

Identification of Raphael's Paintings

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Introduction

Raphael was a famous and enormously productive Italian painter. During his short but splendid life, he created so many excellent and precious paintings. With the access to some photos of Raphael's work, some disputed ones and some forgeries, our team attempts to identify these works through statistical learning methods. To implement this task, the key point is to find appropriate features and effective learning methods.

Materials



Figure 1: Some samples

- ▶ Data information
 - ▷ The data is provided by Prof. Yang WANG from HKUST.
 - ▷ It contains 28 digital paintings, 12 of Raphael, 9 forgeries and the rest 7 are disputed.

Feature Extraction

- ▶ Edge Features
 - ▷ We use 18 filters in [H.Liu et al.(2015)] that consist of the low-pass filter, Sobel operators and second-order difference operators in different directions.
 - ▷ We take three moment statistics from the filtering result above as the features.They are (i) the mean of the entries in the coefficient matrix, (ii) the standard deviation of the entries in the coefficient matrix, and (iii) the percentage of the tail entries which are those entries that are more than one standard deviation from the mean.

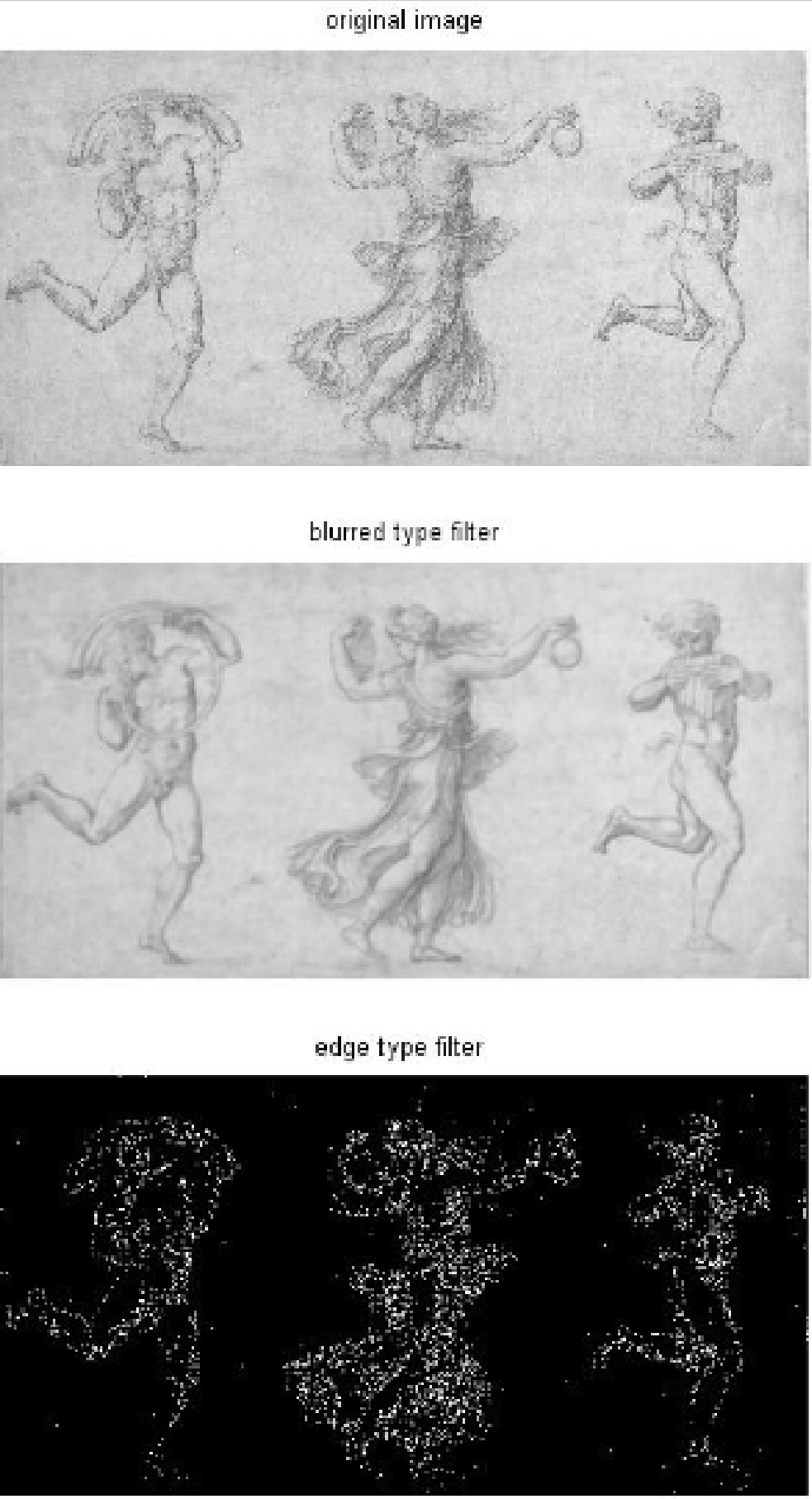


Figure 2: Edge Features

- ▶ HoG Features
The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image.

Modeling

- ▶ Modeling for the edge features
 - ▷ Feature Sletion
We think the coefficient matrices generated by the low pass filter and Sobel operators are most important. So we use the mean and the percentage of the tail entries of these matrices to build our model.
 - ▷ Dimension Reduction
We use MDS method with Manhattan distance to reduce the dimension of features.
 - ▷ Classifiers
We use classifiers including SVM, Tree and QDA to implement our task.
- ▶ Modeling for the HoG features
 - ▷ Full Features
Here we use all the features extracted above.
 - ▷ Modeling
The following procedures are the same as the first class.

Results of Identification for Raphael's work and Forgeries

▶ MDS Results

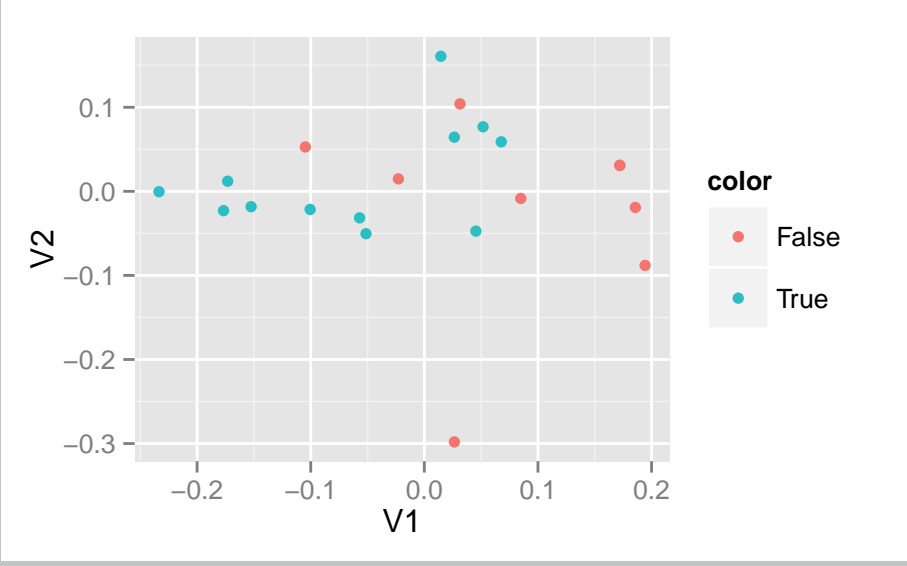


Figure 3: Edge Features

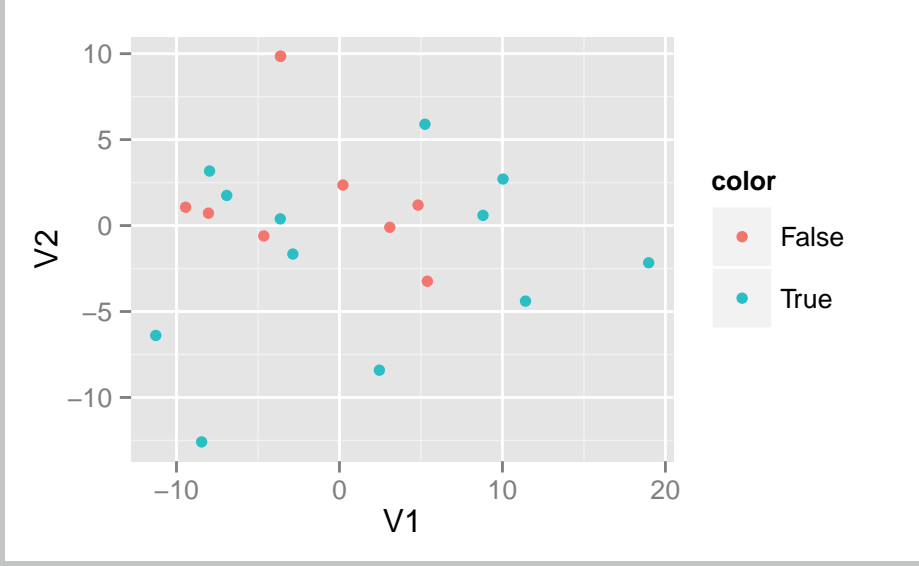


Figure 4: HoG Features

▶ Edge Features

Features Used	Methods	TPR(TP)	TNR(TN)	Accuracy
All features used	SVM	0.667	0.556	0.619
	MDS+QDA	0.583	0.667	0.619
With feature selection	MDS+Tree	1	0.556	0.810
	MDS+SVM	0.75	0.444	0.619
	MDS+QDA	0.833	0.556	0.714
	SVM	0.75	0.667	0.714

Table 1: Result for edge features

▶ HoG Features

Features Used	Methods	TPR(TP)	TNR(TN)	Accuracy
All features used	MDS+SVM	0.5	0.222	0.380
	MDS+QDA	0.833	0.778	0.810

Table 2: Result for HoG features

Results of identification for the Disputed Paintings

Disputed IDs	Based on Edge Features		Based on HoG Features
	MDS+Tree	SVM	MDS+QDA
1	1	1	1
7	0	0	1
10	0	0	1
20	0	0	1
23	0	0	0
25	1	1	1
26	0	0	0

Table 3: 1 represents True and 0 represents False

Conclusions

- ▶ For the first-order edge features, the model MDS cooperated with Tree gains the best result after feature selection.While for HoG features, a comparable result has been achieved by the model MDS cooperated with QDA without feature selection. We anticipate a significant improvement with feature selection for the HoG feature scenario, but how to do that still remains to be solved.
- ▶ The identification for the disputed 7 paintings indicates that the paintings, corresponding to IDs of 1, 23, 25, and 26, respectively has the same prediction based on the two class of features. So we think the identifications for these paintings are credible. As for the rest paintings, it needs further work to get more credible conclusions.
- ▶ Motivated by the work in [Gatys et al.(2015)], we have attempted to extract features through neural network method and as well got the styles of the pictures, but how to make judgement applying these styles need further work in the future.

References

- [H.Liu et al.(2015)] H.Liu et al., Geometric tight frame based stylometry for art authentication of Van Gogh paintings,Appl.Comput.Harmon.Anal,2015.
- [Gatys et al.(2015)] Gatys, L. A., Ecker,A. S., & Bethge, M. 2015, arXiv:1508.06576

Contribution List

- ▶ Li Yixin extracted the features, Yu Jun did the programming and Cheng Yuan made the poster.