CS 7641 Machine Learning
Assignment 3

Philip Bale
pbale3

Due Sunday April 1st, 2018 11:59pm

Introduction

This assignment explores unsupervised learning and dimensitonality reduction. It begins by examining clustering algorithms, specifically k-means and expectation maximization. It then proceeds to cover four dimensionality reduction algorithms: principal components analysis, individual components analysis, randomized projections, and random forests. After running these six algorithms on the original datasets and observing the results, the results are then piped into a neural network learner for further examination.

Datasets chosen

The datasets chosen were the same datasets chosen for assignment 1. The first dataset is the US permanent visa dataset. This dataset is interesting due to its potential to aid in the visa application process from a cost and time savings potential. It could also enable confidence in those interested in applying for a US permanent visa but doubting their chances of acceptance. At the end of the day, the goal is it to try to determine the application result before time, money, nd other resources are spent.

The second dataset is a home sale price prediction dataset taken from an ongoing Kaggle competiton. This dataset is interesting for two primary reasons: real-world applicability and participating in a Kaggle challenge. First, modeling home prices is both a difficult and lucrative task. If one can succesfully model home sale prices on large sets of data, he/she can make large amounts of money investing in real estate when he/she detects outliers in listed price vs. what it is expected to sell for. This applies to flipping, investing, and remodeling. Second, the dataset is part of an ongoing Kaggle competition that does not have a winning solution yet. By taking part of the competition, the dataset presents the opportunity to work towards a winning solution and advance ones algorithms over time.

Part 1: Clustering Algorithms

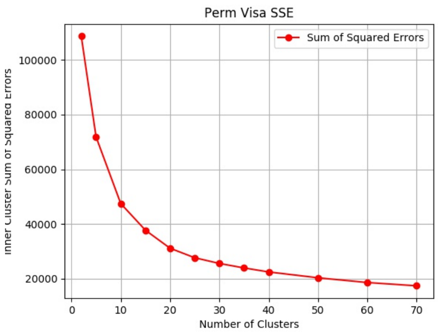
Introduction

K-means clustering is the first algorithm applied to the datasets and expectation maximization is the second. Both algorithms work by clustering: gathering groups of instances together based upon their features. The rationale is that similar instances will likely be labeled the same way–such as identical visa applications obtaining the same outcome.

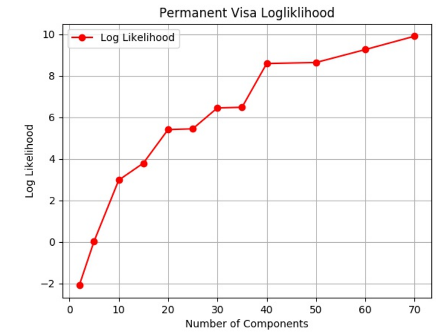
1) k-means clustering

Overview

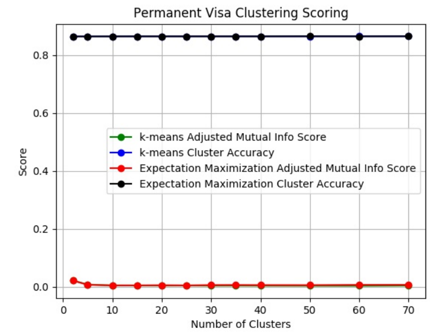
K-means works by clustering n instances into k-clusters of similarity using least-squares Euclidean distance between the instances. In practice, the algorithm converges on 'mean' for each cluster that is representative of the members of that cluster. A variety of cluster sizes were tested to find the best parameters possible.



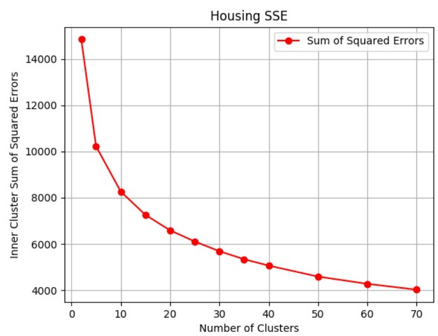
Perm Visa Sum of Square Errors for Clusters vs. # Clusters



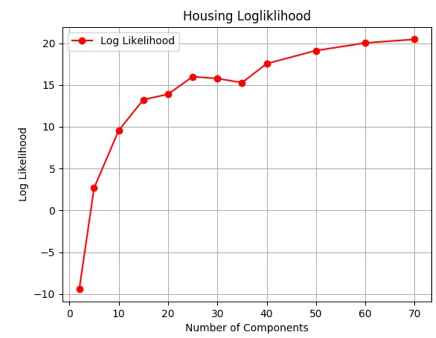
Perm Visa Log Liklihood vs. # Components



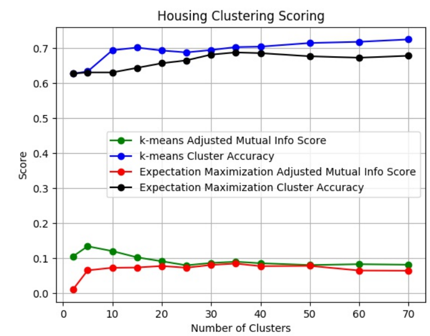
Perm Visa Scoring for k-means and expectation maximization



Housing Sum of Square Errors for Clusters vs. # Clusters



Housing Log Liklihood vs. # Components



Housing Scoring for k-means and expectation maximization

k-Means Analysis

Text

Clusters	**2**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**50**	**60**	**70**
PERM VISA												
SSE	108717	71834	47453	37701	31090	27611	25517	23874	22410	20267	18532	17331
Log Liklihood	-9.44	2.67	9.57	13.25	13.90	16.01	15.78	15.29	17.56	19.12	20.04	20.47
k-Means AMI	0.022	0.008	0.005	0.005	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004
k-Means ACC	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865
EM AMI	0.022	0.007	0.005	0.005	0.006	0.005	0.006	0.007	0.006	0.006	0.007	0.007
EM ACC	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865	0.865
HOUSING												
SSE	14840	10217	8265	7256	6589	6106	5687	5339	5063	4589	4276	4024
k-Means AMI	0.105	0.134	0.120	0.103	0.091	0.080	0.086	0.090	0.086	0.081	0.083	0.081
k-Means ACC	0.628	0.634	0.695	0.702	0.694	0.688	0.695	0.704	0.705	0.715	0.719	0.726
EM AMI	0.010	0.065	0.073	0.073	0.078	0.073	0.081	0.085	0.077	0.078	0.065	0.064
EM ACC	0.628	0.631	0.631	0.644	0.657	0.666	0.682	0.688	0.686	0.677	0.673	0.679

Table of Housing Data Results for Cluster

2) Expectation Maximization

Overview

Expectation Maximization is the second algorithm applied to the datasets and, similar to k-means, is a clustering algorithm. Expectation Maximization works by iteratively finding the maximum liklihood of parameters leading to a labeling of an instance despite possibly not having all data or parameters. For our examples, we used Scikit-learn's Gaussian mixture models to implement the Expectation Maximization algorithm. A varying number of mixture components (or number of distributions) were used to determine the best possible parameters for the clustering.

Expectation Maximization Analysis

Text

Part 2: Dimensionality Reduction Algorithms

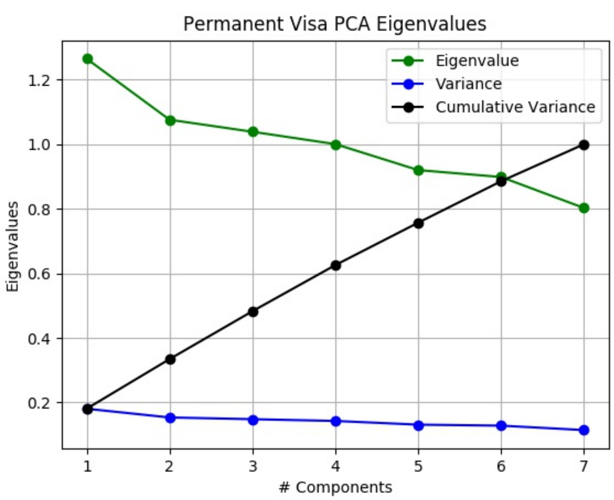
Introduction

Part 2 deals with dimensionality reduction algorithms. The four algorithms used are principal components analysis, individual components analysis, randomized projections, and random forests. After running the algorithms on both datasets, an analysis is provided on the results.

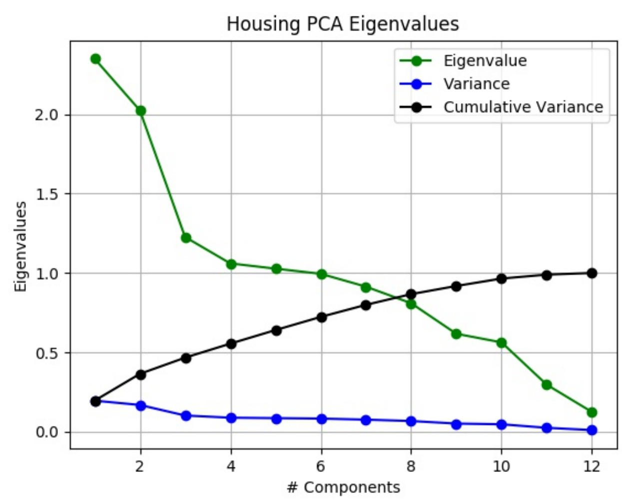
1) Principal Components Analysis (PCA)

Overview

The first dimenstionality reductation algorithm, Principal component analysis is a statistics approach to finding vectors that maximize variance and thus help to determine components that are correlated. Each subsequent component is found with the intent to be orthoganal to the preceding component. The resulting eigenvalue matrix from PCA is therefore maximized for covariance.



Permanent Visa Principal Components Analysis



Housing Principal Components Analysis

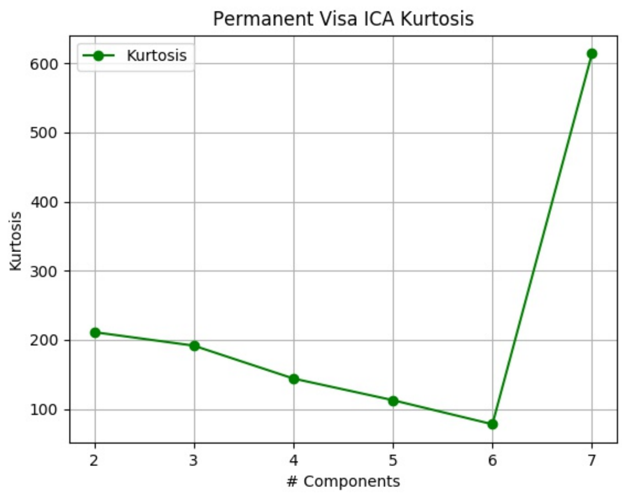
Analysis

IText

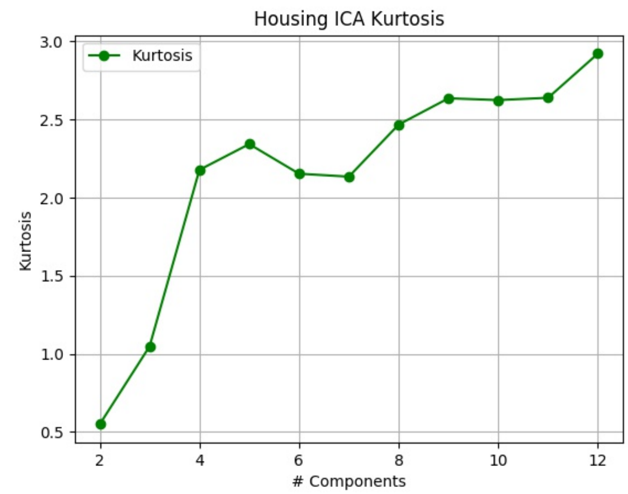
2) Independent Components Analysis (ICA)

Overview

The second dimensionality reduction algorithm, independent components analysis, is an approach to separating a mixture of a data into appropriate subcomponents. As discussed in lecture, a good example of what ICA is used for is the cocktail problem; where one needs to separate various sounds into their sources: a tv show, humans, car noises, etc. Kurtosis is used as a measurement of how gaussian the derived components are.



Permanent Visa Independent Components Analysis



Housing Independent Components Analysis

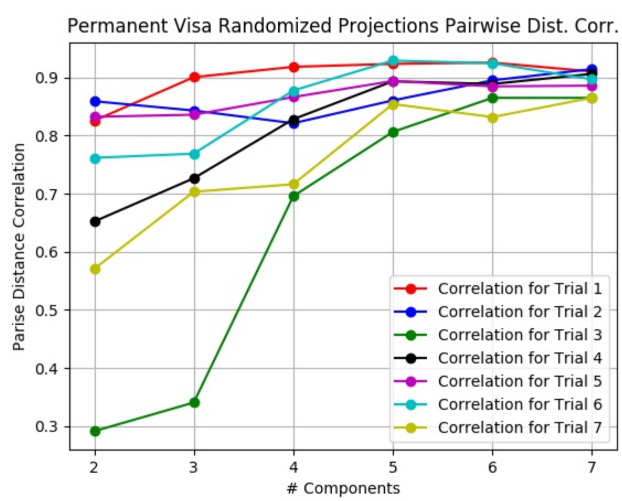
Analysis

IText

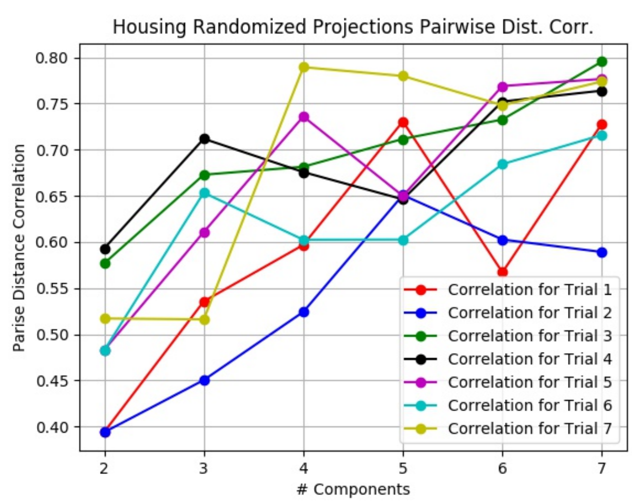
3) Randomized Projections

Overview

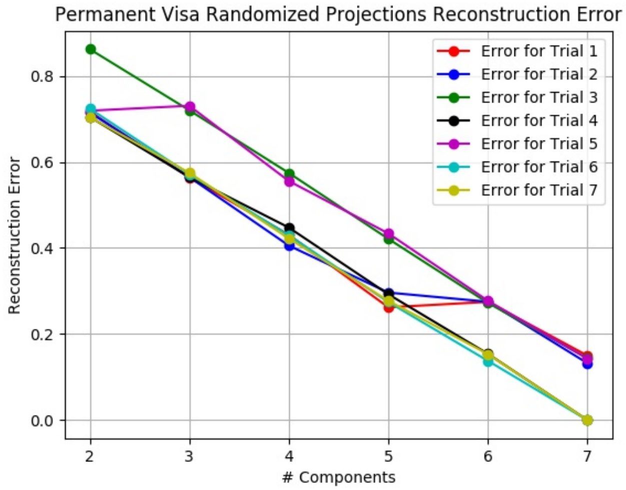
The third dimensionality reduction algorithm, randomized projections, is an approach that randomly generates a projection matrix that attempts to create a lower dimension representation of the data that is approximately accurate to its original state. By varying the number of components to project, we can run varoius tests on how well the lower dimension data captures the original.



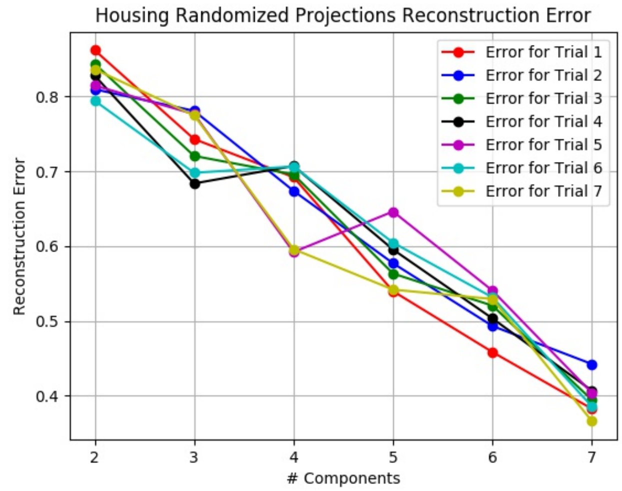
Permanent Visa Randomized Projections Pairwise Correlation



Housing Randomized Projections Pairwise Correlation



Permanent Visa Randomized Projections Reconstruction Error



Housing Randomized Projections Reconstruction Error

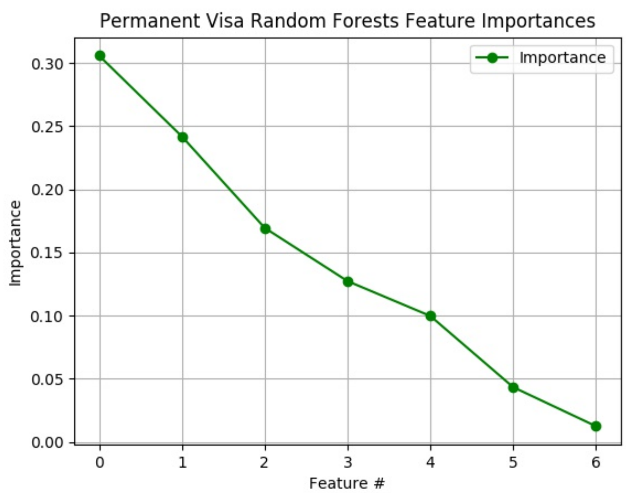
Analysis

IText

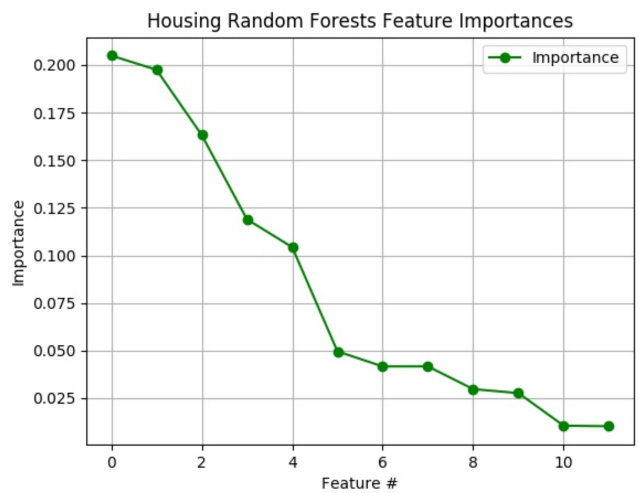
4) Random Forest Feature Selection

Overview

The fourth, and last, dimensionality reduction algorithm, random forest feature selection, is an approach that uses an ensemble of decision trees conditioned on different features. By training the decision tree and observing the impact of each feature by its ability to classify data correctly, we can select the most important features and disregard unimporant features.



Permanent Visa Random Forest Feature Importances (Descending Order)



Housing Random Forest Feature Importances (Descending Order)

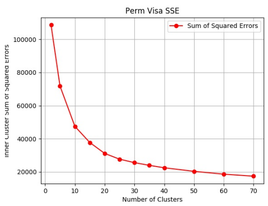
Analysis

IText

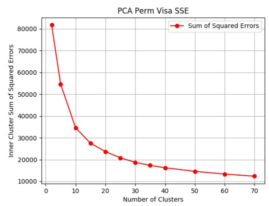
Part 3: Dimensionality Reduction and Clustering

Overview

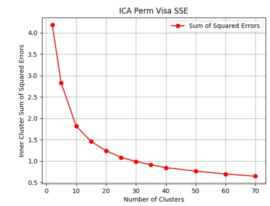
k-Means after Dimensionality Reduction



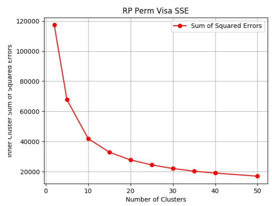
Original Visa Data



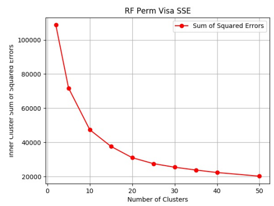
PCA



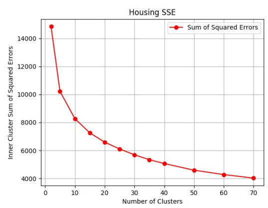
ICA



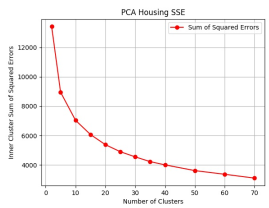
Randomized Projections



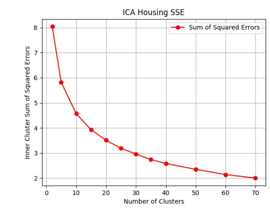
Random Forest



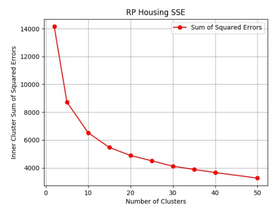
Original Housing Data



PCA



ICA



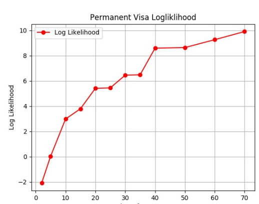
Randomized Projections

Random Forest

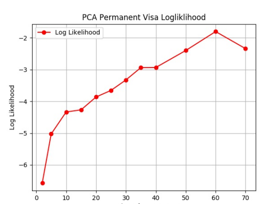
SSE Analysis

Text

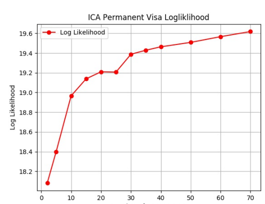
Expectation Maximization after Dimensionality Reduction



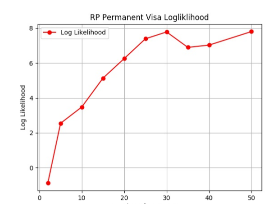
Original Visa Data



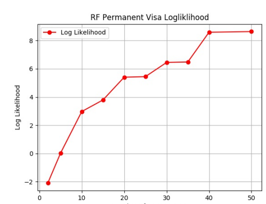
PCA



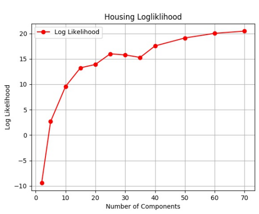
ICA



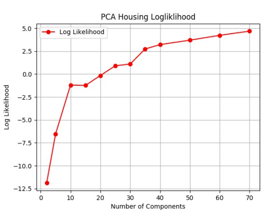
Randomized Projections



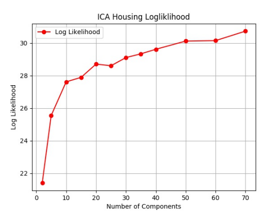
Random Forest



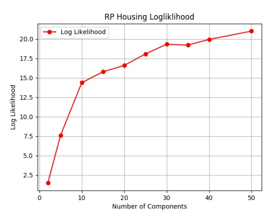
Original Housing Data



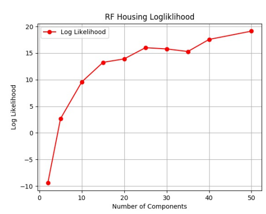
PCA



ICA



Randomized Projections



Random Forest

PCA Analysis

Text

Conclusion

Todo conclusion