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Optical Fourier and Holographic Techniques for Medical Image Processing with Bacteriorhodopsin

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The biological photochrome bacteriorhodopsin (bR) shows many intrinsic optical and physical properties. The active chromophore in bR is a retinal group which absorbs light and goes through a photocycle. The unique feature of the system is its flexibility – the photocycle can be optically controllable since the process of photoisomerization can go in both directions depending on wavelength, intensity and polarization of the incident light, opening a variety of possibilities for manipulating amplitude, phase, polarization and index of refraction of the incident light. Over the years we studied the basic nonlinear optics and successfully exploited the unique properties for several optical spatial filtering techniques with applications in medical image processing. For nonlinear Fourier filtering, the photo-controlled light modulating characteristics of bR films are exploited. At the Fourier plane, the spatial frequency information carried by a blue probe beam at 442 nm is selectively manipulated in the bR film by changing the position and intensity of a yellow control beam at 568 nm. In transient Fourier holography, photoisomerizative gratings are recorded and reconstructed in bR films. Desired spatial frequencies are obtained by matching the reference beam intensity to that of the particular frequency band in object beam. A novel feature of the technique is the ability to transient display of selected spatial frequencies in the reconstructing process which enables radiologists to study the features of interest in time scale. The results offer useful information to radiologists for early detection of breast cancer. Some of the highlights will be presented.