Optical filtering, imaging, and super-resolution imaging through strongly scattering media

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Abstract: The scattering media such as frosted glass or biological tissue and human skin seems only diffusing light, creating random speckles, and deteriorating our visual ability as well as imaging capability. First, we demonstrate that scattering media not only help us to take photos but also do optical filtering at the same time. More interestingly, a single piece of optical diffuser can work as a lens and multiple filters for a single-shot multispectral camera. These can be achieved after simple measurements to characterize the static scattering media. Beside the ground glass optical diffusers, i.e. the static scattering media, that can be pre-characterized, there are various biological tissues which are dynamic optical diffusers and cannot be characterized, creating enormous challenges to realize the object hidden behind even at low resolution. Here, we demonstrated stochastic optical scattering localization imaging (SOSLI) to take super-resolution images through scattering media non-invasively. We simply use a camera (without any lens) to capture multiple speckle patterns created by stochastic emitters in the object. Then, our computational approach with a phase retrieval algorithm, point spreading function (PSF) estimation, deconvolution and localization can sharply retrieve the object hidden behind scattering media. Nanometer scale objects were realized from their speckle patterns through dynamic scattering media. SOSLI resolution shows 8-fold enhancement compared to the diffraction limit. The dynamic media allows to decorrelate 80% between two consecutive speckle imaging shots. Our results present a new and practical approach towards sub-diffraction limited biological imaging with superior clarity.

Bio: Dr. (Steve) Cuong Dang is an Assistant Professor at school of Electrical and Electronic Engineering, Nanyang Technological University (NTU). He received Ph.D. in Physics and M.Sc. in Electrical and Computer Engineering from Brown University, Rhode Island, USA. Dr. Dang's research on nanophotonics and nanomaterials, as well as their applications in sensors, photovoltaics, light-emitting diodes and lasers has been published and highlighted in top international journals including Nature Photonics and Nature Nanotechnology. Dr. Dang's research is extending to manipulating and exploiting scattered light through highly scattering media with direct applications in biomedical imaging, photoacoustic imaging and optogenetics.

Dr. Dang's research and development with QD Vision Inc., Lexington, MA, USA was recognized with the first quantum dot product for solid state lighting: "Quantum Light™ Optic". Then it has been further developed as "Color IQ", the world's first high-volume Quantum Dot product for LCD Televisions. Sony's BRAVIA 4K 65-inch Televisions that use QD Vision's Color IQ were named Best of Show Product at Consumer Electronics Show (CES) 2013 with their colour enhancement.