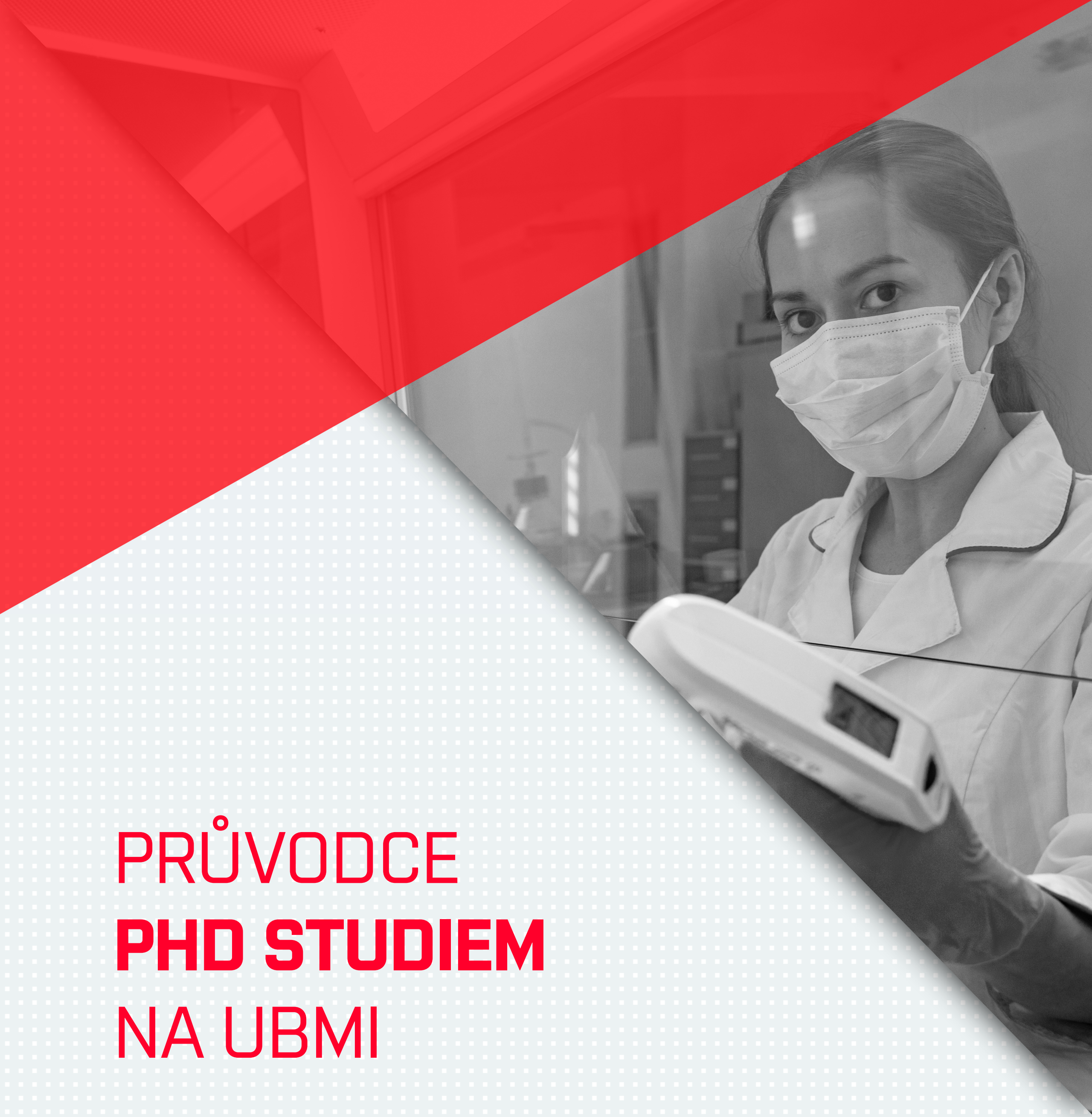

# PRŮVODCE **PHD STUDIEM** NA UBMI

# DOKTORSKÉ STUDIUM NA UBMI

Během doktorského studia se především zaměříte na vědeckou práci v základním i aplikovaném výzkumu. Většina témat, která na UBMI řešíme, jsou realizována ve spolupráci se zahraničními či domácími partnery. Proto jako doktorand získáte řadu cenných zkušeností a dovedností při práci v mezinárodních týmech či ve vědeckých laboratořích.

Standardní doba studia je 4 roky,  z toho několik měsíců doktorandi obvykle tráví na zahraniční stáži. Naši doktorandi měli možnost pracovat  například na Leipzig University, University of Minnesota, University of Nebraska – Lincoln, Ludwig-Maximilians-Universität München či University of Valencia. Během těchto pobytů poznáte řadu významných odborníků z oboru, ale také skvělých lidí, kteří jsou nadšení pro vědu stejně jako vy.

V průběhu studia absolvujete několik kurzů, které doplní znalosti z oblasti vaší disertační práce, soft skills a naučí vás týmové práci. Také se budete podílet na výuce, povedete bakalářské a diplomové práce, aktivně se budete účastnit odborných konferencí či workshopů a budete publikovat ve vědeckých časopisech…ale především se budete věnovat vědeckému bádání a podnikat první velké kroky ve svojí vědecké kariéře.

# PROČ STUDOVAT PHD PRÁVĚ NA UBMI?

- kvalitní vědecké zázemí ve špičkových laboratořích
- práce na vědeckých projektech, které mají smysl
- podpora individuálního i týmového přístupu během studia
- navýšení stipendia nad rámec standardní podpory
- podpora účasti na konferencích a stážích
- kvalitní týmové zázemí tvořené školiteli a vědeckými kolegy

## KVALITNÍ VĚDECKÉ ZÁZEMÍ VE ŠPIČKOVÝCH LABORATOŘÍCH

Vybavení našich laboratoří každoročně obnovujeme, abychom mohli dělat vědu na světové úrovni.

Například do laboratoří biofyziky a bioinformatiky jsme za posledních 5 let investovali více jak 35 mil. Kč.

## PRÁCE NA VĚDECKÝCH PROJEKTECH, KTERÉ MAJÍ SMYSL

Řada minulých i běžících projektů na UBMI je podpořena národními agenturami, které poskytují dotace pouze na kvalitní výzkumné záměry.

## PODPORA INDIVIDUÁLNÍHO I TÝMOVÉHO PŘÍSTUPU BĚHEM STUDIA

Každý člen týmu pracuje jiným způsobem a proto podporujeme týmovou práci a současně i individualitu s možností prosadit vlastní nápady.

## NAVÝŠENÍ STIPENDIA NAD RÁMEC STANDARDNÍ PODPORY

Obdržíte dodatečné stipendium do výše minimálně 20 tis. Kč.

Kromě toho budete odměňováni za vaše vědecké výsledky a pedagogické působení.

## KVALITNÍ TÝMOVÉ ZÁZEMÍ TVOŘENÉ ŠKOLITELI A VĚDECKÝMI KOLEGY

Váš školitel bude vaším hlavním *vědeckým guru*.

Nicméně naše tradiční neformální coffee meetings jsou neocenitelným zdrojem inspirace pro řešení malých problémů i velkých výzev, které vás jistě budou čekat.

## PODPORA STÁŽÍ A SPOLUPRACÍ U ZAHRANIČNÍCH PARTNERŮ

Tadičně podporujeme výjezdy do zahraničí, kde mají doktorandi možnost naučit se nové postupy ve výzkumu a prezentovat svoje výsledky

# JAK SI ZVOLIT VÝZKUMNÉ ZAMĚŘENÍ DISERTAČNÍ PRÁCE?

UBMI nabízí širokou paletu témat vycházejících z aktuálně řešených projektů. Můžete se tak zapojit třeba do výzkumu mitochondriální aktivity buněk v regenerativní medicíně, do analýzy bakteriálních genomů, farmakokinetického modelování, vývoje metod pro analýzu biomedicínských obrazových dat z celé řady modalit, hodnocení zdraví a fyzické aktivity pomocí nositelné elektroniky a řady dalších témat. Aktuální nabídku pro rok 2022 najdete v tomto průvodci.

Máte vlastní nápady a vize pro výzkum? Skvělé! V tom případě kdykoliv oslovte kteréhokoliv výzkumníka na UBMI a domluvte se s ním na podrobnostech. Nové nápady vítáme.

## TERMÍNY A TIPY

**Nabídka témat je každoročné zveřejněná obvykle začátkem dubna a termín podání přihlášek je v polovině května. Pokud máte o doktorské studium zájem nebo máte jakýkoliv dotaz, kontaktujte docenta Koláře kdykoliv během vašeho bakalářského či magisterského studia.**

# PHD TÉMATA 2022

## WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of retinal imaging, image and signal processing, machine learning
- A sound knowledge of programming languages (eg. Matlab, Python)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# New imaging and image processing approaches for retinal diseases monitoring

### Introduction

Retinal imaging has undergone great development over the last decade. In addition to anatomical imaging, research also focuses on functional imaging - measuring flow, perfusion, blood velocity or oxygenation of tissue on the retina. These imaging methods are important for assessment of various retinal diseases as well as systemic diseases.

### Supervisors

doc. Ing. Radim Kolář, Ph.D.

### Topic

The topic is focused on methods for simultaneous evaluation of retinal oxygenation and blood circulation including development of a specific ophthalmic device and appropriate image processing methods. The basic concept of this ophthalmic device has been already designed and verified during last 3 years. The modifications of this concept will enable to capture retinal videosequences at multiple wavelengths and simultaneous acquisition of various biosignals – mainly electrocardiogram, photoplethysmographic and respiratory signal. The doctoral student will thus participate in an interdisciplinary research in the frame of this project, which covers areas such as retinal imaging and its functional evaluation, as well as advanced image and signal processing and machine learning. The aim of the research is to find a methodology for the evaluation of retinal oxygenation, including potentially important biomarkers suitable for the diagnosis of specific diseases. The applied methodology will include specific image processing to extract new spatial maps related to blood volume changes, extraction of specific temporal signals from video data and application of appropriate methods to reveal the relation between physiological signals and retinal image data.

Project will be solved mainly at the Department of Biomedical Engineering. However, cooperation with our foreign partners is expected - Leipzig University and Friedrich-Alexander-Universität Erlangen-Nürnberg in Germany and University of Minnesota, USA.

### Relevant publications


https://opg.optica.org/boe/fulltext.cfm?uri=boe-12-12-7405&id=464723

https://link.springer.com/article/10.1007%2Fs00417-020-04934-y

https://opg.optica.org/boe/fulltext.cfm?uri=boe-9-12-6237&id=401275

## WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of medical imaging, image processing, machine learning.
- A sound knowledge of programming languages (eg. Matlab, Python).
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment.
- English communication skills.

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration.
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# Advanced methods for analysis of brain diseases from medical image data

### Introduction

The observation of structural, intensity and shape changes of brain pathologies is crucial for the diagnosis and treatment planning. Nowadays, the non-invasive imaging methods became important for the disease diagnosis, prognosis, and its effective treatment. The diseases prediction is not easily achievable and thus the application of advanced methods of image processing including pre-processing, feature extraction and selection and definition of the prediction models is needed.

### Supervisor

Ing. Jiří Chmelík, Ph.D.

### Supervisor – specialist

MUDr. Petr Ouředníček, Ph.D.

### Co-operating institution:

ICRC Brno, The University Hospital Brno

### Topic

The topic is focused on analysis the brain disease diagnosis and treatment process. The analysis will be based on newly developed advanced image processing methods applied on the image data acquired by the most frequently used imaging techniques such as computed tomography, magnetic resonance, etc. In the first stage, the doctoral student should prepare image data and propose a pre-processing approach enabling the analysis of specific features. It requests application of an image normalization, segmentation and registration methods also utilizing machine learning techniques. It would be followed by the extraction and analysis of relevant image features, and formulation of specific prediction models reflecting the disease viability, staging and localization. The aim of the research is to find a methodology for the evaluation of disease changes from imaging data suitable for the diagnosis and treatment planning.

The topic will be solved at the Department of Biomedical Engineering, however, cooperation with our foreign partners is expected - International Clinical Research Center of St. Anne's University Hospital Brno, General University Hospital in Prague and Masonic Institute for the Developing Brain, Department of Pediatrics, University of Minnesota, USA.

### Relevant publications

[1] ZHANG, Li, Mingliang WANG, Mingxia LIU and Daoqiang ZHANG. 2020. A Survey on Deep Learning for Neuroimaging-Based Brain Disorder Analysis. Frontiers in Neuroscience. 14, 1-19. https://doi.org/10.3389/fnins.2020.00779

[2] KHAN, Protima, Md. Fazlul KADER, S. M. Riazul ISLAM, Aisha B. RAHMAN, Md. Shahriar KAMAL, Masbah Uddin TOHA and Kyung-Sup KWAK. 2021. Machine Learning and Deep Learning Approaches for Brain Disease Diagnosis: Principles and Recent Advances. IEEE Access. 9, 37622-37655. https://doi.org/10.1109/ACCESS.2021.3062484

## WHO WE ARE SEEKING

- A sound knowledge of programming languages (e.g. Matlab, Python)
- Knowledge or interest in Android/iOS applications programming is advantageous
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills in written and oral form

## WHAT WE OFFER

- Participation in established scientific team which regularly publish in high prestige international journals, e.g. Scientific Reports or IEEE Transactions on Biomedical Engineering
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Advanced algorithms for monitoring human health and activity using a smartphone

### Introduction

We have a long-term stable team of 6 people who regularly publish in impacted journals. We process biosignals and signals from mobile devices in collaboration with the Mayo Clinic in Minnesota and the Office of Naval Research USA. We are looking for colleague which will help us with „Advanced algorithms for monitoring human health and activity using a smartphone“.

### Supervisor

Ing. Andrea Němcová, Ph.D.

### Topic

The theme of this dissertation is focused on monitoring of human health and activity using a smartphone and its integrated sensors (especially accelerometer, gyroscope, magnetometer, GPS, microphone, camera). The main motivation is the availability and great potential of smartphones, which is far from being used in health monitoring. The thesis has two main objectives. The first objective is to explore the potential of a smartphone and how to use it for human health and activity monitoring and to critically evaluate its real usability. The second objective of the thesis is to design advanced algorithms for processing of data captured by a smartphone (e.g. for the purpose of human activity classification, blood pressure determination, blood oxygen saturation estimation, ...) and to evaluate the performance and applicability of these algorithms in practice. It is possible to use smartphones available at the department to record own data.

Project will be solved mainly at the Department of Biomedical Engineering. However, it is expected close cooperation with our partners from Mayo Clinic (https://www.mayoclinic.org/) and Office of Naval Research (https://www.onr.navy.mil/) within the ongoing project „Health and Activity Monitoring by Wearables in Extreme Conditions”.

### Relevant publications

https://www.sciencedirect.com/science/article/pii/S1746809420300847

https://www.mdpi.com/1424-8220/20/24/7195

https://ieeexplore.ieee.org/document/9662674

# Advanced methods for analysis of bacterial methylomes on a genome-wide scale using nanopore sequencing

## WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of computational biology, bioinformatics, and functional annotation of non-model organisms
- A sound knowledge of programming languages (e.g., R, Matlab, Python)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

### Introduction

Changes in the expression of genetic information that are not caused by changes in the primary structure of DNA are referred to as epigenetic changes. A typical example can be found in DNA methylation, which was discovered in bacteria more than a half century ago. Despite that, a majority of studies aims on 5-methylcytosine (5mC) methylations in eukaryotic genomes by utilizing bisulfite sequencing with the next generation sequencing platforms. Unfortunately, bacterial methylomes are formed not only by 5mC, but also by N6-methyladenine (6mA) and N4-methylcytosine (4mC) methylations, which are undetectable (6mA) or difficult to detect (4mC) by this approach.

### Supervisor

Mgr. Ing. Karel Sedlář, Ph.D.

### Topic

The topic is focused on the solution existing in the utilization of the third generation sequencing (TGS) platforms. Although the nanopore TGS sequencing allows theoretically the detection of all above-mentioned types of methylations, this potential remains currently unused due to the lack of bioinformatics tools for the detection of methylated nucleotides in the current signal that is produced during data acquisition. The aim of this dissertation is to create a methodology for the detection of methylations using advanced bioinformatics and digital signal processing techniques for filtering and analyzing this noisy current signal, referred to as squiggle. The whole methodology will be designed using data produced by Oxford Nanopore Technologies MinION and MinION/Flongle sequencing devices that UBMI owns. Suitable bacterial strains will be provided by cooperating institutions, mainly University Hospital Brno (pathogenic bacteria), UCT Prague, and the Faculty of Chemistry BUT (industrially utilizable bacteria).

Project will be solved mainly at the Department of Biomedical Engineering. However, cooperation with our foreign partners is expected - Ludwig-Maximilians-Universität München in Germany and HES-SO Valais-Wallis in Switzerland.

### Relevant publications


https://www.nature.com/articles/nmeth.4184

https://academic.oup.com/bioinformatics/article/35/22/4586/5474907

https://www.frontiersin.org/articles/10.3389/fmicb.2021.685670/full#B12

## WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of biological sequence analysis, signal processing and machine learning
- A sound knowledge of programming languages (eg. Matlab, Python)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Participation in established scientific team which regularly publish in high prestige international journals e.g. Frontiers journals, BMC Bioinformatics, Plos ONE
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Utilization of signal processing techniques for refinement of nanopore sequencing data decoding

**Introduction**

The rapid increase of available microbial genome sequencing data reiterates the importance of developing of ultra-fast tools for comparative genomics. Although the genomic signal processing methods have previously proved to be very effective for huge amount of genomic data, their massive utilization have not yet occurred. But nowadays, with coming the third generation of sequencers produced raw genomic data in the current signal form, the refocus on signal processing technique becomes important again.

**Supervisor**

Ing. Helena Škutková, Ph.D.

**Co-Supervisor**

doc. Mgr. Martina Lengerová, Ph.D.

**Topic**

The aim of the dissertation is to develop methodology for pre-processing of raw nanopore sequencing data consisting from signal reads called “squiggles”. The proposed procedure should precede DNA sequence decoding, where the neural networks are used exclusively nowadays. The decoding step called “basecalling” is the main source of errors in nanopore sequencing data processing. Although the nowadays basecalling methods for nanopore sequencing have significantly increased accuracy in the last years, it still can fall to 95 % and that is insufficient for clinical utilization. Appropriate combination of advance signal filtering of high level noise, signal segmentation into specific sections called “events” corresponding to DNA symbols and mutual adjustment of events durations by dynamic time warping can significantly improve accuracy of genetic information decoding.

Project will be solved mainly at the Department of Biomedical Engineering. However, it is expected close cooperation with Department of Internal Medicine – Hematology and Oncology.

**Relevant publications**

https://www.sciencedirect.com/science/article/pii/S2001037018301557

https://www.frontiersin.org/articles/10.3389/fmicb.2021.631605/full

https://journals.plos.org/plosone/article/comments?id=10.1371/journal.pone.0221187

WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of biomedical signal processing, deep learning, signal fusion (e.g. ECG, PPG, GPS, motion data) and wearable devices
- A sound knowledge of programming languages (e.g. Matlab, Python, Android)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills in written and oral form

WHAT WE OFFER

- Participation in established scientific team which regularly publish in high prestige international journals e.g. Scientific Reports or IEEE Transactions on Biomedical Engineering
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Advanced methods for biological signals quality estimation

**Introduction**

We have a long-term stable team of 6 people who regularly publish in impacted journals. We process biosignals and signals from mobile devices in collaboration with the Mayo Clinic in Minnesota and the Office of Naval Research USA. We are looking for colleague which will help us with „Advanced methods for biological signals quality estimation“.

**Supervisor**

Ing. Lukáš Smital, Ph.D.

**Topic**

The topic of dissertation thesis is focused on biological signals quality monitoring by wearable devices (e.g. PPG, ECG). Other concurrently sensed signals such as accelerometer data can be also used for this purpose. The thesis has two main objectives. The first objective is to propose signal quality classes with respect to possible sources of interference as well as the subsequent utilization of the signal. The second objective is to design advanced algorithms for real-time signal quality estimation and to verify the usability of the signal class for its intended purpose. Applicants are expected to have knowledge of programming in Matlab or Python and base knowledge of processing and analysis of 1D signals. It is possible to use wearable devices available at the department to record own data.

Project will be solved mainly at the Department of Biomedical Engineering. However, it is expected close cooperation with our partners from Mayo Clinic (https://www.mayoclinic.org/) and Office of Naval Research (https://www.onr.navy.mil/) within the ongoing project „Health and Activity Monitoring by Wearables in Extreme Conditions”.

**Relevant publications**

https://ieeexplore.ieee.org/document/8970507

https://ieeexplore.ieee.org/document/8501960

https://www.nature.com/articles/s41598-019-55323-3

WHO WE ARE SEEKING

- Enthusiasm for research
- Master´s degree in Microbiology, Molecular Biology Systems Biology, Computational Biology, Bioinformatics, Biophysics, Computer Science or a related discipline
- Basic experience with R or other statistical programs and work with the command-line is mandatory
- Experience with programming and analysis of biological high-throughput data is a plus
- Fluent English
- Good communication and writing skills

WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
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# Detection and prediction of horizontal gene transfer between bacteria

**Introduction**

The microbiome is the collection of microorganisms and their genetic material within an environment, e. g. human, animal, river microbiome. It is a dynamic system which is shaped by ability to transfer genetic material between different bacterial species. Horizontal gene transfer mediated by mobile elements plays a central role in the evolution of many environments and their bacterial members. It is very common in human pathogenic bacteria; the process contributes to increased pathogenesis and virulence, and also to resistance to antibiotic treatment. The resistance traits are often transferred from pathogenic to helpful and commensal bacteria in the environment and further disseminated to other environments.

**Supervisor**

Mgr. Darina Čejková, Ph.D.

**Topic**

The PhD topic will be focused on the identification and characterization of mobile genetic material (transposons, plasmids, antibiotic resistance genes) from complex ecosystems but also from individually sequenced microbiota member and to determine the bacterial reservoirs of such genes and traits. The bioinformatic approaches will consider high-throughput shotgun data analysis from animal farms. Other sequencing technologies and strategies (e.g. Oxford Nanopore Sequencing, plasmidome sequencing, functional metagenomics) will be used and analyzed as well. In parallel, novel computational methods will be designed to examine to which extent closely related species share horizontally acquired genes and to distinguish those genes from phylogenetically shared genes. The outcome of the project will track and link the reservoirs and horizontal transfer of antibiotic resistance genes, with the ultimate goal of slowing down the dissemination of drug resistance.

**Relevant publications**

https://pubmed.ncbi.nlm.nih.gov/33558560/

https://journals.asm.org/doi/10.1128/mSystems.00283-21

https://www.nature.com/articles/s41467-020-17278-2

## WHO WE ARE SEEKING

- Interest in scientific activities, image processing and machine learning
- Knowledge of programming languages (eg. C++, Python, Matlab)
- Relevant degree with appropriate engineering and/or IT knowledge
- English communication skills

## WHAT WE OFFER

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- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Medical image segmentation using deep learning techniques

### Introduction

Medical image processing and especially image segmentation is area in very intensive development. Medical imaging systems are more often used and provide images with higher and higher resolution. Automatic algorithms for image segmentation allow faster and more accurate diagnosis.

### Supervisor

Ing. Vratislav Harabiš, Ph.D.

### Topic

The theme of this thesis is aimed on medical image segmentation and classification using deep learning methods. The first aim of this thesis is to improve on actual methods for segmentation of 2D medical images. In next step these methods will be adapted for segmentation of 3D volume images, especially images from microCT system. The classification of images using deep learning methods will be also part of this thesis. Machine learning methods, especially neural networks, which represents new and perspective algorithms of image processing, will be used for the solution of this thesis. The main aim of this thesis is to extend possibilities of automatic processing and classification of large volume of data like images from CT scanners.

PhD students will complete a six-month internship at attractive partner universities abroad. Department of Biomedical Engineering provides doctoral students with a stipend and/or a part-time contract beyond the state stipend when joining a grant project or engaging in teaching.

### Relevant publications

https://ieeexplore.ieee.org/abstract/document/9356353

https://link.springer.com/article/10.1007/s10278-019-00227-x

https://www.nature.com/articles/s41592-020-01008-z

## WHO WE ARE SEEKING

- Deep interest in regenerative engineering
- Deep interest in genetic characterization methods
- A sound knowledge of laboratory techniques (eg. fluorensent microscopy, cell cultivation)
- A relevant degree with appropriate engineering transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
- The doctoral students complete 3-6 months of internships at partner universities abroad
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# Functialization of bioinks to promote regenerative capacity of 3D bioprinted constructs

### Introduction

Tissue bioprinting occupies a critical crossroads position between the fields of biomaterials engineering, cardiovascular biology, and 3D design and modeling. A major challenge is the lack of systematic characterization of the physical and chemical properties of hydrogel-based bioinks that are applicable to organ and tissue bioprinting. Tailoring bioink properties to mimic the native tissue extracellular matrix is of great importance.

### Supervisor

Prof. Ivo Provazník

### Topic

The work is focused on the research of new approaches in design of nanomaterial-based bioinks for 3D-bioprinting of heart tissue constructs. To generate a bioink that is supportive to cardiac cells, high-throughput analysis techniques, such as transcriptome analysis (RNA-Seq) can be used to characterize the native cardiac tissue extracellular matrix (ECM). Incorporating certain proteins or inhibitors in the tissue generation pipeline (specifically in cardiac bioink) may promote the regenerative capacity of printed constructs. Functionalizing the bioink with ECM proteins, such as cadherins, connexins, and collagen, can be used to promote cell attachment, migration, and remodeling. Other approaches can also help to promote tissue maturation and vascularization in cardiac constructs. However, development of new cardiac-specific bioinks requires tailored biomaterials and precisely tuned selection of macromolecules. New methods are also needed to incorporate functional vascular networks within printed constructs that can be perfused to maintain functionality of large-scale tissue constructs. Thus, the project also aims to enhancing temporal and spatial resolutions of bioprinting to achieve more advanced cardiac tissue substitutes for regenerative medicine.

### Relevant publications


Maan Z, et al. Smart Bioinks for the Printing of Human Tissue Models. Biomolecules (2022)

Gold KA, et al. 3D Bioprinted Multicellular Vascular Models. Adv Healthcare Mater (2021)

Cao X, et al. Bioprinting of Small-Diameter Blood Vessels. Engineering (2020)

## WHO WE ARE SEEKING

- Deep interest in regenerative engineering
- Deep interest in bioprinting
- A sound knowledge of laboratory techniques (eg. fluorensent microscopy, cell cultivation)
- A relevant degree with appropriate engineering transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
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# Methods and materials for 3D bioprinting of blood vessels

### Introduction

Bioprinting in 3D is an advanced manufacturing technique capable of producing tissue-shaped constructs. A range of hydrogel bioinks was introduced to design these structures; however, there is a limitation in available bioinks that can mimic the vascular composition of native tissues. Current bioinks lack high printability and are unable to deposit a high density of living cells into complex 3D architectures, making them less effective.

### Supervisor

Prof. Ivo Provazník

### Topic

The work is focused on the research of new approaches in design of a 3D-bioprinted model of a blood vessel that mimics its behavior in living organism. 3D-bioprinted vessels provide a tool to understand vascular disease pathophysiology and assess therapeutics in preclinical trials. Bioprinting in 3D is a technique capable of producing constructs in a layer-by-layer fashion with embedded living cells, making the arrangement to mirror multicellular makeup of vascular structures. There is a limitation in available hydrogel bioinks that can mimic the vascular composition of native tissues. Current bioinks lack high printability and are unable to deposit a high density of living cells into complex 3D tissue architectures. The main aim of the project is to develop a new nanoengineered bioink to print anatomically accurate multicellular blood vessels. The nanoengineered bioink will be printed into 3D cylindrical blood vessels consisting of living co-cultures of endothelial cells and vascular smooth muscle cells. The final construct must provide the opportunity to model vascular function and disease impact. The project require design and characterization of appropriate nanomaterials to develop a new bioink.

### Relevant publications


Gold KA, et al. 3D Bioprinted Multicellular Vascular Models. Adv Healthcare Mater (2021)

Cao X, et al. Bioprinting of Small-Diameter Blood Vessels. Engineering (2020)

Christensen K, et al. Freeform Inkjet Printing of Cellular Structures with Bifurcations. Biotechnol Bioeng (2015)

## WHO WE ARE SEEKING

- Deep interest in artifficial intelligence approaches for medical applications
- Deep interest in genomics
- A sound knowledge of programming languages (eg. Python, R)
- A relevant degree with appropriate IT knowledge transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Deep learning as a computational modelling technique for genomics

### Introduction

As a data-driven science, genomics utilizes machine learning to search for dependencies in data and hypothesize novel biological phenomena. The need for extraction of new insights from the exponentially increasing volume of genomics data requires more expressive machine learning models. Deep learning is becoming the method of choice for many genomics modelling tasks such as predicting the impact of genetic variation on gene regulatory mechanisms.

### Supervisor

Prof. Ivo Provazník

### Topic

The main aim of the project is to design novel tools for genomic data partitioning and prediction, fitting parameters and choosing hyperparameters for optimal training of deep neural networks. The tools will be used to discover local patterns and longe-range dependencies in sequential data and modelling transcription factor binding sites and spacing. The project requires deep research in the field of existing machine learning applications for the analysis of genome sequencing data sets, including the annotation of sequence elements and epigenetic, proteomic or metabolomic data. Supervised, semi-supervised and unsupervised machine learning methods, as well as of generative and discriminative modelling approaches will be considered. The capacity of deep learning models to identify transcription factors binding sites from DNA sequences will be investigated based on searching dependencies in the data.

### Relevant publications

Kopp W, et al. Deep learning for genomics using Janggu. Nat Commun 11, 3488 (2020)

Eraslan G, et al. Deep learning: new computational modelling techniques for genomics. Nat Rev Genet 20, 389-403 (2019)

## WHO WE ARE SEEKING

- Deep interest in artifficial intelligence approaches for medical applications
- Deep interest in electrocardiology
- A sound knowledge of programming languages (eg. Matlab, Python, C++)
- A relevant degree with appropriate IT knowledge transferable to the scientific environment
- English communication skills

## WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
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# Arrhythmia detection and classification in ambulatory electrocardiograms using deep learning

### Introduction

Computerized electrocardiogram (ECG) interpretation plays a critical role in the clinical ECG workflow. Widely available digital ECG data and paradigms of artificial intelligence present an opportunity to substantially improve the accuracy of automated ECG analysis. Advanced AI methods, such as deep-learning convolutional neural networks, enable rapid, human-like interpretation of the ECG, while signals and patterns largely unrecognizable to human interpreters can be detected by multilayer AI networks with precision, making the ECG a powerful, non-invasive biomarker.

### Supervisor

Prof. Ivo Provazník

### Topic

The main aim of the project is to demonstrate that an end-to-end deep learning approach can classify a broad range of distinct arrhythmias from single-lead ECGs with high diagnostic performance similar to that of cardiologists. The developed algorithms for computerized ECG interpretations will improve the efficiency of expert human ECG interpretation by accurately triaging or prioritizing the most urgent patterns. To reach the aim, the project requires deep research in appropriate AI technologies and searching for the most efficient paradigma enabling for revealing hidden information and/or patterns in vast datasets. Further, a wide-range meta-analysis accross a number of results based on various ECG recording databases will be necessary.

### Relevant publications


Siontis KC, et al. Artificial intelligence-enhanced electrocardiography in cardiovascular disease management. Nat Rev Cardiol (2021)

Hannun AY, et al. Cardiologist-level arrhythmia detection and classification in ambulatory electrocardiograms using a deep neural network. Nat Med 25, 65-69 (2019)

Lopez-Jimenez F, et al. Artificial Intelligence in Cardiology: Present and Future. Mayo Clinic Proc 95(5):1015-1039 (2020)

WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of biomedical signal processing, deep learning, signal fusion (e.g. ECG, PPG, GPS, motion data) and wearable devices
- A sound knowledge of programming languages (e.g. Matlab, Python, Android)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills in written and oral form

WHAT WE OFFER

- Participation in established scientific team which regularly publish in high prestige international journals e.g. Scientific Reports or IEEE Transactions on Biomedical Engineering
- The doctoral students complete 3-6 months of internships at partner universities abroad
- The Department provides doctoral students with a scholarship beyond the state scholarship in the form of a supplementary stipend or salary when participating in a grant project

# Advanced detection of ECG significant points during pathological events

**Introduction**

We have a long-term stable team of 5 people who regularly publish in impacted journals. We process biosignals and signals from mobile devices in collaboration with the Mayo Clinic in Minnesota and the Office of Naval Research USA. We are looking for colleague which will help us with „Advanced detection of ECG significant points during pathological events“.

**Supervisor**

Ing. Martin Vítek, Ph.D.

**Topic**

The theme of this dissertation is focused on reliable and accurate detection of ECG significant points during pathological events. The thesis has two main objectives. The first objective is to map the potential of nowadays algorithms for QRS complex detection and ECG records delineation during various pathological events and to define their deficiencies. The second goal of the thesis is to design an advanced delineation algorithm that will work reliably during most common pathological events and verify its robustness on standard ECG databases. Applicants are expected to have knowledge of programming in Matlab or Python and base knowledge of processing and analysis of 1D signals.

Project will be solved mainly at the Department of Biomedical Engineering. However, it is expected close cooperation with our partners from Mayo Clinic (https://www.mayoclinic.org/) and Office of Naval Research (https://www.onr.navy.mil/) within the ongoing project „Health and Activity Monitoring by Wearables in Extreme Conditions”.

**Relevant publications**


https://ieeexplore.ieee.org/document/8970507

https://ieeexplore.ieee.org/document/6357230

https://www.sciencedirect.com/science/article/pii/S1746809420300847

https://www.nature.com/articles/s41598-019-55323-3

WHO WE ARE SEEKING

- Deep interest in scientific activities in the field of signal processing
- A sound knowledge of programming languages (eg. Matlab, Python)
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills

WHAT WE OFFER

- Our core objective is to provide the doctoral students with a supportive and highly scientific work environment that fosters collaboration
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# Computerized fetal heart rate analysis

**Introduction**

We have a long-term stable team of 5 people who regularly publish in impacted journals. We process biosignals and signals from mobile devices in collaboration with the Mayo Clinic in Minnesota and the Office of Naval Research USA. We are looking for colleague which will help us with „Advanced detection of ECG significant points during pathological events“.

**Supervisor**

Doc. Ing. Jana Kolářová, Ph.D.

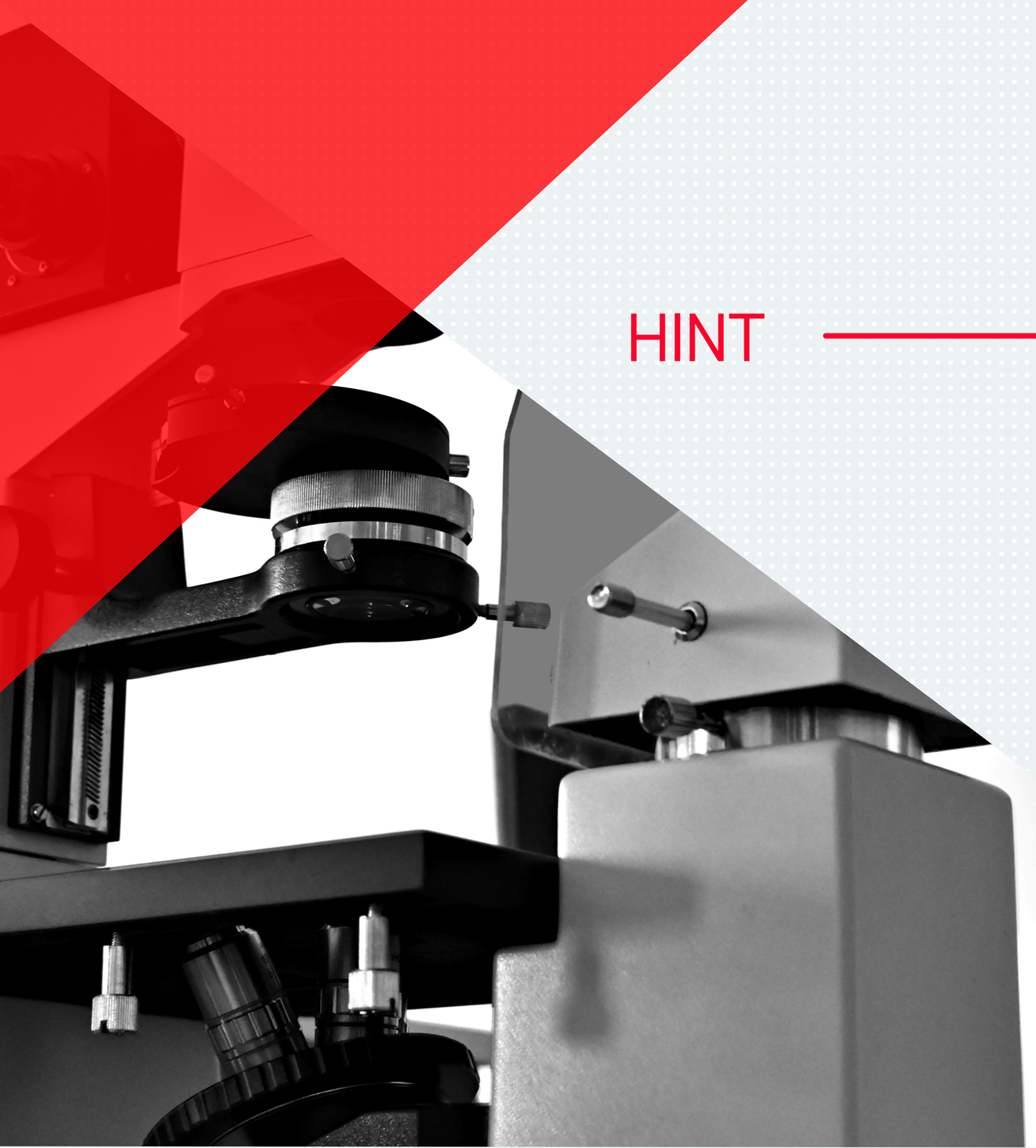
**Topic**

The topic of the study is focused on the analysis of fetal heart rate (CTG, cardiotachogram) in order to monitor CTG changes in fetuses with premature amniotic fluid outflow during pregnancy. During the doctoral study, the student will get acquainted with the methods of CTG analysis and CTG variability in order to determine the current state of the fetus. CTG signals obtained from two groups of pregnant women (with premature amniotic fluid outflow and normal pregnancy) using advanced methods will be analyzed and compared with results obtained by physicians using currently generally accepted CTG assessment criteria.

The data analysis will take place in cooperation with the medical team of the maternity ward of the Brno University Hospital.

**Relevant publications**

Dragoş-Daniel Ţarălungă, Georgeta-Mihaela Ungureanu, Ilinca Gussi, Rodica Strungaru, Werner Wolf, "Fetal ECG Extraction from Abdominal Signals: A Review on Suppression of Fundamental Power Line Interference Component and Its Harmonics", Computational and Mathematical Methods in Medicine, vol. 2014, Article ID 239060, 15 pages, 2014. https://doi.org/10.1155/2014/239060



# HINT

Are you interested in any of the above topics? Have you already chosen one?

Then contact a potential supervisor and arrange a meeting before you apply. You will discuss specific scientific questions you may have as well as general questions about doctoral studies.

# HOW TO APPLY?

You are invited to apply through university e-application at:

https://www.vutbr.cz/eprihlaska/en/

Deadline for application: May 15. 2022

Additional documents: Motivation letter