Title: **Novel approaches on horizontal gene transfer in bacteria**

Supervisor: **Darina Čejková, Ph.D.**

Introduction

The microbiome is the collection of microorganisms and their genetic material within an environment. It is a dynamic system which is shaped by ability to transfer genetic material between different bacterial members. Horizontal gene transfer mediated by mobile elements plays a central role in the adaptation of individual bacteria to the environmental conditions, and thus it contributes to the evolution of bacterial genomes. Mobile genetic elements are commonly found in human pathogenic bacteria; herein, they contribute to increased pathogenesis and virulence, and also to failure to any antibiotic treatment. The elements associated with resistance traits are transferred from pathogenic through host commensal bacteria to environmental bacteria (and *vice versa*), and thus the multi-drug resistant bacteria can be detected worldwide, even from the pristine environments. This increased resistance represents major concerns and threads to global health.

Topic

The PhD topic will be focused on the identification and characterization of mobile genetic material (transposons, plasmids, antibiotic resistance genes) from complex and to determine the bacterial reservoirs of such genes and traits – both in wet and dry lab. 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.

For more information about this topic please contact Darina Čejková - cejkovad@vut.cz.

Relevant publications

https://pubmed.ncbi.nlm.nih.gov/33558560/
https://journals.asm.org/doi/10.1128/mSystems.00283-21
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9338424/

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
- 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

Application

You are invited to apply through university e-application at:
https://www.vutbr.cz/eprihlaska/en/

Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **New methods for studying skin layers in drug application and tissue regeneration**

Supervisor: **Ing. Vratislav Čmiel, Ph.D.**

Introduction

Examination and accurate qualification of skin and subcutaneous layers during their regeneration is a very current biomedical problem. This problem is also related to the qualification of tissue properties at different depths together for analysing of the stability or degradation of transplants and implants in regenerative medicine.

Topic

This research topic focuses on the development and testing methodology of trans endodermal drug delivery of different types of drugs (labelled nanoparticles, liposomes, exosomes or others) across model and real skin layers. The PhD student will primarily perform research in the biology lab and will target the creation of model skin epithelial cultures and apply laboratory procedures, trans-epithelial/endothelial electrical resistance method, and confocal fluorescence microscopy techniques to test the model layer and analyse drug transfers through the model layer in in-vivo experiments. It will also include the use of supporting techniques (e.g., optical coherence tomography) for testing transfers to real skin in in-vivo experiments on animal models. The PhD student will participate in interdisciplinary research in the project, which covers experimental work with endothelial and epithelial cells, create cell mono and multiple layers including testing of model layers, testing, and applying modern drugs, using advanced instrumentation and methodology for image data acquisition and interpretation and further analysis.

Project will be solved mainly at the Department of Biomedical Engineering. However, cooperation with our partners is expected - Veterinary research institute in Brno. The project will involve additional funding for the student and involvement in research projects in collaboration with this research organisation.

For more information about this topic please contact Vratislav Cmiel - cmiel@vut.cz

Relevant publications

https://onlinelibrary.wiley.com/doi/full/10.1111/srt.12868
https://onlinelibrary.wiley.com/doi/full/10.1111/j.1600-0625.2011.01335.x
https://pubmed.ncbi.nlm.nih.gov/24916997/

Who we are seeking

- Interest in scientific activities in the field of cell and tissue biological engineering
- A relevant degree with appropriate bio-engineering 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

Application

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Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Electrical properties of PVDF fibers as scaffold for biomedical applications**

Supervisor: **Doc. Mgr. Zdenka Fohlerová, Ph.D.**

Co-supervisor: **Ing. Pavel Tofel, Ph.D.**

Introduction

Piezoelectric materials are smart materials that can generate electrical activity in response to minute deformations. For biomedical applications, piezoelectric materials allow for the delivery of an electrical stimulus without the need for an external power source. As a scaffold for tissue engineering, there is growing interest in piezoelectric materials due to their potential of providing electrical stimulation to cells to promote tissue formation.

Topic

The project is focused on the fabrication of fibers from polyvinylidene fluoride (PVDF), an attractive material for making functional scaffolds, via electro-spin coating method. The choice of PVDF is due to an excellent piezoelectricity and good biocompatibility. Electrospun PVDF scaffolds can produce electrical charges during mechanical deformation, which can provide necessary stimulation for repairing tissue. The candidate will work on the fabrication of scaffolds with randomly oriented or uniaxially aligned fibers. The scaffolds will be characterized using various methods such as SEM, XPS, FTIR, XRD, contact angle. The main part of the project will focus on determining the piezoelectric properties of PVDF fibers and their potential contribution in the use of these piezoactive materials in liquid environments and as part of hydrogel structures. In addition, the biological characterizations of scaffolds including viability assays and the detection of parameters demonstrating electromechanical activation of cells will be performed.

Project will be solved at the Department of Biomedical Engineering and the Department of Physics, Brno University of Technology

For more information about this topic, please contact:
Zdenka Fohlerova – fohlerova@vut.cz or Pavel Tofel – tofel@vut.cz

Relevant publications

http://dx.doi.org/10.1016/j.actbio.2015.07.010
http://dx.doi.org/10.1002/adfm.201909045
https://doi.org/10.3390/nano9070952

Who we are seeking

- Highly motivated students with deep interest in scientific activities in the field of nanotechnology and biomedicine
- Independence, enthusiasm, persistence, and attention to detail
- Good English communication skills

What we offer

- We offer a highly collaborative, collegial, and family friendly, international working environment.
- The 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

Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/
Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter and CV

Title: **Advanced methods of medical images analysis in modern CT scanners**

Supervisor: **Ing. Jiří Chmelík, Ph.D.**

Supervisor – specialist*:* ***MUDr. Petr Ouředníček, Ph.D.***

Co-operating institution: **FNUSA/*ICRC Brno, The University Hospital Brno***

Introduction

Computed tomography scanners are one of the most used modalities for diagnosing various diseases and pathologies. Nowadays, the development and clinical use of modern CT scanners enabling multi-energy X-ray imaging using multilayer detectors or even single photon level imaging are taking place. At the same time, the devices provide a range of parametric images, such as monoenergetic images, material decomposition images, etc. It appears that this information increases the diagnostic yield of CT imaging, with a significant dose reduction, which is in the interest of the wide medical community.

Topic

The topic will aim to development of advanced image processing and analysis methods involving machine learning and deep learning approaches with scope for multiparametric images acquired by multilayer CT detectors. The student will focus on the development, implementation and validation of preprocessing, segmentation, detection, classification and prediction tasks considering the character of multiparametric images. The proposed complex computer-aided diagnostic tool will help increase diagnostic accuracy and reproducibility, speed of the examinations and decrease the inter-/intra-expert variability and routine workload.

The topic will be solved at the Department of Biomedical Engineering. However, cooperation with our external partners is expected – national clinical institutions (FN Brno, VFN Prague, FNUSA/ICRC Brno) and foreign institutions (IRST IRCCS Meldola Italy, Philips Healthcare Netherlands, DKFZ Heidelberg Germany), allowing clinical evaluation of the results and their discussion with medical experts.

For more information about this topic please contact Jiri Chmelik - chmelikj@vutbr.cz

Relevant publications

[1] Rassouli et al. *Detector-based spectral CT with a novel dual-layer technology: principles and applications,* https://doi.org/10.1007/s13244-017-0571-4.

[2] Kruis et al. *Improving radiation physics, tumor visualisation, and treatment quantification in radiotherapy with spectral or dual-energy CT*, https://doi.org/10.1002/acm2.13468.

Who we are seeking

- Deep interest in the field of medical imaging, image processing, and machine learning.
- Sound knowledge of programming languages (e.g., Python, MATLAB).
- 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 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.

Application

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

Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Advanced methods for MRI image analysis to improve image clarity and disease diagnosis**

Supervisor: **Ing. Roman Jakubíček, Ph.D.**

Introduction:
Magnetic resonance imaging is nowadays becoming an increasingly accessible and progressive modality, often replacing previous diagnostic standards and often becoming the first-choice examination. Consequently, the amount of data acquired by this modality is also increasing and thus the time requirements for its analysis by medical experts are higher. Supporting diagnostic tools then provide medical experts with an easier and more accurate view of the captured data, making it easier to work with it and offering the possibility of automated supporting diagnostics. Specifically, this can include the co-registration of contrast scans at different stages, automated segmentation of areas or pathologies, and their analysis in relation to the current diagnosis or prognosis.

Topic:
The topic focuses on the development, implementation and validation of advanced image processing techniques involving deep learning methods. The student will be work with data from MR modality, such as MRI of breast or brain tumours (gliomas), where the main task is to provide data pre-processing capabilities, extraction of parametric maps from multiphase or perfusion scans, analysis of the resulting parameters, and correct interpretation of the resulting relationships to the current diagnosis or prognosis. At the initial stage, however, this requires a thorough study of the issues, research and familiarisation with the data and their pre-processing. The student will be a valuable member of a stable research group, which has long been cooperating with several national medical institutions (FNUSA, ICRC Brno, FN Brno, VFN Prague) including foreign ones such as IRST IRCCS Meldola Italy, King' College London or Philips Healthcare, Netherlands.

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.

For more information about this topic please contact Roman Jakubicek - jakubicek@vut.cz

Relevant publications
https://ieeexplore.ieee.org/document/7918737
https://doi.org/10.1093/noajnl/vdaa049
https://doi.org/10.3389/frobt.2018.00120

Who we are seeking

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

What we offer

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Application
You are invited to apply through university e-application at:
https://www.vutbr.cz/eprihlaska/en/

Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Signal processing techniques for digital drawing tests**

Supervisor: **Ing. Oto Janoušek, Ph. D.**

Introduction

Drawing tests are a common tool in psychological evaluations as they provide insight into an individual's development. These tests have several advantages for patients but can be difficult for evaluators to interpret and are subject to personal bias. The digitization of drawing tests together with the subsequent development of signal processing techniques will bring objectivity to the assessment process and create new psychometric markers for reliable diagnosis.

Topic

The topic is focused on creating innovative signal processing methods for automatic analysis of the drawing process. The PhD student's goals will be to investigate the characteristics of drawing data and create quantifiers to describe time characteristic and distortion level of digital drawing strokes that will facilitate the automatic evaluation of drawing process. PhD student will assess the effectiveness and suitability of developed methods for use in the pediatric population.

The PhD student will be involved in interdisciplinary research carried out mainly at the Department of Biomedical Engineering in collaboration with the psychologist and digital drawing acquisition experts, but international cooperation as well as internships at partner universities abroad is expected. The drawing data acquisition concept has already been designed and validated, and pilot experiments have been completed with data available for analysis. As a result, the student will be able to smoothly integrate into the research with the goal of identifying potentially significant psychometric markers that can be used to diagnose specific diseases.

For more information on this topic, contact Oto Janoušek – janouseko@vut.cz.

Relevant publication

https://link.springer.com/article/10.3758/s13428-021-01746-8

Who we are seeking

- Deep interest in scientific activities in the field of signal processing
- A sound knowledge of Python
- A relevant degree with appropriate engineering and/or IT knowledge, transferable to the scientific environment
- English communication skills
- Czech / Slovak native speaker - native knowledge of Czech or Slovak is required due to communication with children during data collection.

What we offer

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Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/
Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Health and activity monitoring using smart/experimental devices**

Supervisor: **Doc. Ing. Jana Kolářová, Ph.D.**

Introduction

In 2021, there were 6.4 billion smartphone users worldwide and in the same year there were sold more than 500 million wearables units. Regular self-monitoring by smart devices can help to prevent or at least reveal many health and activity problems. Even if the smart devices measurements may not be as precise as certified devices, they can play a vital role in prevention because of the overall availability.

Topic

Commercial smart devices (e.g. smartphone, smartwatch, smartring) are widespread in the world population and their development is very fast. Nowadays, some experimental devices are developed and tested (e.g. electronical tatoos, bioimpedance sensors). The main objective of this Ph.D. thesis is to develop robust, fast and efficient algorithms for health and activity monitoring using smart devices. Development of cuff-less non-invasive blood pressure estimation algorithm is highly desired because of its potential to reveal high blood pressure in general public. Heart rate variability is another important health feature which can be monitored using smart devices. It brings important information about health and is useful for athletes to monitor their performance and recovery. The aforementioned sensors and features can help to detect or even predict cardiovascular diseases. Fusion of health features with activity features brings comprehensive view on the monitored subject. There exist datasets suitable for development of such algorithms, however it is expected to create own database using commercial and experimental smart devices available at DBME and it is possible to develop own experimental device.

Project will be solved mainly at the Department of Biomedical Engineering. It is expected the student will be involved in planned grant project "Smartphone-based cuffless blood pressure measurement and cardiac arrhythmias detection". Our team cooperates with national and foreign partners within the H2020 project "NextPerception". The student may be involved in this cooperation.

For more information about this topic please contact Andrea Němcová – nemcovaa@vut.cz.

Relevant publications

https://www.ahajournals.org/doi/full/10.1161/HYPERTENSIONAHA.121.17747
https://www.elsevier.com/books/photoplethysmography/kyriacou/978-0-12-823374-0
https://pubmed.ncbi.nlm.nih.gov/35708294/

Who we are seeking

- Deep interest in scientific activities in the field of signal processing, smart devices, machine learning
- A sound knowledge of programming languages (e.g. Matlab, Python)
- 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

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Application

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Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **New imaging and image processing approaches for retinal diseases monitoring**

Supervisor: **Doc. Ing. Radim Kolář, Ph.D.**

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.

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.

For more information about this topic please contact Radim Kolář - kolarr@vut.cz.

Relevant publications

https://doi.org/10.1364/BOE.441451
https://doi.org/10.1038/s42003-022-03441-6
https://doi.org/10.1002/jbio.202200094

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)
- Interest in developing hands-on experimental skills.
- 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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Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/
Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Detection and characterization of pulmonary nodules in lung cancer low-dose CT screening**

Supervisor: **Ing. Martin Mézl, Ph.D.**

Introduction

Lung cancer is the leading cause of cancer-related death worldwide with low five-year survival rates. Several studies around the world demonstrated possible reduction in lung cancer mortality by annual screening program. From historical point of view, the chest X-rays were used for screening purposes. But in recent years with progress in CT technology (both in hardware and software part), the low-dose CT can be used as a tool for screening studies.

Topic

The topic is focused on methods for detection and characterization of pulmonary nodules in lung cancer low-dose CT screening image datasets. All data are available at cooperating institution Masaryk Memorial Cancer Institute in Brno where the screening programme is running since September 2022.

The basic task for the topic is detection of nodules in lung cancer with various techniques of image processing. This part is well described in literature and several studies are published each year. Nodules are in form of opacities in lung parenchyma with no relation to a normal anatomy. Second task is nodule characterization based on classification on two main criteria – size and type. The aim of characterization is to find predictors of tumours malignancy. The results will be compared with an expert in radiology field and also with commercially available CAD system for CT scans evaluation.

Project will be solved mainly at the Department of Biomedical Engineering with strong cooperation with Masaryk Memorial Cancer Institute in Brno.

For more information about this topic please contact Martin Mézl - mezl@vut.cz.

Relevant publications

- Schreuder, et al. Translational Lung Cancer Research, 2021. doi: 10.21037/tlcr-2020-lcs-06
- Jacobs, et al. Radiology: Artificial Intelligence, 2021. doi: 10.1148/ryai.2021210027
- Cellina, et al. Diagnostics, 2022. doi: 10.3390/diagnostics12112644

Who we are seeking

- Deep interest in the field of medical 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

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Application

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Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Advanced algorithms for health monitoring using smart devices**

Supervisor: **Ing. Andrea Němcová, Ph.D.**

Introduction

In 2021, there were 6.4 billion smartphone users worldwide and in the same year there were sold more than 500 million wearables units. Regular self-monitoring by smart devices can help to prevent or at least reveal many health problems. Even if the smart devices measurements may not be as precise as certified devices, they can play a vital role in prevention because of the overall availability.

Topic

The topic of this Ph.D. thesis is focused on monitoring of human health using smart devices (e.g. smartphone, smartwatch, smartband). Smart devices have various integrated sensors which potential is not fully exploited. Especially from PPG, many health features (such as heart rate, breathing rate, blood oxygen saturation, glycemia) can be computed. Smart devices can currently detect atrial fibrillation from ECG or PPG signals. However, it is possible to detect more pathologies. Practical objective of this Ph.D. thesis is to develop advanced algorithms for extraction of health features and to evaluate the performance and applicability of these algorithms in practice. It will be necessary to develop reliable PPG waves detector. It is possible to use some publicly available datasets with annotations and it is possible to create own database with use of smart devices available at DBME.

Project will be solved mainly at the Department of Biomedical Engineering. It is expected the student will be involved in planned grant project "Smartphone-based cuffless blood pressure measurement and cardiac arrhythmias detection". Our team cooperates with partners from Mayo Clinic (https://www.mayoclinic.org/) and Office of Naval Research (https://www.onr.navy.mil/). The student may be involved in this cooperation.

For more information about this topic please contact Andrea Němcová – nemcovaa@vut.cz.

Relevant publications

https://www.sciencedirect.com/science/article/pii/S1746809420300847
https://www.springerprofessional.de/en/smart-watch-for-smart-health-monitoring-a-literature-review/23137094
https://www.mdpi.com/2076-3417/11/2/618

Who we are seeking

- Deep interest in the field of signal processing, smart devices, machine learning
- A sound knowledge of programming languages (e.g. Matlab, Python)
- 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

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- 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

Application

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Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Computational modelling of heart failure using methods of artificial intelligence**

Supervisor: **Ing. Filip Plešinger, Ph.D.**

Introduction

Heart diseases is a global cause of death; by World Health Organization (WHO) it causes 30% mortality worldwide. Therefore, assessment of a risk of heart failure is of vast importance in both treated patients and healthy population.

Topic

The topic is focused on predicting of heart failure in hospitalized patients or patients in a home care. The applied methodology will contain work with high-dimensional data: laboratory values and biometric values with their changes in time as well as continuous data from electrocardiograph acquired by several kind of devices (from clinical ECG devices to wearables for home-care monitoring). The applicant will have to find proper pre-processing approaches for specific data and experiment with machine learning methods. Then machine learning methods will be used to find optimal model. The applicant will be motivated to use deep-learning methods whenever allowed by dataset. Developed method are expected to assess a risk of heart failure in short (days) and long (months) terms.

This project will be solved at the Institute of Scientific Instruments of the Czech Academy of Sciences and is connected to the ongoing project of Technological Agency of the Czech Republic.

For more information about this topic please contact Filip Plešinger – fplesinger@isibrno.cz.

Relevant publications

https://www.sciencedirect.com/science/article/pii/S1959031820300828

https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/s12911-019-0915-8

https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0219302&type=printable

Who we are seeking

- Skills in data pre-processing, machine and deep-learning
- A perfect knowledge of Python
- A relevant degree with appropriate engineering and/or IT knowledge
- English at very good communication level – live presentations at international conferences abroad is expected.

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

Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/

Submission of application: April 1 to April 30, 2023

Additional documents: Motivation letter

Title: **Methods and materials for 3D bioprinting of blood vessels**

Supervisor: **Prof. Valentine Provazník**

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.

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.

For more information about this topic please contact Prof. Valentine Provazník - provaznik@vut.cz.

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 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
- The doctoral students complete 3-6 months of internships at partner universities abroad
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Application

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

Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: Study of Antibacterial Nanomaterials for Implant Coating Applications

Supervisor: Dr. Rima Paul, Ph.D.

Introduction

Tissues in the periphery of an implant material are vulnerable to infections and occurrence of such infections can lead to the failure of the implant and the surgery. The use of antibiotics is a common practice in such cases. But, bacterial infection may form a biofilm on the surface of the implant material and eventually reduce or can completely inhibit the antibacterial efficiency of the bactericidal drugs. Thus, the addition of antibacterial coatings onto the surface of the implants can resolve the issue of the development of such infections.

Topic

By virtue of their high surface area to volume ratio, nanomaterials have higher antibacterial properties in comparison to the traditional antibacterial counterparts. These nanomaterials can provide more active area for biological interactions to occur and are likely to have exceptional research values in implant coating applications. The aim of the project is to prepare such nanomaterials, characterize them to know their morphologies, chemical compositions as well as their stability and thereafter study their antibacterial properties and biocompatibility. It will be an interdisciplinary research project where the doctoral student will acquire the experience of preparing nanomaterials mainly through chemical techniques and characterize them using electron microscopy, X-ray diffractometry & different spectroscopic analyses. The student will get exposure to experimentally investigate the compatibility of the synthesized nanomaterials to different cell lines, explore their antibacterial properties and eventually prepare nanocoatings for implants.

The project will be carried out mainly at the Department of Biomedical Engineering, however, collaboration with our partner organizations is also expected.

For more information on this topic please contact Rima Paul – paul@vut.cz

Relevant publications

https://www.frontiersin.org/articles/10.3389/fbioe.2020.576969/full
https://link.springer.com/article/10.1186/s11671-020-03418-6
https://pubmed.ncbi.nlm.nih.gov/26437582/

What are we seeking

- Candidates having deep interest in nanotechnology for biomedical applications
- A relevant degree with appropriate science/engineering knowledge
- 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

Application

You are invited to apply through university e-application at:
https://www.vutbr.cz/eprihlaska/en/

Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **New approaches in recruiting bacterial genomes from metagenomes**

Supervisor: **Mgr. Ing. Karel Sedlář, Ph.D.**

Introduction

Recent advances in DNA sequencing allowed routine sequencing of environmental samples. However, current computational tools hardly keep up with constantly changing lab techniques and the growing output of sequencing devices. Therefore, novel computationally efficient techniques are needed to recruit particular genomes from metagenomes.

Topic

The topic is focused on methods for recruiting particular bacterial genomes from environmental samples, i.e., metagenomes. While in the past all newly described bacteria had to be isolated and their culture had to be made publicly available, a recent initiative SeqCode brought a nomenclatural code for prokaryotes described directly from sequence data as many microbial species are uncultivable with current techniques. Moreover, even for newly published cultured bacteria, environmental evidence based on searching in publicly available metagenomes is nowadays required by scientific journals. Although tools to produce metagenome-assembled genomes exist, searching metagenomes for particular analysed genomes is done exclusively with BLAST and is not rigorously described. Unfortunately, due to the repetitive segments of bacterial genomes, false hits are always found and quantification of data, i.e., assuming an abundance of a genome in a metagenome, is therefore biased. The aim of the research is to find a methodology for quantification as precise as possible. The applied methodology will include specific steps to process short NGS as well as long TGS reads to cover all currently used sequencing technologies.

The project will be solved mainly at the Department of Biomedical Engineering. However, cooperation with our national (University Hospital Brno, the Faculty of Chemistry BUT, and Czech Collection of Microorganisms) and foreign partners (Ludwig-Maximilians-Universität München in Germany and HES-SO Valais-Wallis in Switzerland) is expected.

For more information about this topic please contact Karel Sedlář - sedlar@vut.cz.

Relevant publications

https://www.nature.com/articles/s41564-022-01214-9
https://www.frontiersin.org/articles/10.3389/fbinf.2021.826701/full
https://www.sciencedirect.com/science/article/pii/S2001037021004931

Who we are seeking

- Deep interest in scientific activities in the field of computational biology and bioinformatics, especially analysis of non-model bacteria
- Sound knowledge of programming languages (e.g., R, 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

Application

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Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Utilization of signal processing techniques for refinement of nanopore sequencing data decoding**

Supervisor: **Ing. Helena Škutková, Ph.D.**

Co-supervisor*: doc. Mgr. Martina Lengerová, Ph.D.*

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.

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, University Hospital Brno.

For more information about this topic please contact Helena Škutková - skutkova@vut.cz.

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 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

Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/
Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter

Title: **Advanced methods for biological signals quality estimation**

Supervisor: **Ing. Lukáš Smital, Ph.D.**

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".

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".

For more information about this topic please contact Lukas Smital - smital@vut.cz.

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

- 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

Application

You are invited to apply through university e-application at: https://www.vutbr.cz/eprihlaska/en/
Submission of application: April 1 to April 30, 2023
Additional documents: Motivation letter