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A FLEXIBLE SINGLE IMAGE TECHNIQUE FOR RESOLUTION ENHANCEMENT OF THE FOURIER TRANSFORM FRINGE ANALYSIS METHOD

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ABSTRACT

Fourier Transform Profilometry (FTP) is one of the most popular fringe analysis methods in Optical Metrology for a wealth of applications in Mechanical Engineering, such as shape profilometry or defect detection with shearography or holographic interferometry methods. Gradient range and spatial resolution in the FTP method depend on the size of the filter window in reciprocal space. The authors have previously reported on a method that uses a single crossed fringe pattern for the elimination of the fundamental frequency and enlargement of the carrier window, which is therefore inherently able to cope with dynamic situations. This article describes an improved version of the technique that no longer resources to bit-shifting operations, greatly improving the flexibility of the previously reported technique, whilst retaining its main advantages.

Keywords: three-dimensional measurement, shape measurement, optical metrology, profilometry, fringe projection, structured light.

INTRODUCTION

The Fourier transform method is an elegant and most successful technique for fringe pattern analysis (Takeda, 1982). Apart from its elegancy and effectiveness, this method also stands as one of the very few that requires a single frame for a full field three-dimensional image deployment, which means it can cope with dynamical situations, in opposition to many of the remaining fringe pattern analysis methods that require the object to stay still. The method is simple and effective, but it has serious limitations related to sampling and windowing (Kujawinska and Wojciak, 1991).

A few years back we reported on a method to eliminate the image background intensity known as DC term (Tavares and Vaz, 2006). This term is responsible for a frequency peak in the centre of the spectrum that leaks or spreads into the adjacent orders, thus limiting the amount of frequencies that can be used in the elimination of the carrier frequency. This technique is not exempt from errors that may arise from illumination changes between the two frames acquisition, among other. We have recently been drawn to a simple solution to overcome this issue by using a single image with a crossed orthogonal grating and a simple bit-shifting operation, although the proposed method shown a limitation on the usable grating frequencies that limited its applicability and might hinder the approach (Tavares and Vaz, 2013). The method advanced herein, removes that limitation by resourcing to a minimum kernel gradient approach and dropping the bit-shifting operation altogether.

RESULTS AND CONCLUSIONS

The result from removing the DC intensity is shown in Fig. 1 and the corresponding Fourier Transforms in Fig. 2, along with the window for removal of the carrier frequency resulting from the application of the new algorithm.

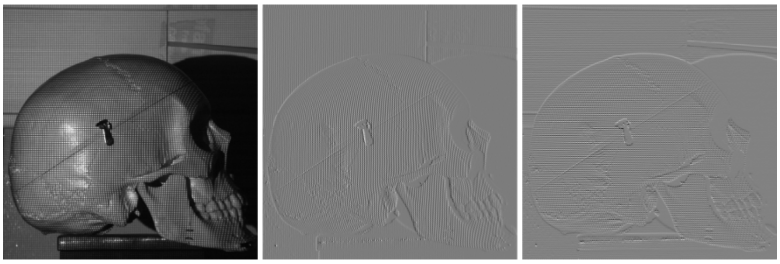

Fig. 1 - Original and gradient images showing the removal of the background intensity

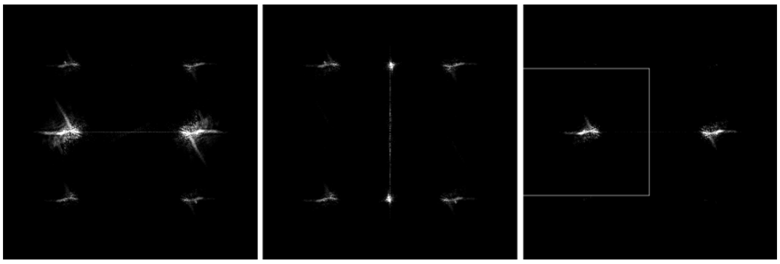

Fig. 2 - Fourier Transforms and the resulting carrier removal window, free of leakage artefacts

This work advances a flexible method for improving the Fourier Fringe Analysis method frequency resolution by using a single image with crossed frequencies and a gradient technique. The final results after back transformation and unwrapping are very promising and the method can be applied to dynamical, moving, subjects without loss of resolution.

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