Application of Mathematics in Artificial Intelligence and Machine Learning

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Abstract: **Mathematics plays a very important role in day-to-day life. Be it any field such as, technology, aerospace, medical, etc., mathematics is used in its respective ways. Same is the case with artificial intelligence and machine learning. The automation in machines is highly dependent on the theories of mathematics. The most often mathematics concepts used in AI are matrices, integral calculus, probability distributions, optimization, tabu search, sequential quadratic programming etc.**

Keywords: **Artificial Intelligence, Machine Learning, Linear algebra, Vector space, Eigen values and Eigen vectors, Calculus.**

1. Introduction

Artificial Intelligence and Machine Learning are the branches of engineering in which mathematics and science are fundamental. Artificial Intelligence slowly became a part of our lives. Before we could realize, AI has become a necessity. We were already dependent on it for every other thing in our life. In the learning of Mathematics and AI, it often appears as disconnected areas whereas they are two necessary branches of the same tree. Either of them alone produces only ethereal structures, or routines and ad-hoc/emergence programs. For the same reason it's mandatory to study, progressively, from the lower educational levels, both disciplines as they are naturally linked. Mathematics plays an important role as it builds the foundation for programming. The theories are used to make assumptions about the underlying data when we are designing these deep learning or AI algorithms. It is important for us to understand the key probability distributions. Machine learning is powered by four critical concepts and is Statistics, Linear Algebra, Probability, and Calculus. While statistical concepts are the core part of every model, calculus helps us learn and optimize a model

2. How Mathematics is Used in Artificial Intelligence and Machine Learning

So how does AI work? Is it any sort of rocket science? No, it isn't. It's all about the integration of mathematical concepts into Programming to give the output that mimics human behavior. It's more of a combination of mathematics and AI rather than just being some sort of science fiction.

Artificial intelligence problems constitute on two general categories:
1. Search Problems
2. Representation Problems.

Following them are interconnected models and tools like:
1. Rules
2. Frames
3. Logics
4. Nets

Behind all the significant advances, there is mathematics. The concepts of Linear Algebra, Calculus, game theory, Probability, statistics, and advanced logistic regressions.

3. Some of the Mathematical Tools that are Used in Artificial Intelligence and Machine Learning

Mathematical Concepts Important for Artificial Intelligence and Machine Learning:
1) Linear Algebra
2) Calculus
3) Probability Theory
4) Discrete Math
5) Statistics

A. Linear Algebra

Linear algebra is applied in machine learning algorithms in loss functions, regularization, covariance matrices, Singular Value Decomposition (SVD), Matrix Operations, and support vector machine classification. It is also applied in machine learning algorithms like linear regression. Descriptive statistics is all about logistic regression, distributions, discrimination analysis, and hypothesis testing. Discrete mathematics is concerned with non-continuous numbers, often integers. Many applications make the use of discrete numbers necessary.

1) Vector Space

Vector Space model or term vector model is an algebraic model for representing text documents (and any objects, in general) as vectors of identifiers, such as, for example, index terms.

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Fig. 1.

2) Eigen Values and Eigen Vectors

Eigen vectors are unit vectors, which means that their length or magnitude is equal to 1.0. They are often referred to as right vectors, which simply means a column vector.

Eigen values are coefficients applied to Eigen vectors that give the vectors their length or magnitude.
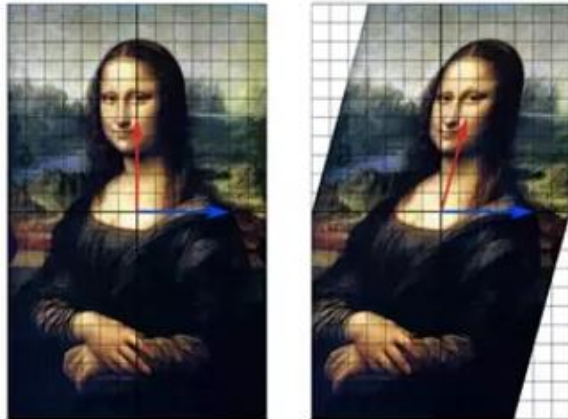

Fig. 2.

B. Calculus

Calculus plays a very important role in the applications of artificial intelligence. From model analysis to method research, the method has been integrated into many aspects of our application of artificial intelligence. Calculus is a very important pillar of mathematics. It is precisely foreign science that uses the concept of calculus to solve the problems of the application of artificial intelligence.

1) Fundamental Theorem

The fundamental theorem of calculus is a theorem that links the concept of differentiating a function with the concept of integrating a function. The two operations are inverses of each other apart from a constant value which depends where one starts to compute the area.
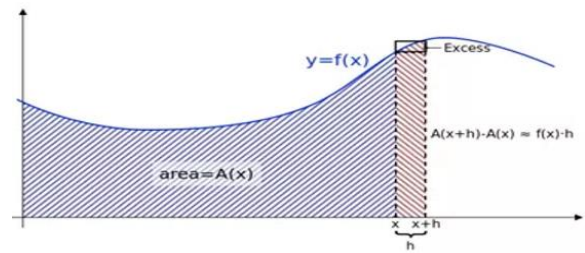

Fig. 3.

2) Differential Calculus

Differential calculus deals with the rate of change of one quantity with respect to another. Or you can consider it as a study of rates of change of quantities. For example, velocity is the rate of change of distance with respect to time in a particular direction.

Fig. 4.

4. Conclusion

A framework is demonstrated for mathematicians to use machine learning that has led to mathematical understanding across two discrete disciplines: one of the first connections between the algebraic and geometric structure of knots and a projected resolution to a long-standing open conjecture in representation theory. Rather than use machine learning to directly generate guesses, we focus on helping guide the highly modified perception of expert mathematicians, yielding results that are both interesting and deep. Intuition plays an important role in elite performance in many human quests. The role of AI in assisting intuition is far more natural. Here we show that there is indeed rich space to support mathematicians in this part of their work. It is our hope that the framework is an effective mechanism to allow for the introduction of machine learning into mathematician's work and encourage further collaboration between the two fields.

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