K. J. Somaiya College of Engineering, Mumbai – 400 077
(A Constituent College of Somaiya Vidyavihar University)
Dept. of Science and Humanities
F.Y. B. Tech. Semester –I (2022-23)
Applied Mathematics-I
IA-II

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Applications of Eigenvalues and Eigenvectors in Data Analytics

Eigenvalues and eigenvectors are fundamental concepts in linear algebra that have a wide range of applications in data analytics. Here are a few examples:

PCA

- **Clustering**
- **SVD**
- **LSA**
- **Markov Chains**
- **Linear regression**
- **Factor Analysis**
- **Financial Modeling**
- **Graph Analysis**
- **Network Analysis**

Order of the matrix = 10
No. of eigenvalues = λ = 10

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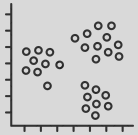
λ_1 Principal Component Analysis

This is a statistical technique used to reduce the dimensionality of a dataset (data compression). It is done by finding a set of orthogonal axes, called principal components, which capture the maximum variance in the data. These axes are defined by the eigenvectors of the covariance matrix of the data, and the amount of variance captured by each axis is given by the corresponding eigenvalue. They are used to project the data onto a lower-dimensional space, which can be useful for visualizing high-dimensional data and reducing its complexity. This method is also used for identifying patterns in multi-dimensional datasets.



λ_2 Clustering

Eigenvectors can be used to identify clusters in data by grouping points that are close together in the space defined by the eigenvectors. Clustering can be used to identify patterns in the data that correspond to the eigenvectors of the data's covariance matrix. This can be useful for identifying groups of similar data points in a dataset. Eigenvalues and eigenvectors can also be used in clustering algorithms, such as k-means clustering, to find patterns in the data. For example, in image clustering, eigenvectors can be used to identify patterns in pixel intensity and group similar images together.

λ_3 Singular Value Decomposition

SVD is a factorization technique that involves finding the eigenvalues and eigenvectors of the matrix that is being decomposed. It is used in several data analytics applications such as-
#1#Recommendation systems: Eigenvalues and eigenvectors can be used to identify patterns in user behavior and to make recommendations based on these patterns.
#2#Natural language processing: Eigenvalues and eigenvectors are used to understand the underlying structure of a dataset.
#3#Image compression: Eigenvalues and eigenvectors can be used to represent an image in a lower-dimensional space.

λ_4 Latent Semantic Analysis

Eigenvectors can be used to identify the latent topics or themes within a document or a dataset of documents. These topics or themes can then be used to classify the documents or to build a search engine that returns relevant documents in response to a query. LSA represents each of the document as a weighted sum of the eigenvectors of the data's term-document matrix, with the weights representing the importance of each eigenvector in the document. The corresponding eigenvalues indicate the importance of each eigenvector in describing the variance of the data. This technique uses SVD to identify latent concepts in the data.

λ_5 Markov Chains

A Markov chain is a mathematical system that undergoes transitions from one state to another according to certain probabilistic rules. The eigenvalues and eigenvectors of the transition matrix of a Markov chain can be used to analyze the long-term behavior of the system.

λ_6 Linear Regression

Eigenvalues and eigenvectors can be used to solve the normal equation, which is a system of linear equations that is commonly used in linear regression.

λ_7 Factor Analysis

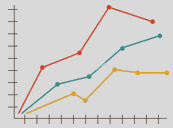
Factor analysis is a statistical method used to identify underlying factors or patterns in a dataset. It is based on the idea that the observed variables can be explained by a smaller number of underlying latent variables. The eigenvalues of the correlation matrix are used to determine the relative importance of the factors.

λ_8 Financial Modeling

Eigenvalues and eigenvectors can be used to model the risk and return of financial assets. For example, the eigenvectors of the covariance matrix of a portfolio of stocks can be used to identify the factors that drive the returns of the portfolio.

λ_9 Graph Analysis

Eigenvectors can be used to analyze the structure of a graph and identify important nodes or clusters. For example, in social network analysis, eigenvectors can be used to identify key influencers in a network.
#1#Graph partitioning: Eigenvectors can be used to partition a graph into two or more disjoint subsets by identifying the cut points in the graph that correspond to the largest eigenvalues of the graph's adjacency matrix.
#2#Graph theory: In graph theory, the eigenvalues and eigenvectors of the adjacency matrix of a graph can be used to identify the structure of the graph and its connectivity.



λ_10 Network Analysis

Eigenvalues and eigenvectors can be used to analyze the structure of networks and to identify important nodes or clusters within the network. For example, the eigenvectors of the adjacency matrix of a network can be used to identify the communities or subgroups within the network.

References:

- Wikipedia
- MathWorks
- Khan Academy
- OpenAI