



# An Approach of Machine Learning Algorithms Through Linear Algebra

R.Malarkodi<sup>1</sup>

<sup>1</sup>Department of Mathematics, St. Joseph's College of Engineering and Technology, Thanjavur, Tamilnadu, India.

\*Corresponding author

DoI: <https://doi.org/10.5281/zenodo.7908969>

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## Abstract

Computing devices can utilize machine learning to forecast the future or make decisions without being specifically programmed. Machine learning is able to build smart algorithms and evaluate more data from facts. Machine learning is based on the study of vectors, matrices, planes, maps, and lines, all defined by way of the field of linear algebra. Linear algebra concepts are used to design algorithms in machine learning. It applies machine learning algorithms to work on large amount of amounts of data. In supervised and unsupervised machine learning, linear algebra concepts which include logistic regression, linear regression, decision trees, and component analysis are used.

**Keywords:** Machine Learning, Data and Algorithm, Linear Algebra.

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## 1. Introduction

The field of computer science and artificial intelligence referred as machine learning focuses on simulating human learning processes using data and algorithms to improve the system's accuracy over time. A computer system can use past information to forecast the future or make some decisions without being explicitly programmed because of machine learning. In order to enable a machine learning model to produce reliable results or make predictions based on that

data, a vast amount of structured and semi-structured data is used in machine learning. Based on the methods and way of learning, machine learning is divided into mainly four types, which are:

1. Supervised Machine Learning
2. Unsupervised Machine Learning
3. Semi-Supervised Machine Learning
4. Reinforcement Learning

## 2. Supervised Machine Learning

The labeled data in supervised learning indicates which inputs have previously been translated to which output. More precisely, we may state that after training the machine with input and related output, we ask it to predict the outcome using test dataset. **To map the input variable (x) with the output variable (y) is the main objective of the supervised learning technique**

For an example, We will train the machine to recognize photographs by showing it details like the size and shape of a cow's and cat's tail, the shape of the eyes, the color, the height (cows are taller, cats are shorter), etc. After training, we input a cat image and ask the computer to recognize the object and forecast the outcome.

Now the machine is educated, it will examine every characteristic of the thing, including height, form, color, eyes, ears, tail, and so on, and determine that it is a cat. The output of the classification will be a cat. This is the method the computer uses to recognize the objects in supervised learning. **Applications of supervised learning in the real world include spam filtering, fraud detection, and risk assessment.**

### 3. Unsupervised Machine Learning

The only input for unsupervised machine learning is data (X). There is no associated output variable (Y) for it. The data's distribution or underlying structure is both aimed to learn more about the data. Because there are no proper answers or teachers, this type of learning is known as unsupervised learning. The interesting structure in the data can be found and presented by algorithms on their own. It may also be divided into clustering and association issues.

### 4. Semi-Supervised Machine Learning

Only some of the input variables (X) in semi-supervised machine learning have an output variable (Y) present. It combines an unsupervised machine algorithm with supervised machine learning. Here, we may combine both.

- a. Using the supervised learning technique, we want to create the best predictions for unlabeled data so that we can utilize those predictions for fresh, unforeseen data.
- b. To learn about and comprehend the structure in the input variables, use unsupervised learning techniques.

### 5. Reinforcement Learning

The machine is exposed to the world, and it develops self-learning capabilities using both positive and negative input. Machine learning is based on prior. It is directed to make specific decisions. It tries to capture the best possible knowledge to make accurate business decisions.

### 6. Foundation of Machine Learning

Machine learning's foundation is linear algebra. Matrix operations, a component of linear algebra, are used to determine the values of the variables X and Y. Linear algebra is therefore

required in machine learning. In addition to being organized as systematic rules, all operations in linear algebra also use a structured representation of the information that a computer can easily comprehend. Comprehending LU decomposition, orthogonalization, matrix operations, projections, Eigen values, Eigen vectors, vector spaces, Singular Value Decomposition (SVD), and other topics is necessary for comprehending machine learning techniques in linear algebra. Applications of linear algebra in machine learning include natural language processing on tabular datasets, data files such as encoding and dimensionality reduction, pictures, etc.

#### Linear Algebra in Supervised learning algorithms

- Logistic Regression
- Linear Regression
- Decision Trees
- Support Vector Machines (SVM)

#### Linear Algebra in Unsupervised learning algorithms

- Single Value Decomposition (SVD)
- Clustering
- Components Analysis

### **7. Data Set in Machine Learning**

The key to success in the field of machine learning or to become a great data scientist is to practice with different types of datasets. But discovering a suitable dataset for each kind of machine learning project is a difficult task.

**8. A dataset is a group of data that has been organized in some way. Any type of data, including series, arrays, and database tables, can be found in a dataset. data types in datasets**

- *Numerical information, including temperature, housing price, etc.*
- *Categorical data: Examples include Yes/No, True/False, Blue/Green, and so forth.*
- *Ordinal data: While similar to categorical data, this data can be quantified through comparison.*

### **8.1. Images and Photographs**

Images and pictures are utilized in machine learning for computer vision applications. Because an image has a table structure with a height and width for each pixel, it serves as an example of a matrix in linear algebra. Additionally, other actions on photos, such as cropping, scaling, resizing, etc., are carried out utilizing linear algebraic notations and operations.

### **8.2. One Hot Encoding**

We sometimes need to work with categorical data in machine learning. One-hot encoding is a popular encoding technique that is used to encode certain categorical variables in order to make them simpler and easier to work with.

In the one-hot encoding method, a table is generated that displays a variable with a row for each sample in the dataset and a column for each category. Additionally, each row is encoded as a binary vector with either a value of zero or one. Here is an illustration of sparse representation, a branch of linear algebra.

### **8.3. Linear Regression**

A common machine learning method that was adapted from statistics is linear regression. In order to predict numerical values in machine learning, it describes the link between input and output variables. With the aid of matrix factorization techniques, linear regression issues are

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typically resolved using the Least Square Optimization approach. The idea of linear algebra's LU decomposition, also known as singular-value decomposition, is one of the frequently used matrix factorization techniques.

## 9. Analysis by Principal Components

A machine learning task frequently experiences the dimensionality curse. It indicates that the data's characteristics are more complex and closely connected. Because the target variable would be equally influenced by both features rather than just one, the difficulty that results is that it becomes impossible to grasp how each component effects the target variable. Higher dimensional data has another drawback: it is impossible to visualize because you can only, at most, plot 3-D data on a plane. As a result, the model's performance could not be properly interpreted. You can decrease the dimension of your data through a procedure known as PCA, or Principal Component Analysis data to a 2-D or 3-dimensional data. To ensure that no information is lost, the dimension reduction is carried out while maintaining the maximum variance (95% to 99%). From a higher dimension, the data is condensed to two or three independent principal components.

Currently, the mathematics underlying principal component analysis adheres to the idea of orthogonality. Reduce the projected inaccuracy between the data points and the lower dimension sub-space by projecting data from higher dimensions onto a lower dimension sub-space. The variance would grow if the expected inaccuracy was reduced.

The first principal component would carry the highest variance in the day once the number of principal components (let's say two or three) has been determined.

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## 9.1. Singular Value Decomposition

A matrix factorization technique applied to different fields of science, technology, and other fields. Machine learning has recently led to a rise in the importance of singular value decomposition in data mining innovations. Matrix Factorization is the name of the result of matrix representation.

$$M = \text{Conjugate Transpose of Unitary Matrix} * \text{Unitary Matrix} * \text{Diagonal Matrix}$$

The conjugate transpose causes the row and column indexes for each element to switch places. Singular value decomposition could be used to unravel information in higher dimensional raw data. We apply the Singular Value Decomposition principle of machine learning to compute Principal Component Analysis. Singular Value Decomposition has several uses, including processing natural data with Natural Language Processing, recommending products, and image processing. The Singular Value Decomposition, however, differs from Principal Component Analysis in that it may locate a matrix's diagonal using specific matrices. These matrices are simple to work with and can be studied. Additionally, the data may be divided into separate parts for compression.

## 10. Conclusion

In the field of computer science, machine learning is constantly revolutionizing research. Machine learning is used in the modern world to address real-time problems by storing, manipulating, extracting, and retrieving data from vast sources. This paper focuses on the effective and successful development of machine learning algorithms using various basic concepts of linear algebra

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