MATH6380p Project 1: Feature Extraction and Transfer Learning

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Source Code: github.com/shizhediao/MATH-6380P-Project1

Introduction

In this project, we explored the extracted features of Fashion-MNIST dataset using pre-trained deep neural network and scattering nets. With the extracted features, we firstly visualized them using PCA and t-SNE. Then we computed various statistics of the extracted features. Lastly, to study how extracted features and classifiers affect prediction accuracy, we performed an image classification task on Fashion-MNIST dataset using the extracted features and classifiers including Logistic Regression, SVM, LDA and Random Forest.

Fashion-MNIST Dataset

Fashion Mnist: Fashion-MNIST is a dataset of Zalando's article images, consisting of a training set of 60,000 examples and a test set of 10,000 examples. Fashion-MNIST is a direct drop-in replacement for the original MNIST dataset for benchmarking machine learning algorithms.

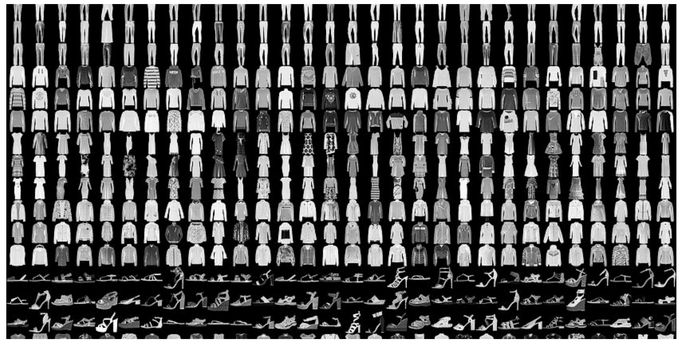
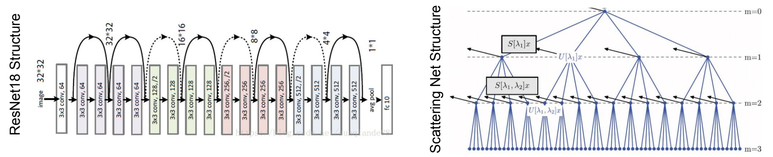


Figure 1. samples in Fashion-MNIST dataset

Feature Extraction

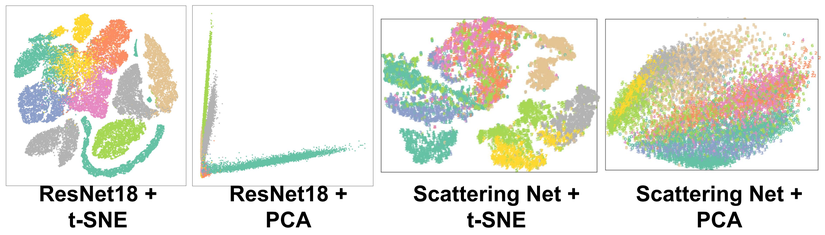
Scattering Net: A wavelet scattering network computes a translation invariant image representation, which cascades wavelet transform convolutions with non-linear modulus and averaging operators. We use 2D scattering transform for an image with size 28*28.

ResNet18: As for the deep model, we use the pretrained ResNet18 on ImageNet to extract feature map, which is the hidden features before the final linear lay in ResNet18.



Feature Visualization

We performed t-SNE and PCA on the two set of extracted features, and preserved the top 2 dimensions. The resulting plots are shown as Figure 2, and each label category are color-coded for clarity.



ResNet18 + t-SNE | ResNet18 + PCA | Scattering Net + t-SNE | Scattering Net + PCA

Figure 2. applying t-SNE and PCA on extracted features

Statistics of Extracted Features

To better understand extracted features, we computed some statistics of the extracted features. Table 1 listed all the statistics which are scalar values.

	ResNet18	Scattering Net
contraction of within class variation (NC1)	-22536871	133438243
closeness to equal-norms of class-means	0.23064	0.23645
closeness to maximal-angle equiangularity	0.28622	0.53371

Table 1. Some statistics of Extracted Features

More statistics can be found in our submitted ipynb file.

Image Classification

To study how extracted features and classifiers affect prediction accuracy, we performed Logistic Regression, Support Vector Machine, Random Forest and Linear Discriminant Analysis on ResNet18's and Scattering Net's features and raw Fashion-MNIST features. Results are shown in Figure 3.

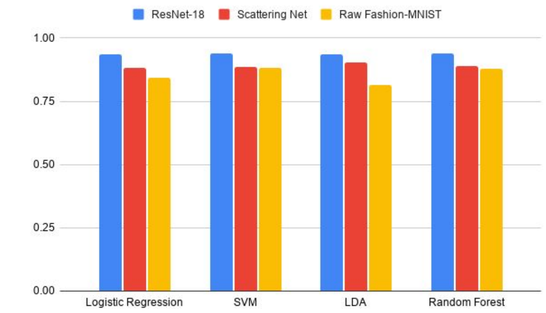


Figure 3. Image Classification results

Analysis

Feature Visualization: From Figure 2, we can observe that points from the two ResNet18 plots forms better clusters comparing to ones from the two Scattering Net plots, which advises that extracted features from ResNet18 has better quality. Then, by comparing plots of t-SNE with plots of PCA, we can see points processed by t-SNE can forms better clusters.

Image Classification: The results of ResNet18 outperforms ones from Scattering Net and raw Fashion-MNIST across all classifiers. This could be because ResNet18 is a more sophisticated model comparing with Scattering Net and thus the quality of its extracted features is higher than all other involved features. The performances of features on different classifiers are consistent, which hints that the involved classifiers doesn't have much impact on accuracy performance, at least in the Fashion-MNIST image classification task.

Contribution

Shizhe Diao: Feature extraction, feature visualization, statistic of features
Jincheng Yu: Feature extraction, feature visualization, statistic of features
Duo Li: Feature extraction, Image Classification
Yimin Zheng: Image Classification, Analysis

Reference

LeCun, Y., Cortes, C., & Burges, C. J. (2010). MNIST handwritten digit database.

Xiao, H., Rasul, K., & Vollgraf, R. (2017). Fashion-mnist: a novel image dataset for benchmarking machine learning algorithms. *arXiv preprint arXiv:1708.07747*.