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Case-based object recognition for airborne fungi recognition

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Summary

Objective: Model-based object recognition is a well-known task in Computer Vision. Usually, one object that can be generalized by a model should be detected in an image based on this model. Biomedical applications have the special quality that one object can have a great variation in appearance. Therefore the appearance of this object cannot be generalized by one model. A set of cases of the appearance of this object (sometimes 50 cases or more) is necessary to detect this object in an image. The recognition method is rather case-based object recognition than model-based object recognition. Case-based object recognition is a challenging task.
Methods and material: It puts special requirements to the similarity measure and needs a matching algorithm that can work fast in a large number of cases. It also needs a case acquisition procedure that can capture the great variation in appearance of an object and generalize these data into a case description. In this paper we describe the chosen case representation, the similarity measure and the matching as well as the case acquisition procedure. We evaluate our method based on a large enough set of digital images containing biological objects such as fungi spores.
Results: We can show that the similarity measure is superior to detect the objects in the images. The developed method for case acquisition and learning of generalized cases allows us to learn interactively a sufficient number of cases that are further stored into our case base. Finally, we give results on the performance of the system by calculating the recognition rate.
Conclusion: These result show that we have developed a novel similarity measure for object detection in digital grey-level images and a novel procedure for case acquisition and learning that allows us to learn a sufficiently large enough case base and to generalize over a group of cases.

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1. Introduction

Case-based object recognition is used to detect objects of interest on a complex background where thresholding-based image segmentation methods fail. The basis for such a recognition method is a set of cases of the appearance of the object that should be recognized. A case is comprised of a set of contour points of an object and the object name. The recognition is done by retrieving similar cases from the case base and successively matching these cases against the images. Objects whose points match the case points give a high recognition score and they are marked in the actual image.

In this respect case-based object recognition differs from model-based object recognition [1,2]. Model-based object recognition is a well-known task in Computer Vision. Usually, one object that can be generalized by a model should be detected in an image based on this model. Biomedical applications have the special quality that one object can have a great variation in appearance. Therefore, the appearance of this object cannot be generalized by one model. A set of cases of the appearance of this object (sometimes 50 cases or more) is necessary to detect this object in an image.

Case-based object recognition is a challenging task. It puts special requirements on the similarity measure and needs a matching algorithm that can work fast in a large number of cases. The basis for such an object recognition method is a good set of cases that describes the variation in appearance of the object on different abstraction levels, so that it is possible to detect an object with a sufficiently high recognition score. Besides the case-based object recognition method, we developed a special case acquisition procedure which mines a large number of data for a more generalized case description. This case is put into the case base for case-based object recognition.

In this paper we describe our work on an application for health monitoring. Airborne microorganisms are ubiquitously present in the various fields of indoor and outdoor environments. The potential implication of fungal contaminants in bio-aerosols on occupational health is recognized as a problem in several working environments. The continuous monitoring of airborne biological agents is consequently a necessity, as well for the detection of risks for human health as for the smooth sequence of technological processes. We use our case-based object recognition method in order to recognize fungi spores in digital microscopic image. The object recognition unit is our first step on the way to an automatic image interpretation system for the detection and interpretation of airborne fungi spores. Note that the recognition method furnishes us information only if there is an object in the image that is very likely a fungi spore. It gives us also information about the shape of the object, but it does not give us the final information about the kind of fungi spore. This information can only be obtained after further processing steps.

In this paper we consider six digital microscopic images of fungal cultures. The acquisition technique and the sample images are given in Section 2. In Section 3 we describe the basic architecture of a case-based object recognition system. Different image and case representations are presented in Section 4. An overview about similarity measures for object recognition is given in Section 5, as well as the similarity measure that we developed for our application. In Section 6 the hypothesis-test strategy is presented. The overview about the recent matching algorithm is given in Section 7. We discuss the case acquisition in Section 8. Finally, we give results on the performance of the system in Section 9 and discuss implementation details. Conclusions and an outlook to further research are given in Section 10.

2. Image acquisition and sample images

2.1. Fungal cultures

Six fungal strains representing species with different spore types were used for the study (Table 1). The strains were obtained from the fungal stock collection of the Institute of Microbiology, University of Jena/Germany and from the culture collection of JenaBios GmbH. All strains were cultured in Petri dishes on 2% malt extract agar (Merck) at 24 °C in an incubation chamber for at least 14 days. For microscopy fungal spores were scrapped off from the agar surface and placed on a microscopic slide in a drop of lactic acid. Naturally hyaline spores were additionally stained with lacto phenol cotton blue (Merck). From the spores of these species a database of images was produced.

2.2. Image acquisition

Image acquisition was conducted using a Zeiss-Axiolab transmission light microscope equipped with a 100× lens and a NIKON Coolpix 4500 digital color camera. The magnification is 1000×, using a 100× objective. The resulting pixel size ranges from 0.1 to 0.025 μm. The average spore size of common airborne fungi varies between 2 and 40 μm. Some