
Principles of Data Science Project 1

Dimension Reduction

Hongzhou Liu
517030910214
deanlh@sjtu.edu.cn

Xuanrui Hong
517030910227
aaa@bbb.ccc

Qilin Chen
517030910155
1017856853@sjtu.edu.cn

To Xuanrui Hong:

Method
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To Qilin Chen:

ExperiementFeature SelectionConclusionXuanrui HongFeature Selectionpushgit pull 24
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- Prj1/ResultSVMSVMRBF2
- Baselinebaseline
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- SVMSVM
- AutoEncoderPrj1/Projection/AutoEncoder.py
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Abstract

TODO: Hongzhou Liu

1 Method

1.1 Feature Selection

1.1.1 Select-k-best

SelectKBest is one of the methods of univariate feature selection, which works by selecting the best features based on univariate statistical tests. It removes all but the k highest scoring features.

1.1.2 Variance Threshold

VarianceThreshold is a simple approach to feature selection. It removes all features whose variance doesn't meet some threshold. The principle is that features with small variance often contain less data information.

1.1.3 Tree-based Selection

Tree-based feature selection combines SelectFromModel and ExtraTreesClassifier. SelectFromModel is a meta-transformer that can be used along with any estimator that has a *coef_* or *feature_importances_* attribute after fitting. The features whose *coef_* or *feature_importances_* values are below the provided threshold parameter are considered unimportant and removed. ExtraTreesClassifier can be used to compute feature importances, which happens to cooperate with SelectFromModel to discard irrelevant features.

1.2 Feature Projection

1.2.1 PCA

Principal component analysis is one of the most widely used data dimensionality reduction algorithms. It performs a linear mapping of the data to a lower-dimensional space in such a way that the variance of the data in the low-dimensional representation is maximized.[1] Formally, the optimization goal is

$$\max_v \frac{1}{n} \sum_{i=1}^n (v^T x_i)^2 = \frac{1}{n} v^T X X^T v \quad (1)$$

where v is the new axis.

$$s.t. \quad v^T v = 1 \quad (2)$$

Using lagrange Multiplier we can get

$$X X^T v = \lambda v \quad (3)$$

We can see that v is the eigenvector of $X X^T$, and λ is the corresponding eigenvalue. Therefore, v can be calculated by performing eigenvalue decomposition to the co-variance matrix $X X^T$. Then we can get the data after dimensionality reduction.

1.2.2 Kernel PCA

In general, principal components analysis is suitable for linear dimensionality reduction of data. Kernel PCA can achieve nonlinear dimensionality reduction of data and is used to process linear inseparable data sets.

The general idea of KPCA is: for the matrix in the input space, we first use a non-linear mapping to map all samples in a high-dimensional or even infinite-dimensional space, and then perform PCA dimensionality reduction in this high-dimensional space.

1.2.3 LDA

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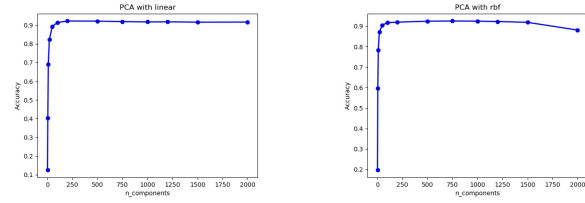
1.3 Feature Learning

1.3.1 t-SNE

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1.3.2 LLE

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(a) metric Mean Rank comparison on dataset Freebase (b) metric Mean Rank comparison on dataset AceKG

Figure 1: Mean Rank and Hits

1.3.3 AutoEncoder

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2 Experiment

2.1 Baseline

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Training Set : Test Set = 6:4

Linear SVM: Best $C = 0.002$, best accuracy = 0.932815 (baseline)

Kernel SVM with RBF kernel: Best $C = 5.0$, best accuracy = 0.935160 (baseline)

2.2 Feature Selection

2.2.1 Select-k-best

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2.2.2 Variance Threshold

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2.2.3 Tree-based Selection

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2.3 Feature Projection

2.3.1 PCA

Principal component analysis(PCA) is the most typical feature projection method based on dimension reduction, since PCA provides a roadmap for how to reduce a complex data set to a lower dimension to reveal the sometimes hidden, simplified dynamics that often underlie it. Kernel principal component analysis(kernel PCA) provides an extension of traditional PCA using techniques of kernel methods, which project source data into a higher dimensional space, providing with better reduction and classification performance. In this section, two experiment settings can derive from the rule: We use kernel PCA on different number of aim component [2, 5, 10, 20, 50, 100, 200, 500, 750, 1000, 1200, 1500, 2000], and we give our results on two types of kernel: linear kernel and radial basis function kernel. We adopt classification accuracy as metric in this section.

2.3.2 LDA

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2.4 Feature Learning

2.4.1 t-SNE

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2.4.2 LLE

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2.4.3 AutoEncoder

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3 Conclusion

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Acknowledgement

References

- [1] Karl Pearson. Liii. on lines and planes of closest fit to systems of points in space. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, 2(11):559–572, 1901.