Term Project

Hidden Markov Models and Anomaly Detection

Group 15

Tasks

1. Principal Component Analysis
2. Training and Testing Hidden Markov Models
3. Anomaly Detection

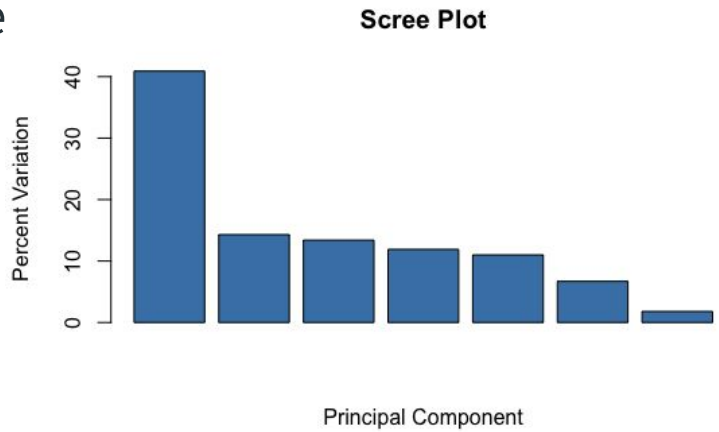
1.

Principal Component Analysis

1. Reduces dimensionality of data
2. Retains patterns and trends
3. Simplifies data analysis

Principal Component Analysis

1. Each component is responsible for certain percentage of variability
2. Pick the component with the highest percentage



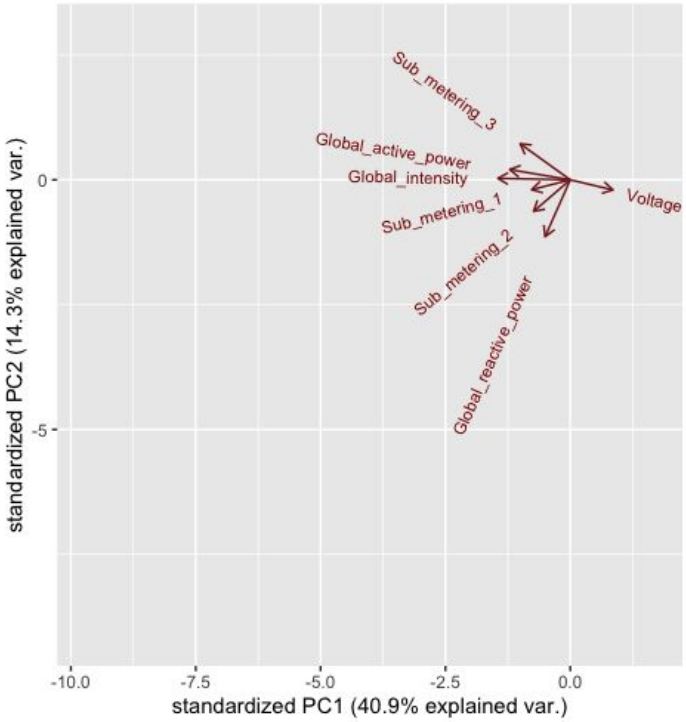
Principal Component Analysis

Variables	Correlation
Global active power	-0.46
Global reactive power	-0.19
Voltage	0.33
Global Intensity	-0.55
Sub metering 3	-0.29
Sub metering 2	-0.28
Sub metering 3	-0.38

Loading values of PCA 1

Principal Component Analysis

1. Vectors represent the coefficient of the variable on the principal components
2. Vectors pointing in the same direction have similar effect on the component



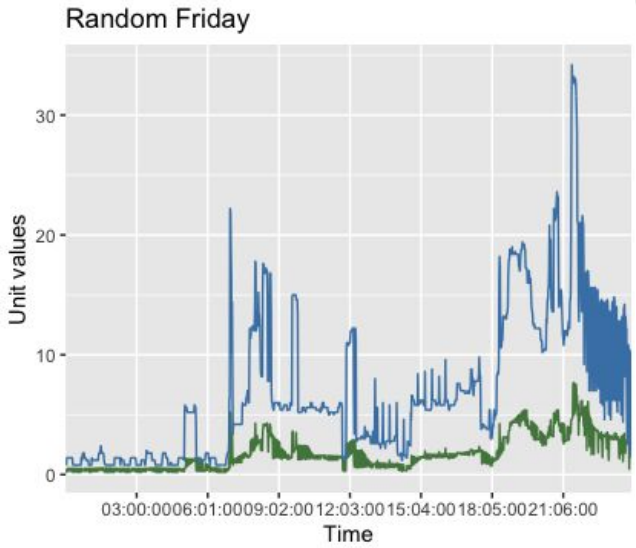
2. Hidden Markov Model

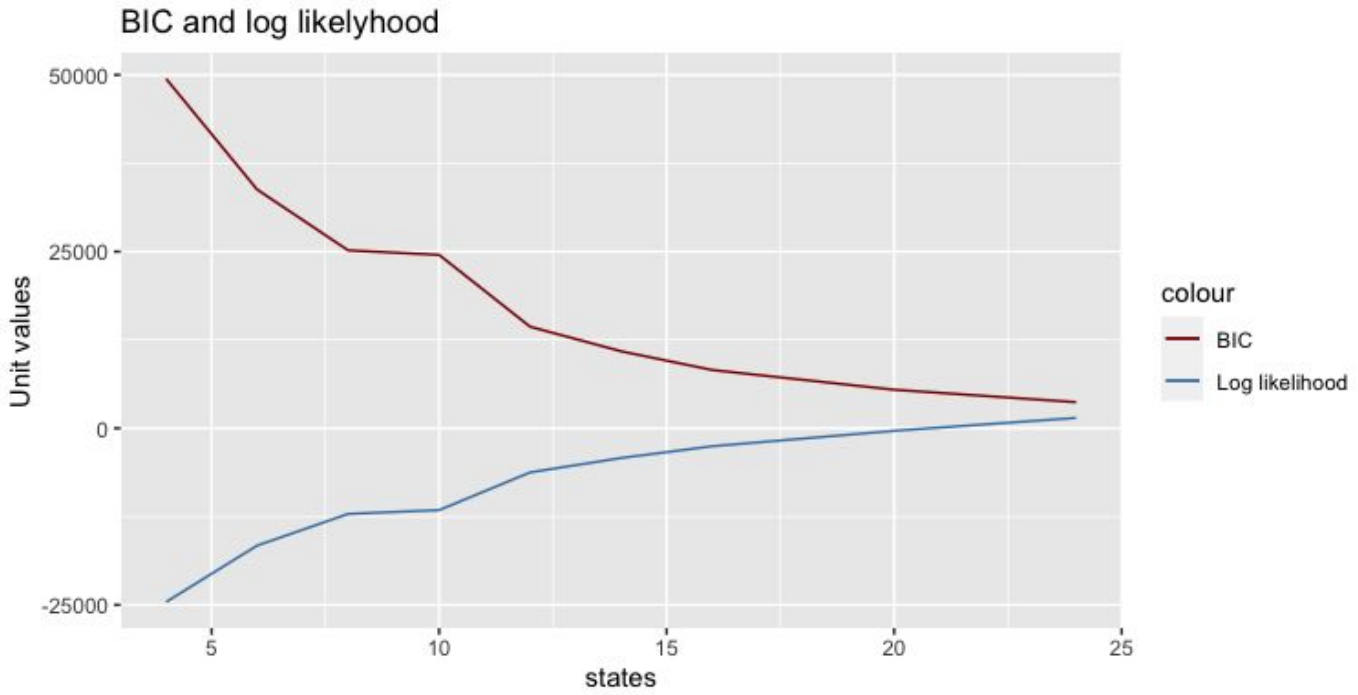
Stochastic processes where the states are unobservable and then next state relies only on the present state

Data Preprocessing

1. We picked Fridays from 6:00 PM to 10:00 PM
   I. Peaks
   II. Pattern observed
2. Divided dataset into 70%

for training and 30% for testing





The log likelihood and BIC reduces as the number of state increases.

Hidden Markov Model

1. Picked state 20
   I. Had the highest log likelihood and the lowest BIC
   II. No overfitting

States	Test log likelihood	Train log likelihood
16	-34.88603	-23.82227
20	-18.44902	-3.38566

State 20 is picked as it has a high log likelihood for test and train data

3. Anomaly Detection

Identification of unexpected events or observations that deviate from the norm

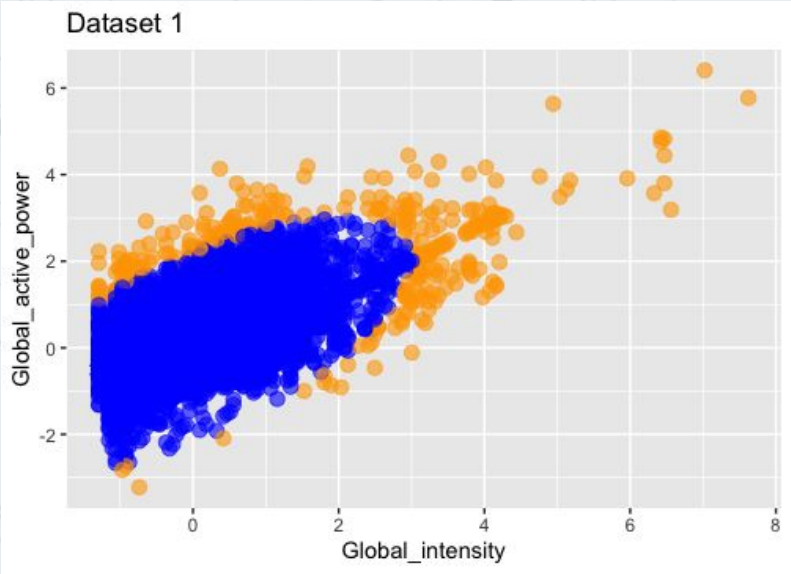
Anomaly Detection

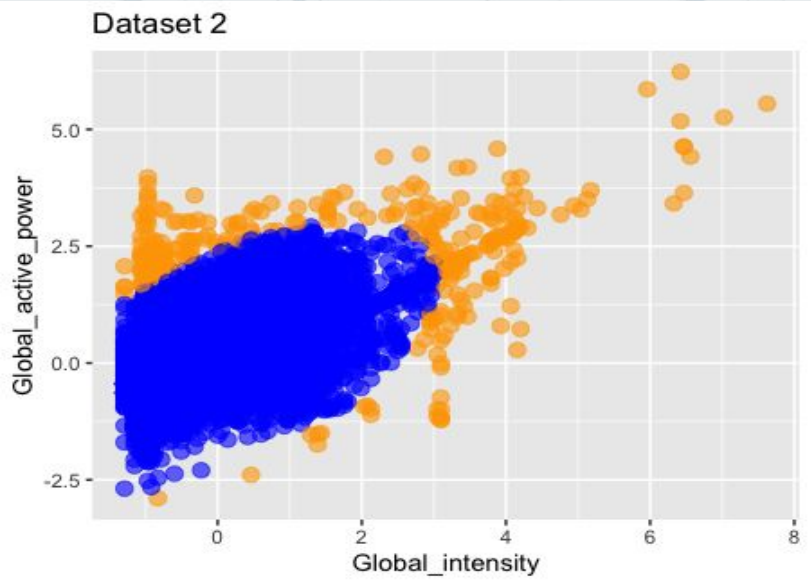
1. Presence of outliers gives a lower log likelihood at the chosen state

Dataset	BIC	Log likelihood
1	9677.169	-2647.221
2	11434.964	-3526.119
3	10286.065	-3683.649

Hypothesis: Dataset 3 is the most anomalous

Anomaly Detection

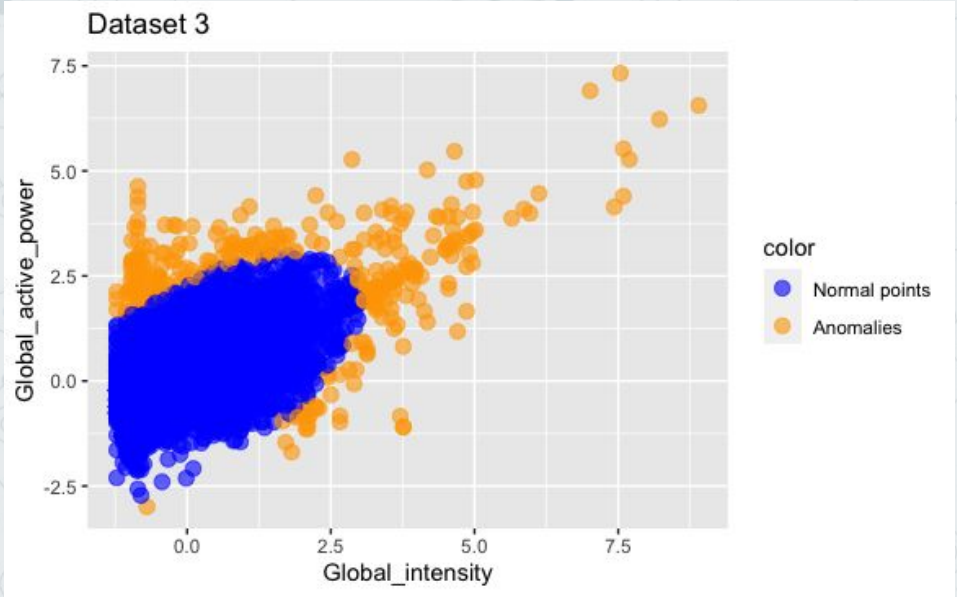




Normal Data points

Anomalous Data points

Anomaly Detection



1. Mahalanobis Distance was used to compute the distance of each point
2. If distance > cutoff distance then its marked as an anomaly
3. Dataset 3 is the most anomalous
4. Aligns with our previous hypothesis

Normal Data points

Anomalous Data points

Lessons Learned

1. PCA analysis to reduce complexity
2. Training and testing HMM models
3. Anomaly detection in a multivariate model

Thanks!

Any questions?