Directional filters for fringe pattern denoising

Jesús Villa[a], Juan Antonio Quiroga[b] and Ismael de la Rosa[a]

[a] Laboratorio de Procesamiento Digital de Señales, Facultad de Ingeniería Eléctrica, Universidad Autónoma de Zacatecas, Av. Ramón López Velarde #801, C.P. 98000, Zacatecas, México.

[b] Departamento de Óptica, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Ciudad Universitaria S/N, 28040, Madrid, Spain.

ABSTRACT

For a successful phase demodulation it is important to have a good quality fringe pattern image. For this reason preprocessing fringe patterns is, many times, an unavoidable task. Often, noise removal is the main problem to be solved, however, the use of ordinary linear filters is not always a proper procedure specially in the presence of high density fringes because the signal and noise are mixed in the Fourier space. Also, as fringe pattern images are two-dimensional functions, frequencies are two-component vectors which requires consider the filtering direction. We present a new denoising technique for preprocessing fringe pattern images which requires to previously estimate the fringe orientation. For cases of high noise levels we modify the proposed technique by means of a regularized local cost function in order to get a better noise response. We present a noise response analysis of the proposed technique, some experimental results and its application to wrapped phase maps denoising.

Keywords: Fringe orientation, filtering

1. INTRODUCTION

Demodulation of digital fringe patterns is widely used in optical tests such as ESPI techniques, holographic interferometry or moiré interferometry. Experimental conditions in these kind of tests strongly influence the quality of the fringe images, for example affecting the visibility, the illumination, or introducing noise, evermore, noise is an inherent characteristic of ESPI fringes. For this reason in many cases preprocessing fringe patterns is unavoidable for an easier and more accurate phase demodulation. Denoising fringe patterns, however, may not give good results if ordinary linear filters are used. A common problem using ordinary filters, for example convolution filters or filters in the Fourier space, is that in high frequency zones the fringes may be blurred because noise and signal are mixed in the frequency space. A possible solution for this filtering problem may be the use of adaptive filters which locally adapts its wideband according to the signal and/or noise. A convenient manner of filtering fringe patterns is applying Spin filters[1–3] which uses the fringe orientation information in order to select a filtering orientation. Spin filters may be considered one-dimensional filters because they process information along lines in the fringe's tangent direction. The discrete nature of digital fringe pattern images, however, enforces to process information along discrete lines and orientations which introduces structures in the processed fringe pattern. Other drawback of this kind of filters is that they are so sensitive to errors in the orientation estimation which is common in noisy low-density fringe zones.

In this paper we present a new kind of oriental filters which reduces the inconveniences of Spin filters while keeping their advantages with respect to ordinary filters. The proposed filters also requires to previously estimate the fringe orientation but, as will be shown, in many situations the presented filters can considerably reduce errors caused by noise and bad orientation estimations.

This paper is organized in the following way: In section 2 we describe the problem of fringe pattern filtering and we present the proposed filters. In section 3 we realize a noise response comparison of the proposed filtering technique with the Spin filtering. In section 3 we also present experimental results and the application of our technique to wrapped phase maps filtering. Finally, in section 4 we present the conclusions.

Further author information: Jesús Villa can be reached by e-mail at jvillah@uaz.edu.mx

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