Relationship Between Mathematics and Machine Learning

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Abstract: **Machine learning is the Branch of Computer Science that is forming as they process increasing amounts of data and predict outcomes more accurately without explicitly programming them to perform it. In recent years, machine learning (ML) has gained a lot of attention due to the innovation and advancement it provides to enhance existing technology. Here we discuss the fundamental mathematical need for machine learning. Combining mathematics, linear algebra, statistics, and probability is the basis of machine learning. In this paper, we study that machine learning mathematics is essential and how the matrix which is a branch of Mathematics works in Machine learning. The relationship between machine learning and matrix mathematics is examined in this work. Data manipulation and representation are supported by matrix ideas, which improve model optimization and predictive analytics. A real-world scenario is used to demonstrate how matrices make accurate Predictions possible.**

Keywords- Machine Learning, Linear Algebra, Statistic, Probability, Matrix and Programming

I. INTRODUCTION

Matrix mathematics is a fundamental concept within the field of linear algebra Researchers in mathematics who research linear algebra work with vector spaces, linear equations, and frequent matrices and linear transformations. Matrices are a fundamental part of linear algebra and are used in numerous fields of mathematics and science to represent systems of linear equations, transformations, and operations.[1] A matrix is a rectangular array of numbers in which numbers are contained within a square bracket. Alternatively, a matrix is a 2-dimensional collection of rows and columns.

Machine learning is a subfield of artificial intelligence (AI) and computer science that focuses on using data and algorithms to simulate how humans learn, gradually increasing its accuracy.[2] Data from a machine learning issue, such as feature values, may be present in the matrix's integers or matrix elements. Recent advances in machine learning, especially in the field of deep learning, are amazing, and important research papers may result in advances in technology that are being utilized by billions of people.[3] In this paper, we discuss the application of Mathematical concepts in Machine Learning.[4]

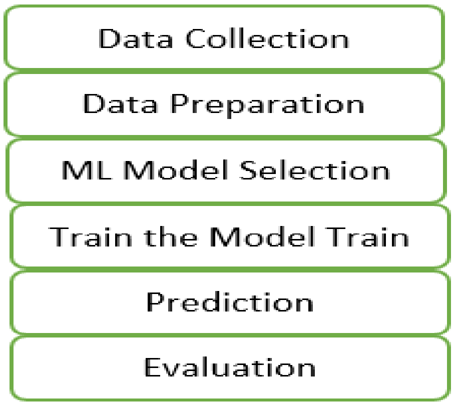
II. MACHINE LEARNING PROCESS

ML has enabled it feasible for PC frameworks' first assets to learn without being actively modified. In the fields of detection, estimation, prediction, and classification, ML has provided whole new skills.[5] A detailed breakdown of the machine learning process given in the following figure illustrates the major phases followed for proposing a model for a particular problem via Machine Learning.[6][7]

A. *Data Preparation:* In this step, the data set is stacked and processed for use in the ML model. The data must be split into two segments. The first big segment is utilized in preparing the model and the subsequent assessment of the model. There are diverse pre-preparing and clamor evacuation calculations that guarantee the great nature of information by expelling commotion from the example information.

B. *ML Model Selection:* There are numerous machine learning (ML) techniques and methods for creating models. The applicability of the model determines which strategy is used. Depending on the application, several models provide varying accuracy rates. Choose a model that is suitable for those specific problems.

C. *Train the Model:* The ML model is instructed in this step to repeatedly skip training data to the model. Each cycle involves feeding the model training data, which are then compared against the model's predictions of the outcomes. Similar to training data, where outcomes are already available, the model picks up prediction skills.



Prediction: The value of ML becomes visible at this moment. Here, the suggested model is applied to predict the expected outcome.

Evaluation: It demonstrates the model's performance by comparing it against data that were never utilized in the training stage. The accuracy of the proposed model is predicted using the testing informational index [7].

III. MACHINE LEARNING PROCESS USING MATHEMATICS

A. *Feature Extraction:* The problem is mathematically framed partly by math. The issue is defined as a mathematical challenge, such as regression (fitting a function to data), classification (assigning labels based on attributes), or clustering (assembling related data points).

When performing data preparation, mathematics is involved. It can include collecting summary statistics (mean, variance), utilizing mathematical imputation techniques to handle missing values, and changing the data (normalization, scaling) to ensure the algorithms work effectively.

B. *Extraction:* Mathematical techniques can help to select the most relevant features. We might use statistical tests to determine important or reduction techniques to extract essential information from

C. *Model selection:* Choose a mathematical model based on the characteristics of data and problem. Linear models, decision trees, support vector machines, neural networks, and other models have mathematical foundations that determine how to capture relationships in the data.

IV. HOW MATRIX WORK IN MACHINE LEARNING

Matrices are central to the functioning of many machine learning algorithms. Data, model parameters, and calculations are efficiently represented and handled. Matrix operations in machine learning look like as follows:

A. Data Representation: Data usually appears in matrix form in machine learning. The matrix's columns and rows each represent a feature or attribute, and each row represents a data point. Algorithms may deal with and analyze data better when using matrix operations due to this tabular representation. Matrix-based data representation is an essential idea in machine learning because it makes it possible to efficiently organize and interpret data. Matrix representations of data in machine learning look like this:

Example: Imagine you have a bunch of data, like information about houses: their sizes and prices. You want to teach a computer to predict the price of a house based on its size. Here's how you can represent this data using matrices*:*

1) *Data Collection:* Let's have data for three houses;

House 1: Size = 1200 sq. ft, Price = ₹ 1,50,000
House 2: Size = 900 sq. ft, Price = ₹ 1,20,000
House 3: Size = 1500 sq. ft, Price = ₹ 1,80,000

2) *Creating Matrix:* Create a Matrix where each row represents a house and each column represents a feature (size and price). Here's what it looks like:

Size (sq. ft)	Price (₹)
1,200	1,50,000
900	1,20,000
1,500	1,80,000

This matrix expresses the relationship between house size & prices.

3) *Matrix Notation:* The columns of the matrix represent the properties of size and cost, while each row represents a house. In mathematics, we may express it as Let X be a given matrix.

X = [1200 150000]
[900 120000]
[1500 180000]

4) *Using Matrix for Prediction:* Now if we want to use data to predict the price of a new house, you can represent the size of the new house as a matrix: New House Size = [1100]

5) *Matrix Multiplication:* We will carry out a matrix multiplication between the new house size matrix and the initial data matrix to predict the cost of the new house:

Predicted Price = New House Size * X

= [1100] * [1200 150000]
[900 120000]
[1500 180000]

When we multiply matrices, we get the predicted price for the new house:

Predicted Price = [165000]

Therefore, based on the information you have, the computer estimates that the cost of the new home, which is 1100 square feet in size, will be roughly ₹ 165,000.

CONCLUSION

In the ever-changing world of technology. Through a combination of mathematical ideas and advanced algorithms, machine learning is a disruptive force. The foundation of this revolution is the relationship between machine learning and matrix algebra. Machine learning combines mathematics, linear algebra, statistics, and probability to use the power to recognize complex patterns and make predictions with formerly unattainable precision. Because mathematics, linear algebra, statistics, and probability all come together, machine learning can predict outcomes without explicit programming. The basis of machine learning is this union, and at its heart, matrices function as the silent architects. By coordinating the movements of algorithms, matrices allow for the effective representation and manipulation of data.

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