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A Painting Artist Recognition System Based on Image Processing and Hierarchical SVM

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***Abstract*— Over the past years, forgery paintings of famous artists have been sold as original. In order to spot the fake painting, the experts make the decision based on personal experience and with the help of examining some characteristics of the painting and painter. Applying the image processing methods to artwork can reduce the need of the expert and provide quick and reliable results to recognize the originality of the artwork. In this paper, the proposed method is able to identify the painter of artwork using image processing and data mining techniques. The method consists of two typical main stages, feature extraction, and classification. In the feature extraction, 11 statistical features are extracted from each image. These features have been selected in such a way that maximize the distinction of painters. In the second step, the painters are identified by hierarchical classification. In order to evaluate the performance of proposed method, it has applied to a collection of 348 paintings from eight Iranian artists. The method has been able to identify the artwork painter with the accuracy about 84.21%.**

***Keywords*— Hierarchical Classification; Support Vector Machine; Iranian Painting; Forgery .**

I. INTRODUCTION

In spring 2013, a forged Sohrab Sepehri's painting was sold for $147,750 at the Christie's auction in London. It is not the only example of forged Iranian painting and not only for Iranians. As technology progresses and computer processing speeds up, as well as image processing techniques, computers can be great helpful instruments to experts to detect the style and characteristics of painting and compare it with similar paintings of the target artist.

Technically by converting the painting into a digital image and applying image processing techniques, it is possible to detect its artist with a very low error rate. The automatic detection of style and artist of painting images can also be helpful in organizing them in the large collections and comparing different art styles [2]. For example in [3], by review and comparing the artworks of an artist with others, it was tried to answer that the artist was influenced in his work by which style.

When we want to process an artwork (in this case painting), we should find and extract features those can be varied between different artists and similar for artworks made by an artist. Examples of such features can be empty space, texture, shape, color, and image brightness [3]. Therefore, one of the main challenges is to identify the significant features and extract them from the image.

Image processing can give a solution for cultural heritage problems, especially in the identification and restoration of artworks [4]. Helping to classify artwork, analyzing before restoring old paintings, using digital coloring to fill the lost color [5] and identification of materials used in the painting [6] are some tasks that can be done by image processing.

In order to identify the artist of a painting, artwork experts examine a variety of characteristics such as painting style, painter's signature and compare them with other works of the artist. The artwork style is a remarkable quality factor of painting. In fact, the appearance of an artwork enables us to decide that which group (or style) of paintings or which painter it belongs [2].

The aim of this paper is to identify the painter of an artwork using image processing and data mining techniques. The database for training and validation of the system consists of 348 works from eight Iranian artists, which are collected by authors of this paper.

First, the system extracts features of the artwork from the training data set. In order to identify the artwork painter, extracted features are given to a hierarchical classification system that uses the support vector machine (SVM) method.

The paper is organized in 4 sections. In section 2, the proposed method is explained in more details. Section 3 describes data collection, preprocessing, applying the proposed method, and performing experiments. Finally,

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section 4 summarizes the results and the conclusions are also provided in this section.

II. Proposed Method

In this section, a system for identifying the painter of an artwork is presented. The proposed method has two typical phases, training and testing the system.

A. Training Phase

In this phase, 80% of the database is assigned to the training. This phase consists of three main steps: 1) Preparation and normalization of data, 2) Feature extraction, and finally 3) Hierarchical classification using SVM.

Before the feature extraction, it is necessary to normalize the artworks images (3D matrices including RGB channels). After the preprocessing stage, the features are extracted from training set images and are fed to the classification system in order to train it.

1) Preparation and normalization of data

The collected artworks are digital images with RGB color format, which must be prepared and normalized to extract various features. For example, in order to obtain the histogram average for S component of the HSV color space, the images must be taken into the HSV color space, and then the histogram average of S component is computed.

A feature may individually need a preprocessing procedure. For example, to compute the HOG features, all artworks are also resized to 600x600 px.

2) Feature Extraction

As aforementioned, only those features of artworks images are selected that give high distinction degree between different painters and high similarity between images from each painter. By choosing the appropriate features, the proposed algorithm is able to provide answers with high confidence [15].

Each of Iranian prominent artists has his/her own style, which one can usually guess the artist's name at first glance by observing his/her artwork. Fig. 1 shows two works artworks by Hossein Behzad and Sohrab Sepehri. It is clear that from the human viewpoint, the style of painting, texture [12], colors [11], objects, the presence or absence of the face are different in these two artworks [10].

In the literature, the researchers used several features such as LBP, HOG [13] features in different color space such as HSV [14]. Performing several experiments, among the features that can be extracted from the works of artists, the following eleven features are selected as the robust features for the classification.

1) Average of HOG[1] feature

2) Average of LBP[2] feature

3) HOG standard deviation

4) LBP standard deviation

5) Average of gray histogram

6) Average of image edges histogram

7) Means of image edges features

8, 9) Average and standard deviation of histogram for S component from HSV color space

10, 11) Average and standard deviation of histogram for B channel from RGB color space.

Fig 1. Left: the artwork by Sohrab Sepehri; Right: The artwork by Hossein Behzad.

3) Hierarchical classification using SVM

In this section, the data will be classified and the artist of each hierarchy level is assigned using SVM. At each level, the hierarchical method checks whether the artwork belongs to the artist of this level or not. The artist of each level is also selected according to the highest average of Correct Classification Rate (CCR) using SVM. The hierarchical classification procedure is as follows:

1. The database is divided into two classes:

   A. Artworks by a target artist. These images are labeled with 1 as class name.

   B. Artworks by other artists. These images are labeled with 0 as class name.

2. The training dataset is fed into SVM in order to capture the trained pattern of the target artist.

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[1] Histogram of Oriented Gradients

[2] Local Binary Patterns

3. Repeat steps 1 and 2 for each artist. Note that two classes of step 1 are changed according to the target artist.

4. The artist with the maximum CCR is assigned to the first level of the hierarchical approach. We call this artist "victorious artist" of this level.

5. Remove the artworks by the victorious artist from the database.

6. In order to determine victorious artist of a hierarchy level, repeat steps 1 through 5 as long as there is more than one artist whose their artworks are in the database. Note that, in each iteration, the level in step 4 is increased by one and a victorious artist will be assigned to this level.

Each level of the hierarchical approach using SVM determines whether the new data belongs to the artist of this level or not.

B. Testing Phase

In this phase, a new artwork whose artist is not specified, is fed into the proposed algorithm. First, the features of image is extracted. Second, the algorithm starts at the highest level that relates to the artist with the best CCR. At each level of the hierarchical approach, SVM determines whether the new artwork given to the system belongs to the painter of this level or not. If the answer is yes, the algorithm process ends. Otherwise, the artwork must be delivered to next level. This procedure continues until the final result is reached.

III. EXPERIMENTS

In this section, we evaluate the proposed method by dividing the database into training and testing sets.

A. Database

To evaluate the proposed algorithm in practice, 348 artworks by eight Iranian artists has been collected. Name of the artist and amount of his artworks included in the collected database are reported at Table 1. Artworks belong to the first four artists of Table 1 are taken from [8].

Table 1. The used database.

Artist's name	Number of artworks
Hossein Behzad	34
Mahmoud Farshchian	50
Kamal-ol-Molk	79
Sohrab Sepehri	80
Manoucher Yektai	27
Mohsen Vaziri-moghaddam	39
Nasrin Khosravi	20
Bahman Mohasses	19

B. Experiments

Before applying the hierarchical approach, the CCR for each artist's artworks class is obtained using SVM. Then each stage of the hierarchy is assigned to one of the artists. Therefore, the proposed algorithm of our method will include eight levels which each of them represents the trained pattern of a specific artist. Later, SVM determines whether the new data belongs to the artist of a level or not.

The experiment consists of the following two main parts:

1. System training (with 80% of the database) in which the artist for each level of the hierarchical approach is determined and assigned to the level using SVM

2- Applying the system (with 20% of the database) in order to evaluate its performance.

1) System Training

The system training steps and hierarchy level assignment are as follows. The eleven features are extracted from each of 348 artworks of the database and the hierarchical SVM is created. Tables 2-4 illustrate the experiment results for first to third levels of hierarchical approach. According to Table 2, Hossein Behzad has the maximum of CCR 98.51% obtained by SVM. Therefore, he is selected as the victorious artist for the first level. After performing the above eight steps, the proposed algorithm levels have been obtained as shown in Table 5. The diagram of associated trained system is shown in Fig 2.

Table 2. Results of the first level of the hierarchical approach. Hossein Behzad is assigned to the first level.

Class name	CCR (%)
Behzad: 1, Others: 0	98.51
Farshchian: 1, Others: 0	85.25
Kamal-ol-Molk: 1, Others: 0	93.38
Sepehri: 1, Others: 0	96.71
Yektai: 1, Others: 0	92.21
Vaziri-moghaddam: 1, Others: 0	96.12
Khosravi: 1, Others: 0	94.18
Mohasses: 1, Others: 0	94.62

Table 3. Results of the second level of the hierarchical approach. Behzad's artworks are removed from the database and Sohrab Sepehri is assigned to the level.

Class name	CCR (%)
Farshchian: 1, Others: 0	86
Kamal-ol-Molk: 1, Others: 0	92.28
Sepehri: 1, Others: 0	97.74
Yektai: 1, Others: 0	91.03
Vaziri-moghaddam: 1, Others: 0	95.52
Khosravi: 1, Others: 0	93.23
Mohasses: 1, Others: 0	93.82

Table 4. Results of the third level of the hierarchical approach. Sepehri's artworks are removed from the training database of the second level and Nasrin Khosravi is assigned to the 3rd level.

Class name	CCR (%)
Farshchian: 1, Others: 0	84.65
Kamal-ol-Molk: 1, Others: 0	90.02
Yektai: 1, Others: 0	88.46
Vaziri-moghaddam: 1, Others: 0	93.7
Khosravi: 1, Others: 0	96.59
Mohasses: 1, Others: 0	91.53

Table 5. The proposed algorithm levels based on our database.

Level	Painter	CCR (%)
Level 1	Behzad	98.51
Level 2	Sepehri	97.74
Level 3	Khosravi	96.59
Level 4	Farshchian	94.41
Level 5	Mohasses	93.66
Level 6	Yektai	94.89
Level 7	Kamal-ol-Molk	93.58
Level 8	Vaziri-moghaddam	92.95

2) System Evaluation

20% of the database (70 artworks) are randomly selected and put in a separated matrix as the testing set. The trained system is evaluated using this dataset.

3) Results

We trained and tested the system 100 times (in each iteration, the train and test dataset are randomly selected). The accuracy of system is reported in Table 6.

Table 6. The result of testing system with 384 artworks from eight painters.

Minimum of CCR (%)	Maximum of CCR (%)	Mean of CCR (%)
77	91	84.21

IV. Conclusions

In this paper, a painting artist recognition system based on image processing and hierarchical SVM is proposed. The suggested system has widespread application in data classification. The output of such system is the overall classification of data at the hierarchical levels. This allows focusing individually on a specific class that is related to a hierarchy level. The system hierarchy is constructed based on correct classification rate of the trained pattern of class. This criterion has direct impact on assignment of a hierarchy level to a class and depends on selected features. Hence, features should be selected in such ways that express better description and distinction of database classes and consequently the associated levels.

The proposed method is evaluated on a set of 348 artworks form eight Iranian famous painters. The mean accuracy of system recognition is 84.21% and it is shown that the system is able to classify the painter of each artwork. As for future work, we would consider some features of frequency space obtained from wavelet transform in order to improve the performance of the system.

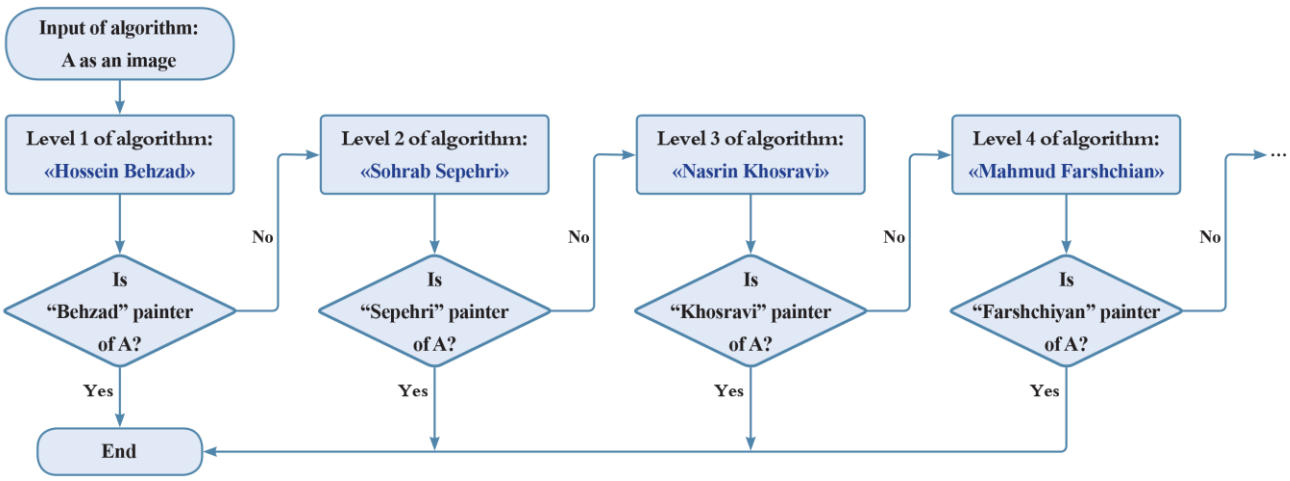

Fig 2. The digram of the proposed trained system.

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