH, Lithuania), Laboratory of Biomechanics (OTH Regensburg, Germany) and Institute of Biomedical Engineering (Bialystok University of Technology BUT, Poland) are pleased to welcome you to our first joint BIP "Sensor Driven Modelling for Healthy Living" offering you lectures, workshops, laboratory and cultural activities. The program will be organized in two stages – first stage will contain remote lectures (05-09 May 2025), and second stage is 5-day program in-person in Vilnius, Lithuania (19-23 May 2025).

Summary

This module focuses on utilizing predictive models to enhance decision-making in the field of active healthy living. It equips students with the tools and knowledge to analyse and model the musculoskeletal system, using advanced technologies like AnyBody musculoskeletal software, optical motion capture (BTS) and inertial motion capture (Xsens). Additionally, students will learn how to measure and process biosignals and apply AI techniques to develop personalized solutions for age-related health challenges. The integration of advanced analytic techniques allows for enhanced analysis and predictive modelling, fostering innovation in healthcare applications such as rehabilitation and injury prevention, facilitating healthy living.

Target students:
Biomedical engineering, Medical Engineering, Biomechanical Engineering, Rehabilitation Engineering

Dates of virtual component:
5th May 2025 – 9th May 2025

Dates of physical activity:
19th May 2025 – 23rd May 2025

Contact hours:
30 h (15h online + 15h in person)

ECTS issued:
3 ECTS

Main responsible: Julius Griškevičius (VILNIUS TECH)

Co-authors: Kristina Daunoravičienė (VILNIUS TECH), Sebastian Dendorfer (OTHR), Jolanta Pauk (BUT)

Registration form and main contact:

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Purposes, overview, description

Learning objectives

The aim of this module is to provide students with interdisciplinary knowledge in musculoskeletal modelling, biosignal measurement, and predictive modeling to support healthy living. By the end, students will be able to develop data-driven, advanced analytic techniques to improve health outcomes, addressing issues like mobility, injury prevention, and rehabilitation.

1. Understand the fundamentals of musculoskeletal modeling and its applications in healthcare.
2. Gain proficiency in using motion capture systems to collect and analyze human movement data.
3. Acquire skills in biosignal measurement and processing techniques for real-time assessment of musculoskeletal performance.
4. Apply advanced analytic techniques for decision-making in healthcare scenarios, particularly for active healthy ageing.
5. Develop interdisciplinary teamwork skills by collaborating on a project that integrates modeling, biosignals, and predictive modeling.
6. Present project outcomes effectively, demonstrating the integration of theoretical knowledge and practical applications.

Contents

The module combines state-of-the-art technologies like AnyBody, BTS, and Xsens systems with biosignal measurement tools to provide students with an in-depth understanding of musculoskeletal modeling and healthcare applications. Advanced analytic techniques integration enhances the learning experience, enabling students to make data-driven decisions in real-life scenarios.

- Theoretical modules introduce the principles of musculoskeletal modeling, motion capture, and predictive modeling in healthcare.
- Practical sessions allow students to gather and analyze real-world data, integrating motion capture and biosignal measurements into a proof-of-concept solution.
- The final project challenges students to address real-world problems, such as mobility improvement or fall prevention in ageing populations, by applying learned techniques.
- Students will work in teams, simulating a collaborative, professional environment, and will be guided by mentors and experts throughout the program.

Methods

1. **Online Learning Modules.** Participants will start with a series of online courses covering the basics of musculoskeletal modeling, motion capture systems, biosignal measurement, and predictive modeling. These modules will include video lectures, readings, and quizzes to ensure a strong theoretical foundation.

2. **Collaborative Projects.** Students will work in interdisciplinary teams to develop solutions for real-world health challenges. These projects will require the integration of modeling, motion capture, biosignal data, and predictive modeling.

3. **Hands-On Workshops**. In-person workshops will provide practical training on musculoskeletal modeling, motion capture systems, as well as biosignal measurement tools. Participants will collect and analyze data to create musculoskeletal models.

4. **Peer Learning and Networking**. Group discussions, collaborative tasks, and networking opportunities will enable participants to learn from each other's diverse perspectives and experiences.

5. **Mentorship and Feedback**. Each participant will receive guidance and detailed feedback from experienced mentors, ensuring their project outcomes are well-rounded and impactful.

6. **Final Presentation and Evaluation**. Teams will present their projects to a panel of experts, showcasing their integration of theoretical knowledge and practical skills in addressing a healthcare problem. The evaluation will focus on creativity, data-driven insights, and practical applicability.

Evaluation

Assessment will evaluate both individual and group performance, emphasizing active participation, collaboration, and critical reflection. Students will be graded on the following criteria:

1. **Participation and Initiative.** Active involvement in individual and group activities throughout the course, demonstrating initiative and constructive contributions to discussions.

2. **Task Involvement.** Engagement with the proposed tasks, including the quality of effort in data collection, analysis, and application during hands-on and project-based sessions.

3. **Discussion Contributions.** Participation in group discussions and the final day's reflection session, showcasing the ability to critically evaluate and integrate course content.

Grading Structure. The final mark, graded on a 0–10 scale, will be derived from the following components:

- **Group/Individual Tasks (70%).** Assessed through the completion of hands-on exercises, collaborative projects, and intermediate deliverables throughout the course.

- **Individual Critical Reflection (30%).** Evaluated based on a written or oral reflection at the end of the course, analyzing the learning process, integration of knowledge, and potential applications in real-world scenarios.

Preliminary program

Date	Time	Remote	
20250509	14:30-16:05	Opening of the course, introduction to the concepts and Sensor Driven Modelling in Healthcare.	VTECH, OTHR, BUT
20250510	14:30-17:55	Fundamentals of Musculoskeletal Modelling and Simulation Tools (AnyBody).	OTHR
20250511	14:30-17:55	Motion Capture technologies (BTS, Xsens) and their applications for Data Collection.	OTHR, VTECH
20250512	14:30-16:05	Fundamentals of Biosignal Measurement and Processing Techniques.	VTECH
	16:20-17:55	Integration of Biomechanical Models and Biosignal Data for Real-Life Applications.	OTHR, VTECH
20250513	14:30-17:55	Data-Driven Applications in Biomechanics and Healthy Living	BUT, OTHR, VTECH
		On-site	
20250519	10:20-13:45	Hands-on practice with the AnyBody Modelling System for musculoskeletal simulation.	OTHR
20250520	10:20-16:05	Practical training with BTS and Xsens motion capture systems to record and analyze human motion.	VTECH, OTHR
20250521	10:20-13:45	Use of biosignal measurement tools for EMG and other relevant signals.	VTECH, OTHR
20250522	10:20-11:55	Application of advanced data analysis techniques to interpret collected data and make predictive decisions supporting active ageing.	BUT
	12:10-16:05	Group projects focused on developing data-driven solutions for health-related challenges, such as mobility improvement or fall prevention in older adults, solutions for healthy living promotion and facilitation	VTECH, OTHR, BUT
20250523	10:00-13:00	Project presentations, closing ceremony	

Lectures and Workshops

Remote Sessions

Date: 2025-05-09

Prof. dr. Julius Griškevičius, Prof. dr. Kristina Daunoravičienė, Prof. dr. Sebastian Dendorfer, Prof. dr. Jolanta Pauk

Opening of the Course, Introduction to the Concepts, and Sensor Driven Modelling in Healthcare (Lecture)

This session introduces the program, its goals, and structure. It provides an overview of sensor driven modeling in healthcare, focusing on data-driven decision-making for active ageing. Participants will explore the potential of AI in musculoskeletal health, rehabilitation, and personalized treatment.

Date: 2025-05-10

Prof. dr. Sebastian Dendorfer (Germany)
OTH Regensburg, Laboratory of Biomechanics (Germany)

Fundamentals of Musculoskeletal Modelling and Simulation Tools (AnyBody)

Participants will gain foundational knowledge of musculoskeletal modeling, focusing on the AnyBody Modeling System. The session covers its core principles, capabilities, and applications in analyzing human motion and designing health-related solutions.

Date: 2025-05-11

Motion Capture Technologies (BTS, Xsens) and Their Applications for Data Collection

This session introduces advanced motion capture systems (BTS, Xsens). It explores their applications for collecting and analyzing human movement data, emphasizing their role in biomechanical modeling and healthcare scenarios.

Date: 2025-05-12

Prof. dr. Kristina Daunoravičienė (Lithuania)
Vilnius Tech, Department of Biomechanical engineering

Fundamentals of Biosignal Measurement and Processing Techniques

This topic covers the principles of measuring biosignals, exclusively of a bioelectric nature, with a focus on the specifics and methods of electromyography (EMG) measurement. Participants will learn methods for processing and interpreting biosignals to assess muscle functional capabilities and performance.

Date: 2025-05-12

Prof. dr. Sebastian Dendorfer (Germany), M.Sc. Lukas Gschossmann (Germany)
OTH Regensburg, Laboratory of Biomechanics (Germany)

Integration of Biomechanical Models and Biosignal Data for Real-Life Applications

Building on previous sessions, this topic demonstrates how to integrate motion capture and biosignal data into musculoskeletal models. Participants will explore practical applications in healthcare, including mobility enhancement and rehabilitation.

Date: 2025-05-13

Prof. dr. Jolanta Pauk (Poland)
Bialystok University of Technology (Poland)

AI and Machine Learning Applications in Biomechanics and Healthy Living

This session explores how advanced data analysis techniques can enhance biomechanical data analysis, predictive modeling, and decision-making. Participants will examine case studies on using data-driven approaches to support active healthy ageing and develop innovative health solutions.

On-Site Sessions

Date: 2025-05-19

Prof. dr. Sebastian Dendorfer (Germany), dr. Franz Süß (Germany)
OTH Regensburg, Laboratory of Biomechanics (Germany)

Hands-On Practice with the AnyBody Modelling System for Musculoskeletal Simulation

Participants will engage in practical exercises with the AnyBody Modeling System, simulating human movement and exploring its applications for real-world health challenges.

Date: 2025-05-20

Practical Training with BTS and Xsens Motion Capture Systems

This session involves hands-on training with BTS and Xsens systems to record and analyze human motion. Participants will learn data collection techniques and how to integrate them into biomechanical models.

Date: 2025-05-21

Prof. dr. Kristina Daunoravičienė (Lithuania)
Vilnius Tech, Department of Biomechanical engineering
Use of Biosignal Measurement Tools for EMG and Other Relevant Signals

Participants will use biosignal measurement tools to collect EMG signals for different purposes, applying this data to assess musculoskeletal function and performance in real time.

Date: 2025-05-22

Application of Advanced Data Analysis Techniques to Analyze Collected Data and Make Predictive Decisions Supporting Active Ageing

This session focuses on applying advanced data analysis techniques to collected data, teaching participants how to develop predictive models for health interventions aimed at active ageing.

Date: 2025-05-22

Group Projects: Model based solutions for Health-Related Challenges

Teams will work collaboratively on projects addressing mobility improvement, fall prevention, and other ageing-related challenges. Using the skills and tools acquired, they will develop prediction models, data-driven solutions for healthy living promotion.

Date: 2025-05-23

Project Presentations and Closing Ceremony

Teams will present their project outcomes to a panel of experts, showcasing their integration of advanced analytic techniques, motion capture, and biosignal analysis. The program concludes with feedback, awards, and a closing ceremony celebrating participants' achievements.

Each lecture will be supplemented with guided exercises, case studies, and virtual labs to solidify the students' understanding.

The in-person sessions will conclude with the presentation of student projects, where they will showcase how they integrated modelling, motion capture, prediction models and biosignal processing into a solution addressing a specific health problem.

Suggested Project Topics

1. **Fall Prevention System for Older Adults**

Develop a predictive model using motion capture and biosignal data to identify individuals at risk of falling. Create a prototype system that suggests personalized exercise regimens to improve balance and coordination.

2. **Ergonomic Assessment and Optimization for Work Environments**

Use motion capture and biomechanical modeling to evaluate workplace ergonomics. Develop recommendations for posture correction and workspace design to reduce musculoskeletal strain.

3. **Wearable Device Integration for Real-Time Biosignal Monitoring**

Conceptualize a wearable device that monitors biosignals like EMG to assess muscle fatigue in real time. Integrate this data into a decision-support system for athletes or rehabilitation patients.

4. **Custom Orthotic Design Using Musculoskeletal Models**

Create a workflow for designing custom orthotic devices using data from musculoskeletal models and motion analysis. Simulate their impact on mobility and comfort for individuals with specific gait abnormalities.

5. **Optimizing Physical Activity for Healthy Ageing**

Design a data-driven exercise program for older adults based on motion capture and musculoskeletal modeling. Demonstrate how the program promotes mobility and reduces the risk of musculoskeletal conditions.

6. **Dynamic Balance Analysis and Training System**

Develop a system that uses motion capture and biosignals to evaluate and improve dynamic balance. Propose training interventions based on individual biomechanical data.

7. **Data-driven Prosthetic Design and Control**

Use musculoskeletal modeling and biosignals to design a more efficient and user-friendly prosthetic limb. Incorporate AI to adapt the prosthetic's behavior to the user’s movement patterns.

8. **Virtual Reality Rehabilitation for Elderly Patients**

Integrate motion capture data into a VR environment to create engaging rehabilitation exercises. Propose how the system can be tailored to individual needs using AI.

9. **Personalized Exercise Planning for Sports Injury Prevention**

Combine motion capture and biosignal data to design a personalized injury prevention program for athletes. Highlight how predictive modeling can adjust the program based on performance data.

10. **Assistive Technology for Improving Daily Activities in Elderly**

Design a device or system that integrates real-time motion and biosignal analysis to assist elderly individuals in performing daily tasks. Focus on reducing strain and improving quality of life.