Phase unwrapping fitting local planes to phase gradient

E. Gonzalez-Ramirez[a], E. de la Rosa Miranda[a], L. R. Berriel-Valdos[b], Tonatiuh Saucedo Anaya[c], Ismael de la Rosa Vargas [a], and Ma Auxiliadora Araiza Esquivel[a]

[a]Unidad Académica de Ingeniería Eléctrica, Universidad Autónoma de Zacatecas, Antiguo Camino a la Bufa No. 1, Col. Centro. C. P. 98000, Zacatecas, Zac. México

[b]Departamento de Óptica, Instituto Nacional de Astrofísica, Óptica y Electrónica, Luis Enrique Erro No. 1, Santa María Tonantzintla, San Andrés Cholula, C.P. 72840, Puebla, México

[c]Unidad Académica de Física,Universidad Autónoma de Zacatecas, Antiguo Camino a la Bufa No. 1, Col. Centro. C. P. 98000, Zacatecas, Zac. México

ABSTRACT

Phase unwrapping is an intermediate step for interferometry analysis. When phase is smooth, its unwrapping can be carried out fitting local planes with finite extension at each point of the phase gradient. We propose a method easy to implement that spends the same computation time than those techniques based on basis functions.

Keywords: Phase unwrapping, interferometry, curve fitting.

1. INTRODUCTION

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 methods are based on the fact that some physical magnitudes modulate a fringes pattern called interferogram. This interferogram needs to be demodulated to recover the phase data that are related to the magnitudes used in the modulation process.

Many techniques for phase recovery such as Fourier based,[3] phase stepping[4] or regularization,[5–7] provide a non-continuous phase wrapped in the interval $(-\pi, \pi]$. This phase needs to be unwrapped as a step to carry out the measure 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 proper results. A robust alternative for many cases is the least-squares solution which is described in matrix form by Hunt.[9] Other robust algorithm to find a solution in the presence of path-integral phase inconsistencies using the cosine transform is that proposed by Ghiglia and Romero.[10] The methods above mentioned present long processing time and computational complexity that make them inconvenient for some applications. When the phase is smooth, the time of processing can be shortened by solving the phase unwrapping problem using a linear combination of local basis functions.[11] In this work we propose a phase unwrapping algorithm which uses local planes to approximate the wrapped phase.

In this paper we give, in section 2, the fundamentals of the phase unwrapping problem. We describe, in section 3, our proposed phase unwrapping technique. Numerical and real experiments are presented in section 4 and finally, in section 5, we summarize some conclusions.

Interferometry XVI: Techniques and Analysis, edited by Joanna Schmit, Katherine Creath, Catherine E. Towers, Jan Burke, Proc. of SPIE Vol. 8493, 84930Q · © 2012 SPIE · CCC code: 0277-786/12/$18 · doi: 10.1117/12.928891