Computational 4D imaging for understanding pain-processing neural circuit

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Computational imaging is a technology based on optics and information science. One of the key techniques in computational imaging, light-field imaging, optically encodes 3D space into a 2D image and computationally reconstructs the 3D information from that single 2D image. This enables volumetric imaging in a single camera exposure without the spatial scanning required by confocal or light-sheet microscopy. Here, we present a solution to the limited spatial resolution that has constrained the broader adoption of light-field imaging. Building on this advance, we developed millimeter-wide, scan-free, high-resolution computational optical sectioning light-field microscopy to achieve ultrafast 4D imaging, thereby revealing a circuit-level computational principle of somatosensory manifold emergence in mice. By combining this imaging technology with complementary innovations, we also developed light-field 3D fiber imaging and deep-brain quantum-sensing endomicroscopy using fluorescent nanodiamond. In this presentation, we introduce these technologies and highlight the biological discoveries.