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Scattering-Suppressed 3D optical imaging of internal organs using near-infrared transillumination

Abstract:

Accurate visualization of internal organ structures through optical imaging faces fundamental challenges due to the highly scattering nature of biological tissue. Near-infrared (NIR) light in the 700–1200 nm range can penetrate tissue and enable transillumination-based imaging; however, significant scattering often degrades image quality. To overcome this limitation, we propose an advanced imaging framework that combines theoretical modeling, computational deblurring, and deep learning to recover three-dimensional (3D) anatomical structures from single-shot two-dimensional (2D) transillumination data. We model light propagation in turbid media using diffusion theory to derive a depth-dependent point spread function (PSF). This PSF is used to simulate paired datasets of blurred and sharp images, which in turn serve as training data for a neural network. The proposed network performs three tasks: correcting blurring artifacts, estimating the depth of absorbing features, and reconstructing 3D internal structures from blurred 2D inputs. Both simulation studies and experimental results validate the system's ability to suppress scattering-induced degradation and recover detailed 3D representations. This technique represents a promising advancement in noninvasive imaging, with potential applications in diagnostic medicine, functional monitoring, and deep tissue analysis using safe and accessible NIR light.

Biography

Koichi Shimizu received his M.S. (1976) and Ph.D. (1979) degrees from the University of Washington, Seattle, USA. He served as a Research Associate at the University of Washington from 1974 to 1979. From 1979 to 2016, he held academic positions as Assistant Professor, Associate Professor, and Professor at Hokkaido University, Sapporo, Japan. He is currently Professor Emeritus at Hokkaido University, Invited Research Professor at Waseda University, Japan, and Professor at Xidian University, Xi'an, China. His research has focused on biomedical engineering. He served as an Associate Editor of IEEE Transactions on Information Technology in Biomedicine from 1999 to 2007. He is a Fellow of the Electromagnetics Academy and members of the editorial board of Scientific Reports (Nature Portfolio) and Advanced Imaging