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Original article

Figure spotting in Indian heritage image

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ABSTRACT

Figure spotting is one of the important applications in the field of content-based image retrieval. With the recent advances in 3D shape analysis, Wave Kernel Signature (WKS), a kernel-based feature descriptor under the foundation of quantum mechanics performs well than the other kernel based feature descriptors. In this paper, we adopt the WKS as a 2D local patch descriptor for figure spotting. An effective search technique is developed to spot the regions of interest within an image for a given query image. We also use the classical feature descriptors such as scale-invariant feature transform (SIFT), speeded up robust features (SURF), and the histogram of oriented gradients (HOG) for figure spotting and compare their performances. The proposed technique is tested on a dataset which contains 594 images collected from two heritage temples. The performance of the proposed technique is measured using standard evaluation metrics and shows promising results of the proposed method.

1. Introduction

In any heritage site, a huge number of Cultural artifacts are found which have historical and artistic values. These artifacts reveal the details of socio-economic condition, cultural, religious activities of the people, political and administrative set up of the various rulers and dynasties of a bygone era.

The “Jorbangla” temple and the “Madan Mohan” temple of Bishnupur in West Bengal (India) are such kind of heritage sites. The “Jorbangla” temple was built by Malla king Raghunatha Singha in 1655 AD and The Malla king Durjan Singha built the “Madan Mohan” temple in 1694 AD. These temples are made of laterite stone and the finest example of the classical temple architecture of Bengal. The “Jorbangla” is in the form of a pair of hut shaped structures with sloping roofs (called as ‘Bengalchala’) joined together and surmounted by a ‘sikhara’ or tower on the top and the “Madan Mohan” is with a single ‘sikhara’ on a curved ‘Bengalchala’ roof (see Fig. 1).

The exterior and the interior walls and ceilings of both the temples depict exquisite and elaborate terracotta ornamentations. These terracotta panels narrate the scene from the epics such as “Ramayana”, Krishnalila, hunting or fighting scenes, and various other depictions of contemporary social life. So detecting or spotting a character or a pose in the form of a sub-image in an image or in a collection of images help to extract semantics and description of such illustrative panels.

The digital preservation of these artifacts is very important as these are deteriorating day by day. Art of terracotta is a kind of tangible architectural heritage resource. The tangible heritage resources can be digitized in the form of 2D modeling [1] and 3D modeling technique [2,3].

The collection of such digital heritage resources requires fast, effective tools for search and retrieval of relevant items. This needs for development of algorithms for searching and retrieval of digital heritage resources. In general, the text-based descriptions are used to annotate content media manually for searching purpose. In traditional search method, content media was manually annotated using text-based descriptions of the contents of each item. The retrieval is done using keywords. The text-based approaches are time-consuming may not capture the keywords desired to describe the image. The limitations of the aforesaid approach has motivated the researchers to find the alternatives and one of the alternatives is content-based image retrieval. In case of content-based image retrieval, features like color, texture, shape etc. are used to describe an image.

In case of our problem, the query image is part of an image stored in the dataset and it may occur in more than one image and more than one place in the target image(s). Hence, both the aforesaid approaches are not applicable for the problem under consideration and motivate us to design figure spotting tool for locating a particular artifact within a dataset. In the proposed scheme, both the query image and the dataset images are represented using local

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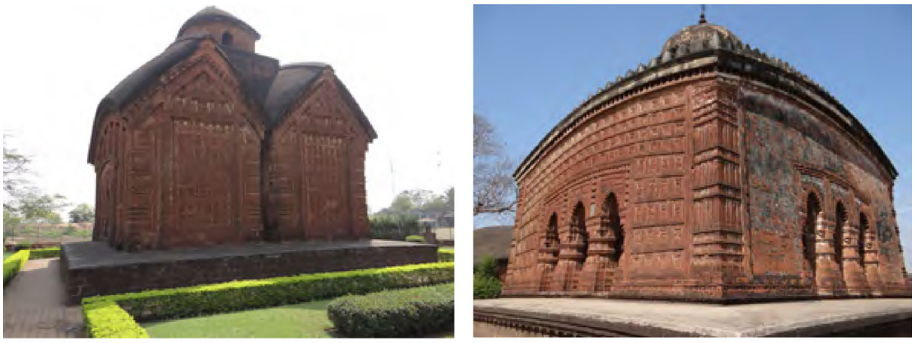

Fig. 1. A snapshot view of two temples.

descriptors. The query image is compared based on one or on a combination of these descriptors.

The aim of this paper is to spot an item where a query image is provided for searching the similar type objects from the terracotta panel image. To the best of our knowledge, this kind of application yet not reported. The method of image spotting proposed in this paper is a simple one. From the query image and as well as from the panel image the features are extracted under the framework of quantum mechanics. We also use other the state of the art descriptors such as (SIFT) descriptor [4], (SURF) [5] and (HOG) descriptor [6] for figure spotting. Finally, we compare the performance of the spotting scheme using different descriptors.

1.1. Related work

The cultural heritage resources can be broadly classified into two categories, namely, tangible and intangible heritage resources [7]. Buildings, historic places, monuments, and artifacts belong to tangible heritage resources that are considered notable of preservation for the future. On the other hand Performing arts, social practices, rituals, festive events, knowledge and practices that inherit from our ancestors fall into intangible heritage resources.

From a decade, various researchers have developed various techniques for preserving these intangible and tangible heritage resources for their purposeful applications. Such kind of intangible heritage preservation applications are presented in [8–11].

Bacci et al. [12] provide the historical and archaeological analysis of Basilica of Bethlehem. The archaeological analysis shows that without altering the basic weight bearing structure how the major changes in the structure in its entirety. In [13], a method has proposed for automatic reconstruction of 3D archaeological relief objects from line drawings. The construction of relief objects consists of two steps: base estimation and relief construction. For base estimation in a particular drawing, models having similar outline is searched within a database. The most similar model is deformed to get the best match drawing. The deformation is done by solving the linear optimization problem. Now the outline of the 3D model that is most similar to the given drawing is chosen for relief construction. Aletras et al. [14] proposed a technique to find out the similar items in the digital library. They have used a combination of a corpus and knowledge-based approaches for similarity measure.

A monument recognition method is reported in [15]. This technique used kNN classification and landmark recognition techniques to recognize monument in an image.

A Naïve Bayes classifier model [16] based on edge histogram is used to group the Thai E-San Heritage images into two classes; (i) heritage images which involve human activities; and (ii) heritage images with non-human activities.

In [17], a method of image retrieval using repetitive patterns by SIFT is reported. The repetitive part of the image is represented by lattice or line pattern. Mishra et al. [18] proposed a real-time system for retrieving the Heritage image. The database images and query images are described by 64D SURF descriptors. In addition to SURF, the color channels are also used to measure the similarity. Principal component analysis is done to make the system efficient. Next multidimensional indexing of the pre-computed image features is performed based on SR-tree.

In [19], a decision fusion framework is used to retrieve the images from artistic repositories. The fuzzy theory using low-level feature distances is utilized to measure the similarity between the images.

A system for seamless cross-collection content and meta-data based searching of museum image collections database is proposed in [20]. Here, the multi-scale color coherence vector (MCCV) technique is used which can provide an effective sub-image retrieval. If the sub-image and the target are at different resolutions, this method is also worked well.

Ardizzone et al. [21] presented an image retrieval system for an artistic database on cultural heritage. They proposed a similarity function based membership values of the Fuzzy c-means theory. In [22], an image retrieval technique is presented for efficient search in cultural heritage images. Here, the proposed method extracts features by using LBP and clusters them as a low-level patterns. Higher-level patterns are formed from the low-level patterns by pattern instantiation. The similarity between two patterns is identified as a function of the similarity between both the structure and the measure components of the patterns.

In [23], computer vision application on mobile phones is demonstrated. One can take a picture at a heritage site and can get the associated annotations on his/her mobile phone using the application. For this, they have used a Bag of visual Words (BoW) image retrieval system, and an annotated database of images.

Picard et al. [24] proposed an automatic labeling and interactive search method for cultural heritage collections. In the labeling phase, a set of keywords is inferred automatically for each newly digitized artifact. The wordbook of all possible keywords can be very large. These keywords are to ease the work of specialists searching throughout the entire collection by querying very precise keywords.

1.2. Our contribution

Wave Kernel Signature (WKS) [25,26] is designed for 3D image shape analysis and shape segmentation. We use the WKS to describe the 2D local patches of a particular image that is deformed due to the ageing. These descriptors are used for figure spotting. To avoid the dense search throughout the panel image, we develop

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