Polarization Phase Shifting Analysis on the Pixelated Phase-Mask Dynamic Interferometer

°David-Ignacio Serrano-García and Yukitoshi Otani

Utsunomiya University, Center of Optical Research and Education, Utsunomiya, Tochigi, Japan
serrano_d@opt.utsunomiya-u.ac.jp

Keywords: Interferometry, Polarization, Phase Shifting Technique.

Abstract

The principal property in the Pixelated Phase-Mask (PPM) Interferometers is the capability of retrieve several phase shifted interferograms that will be used to calculate the phase information of the sample in a single capture[1]. As a result, dynamic events can be analyzed successfully[2]. A typical PPM interferometer is mainly composed by two systems: the polarization interferometer and the system in charge of obtaining the replicas of the interferogram (the pixelated phase camera) by adding polarization phase shifting techniques [3]. The purpose of this research is to analyze when the components of the interferometer present non-ideal polarization properties and how they will affect in the measurement, by taking the pixelated camera as a detector.

Basic Principle

Figure 1 shows an implementation of a polarizing Michelson type interferometer that can be used with the pixelated phase camera. The purpose of the first non-polarizing beam splitter is to obtain orthogonal polarizing states in the object and reference beam respectively at the output. Using the Jones matrix approach, an homogeneus elliptical retarder (R) and diattenuator (D) can be represented as [4]:

$$R = \begin{pmatrix} e^{i\varphi/2}cos^2\alpha + e^{-i\varphi/2}sin^2\alpha & (e^{i\varphi/2} - e^{-i\varphi/2})sin\alpha cos\alpha e^{-i\delta} \\ (e^{i\varphi/2} - e^{-i\varphi/2})sin\alpha cos\alpha e^{i\delta} & e^{i\varphi/2}sin^2\alpha + e^{-i\varphi/2}cos^2\alpha \end{pmatrix},$$

$$D = \begin{pmatrix} P_x cos^2\alpha + P_y sin^2\alpha & (P_x - P_y)sin\alpha cos\alpha e^{-i\delta} \\ (P_x - P_y)sin\alpha cos\alpha e^{i\delta} & P_x sin^2\alpha + P_y cos^2\alpha \end{pmatrix}. \quad (1)$$

Where (P_x, P_y) represent diattenuations parameters, (φ) phase retardance and (δ, α) represents ellipticity parameters of the component. The interferograms capted by the pixelated camera can be retrieved as:

$$I_1 = \left|POL_{0°}R_{QWP}(D_T D_T + D_R R_S D_R)\vec{J}_{inc}\right|,$$

$$I_2 = \left|POL_{90°}R_{QWP}(D_T D_T + D_R R_S D_R)\vec{J}_{inc}\right|,$$

$$I_3 = \left|POL_{45°}R_{QWP}(D_T D_T + D_R R_S D_R)\vec{J}_{inc}\right|,$$

$$I_4 = \left|POL_{-45°}R_{QWP}(D_T D_T + D_R R_S D_R)\vec{J}_{inc}\right|. \quad (2)$$

The main purpose of this approach is to modelate the polarizing beam splitter (PBS), the Quarter Wave Plate (QWP) and the Sample as non ideal components by taking into account the passage of the reference-object beams and making the proper assumptions for each component during the passage.

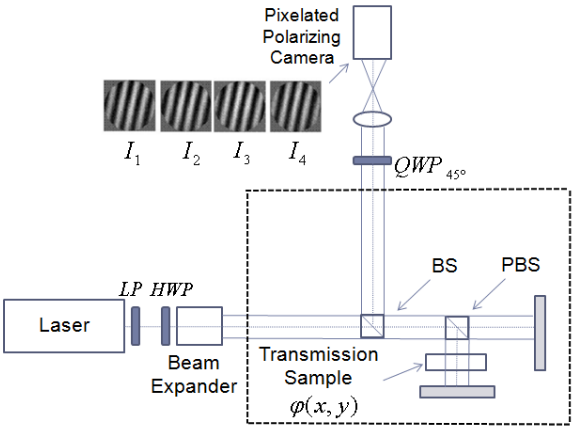

Figure1. Polarizing Michelson type interferometer that can be used with the pixelated phase camera.

Acknowledgments

D-I Serrano-García is currently occupying a post doc position at Utsunomiya University in the Center for Optical Research & Education (CORE) and acknowledge the funding supported provided under The Project for Bio-Imaging and Sensing at Utsunomiya University.

References

[1] W.J. Novak M., Millerd J., Brock N., North-Morris M., Hayes J., Analysis of a micropolarizer array-based simultaneous phase-shifting interferometer., Appl. Opt. 44 (2005) 6861–6868.
[2] K. Creath, G. Goldstein, Dynamic quantitative phase imaging for biological objects using a pixelated phase mask., Biomed. Opt. Express. 3 (2012) 2866–80.
[3] P. Hariharan, M. Roy, Achromatic phase-shifting for two-wavelength phase-stepping interferometry, Opt. Commun. 126 (1996) 220–222.
[4] D.H. Goldstein, Polarized Light, 3rd ed., CRC Press, 2010.