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

- 08.04. Themenvorstellung
- Bis 15.04. 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 15.04. 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**

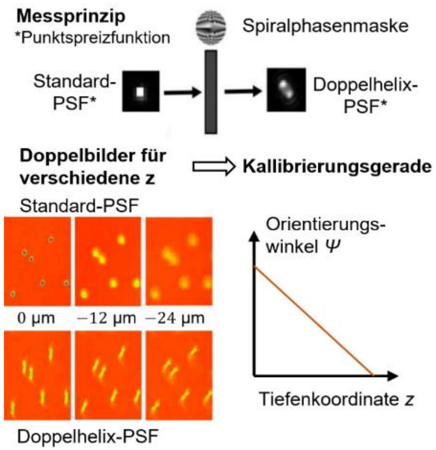
Oberseminar „Messsystemtechnik“

Adaptive 3D-Mikroskopie in kleinskaligen Strömungen

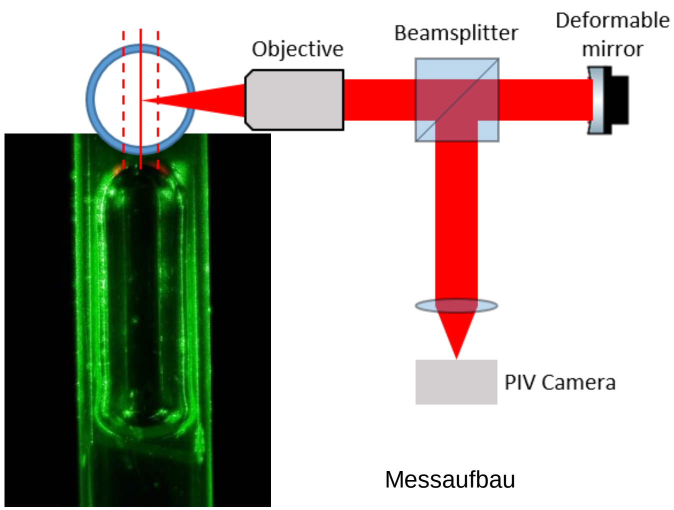
Motivation

Zur Untersuchung von kleinskaligen Strömungen werden unter anderem Mikroskope eingesetzt. Diese sind allerdings auf 2D-Messungen beschränkt, wodurch interessante dreidimensionale Phänomene nicht gemessen werden können. Für volumetrische Messungen wird die Tieferinformation benötigt, welche auf verschiedene Arten gewonnen werden kann.

Ziel dieser Arbeit ist es, ein Messsystem aufzubauen, welches zur 3D-Vermessung von Strömungen geeignet ist. Eine Phasen-maske erzeugt hierzu helikale Wellenfronten, welche punktförmige Objekte als Doppelbild darstellt. Je nach Abstand zur Brennebene dreht sich das Doppelbild und lässt so die Tiefenmessung zu. Eine besondere Herausforderung ergibt sich durch die Messung durch gekrümmte Oberflächen, welche für Messabweichungen sorgen. Diese Messabweichungen sollen in dieser Arbeit ebenfalls reduziert werden.



Messprinzip 3D-PTV



Messaufbau

Aufgaben

- Aufbau und Charakterisierung eines 3D-Messsystems für die adaptive Strömungsmessung
- Messung verschiedener Strömungen und Untersuchung unterschiedlicher Einflüsse

Stichworte

3D-Mikroskopie, Punktspreizfunktion, Bildverarbeitung, Strömungsmechanik

Kontakt

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- Internet: http://tu-dresden.de/et/mst

TECHNISCHE UNIVERSITÄT DRESDEN

Professur für Mess- und Sensorsystemtechnik

Smart Beamshaping by Machine Learning

Motivation

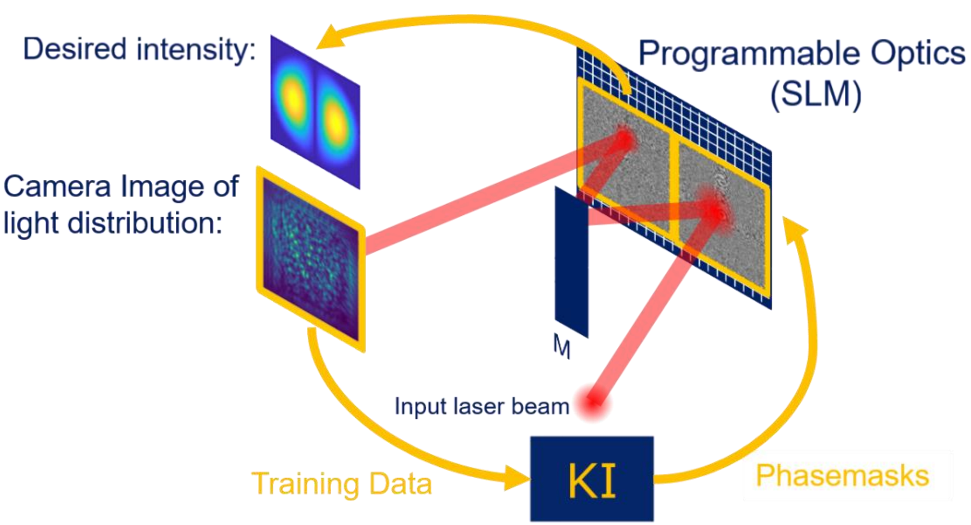
The global internet infrastructure is mainly based on optical fibers. Whereas single mode fibers (SMF) are used for long-haul, multimode fibers (MMF) are well established for short-range distances. Further, MMFs offer high potential to increase data capacity, as well as data security through spatial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

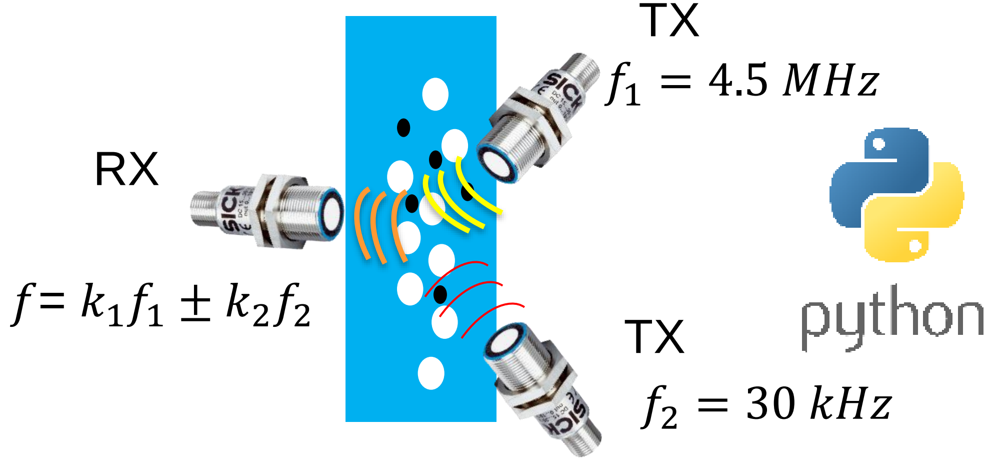
Exploration of multiple evaluation techniques for intermodulated bubble oscillation scattering

Motivation

Measuring the parameters of three phase flows is an ongoing hurdle. In froth flotation processes, bubbly liquids contain particles as well. When determining the three phases (water, air, particles) it is hard to distinguish the impact of the phases on the ultrasound signal.

Luckily bubbles show a non-linear behaviour when oscillating, due to an excitement through ultrasound (f_2). The non-linearity leads to a mix of the measurement frequency (f_1) and the excitement frequency. The scattered wave can then be recorded by an RX-transducer. We can thus distinguish between bubbles and particles and even measure a bubble size distribution.

Unfortunately the amplitude of the received frequency is comparably small but we do know the signal we are expecting. Therefore we want to investigate different analysing methods (i.e. convolution, Lock-In amplifier, ..) and compare them with one another.



Tasks

- Familiarization with Intermodulation in Bubble Oscillation Behaviour
- Implementation of multiple concepts of data analyzing for known, expected signals
- Comparison of different concepts

Keywords

Ultrasound, Python, Bubbly Liquid, Oscillation, Data Processing

Contact

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TECHNISCHE UNIVERSITÄT DRESDEN

MST

Professur für Mess- und Sensorsystemtechnik

Two-Photon-Microscopy for Deep-Tissue Imaging

Oberseminar in ET/MT/Physics/PoL

Background

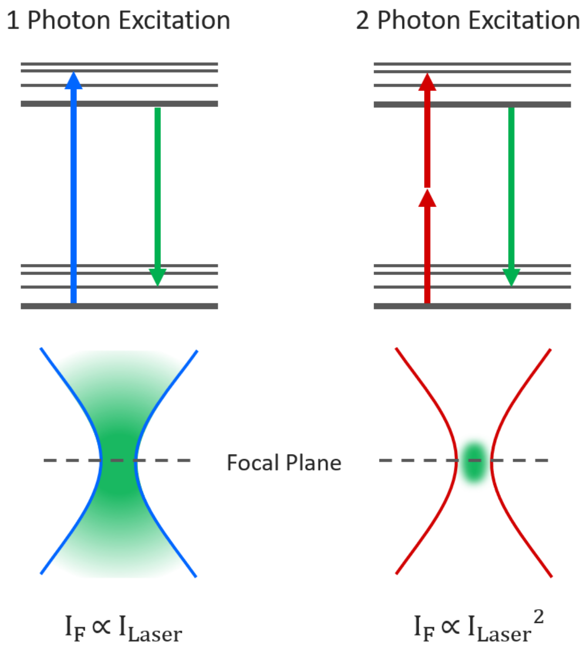
Understanding developmental and organizational processes in living cells is an important part of biomedical research (see Nobel Prizes Physiology/Medicine 2022 and 2016) and needs optical methods for observation. Two-photon microscopy is one such method to look deep into living tissue without physical slicing. For this purpose, an optical setup of a two-photon microscope needs to be realized, characterized and complemented by adaptive optics. Adaptive optics enable pre-shaping of light before it enters the sample, by doing so disturbing influences of the surrounding tissue (optical aberrations) can be corrected. Thereby, the obtained images have higher resolution and the focal plane can be shifted deeper into the tissue.

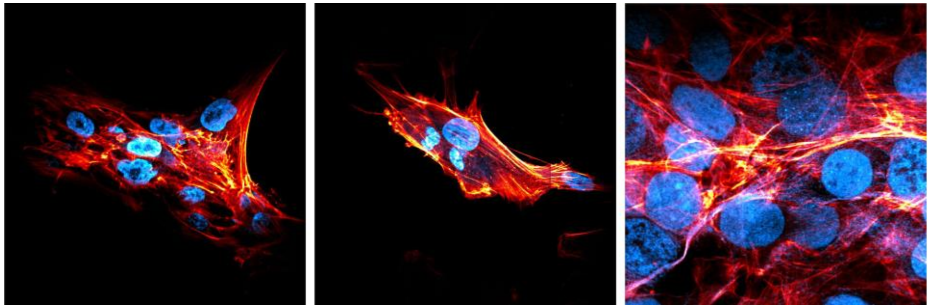
Tasks

- Build and characterize a two-photon-microscope
- Set up a imaging pipeline
- Add adaptive optics for wavefront shaping

Contact

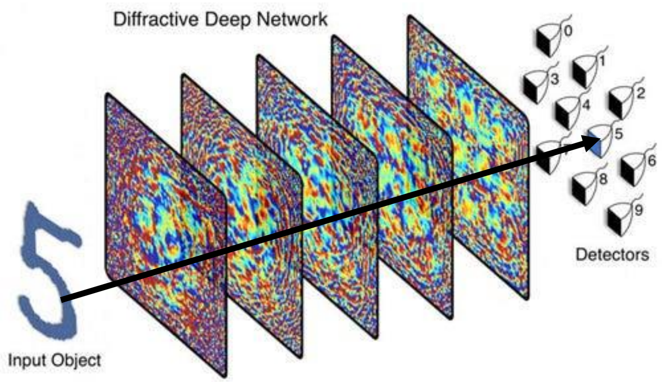
• Katharina Schmidt, BAR I56D, E-Mail: katharina.schmidt1@tu-dresden.de

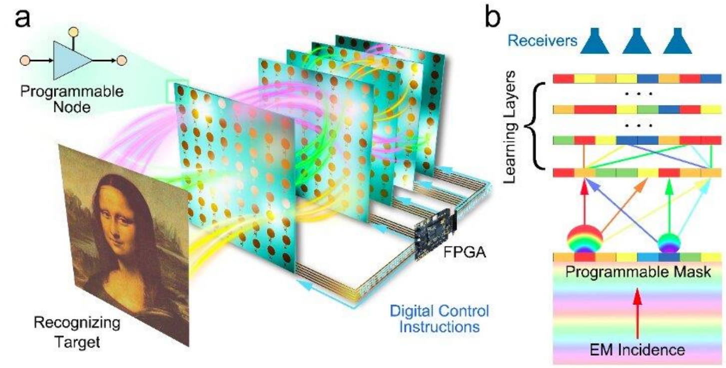




ET/RES/Physics/PoL/Info

Optical diffractive deep neural network-based light manipulation





(1) https://medium.com/generate-vision/the-paperoftheweek-41-was-all-optical-machine-learning-using-diffractive-deep-neural-networks-d9f0a25e99a8

(2) Rademacher, G., Puttnam, B.J., Luís, R.S. et al. Peta-bit-per-second optical communications system using a standard cladding diameter 15-mode fiber. Nat Commun 12, 4238 (2021).

Motivation

Optical Diffraction Neural Networks (ODNN) are a prominent example of the combination of deep learning and photonics, demonstrating the great potential of all-optical computing. Each pixel on the diffractive layer is a parameter that can be learned by the computer.

ODNN play a crucial role in processing information at high speed, especially in the field of optical communication and optical signal processing. In this project, different application scenarios of ODNN will be explored through simulation, such as image classification, image reconstruction, and optical mode conversion. Different hyperparameters for the training and network architectures will also be studied.

Tasks

- Implementation of optical diffractive neural network
- Training of optical diffractive neural network for image processing
- Training of optical diffractive neural network for mode conversion
- Analysis of quality metrics

Key words

Deep learning, ptical computing, optical diffractive neural network, simulation, python

Contact

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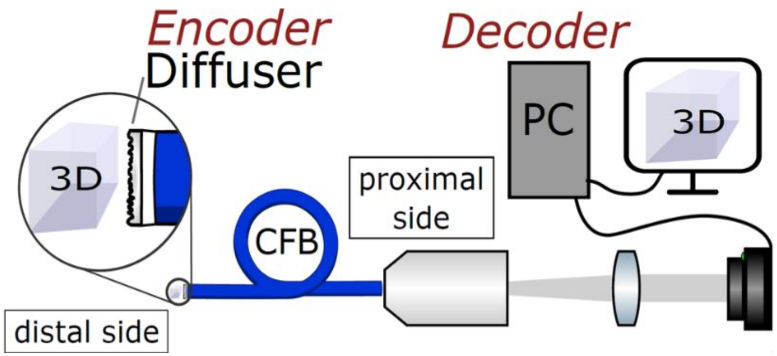
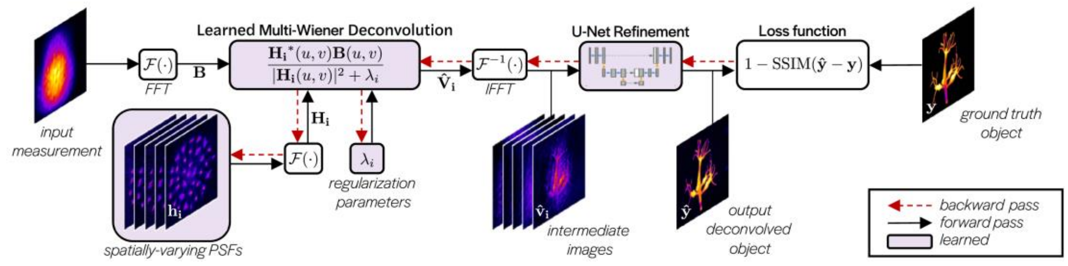
ET/MT/RES/Physics/PoL/Info

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

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Themenübersicht

Thema	Kürzel	Betreuer
Adaptive 3D-Mikroskopie in kleinskaligen Strömungen	3DMic	Clemens Bilsing
Smart Beamshaping by Machine Learning	SmartBeam	Dennis Pohle
Exploration of multiple evaluation techniques for intermodulated bubble oscillation scattering	OsciBub	Hannes Emmerich
Two-Photon-Microscopy for Deep-Tissue Imaging	2PMic	Katharina Schmidt
Optical diffractive deep neural network-based light manipulation	D^2NN	Qian Zhang
Parameter study for physics-informed neural network image reconstruction in diffuser endoscopy	DiffScope	Tom Glosemeyer

Questions?