Fossil diatom fragments analysis using one binary ring mask invariant to rotation and scale

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1. Introduction

In pattern recognition recent investigations have used adaptive rings mask [1-2], getting a robust vectorial signature methodology invariant to rotation. In this paper a new methodology to recognize diatom fragments is presented. This technique uses an adaptive rings mask invariant to rotation and scale. This ring mask is obtained from the modulus of the 2D scale transform of the image to be recognized, in this case diatoms.

Diatoms are one of the basic sources for the formation of organic matter in the ocean, and actively participate in sedimentation, not only during recent periods of time but throughout the remote past. The presence of diatom valves in marine paleo-environments has been used for the study of climatic changes as well as geomorphological processes [3-4]

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 [5]. The analysis of these samples requires a great amount of time and experience and, on the other hand, the samples analyzed frequently contain material with different fragmentation degrees and this can lead to confusion and loss of information. Therefore, it is necessary the development of new techniques to facilitate the species recognition, even with fragments of the organisms.

2. The invariant system to rotation and scale

The algorithm proposed in this paper generates an adaptive binary rings mask from the modulus of the separable 2D scale transform of the target image. In addition this binary mask takes samples from the modulus of the 2D scale transform of target image and each problem image to generate their vectorial signature. The first step of the digital algorithm is to take the transect of more energy on the modulus of the 2D scale transform in order to make a rotation of 360º of this transect to generate an adaptive mask of binary rings (Fig. 1a). Once the vectorial signatures for the target and the problem image are obtained, then the signatures are compared using a k-law nonlinear correlation.

The construction of the concentric binary rings begin in the center of the central cross-section of the modulus of the 2D scale transform (Fig. 1b). Identifying the positive slopes in $f(c_x,y)$ a binary function $z(y)$ is generated (Fig. 1c). The condition is:

$$\text{IF } [f(c_x,y(1:128))=\text{positive slope}] \text{ THEN } z(y)=1, \text{ ELSE } Z(y)=0.$$

From this reference (Fig. 1c), adaptive concentric rings mask are generated (Fig. 1d).

Different species of fossil diatoms were studied, but some of them are presented in the Fig. 2 and 3 including some of their fragments.

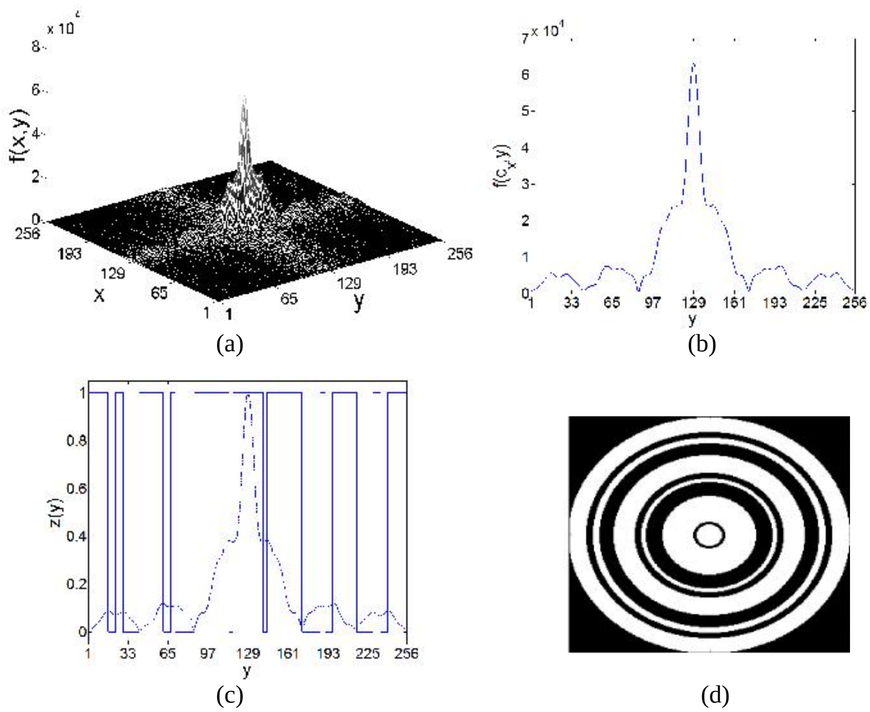

Figure 1 (a) Modulus of the 2D scale transform of letter T Arial. (b) Central cross-section of the modulus of the 2D scale transform, c_x represents the central pixel in x axis. (c) Binary function z(y) (d) Binary mask of concentric rings for letter T Arial.

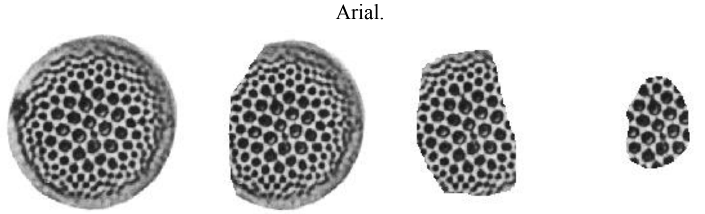

Figure 2 Thalassiosira oestruppii var 1

Figure 3 Thalassiosiosira oestruppii var 2

3. Results

Each diatom entire or fragmented was rotated from 0^o to 359^0 and scaled from 90% to 110%. Table 1 show us the level of confidence in the recognition of the fossil diatom fragments. Diatom A has a level of confidence of 95.4 % without to consider diatoms O and Q, because some of their fragments are confused one each other. In another case, diatom G, I and Q can be recognized totally it does not matter all the fragments of the other species with a confidence of level of 95.4%. Diatom K and L when were compared with all different species entire and fragmented had a level of confidence of 68.3 %.

Diatom		
A *Actinocyclus ingens -Rattray*	95.4%	without O, Q
B *Azpeitia sp*	95.4%	without C
C *Azpeitia nodulifera – (Schmidt) Fryxell et Sims*	95.4%	without B
D *Actinocyclus ellipticus – Grunow in van Heurck*	95.4%	without J, L
E *Actinocyclus ellipticus var moronensis – (Deby ex Rattray) Kolbe*	68.3%	without B, S, T
F *Denticulopsis praedimorpha – Barron ex Akiba*	68.3%	without H, I, N
G *Nitzchia praereinholdii - Schrader*	95.4%	
H *Bogorovia praepaleacea – (Schrader) Jouse*	95.4%	without M
I *Thalassiosira oestruppii var 1*	95.4%	
J *Thalassiosira oestruppii var 2*	95.4%	without O, Q
K *Thalassiosira domifacta – (Hendey) Jouse*	68.3%	
L *Asteromphalus imbricatus – Wallich*	68.3%	
M *Pseudotriceratium cinnamomeum –(Greville) Grunow*	68.3%	without I, K
N *Thalassiosira kozlovii – Makarova*	95.4%	without S
O *Coscinodiscus radiatus –Ehrenberg*	68.3%	without P
P *Diploneis bombus – Cleve – Euler in Bachman et Cleve-Euler*	68.3%	without M, R, S, T
Q *Stephanodiscus sp*	95.4%	
R *Actinoptychus undulatus – (Bailey) Ralf*	68.3%	without M, P
S *Actinoptychus bipunctatus – Lohman*	68.3%	without T
T *Actinoptychus splendens – (Shabolt) Talf ex Pritchard*	68.3%	without O
U *Nitzschia reinholdii – Kanaya emend Barron & Baldauf*	95.4%	without G

Table 1 Recognition of diatoms.

4. Conclusions

This system worked in an excellent manner because can to recognize much of the entire and fragmented 21 different species of fragmented diatoms. It is necessary to make more work in this type of recognition in order to know exactly the minimum percentage of fragment needed for recognizing the specie.

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References

[1] J. Álvarez-Borrego and S. Solorza, "Digital system of invariant correlation to position and rotation." *Opt. Commun.* **283** (19), 3613-3630 (2010).

[2] J. Álvarez-Borrego, S. Solorza and M. A. Bueno-Ibarra, "Invariant correlation to position and rotation using a binary mask applied to binary and gray images". *Opt. Commun.* **294**, 105-117 (2013).

[3] M. Hajós, "Upper Eocene and lower Oligocene diatomaceae, archaemonadaceae and silicoflagellates in southwestern pacific sediments", Tech. Rep. DSPP **5**(35), p. 817–883 (1976).

[4] I. Kiozumi and U. Tanimura, "Noegene diatom bioestratigraphy of the middle latitude western north pacific", Deep Sea Drilling Project leg 86. Initial Rep. DSDP, **86**, p. 269-300 (1985).

[5] M. A. Esparza-Álvarez, "Paleocología de sedimentos diatomaceous de la formación Tortugas en el área de bahía Asunción, Baja California Sur, México". MSc Thesis, Marine Science Faculty, UABC, Eda. México, (1995).