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Detection of a polymorphic Mesoamerican symbol using a rule-based approach

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Abstract

This paper describes a technique to recognize a Mesoamerican symbol whose shape is extremely variable. We extract symbols from a drawing and we encode them as discrete curves. We perform the recognition using a set of rules that define the correct symbol. One of the rules is the presence of a single symmetry axis. We describe a comparison metric between curves in order to search for symmetries. The other rules used for the recognition concern the morphology of the symbol. The proposed technique proves to be fast and efficient. We present recognition results obtained on various pre-hispanic images. The rule-based approach proposed and implemented here, appears suitable to detect polymorphic signs, a common feature of Mesoamerican symbols. To the best of our knowledge, this is the first study of pattern recognition into the field of Mesoamerican iconography.

Keywords: Rule-based recognition; Polymorphic symbol; Mesoamerican symbol; Symmetry axes; Curve comparison metrics; Morphology analysis

1. Introduction

Most of the high cultures developed in Mesoamerica (Olmec, Maya, Teotihuacan, Aztec, etc.), characteristically used plastic shapes and media to represent religious thinking. Those images are then, direct sources of data on the subject and have been studied by iconography and other disciplines, in pursuing that fundamental piece of knowledge. The vastness and complexity of such a universe, however, have naturally limited research to specific sites, cultures, regions and epochs. Even so, few studies have conceived the Mesoamerican iconographic complex as a whole, focusing on the common elements found in different cultures, times and regions [1–4]. With the same approach and comparative iconographic analyzes, four main signs have been recently identified in a large sample of Mesoamerican monuments [5,6]. Based on their high incidence in different cultures, regions and epochs in Mesoamerica, their continuous presence in principal monuments, and the central positions they often occupied in images, they have been identified as symbols.

In this work, the polymorphic shape of one of those symbols was studied, defined and compared by pattern recognition means. Thus, this work deals with shape of symbols. Shape is an intrinsic property of objects. Whereas color, motion, and intensity are relatively simply quantified by a few well-understood parameters, shape is much more subtle [7]. Natural or painted shapes are incredibly complex. It is not clear what aspects of shapes are important for applications such as recognition. Several authors have used different techniques for shape analysis and recognition, such as sequential extraction of shape features [8], medial axis transforms, mirroring axes [9]. Pavlidis [10] reviewed these and other methods.

Ballard and Brown [7] proposed the template matching, which is an operation for finding out how well a template

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(a shape) matches a window of a given binary image. This binary image may be considered as another shape. Strachan et al. [11] presented a method to compare the shapes of two fishes based on invariant moments, optimization of the mismatch, and shape descriptors. Another measure of shape similarity was presented in Ref. [12] by means of the *shape numbers*, which are related to the resolution of the digitalization scheme. These methods find the best matching between shapes.

Recently, other methods related to shape similarity have been proposed. Gunsel and Tekalp [13] propose a new shape-similarity metric in two eigenshape space for object/image retrieval from a visual database via query-by-example. Carlin [14] presents five different new performance measures for shape similarity retrieval. Mokhtarian and Abbasi [15] propose a method for shape-similarity retrieval under affine transforms based on the maxima of curvature scale space image. Mahmoudi et al. [16] present a method for image retrieval based on shape similarity by edge orientation autocorrelogram. Torsello and Hancock [17] propose a skeletal measure of 2D shape similarity.

Due to the complexity to detect Mesoamerican symbols, which are polymorphic, we propose a rule-based approach. Several authors have used this type of approach, such as: Ding and Young [18] have implemented a rule-based system to complete shape from imperfect contour. Another example of this type of systems is presented by Ahmed and Ward [19], who developed a novel rule-based system for thinning of characters. In this paper, we define a few rules that appear to be common to the many forms of the studied symbol. These rules are general enough to characterize the symbol in spite of its variability but they are specific enough to discriminate between correct and incorrect symbols in most of the cases. In Section 2, we will present an overview of the problem we want to solve and the approach we developed. In Section 3, we will describe the preliminary stages of extracting shapes from an image and normalizing them. In Sections 4 and 5, we will explain in more details the implementation of the proposed rules, concerning the number of symmetry axes and the morphology of the shape, respectively. In Section 6, we will give some recognition results. We will present our conclusions in Section 7.

2. Overview

2.1. Presentation of the problem and proposed solution

Iconographists have constituted large databases of pictures and drawings of Mesoamerican artifacts and monuments. We would like to be able to perform an unsupervised inspection of this database and automatically locate in each image some particular symbols. The symbol we study in this paper is the most basic of four newly identified transcultural Mesoamerican signs [5,6]. We refer to it as the symbol *One*. Fig. 1 shows a few examples of occurrences of this symbol.

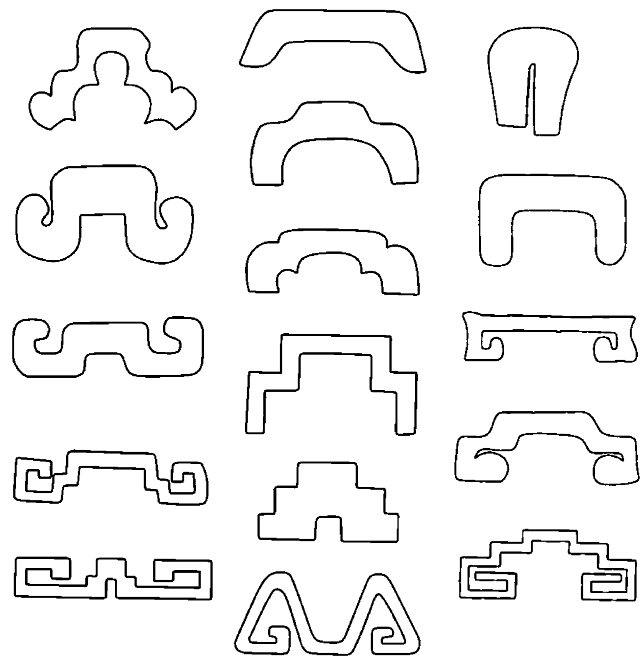

Fig. 1. Examples of occurrences of the symbol One.

It can be seen that there is a great variability of shape between the various instances of the class One. This variability makes it almost impossible to use a template matching approach. This is all the more true as we do not know in advance all the possible forms of the symbol. So we have to rely on a more conceptual representation of the shape. We therefore looked for rules that characterize prominent features of the symbol and are verified by the various instances of the class. We found out that the symbol One can be mostly defined as a symmetric arch. In order to comply with the symmetry property, we define as a first rule that a One has to possess one and only one symmetry axis. Second, we test the arch property by defining several morphological rules that basically check that the central part of the symbol is an arch with suitable proportions.

In addition to the problem of shape variability, we also have to deal with the problem of speed. Since we need to test a large number of images and every image contains many symbols, we are interested in designing a fast recognition algorithm. With this idea in mind, we chose to use a boundary representation of our symbols. This approach is faster than a region-based approach because we only need to perform operations on the boundary points rather than on all of the inside points of the symbol. In Section 3, we describe how we extract elemental symbols from a composite image and how we represent them using their boundaries.

2.2. Vocabulary convention

In the following we will use a number of vocabules to refer to various aspects of the symbols. For the sake of