IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Mathematics In Artificial Intelligence

Ms. Deepashri Jayant Hadphadkar

Associate Professor

Department of Mathematics and Statistics

S.K.Somaiya College of Arts, Science and Commerce, Mumbai, India

ABSTRACT : The concept of artificial intelligence has been of interest to people across the entire world since its beginning. Artificial intelligence (AI) is the capacity of the machines to perform cognitive functions such as thinking, seeing, learning, solving problems, and making decisions. Its inspiration was the manner in which humans deploy their minds to observe, acquire knowledge, think and determine what to undertake. It has already affected the homes of people, their places of work and political system. Very soon, we will have a robot which can drive cars to work, run warehouses as well as assist in looking after old people and small children. It brings challenges as non-understandable black box algorithms, unethical use of data, and even the disappearance of jobs, yet it can also help to solve some of the greatest problems of the contemporary society. The variety of stakeholders should work in collaboration to maximize accountability, transparency, privacy, and impartiality to create trust due to the high rate of growth of machine learning (ML), as the technology can independently acquire and evolve in all spheres of everyday life, and because the rapid pace of development poses a risk to increase the scope and the magnitude of the application of artificial intelligence. Mathematics is the foundation on which artificial intelligence (AI) are built to give us the basic frameworks and tools to construct complex algorithms and models, enabling machines to process data, learn, and make predictions.

Keywords: Artificial Intelligence (AI), Machine Learning (ML), Linear Algebra, Eigen values

Introduction: Mathematics serves as the backbone of AI algorithms and models, empowering machines to process, analyse, and interpret vast amounts of data .The importance of specific areas of mathematics, including calculus, probability theory, linear algebra, and optimization in the design of AI systems. Artificial intelligence (AI) and machine learning (ML) are driving innovations and progress in various industries, and industries such as healthcare, banking, transportation, and entertainment are no exception. To design algorithms and models capable of learning with data, making predictions, and finding solutions to difficult problems, these technologies rely on mathematical concepts to a large extent. In order to create more dependable, efficient and understandable frameworks, one will have to understand the mathematical basis of AI . Linear algebra, calculus, probability theory, and optimization are simple mathematical tools that are essential to AI systems development and application. To illustrate, high-dimensional data manipulation necessitates that one uses linear algebra enabling to carry out operations such as matrix multiplications, decompositions among others that are essential in many machine learning methods. Neural network optimization and loss functions minimization of the form of gradient-based differentiation and integration requires calculus, particularly differentiation. Probability theory forms the basis of probabilistic models and the inference techniques that allow one to make sound decisions when faced with uncertainty since it addresses the uncertainty exists in the data and model estimates. Calculus plays a crucial role in optimizing

AI models. Techniques such as gradient descent and back propagation utilize calculus to minimize errors and adjust the parameters of machine learning models. These mathematical techniques enable AI systems to learn from data and continuously improve their performance. Probability theory and statistics are vital in AI for tasks such as natural language processing, computer vision, and decision-making.

CONCEPTUAL BACKGROUND:

Mathematics is a human activity involving the solution of problematic situations in finding the responses or solutions to these external and internal problems, mathematical objects progressively emerge and evolves. According to Piagetian constructivist theories, people's acts must be considered the genetic source of mathematical conceptualization. Mathematical problems and their solutions are shared in specific institutions or collectives involved in studying such problems. Thus, mathematical objects are socially shared cultural entities. Mathematics is a symbolic language in which problem-situations and the solutions found are expressed. The systems of mathematical symbols have a communicative function and an instrumental role. Mathematics is a logically organized conceptual system. Once a mathematical object has been accepted as a part of this system, it can also be considered as a textual reality and a component of the global structure. It may be handled as a whole to create new mathematical objects, widening the range of mathematical tools and, at the same time, introducing new restrictions in mathematical work and language.

RESEARCH METHODOLOGY:

The collection of data for preparing the said research paper is based on secondary data. The Secondary Data is collected from various reference books related to Artificial Intelligence, Fundamentals of Computer Algorithms, Linear Algebra and Optimization for Machine Learning etc. For said research study secondary data is also collected from the National and International Research Journals which are related to Artificial Intelligence, Mathematics etc.

MATHEMATICS IN ARTIFICIAL INTELLIGENCE:

Learning Algebra: Linear algebra is a basic field of mathematics that is a crucial part of artificial intelligence (AI). Linear algebra is strong because it makes use of vectors, matrices, and linear transformations to describe and solve complex problems. The key methods of AI to apply algebraic learning comprise Data Manipulation.

Vectors and Matrices: Linear algebra enables many operations such as addition, multiplication, and inversion thereby providing a concise and efficient way of expressing data in the form of vectors and matrices. Data is often represented in a form of vectors and matrices in artificial intelligence. A vector is simply a one-dimensional array of numbers that may either be a single value of data or even an entire compilation of attributes in data set. A picture may be represented as a vector where each of the components represents a pixel value. More complex structures such as datasets are simulated with two-dimensional arrays (matrices) with each column representing a feature and each row a piece of data. Linear algebra provides several operations to handle such arrays such as matrix multiplication which is critical to most machine learning models. The input data and weights are multiplied, and the activation functions are applied to the results.

Eigen Values and Eigen Vectors: The fundamental concepts of linear algebra, eigenvalues and eigenvectors finds a variety of applications in artificial intelligence, in particular to the various dimensionality reduction methods. With a clear knowledge of eigenvalues and eigenvectors, AI systems can simplify complex data sets ensuring more effective computing and the overall performance of machine learning models. By applying these concepts to the high-dimensional data, AI can analyse it more promptly and effectively and reveal the most relevant aspects.

Linear Transformation: The AI is based on linear transforms to represent the features space and data space operation such as translation, scaling, and rotation. To determine patterns or features of interest, such as edges or forms, prior to creating predictions, AI models can, e.g. distort data by a series of linear operations (such as convolutions in Convolutional Neural Networks) during image recognition tasks. Linear transformations (rotated, scaled, and translated Data-Data) This is because linear transformations are used to turn data to data, and are represented in matrices, allowing a variety of pre-processing steps in machine learning algorithms.

Calculus: Calculus is a mathematical foundation for ML and AI. It helps AI understand how models work and find the best weights for ML models. Calculus also helps AI understand the behaviour of neural networks. Calculus helps AI learn and understand the world like humans do. It focuses on rates of change and uses a step-by-step reasoning process that considers cause and effect. Calculus deals with changes in parameters, functions, errors, and approximations.

Matrix Decomposition: The two most frequently used methods of matrix decomposition in machine learning algorithms are LU decomposition and Cholesky decomposition, which are both utilized while training linear models, solving optimization problems, and while solving a system of linear equations. Such techniques simplify calculations, thereby enhancing the environment of the algorithm training. One of the examples is that the normal equations of linear regression can be solved more efficiently by matrix decomposition, as opposed to the explicit inversion of matrices.

Multivariate Calculus: Multivariate functions are often modelled in machine learning models, especially deep learning models. Under such circumstances, the loss function of a model is modified to each parameter as a multivariate with the help of multivariate calculus and partial derivatives. As an example, the weight in any given neural network is updated based on its partial derivative about the loss function. Calculation of these updates is done using the chain rule of calculus which allows the backwards propagation of error gradient through the output layer to the hidden layers and ultimately at the input layer. The model gradually optimizes the best parameters by often changing the bulks in the direction which minimizes the loss function. One of such techniques is the Newton Method that performs better updates of model parameters by taking the first and second derivatives. By combining second-order information (so as to approximate the curvature of the loss function), this method allows the step size to be more accurately estimated and the convergence to be faster. Second-order methods, however, tend to be computationally expensive and may not be quite effective with complex models and large datasets.

AI algorithms and models :

Mathematics is the fundamental basis for AI algorithms and models, enabling machines to efficiently handle, examine, and understand extensive quantities of data. Linear algebra allows data to be depicted and manipulated, facilitating tasks such as image recognition, natural language processing, and recommendation systems. For instance, linear algebra is crucial in developing neural networks, which are the building blocks of deep learning. Likewise, Matrices and vectors are utilized in neural networks to symbolize and manipulate data, facilitating intricate calculations and empowering AI systems to extract significant insights from the data.

Developing machine learning algorithms requires proficiency in linear algebra, calculus, probability theory, and statistics. These algorithms utilize mathematical equations and functions to detect patterns, make predictions, and categorize information.

In addition, Mathematicians have made significant progress in optimization theory the foundation for training and refining AI models.

Conclusion: The basic module on which AI technologies are developed is mathematics. The mathematical concepts that AI systems can be used to help solve include linear algebra, calculus, probability, optimization, and graph theory, enabling them to process large amounts of data, make defensible decisions and adapt to complex and dynamic circumstances. Future developments in the field of AI will depend on understanding the mathematical principles behind it better to enable easier development. This is already being felt by the government, businesses, and households. Soon the future is witnessing robots driving cars, managing warehouses, and even assisting in looking after the elderly as well as the children AI and mathematics are mutually reinforcing with the activities of one stimulating the activities of the other. Continuous research in mathematics is likely to be the key driver of AI development in the future, which will provide the basis of increasingly advanced and more powerful AI systems. As the scope and size of the usage of AI in all spheres of everyday life is rising with the rapid development of machine learning (ML) and the technology will learn and develop independently, the collaboration of multiple stakeholders is essential to maximize accountability, transparency, privacy, and impartiality to build trust in AI.

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