ISSN 1870-4069

Computer Vision Algorithm Implementing Geometric Morphometry to the Shape Analysis

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Abstract. The present work defines the guidelines to develop a shape analyzing system in order to classify an image set. The classification process considered geometric morphometry as principal theory for pattern recognition and to extract scale-rotation-invariant key points. This research also compares some theories and techniques for pre-processing and segmentation steps of the general image identification process due to sample images. The research´s output considers an automated system to sex classify sea turtle hatchlings according to the shell morphology patterns.

Keywords: computer vision, digital image processing, geometric morphometry.

1 Introduction

Computer vision is a science focused on the development of automatic systems to simulate the biological visual perception system. The principal purpose of this science is to allow machines to make decisions recognizing and identifying objects around them. The computer vision systems are based on algorithms to analyze information extracted from digital images. These algorithms can obtain information about physical and structural characteristics such as the shape, the color and some metrics [1-5].

Computer vision systems are used in many different sciences to help scientists to make and to support decisions. The results of a shape analysis could diagnose a disease, confirm the identity of a person or classify a group of products. In Biology, the implementation of these systems aims to assist biologists in some identification processes. Particularly in this field, it is needed to get and to analyze some shape patterns to recognize an individual [6].

In 2014, Navarro [7] described the relationship between sea turtle hatching statistics and climate phenomena in nesting lands. He also suggested the difference be- tween male-female sea turtle hatchlings as principal indicator to predict global warming progress. Although, the method to get exactly the genre of a sea turtle implies to kill the hatchling, some biologists pose new techniques to infer this type of information by analyzing specific shape patterns in the shell. These techniques consider that the morphological structure of each individual is unique so that is possible to classify animals studying the biological structure to find classification patterns [8,9]. Some other authors explain the necessity of applying quantitative methods (based on metrics) to get accurate results. Geometric morphometry as a quantitative theory for shape analysis shows the benefits of its implementation in the general image identification process [9-11].

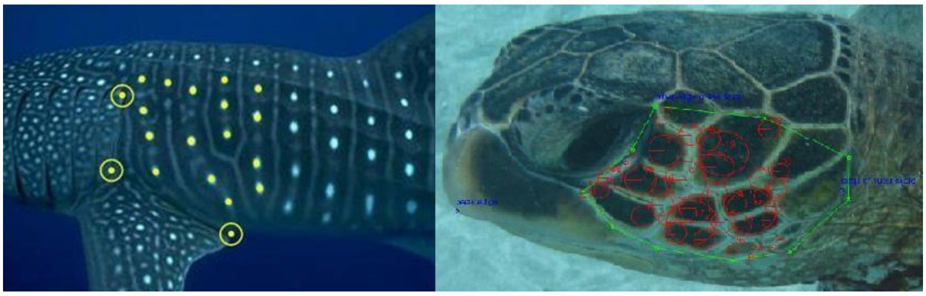

Fig. 1. Examples of patterns based on spots dispersion (left) and shape (right) to identify an individual. Obtained from [12] and [13] respectively.

These days, there is software created to assist and to make decisions based on quantitative characteristics. Avoiding subjective criteria in biologic shape analysis is real important to get accurate classifications. The Interactive Individual Identification System (I^3S) generates a unique footprint for each specimen analyzed as shown in Fig. 1. The $I^3S\ Pattern$ version automatically gets a recognition pattern based on the key points of the region of interest. The major disadvantage of this tool is that the final results depend on personal criteria of the scientist that is doing the analysis [12,13]. C. Town *et al.* [14] posed the “Manta Matcher” as an automated system to identify manta rays by analyzing key-point features extracted from images. The system was innovative due to the implementation of an algorithm with adaptive phases to reduce image noise and to accurate contrast equalization. However, the restrictions are the same; biologists need to supervise all the process and to make decisions for example the user must assure that the images are in the selected normal position.

Thus the present work defines the guidelines to develop a shape analyzing system to get a correct pattern recognition and classification of sea turtle hatchlings into two groups (male or female) by applying geometric morphometry. The system will implement computer vision algorithms to process 2D digital images of sea turtle hatchlings and to approach the aim.

2 Methodology

An abstraction of the general image processing methodology could be appreciated in the diagram of Fig. 2. This methodology defined the order in which different algorithms should be implemented for the recognition process. For this reason, it could be used to guide the research approach presented in this paper.

Third stage: Region of Interest (ROI) selection is really important and refers to select the region of the individual where are enough landmarks (key points) located to create a unique shape pattern. The next phase considers the implementation of pre- processing algorithms. Sometimes it is needed the noise removing applying filtering algorithms to vanish and homogenize the information of the region. There are other many times that the emphasis of existing differences in the information is needed as well, so a contrast equalization algorithm is applied.

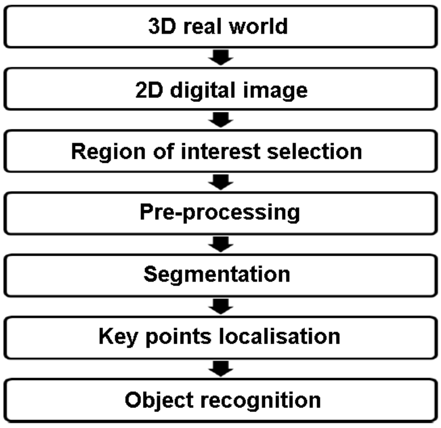

Fig. 2. General image-processing methodology.

The fifth stage refers to separate the image information into different sets. This could be considered as the first approach to the object recognition because the structure of each figure in the image is defined in accordance with those sets. The next step is to locate the information used to create the shape patterns. These patterns could be described by some important points (landmarks in Biology) or the figure edges. The final phase is related to the recognition process. Once the landmarks have been located, a recognition algorithm is trained to recognize the patterns and classify the images into different groups.

2.1 Sample Images

As said before the principal aim of this work is to verify the results of the object classification based on shape analysis by applying geometric morphometry. To accomplish that aim two sets of images were selected, but the only condition to apply this technique is to have shape patterns for object recognition. The first image set considers around 30 images of turtle hatchlings for a sex classification system and the second includes images of basic geometric figures (squares and rectangles) with controlled conditions about color intensity. The second set only had the purpose to validate the application of geometric morphometry for pattern classification based on any shape into groups.

3 Results

For the turtle hatchling images the region of interest was selected according to biologist recommendations as shown in Fig. 3. The type of information contained in each image of this set needed to be treated applying pre-processing algorithms. In Fig. 3, the result images of the implementation of these algorithms are shown.

Fig. 3. Preprocessing image results.

In the segmentation stage different algorithms were implemented: threshold, statistical analysis and fuzzy clustering. Fuzzy clustering algorithm analyzes and classifies complex parameters based on fuzzy logic fundamentals [15].

Fig. 4 shows the result of fuzzy clustering segmentation, as an iterative algorithm could take long time to get the accurate classification clusters. Fig. 5 shows the alternative method for image segmentation by means of the image statistical analysis. This algorithm applies the principal statistical moments.

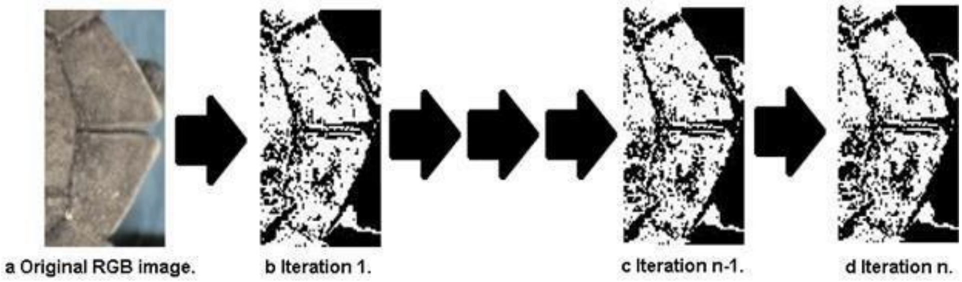

Fig. 4. Results of fuzzy clustering segmentation process.

The set on geometric figure images was used to validate the implementation of the geometric morphometry algorithm. Fig. 6 shows the geometric figures used to train the classification algorithm.

The results of classification process implementing the geometric morphometry theory are shown in Fig. 7. The geometric figure image set was integrated by ten different images. The obtained results applying this theory are also in Fig. 7.

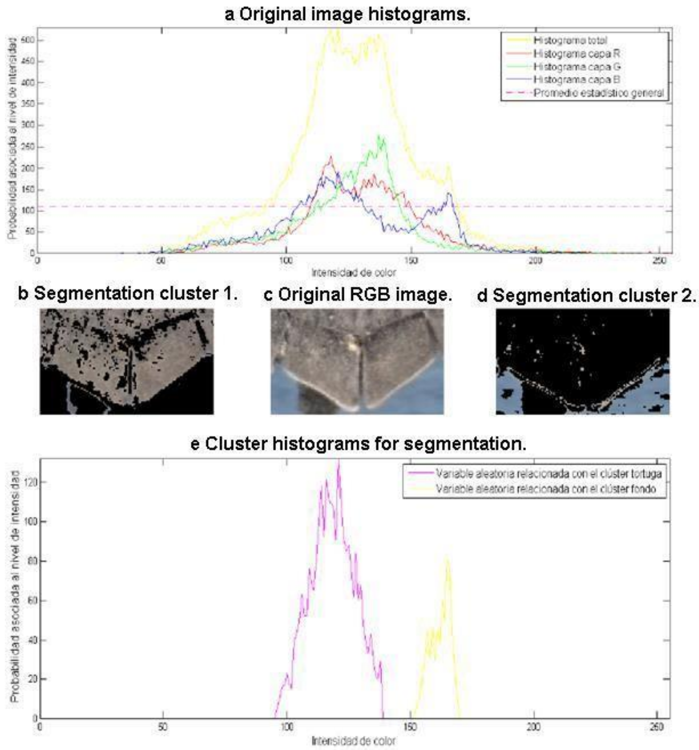

Fig. 5. Segmentation process considering statistical image analysis.

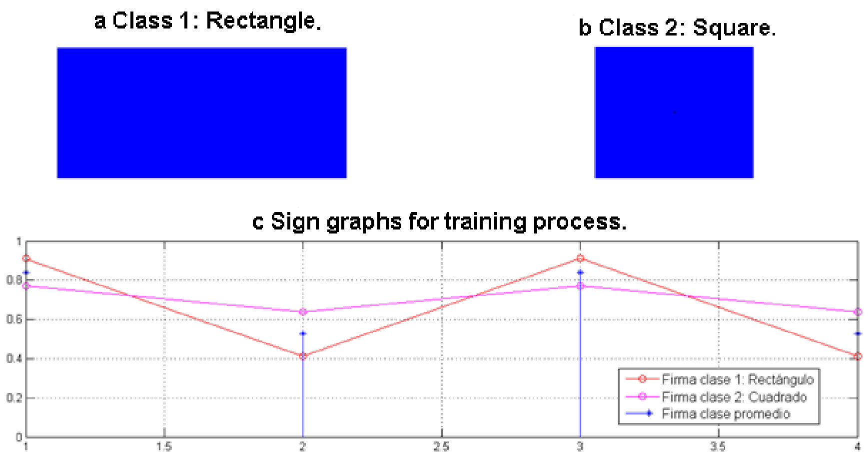

Fig. 6. Income information for classification process.

Fig. 7. Results and images of classification process.

4 Conclusions

This paper only presents results until the fifth stage of the general image processing methodology applied to the sex classification system. The third phase results to be really important as [7,8] and [9] mentioned before. The selection of the right region of interest could make easier the activities of the following steps.

Those previous works also mentioned the necessity of validate with the specialist all the results automatically generated. This condition could be explained with the results obtained with different segmentation algorithms.

Segmentation results are considered as not good enough to implement any of the automatic algorithms studied. In conclusion in this part of the process could be better consider the opinion of the biologist. The automatic system will only help to make easier the localization of key points, but the biologist will select where this points are.

The shape analyzing algorithm has been validated with the geometric figure image set, so it could be implemented in the pattern recognition system to identify the sex of a turtle hatchling. This work is still in progress.

The next step is to continue implementing the shape analyzing algorithm to the recognition system and in a long term could be to implement this new assistant system in a mobile device to give facilities and help the turtle protection.

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