MATH6380P Project 1

Real or Fake? A Comparison Between Scattering Network & Resnet-18

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Introduction

Objective

Digital signal processing combined with machine learning provides us with a new way of identifying fake artworks. In this project, we aim to compare the effectiveness of the **Scattering Network** and **Resnet-18** in forgery detection.

Data

The data consists of 28 scanned images of sketches, where:

- 12 are attributed Raphael (genuine)
- 9 are NOT attributed to Raphael (fake)
- 7 are disputed

Methodology

Data Pre-processing

- **Random Cropping:** To get a sufficiently big data set, we randomly cropped 200 patches of size 224×224 from each labelled image to obtain a total of 4200 training samples.

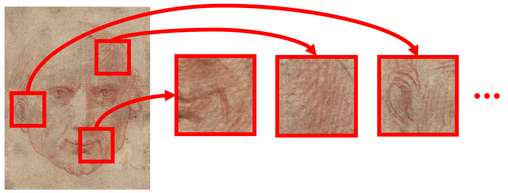

Figure 1. 200 random patches are extracted from each image.

Feature Extraction

- **Scattering Network (SN):** This was proposed by Bruna and Mallat [1]. Our scattering network contains 2 layers.
- **Resnet-18 (R18):** This was proposed by Microsoft [2]. For feature extraction, we only use the outputs from the convolutional layers with pretrained weights.

Classifiers

- **Logistic Regression (LR)**
- ***k*-Nearest Neighbours (KNN)**
- **Random Forest (RF)**
- **Support Vector Machine (SVM)**

Evaluation

- **Leave-one-out-cross-validation (CV):** We train our model on all but one labelled images, and test it on that one image. We repeat this for every labelled image.

Computing & Visualising Feature Vectors

Obtaining Feature Vectors

For each of the 4200 labelled patches, 2 feature vectors are computed:

- **Scattering Net:** Before being processed by SN, the images were first adapted to greyscale. The resulting feature vectors have 417 dimensions.
- **Resnet-18:** All images are first transformed into the RGB format. The resulting features have 512 dimensions.

Visualisation

We used 6 dimension reduction methods: PCA, MDS, ISOMAP, Standard LLE, Spectral Embedding, and t-SNE.

- **Resnet-18:** Whilst PCA and MDS do not show distinctive clustering, manifold learning methods like TSNE and ISOMAP can demonstrate that images of the same label are indeed grouped together.
- **Scattering Net :** This time, a 2-dimensional visualisation is not sufficient to demonstrate the separation of the two groups, possibly due to the fact the original points are not confined on a 2D manifold.

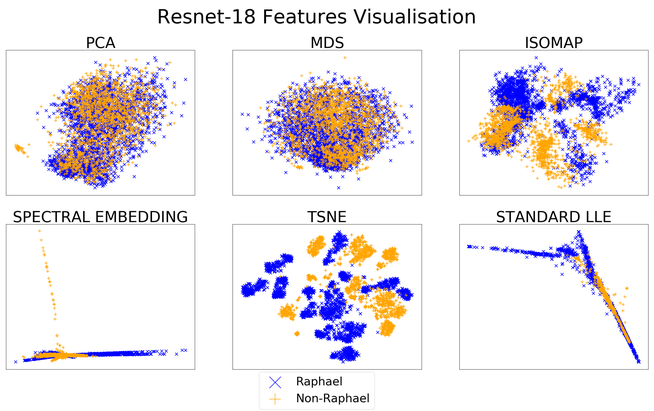

Figure 2. Visualisations of the feature vectors of R18 (upper) and SN (lower). **Blue** points are genuine Raphael's sketches, whereas **orange** ones are non-Raphael.

Classification Results

The classification results are summarised in Table 1. One can see that classification on R18 features produces more stable results, whereas that on SN features attained higher accuracies. From another viewpoint, LR and SVM are tend to be more reliable, while RF and KNN produced either unsatisfactory or drastic results. Overall, SN+LR produced the highest accuracy of 95.24%.

		Classifier			
		LR	KNN	RF	SVM
Feature Extraction Method	R18	80.95%	85.71%	76.19%	80.95%
	SN	95.24%	52.38%	71.42%	90.48%

Table 1. Accuracies obtained from the leave-one-out-cross-validation.

Judging the Disputed Drawings

Using our trained models, we made predictions on the 7 disputed drawings. Most of the classifiers deem image 1 and 23 as genuine, and image 10 is regarded by all as fake. However, the decisions for other images are split between the classifiers. R18 and SN classifications results agree on most images except for Image 20 and 26, which are classified as fake using R18 features, but genuine using SN features.

		Feature Extraction Method							
		R18				SN			
Classifier		LR	KNN	RF	SVM	LR	KNN	RF	SVM
Image ID	1	✓	✓	✓	✓	✓	✓	✓	✓
	7	✗	✗	✓	✓	✓	✗	✗	✓
	10	✗	✗	✗	✗	✗	✗	✗	✗
	20	✗	✗	✗	✗	✓	✗	✓	✓
	23	✗	✓	✓	✗	✓	✗	✗	✓
	25	✓	✓	✓	✓	✓	✓	✗	✓
	26	✗	✓	✗	✗	✓	✗	✓	✓

Table 2. Predictions of the unlabelled images. ✓ means genuine, ✗ means fake.

Figure 3. The disputed drawings.

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- **TAN Haiyi**: Implementing the scattering network for feature extraction

References

1. J. Bruna, S. Mallat. *Invariant Scattering Convolution Networks*. arXiv. 2012.
2. K. He, X. Zhang, S. Ren, J. Sun. *Deep Residual Learning for Image Recognition.* arXiv. *2015.* Retrieved from: https://arxiv.org/pdf/1512.03385.pdf.