Automatic Color Images Classification Algorithm

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Abstract

Numerous research works about the extraction of objects from images have been published. However only recently the focus has shifted to exploiting low-level features to classify images automatically into semantically meaningful and broad categories. This paper presents a novel automatic color image classification algorithm. Initially the color image is divided into classes; each class is a group of pixels that they have the same color after that the object is extracted from the image. In the recent work, an automatic color images classification algorithm is synthesized and analyzed. The suggested method was running on group of color images to determine the best parameters of suggested algorithm. We run our algorithm with initial value of elaboration coefficient $\varphi = 5$ and we found that the automatic classification algorithm achieved minimum classification error and minimum running time when φ incremented by step $d\varphi = 1$ and φ becomes ≥ 20 .

Key words: *Automatic color image classification algorithm, Area, Class, Elaboration image coefficient, Vector.*

1.Introduction

The increasing use of digital imagery in many fields of science and engineering introduces a demand for accurate image analysis and classification. Applications include remote sensing, face recognition, and biological and medical image classification. Although attracting considerable attention in the past few years, image classification is still considered a challenging problem in machine vision due to the very complex nature of the subjects in real-life images, making quantitative similarity measures difficult.

Today automatic color image classification (ACIC) algorithm is one of the most important components of machine vision.

Machine vision realization is the main challenge of artificial inelegance. It is so difficult to find comprehensive solution of machine vision problems, because there is no consensus theoretical base and lack of computer resources.

Many works tried to solve the machine vision problem for concern class of images [1, 2, 3]; these works laid extra limitation on the input information. Example, face identification systems based on the previous knowledge of face position in the image [4, 5]. In addition, synthesis and realization of objects identification required more resources for different applications. In this paper, main task is to develop algorithms for image analysis and recognition without extra tuning or learning and without any limitation as in [1, 2]. The size and location of objects on the image are the first stage of synthesizing of machine vision algorithms. In this paper, we suggested automatic method of objects detection not depending on the size and location of objects on the image.

2. Related work

Only recently automatic semantic classification of images based on broad and general-purpose classes has been the topic of some research, i.e., automatic classification of images into semantic classes, which are meaningful to normal people. You do not have to be an expert in a specific field in order to do the classification. Examples of broad and general-purpose semantic classes are outdoor scenes versus indoor scenes and city scenes versus landscape scenes.

In [6] and [11] Vailaya et al. describe a method to classify vacation images into classes like indoor/outdoor, city/landscape, and sunset/mountain/forest scenes. They use a Bayesian framework for separating the images.

Gorkani et al. propose a method of separating city/suburb versus country/landscape scenes using the most dominant orientation in the image texture [6]. The dominant orientation differs between city and landscape images. The authors state that it takes humans almost no time or 'brain power' to distinguish between those image classes, so there should exist an easy and fast to calculate feature.

Yiu et al. classify pictures into indoor/outdoor scenes using color histograms and texture orientation [7]. For the orientation they use the algorithm by Gorkani and Picard [6].

The vertical orientation serves as the discriminant feature, because indoor images tend to have more artifacts, and artifacts tend to have strong vertical lines.
Bradshow proposes a method for labeling image regions as natural or man-made. For instance, buildings are man-made, while mountains in the background are natural. He also propose how this feature can be used for indoor/outdoor classification [8].
Swain et al. describe how to separate photographs and graphics on web pages [9,10]. They only search for ‘simple’ graphics such as navigation buttons or drawings, while our work deals with artificial but realistic-looking images, which would be classified as being natural by their algorithm. The features that Swain et al. use are: number of colors, most frequent color, farthest neighbor metric, saturation metric, color histogram metric, and a few more [9,10].

2. Problem statement

Assume the input vector is $V = (x^i, i = 1 \cdots n)$, which represent the color image, where x^i is a polynomial random point. Every element in the vector $x^i = (x_1^i, x_2^i, x_3^i)$ represents brightness of red, green, blue color respectively.
Color image is divided into classes; each class is a group of pixels that have the same color.

3. Synthesis of ACIC algorithm

The purpose of the present work is the synthesis of ACIC algorithm. The main idea is based on building area R around selected class Ω and check if the point from area R belongs to class Ω by equation (1). The problem is solved by checking if the color characteristics $x^i = (x_1^i, x_2^i, x_3^i)$ of class Ω are approximately equal to points $x^j = (x_1^j, x_2^j, x_3^j)$ from area R by equation (2) and additional knowledge about the objects in the image by equation (3). Area R *is defined by set of* elements x^j bounded by class Ω.

$$m(x) = \left\{ \begin{array}{l} \left\| x^i - x^j \right\| \le \varphi \dot{e} \, \alpha_1 < \frac{D^i_{x_1x_2}}{D^j_{x_1x_2}} < \alpha_2 \, \dot{e} \, \alpha_1 < \frac{D^i_{x_1x_3}}{D^j_{x_1x_3}} < \alpha_2, \, x^i \in \Omega_m, \\ \\ x^j \dot{\notin} \Omega_m \end{array} \right\} \qquad (1)$$

Where $\begin{array}{l} x^i - point \in \Omega_m \\ x^j - point \in R \end{array}$

$\varphi -$ Elaboration image coefficient (EIC)

$\alpha_1 \approx 0.8, \alpha_2 \approx 1.2 -$ In advance selected threshold points

The adjacency factor between points x^i *and* x^j is defined by

$$\left\| x^i - x^j \right\| = \sqrt{\sum_{k=1}^{3} (x_k^i - x_k^j)} \le \varphi \qquad (2)$$

$D^i_{x_1x_2}, D^i_{x_1x_3} -$ Differences of characteristics, they are fixed for separated images and not depending on the noises as brightness.

$$D^i_{x_1x_2} = \left| x_1^i - x_2^i \right|, D^i_{x_1x_3} = \left| x_1^i - x_3^i \right| \qquad (3)$$

4. Suggested Method

begin
while(V is not empty)
begin
$m \leftarrow value$
remove x^i *from* V
insert x^i *onto* V_m *of* Ω_m
build area R *of class* Ω_m
if(using equation(1) all points $x^j \in R$ *and also all* $x^j \in \Omega_m$*)*
begin
remove x^j *from* V
insert x^j *onto* V_m
end
else
$m \leftarrow m + 1$
end end

Empirical studies show that the efficiency of ACIC algorithm depends on the election of image elaboration coefficient φ, large variations of point φ for different input vectors complicate the situation and the ability of errors minimization dose not exist because there is no fixed value for φ.

5. Iterative method of image contest tuning in ACIC algorithm:

Large values of φ make ACIC algorithm insensitive for color of points in vector V. Implementing the method for large values of φ produces one class, which includes all points.

To minimize the number of errors: first select the value of φ as minimum as possible $\varphi < 5$, this puts at least one object in the image of one class. For true points' recognition, systematically increment the value of φ by small value $d\varphi$, this leads to equally distributed values of φ over classes.

Suggested algorithm:

```
begin
// vector V is the input data
φ ← value
y ← 0
m ← 1
L1: select class Ω_m
build area R for class Ω_m // by removing points from V
i ← 0
count ← 0
while(i ≤ N) // where N number of points in R
begin
// by using equation1
if (x^i ∈ R and x^i ∈ Ω_m)
count ← count + 1
i ← i + 1
end
if (count equal zero)
begin
m ← m + 1
y ← y − 1
goto L1
end
if ( y equal zero )
begin
φ ← φ + dφ
goto L1
end
if (30 ≤ φ ≤ 35 and vector V is empty )
goto L2
else
goto L1
L2 : end
```

Accurate classification can be achieved by redistributing boundary points over medley classes. Each point will be belonged to the class, which has $M_{\Omega_i}(x)$ approximately nearby to mean characteristic.

$$\bar{x}^i = \frac{1}{3}\sum_{j=1}^{3} x_j^i, \quad M_{\Omega_i}(x) = \frac{1}{3|\Omega_i|}\sum_{\Omega_i}\sum_{j=1}^{3} x_j^i \qquad (4)$$

$$m(x) = \begin{cases} \left|\bar{x}^i - M_{\Omega_1}(x)\right| < \left|\bar{x}^i - M_{\Omega_2}(x)\right|, & x^i \in \Omega_1 \\ \left|\bar{x}^i - M_{\Omega_1}(x)\right| \ge \left|\bar{x}^i - M_{\Omega_2}(x)\right|, & x^i \in \Omega_2 \end{cases}$$

For the condition of transmitting point from one class to another, the mean factors of the classes have to be calculated by equation (4). For this calculation the following recurrence equations, are used.

$$\begin{aligned} M_{\Omega_i\, i} &= \frac{n-1}{n(n-1)}\sum_{i=1}^{n-1} x^i + \frac{1}{n}\, x^n = M_{\Omega_i} + \frac{1}{n} x^n \\ M_{\Omega_j} &= \frac{n-1}{n(n-1)}\sum_{i=1}^{n-1} x^i - \frac{1}{n} x^n = M_{\Omega_j} - \frac{1}{n} x^n \end{aligned} \qquad (5)$$

Where Ω_i class to which point x^n transferred, Ω_j class from which point x^n convicted.

The results of modified ACIC algorithm implementation are given by set of vectors V_j, $j = 1 \cdots m$ that characterized separates objects on the image.

6. Experimental efficiency characteristics of ACIC algorithm

ACIC algorithm efficiency experimented by running algorithm on 30 images with the same size (300x250) that have been taken in different environment lightness. Initially images are given to expert, who processed each image and defined objects and exactly the sizes of these objects on each image. Then these images are processed by our algorithm for different values of $d\varphi \in \{1,3,5\}$. Initially value of image elaboration coefficient φ was selected equal 5 and a maximum value is taken equal 40. Then the results from expert η^i and algorithm $\bar{\eta}^i$ are compared.

Efficiency characteristic determined as probability of automatic classification error of objects in the color images and calculated by equation (6).

$$\bar{P} = \frac{1}{n}\sum_{i=1}^{n} 1(\eta^i, \bar{\eta}^i),$$
$$1(\eta^i, \bar{\eta}^i) = \begin{cases} 0, \eta^i = \bar{\eta}^i \\ 1, \eta^i \neq \bar{\eta}^i \end{cases} \quad (6)$$

As a result, arithmetic mean of efficiency characteristics $\overline{P_i}$ of ACIC algorithm calculated in the range of one elaboration coefficient and step $d\varphi$ by equation (7).

$$\overline{\overline{P_j}} = \frac{1}{N}\sum_{i=1}^{N} \overline{P_{ij}}, \quad N = 20,\ j = 1 \cdots 3 \quad (7)$$

Figure 1 shows experimental results of ACIC algorithm efficiency characteristic.

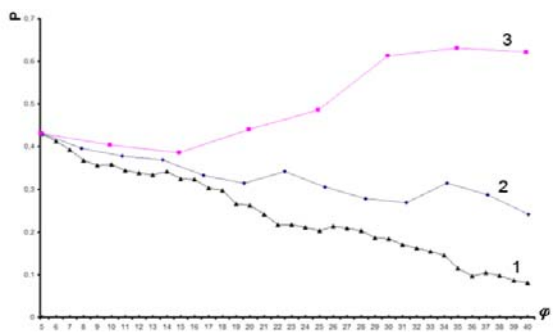


Fig.1. Relationship between characteristic efficiency P_j, $j = 1 \cdots 3$ and values of elaboration coefficient φ . Curve 1 for $d\varphi = 1$, curve 2 for $d\varphi = 2$ and curve 3 for $d\varphi = 5$.

Processing speed of suggested ACIC algorithm is experimented on set of input data. Algorithm speed is defined as computer time consumed on running ACIC. Speed estimated for each color image and each step of $d\varphi$, then the median of results are calculated. Algorithm tested on $2GHz$ computer. Figure 2 shows the speed characteristics of algorithm.

The experimental results of ACIC algorithm show:

1. To obtain minimum errors of classification select $d\varphi = 1$, but in this case the processing speed significantly is decreased.
2. Accepted quality and processing speed can be achieved by companying $d\varphi$.
3. Differences between efficiency characteristics of algorithm in interval $\varphi \in \{5,20\}$ and for $d\varphi = 1$ and $d\varphi = 3$ are insignificant.
4. Maximum quality of ACIC is obtained when $d\varphi$ selected equal one.

Figure 3 shows the running results of ACIC algorithm**.**

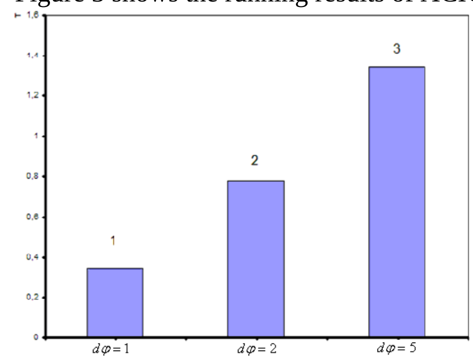
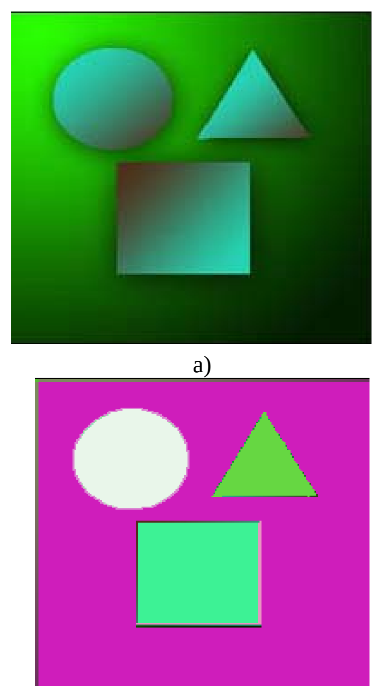


Fig.2. Relationship between running time of algorithm and steps $d\varphi$. Column 1 for $d\varphi = 1$, column 2 for $d\varphi = 2$ and column 3 for $d\varphi = 5$



a)

b)

Fig.3. Results of algorithm implementations. a) Input color image. b) Implementation results of algorithm. Objects Localized as unicolor fragments of image

7. Conclusion:

Automatic classification of images is a very interesting research field. Object extracting is the basic problem of machine vision. In this paper, we propose an effective algorithm for extracting objects from color images. As we mentioned above the proposed ACIC algorithm does not depend on noises as lightness, sizes and location of objects on the image.

Our experiments have shown that the effective and the minimum running time of ACIC algorithm are achieved when the following conditions are concerned:

1. While $\varphi < 20$, initial value of EIC φ selected equal 5 and the step $d\varphi$ selected equal 3;
2. When $\varphi \geq 20$, to achieve minimum automatic classification error and minimum running time $d\varphi$ selected equal 1.

The results, from running ACIC algorithm served as an important stage of building intellectual system like face identification, automated security and hand writing recognition systems.

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