Lab Assignment-1 Feature Transformation using PCA algorithm

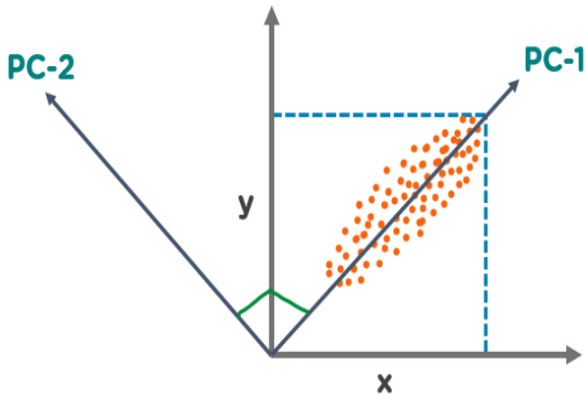
Aim- To use PCA Algorithm for dimensionality reduction.

Objectives- Apply PCA algorithm & transform this data so that most variations in the measurements of the variables are captured by a small number of principal components so that it is easier to distinguish between red and white wine by inspecting these principal components.

Theory-

What is Principal Component Analysis?

The Principal Component Analysis is a popular unsupervised learning technique for reducing the dimensionality of data. It increases interpretability yet, at the same time, it minimizes information loss. It helps to find the most significant features in a dataset and makes the data easy for plotting in 2D and 3D. PCA helps in finding a sequence of linear combinations of variables



In the above figure, we have several points plotted on a 2-D plane. There are two principal components. PC1 is the primary principal component that explains the maximum variance in the data. PC2 is another principal component that is orthogonal to PC1.

Applications of PCA in Machine Learning

- PCA is used to visualize multidimensional data.
- It is used to reduce the number of dimensions in healthcare data.
- PCA can help resize an image.
- It can be used in finance to analyze stock data and forecast returns.
- PCA helps to find patterns in the high-dimensional datasets.

Advantages of PCA

- Dimensionality reduction: By determining the most crucial features or components, PCA reduces the dimensionality of the data, which is one of its primary benefits. This can be helpful when the initial data contains a lot of variables and is therefore challenging to visualize or analyze.
- Feature Extraction: PCA can also be used to derive new features or elements from the original data that might be more insightful or understandable than the original features. This is particularly helpful when the initial features are correlated or noisy.
- Data visualization: By projecting the data onto the first few principal components, PCA can be used to visualize high-dimensional data in two or three dimensions. This can aid in locating data patterns or clusters that may not have been visible in the initial high-dimensional space.
- Noise Reduction: By locating the underlying signal or pattern in the data, PCA can also be used to lessen the impacts of noise or measurement errors in the data.
- Multicollinearity: When two or more variables are strongly correlated, there is multicollinearity in the data, which PCA can handle. PCA can lessen the impacts of multicollinearity on the analysis by identifying the most crucial features or components.

Disadvantages of PCA

1. Interpretability

2. Information loss
3. Outliers
4. Scaling
5. Computing complexity

PCA Approach

- Standardize the data.
- Obtain the Eigenvectors and Eigenvalues from the covariance matrix or correlation matrix, or perform Singular Value Decomposition.
- Sort eigenvalues in descending order and choose the k eigenvectors that correspond to the k largest eigenvalues where k is the number of dimensions of the new feature subspace ($k \leq d$).
- Construct the projection matrix W from the selected k eigenvectors.
- Transform the original dataset X via W to obtain a k-dimensional feature subspace Y.

Uses of PCA

- Data compression
- Feature extraction
- Visualization
- Data pre-processing

Conclusion- The principal component analysis is a widely used unsupervised learning method to perform dimensionality reduction.