AUTOMATIC RECOGNITION OF FREE HAND DRAWINGS BY EUGÈNE DELACROIX

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Abstract

Proof of authenticity of free hand drawings of artists is one of the major problems in history of arts. Usually the authentication of drawings is performed manually by experts based on visual inspection of typical features that are characteristic for the artist. This often leads to ambiguous results since the visual inspection is based on subjective criteria, experience, and background information.

Here we show how automatic pattern recognition methods can be applied to decide if a drawing belongs to the work of a certain artist. As example we compare drawings by Delacroix (1798 - 1863) with the work of other artists whose drawings show similar characteristics. Based on higher order features we are able to achieve a correct assignment to the artist for about 87% of the drawings.

1 Introduction

Authentication of artistic work is a major field in art history. After the death of famous artists often an increase in the number of works ascribed to them can be observed, e.g. the number of drawings ascribed to Michelangelo rose from 244 in 1911 up to 633 in 1980 [7]. Thus, a certification of the genuineness of a work is of high value.

For the authentication of paintings elaborated methods usually based on a physical analysis of the drawing material exist. However, for free hand drawings and sketches these methods do not lead to meaningful results because the drawing material is more commonly used. Often only a region or a time period can be determined by them. Hence, the authentication of a drawing is mainly based on the visual inspection of an expert. Since the drawings even of the same artist can look very different the result depends on subjective criteria, experience and background information about the life and work of the artist, and is very time consuming.

In this paper we show how automatic pattern recognition methods can be applied to decide if a drawing belongs to the work of a certain artist, thus supporting the art historian in his manual inspection. Our investigation is based on drawings by Delacroix and contemporary artists.

The paper is organized as follows: Section 2 describes the type of drawings our analysis is based on. Section 3 discusses the usability of different feature extraction methods for the authentication of drawings and sketches. In Section 4 we present a feature extraction method based on higher order features. Experimental results for the classification of the drawings by Delacroix and other artists are shown in Section 5. The paper finishes with a conclusion.

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2 Drawings

The data we used for our investigation are photographs of drawings and sketches by Delacroix and other artists, e.g. Liebermann, Bonnard, Janssen, Kirchner etc. They are drawn with coal, pencil or red chalk on white, light grey or cream coloured paper of different qualities. The size of the drawings varies between 6.5×8.8 cm and 47.1×73.2 cm. We scanned the photographs as binary images to exclude variations in contrast or intensity due to the variations in background or paint colour. The original size ratios of the drawings have been preserved in the scanned photographs, the resolution is 300×300 dpi. The content of the drawings differs largely for the two classes consisting of drawings made by Delacroix or other artists, respectively, as well as for the drawings within one class. E.g. we had drawings from the early years of Delacroix´s work, from the late years, neatly composed drawings, but also unfinished sketches. Figure 1 shows some examples of drawings by Delacroix and other artists from our database of 41 drawings (19 by Delacroix, 22 by other artists).

Figure 1: Examples of drawings by Delacroix (first row) and other artists (second row)

3 Feature Extraction Methods for Drawings

As in most recognition tasks we first try to find suitable features that can then be classified in a second step. So far there do not exist common feature extraction methods for the automatic inspection of drawings. In the literature the assignment of small unsigned oil paintings showing portraits to a set of possible artists

is reported [9]. Here the colours and the technique of painting, i.e. how the colours are put on the canvas (e.g. dotted or sketched), are used as features. Both cannot be applied to drawings.

The classification performed by art historians is mainly based on experience and intuition. They distinguish between artists forming the shape of an image by continuous contourlines and those using short lines to express movements. Perrig [8] has published a technique for the systematic manual analysis of drawings and applied it successfully to the analysis of drawings by Michelangelo. It consists in a detailed analysis of the length, thickness, and curvature of lines. Although this technique is also applied to drawings by other artists, it is often difficult for the art historians to determine meaningful features or to find a definite decision based on these properties. In many cases the features are ambiguous and the decision cannot be fixed on certain properties but is made by intuition.

Similar to drawings at least with respect to the material used is handwriting like signatures and numerals. In automatic signature verification many feature extraction methods have been applied and tested successfully [1, 2, 3]. However, the recognition process in signature verification focuses on the authentication of a single word that is rewritten in a more or less similar way. Therefore features can be applied that take into account this certain word as a whole like size and mean stroke direction or pressure and speed for dynamic signature verification [5]. This is not feasible in the authentication process of highly varying drawings.

Moreover, commonly used features for signature or numeral verification that take into account the length, thickness and curvature of lines or special points in the skeleton like fork points or cross points [6] can only be applied with a high computational effort to the automatic authentication of drawings. This is due to the fact that a drawing usually consists of a very large number of highly intersecting strokes where one line cannot be followed unambiguously. What may be even more serious is that parts of the strokes, depending on the type of pencil used and the pressure applied, can fall apart into clusters of single dots in the binarization process sometimes even appearing like noise. Then the lines first have to be reconstructed by expensive preprocessing methods.

For the authentication of drawings the extraction of more general features is important rather than high precision features. Therefore, here we propose a set of fast calculable features based on statistics of local features.

4 Features of Blackness-Distribution and Orientation

An important feature for the authentication of drawings may be the ratio of dark and bright areas in the drawing. Since the ratio of black to white pixels in a binarized drawing depends on the sujet and the binarization process the degree of blackness in subareas of a drawing has a certain significance.

For the calculation of features the drawing is divided into $M \times N$ subareas of equal size. Surplus pixels can be neglected due to the high resolution of the scanned drawings. For the subareas the ratio

$$\text{subratio} = \frac{\text{number of black pixels}}{\text{number of all pixels}}$$

is calculated. This value is then normalized by the ratio of black to all pixels for the whole drawing. From the resulting $M \times N$ values presenting a normalized measure of the average blackness of the subareas a histogram is calculated showing the distribution of the ratios over certain intervals. The histogram values fall into eight different bins consisting of the intervals $[0, 0.25], (0.25, 0.5], (0.5, 0.75], (0.75, 1], (1, 2], (2, 3], (3, 4], (4, \infty)$.

As an example the derived histograms for the two drawings in the first column of Figure 1 are shown in Figure 2.

The histograms show certain characteristics for the two classes of drawings by Delacroix and by other artists that can be represented by higher order features calculated from the histogram values. We use the following features:

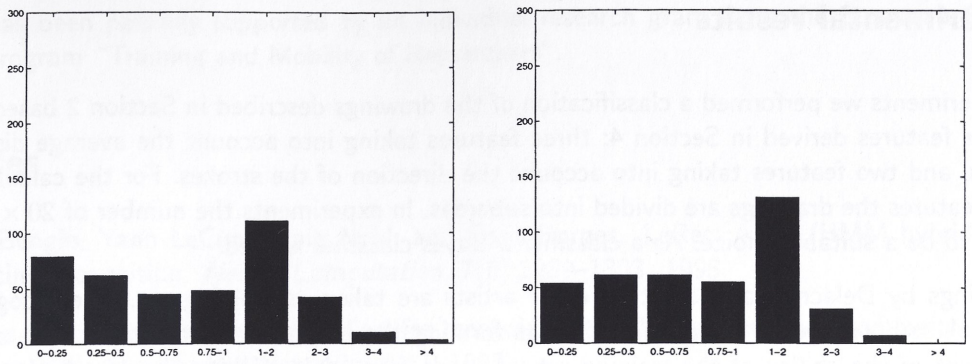

Figure 2: Histograms of the average blackness measure of the subareas for the two drawings in the first column of Figure 1 (left: Delacroix, right: Boulanger)

- difference of the third and fourth histogram value
- quotient of the fifth and fourth histogram value
- product of the first and fourth histogram value

Additionally the direction of the strokes in the drawings is taken into account by evaluating the results of a filtering operation with Kirsch-masks. They have been applied successfully to exploit the orientation information of numerals in [2]. The Kirsch-operator utilizes a set of eight convolution kernels to detect edges in one of the eight basic directions of an 8-neighbourhood [4]. An example for a Kirsch-mask for the detection of horizontal edges is:

5	5	5
-3	0	-3
-3	-3	-3

We consider only the number of pixels with value 15 in a drawing. In order to neglect the succession black-white or white-black for the edges we derive four directional features by summing the number of pixels with value 15 for corresponding Kirsch-masks. Thus, we get features representing a measure for the frequency of the occurrence of edges in one of the four directions

- vertical (|)
- right-diagonal (\)
- left-diagonal (/)
- horizontal (–)

A detailed analysis of the filtering results with the different Kirsch-operators on a subset of the drawings shows that the mean value for the vertical and left-diagonal edges of the drawings by Delacroix deviates significantly from the mean value of drawings by other artists. To enhance this fact two higher order features are computed from the four directional features: the product of the features for the vertical and left-diagonal edges, and the product of the features for the horizontal and right-diagonal edges.

Both types of features, those for the blackness distributions and those for the orientations, can be computed in a fast way directly on the scanned drawings without any preprocessing.

5 Experimental results

For the experiments we performed a classification of the drawings described in Section 2 based on the five higher order features derived in Section 4: three features taking into account the average distribution of black pixels, and two features taking into account the direction of the strokes. For the calculation of the first three features the drawings are divided into subareas. In experiments the number of 20×20 subareas has proved to be a suitable choice. As a classifier a Bayes classifier is used.

Eight drawings by Delacroix and eight by other artists are taken as training set. The recognition rates are then evaluated on the 25 remaining drawings forming the test set. In order to achieve a result that is independent of the choice of the training set we made four trials, picking the 16 training patterns at random. Tabular 1 shows the recognition rates.

Table 1: Recognition rates for different training sets

	1. test	2. test	3. test	4. test	average
Delacroix	11/11	9/11	8/11	9/11	84 %
other artists	12/14	13/14	14/14	11/14	89 %
average	92 %	88 %	88 %	80 %	87 %

It can be seen that on average 87% of the drawings can be recognized correctly as drawings by Delacroix or other artists, resp. For one test set even a recognition rate of more than 90 % is achieved. Due to the variety of drawings from different working periods of Delacroix and the strong variations among the drawings of other artists this is a very remarkable result. It is especially interesting as the features do not take into account the typical properties like length or curvature of lines which are proposed for the manual authentication by Perrig [8]. An analysis of the misclassified drawings shows that errors occur mainly for drawings where a very simple assignment can be performed by an expert due to the classic "closed-contour" property. On the other hand the classification of drawings that are very ambiguous like the two drawings in the first column of Fig. 1 where even art historians may fail does not pose a problem for the automatic classification based on the higher order features proposed here. Therefore the recognition system can serve as a good first classification for the authentication of drawings by Delacroix.

6 Conclusion

In this paper a method is presented for the automatic classification of free hand drawings. It uses higher order features based on local information about the ratio of dark and bright areas in the drawings and the main orientation of edges. Both types of features are calculated in a fast way directly on the scanned drawings without any preprocessing. No expensive analysis of contour lines etc. is necessary. Experiments with drawings by Delacroix and other artists both comprising a variety of drawing styles show that about 87 % of the drawings can be classified correctly into one of the two classes. As a remarkable result drawings that are difficult to classify for an art historian are classified correctly. Therefore the proposed recognition system could be applied for the authentication of drawings by Delacroix.

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