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Stereo-measurements on optimal patterns based on Spectral Analysis

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Introduction. The measurement of displacement and strain maps is usually performed using pattern tracking techniques, the most common being Digital Image Correlation (DIC). In such techniques, the quality of the measurement is closely tied to the texture present on the sample surface. It can easily be demonstrated that the optimum pattern is the one that maximizes the grey level gradient in the images, which leads to a periodic checkerboard pattern on the sample surface (cf. Fig. 1).



Fig. 1 – Example of a checkerboard pattern (square size of 100 [μm])

While DIC is not well suited to analyse periodic patterns, Localized Spectrum Analysis (LSA) takes profit of the periodicity to minimize the optical residual in the frequency domain⁽¹⁾. Thanks to this checkerboard pattern, LSA offers high metrological performance and enables having controlled and reproducible patterns on the tested specimens. Although this technique was successfully used in 2D in different applications, no extension to 3D has been proposed. In this talk, the extension of 2D-LSA to stereo-LSA will be presented.

Methods. Conducting stereo measurements involves two more steps than standard in-plane measurements. The optical system needs first to be calibrated, in order to be able to reconstruct the observed surface in 3D⁽²⁾. Then, the matching between the images obtained from the different cameras must be performed. Even when considering a flawless optical system, the different observation angle of each camera makes it difficult to obtain a good matching between the images using LSA. This is due to the large displacements (especially large rotations) between the two images, which lead to have very different wave-carriers in each camera. A specific procedure was then developed to deal with images having different wave-carriers. The observed surface can finally be reconstructed in 3D using the calibration parameters and the pixelwise matching of the images obtained from the different cameras.

Application and results. An experiment was setup to observe the out-of-plane displacement induced by the phase transformation of a shape memory alloy. The specimen is a Cu-Al-Ni single crystal which exhibits a martensite-austenite transformation in the temperature range [-20, +41] °C. Heating and cooling was obtained by setting the sample on a Peltier cell. Fig. 2 (a) shows the in-plane shear strain obtained by LSA. The out-of-plane displacement is given in Fig. 2 (c). It can be seen that significant out-of-plane displacement is obtained where the martensite wedges are visible.

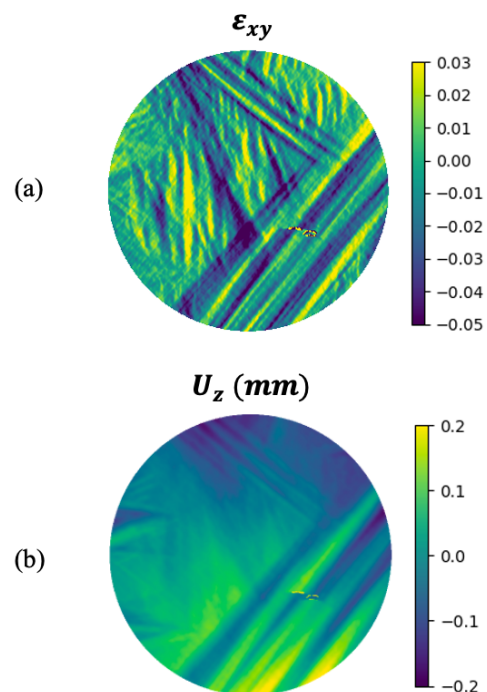


Fig. 2 – (a) In-plane shear strain and (b) out-of-plane displacement obtained on the sample by stereo-LSA.

Conclusion. An extension to standard 2D-LSA has been proposed to perform stereo measurements. Thanks to the optimal pattern deposited on the sample surface very high metrological performance can be obtained. More details about the method and its accuracy will be presented during the talk.

References.

- (1) Grédiac, M., et al., *Exp. Mech.*, **59**, (2019), 207-218.
- (2) Sutton, M. A., et al., *Image Correlation for Shape, Motion and Deformation Measurements*, (2009), Springer US.