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Image Processing for Cultural Heritage

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With the advent of affordable imaging devices and efficient processing algorithms, the use of images as the main investigation tools has become very popular even outside scientific communities. Cultural heritage is no exception to this developing phenomenon. In particular, the number of images acquired in cultural institutions and used in cultural heritage projects has recently soared thanks to the development of novel imaging techniques and powerful processing methods. This enormous image exploitation has now introduced a feedback loop by uncovering new problems waiting to be solved by our community. Designing practical algorithmic solutions will potentially have a tremendous impact on cultural heritage applications, which include all levels of image-related science, from data acquisition, processing, analysis and understanding to data visualization. This Special Section on Image Processing for Cultural Heritage focuses on the emerging field. The guest editors have gathered interesting papers tackling important cultural heritage problems by developing image-processing techniques. These problems span the entire field from the introduction of novel imaging modalities to image retrieval and from three-dimensional (3-D) reconstruction to automatic labelling. In that sense, the special section represents a good overview of the wide diversity of problems in cultural heritage applications on which SPIE researchers could help improve the current state of the art.

The goal of this special section is to give a brief overview of recent image-processing advances in the context of cultural heritage. Twenty-six papers have been selected and could be divided into four categories according to application or context. Some of them are briefly described below.

The first category focuses on archaeological context. In “Convolutional neural network for pottery retrieval,” Benhabiles and Tabia exploit convolutional neural network (CNN) to classify 3-D pottery. The authors propose to extract two-dimensional (2-D) images from different point of views of a given 3-D mesh. These images are then used as inputs to a CNN model to achieve local features, which are then aggregated using a BoW. A 3-D pottery dataset composed of 1012 samples has been used to evaluate the proposed method. In “Reconstruction of measurable three-dimensional point cloud model based on large scene archaeological excavation sites,” Zhang, Zhang, and Zhang focus on 3-D reconstruction of excavation based on photogrammetry and computer vision algorithms. The objective was to propose a low-cost method with accuracy at least equivalent to the existing methods. The acrobatic figurines in the Qin Shi Huang mausoleum excavation have been used to evaluate the proposed method.

Among the selected papers, some are concerned with image analysis. In “Using automatic generation of Labanotation to protect folk dance,” Wang et al. present a motion-based method to automatically generate Labanotation. After some specific treatments, each movement is analyzed and the corresponding notation is selected. The proposed method has been evaluated and validated by an expert. In “Hyperspectral imaging as new technique for investigating the effect of consolidating materials on wood,” Bonifazi et al. present a comprehensive study of imaging techniques used for identifying wood finishes. The authors applied several finishes (epoxy resin, acrylic resin, linseed oil, etc.) to a set of wood samples that were then artificially aged. Using hyperspectral measurements, the paper first presents an analysis of the effect of the different finishes on the reflectance before and after aging. Then, a classification method able to distinguish between the finishes using hyperspectral data is described.

Retrieval is an important stage in cultural heritage that permits exploitation of the existing data for several objectives (exposition, documentation, etc.). In “Combination of image descriptors for the exploration of cultural photographic collections,” Bhownik et al. discuss the retrieval problem for cultural photographic collections. The goal of this study is to help people to find information from a query image and also to facilitate their exhibition. The authors were especially interested to find the best features combination for this specific content. For that, three public datasets with various scene types, including Paris and Oxford landmarks, have been presented and used to evaluate the method. In “New public dataset for spotting patterns in medieval document images,” En et al. propose a new public dataset composed of 1500 images for spotting patterns in historical document images. They also provide a baseline system and its experimentation results on the dataset, serving as a baseline for future evaluation and showcasing the intended use of the new dataset.

Reconstruction and visualization of data in the cultural heritage field are also essential in many applications. Voulodimos et al. present in “Four-dimensional reconstruction of cultural heritage sites based on photogrammetry and clustering” a complete system for the efficient 4-D modeling and presentation of cultural heritage sites. Two approaches were developed with complementary benefits: content-based filtering and photogrammetry precision. Moreover, the concept of change history maps was proposed to address the computational limitations involved in 4-D modeling, i.e., capturing 3-D models of a cultural heritage landmark or site at different time instances. The described methods have been successfully applied and evaluated in challenging real world scenarios, including the 4-D reconstruction of the historic market square of the German city of Calw. In “Three-dimensional reconstruction of Roman coins from photometric image sets,” MacDonald, Almeida, and Hess propose a method that aims to increase the spatial resolution of 3-D representation of coins by combining fine photometric detail derived from a set of photographic images. This study demonstrated that photometric image data can be combined successfully with laser scanner data to produce a digital elevation model that has the best characteristics of both: the geometric accuracy of the laser scanner with the fine detail and realistic color of the imagery from the camera.

Finally, we would like to thank all of the authors who have participated in this special section, as well as the reviewers for their contributions and time. We also want to thank the editorial staff for its support and advice. We hope that this special section will contribute to the development of this field.