Zhenyu Dong

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EDUCATION

California Institute of Technology — Pasadena CA, USA
Ph.D. in Electrical Engineering — Sept 2022 – Expected March 2027
M.S. in Electrical Engineering — Sept 2022 – June 2025

- Advised by Prof. Changhuei Yang
- Research areas: Computational Imaging, Refractive index tomography, Imaging through scattering medium

Zhejiang University — Hangzhou, China
M.S. in Optical Engineering — Sept 2019 – June 2022

- Advised by Prof. Qing Yang
- Research areas: Multimode fiber imaging, Imaging through scattering medium

B.E. in Opto-Electronics Information Science and Engineering — Sept 2015 – June 2019

- Advised by Prof. Yaoguang Ma
- Research areas: Metasurface design, Optical Imaging

AWARDS

China's Top 10 Advances in Optics – Fundamental Research Category — 2023
Light10: Top 10 Socially Influential Events in China's Optics Field — 2023

RESEARCH EXPERIENCE

Fiber bundle confocal endoscopy — 2019-2021

∘ *Integrated dual-modal confocal and electronic endoscopy*

- Built a laser-scanning confocal microscope for reflection-mode fluorescence imaging through a fiber bundle.
- Integrated confocal and electronic endoscopy into a dual-modal system, combining wide-field navigation with high-resolution close-up imaging; validated the system on human anatomical and stomach models.

∘ *3D confocal endoscopy with a hyper-dispersive metasurface* — *Chinese Patent (2022)*

- Designed a hyper-dispersive metasurface with enhanced negative chromatic dispersion for wavelength-dependent axial focusing and depth-encoded 3D imaging in fiber-bundle confocal endoscopy.
- Performed FDTD simulations of meta-atoms and optimized phase profiles at nine wavelengths using particle swarm optimization.

Multimode-fiber (MMF) endoscopy — 2020-2022

∘ *Bend-resistant 3D imaging through MMFs (STABLE)* — *Nature Photonics (2023)*

- Developed STABLE, a bend-resistant 3D imaging method that enables MMF imaging under practical fiber deformations. Proposed a single-DMD scheme for simultaneous amplitude, phase, and polarization modulation of the fiber incident wavefront, enabling full-vector transmission-matrix (TM) measurement of long and bent MMFs and precise wavefront control at the fiber output.
- Implemented reflective guide stars as closed-loop feedback to identify the optimal fiber TM from a compact pre-calibrated TM library, enabling efficient compensation of bending-induced TM variations and stable imaging under fiber deformation.
- Demonstrated high-resolution in vivo MMF endoscopic imaging of the gastrointestinal tract in living mice.
- Contributed to imaging system development and experiments; performed numerical simulations to investigate mode and polarization coupling in MMFs and used modal degeneracy to explain the feasibility of bend-resistant imaging.

◦ *3D compressive imaging through MMFs* *Science Bulletin (2022)*

- Proposed a compressive-sensing approach for high-speed 3D imaging through MMFs, generating multiple 3D focal spots via wavefront modulation for volumetric scanning and reconstructing the 3D volume by solving the corresponding inverse problem.
- Demonstrated superior volumetric imaging performance of multi-focus 3D scanning over random-speckle illumination through MMFs.
- Achieved an eightfold improvement in imaging speed and demonstrated 3D fluorescence imaging of complex biological samples, including lung tissue slices and microbeads.

◦ *MMF imaging using neural networks* *Optics Letters (2022)*; *Laser & Photonics Reviews (2025)*

- Implemented a CNN-based framework to deblur and denoise MMF endoscopic images degraded by spatially varying PSFs, achieving 5-ms reconstruction and up to three orders of magnitude speedup over iterative methods.
- Developed RTMnet, a physics-guided framework integrating the rotational memory effect, Radon transform, and Fourier neural operator for efficient image transmission through MMFs, with strong rotational generalization and reduced computational cost.

Non-invasive imaging of embryonic blood vessels in intact chicken eggs 2023-2024

◦ *Laser speckle contrast imaging (LSCI) of chicken embryos* *Biomedical Optics Express (2024)*

- Built a non-invasive LSCI system for visualizing extra-embryonic blood vessels through intact avian eggs, enabling detection of vessels as small as ~100 μm in diameter.
- Improved temporal resolution for real-time and longitudinal monitoring of blood-flow dynamics and embryonic heart rate through intact eggshells.
- Extended longitudinal vascular imaging to day 5 by developing a time-domain Fourier high-pass filtering method to suppress low-frequency artifacts from eggshell cracks and embryo body movements.
- Implemented a machine-learning framework with feature extraction to classify embryonic developmental stages from LSCI images, achieving 85% accuracy.

◦ *LSCI for drug injection reaction monitoring* *Developmental Biology (2025)*

- Built an automated, incubator-integrated LSCI platform for longitudinal monitoring of embryonic heart rate, blood-flow dynamics, and vascular structures.
- Established its potential as a rapid, quantitative platform for screening cardiovascular drugs and assessing their effects on embryonic heart function.

◦ *Early-stage chicken embryo sex prediction using deep neural networks* *PLoS One (2026)*

- Integrated LSCI with deep learning to investigate early-stage sex differentiation of chicken embryos from extraembryonic vascular patterns.

Refractive-index (RI) tomography of thick 3D specimens 2023-2027

◦ *Analytic Fourier Ptychotomography (AFP)* *Nature Communications (2026)*

- Developed AFP, a fully analytic and non-iterative framework that leverages a 'finite-sample-thickness prior' to transform the 3D inverse scattering problem into analytically solvable linear equations for complex-valued RI reconstruction.
- Introduced an analytic aberration-correction scheme that exploits spectral redundancy across angular illuminations, enabling correction of complex and field-dependent system aberrations without iterative optimization or parameter tuning.
- Derived an analytic darkfield spectrum recovery and extension scheme to synthesize high-spatial-frequency information beyond the objective NA, extending the synthetic NA from 0.41 to 0.99 and achieving two-fold resolution enhancement in both lateral and axial dimensions.
- Built and validated AFP across multiple microscope configurations, illumination sources, and wavelengths, enabling 3D imaging of mouse embryos, visualization of plant root–bacteria interactions, volumetric imaging of mouse brain tissue up to 100 μm thick, and 3D UV pathology of human tissue.

◦ *4D refractive-index tomography for human and mouse embryo imaging* *Manuscript in preparation*

- Developed an intensity diffraction tomography method for robust 3D RI reconstruction under non-NA-matching illumination, integrating beam-propagation optimization and computational aberration correction.
- Built an automated, incubator-compatible dual-channel RI and fluorescence imaging platform with 3D sample tracking for time-lapse, label-free 4D imaging of mammalian development.

- Demonstrated time-lapse imaging of oocyte meiosis and mouse/human preimplantation embryo development, capturing mitosis and embryo cleavage dynamics.

○ *Refractive-index tomography with quasi-isotropic 3D resolution* *Project in progress*

PUBLICATIONS

Patents

1. [Provisional] **Z. Dong**, H. Zhou, R. Cao, C. Yang, "Analytic Fourier ptychotomography for volumetric refractive index imaging." CIT-9298-P (2025).
2. **Z. Dong**, S. Mahler, C. Readhead, C. Yang, "Non-invasive laser speckle imaging of extra-embryonic blood vessels." U.S. Patent Application, US19/056,622 (2025).
3. Q. Yang, Z. Wen, **Z. Dong**, Q. Deng, X. Liu, "A Frequency-Domain Tracking-Based Method and System for Stable Imaging Through Multimode Fibers." Chinese Patent, ZL202210067529.X (2022).
4. Q. Yang, **Z. Dong**, Z. Wen, J. Xu, Y. Ma, L. Wang, X. Liu, "A multidirectional 3D confocal fiber bundle imaging device and method based on dispersive metasurface." Chinese Patent, ZL202110108456.X (2022).

Peer-Reviewed Publications [* indicates equal contribution]

5. S. Mahler*, A. Arora*, C. Readhead*, S. Yin*, S. N. Hari, E. Wang, C. I. Moxley, A. A. Adeboye, **Z. Dong**, H. Zhou, X. Chen, M. Bronner, and C. Yang, "Detection of non-invasive sexing of early chick embryos in intact eggs using laser speckle contrast imaging and deep neural networks," ***PLoS One***, 21 (6), 0323847 (2026).
6. H. Zhou*, S. Zhao*, Y. Fan, **Z. Dong**, O. Zhang, V. Gradinaru, and C. Yang, "Digital defocus aberration interference for automated optical microscopy," ***Nat. Commun***. (2026).
7. **Z. Dong***, H. Zhou*, R. Cao*, O. Zhang, S. Zhao, P. Lyu, R. Alcalde, and C. Yang, "Analytic Fourier ptychotomography for aberration-free and high-resolution volumetric refractive index imaging," ***Nat. Commun***. 17 (1), 727 (2026).
8. N. Liu, L. Wang, Z. He, H. Zhang, **Z. Dong**, D. Li, P. Yan, and Q. Xiao, "Rotational Memory Effect-Inspired Radon Domain Learning Empowers Image Transmission Through Multimode Fibers," ***Laser Photonics Rev***, 19 (24), 00089. (2025).
9. C. Readhead*, S. Mahler*, **Z. Dong**, Y. Sato, C. Yang, and ME. Bronner, "Automated non-invasive laser speckle imaging of the chick heart rate and extraembryonic blood vessels and their response to Nifedipine and Amlodipine drugs," ***Dev. Biol.***, 519, 46-54 (2025).
10. [**Journal Cover, Editor's Pick**] **Z. Dong***, S. Mahler*, C. Readhead, X. Chen, M. Dickson, M. Bronner, and C. Yang, "Non-invasive laser speckle contrast imaging (LSCI) of extra-embryonic blood vessels in intact avian eggs at early developmental stages," ***Biomed. Opt. Express***, 15 (8), 4605-4624 (2024).
11. Z. Wen, **Z. Dong**, Q. Deng, C. Pang, C. Kaminski, X. Xu, H. Yan, L. Wang, S. Liu, J. Tang, W. Chen, X. Liu, and Q. Yang, "Single multimode fibre for in vivo light-field-encoded endoscopic imaging," ***Nat. Photonics***, 17 (8), 679-687 (2023).
12. Q. Deng, Z. Wen, **Z. Dong**, J. Tang, W. Chen, X. Liu, and Q. Yang, "Spatially variant deblur and image enhancement in a single multimode fiber imaged by deep learning," ***Opt. Lett.***, 47 (19), 5040-5043 (2022).
13. [**Journal Cover**] **Z. Dong**, Z. Wen, C. Pang, L. Wang, L. Wu, X. Liu, and Q. Yang, "A modulated sparse random matrix for high-resolution and high-speed 3D compressive imaging through a multimode fiber," ***Sci. Bull.***, 67 (12), 1224-1228 (2022).

Conference Proceedings / Abstracts

1. H. Zhou, S. Zhao, Y. Fan, **Z. Dong**, O. Zhang, V. Gradinaru, and C. Yang, "Digital defocus aberration interference for autofocusing and digital refocusing in microscopy," Proc. SPIE, PC1386504 (2026).

PRESENTATIONS AND TALKS

1. "Analytic Fourier ptychotomography for volumetric refractive index imaging." | SPIE Photonics West, San Francisco, 2026

SKILLS

Professional Skills:

- **Expert** in research fields such as Computational Imaging, Imaging through scattering medium, Wavefront Shaping, Diffraction Tomography, Digital Holography, Optical Fiber Imaging, Inverse Problems, and Super-resolution Imaging.
- **Expert** in Wavefront Shaping techniques, such as Transmission Matrix, Speckle Correlations, Memory Effect.
- **Expert** in Quantitative Phase Imaging techniques, such as Refractive Index Tomography, Fourier Ptychographic Microscopy, and Differential Phase Contrast Microscopy.
- **Skilled** in Optical System Design, Alignment and Optimization of Complex Optical Imaging System, and Optical Simulations.
- **Experienced** in Fluorescence Microscopy, such as Light Sheet Microscopy, Light Field Microscopy, Confocal Microscopy and Structured Illumination Microscopy.
- **Experienced** in Machine Learning and Deep Learning, with applications in image classification, segmentation, generation and physics-guided computational imaging.

Programming & Software:

- Proficient in **Instrument Control**, **Image/Signal Processing** and **Numerical Simulation**
- Experienced in various **Programming Skills** such as MATLAB, Python (PyTorch), C, and LabVIEW.
- Skilled in various **Engineering Software** such as Lumerical FDTD, SOLIDWORKS, Zemax and ImageJ.

PROFESSIONAL SERVICES

Journal Reviewer

- Optica
- Photonics Research
- Optics Letters
- Biomedical Optics Express
- Optics Express
- Applied Optics
- Optical Materials Express
- Journal of the Optical Society of America A
- Journal of the Optical Society of America B
- Optics Continuum
- Chinese Optics Letters
- Advanced Photonics Nexus

Professional Societies

- Optica (formerly known as OSA) | Student Member 2023-Present

TEACHING EXPERIENCE

Teaching Assistant

- Caltech BE/EE/MedE 189a: Design and Construction of Biodevices [Head TA] 2025 Fall
- Caltech BE/EE/MedE 189a: Design and Construction of Biodevices 2024 Spring