3D Light-Field Endoscopy Using a Gradient Index Lens Array (#8283)

The first quantitative 3D endoscope, using light-field acquisition and reconstruction.

Georgia Tech inventors have created the first quantitative 3D endoscope, using light-field acquisition and reconstruction. It is a 3D endoscope using anywhere between 3 to 7 customizable gradient index (GRIN) lenses and fiber channels to capture the image. Furthermore, this endoscope utilizes an algorithm that helps to create a 3D image on the screen. Currently, surgeons use a 2D endoscope that has only one GRIN lens; and if they want a 3D image, surgeons have to use 3D glasses. As a newly discovered imaging scheme, light-field imaging allows for scanning-free, volumetric and scalable acquisition and reconstruction of 3D data. They have established both hardware prototypes and software for the system. The system has been validated both theoretically and experimentally, allowing for imaging and reconstructing a 5mm × 5mm × 10mm volume with a 50-100 ?m lateral resolution and a 100-200 ?m axial resolution. The algorithm allows for volumetric reconstruction, and the eventual goal is to have real-time visualization. Such an algorithmic framework is currently being tested. The inventors claim that the light-field scheme allows the scope to be designed for either adults or kids, as well as for various body parts such as the brain or kidney.

Benefits/Advantages

- **Measurements:** system achieves 'true quantitative' 3D information
- **Imaging and visualization:** system brings a great potential for fast 3D quantitative imaging, visualization, and synthesis of the focal stacks
- **Material**: method is glass-free

Potential Commercial Applications

- Clinical and pediatric endoscopy
- Bronchoscopy
- Colonoscopy
- Laryngoscopy
- Etc.

Background/Context for This Invention

Endoscopes are indispensable tools used for clinical diagnosis or surgical guidance. However, conventional endoscopes in the clinical practice are mostly 2D, and the existing 3D techniques only provide the stereotype of perspective views. A true quantitative 3D endoscope is still lacking in great demand,

especially for surgeries in dense areas such as the brain, blood vessels and tumors, where the physicians need the quantitative 3D information to accurately operate on the pathological parts. Here, the inventors have developed novel 3D endoscopy using light-field imaging strategies.

Dr. Shu Jia
Assistant Professor – Georgia Tech School of Biomedical Engineering

Changliang Guo
Post-Doctorate - Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University

More Information

Publications

[3D light-field endoscopic imaging using a GRIN lens array](#), Applied Physics Letters, March 12, 2020

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/3d-light-field-endoscopy-using-gradient-index-lens-array
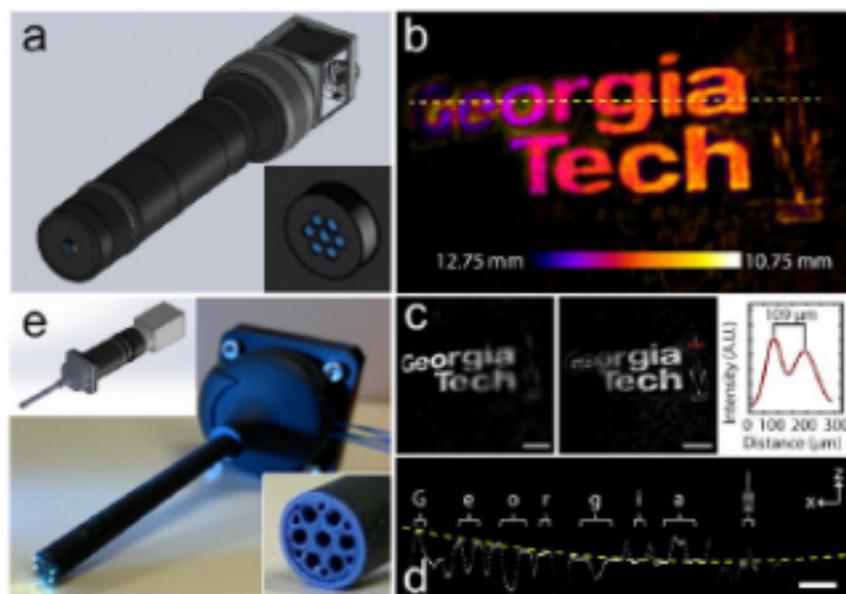
Images:

Figure 1. 3D light-field endoscopy. (a) Sketch of Prototype V1 using a GRIN lens array (blue channels in inset). (b) Depth-colored reconstruction of a 3D Georgia Tech logo. (c) Two synthetic axial stacks at 12.75 mm (left) and 11.40 mm (center), showing different in-focus regions through computation. The red line scan resolves the Tech Tower triangle (right). (d) Cross-sectional image in x-z corresponding to the dashed line in (b). The reconstructed bright logo regions agree well with the actual curved surface (yellow dashed line). The rest of the profile corresponds to the background offsets. (e) Photograph of Prototype V2 using clinically-relevant design parameters and its perspective sketch (upper left inset). Optical fibers for illumination are implemented through the 6 narrower channels surrounding the 7 GRIN lens channels (lower right inset). In both (a) and (e), GRIN lens diameter = 1 mm and array pitch = 1.4 mm. The endoscope diameter in (e) is 5 mm, meeting the 2-6 mm range for most endoscopes. Scale bars: 2 mm (c), 1 mm (d).