Tingting Wu

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Research Expertise

5 years of experience in developing optical microscopy hardware and computational imaging algorithm. Experience in developing optical microscopy for 3D position sensing and 3D orientation (polarization) sensing of single molecules, and developing neural network and iterative algorithms to estimate the 3D position and 3D orientation of single molecules for super-resolution imaging.

Education

Ph.D. Candidate in Department of Electrical and System Engineering Sep 2018 - Dec 2023 (expected, flexible)
Imaging Science Program Mentor: Prof. Matthew D. Lew
Washington University in St. Louis (WashU)

Courses: *Optimization, Computer Vision, Machine Learning, Modern Optical Imaging, Theoretical Imaging Science, Computational Methods for Imaging Sciences, Mathematics of Imaging Science, Biological Imaging Technology, ...*

B.S. in Department of Electrical and Electronic Engineering 2014-2018
Optoelectronics Science and Engineering Program Graduate with Honor
Southern University of Science and Technology (SUSTech)
Courses: *Signal Processing and Systems, Probability and Statistics, Linear Algebra, Calculus, Geometric and Wave Optics, Optical Design with Zemax, Java, Electrical Circuits, Analog Circuit, Digital Circuit, General Physics ...*

Honor & Awards (selected)

Outstanding Research Award	Imaging Science PhD program	2023
Student Scholar Award	Microscopy and Microanalysis (M&M) meeting	2021
summa cum laude Graduation with Highest Honors in Electrical Engineering	SUSTech	2018
Outstanding Graduate Student Assistant to the Instructor (AI) Award	ESE at WashU	2021
Travel award from Biophysical Society Conference	Biophysical Society	2023

Research Experience

Graduate research at Lew Lab, WashU Sep 2018 - Present
All projects results in first-author publications

Optical microscopy hardware design using optimization algorithms, wavefront shaping, and polarization modulation

- Point spread function engineering through wavefront shaping. Using my optimization algorithm built in Tensorflow, we designed a wavefront shaping mask to optimize the optical microscope to enable six-dimensional (3D position and 3D orientation) imaging of single molecules. Optica, 2022
- Smart microscopy design using adaptive polarization modulation of light. We in-live adapt and design the microscope's structure (polarization and excitation light structure) based on the data captured in previous microscope settings. This design enables sparse estimation of multiple orientation clusters even if they are spatially overlapped.
- Evaluation metric design based on information theory. Design evaluation metric to efficiently quantify 'how much information' is contained in a certain microscope design for the interested parameters (e.g., 3D position, 3D orientation). This metric can be used to design new microscopes or evaluate existing microscopes. Optica, 2020

Imaging estimation software design using neural network and optimization algorithms

- Deep-Learning based imaging processing algorithm design. We built the first convolutional neural network that enables simultaneous estimates of the orientations and locations of single molecules from overlapped images. Optics Express, 2022
- Iterative optimization-based imaging processing algorithm design. Estimating the 6D parameters using images with only ∼30 pixels and hundreds of photons is challenging. We design an imaging estimation algorithm using negative-loglikelihood, FISTA algorithm, and sparsity regularization to simultaneously estimate 6D information of single molecules from noisy images. Optica, 2022

Six-dimensional imaging on cell and biomolecular condensates application

- Mapping the structure of biomolecular condensates using single-molecule imaging and tracking of fluorogenic probes. We fundamentally altered the long-believed homogenous images of condensates and experimentally show hub-and-spoke organization inside condensates where hub and spoke have different hydrophobicity. BioRxiv, 2023
- Imaging the 6D structure (3D position and 3D orientation) of the membrane of BEAS-2B cells after it been affected by influenza virus.

Advisor: Prof. Matthew D. Lew

Undergraduate research at SUSTech

- **Phase retrieval algorithm design for optical ptychography.** study the scanning coherent diffraction imaging (ptychography) at visible light wavelengths and reconstruct the image using iterative phase retrieval algorithm

- **Optical fiber sensor design using interference.** design refractive index fiber sensor and displacement fiber sensor based on the interference between lights in cladding mode and in core mode J. Phys. Commun, 2018

Publications

(Citations 133, h-index 5, i10-index 2 via google scholar)
∗ equally contributed

Peer-Reviewed Journal Publications

[10] **T. Wu**, M.R. King, M. Farag, R. V. Pappu, and M. D. Lew. "Single fluorogen imaging reveals spatial inhomogeneities within biomolecular condensates". In: ***BioRxiv*** *(**Nature Physics** under revision)* (2023). DOI: https://doi.org/10.1101/2023.01.26.525727.

[9] **T. Wu**, P. Lu*, Md A. Rahman*, X. Li*, and M. D. Lew. "Deep-SMOLM: deep learning resolves the 3D orientations and 2D positions of overlapping single molecules with optimal nanoscale resolution". In: ***Optics Express*** 30.20 (2022), p. 36761. DOI: 10.1364/oe.470146.

[8] **T. Wu**, J. Lu, and M. D. Lew. "Dipole-spread-function engineering for simultaneously measuring the 3D orientations and 3D positions of fluorescent molecules". In: ***Optica*** 9.5 (2022), p. 505. DOI: 10.1364/optica.451899.

[7] T. Ding*, **T. Wu***, H. Mazidi, O. Zhang, and M. D. Lew. "Single-molecule orientation localization microscopy for resolving structural heterogeneities within amyloid fibrils". In: ***Optica*** 7.6 (2020), pp. 602–607. DOI: 10.1364/optica.388157.

[6] **T. Wu**, L. Xu, and X. Zhang. "High sensitivity refractive index sensor based on the semicircular bent fiber". In: ***Journal of Physics Communications*** 2.6 (2018), p. 065009. DOI: 10.1088/2399-6528/aacbob.

[5] M. R King et al. "Macromolecular Condensation Organizes Nucleolar Sub-Phases to Set Up a pH Gradient". In: *(**Cell** under review)* (2013). DOI: 10.2139/ssrn.4520791.

[4] E. Bruggeman et al. "POLCAM: Instant molecular orientation microscopy for the life sciences". In: ***BioRxiv*** *(**Nature Methods** under review)* (2023). DOI: 10.1101/2023.02.07.527479.

[3] O. Zhang, Z. Guo, Y. He, **T. Wu**, M. D. Vahey, and M. D. Lew. "Six-Dimensional Single-Molecule Imaging with Isotropic Resolution using a Multi-View Reflector Microscope". In: ***Nature Photonics*** (2022). DOI: https://doi.org/10.1038/s41566-022-01116-6.

[2] O. Zhang, W. Zhou, J. Lu, **T. Wu**, and M. D. Lew. "Resolving the three-dimensional rotational and translational dynamics of single molecules using radially and azimuthally polarized fluorescence". In: ***Nano Letters*** 22.3 (2022), pp. 1024–1031. DOI: 10.1021/acs.nanolett.1c03948.

[1] D. Feng, Z. Ge, D. Wu, Y. Chen, **T. Wu**, J. Li, and J. He. "Enhanced thermoelectric properties of SnSe polycrystals via texture control". In: ***Physical Chemistry Chemical Physics*** 18.46 (2016), pp. 31821–31827. DOI: 10.1039/C6CP06466C.

Books and Review Papers

[1] **T. Wu** and M. D. Lew. "Book: Coded Imaging, Chapter: Dipole-Spread Function Engineering for 6D Super-Resolution Microscopy". In: ***Springer Nature*** (in print).

Patents

[2] M. D. Lew and **T. Wu**. "Pixel-Wise Point Spread Function Engineering Systems And Methods". In: *United States Patent Application* (17/880,648, 2023).

[1] M. D. Lew, **T. Wu**, and T. Ding. "Systems and Methods for Performing Optical Imaging Using Duo-Spot Point Spread Functions". In: *United States Patent Application* (PCT/US2021/018235, 2021).

Conference Publications

[2] **T. Wu**, J. Lu, and M. D. Lew. "pixOL: pixel-wise point spread function engineering for measuring the 3D orientation and 3D location of dipole-like emitters". In: ***Microscopy and Microanalysis***. Vol. 27. S1. 2021, pp. 858–862. DOI: 10.1017/S1431927621003366.

[1] **T. Wu**, T. Ding, H. Mazidi, O. Zhang, and M. D. Lew. "A computationally-efficient bound for the variance of measuring the orientation of single molecules". In: ***Single Molecule Spectroscopy and Superresolution Imaging XIII***. Vol. 1124616. February. SPIE, 2020, p. 35. DOI: 10.1117/12.2543813.

Conference Presentations

Oral Presentations

[5] "Mapping inhomogeneous network structures within biomolecular condensate using single-molecule imaging and tracking of fluorogenic probes". In: *Biophysical Society* (2023), San Diego, Ca, US.

[4] "Deep-SMOLM: imaging the 3D orientations and 2D positions simultaneously of single molecules using deep learning". In: *Gordon Research Seminar* (2022), Portland, Maine, US.

[3] "pixOL: pixel-wise point spread function engineering for measuring the 3D orientation and 3D location of dipole-like emitters". In: *Focus on Microscopy* (2022), Online.

[2] "pixOL: pixel-wise point spread function engineering for measuring the 3D orientation and 3D location of dipole-like emitters". In: *Microscopy and Microanalysis (M&M) Meeting* (2021), Online.

[1] "High sensitivity refractive index sensor based on a semicircle bent fiber". In: *2017 10th International Conference on Computer and Electrical Engineering (ICCEE 2017)* (2017), University of Alberta, Edmonton, Canada.

Poster Presentations

[3] "Deep-SMOLM: imaging the 3D orientations and 2D positions simultaneously of single molecules using deep learning". In: *Gordon Research Conference* (2022), Portland, Maine.

[2] "pixOL: pixel-wise point spread function engineering for measuring the 3D orientation and 3D location of dipole-like emitters". In: *Biophysical Society* (2022), San Francisco, US.

[1] "A computationally efficient bound for the variance of measuring the orientation of single molecules". In: *SPIE Photonic West* (2022), San Francisco, US.

Skills

- **Optics** microscopy design, simulation using geometric and wave optics, Fourier Optics, polarization system design, camera characterization, laser alignment, etc.
- **Computation** imaging estimation algorithm design based on iterative optimization and neural network, 3D image reconstruction, etc.
- **Programming** Matlab, Python, Java, TensorFlow and PyTorch
- **Wet labs** cell imaging, biomolecular condensates imaging
- **Soft skills** communication cross-group and in-group collaboration, scientific presentation and leadership

Other Professional Activities

- **Co-chair** for "Platform: Condensates: Physical Properties and Modeling II" at Biophysics Society Conference 67th annual meeting 2023

- **Initiator and Committee co-chair** of imaging science student seminar in WashU 2019-2021
  I organized ~20 seminars. I also build our 'imaging science library' for sharing the recorded presentations.
- **Invited research presenter** for incoming PhD students in math camp, WashU 2022
- **Committee member** for imaging science pathway retreat, WashU 2021
- **Mentor** for assistants instruction (AIs) in ESE 2021 fall, 2022 fall
- **Volunteer** of portal to the public, Saint Louis Science Center 2020
- **Assistant Instructor** of ESE 105, Intro to Electrical and Systems Engineering, WashU 2019 fall, 2020 fall
- **Publicity Minister** of Optical Society of America (OSA) in SUSTech 2017-2018
- Member of SPIE 2019-now
- Member of OSA 2017-now
- **Peer Tutor** of physics for international students in SUSTech 2017-2018