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Particle Image Classification in Digital Holographic Microscopy by Normalized Cross Correlation

Khairul Fikri Tamrin
Department of Mechanical and Manufacturing Engineering
Universiti Malaysia Sarawak
94300 Kota Samarahan, Sarawak, Malaysia
tkfikri@unimas.my

Bahbibi Rahmatullah, Suzani Mohamad Samuri and Siti Tasnim Mahamud
Computing Department
Sultan Idris Education University (UPSI)
35900 Tanjong Malim, Perak, Malaysia

***Abstract*—Digital holographic microscopy is a promising technique for micro-scale fluid and solid measurements. It offers numerical advantage for digital image post-processing through manipulation of amplitude and phase embedded in the digital hologram. Previously, an off-axis digital holographic microscope was utilized to investigate aggregation of artificial platelets in the blood vessel. To mimic blood flow parameters to the minutest details, a cylindrical micro-channel was employed but this introduced astigmatism in the reconstructed particle images. This paper proposes the application of normalized cross correlation in feature matching technique so that astigmatic image can be efficiently classified prior to digital aberration correction. Here, automatic image classification relies on the computed normalized cross correlation coefficients with two dissimilar (astigmatic and focused) reference images. The method successfully classified eight images as astigmatic out of three hundred randomly chosen images. Limitation of the present method is also discussed. The method is foreseen useful for automatic image classification of a considerably large number of images usually acquired in digital holographic microscopy.**

Keywords—image classification; digital holographic microscopy; cross correlation; pattern matching; feature matching

I. INTRODUCTION

Image registration is an indispensable method in fluid and solid measurements, computer vision, medical imaging etc. Of many approaches in image registration, feature matching is recognized as a supervised pattern recognition technique that utilizes some distinctive and detectable features in the reference image as a means to classify unknown samples into one of the known classes on the basis of its pattern. In addition, those features ideally should be unaffected by noise as well as variation in the imaging conditions.

Cross correlation has found numerous applications in engineering fields. For instance, cross correlation is used in particle image velocimetry to determine particle displacement and velocity between several consecutive exposures [1] in complex and turbulent flows [2]. In solid mechanics, two-dimensional digital cross correlation is used to determine crack [3], in-plane displacement and strain [4] of composite materials. In addition, cross correlation is also applicable in feature matching procedures as a similarity measure e.g., face recognition [5] and medical image classification [6].

This paper presents a new application of normalized cross correlation as a feature matching technique for classifying reconstructed particle images recorded using a digital holographic microscope as reported in [7]. The particle images were discovered to fall into two major categories: (a) focused and (b) astigmatic. Astigmatism in some of the identified particle images was found due to the experimental setup. The work discussed in this paper initially employs image cropping as a way to remove unwanted noise [8] and reduce computation load. This is then followed by calculation of normalized cross correlation coefficients with two reference images, whereby each image represents its own class. Unclassified image with higher coefficients is regarded to be in the same class as the reference image. In the following section, the theory of normalized cross correlation is first discussed.

II. METHODOLOGY

A. Theory

The degree of similarity between two images can be determined by cross correlation [9]. Particle image classification by cross correlation relies on the computed cross