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3-D surface reconstruction of biological tissues through multiple-polarization interference

Samik Saha[1], Partha Roy Chaudhuri [1]

[1] Indian Institute of Technology, Kharagpur, India.
E-mail: roycp@phy.iitkgp.ernet.in

1. Introduction

3-D imaging of microscopic structures with finer details is now a matured technology enriched by numerous advanced platforms like Phase-Microscopy, Stereoscopy, Holography, Depth-resolved, Angle-resolved, Differential Interference Contrast and many more [1-2]. Today nearly all the advance imaging methods demand very good quality sample preparation. This could be time consuming and may require chemical die causing the natural freshness of the sample to degrade. Keeping this in our mind, we devised a table-top experiment and demonstrated the reconstruction of 3-D surface of biological tissues through interference of high-coherence transmitted polarized lights. The experiment involves differential interference configuration of polarized light with precise alignment and stability in the measurement, which requires only a thin slice of sample on a glass slide; no other sample preparation is required.

2. Theory and experimental set-up

The experimental schematic is given in Fig. 1. We followed two techniques.
In **3-polarisation imaging**, we record three image-projections corresponding to three distinct orientations of the transmitted polarized light (one shown in Fig.2 (a)) yielding the arrayed phase information and hence the structural anisotropy of the sample tissue that is translated into a 3-D anisotropic image using the following relation [3].

$$I_0 = I_1 + I_2 + 2\sqrt{I_1.I_2}\cos\delta \quad \text{-----} \qquad (1)$$

We used a long-hand MATLAB code to handle the amplitude and phase of image matrices in the algebraic calculation and reconstruction of the final image as shown in Fig. 2(b).

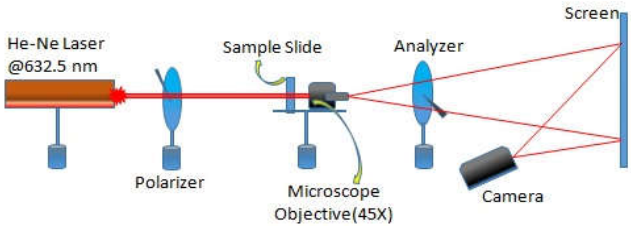

Fig. 1: Schematic of the 3-D imaging set-up

In **10-polarisation imaging**, we record 10 images corresponding to 10 distinct orientations of the transmitted polarized light in a similar manner which drastically improves the image quality due to availability of more image information in the processing algorithm (see Fig. 2.(c)).

3. Results

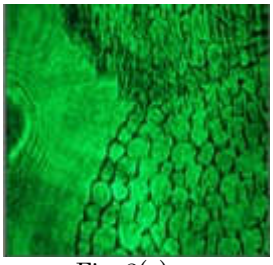

Fig. 2(a)

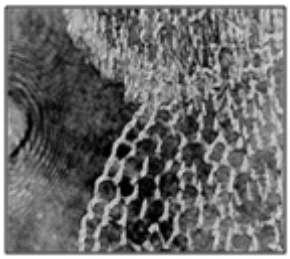

Fig. 2(b)

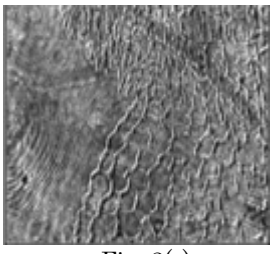

Fig. 2(c)

Fig. 2: (a) Recorded raw image of Phloem cells (b) 3-D image obtained from 3-polarisation set (c) 3-D image obtained from 10-polarisation

4. Conclusion and discussion

3-D quality of the generated image depends on the number of raw images used in the image processing. A set of three images generates one phase matrix. Thus in 3-Polarisation imaging we get one phase matrix and in 10-polarisation imaging we have eight phase matrices (by taking three consecutive images and using the equation (1)). When we add these phase matrices, we get a matrix which basically contains the depth information about the sample. Thus large number of raw images enhance the 3-D quality but it also increase the computation time.

5. References

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reconstruction of Fresnel off-axis holograms. *APPLIED OPTICS.* Vol. 38, No. 34, December 1999.

[2] David J. Stephens, *et al.* Light Microscopy Techniques for Live Cell Imaging. *Science* .300, 82 (2003).

[3] Olivier Morel, et.al. *OPTICS AND SPECTROSCOPY.* June 2006.