MATH 6380O Project1

Image Classification with Extracted Feature

ZHANG Jianhui, FAN Min, ZHU Weizhi, ZHANG Hongming

Introduction & Objectives

This is the first project of MATH 6380O. The final objective of this project is training an classifier to distinguish Raphael paintings from fake ones.

In this project, we did research on different feature extraction methods, including scattering and pre-trained models. To clearly understand the extracted features, we visualized them with unsupervised methods. We also used that feature to train several classification models. We did our experiment on the Raphael's paintings dataset.

Our classification method mainly consists of three parts: (1) Data Sampling (2) Feature Extraction (3) Classification. We do a random sampling on the high resolution paintings to form our training dataset. Then we use some pre-trained CNN and pre-defined scatter networks as our feature extractor. Finally, we do classification task using some traditional supervised learning algorithm based on the feature extracted.

During test period, we test on each sample images of a painting, and then use a voting scheme to determine the final result of a painting.

Feature Extraction Parameter

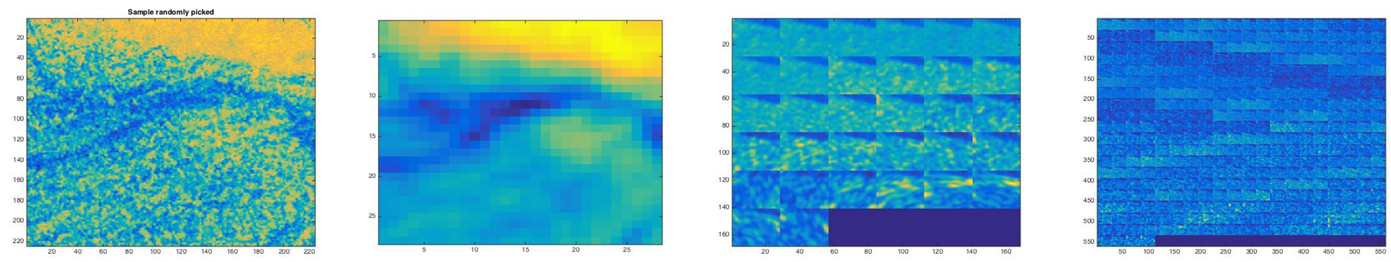
I. Feature Extraction by scattering net
Feature Dimension : 1251

II. Feature Extraction by pre-trained model(Resnet)
Feature Dimension : 2048

III. Feature Extraction by pre-trained model(Vgg)
Feature Dimension: 512

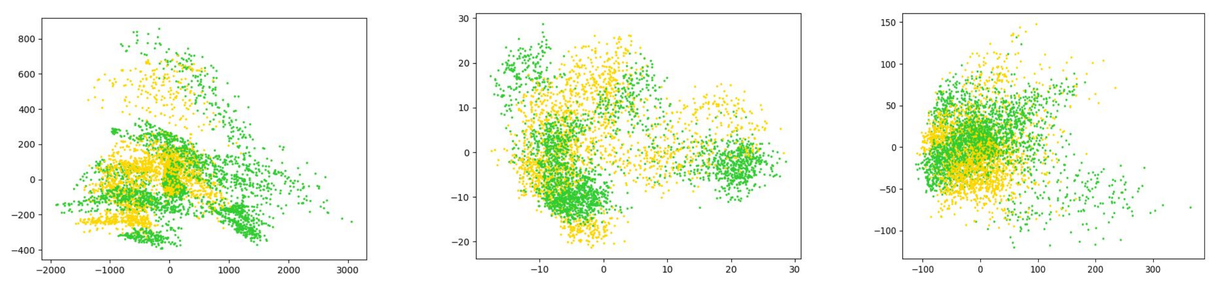
Feature Visualization

1. For the scattering transform, we randomly picked one sample from 5,400 samples cropped from 28 paintings as an example.

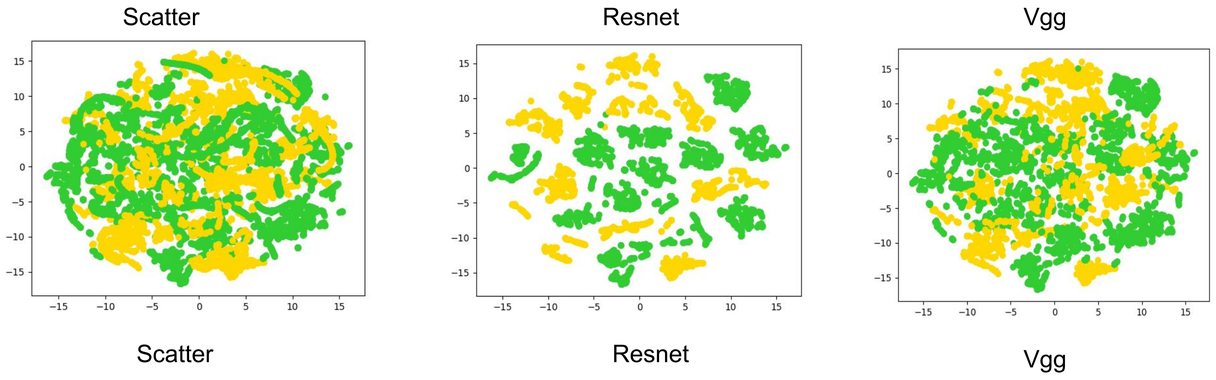


2. To clearly show the final extracted feature, we visualize them using different unsupervised methods. In our experiment, we visualized them with PCA and t-SNE. As introduced, we have three different features extracted from those samples. For all the samples cropped from Real painting, we label them with green and for all the samples cropped from Fake painting, we label them with yellow.

(1) PCA:



(2) t-SNE:



Data Prepare

- Data Sampling

First, we remove the paintings with "Unknow" label and use a "leave one out" scheme to choose training data and testing data.

Then we sample 200 images adaptively chosen (by setting an adaptive threshold on variance) of size 224 * 224 on each of the high resolution paintings to compose our training and test dataset. The whole dataset contains 4200 images labeled with "Raphael" and "Not Raphael". We then use leave one (group) out and 7-folds cross validation schemes to do estimation for test error.

The reason we sample data in this way are based on two reasons. On one hand, machine learning methods are hungry for data. It is not sufficient to use only 21 paintings. On the other hand, we believe that the key differences between Raphael's paintings and others lie in these small areas. For example, local texture and lines.

In order to get rid of noise picture during the sampling period, we also calculate the variance of the sampled image. If the variance is less than a pre-defined threshold, we skip it and do the random sample again.

Image classification with extracted feature

- Classification

We applied different traditional supervised learning methods on the extracted features.
For the features extracted by ResNet50 and VGG16, we trained KNN, logistic regression and SVM models to do the classification task.

For the features extracted by Scatter Network, we trained a SVM to do the classification task.

We use a "leave one out" scheme to test the final result. We train the models use 20 paintings and use it to predict the left paintings. We repeat this procedure for all the paintings, so that the 21 paintings can all be tested.

The final result is listed in the table below.

Feature	Method	Accuracy on samples	Accuracy on paintings
ResNet50	SVM	66.7%	65.8%
	KNN	71.4%	65.1%
	Logistic Regression	81.0%	71.4%
Scatter Network	SVM	77.3%	80.9%

Analysis & Conclusion

- The key assumption we made is that local features such as texture or partial lines could be very important for us to distinguish whether a painting is Raphael's. As shown in the experiment, we achieve acceptable accuracy in the painting classification task, which proves that such information is helpful and our assumption is correct.
- The feature extracted with scatter and those pretrained CNN models can be easily generalized to a lot of tasks. Even though the pre-trained model is not trained for the classification task, we can simply transfer them into our challenging painting classification task and achieve good result.

Individual Contribution

- ZHANG Jianhui: Training the classification model
- FAN Min: Feature Extraction with scatter
- ZHU Weizhi: Feature Extraction with pre-trained model
- ZHANG Hongming: Visualization of extracted feature

References

[1] Bruna J, Mallat S. Invariant scattering convolution networks[J]. IEEE transactions on pattern analysis and machine intelligence, 2013, 35(8): 1872-1886.

[2] Scikit-learn: Machine Learning in Python, Pedregosa et al., JMLR 12, pp. 2825-2830, 2011.

[3] Maaten, Laurens van der, and Geoffrey Hinton. "Visualizing data using t-SNE." Journal of machine learning research 9.Nov (2008): 2579-2605.