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Mathematics for Artificial Intelligence

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Abstract

In today modern world, Artificial Intelligence (**AI**) playing a key role in technology development. Mathematics is essential for Artificial Intelligence, especially Probability; Calculus and Linear Algebra concepts are most important concepts for development of Artificial Intelligence. The research paper analyzes the applications of AI in today's world and the various mathematical concepts are useful for the development of AI. Artificial Intelligence applications are developing for the benefit of various fields such as Agriculture, Healthcare, Education and Automobile Engineering.

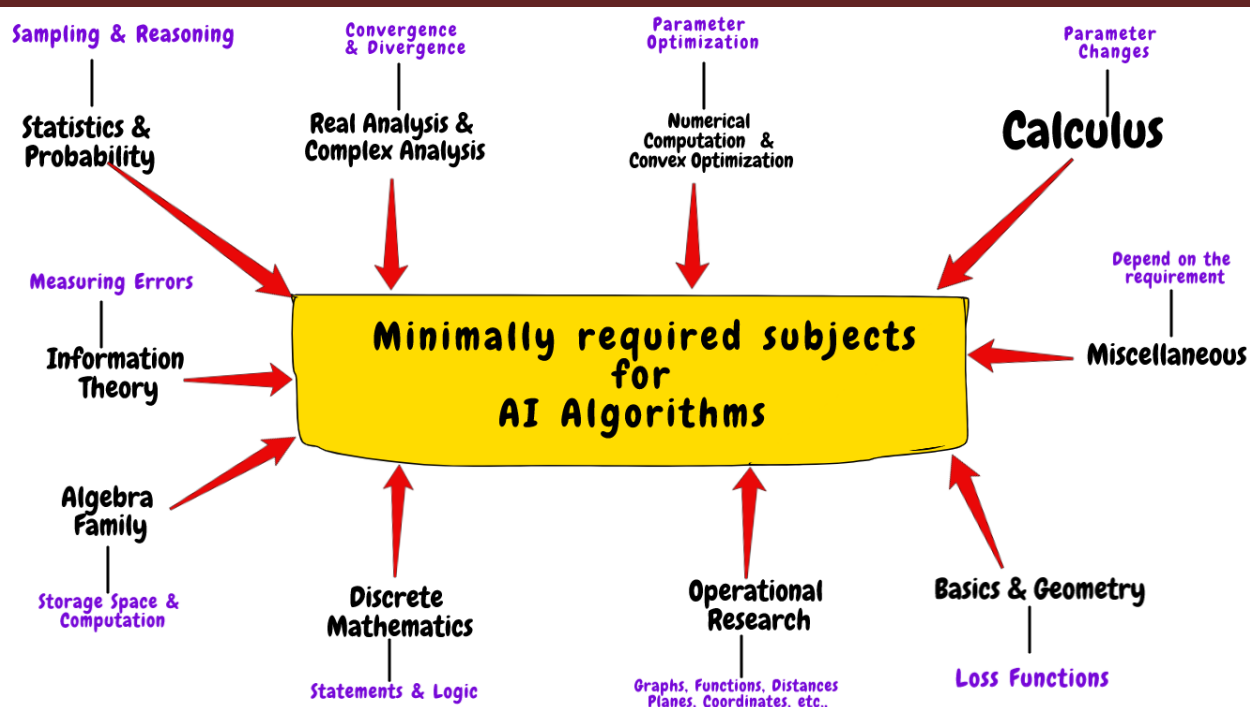
In India, 60% of the population purely depends on Agriculture and All the people needs agriculture products for their life existence. Hence, high demand is there for agricultural products in the country. But, such demand is not properly cashed by the farmers due to lack of awareness on technology, and also farmers moving into the BPL families (i.e Below Poverty Line families). AI technology **helps in detecting disease in plants, pests** and poor nutrition of farms. AI sensors can detect and target weeds and then decide which herbicide to apply within the region and also suggest the market for their products..

The research paper focuses on key components of Mathematics which are essential for development of AI applications for various above fields.

Key words: Artificial Intelligence, Probability, Calculus, Linear Algebra, AI applications, Agricultural Products, Farmers

Introduction: The main branches of **Mathematics** involved in **Artificial Intelligence** are Linear Functions, Linear Graphics, Linear Algebra, Probability and Statistics.

Linear Functions: Linear means straight, a linear function is a straight line and a linear graph represents a linear function. **Linear Graphics** play an important role in Machine Learning / AI. **Linear algebra** is the bedrock of data science. Knowing linear algebra boosts the user ability to understand data science algorithms. **Probability** is how likely something is to occur, or how likely something is true. **Statistics** is about how to collect, analyze, interpret, and present data.

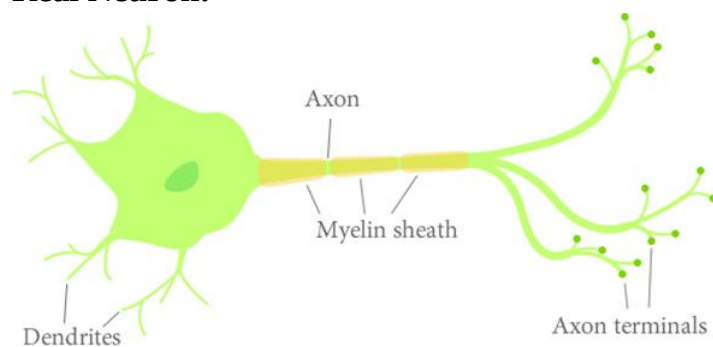


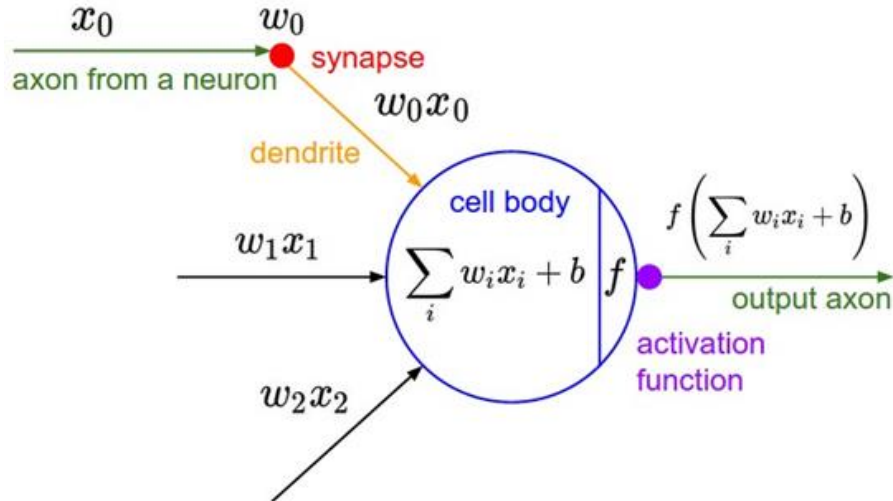
The primary purpose of Artificial intelligence is to create an acceptable model for human understanding and these models can be prepared with the ideas and strategies from various branches of Mathematics.

Consider **self-driving cars**; their goal is to recognize objects and people in videos images. There is mathematics behind these cars in the form of minimization procedures and back-propagation. Mathematics helps AI scientists to solve challenging deep abstract problems using traditional methods and techniques known for hundreds of years.

Concepts: A Non-Linear hypothesis can be done in neural network by forming artificial neurons in three layers, they are Input layer, Hidden layers and Output layer. AI Scientists classify the neural networks from their quantity of hidden layers and the way they connect.

Real Neuron:



Artificial Neuron:

The neural network can be formed by those artificial neurons and it took about 20 years to discover this.

Eigen values and Eigen vectors: [The science of search engine ranking is based on mathematical science.](#) **Page Rank**, which is the very groundwork of Google as a company is based on the mathematical perspective. Page Rank is the algorithm, originally formulated by Larry Page and Sergey Brin in their research paper “**The Anatomy of a Large-Scale Hyper-textual Web Search Engine.**” The application of the basic concept of principal eigen values and eigenvectors, known for hundreds of years, is used behind this tremendous breakthrough. Robot crawlers first retrieve the web pages, and then index and catalog them by assigning Page Rank Values. The credibility of each page depends on the number of links to that page.

The rank $r(P)$ of a given page P is assumed as,

$$r(P) = \sum_{Q \in B_P} \frac{r(Q)}{|Q|}$$

Where,

B_P = all pages pointing to P

$|Q|$ = number of outlinks from Q .

P is the matrix with the terms,

$$P_{i,j} = \begin{cases} \frac{1}{|P_i|} & \text{if } P_i \text{ links to } P_j; \\ 0 & \text{otherwise.} \end{cases}$$

Let's consider a Robot. A robot can only move forward for a certain number of seconds, but not a certain distance. To make the robot go forward, scientists use

mathematics in its programming. Discrete random variables, continuous random variables, Bayes Formula, and normalization are some concepts of probability that are used in Robotics navigation and locomotion along with other concepts of linear algebra.

The two types of discrete random variables most commonly used in machine learning are binary and categorical.

- **Binary Random Variable:** x in $\{0, 1\}$
- **Categorical Random Variable:** x in $\{1, 2, \dots, K\}$.

A binary random variable is a discrete random variable where the finite set of outcomes is in $\{0, 1\}$. A categorical random variable is a discrete random variable where the finite set of outcomes is in $\{1, 2, \dots, K\}$, where K is the total number of unique outcomes.

Each outcome or event for a discrete random variable has a probability.

The relationship between the events for a discrete random variable and their probabilities is called the discrete probability distribution and is summarized by a probability mass function, or PMF for short.

The probability for a continuous random variable can be summarized with a continuous probability distribution. Continuous probability distributions are encountered in machine learning, most notably in the distribution of numerical input and output variables for models and in the distribution of errors made by models. Knowledge of the normal continuous probability distribution is also required more generally in the density and parameter estimation performed by many machine learning models.

Bayes' theorem is also known as **Bayes' rule**, **Bayes' law**, or **Bayesian reasoning**, which determines the probability of an event with uncertain knowledge.

Bayes' theorem can be derived using product rule and conditional probability of event A with known event B: As from product rule we can write:

$$P(A \wedge B) = P(A|B) P(B)$$

$P(A|B)$ is known as **posterior**, which we need to calculate, and it will be read as Probability of hypothesis A when we have occurred an evidence B.

$P(B|A)$ is called the likelihood, in which we consider that hypothesis is true, then we calculate the probability of evidence.

$P(A)$ is called the **prior probability**, probability of hypothesis before considering the evidence

$P(B)$ is called **marginal probability**, pure probability of an evidence.

Conclusion: In this article discussed the importance of Mathematical subjects in AI and explored concepts required in Math subjects. Given an example in Neural Network Architecture along with internal working in Mathematical Perspective. The study is just basics which are supporting to applications which are developed through AI. But, further research includes algorithms through the various mathematics areas for product of AI applications.

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