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Object segmentation within microscope images of palynofacies ☆

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Abstract

Identification of fossil material under a microscope is the basis of micropalentology. Our task is to locate and count the pieces of inertinite and vitrinite in images of sieve sampled rock. The classical watershed algorithm oversegments the objects because of their irregular shapes. In this paper we propose a method for locating multiple objects in a black and white image while accounting for possible overlapping or touching. The method, called Centre Supported Segmentation (CSS), eliminates oversegmentation and is robust against differences in size and shape of the objects.

Keywords: Image processing; Object segmentation; Watershed; Palynomorphs

1. Introduction

Accurate recognition of biological remains found in palaeosediments is the basis of palynology and micropaleontology and this underpins the interpretation of palaeoenvironment, chronostratigraphy and much more. The fundamental importance of accurate recognition of fossil material under the microscope has spurred considerable effort into automating the task. In the last 25 years significant developments have been made in recognising specific types of fossil material under ideal conditions (England et al., 1979; France et al., 2000; Weller et al., 2005).

Nevertheless, obtaining statistically significant, unbiased and reproducible results from automated analysis of microscope images is still regarded as a challenge. Even in the unrealistically simple case of individual, whole, undeformed specimens, difficulties arise from the diversity of the species to be recognised, the variability in the image acquisition techniques as well as the subjectivity of the visual analysis (Bollmann et al., 2004).

Starting with a mixture of objects arranged randomly in an image, we seek to create a collection of individual specimens. Counting objects in an image is straightforward for disconnected objects or objects of a particular known shape. However, counting connected or overlapping objects of arbitrary shape can prove difficult. The standard approach to this task consists of two steps. First, the image is segmented into background and foreground so that the objects of interest appear as a black foreground. Second, the foreground is further segmented to identify separate objects.

☆Code available from server at http://www.iamg.org/CGEditor/index.htm.

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In this paper we expose some deficiencies of the current object-segmentation methods (e.g., their tendency to oversegment and the need for a subjective placement of markers in the image). We propose a new segmentation method whose preset parameter corresponds to the human perception of *overlap* and does not depend on the image resolution.

The rest of the paper is organised as follows. Section 2 gives more details about the type of palynological images considered in this study and the objects within such images. Section 3 briefly explains the pre-processing of the image to segment out the background. Section 4 presents an overview of existing object-segmentation methods and highlights the problems arising. Section 5 introduces our algorithm for finding object centres, called Centre Support Segmentation (CSS). The results of an experiment are presented in Section 6. Section 7 offers conclusions and outlines future research directions.

2. Challenges of object segmentation in images of palymnomorphs

Finding roughly elliptical cells or pollen spores in an image is considerably easier than finding objects in palynomorph images. The material being analysed has arisen from biological remains. These remains are subjected to initial distress at time of deposition and subsequently altered and deformed by burial stresses and tectonic deformation. Furthermore the remains are then retrieved from their current position deep in the Earth by techniques which were not designed primarily for optimum sample preservation. Finally, the processed material is arranged haphazardly on a slide, with both material of interest and other materials overlapping and partially hiding each other.

Fig. 1 shows a typical image of an assemblage of objects retrieved by sieve analysis from a sediment. The material consists of light or transparent objects (palynomorphs and amorphous organic matter) and opaque humic kerogen which can be subdivided into inertinite and vitrinite. The dark objects have irregular shapes and different sizes. Sometimes small dark objects appear within light objects. The light objects, on the other hand, vary in texture, intensity and transparency. Up to now, human intervention has been assumed in detecting the objects in the image. At the next stage, automatic classification of the cropped objects can be

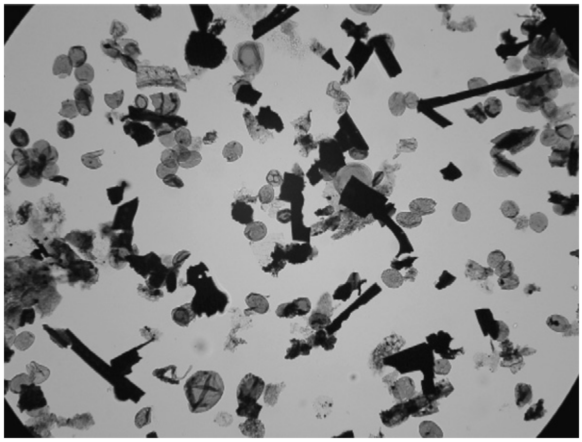

Fig. 1. Microscope image of palynofacies. Dark objects are referred to as ‘‘kerogen’’.

attempted based on expert knowledge, extraction of salient features and various machine learning and pattern recognition methods (Weller et al., 2005). Our goal in this study is to devise an algorithm for automatic identification of dark objects in the image. Such an algorithm will be a step towards a completely automatic classification system for palynological images.

In addition to the task facing the geologist, the image analysis has to address the reality that each slide is seen under different conditions, e.g., variations in light intensity, colour balance, background, etc. These variations need to be accounted for in order to create conditions which are sufficiently similar or standard for the algorithms to be usable and the results to be statistically valid. Only then can the large body of work on recognition of individual specimens be made commercially useful.

3. Image pre-processing to segment the kerogen material as foreground

The first stage of our long-term project is to extract ‘‘dark’’ objects that correspond to kerogen material. These objects will be later classified into inertinite and vitrinite. Hence the background/foreground segmentation must leave only the kerogen material as the foreground while labelling all the light or transparent fossils and amorphous material in the image as background. Below we include some details of our background segmentation algorithm. While this part is not directly related to the proposed Centre Support Segmentation