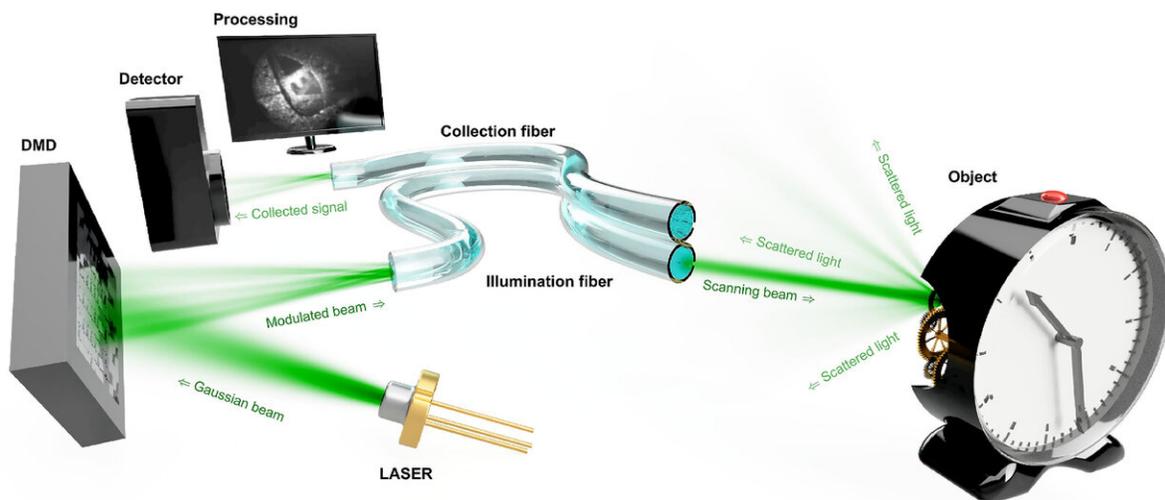


Using holographic endoscopes to observe distant objects

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A sequence of holograms displayed by a digital micromirror device spatially shapes the wavefronts coupled into a multimode optical fiber in such a way that a far-field focus scans the distal field of view. Credit: Tomas Cizmar

Scientists are developing tools to observe the biological machinery in in vivo animal models to be able to understand and better treat severe brain diseases like Alzheimer's disease and many other conditions. Holographic endoscopes attracted researchers' interest because of their

potential to conduct minimally invasive observations inside the human body.

These tools can shed light on the [biological processes](#) occurring at the macromolecular and subcellular levels, which usually remain hidden from sight as most tissue is opaque to visible radiation. In *APL Photonics*, researchers from the Leibniz Institute of Photonic Technology in Germany created a particularly narrow endoscope made of single hair-thin optical fibers that uses holographic methods to reconstruct [images](#) of macroscopic objects placed in front of the far end of the endoscope.

"We were positively surprised that the imaging quality was well-maintained at larger imaging distances, even for objects placed at a half meter from the endoscope," said author Ivo Leite. "We expected that the low number of photons collected in this range would give rise to much higher detection noise."

Efforts in imaging through multimode-fiber endoscopes previously focused on working distances typically smaller than 20 micrometers to resolve micrometer-scale details. This limits the field of view to the size of the fiber core.

The researchers brought the imaging operation to the observation of macroscopic objects, which can be placed far away from the endoscope. Researchers increased the imaging performance in terms of image definition to 100,000 pixels per image frame, an order of magnitude larger than previous holographic endoscopes and reaching the definition of modern video endoscopes.

Their efforts pave the way for bringing this class of minimally invasive endoscopes to clinical applications. The macroscopic imaging modality shown in this study will be essential to analyze biological samples at the tissue scale—just as conventional clinical endoscopes do—as well as to

guide the instrument insertion.

Once a region of interest is identified, the hologram sequence displayed by the [spatial light modulator](#) can be updated to switch the imaging modality and perform observations at the cellular and subcellular levels.

"The potential for such flexibility in imaging operation through the same unmodified endoscope is a unique feature that, we believe, holographic [endoscopes](#) could soon offer," said author Tomas Cizmar.

The researchers' light control methods could be used to deliver practically any type of photonics tool through a hair-thin endoscope, which could have applications in a range of areas, such as optical transfection, subcellular laser surgery, and laser-assisted microfabrication.

More information: "Observing distant objects with a multimode fiber-based holographic endoscope" *APL Photonics*, aip.scitation.org/doi/10.1063/5.0038367

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