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Title:SPECKLE MECHANISM IN HOLOGRAPHIC OPTICAL COHERENCE IMAGING

This thesis provides the first studies on speckle statistics in holographic optical coherence imaging (OCI). The new speckle statistics consider the combination of holographic speckle and photorefractive effects, and is used to optimize the holographic diffraction efficiency and coherent image contrast for biomedical imaging applications.

Speckle mechanisms are understood systematically in a holographic imaging system that consists of low coherence interferometry, dynamic holography and photorefractivity. The holograms are recorded and reconstructed in a photorefractive multiple quantum well device by using non-degenerate four-wave mixing. The newly developed theory provides a comprehensive description of holographic speckle under small and large signal limits. For both conditions, a unit intensity ratio between the writing beam and probe beam is found to be an optimal value for the diffraction efficiency. In the four-wave mixing configuration, the fringe spacing plays an important role in generating holograms. When the speckle exists, the diffraction efficiency highly depends on the comparison between the fringe spacing and speckle size. Speckle contribution to the holographic images can be decreased by employing a fringe spacing larger than the speckle size. However, this will reduce spatial resolution in the imaging system. With a moving grating technique, speckle noises in holographic OCI are successfully suppressed based on a speckle averaging in the CCD camera.

As a practical example, holographic speckle images through turbid media (milk suspensions and polystyrene bead suspensions) are acquired and analyzed. Speckle generated by the turbid medium degrades the lateral and depth resolutions of the hologram due to distortion of the coherence wavefront. The resolution degradation depends on the mean free path (concentration) of the suspensions. Several methods that are proposed in the theoretical analysis are applied to the holographic OCI. The image quality of the test chart is improved. With the combination of signal optimization and noise suppression, holographic OCI becomes a powerful technique for biomedical tissue imaging. Furthermore, holographic optical imaging using two-wave mixing is explored with acceptable image quality due to higher diffraction efficiency than that of conventional four-wave mixing in the photorefractive materials.