Comparative analysis of directional filtering techniques in fringe patterns

N. Escalante*, J. Villa, I. De la Rosa, E. González-Ramirez and M. Araiza

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

ABSTRACT

We present a comparison of some methodologies that exist for directional filtering of fringe patterns. An important task in fringe image processing is the noise filtering. The implementation of linear filters is not always a proper procedure in the presence of high density fringes because the signal and noise are mixed in Fourier space. The objective of this report is to carry out a comparison of existing procedures to determine which of them provides a better image estimation. The techniques considered in this work are: Regularized Filters (RQCF), Oriented spatial filter masks (OSFM), Second-Order Oriented partial differential equations (SOPDE) and Directional filters (DF). To compare these techniques, we analyze their performance for different noise levels, using synthetic fringe images.

Keywords: Filtering, Fringe orientation, fringe pattern, directional filtering

1. INTRODUCTION

Fringe patterns produced by various optical interferometric techniques encode the information of deformation, refractive index, vibration, etc. Noise, as one of the main problems, affects further processing of the fringe patterns and reduces the final measurement quality. Mathematically, images can be represented as two or three dimensional arrays, in which each element represents the intensity. The real image can be modeled by:

$$g = H(x) + n, \tag{1}$$

where H may represent the blurring, x is the exact sharp image, g is the corrupted image and n is additive noise. Then, the problem of reconstructing the true image reduces to solving (1) for x;[1,2] unfortunately, this is not always easy. Choosing the right algorithm that will either do a complete recovery or minimize the existing errors, proves to be one of the big challenges.

Elimination of noise is one of the major works to be done in computer vision and image processing, as noise leads to the error in the image. Presence of noise is manifested by undesirable information, which is not at all related to the image under study, but in turn disturbs the information present in the image. It is translated into values, which are getting added or subtracted to the true gray level values on a gray level pixel. This unwanted information can be introduced because of so many reasons like: acquisition process, acquisition condition, such as illumination level, calibration and positioning or it can be a function of the scene environment.[3]

In many applications linear filtering techniques do not provide satisfactory results. Linear filters have several undesirable limitations or deficiencies in some applications. These include blurring of edges while smoothing noise, a sensitivity to noise while detecting edges, poor smoothing, lose detail, very noise sensitive, outliers exert large influence on output, loss of contours and details of the image as well, the quality of the image is reduced and the consumption level computational complexity in mathematical calculations, among others.[4]

Recently, in fringe pattern analysis some denoising methodologies have been proposed.[5–8] The purpose of this report is to carry out a comparison to determine which of them provides a better image representation. These studied techniques are: Regularized Filters (RQCF), Oriented spatial filter masks (OSFM), Second-order oriented partial differential equations (SOPDE) and Directional filters (DF). These techniques require to

Further author information:
N. Escalante: E-mail: aivineg@uaz.edu.mx

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