Phase Unwrapping using a surface mesh with constraints

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ABSTRACT

Phase unwrapping is an intermediate step for interferogram analysis. A smooth phase associated with an interferogram can be estimated using a curve mesh of functions. Each of these functions can be approximated by a linear combination of basis functions. In some cases constraints are needed to solve the phase unwrapping problem, for example, when estimated values never can be negative. In this work it is proposed a method for phase unwrapping using a set of functions in a mesh which are lineal combinations of Chebyshev polynomials. Results show good performance when applied to noisy and noiseless synthetic images.

Keywords: Phase unwrapping, interferometry, surface fitting.

1. INTRODUCCTION

Interferometric methods are widely used to measure physical magnitudes such as deformation, stress, temperature, etc.[1,2] in a non destructive and non invasive way. These magnitudes modulate a fringes pattern called interferogram which contains the information about the related physical magnitude. Demodulation is necessary to recover the phase data that are related to these magnitudes.

Standard techniques for phase recovery such as Fourier based,[3] phase stepping[4] or regularization[5–7] methods, provide a non-continuous phase wrapped in the interval $(-\pi, \pi]$. This phase needs to be unwrapped as a step to carry out the measurement process of physical magnitudes. It is common to find phase inconsistences or noise that can make the unwrapping process a difficult task. The application of path dependent algorithms[8] improves the unwrapping process but does not always provide reliable results. A robust alternative for many cases is the least-squares approach, described in matrix form by Hunt.[9] Another robust algorithm is that proposed by Ghiglia and Romero[10] to find a solution in the presence of path-integral phase inconsistencies. The above mentioned methods have long processing time and computational complexity that make them inconvenient for many practical applications. When the phase is smooth, the processing time to solve the phase unwrapping problem can be shortened by using a linear combination of basis functions.[11] In this paper we propose a curve mesh to estimate the unwrapped phase where each mesh curve is a linear combination of Chebyshev polynomials. The unknown weights in the linear combination are described in a typical matrix form allowing the matrix inversion using direct method.[12]

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Interferometry XVII: Techniques and Analysis, edited by Katherine Creath, Jan Burke, Joanna Schmit,
Proc. of SPIE Vol. 9203, 920313 · © 2014 SPIE · CCC code: 0277-786X/14/$18
doi: 10.1117/12.2063415