Modul „Oberseminar Messsystemtechnik" (2 SWS, 4 bzw. 2 LP)

Teil A: Wöchentliches Seminar
➔ Anwesenheitsliste

Teil B: Seminararbeit
- betreute Gruppenarbeit à 2-4 Studenten (mind. einmal Konsultation)
- Umfang: je 120 Stunden (Elektrotechnik) bzw. 60 Stunden (Mechatronik)

➔ Benotung:
- ☑ Referat: 20 min Vortrag + 10 min Diskussion, jeweils pro Student
- ☑ Beleg (nur ET): 6 Seiten
  Vorlage auf Webseite
  (Studium → Lehrveranstaltungen → OS Messsystemtechnik)

SG Elektrotechnik (4 LP):
Modulnote = Note des Referats * 1/3 + Belegnote * 2/3

SG Mechatronik bzw. SG Regenerative Energiesysteme (2 LP):
Modulnote = Note des Referats

SG Physik:
Leistungsschein (Ausarbeiten und Halten eines Seminarvortrags)

➔ Ihre Anmeldung im HISQIS ist erforderlich (zwecks Notenmeldung)!

Zeitplan

- 07.04. Themenvorstellung
- Bis 14.04. Einschreibung für die Bearbeitung der Themen per E-Mail (robert.kuschmierz@tu-dresden.de), jedes Thema kann nur durch eine Gruppe bearbeitet werden → „First Come, First Serve“-Prinzip)
- ab 14.04. Bearbeitung der Projekte & wöchentliches Seminar
- ab 01.07. Präsentation der Projektergebnisse und ggf. Abgabe der Belege (in Rücksprache mit dem Betreuer)

Date: Monday, 3. DS., 11:10 – 12:40, BAR I88

Date	WK	Lecturer	Topic
08. April (LB)	15	Dr. Robert Kuschmierz	Introduction to Seminar & Presentation of Topics for Students
15. April	16	**Prof. Lin Center for Systems Biology, Harvard Uni.**	**In vivo flow cytometry: blood cell analysis without drawing blood (Student Chapter, KS,JD)**
19. April, 13:00, BAR 17	16	Ming Lin	Learningbasierte Optimierung einer Phasenmaske für 3D Bildgebung mit Neuronalen Netzen *(Defense of Studienarbeit (TG))*
22. April	**17**	**Ingo Langheinrich, polychip.ai**	**Threshold methods versus deep learning - when it makes sense to use "AI"-algorithms in machine monitoring RK)**
29. April	18	Yuezhen Xu	*t.b.a. (Defense of Studienarbeit (ZD))*
06. May (JC until 12:30)	19	Luca Linhsen	Endoskopische, konfokale Fluoreszenzbildgebung durch phasenkorrigierte Mehrkernfaserbündel (Defense SA, ES)

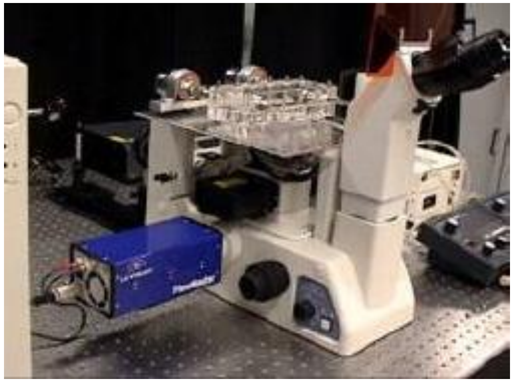
10. June	24	Hannes Bischoff Tobias Irrgang	Compressive-Sensing zur Ultraschallbildgebung mit reduzierten Empfangskanälen, *Defense DA (DW)* Ultraschallbildgebung mit Einkanal-Ultraschallköpfen durch komprimierende Multimode-Wellenleiter, *Defense DA (DW)*
17. Jun	25	Dr. Lars Büttner	Laser Safety & Hazardous Substances Briefing (only for MST members)
24. June	26	-	– China –
01. July	27	NN	Reserved for project defenses
08. July	28	NN	Reserved for project defenses
15. July	29	-	

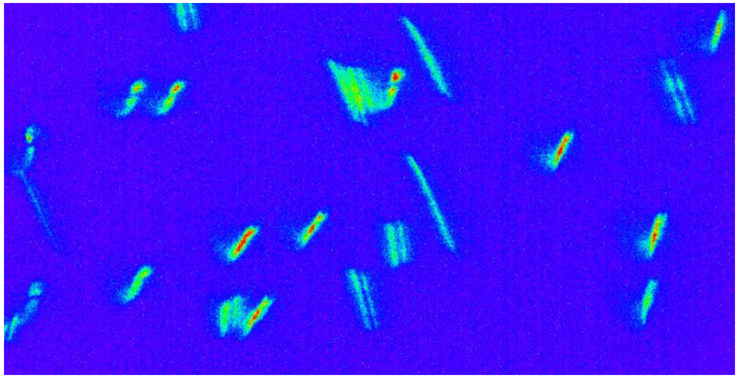
External lecturers are shown in bold, in green are checks and in red are changes. Attention: The seminar plan can be subject to short-term changes, see Inter-

→ Themenvorstellung

Oberseminar „Messsystemtechnik“

Correction of Motion Blur for particle-based measurement techniques


camera-based microfluidic measurement system


Particle image with motion blur

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.

Aufgaben

- 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

Stichworte

Fluid mechanics, image processing, microscopy

Kontakt

- Clemens Bilsing, E-Mail: clemens_matthias.bilsing@tu-dresden.de
- Internet: http://tu-dresden.de/et/mst

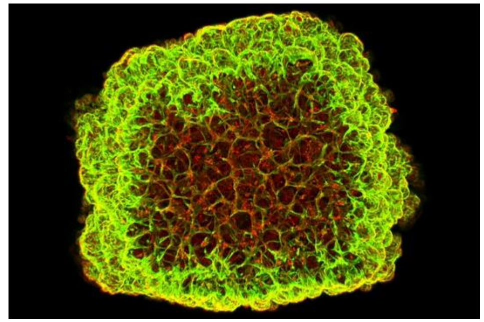
Oberseminar „Messsystemtechnik

Simulative study for optical diffraction tomography

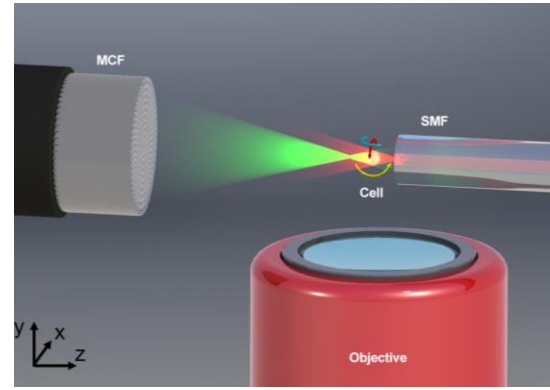
Motivation

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

• Dipl.-Ing. David Krause, BAR I56C, Tel. 463-33666

• E-Mail: david.krause@tu-dresden.de

• Website: http://tu-dresden.de/et/mst

Oberseminar „Messsystemtechnik“

Smart Beamshaping by Machine Learning

Motivation

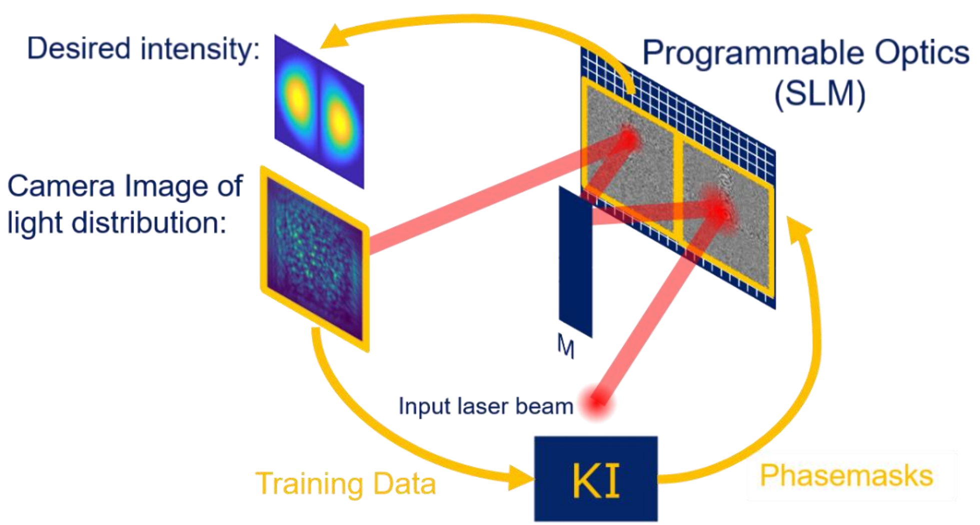
The global internet infrastructure is mainly based on optical fibers. Whereas single mode fibers (SMF) are used for long-haul, multimode fibers (MMF) are well established for short-range distances. Further, MMFs offer high potential to increase data capacity, as well as data security through spatial multiplexing.

For this reason, interfaces between singlemode and multimode signals are required. The challenge is, that singlemode signals simply consist of Gaussian distributions, while multimode signals consist of highly complex patterns.

A new approach is, to implement them fully optical through light conversion. The approach includes a programmable optical device which is used in multiple reflections by a mirror.

Conventionally, an optimisation algorithm is used to determine the required phase masks for the programmable optics, but deviations and uncertainties in the optical system are difficult to take into account. The approach in this work is to machine-learn the entire optical system generating a digital model that consideres system-specific parameters and predicts the required phase masks in a tailored manner.

The task allows to gain fundamental knowledge about deep learning and neural networks, as well as optical setups and measurement techniques. Basic knowledge about neural networks, optics and MATLAB/Python is desirable but not mandatory.



Tasks

- Build desired optical setup for data acquisition
- Implementation and comparison of different neural network architectures
- Investigation on (de-)multiplexing quality

Keywords

fiber communication, deep learning, beamforming, neural networks, signal processing, MATLAB, Python, TensorFlow

Contact

Dipl.-Ing. Dennis Pohle, BAR 24, E-Mail: dennis.pohle@tu-dresden.de

Oberseminar „Messsystemtechnik“

Scalability Study On Photonic Reservoir Computing using Multimode Optical Fibers

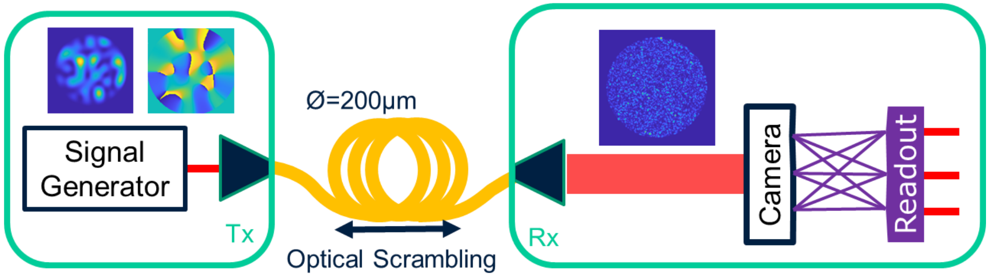
Motivation

Optical scattering processes into higher-order dimensions provide to increase the achievable capacity required for Internet-of-Things and global internet infrastructure, increase security by key generation on the physical layer or can be exploited for optical computing with the speed of light. Multimode fibers (MMF) are such physical devices providing this scattering and are thus used for communication, computing and imaging applications.

In this experiment, dimension-limited probe beams from a signal generator are send through the MMF and the scattered beams are measured by a camera. The optimization of a readout multiplication is investigated for the ability to reconstruct the MMF input, the probe beam. Doing so, the MMF is used for both, data transmission and computing to recover the signal.

The investigations include the generation and measurement of probe beams, the readout optimization and evaluation of the recovered signal. Requirements and boundary conditions for the underlying scattering are of further interest.

The experiment allows to gain fundamental knowledge about fiber optical communications, optical setups, measurement techniques and AI-based approaches. Basic knowledge about optics and MATLAB/Python is desirable but not mandatory.



Tasks

- Generation of optical light fields
- Implementation of optical reservoir for high-dimensional scattering
- Optimization of readout multiplication for signal recovery
- Evaluation on boundary conditions, accuracy and scalability

Keywords

fiber communication, optical computing, beam forming, light field measurement, signal processing, MATLAB, Python

Contact

Dipl.-Ing. Dennis Pohle, BAR 24
E-Mail: dennis.pohle@tu-dresden.de
Website: http://tu-dresden.de/et/mst

Physics-Based Simulation of Signal Transport in Cardiac Tissue

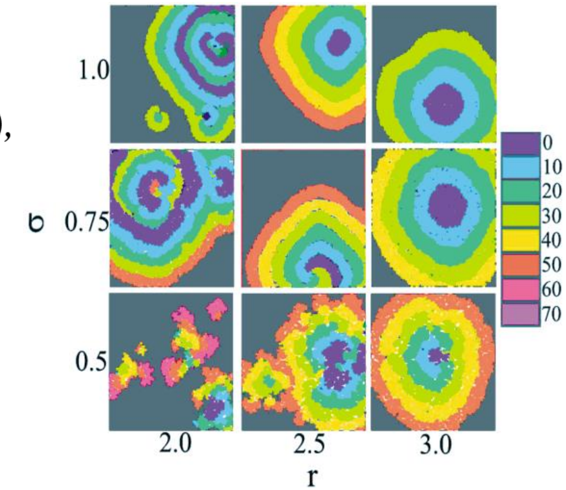
Physics/Pol/Informatics

Motivation

Background:
In heart tissue, self-sustaining spiral contraction waves have been identified as one cause for deadly arryhthmia. The underlying principles and possible treatments are, amongst other methods, researched using cardiac tissue cultures of human cardiomyocytes in vitro. Our lab concentrates on the investigation of these phenomena using genetically light-sensitized cell cultures and light-driven contraction patterns (Optogenetics). Since reentrant spiral waves are not normally observed in healthy tissue, a main topic of investigation is the controlled creation of prolonged spiral states.

In this project, students will adapt existing methods for the simulation of activatable tissue to the subject of contracting heart muscle tissue in vitro. The goal is to generate self-sustaining spiral waves and find boundary conditions for their creation and prolonged existence by varying parameters like signal speed, excitation patterns or the size of the simulated area.

$$\frac{\sum_{D[j,i]<r;\ 0<u_j(t)\le E}}{\sum_{D[j,i]<r;u_j(t)=0 \text{ or } u_j(t)>E}} > \theta_i(t+1),$$



Range of Tasks

- Adaptation of existing concepts for simulation of activatable cells to contracting cardiomyocytes
- Observation of contraction patterns based on different boundary conditions
- Exploration of stimulation patterns for spiral wave generation

Related Topics

Simulation, Optogenetics, Cardiac Diseases

Kontakt

• Felix Schmieder, BAR 25, Tel. 463-33894, E-Mail: felix.schmieder@tu-dresden.de
• Internet: http://tu-dresden.de/et/mst

ET/Informatics

Rotor Core Detection Using Neural Networks for Optogenetic Arrhythmia Treatment

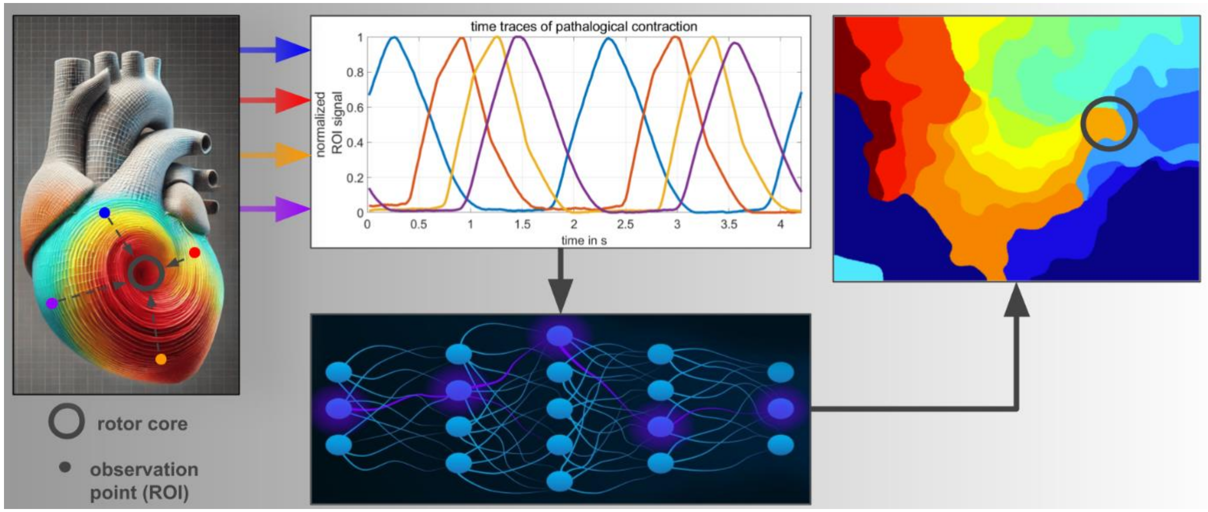
Motivation

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 design a neural network capable of estimating the rotor core position of spiral-shaped contraction patterns based on time signals extracted from known observation points. The neural network will be trained using artificially generated data and subsequently validated with experimentally obtained data.



Range of Tasks

- Design of a suitable neural network architecture
- Training of the neural network with existing datasets
- Evaluation and validation of the network‘s performance

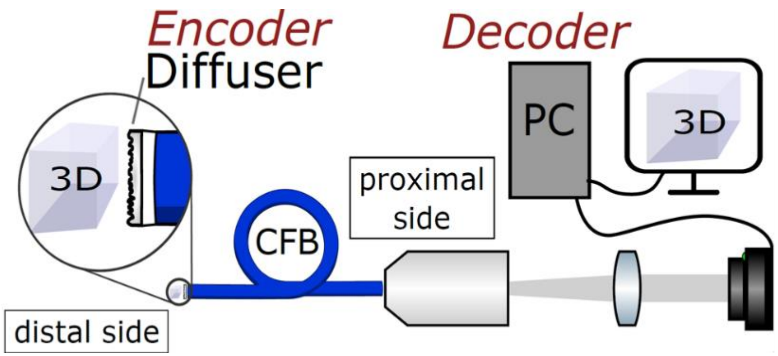
Related Topics

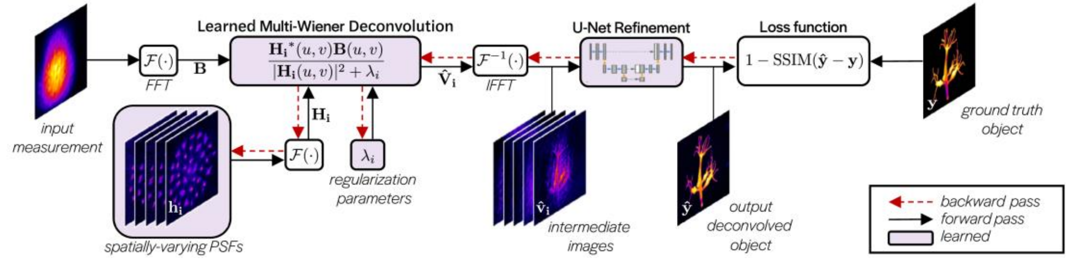
Neural Network, Signal Processing, Optogenetics, Biomedicine

Contact

- Robert Wendland, BAR I55, Tel. 463-36185, 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

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





Kyrollos Yanny et. al., "Deep learning for fast spatially varying deconvolution," Optica **9,** 96-99 (2022)

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,
  E-Mail: tom.glosemeyer@tu-dresden.de

Themenübersicht

Thema	Kürzel	Betreuer
Correction of Motion Blur for particle-based measurement techniques	Motion	Clemens Bilsing
Simulative study for optical diffraction tomography	ODT	David Krause
Smart Beamshaping by Machine Learning	Smart	Dennis Pohle
Scalability Study On Photonic Reservoir Computing using Multimode Optical Fibers	Reservoir	Dennis Pohle
Physics-Based Simulation of Signal Transport in Cardiac Tissue	Cardio	Felix Schmieder
Rotor Core Detection Using Neural Networks for Optogenetic Arrhythmia Treatment	OptoGen	Robert Wendland
Parameter study for physics-informed neural network image reconstruction in diffuser endoscopy	DiffScope	Tom Glosemeyer

Questions?