Digital Image Processing: application to automatic classification of tile panel pathology

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SUMMARY: Digital image processing (DIP) is a technique to extract information from images with application on several areas of engineering and architecture [1; 2; 5], which can be used as a tool to map pathologies on tile panels. This paper presents the processing tasks that must be performed on a tile panel image, to perform corrections on the image, to delineate the pathologies and to classify it´s typology, in order to produce the graphical registration of anomalies or monitor multitemporal changes. Several types of anomalies could be identified like, tile rotation, glaze lack, glaze pores, craquelé, open joints, repaired joints, etc. [3; 4; 5]. The images for these applications are digital photographs and the acquisition must follow some specifications to obtain accurate results.

Depending of the characteristics of the tile panels (like repetitive patterned or historical) different strategies must be implemented for automatic pattern delineation and classification. Object oriented image analysis (OBIA) methodologies and a picture element (pixel) based system, named GeMAPA, developed at LNEC' LabImagem, are presented.

These studies are developed at LNEC´s Digital Image Processing Laboratory (LabImagem) under project «Numerical Images: applications to Engineering» of LNEC's Research and Innovation Plan 2012-2020.

KEY-WORDS: Cultural Heritage, Image processing, OBIA.

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INTRODUCTION

The paper presents Digital Image Processing (DIP) techniques to map anomalies on tile panels for diagnoses and conservation. The images for these applications are digital photographs and the acquisition must follow some specifications to obtain accurate results.

The information extraction could be done with open source DIP software, proprietary software, for specific pattern recognition needs, or software produced on demand. LNEC has resources and experience on those different approaches and developed a software package based on MATLAB® to provide a tool for non-DIP experts to process images of tile panels, façades, etc... Depending of the characteristics of the tile panels, like repetitive patterned or historical, different strategies must be implemented for automatic pattern delineation and classification. Several types of anomalies could be identified like, tile rotation, lack of glaze, glaze pores, craquelé, open joints, repaired joints, etc. [3; 4; 5].

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DIGITAL IMAGE PROCESSING TECHNIQUES

The images could be acquired, with photographic cameras, on the visible band of the electromagnetic spectrum or on other bands like infrared (IRed), thermal, etc. The images acquired on the visible are decomposed on three colors, red (R), green (G) and blue (B), each of one being saved on three different files which can be processed independently as grey scale images or composed on a color image.

Preprocessing

Before information extraction some preprocessing operations must be performed to eliminate errors from different sources. Those operations can be: geometric processing to eliminate geometric deformation of the image acquisition process (figure 1) or to co-register images from different epochs to allow superposition and change detection; radiometric processing to correct illumination problems that could mask anomalies; calculation of indexes from arithmetic operations (or others) between the R, G, B, IRed or other components [3; 5]. Figure 2 presents the blue (a) and red (b) components of the image of a figurative tile panel and the Lack of Glaze index (LGI) [3], proposed by the authors, calculated with formula 1.

$$LGI = log\,(DN_{blue}\text{-}DN_{red}+C) \qquad (1)$$

where DN_{blue} and DN_{red} (digital number) are the intensity level of the blue and red components for each pixel. The lack of glaze is represented by the black elements on figure 2 image (c).

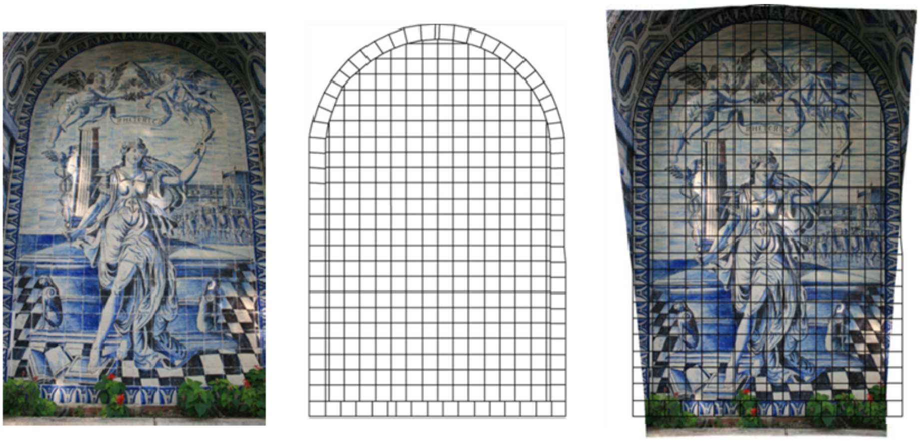


Figure 1 – Geometric registration of a panel with the tile grid to eliminate

a) blue

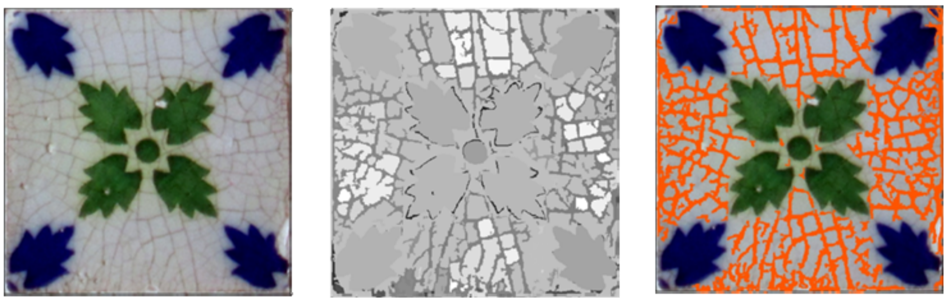
b) red

c) LGI

Figure 2 – a) blue image; b) red image; c) Lack of Glaze Index

Object oriented image analysis

Object oriented image analysis (OBIA) is a DIP methodology well suited for these applications because it is based on image subdivision (segmentation) on zones (objects), based on homogeneity of object properties, and posterior classification of the objects that correspond to pathologies [3; 4; 5]. The software used at LNEC's LabImagem is Definiens® Developer. After an initial random choice of pixels, neighbor pixels are agglutinated producing objects, and its frontier is automatic delineated. After image initial segmentation (on objects), new images are produced, exploring different object properties like form, texture, neighbor objects relations, etc., to be used on the classification phase. Synthetic images like Density, Homogeneity (figure 3), Contrast between object, were used to classify pathologies like Craquelé on figure 3.



Original Homogeneity Craquelé

Figure 3 – Original image and Homogeneity image used on Craquelé classification

A final map is produced with the compilation of all the anomalies classified with different OBIA approaches (figure 4).

Figure 4 – Pathologies map produced with OBIA

Pixel oriented image analysis

Less robust but more suitable to be used by non-experts on DIP, a system for pathologies classification of individual picture elements (pixels) was developed at LabImagem to be used on a personal computer, even in field work if necessary. The system, named GEMAPA – correção GEométrica e Mapeamento de Anomalias em fotografias de Painéis de Azulejos (Geometrical Correction and Anomaly Mapping in Photographs of Glaze Panels) was developed on MATLAB® and has a friendly interface.

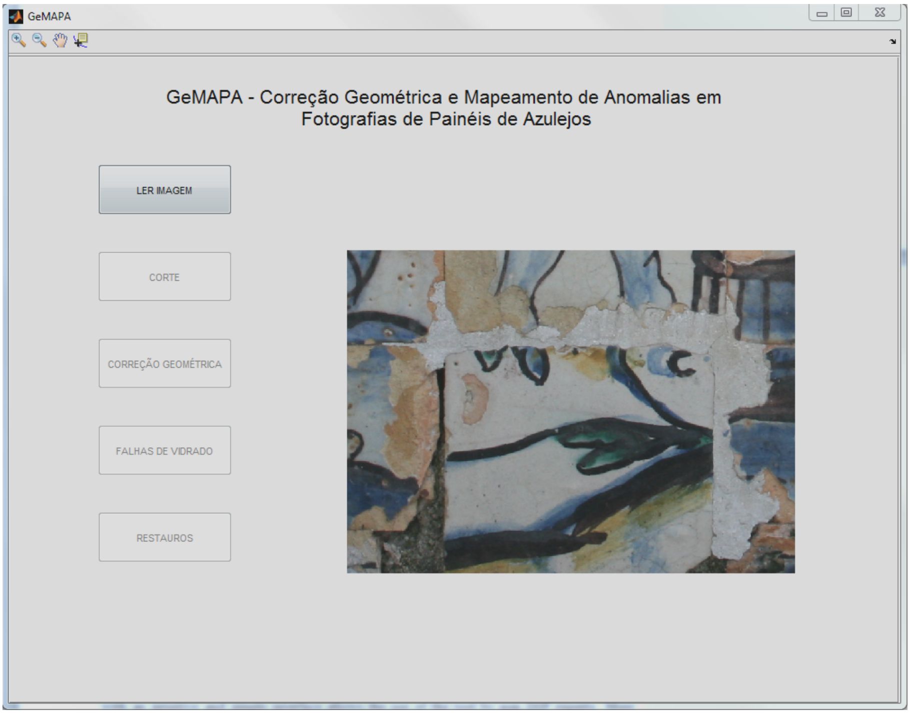


Figure 5 – GeMAPA Interface

The software requires the user to input a photograph of the glaze panel together with the distance between the camera and the panel, the size of the tile and camera properties. The software has a processing option for geometric correction of the photograph. In case the joints present high contrast to the tiles, this procedure can be performed fully automatically. However, in other cases, the user must manually identify a few joint intersections that will be assigned to a regular grid, allowing the image correction. For anomaly identification, two options are implemented witch allow mapping glaze lacunae and restored areas. The operator can immediately see the result of the transformation applied, zoom the image and check the DN values displayed (figure 6). After processing, if the result is satisfactory, the resulting image can be saved to a file. All results produced in GEMAPA are recognized by the open-source GIS software QuantumGIS, where spatial analysis operations such as determining the area of a tile affected by a certain anomaly or identifying which anomalies are present in a certain tile can be performed.

(a) (b)

Figure 6 – GEMAPA results: (a) Photograph of the panel and (b) anomaly map with the glaze lacunae represented in white

CONCLUSIONS

DIP tools are useful to implement an objective methodology for rapid and accurate pathology delineation and classification. The GEMAPA MATLAB® system, developed with an intuitive and simple interface, allows the use of the tool by non-DIP experts. More sophisticated analysis could be performed by DIP experts with the OBIA tools for segmentation and classification. The final pathology map could be exported to QuantumGIS to fill a pathology data base for the tile panel under study.

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