# Chapter 13
# Application of Mathematical Models in Linear Algebra to the Metaverse Ecosystem

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## ABSTRACT

*Linear algebra is a branch of mathematics that is widely used throughout science and engineering. Linear algebra includes arithmetic operations with notation sharing. We can be able to have a better understanding of machine learning algorithms only after having a good understanding of linear algebra. Sometimes, machine learning might be pure linear algebra, involving many matrix operations; a dataset itself is often represented as a matrix. Linear algebra is used in data pre-processing, data transformations, and model evaluation. In this chapter, the basic importance of linear algebra has been discussed, and the close liaison of the subject with current research domain in machine learning and data science has been explored in the light of application of the same in solving some critical issues.*

## INTRODUCTION

Linear algebra is the branch of mathematics concerning linear equations, linear functions and their representations through matrices and vector spaces. It helps us to understand geometrical terms in higher dimensions, and execute mathematical operations on them. By definition, algebra deals in primarily with scalars (one-dimensional entities), but Linear Algebra has vectors and matrices (entities which possess

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two or more dimensional components) to deal with linear equations and functions. Linear Algebra is the heart to almost all areas of mathematics like geometry and functional analysis (Strum et al., 2010). Its concepts are crucial prerequisite for understanding the theory behind Data Science and Machine learning. It is necessary to understand how the different algorithms really work.

Data science is the field of study that combines domain expertise, programming skills, and knowledge of mathematics and statistics to extract meaningful perception from data (Jones et al., 2008). Data science practitioners apply machine learning algorithms to numbers, text, images, video, audio, and more to produce artificial intelligence systems to perform tasks that regularly be in need of human intelligence (Waldrop et al., 2010). In turn, these systems generate insights which analysts and business users can translate into appreciable business value (Davenport et al., 2007). Mathematics in data science is playing very crucial role as this branch is providing not only the data analysis but the data manipulation too (Chapman et al., 2000).

Machine learning is the branch of artificial intelligence and is based on the principle that the systems learn from data and patterns, identifies the several patterns and can be able to make decisions with the nominal human intervention (Hibert & Lopez, 2011). Machine learning is chiefly based on data analysis and so is connected to data science (Philip et al., 2014). Machine learning involves some tasks, set of experiences and performance. The main objective of the machine learning trend is to enhance the performance of any tasks by means of the experiences. In the machine learning trends, multiple inputs are read and analyzed statistically to produce the output. So machine learning introduced the automation in performing the decision making process on the data received and siphon the same for the purpose of modelling.

Data manipulation is the way of manipulating and estimating data which requires the rigorous application of statistics and linear algebra (Ambrust et al., 2010). Matrix is the basic tool in algebra which stores huge amounts of information (Kakhani et al., 2015) in the field of image processing. Matrix operations including its decomposition with eigen vectors contributes a lot towards development of various data model. Similarly, the machine learning model both for the classification and regression requires in-depth knowledge of mathematics, especially linear algebra. The convolution part in the machine learning is being controlled by the algebraic equations. The optimization of model also is heavily dependent on matrix operations.

Calculus is the prime mathematical tool used as the rate measurer, In many data science and machine learning based applications, calculus plays the crucial role. Determination of the tendency in data mapping (Bollean et al., 2009), trends analysis of the regression models and optimization of machine learning models demands the huge involvements and application of calculus-based approach (Slavkovic et al., 2012). In the following sections we will look into the detailed concepts and analysis strategies using sub domain of mathematics linear algebra.

## SCALARS, VECTORS, MATRICES AND TENSORS

- A scalar is a single number which may appear inside any vector also. On the other hand, any vector consists of the scalar terms. The rules for scalar terms manipulation is different from the vector operation.