New software for CENAM's Gauge Block Interferometer

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Extended Abstract: (Submission for workshop Software)

A new software for CENAM´s TESA Gauge Block (GB) interferometer has been designed. This software allows user not only to measure semi-automatically up to 13 GB blocks wrung in the same platen, but also to measure each GB manually.
This software uses a novel method to compute GB phase from digital interferogram. The phase calculation is one of the most important steps in the calibration process. This new algorithm [1],[2] is based in the Bayesian regularization approach which is a well-accepted theoretical framework for this kind of inverse problems.

The interferograms obtained follow equation (1). The task is to compute the phase ϕ map for each pixel $r=[x,y]^T$ in the digital image. In equation (1), a is the illumination background, and b is the contrast

$$g_r = a_r + b_r \cos\left(\omega^t r + \phi_r\right) \tag{1}$$

Particularly, the second order edge preserving potentials are used with an explicit line named PARC-EL [3], illumination and contrast characteristics are needed for recovering phase when the carrier frequencies cannot be estimated with a high precision. Given that the error in the estimation of the frequency carrier produce a tilt in the computed phase it is not possible to discriminate the GB from the platen. In order to solve the appropriate discrimination the functional that is proposed to be to be minimized is:

$$U(a,b,\phi,f) = \sum_{r\in L}\left(a_r + b_r \cos\left(\varpi_{0x} r + \varpi_{0y} r + f_r\right) - g_r\right)^2 + \lambda \sum_{\langle q,r,s\rangle \in L}\left(\Delta^2 f_r - \xi\right)^2 + \gamma \sum_{\langle q,r,s\rangle \in L}\left(\Delta^2 a_r - \xi\right)^2 + \sigma \sum_{\langle q,r,s\rangle \in L}\left(\Delta^2 b_r - \xi\right)^2 + \mu \sum_{r\in L} \Psi(\xi) \tag{2}$$

Where ξ represents the adaptive rest condition (ARC) and the last term accomplish a penalization of an over determination of edges. The first term (data term) in functional (2), penalizes the inconsistencies of the computed fields with respect to the observed fringe pattern. In functional (2) there appears also a regularization term that constrains the solution to be piecewise smooth.
Given that functional (2) is highly non-linear (because of the cosine function and the ARC potentials), it is necessary to provide in its numerical solution a good initial guess for the phase. To accomplish this, it is used the solution computed with the spatial version of the phase stepping Carre method [4].
For solving the functional (2) we need to compute quadratic minimizations by dividing the complete functional into several systems. Such minimizing process can be achieved with standard fast minimization algorithms such a Gauss-Seidel scheme or conjugate gradient [5].

The software was implemented in C language programming using LabWindows/CVI compiler from National Instruments. Original software was based on a DOS platform. In order to implement the new one was necessary to change some communication hardware like: the computer, the frame grabber and the GPIB card

With the new algorithm described above, we have improved the repetibility of the instrument by 30% related to the original one. One disadvantage of this new software is that it takes more computing time since the new algorithm needs 15 seconds more per each measurement.

The software has implemented both, original and new, phase recovery algorithms. Also, a final calibration report can be obtained directly from the new software decreasing possible human errors and increasing efficiency. Last task is very important, because CENAM is only laboratory that can offer GB calibration by interferometry in Mexico.

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