Identification of Raphael's paintings from the forgeries

Sepanta Zeighami

1 Introduction

We were given a total of 28 paintings in high resolution, 12 of which were known to be Raphael's paintings and 10 of them were known to be not his paintings. The goal of the project was to decide whether the remaining 6 paintings were by Raphael or not.

The task can be reduced to a binary classification problem. We need to first perform feature extraction from the paintings, which are very high dimensional data, and then group the paintings into two sets, one paintings by Raphael and one not by him. We tested our models by leave-one-out cross validation. The result shows that we can reach up to more than 90 percent accuracy in this validation method.

2 Feature extraction

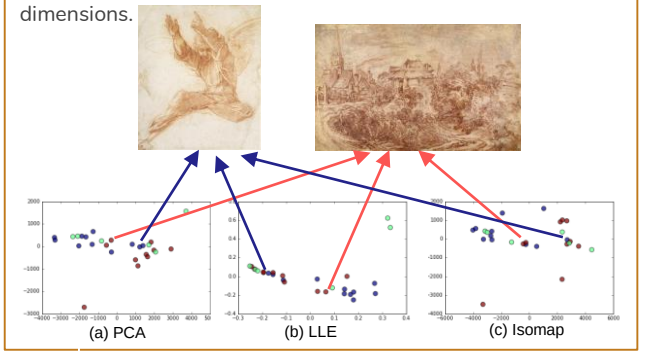
As the data is very high dimensional and there were no overtly explicit features in the given data that marked the difference between the original paintings and the forgeries, we performed general dimensionality reduction methods to reduce the data to a dimensionality in which clustering and classification methods could be effective. For this, tried dimensionality reduction using PCA, Isomap and LLE.

Our results show that based on the classification or clustering method used, either of these four methods can provide effective dimensionality reduction and can yield up to 90 percent accuracy.

Figures below show the result of the dimensionality reduction methods when the data is reduced to 2 dimensions. Even in this case, with a few exceptions, there are explicit groupings of the paintings into two groups.

In the figures below, blue points are original paintings, the red ones or forgeries and the green ones are to be decided. Two general clusters of blue and red points can be seen in this case, but the points that crossed the boundaries are hard to classify and they were commonly mistaken even in higher dimensions.

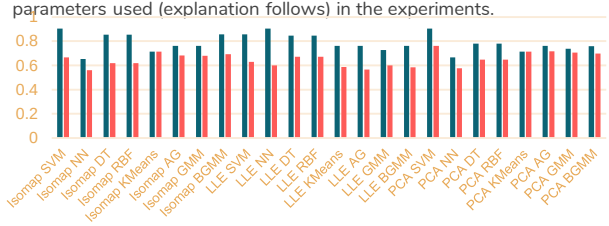
2 Feature extraction (Cont.)



(a) PCA (b) LLE (c) Isomap

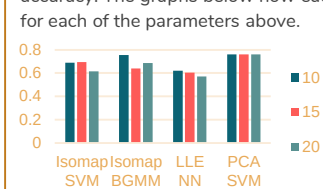
4 Clustering and Classification

We tried various clustering and classification methods on the result of the dimensionality reduced data. We used SVM, Neural Networks, Decision Trees and Gaussian Process classification methods and Kmeans, Agglomerative Clustering, Gaussian Mixture Model and Bayesian Gaussian Mixture Model clustering methods. We also tried convolutional neural networks but they did not work well and were excluded in our results. Figure below shows the result of each classification method together with the dimensionality reduction used. The accuracy values shown are maximum (blue) or averaged (red) of the parameters used (explanation follows) in the experiments.

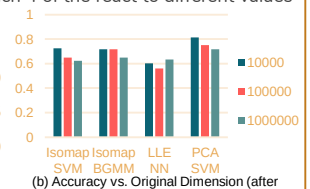


4 Clustering and Classification (Cont.)

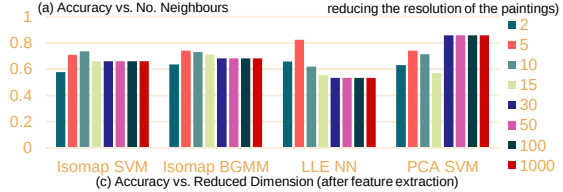
In our evaluation, in our dimensionality reduction, we tried different dimensionality of the output data in feature extraction, number of neighbours used (for Isomap and LLE only) and the resolution of the input data (we tried reducing the resolution of the paintings to increase the running time of the algorithms). Isomap with SVM and BGMM, PCA with SVM and LLE with NN could achieve more than 90 percent accuracy. The graphs below how each 4 of the react to different values for each of the parameters above.



(a) Accuracy vs. No. Neighbours



(b) Accuracy vs. Original Dimension (after reducing the resolution of the paintings)



(c) Accuracy vs. Reduced Dimension (after feature extraction)

5 Analysis & Conclusion

As the graphs above show, in case of LLE and Isomap the algorithms perform better when the dimensionality of the data is reduced to about 10, while for PCA dimensions higher that 30 perform better. Lower number of neighbours, in general, produce better results for both LLE and Isomap Furthermore, surprisingly, the algorithms perform better when the resolution of the original input painting is reduce.

After running the four methods that achieve more than 90 percent accuracy during cross validation on the paintings of unknown sources we obtained that paintings No. 1 and 21 were original and 7, 10,23 and 26 were forgeries. Only the classification of painting 1 and 10 were consistent among the four models while for the other 4 painting the vote of the majority was used for classification.