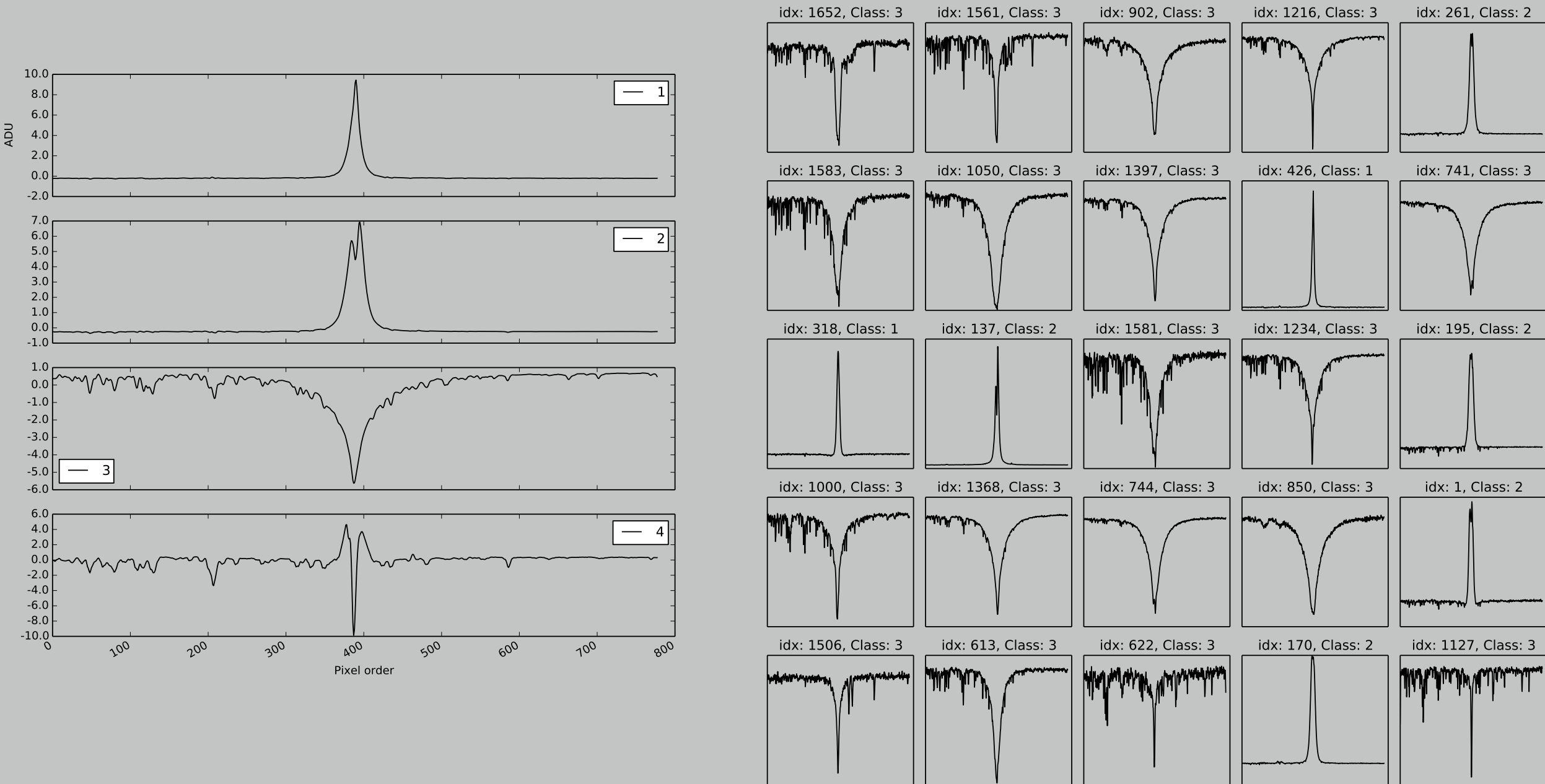


Objectives

- 1. Classify emission star spectra based on H- α line profile.
- 2. Compare methods for dimensionality reduction.
- 3. Tune classifier parameters.

Introduction

There are 1805 manually classified spectra from Ondřejov observatory divided into 4 categories based on profile of the spectra line. We want to train a svm classifier to automatically categorize the rest. Figure on the left shows the average spectrum in each category and on the right there are samples of individual spectra.

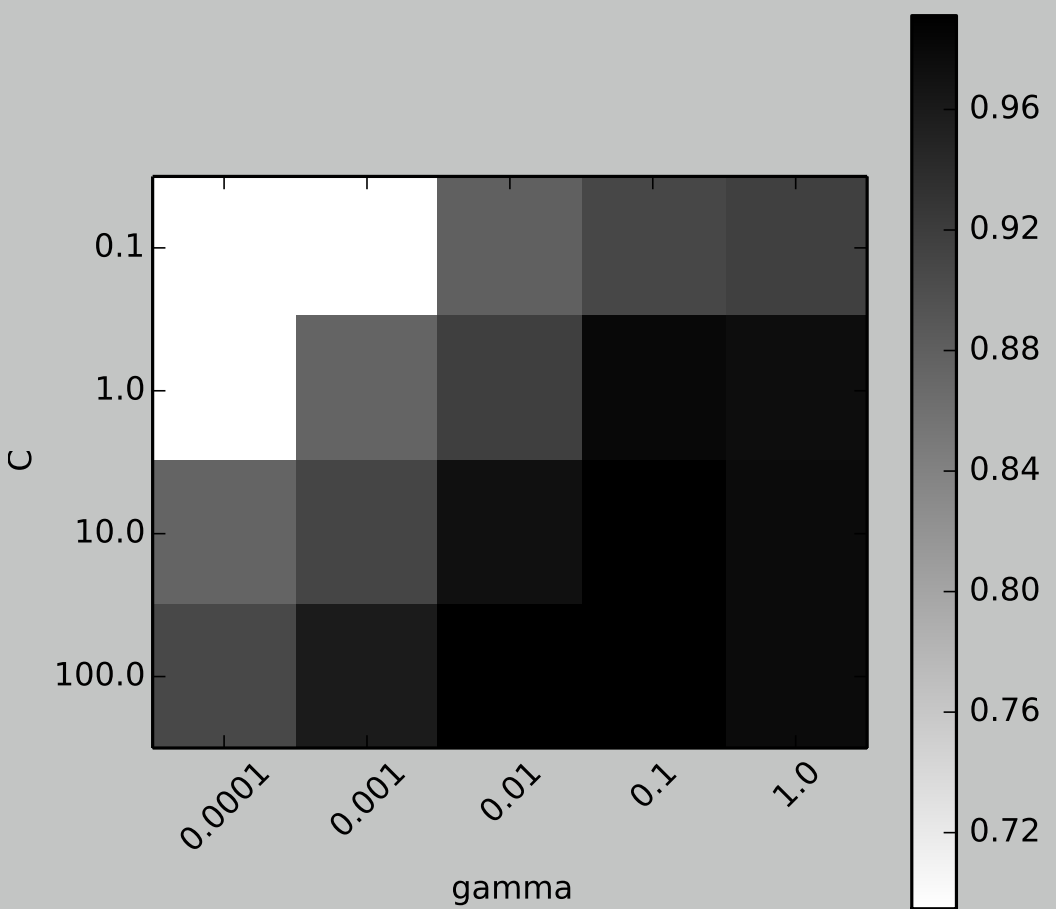


Dimensionality Reduction

- Each spectrum has 778 points. Different approaches were tested for dimensionality reduction.
 - PCA: Principal component analysis. Linear dimensionality reduction using Singular Value Decomposition of the data and keeping only the most significant singular vectors to project the data to a lower dimensional space.
 - Isomap: Isometric Mapping. Can be viewed as an extension of Multi-dimensional Scaling (MDS) or Kernel PCA. Isomap seeks a lower-dimensional embedding which maintains geodesic distances between all points.
 - LLE: Locally linear embedding seeks a lower-dimensional projection of the data which preserves distances within local neighborhoods. It can be thought of as a series of local Principal Component Analyses which are globally compared to find the best non-linear embedding.

Parameters tuning

- Support Vector Machines (SVM) was used as a classifier with rbf kernel ($\exp(-\gamma|\mathbf{x} - \mathbf{x}'|^2)$). Grid search was used to find optimal values for C and γ parameters. There is an example of heatmap for optimal parameters for data reduced by Isomap method.



Classification

- Data were split into training (75%) and testing (25%) sample. Reports for different reduction approaches are shown below compared to non-reduced data sample. Precision = $tp / (tp + fp)$, recall = $tp / (tp + fn)$, f1-score = $2 * (precision * recall) / (precision + recall)$ where tp is true positive, fp false positive and fn false negative.

Category	Precision	Recall	f1-score	Support
1	0.95	0.95	0.95	61
2	0.96	0.96	0.96	74
3	1.00	1.00	1.00	303
4	0.93	0.93	0.93	14
avg/total	0.98	0.98	0.98	452

Table 1: Classification report without dimensionality reduction

Category	Precision	Recall	f1-score	Support
1	0.89	0.95	0.92	61
2	0.96	0.91	0.93	74
3	1.00	1.00	1.00	303
4	1.00	0.93	0.96	14
avg/total	0.98	0.98	0.98	452

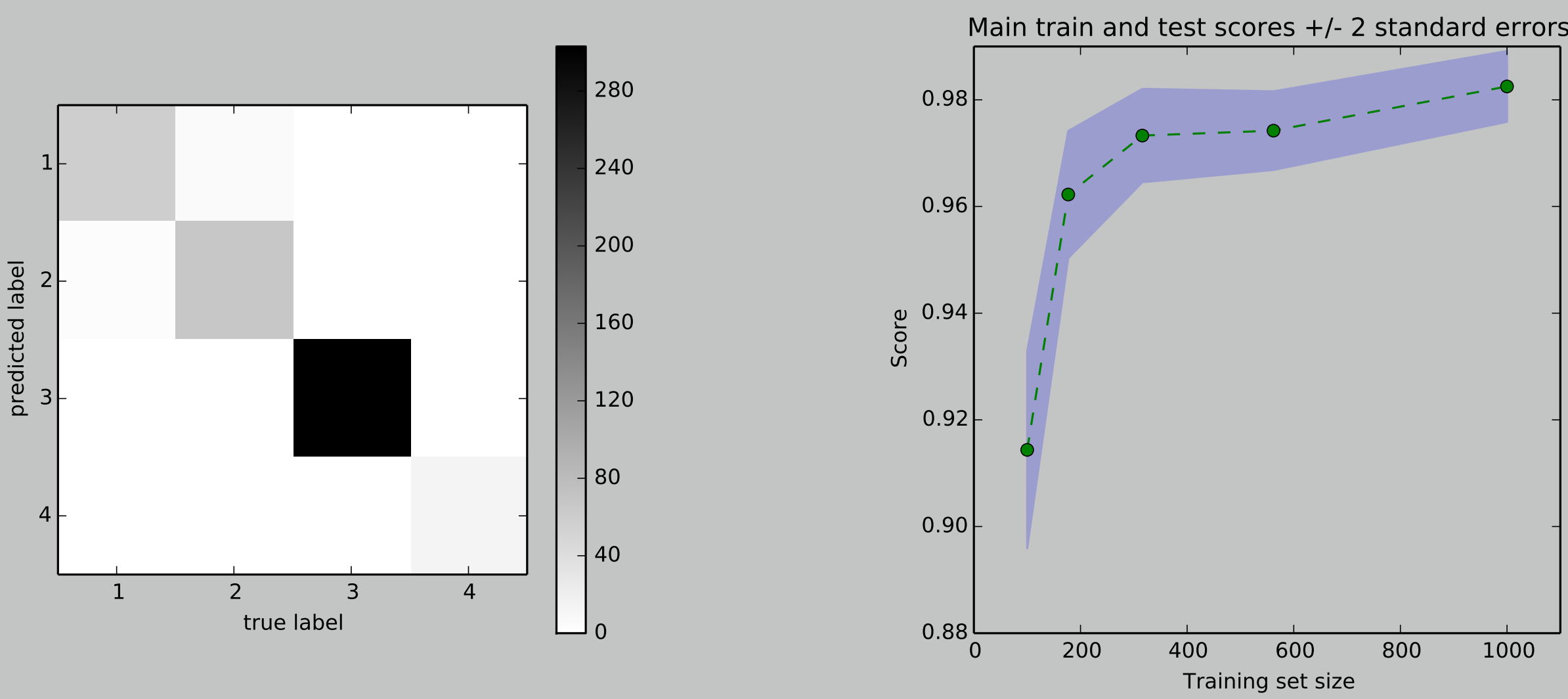
Table 2: ISOMAP Classification report

Category	Precision	Recall	f1-score	Support
1	0.97	1.00	0.98	61
2	1.00	0.97	0.99	74
3	0.99	1.00	1.00	303
4	1.00	0.86	0.92	14
avg/total	0.99	0.99	0.99	452

Table 3: PCA Classification report

Category	Precision	Recall	f1-score	Support
1	0.91	1.00	0.95	61
2	0.99	0.92	0.95	74
3	1.00	1.00	1.00	303
4	0.92	0.86	0.89	14
avg/total	0.98	0.98	0.98	452

Table 4: LLE Classification report



Conclusion

- It is possible to dramatically reduce the number of dimensions of spectra in classification problem (here from 778 to 10).
- PCA, Isomap, LLE and has similar effects in this classification problem.
- It is always important to tune corresponding hyperparameters.

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