EXPLOITING AND EVOLVING R^N MATHEMATICAL MORPHOLOGY FEATURE SPACES

Vitorino Ramos and Pedro Pina
CVRM / Centro de Geo-Sistemas, Instituto Superior Técnico
Av. Rovisco Pais, 1049-001 Lisboa, PORTUGAL
vitorino.ramos@alfa.ist.utl.pt, ppina@alfa.ist.utl.pt

Abstract A multidisciplinary methodology that goes from the extraction of features till the classification of a set of different granites is presented in this paper. The set of tools to extract the features that characterise the polished surfaces of granites is mainly based on mathematical morphology. The classification methodology is based on a genetic algorithm capable of searching for the input feature space used by the nearest neighbour rule classifier. Results show that is adequate to perform feature reduction and simultaneously improve the recognition rate. Moreover, the present methodology represents a robust strategy to understand the proper nature of the textures studied and their discriminant features.

Keywords: Granite textures, feature extraction, size-intensity diagram, feature reduction, genetic algorithms, nearest neighbour rule classifiers.

1. Introduction

Natural ornamental stones are quantitatively characterised in many ways, mostly physical, namely through geological-petrographical and mineralogical composition, or by mechanical strength. However, the properties of such products differ not only in terms of type but also in terms of origin, and their variability can also be significant within a same deposit or quarry. Though useful, these methods do not fully solve the problem of classifying a product whose end-use makes appearance so critically important. Traditionally, the industrial selection process is based on visual inspection, giving a subjective characterisation of the appearance of the materials. Thus, one suitable tool to characterise the appearance of these natural stones is digital image analysis. If the identification of the features (colour, size/shape, texture) that characterise a type of material may seem easier to list, the definition of a set of parameters to

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quantify those features becomes less evident. Those parameters have to clearly characterise each feature for each type of material and should not be redundant.

Mathematical morphology disposes of a set of operators that can handle, in an individual or in a combined mode, with the extraction of the textural features of images in general [3, 12, 16], but also with ornamental stones in particular, namely related to their size/shape, dispersion/orientation and connectivity/neighbourhood. In the present case study, several morphological operators were tested, but there is one that provides significant discrimination between the different textures: it consists of the size-intensity diagram introduced by Lotufo and Trettel [6], that combines both size and intensity information into a single parameter.

In what concerns classification, if the features are significant and synthesize correctly the real texture, a simple approach can be used. Thus, the nearest neighbour rule (k-NNR) was considered to be used, since it is a simple but powerful classification technique [4], even for a small number of training prototypes. In that context, a method was envisaged to perform nearest neighbour optimisation by genetic algorithms (GA) ($i.e.$ via feature reduction). In the basic nearest neighbour rule classifier, each sample (described by their features) is used as a prototype and a test sample is assigned to the class of the closest prototype [2]. It has been shown that in some cases a small number of optimised prototypes can even provide a higher classification rate than all training samples used as prototypes. Another approach consists in using genetic algorithms based methods for searching the feature space to apply in nearest neighbour rule prototypes, which is the case presented in this paper. For instance, Brill $et\ al.$ [1] used a k-NNR classifier to evaluate feature sets for counter propagation networks training. Some other authors used the same approach [14, 15] for another kind of classifiers.

2. Textures studied: Feature selection and extraction

A collection of 14 Portuguese grey granites with several samples per type was constituted [10]. Although this commercial label includes the real grey types, it also includes other similar colourless types (bluish, whitish and yellowish, for instance). The samples of these types of granites used for the development and testing of our research are 30 cm x 30 cm polished tiles. The digital images were acquired (total set of 237 images) using a colour scanner with a predefined regulation set for the brightness and the contrast parameters [10] having a spatial resolution of 150 dpi and a spectral resolution of 256^3 colours. Sample images of each granite texture and respective description are presented in figure 1 and table 1.

The extraction of features was initially envisaged to be implemented in a two-stage approach: globally and locally. It consisted on the extraction of