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Large Depth-of-Field Microscopic 3D Imaging

Computational framework achieving 10x deeper microscopic 3D imaging without resolution loss.

Researchers at Purdue University have developed a computational framework that can achieve large depth-of-field (DOF) microscopic three-dimensional (3D) imaging. DOF is one of the most important properties for microscopic 3D imaging systems since it determines the measurement range of the system. Typical 3D imaging systems use conventional lenses with a fixed focal length. Despite recent advancements in improving microscopic structured-light (SL) systems, DOF continues to be a major limitation. Proposed solutions have only largely increased system complexity and reduced flexibility. Even the laudable focal sweep technique, which effectively extends the DOF without drastically altering the system configuration, does not widely improve microscopic SL systems as it cannot recover well from high spatial frequencies.

This novel computational framework method developed by Purdue University researchers helps 3D microscopic manufacturers achieve 3D imaging with an unprecedentedly large DOF by leveraging digital fringe projection (DFP) and focus stacking techniques. Moreover, this phase-assisted, global-to-local method enables 3D shape reconstruction without the loss of spatial resolution. With a flexible system setup, the method can be integrated seamlessly into generic microscopic SL systems. Robust to non-rigid deform such as inconsistent lens distortion, this framework will prove to be more favorable for real-world applications.

Technology Validation:

Experimental results demonstrate that the computational framework method can achieve a large DOF of 16 approximately 2 mm and field of view (FOV) of approximately 4 mm Ã—3 mm for a spatial 17 resolution of approximately 2.6 Î¼m. The achieved DOF is approximately 10Ã— the DOF of the system without the proposed method.

Advantages:

Technology ID
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Category
Artificial Intelligence & Machine Learning/3D Optical Imaging & Industrial Metrology

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-Achieves precise, aligned images under different focus settings for high-accuracy, large DOF microscopic 3D imaging

-Fast

-Allows flexible system setup

-Uses phase instead of intensity of the image, which is more robust to brightness variations, defocusing changes and scene texture

Applications:

-Micro 3D printing

-Semiconductor packaging inspection

-Micro-mechatronics

-Telecommunications

-Facial recognition

-Quality control

-Robot navigation

TRL: 3

Intellectual Property:

Provisional-Gov. Funding, 2023-03-05, United States

Utility-Gov. Funding, 2024-03-05, United States

Keywords: microscopic 3D imaging,large depth of field imaging,digital fringe projection,structured light microscopy,semiconductor inspection tools,high precision 3D metrology,micro mechatronics imaging,3D reconstruction systems,telecommunications inspection,optical quality control