COMPRESSED SENSING FOR STRUCTURED ILLUMINATION MICROSCOPY

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Several super-resolution microscopy techniques have been shown to surpass Abbe's diffraction limit. Structured illumination microscopy (SIM) is one of the super-resolution techniques. This method enhances lateral resolution by twofold and can reveal a 100-nm super-resolution image [1]. However, SIM requires at least nine raw images to reconstruct the super resolution image. These raw images are the product of an object scene and illumination patterns generated on a spatial light modulator (SLM). An illumination pattern enables us to down-modulate higher frequency components of the scene into the optical transfer function (OTF) of a microscope objective. However, several illumination patterns with different phases are required to extract higher frequency components of the scene and to place them into their original position in the frequency space.

The need for several raw images to reconstruct a single super-resolution image has two important implications. First, fluorescent probes are exposed to illumination light over a long period of time, which causes photobleaching. Second, moving objects cause artifacts in the super-resolution image because of the long acquisition duration. To alleviate these problems, the raw images need to be recorded faster. Compressed sensing (CS) [2,3] can be a candidate for eliminating these problems by reducing the data acquisition time. Optical architectures based on the CS framework usually utilize a photodiode or photomultiplier tube (PMT) which is extremely faster than a camera [4]. In addition, CS can recover the object scene with a small number of measurements. These CS abilities can naturally shorten the acquisition duration. Hence, the scene is exposed to lower excitation light, and the effects of motion artifacts are reduced. In this paper we propose a CS-based approach for SIM and demonstrate its effectiveness with simulations on computer-generated images. Our preliminary results provide a proof-of-principle that encourages us to design an experiment to test our approach on real data.

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