Journal of Modern Optics, 2015
http://dx.doi.org/10.1080/09500340.2015.1013579

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Position and rotation-invariant pattern recognition system by binary rings masks

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(*Received 3 October 2014; accepted 26 January 2015*)

In this paper, algorithms invariant to position, rotation, noise and non-homogeneous illumination are presented. Here, several manners are studied to generate binary rings mask filters and the corresponding signatures associated to each image. Also, in this work it is shown that digital systems, which are based on the k-law non-linear correlation, are k-invariant for $0 < k < 1$. The methodologies are tested using greyscale fossil diatoms digital images (real images), and considering the great similarity between those images the results obtained are excellent. The box plot statistical analysis and the computational cost times yield that the Bessel rings masks are the best option when the images contain a homogeneous illumination and the Fourier masks digital system is the right selection when the non-homogeneous illumination and noise is presented in the images.

Keywords: image processing; pattern recognition; digital systems; binary rings masks; one-dimensional signatures

1. Introduction

One of the goals in the pattern recognition field is to recognize objects automatically with a high level of confidence and a low cost of computational time; it does not matter if the objects are rotated, scaled, displaced, with different kind of noise, different illumination or perhaps they are partially hidden or we have a fragment of it only. The design of new filters for pattern recognition based on correlation has attracted considerable attention [1–10]; most of these filters have been used to recognize micro and macro structures.

Recently, a new methodology based on one-dimensional signatures of the images was presented [9,10]. In these works, shift and rotation were taken into account in the correlation process and different ways to generate the binary rings masks were studied. In this paper, we showed more alternatives to generate the binary rings masks; moreover, illumination and noise variations in the objects to be recognized were analysed. Also, the independence of the system in the non-linear factor k is determined. Finally, here is established the robust algorithm based on binary rings masks that uses lesser computational time.

Because the goal of these systems is to be used in the classification of digital images taken from the life, that is, digital images not generated by computers, therefore the objects used in this paper are microstructures called diatoms (real images). The diatom samples are from Cuenca de San Lázaro in Baja California and they were taken in 1996 in an oceanographic ship called El PUMA [11]. Fossil diatoms are photosynthetic organisms that live in freshwater or marine and they constitute a very important part of the phytoplanktons. The presence of diatom valves in marine paleoenvironments has been used for studying the climatic changes as well as geomorphological processes [12,13]. The identification of diatom fossils requires the analysis of a great number of valves per sample. Generally, to obtain relative abundances and diversity indexes, diatom counts must go from 400 to 10^7 structures per gram [14]. Thus, the analysis of these samples requires the investment of much time and experience. Moreover, these kinds of images are one of the best options to test the efficiency of the pattern recognition digital system because a lot of them are morphologically similar.

The material in this work is organized as follows: in Section 2, the digital system invariant to position and rotation based on the Fourier binary rings masks is explained. Section 3 presents the digital system by the Bessel binary rings masks. Section 4 shows the comparison analysis of the methodologies in Sections 2 and 3, and that given in [15] called vectorial signatures. The confidence level of each of those methodologies, the computational time, noise and the non-homogeneous illumination analysis are presented. Finally, in Section 5 the conclusions are given.

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