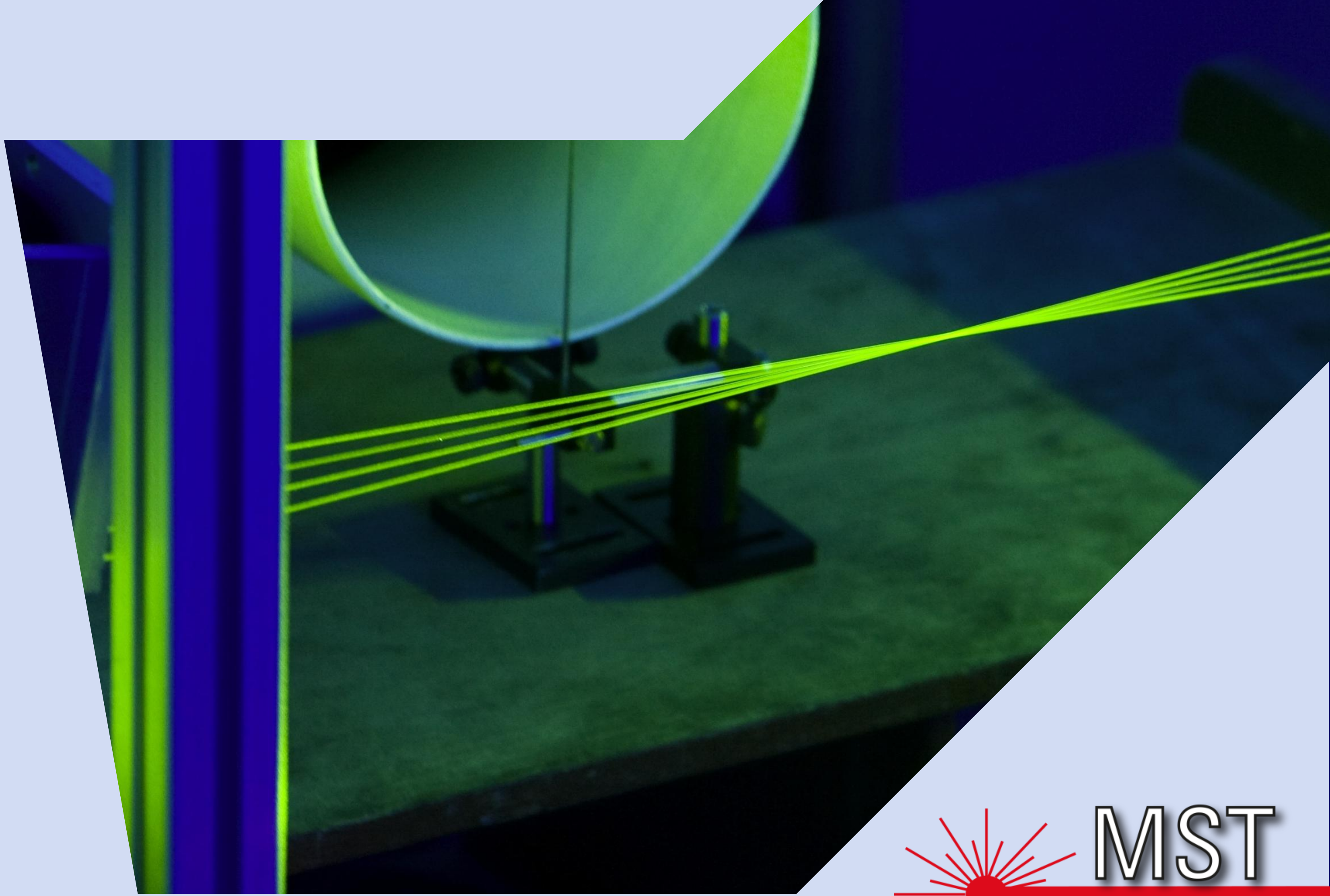
Technische Universität Dresden

Oberseminar & Projekte der MST



Professur für Mess- und Sensorsystemtechnik

Oberseminar Messsystemtechnik

Teil A: Wöchentliches Seminar → regelmäßig auf Aktualisierungen prüfen

Teil B: Seminararbeit - Betreute Gruppenarbeit à 2-4 Studierenden

Umfang

- 120h für Elektrotechnik; 60h für Mechatronik
- Referat: 20 min Vortrag + 10 min Diskussion; pro Person
- Beleg (<u>nur ET</u>): 6 Seiten (Vorlage auf Website)

Benotung

- ET (4 LP): Modulnote = Referat x 1/3 + Belegnote x 2/3
- MT & RES (2 LP): Modulnote = Referat
- Physik: Modulnote = Referat

Projekt: Optische Prozessmesstechnik (MT)

Projektarbeit - Betreute Gruppenarbeit à 2-4 Studierenden

Umfang

- 3 Tage pro Person + Selbststudium
- Referat: 5 min Vortrag pro Person + 10 min Diskussion
- Beleg: 6 Seiten (Vorlage auf Website)

Benotung

- MT (2SWS): Projektarbeit = ½ x Referat + ½ x Beleg

  → Projektarbeit geht zu 40% in die Modulnote ein (Sensoren und Messsysteme – Vertiefung)

Projekt: Photonische Messsysteme (ET)

Projektarbeit - Betreute Gruppenarbeit à 2-4 Studierenden

Umfang

- 3 Tage pro Person + Selbststudium
- Referat: 5 min Vortrag pro Person + 10 min Diskussion
- Beleg: kein Beleg

Benotung

- ET (1SWS): Projektarbeit = Referat
  - → Projektarbeit geht mit 1/7 in die Modulnote ein (Photonische Messsysteme)

Zusammenfassung

	Oberseminar Messsystemtechnik	**Projekt: Optische Prozessmesstechnik**	**Projekt: Photonische Messsystemtechnik**
Studiengänge	ET | MT | RES | Physik	MT	ET
Modul	Oberseminar Messsystemtechnik	Sensoren und Messsysteme Vertiefung	Photonische Messsystemtechnik
Umfang	2 SWS	2 SWS	1 SWS
Leistung	Vortrag (+ Beleg für ET)	Vortrag + Beleg	Vortrag

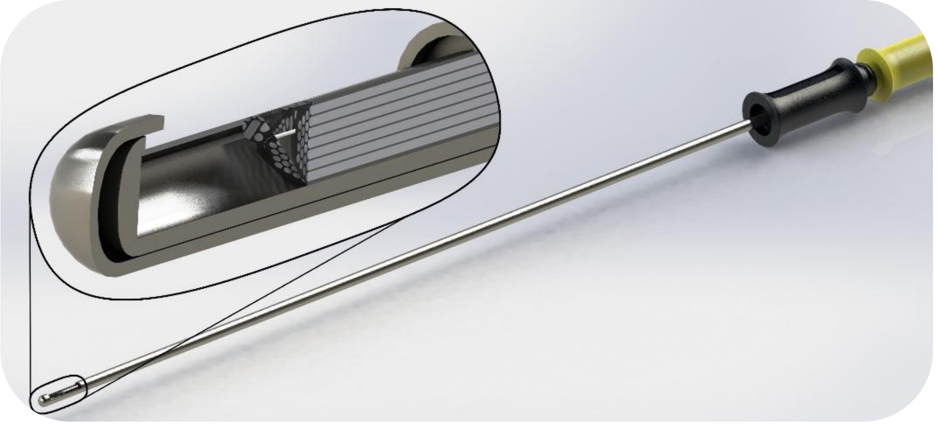
Zeitplan

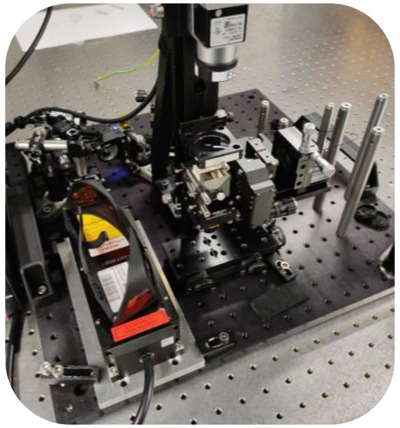
14.10	Themenvorstellung
Bis 19.10	Einschreibung für Themen per E-Mail:
	jakob.dremel@tu-dresden.de
	Jedes Thema kann nur durch eine Gruppe bearbeitet werden
	First Come, First Serve
Ab 20.10	Bearbeitung der Projekte und wöchentliche Seminare
Ab Januar	Präsentationen der Projektergebnisse und ggf. Abgabe der Belege
	(in Rücksprache mit den Betreuenden)

Date	CW	Lecturer	Topic
14 Oct.	42	Dr. R Kuschmierz / J Dremel / Dr. L Büttner	Introduction to the Seminar & Presentation of Topics for Students
20 Oct., 12:00, BAR 17	43	Shiyue Chen	All-in-One Diffractive Neural Networks for Multidimensional Optical Input Processing (SA defense, supervision QZ)
21 Oct.	43	Wuming Zheng Yuezhen Xu	Force Prediction in optical trapping using Neural Networks (intermediate report, supervision DK) Optimization of phase coding mask for Ultrasound Imaging (Diploma defense, supervision ZD)
28 Oct.	44	-	*No show (FiO Conference, Denver)*
04 Nov.	45	Jialong Zhang Zhaoyi Liu	Compressive ultrasonic sensing through open cell metal foam (SA defense, supervision ZD) Online-Oriented Smoothing Iterative Learning Control for FMCW LiDAR Nonlinearity Compensation (JD)
11 Nov. (LB)	46	Dr. Anna Taubenberger BIOTEC	S1 Biosafety Briefing (only for MST members)
18 Nov. (JD,JC)	47	Dr. Lars Büttner	Laser Safety & Hazardous Substances Briefing (only for MST members)

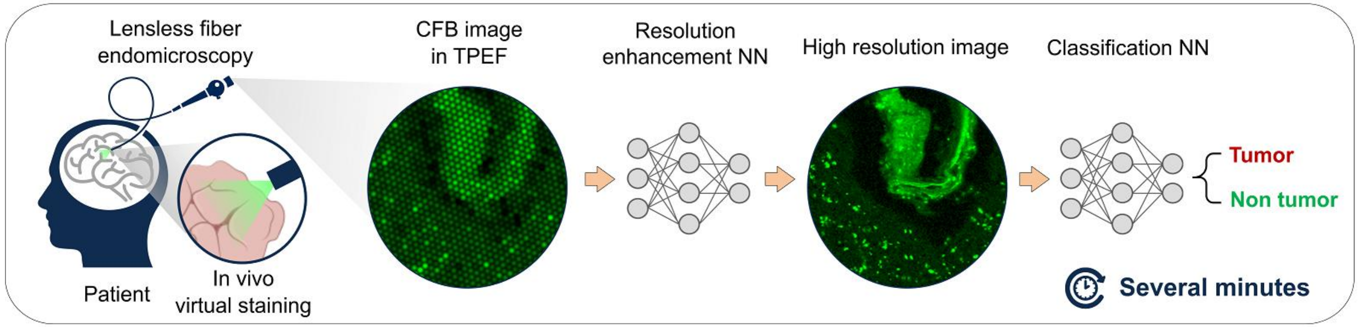
Themen für das Oberseminar & die Projekte

AI-assisted endoscopic tissue differentiation in neurosurgery





Motivation In this project, the spectral properties of the fluorescence of brain tumors are investigated and a miniaturized endoscope is developed to enable optical intraoperative biopsy. The development of a tissue characterization and an AI-supported diagnosis should enable a smooth integration into the clinical work routine in the future. The in vivo tumor diagnosis avoids the removal of brain tissue and its lengthy pathological examination, and would make it possible to start therapy for affected patients at an earlier stage.



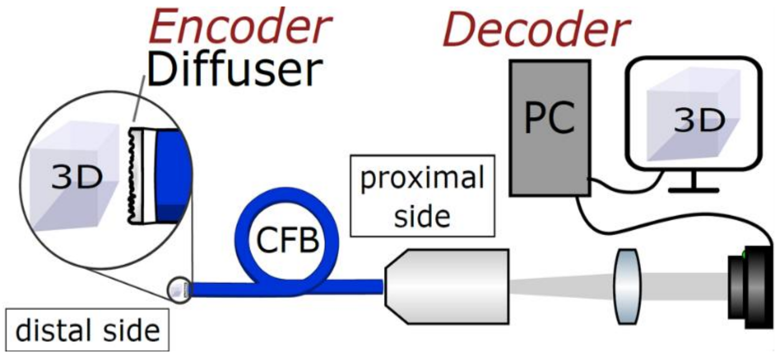
Tasks

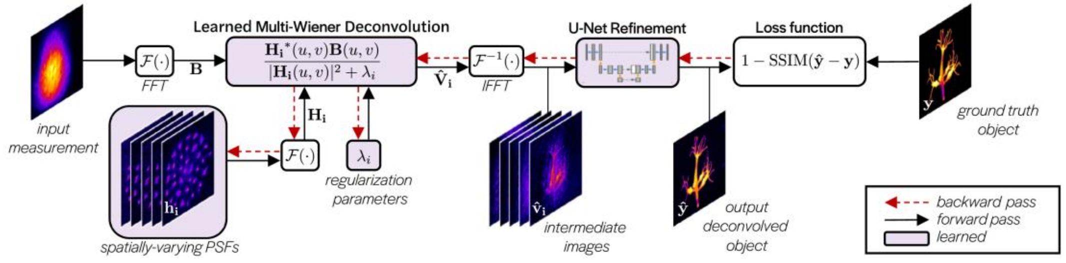
- Characterization of different endoscopes (Lab work, Hardware side)
- Automation of a measurement process of real tissue samples for the training data of neural networks at the university hospital with (Matlab, Software side)

Contact Jakob Dremel jakob.dremel@tu-dresden.de

ET | INF | MT | PHY | POL | RES

Parameter study for physics-informed neural network image reconstruction in diffuser endoscopy





Motivation

Diffuser based imaging is a recent topic in computational optics. The diffuser generates a unique pseudorandom speckle pattern for every point within a volumetric field-of-view on an image plane. By solving the inverse problem, the 3D scene can be reconstructed fast computationally by using neural networks. In conjunction with imaging waveguides, this enables the realization of single shot 3D microendoscopes.

The optimization of the diffuser as well as the other parameters of the optical systems play a crucial role to ensure a successful encoding and decoding process. In this project, different simulation parameters should be explored in conjunction with a physics-informed neural network reconstruction based on spatially-varying deconvolution with multiple Wiener filters. The results should be evaluated by different imaging quality metrics.

Tasks

- Simulation of training data with different optical parameters for the diffuser endoscope
- Training of physics-informed neural network model for image reconstruction
- Analysis of imaging quality metrics

Key words

Endoscopy, Neural Network, Computational Imaging, Python, Matlab

Contact

- Dipl.-Ing. Tom Glosemeyer, BAR 25,
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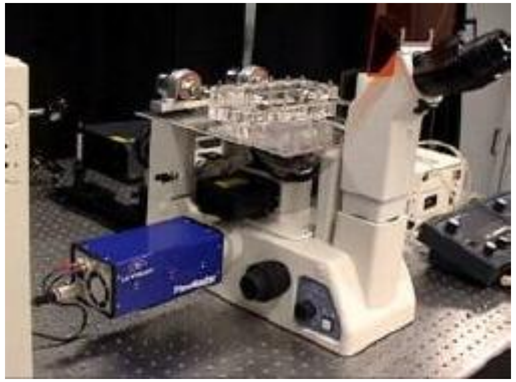
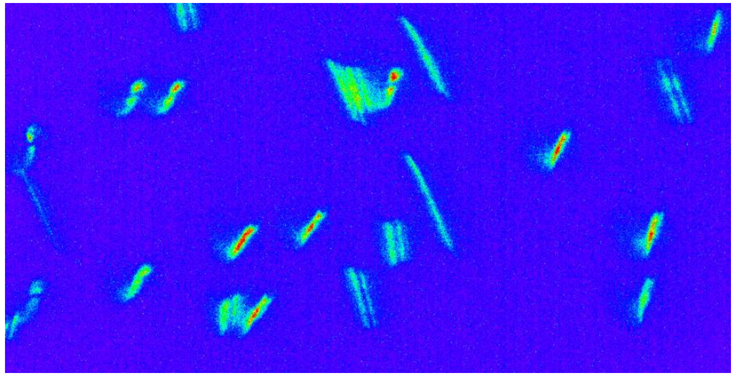
Correction of Motion Blur for particle-based measurement techniques



camera-based microfluidic measurement system

Motivation When measuring fast flows, motion blur can pose a significant challenge. With fluorescence-based measurement methods, however, it is often difficult to achieve sufficiently high particle intensities for short exposure times. In addition, high-speed cameras for very high frame rates are often heavy, unwieldy and expensive. In this article, methods for correcting motion blur in relation to flow measurements will be investigated. First, a literature review will be conducted regarding the state of the art in this field. Subsequently, a suitable algorithm will be implemented, validated and characterized. Finally, the algorithm will be applied to measurement data.



Particle image with motion blur

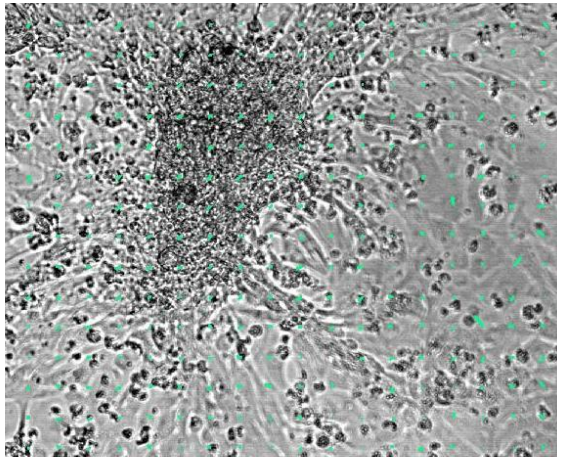
Tasks

- Literature Study
- Implementation of a blind deconvolution algorithm to correct motion blur
- Characterization of the result and application to real measurement data
- Prerequisite: good knowledge of Python and max. 1 person in the group

TUD **Contact** Clemens Bilsing clemens_matthias.bilsing@tu-dresden.de

Electrical Eng./ Mechatronics/ Physics

3D Cardiac System Simulation and Analysis of Stimulation Protocols for Disease Therapy



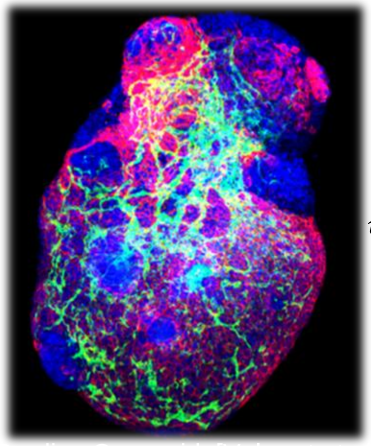
Motivation

Background:

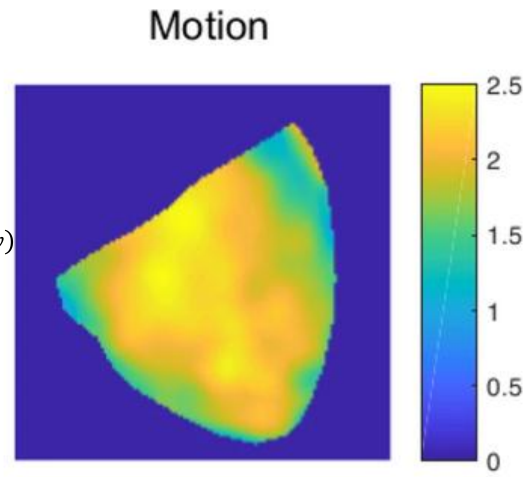
Atrial fibrillation arises from characteristic contraction patterns in cardiac tissue that disrupt heart rhythm and can be life-threatening. In recent years, optogenetic defibrillation has emerged as a promising method to restore normal rhythm by controlling genetically modified cardiomyocytes with targeted light stimulation. Our research explores optogenetic control in living hiPS-CMs (human induced pluripotent stem cell-derived cardiomyocytes) expressing the opsin Chrimson. Using a dedicated optical stimulation and imaging setup, we precisely excite cardiac tissue and analyze its contraction dynamics. Most existing stimulation protocols are based on simplified 2D models with unexcitable borders. To move toward clinical application, the development and evaluation of realistic 3D simulations is essential.

Tasks:

Students will extend an existing 2D cardiac model into a stimulatable 3D system and investigate how cardiac tissue responds to different stimulation protocols, with a focus on mechanisms relevant for arrhythmia termination and therapeutic applications.



$$\dot{u} = \nabla^2 u - f(u) - g(u,v)$$
$$\dot{v} = h(u,v)$$



Range of Tasks

- Extend an existing 2D cardiac model based on simplified PDEs to a 3D framework
- Investigate disease modeling protocols and evaluate respective stimulation parameters
- Test and assess optogenetic cardioversion strategies for arrhythmia termination

Related Topics

Numerical Simulation, Cardiac Organoids, Optogenetics, Biomedicine

Contact

- Robert Wendland, BAR 27, Tel. 463-32712, E-Mail: robert.wendland@tu-dresden.de
- Lars Büttner, BAR 28, E-Mail: lars.buettner@tu-dresden.de
- Internet: http://tu-dresden.de/et/mst

Rotor Core Detection Using Neural Networks for Optogenetic Arrhythmia Treatment

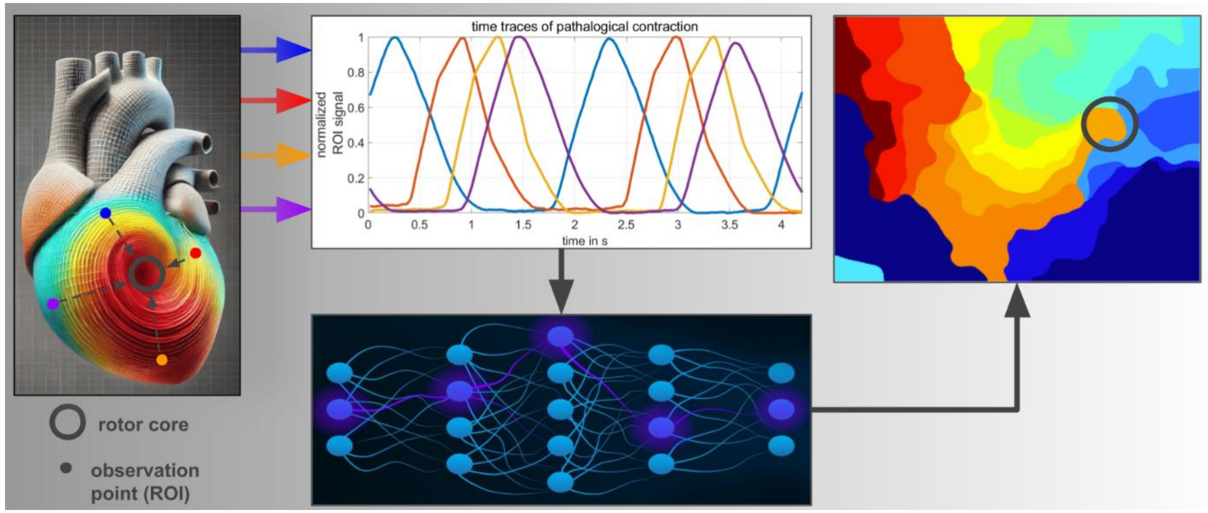
Motivation

Background:

Atrial fibrillation is driven by spiral-shaped contraction patterns in cardiac tissue, disrupting heart rhythm and posing a fatal risk. Over the past decade, optogenetic defibrillation has emerged as a promising approach to restoring normal cardiac rhythm by controlling genetically modified cardiomyocytes with specific light patterns. Our research focuses on optogenetic control in living hiPS-CMs (human induced pluripotent stem cell-derived cardiomyocytes) expressing the opsin Chrimson. Using an optical stimulation and imaging setup, we precisely excite cardiac tissue and analyze the resulting contraction. To advance optical defibrillation strategies, a fast and precise rotor core detection method is essential, as computing an optimal stimulation pattern requires knowledge of the core position.

Tasks:

Students will develop a traning environment for a neural network based on an existing simulation of cardiac networks. They will design a neural network to estimate the rotor core position of spiral-shaped contraction patterns from sparsely sampled cardiac activity. Finally, the performance of the neural network will be evaluated in test scenarios with varying parameters (e.g., SNR).



Range of Tasks

- Development of a training environment
- Design of a suitable neural network architecture
- Evaluation and validation of the network‘s performance

Related Topics

Neural Network, Signal Processing, Optogenetics, Biomedicine

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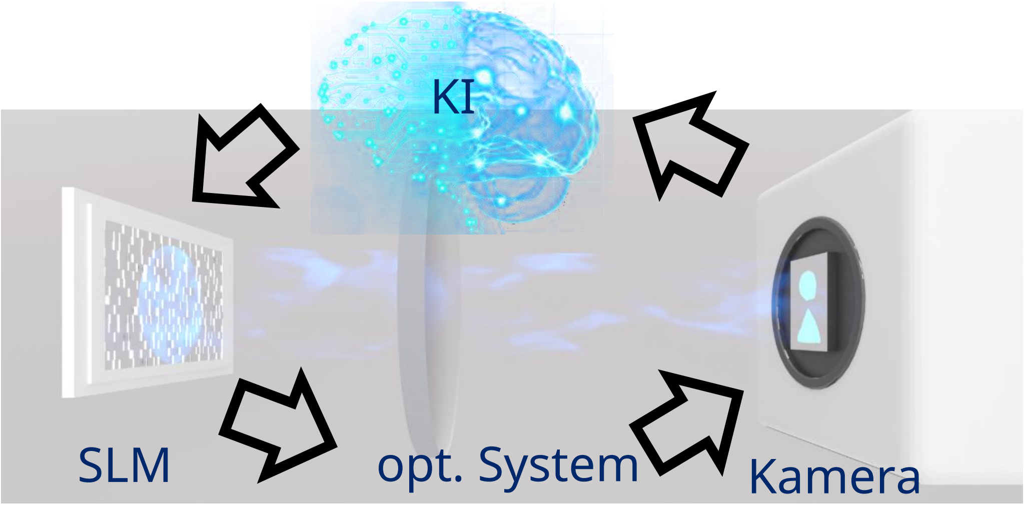
- Robert Wendland, BAR 27, Tel. 463-32712, E-Mail: robert.wendland@tu-dresden.de
- Lars Büttner, BAR 28, E-Mail: lars.buettner@tu-dresden.de
- Internet: http://tu-dresden.de/et/mst

Fast generation of binary holograms with deep learning

Motivation

Together with computer-generated holograms, modern pixelated spatial light modulators open up new possibilities in many applications, namely aberration correction in measutement systems, stuctured illumination in information technology or biomedical research or for the development of holographical displays. Many of these applications benefit from high frame rates, e.g. for real time control. However, light modulators with accordingly high refresh rates often only allow a binary modulation and sufficiently quick calculation of binary holograms. Established algorithms for hologram calculation are often of iterative nature and therefore inherently slow. In contrast, deep learning with neuronal networks promises fixed execution times once properly trained.

Therefore, the use of binary holograms for the fast generation of binary holograms shall be explored in this project using different approaches depending on experience and student group size, ranging from the use of physical models to different means of ground truth data generation.



Range of tasks

- Extension of existing neuronal network/ Design of new neuronal network + training
- Generation of applicable ground truth data with different methods.
- Evaluation of quality metrics and speed

Subjects

Computer generated holograms, artificial neural networks, deep learning, physical modelling

Contact

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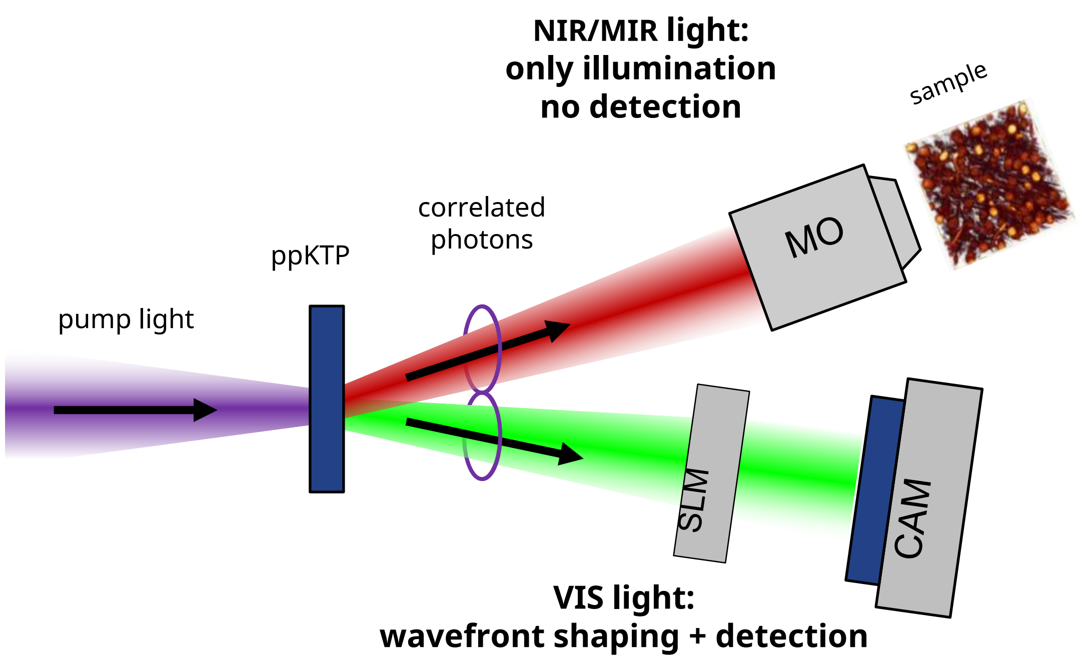
Quantum Enhanced Deep Tissue Imaging

Motivation While deep tissue imaging with near-infrared and infrared wavelengths is strongly desired in biological and medical applications, its realization is difficult due to inefficient detectors in this wavelength range. Recent developments in quantum technologies and in particular the use of entangled photons open a way to probe biological samples in the infrared while detecting photons efficiently in the visible. However, the resulting imaging contrast resulting from absorption and phase changes needs to be interpreted with care. In this project, students will apply an existing quantum imaging microscope for deep tissue studies of well known samples. The gained information will be discussed with respect to resolution, contrast and biological applicability. Image correlation will be part of the software assisted analysis routine.



Tasks

- Familiarize with quantum imaging setup for deep tissue applications
- Perform measurements on well known samples
- Image correlation, data analysis and discussion of the results

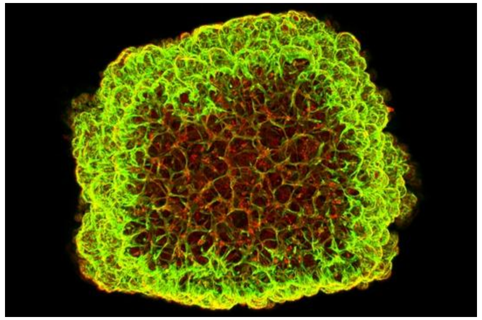
Contact Stefan Krause stefan.krause1@tu-dresden.de

Simulative study for optical diffraction tomography

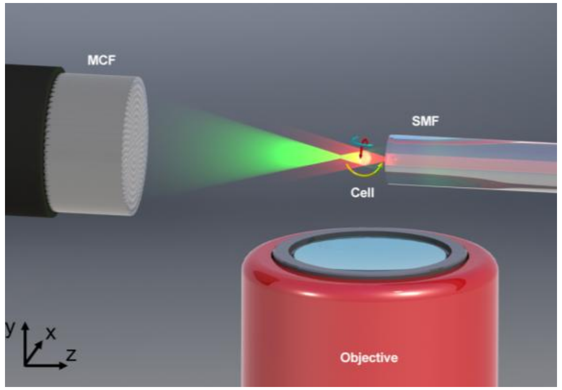
Motivation

Optical trapping represents a powerful non-invasive technique for the capture and manipulation of cells. When employed in conjunction with optical diffraction tomography, it can be utilized to examine the impact of specific diseases on cellular structure. To get a 3D model of the morphology, the cell is optically rotated and multiple images from different viewing angles are taken. However, the orientation of the cell is not know and has to be inferred from the images and tracked over time to enable a accurate reconstruction. The accuracy of the determined orientation depends on the saliency of features from the cell to track and has a certain angle uncertainty.

To investigate the influence of orientation errors on the reconstruction fidelity, a simulative study should for optical diffraction tomography be performed, where random and systematic orientation errors are applied to the orientation. The results can then be used to estimate the required orientation accuracy for an optimal reconstructions.



https://www.helmholtz-hzi.de/forschung/forschungsgruppen/detailseite/innovative-organoid-forschung/



Tasks

- Familiarize with the simulation environment for optical diffraction tomography
- Simulate the influence of different orientation errors on the reconstruction quality
- Estimate the required angle accuracy for optimal reconstruction results

Keywords

MATLAB/Python/…, light scattering, optical trapping, simulation

Contact

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Themenübersicht

Thema	Kürzel	Betreuende
AI-assisted endoscopic tissue differentiation	BrainAce	Jakob Dremel
physics-informed neural network image reconstruction in diffuser endoscopy	Diffscope	Tom Glosemeyer
Correction of Motion Blur for particle-based measurement techniques	Motion-PMT	Clemens Bilsing
Rotor Core Detection Using Neural Networks for Optogenetic Arrhythmia Treatment	RoCoNet	Robert Wendland
3D Cardiac System Simulation and Analysis of Stimulation Protocols for Disease Therapy	CardSyS	Robert Wendland
Fast generation of binary holograms with deep learning	HoloFAST	Felix Schmieder
Quantum Enhanced Deep Tissue Imaging	QuDIT	Stefan Krause
Simulative study for optical diffraction tomography	SimODT	David Krause

Einschreibung für Themen per E-Mail:
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