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IMAGE-BASED MODELLING OF IRREGULAR MASONRY

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ABSTRACT

The study of irregular masonry, typical of historical structures, has received great interest in the last decades, related to the need to improve the reliability of existing masonry structures.

Masonry is an heterogeneous material composed of two phases: blocks (bricks or stones) in a matrix of mortar. In literature, two different approaches have been proposed to study mechanical behaviour of masonry: discrete models and continuous models. Within the former methods there are the homogenization techniques which allow one to define a homogeneous body to study the linear and non-linear behaviour of masonry.

The knowledge of the distribution of the different phases, which is important in order to study the mechanical response of heterogeneous materials, is difficult to define for non-periodic masonry. Image processing techniques enable the creation of accurate 2D material description which therefore can be employed to implement computational models with faithful representation of material morphology.

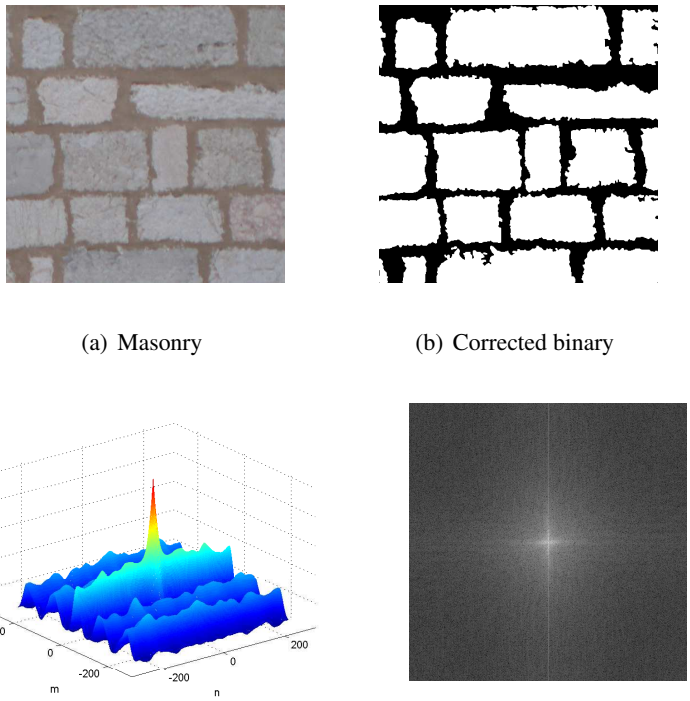
Here a procedure to analyses and identify the distribution of phases for 2D irregular masonry textures is presented. Moreover the coupling of homogenization and image-based modelling techniques are highlighted.

Starting from a colour digital image of a masonry wall, the method applies segmentation techniques to give a binary image where the stones are represented by regions on the background representing the mortar. To achieve this result, the original image, Fig. 1(a), is firstly converted into the grey-level version and then improved with image pre-processing techniques [1], after which histogram thresholding is employed to segment the image and produce the binary representation, Fig. 1(b), where white regions are stones and mortar is the black background. The global threshold is obtained using Otsu's method [2] which computes a grey level that maximises the between-class variance. The result of thresholding is improved with morphological operations to correct errors due to the imperfection in the acquisition method (such as shadows due to incorrect lighting) or to the intrinsic characteristics of the masonry (such as stones with slightly different colours).

In order to understand and describe the irregularity of masonry, the two-point correlation function and the spectrum of the binary image are evaluated [3]: the results are reported in Fig. 1(c) and Fig. 1(d). These functions allow the study of the periodicity of masonry [4, 5] in space and frequency domain. This

analysis has been applied to different masonry textures (from periodic to irregular ones) and allowed to characterise the parameters for their classification.

Eventually, a finite element model is implemented based on the resulting binary image. In order to reduce the overall number of finite elements used, the binary image is processed to associate a cluster of pixel to a single finite element. Then, both essential and natural boundary conditions are applied to the masonry in order to obtain the apparent stiffness matrix of the heterogeneous material [6]. The influence of different typologies of pixel clustering on the resulting apparent mechanical characteristics is also evaluated.



(a) Masonry (b) Corrected binary

(c) Correlation function (d) Fourier spectrum

Figure 1: Result of the digital image processing of masonry

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