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Artificial Intelligence (AI), Machine Learning (ML) &Deep Learning (DL): A Comprehensive Overview on Techniques, Applications and Research Directions

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***Abstract* — The subfield of artificial intelligence (AI) within computer science aims to create intelligent machines capable of performing tasks typically requiring human intelligence. This foundational concept posits that human intelligence can be sufficiently defined for machines to emulate. Machine learning (ML), a branch of AI, enables software programs to enhance their predictive accuracy without explicit programming, using historical data to forecast new output values. Deep learning, a subset of ML, involves training models to organize sounds, text, or images using neural networks and substantial labeled data. In some cases, deep learning models surpass human performance, achieving state-of-the-art accuracy. This research study explores the principles and advancements in AI, ML, and deep learning, emphasizing their transformative potential and applications.**

Keywords— Machine Learning (ML), Artificial Intelligence (AI), Computation, Data Science, Convolution Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Artificial Neural Networks (ANNs).

I. INTRODUCTION

A machine is given information about a language's structure in order to arrive at a faster solution, it is said to be using Artificial Intelligence (AI). This is aided by a learning algorithm that finds patterns in fresh data. No computer has complete artificial intelligence (AI) that is prepared for human behavior as of yet. The gaming industry has seen the most advancements. Nowadays, the best computer chess algorithms can defeat human players. Neural Networks are currently the most widely used branch of artificial intelligence (AI), and they are showing promise in a wide range of fields, including speech recognition and natural language processing. Several programming languages are known as artificial intelligence (AI) languages because they are virtually exclusively utilized for AI applications.

The two most common ones are PROLOG and LISP, while Machine learning is growing very rapidly day by day. We are using it in our daily life even on work, without MI we can't imagine our life. It is used such as Google Maps, Google Assistant, Alexa, etc. It is used in different fields like Image classification,Customer Retention, Identity Fraud Detection, and filtering out spam emails. Diagnostics, Market Forecasting, Weather forecasting, Population Growth prediction, historical stock market information, etc. As research could also be an endless process, new architecture may additionally evolve. [1][2]

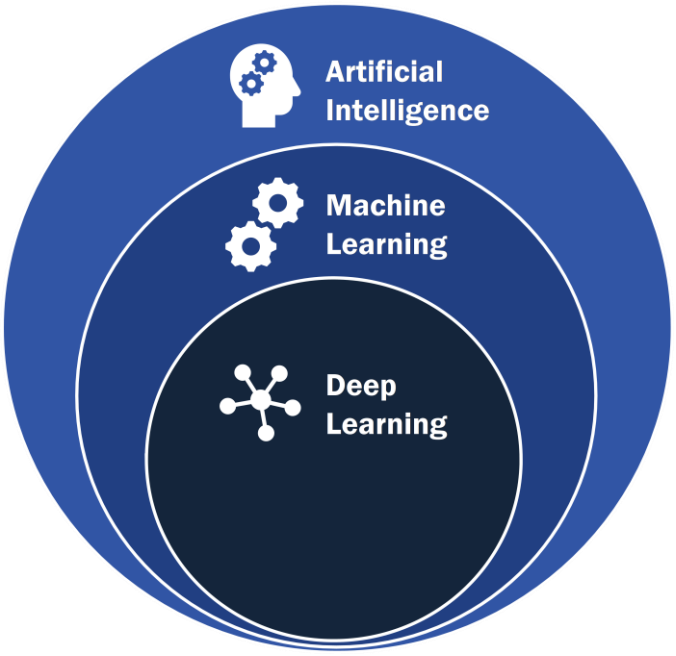

Fig. 1. Position of Deep learning (DL), Machine learning (ML) and Artificial Intelligence (AI).

II. APPLICATIONS OF AI, SOME ARE AS FOLLOWS:

Applications of AI in Gastroenterology

Many ML models have demonstrated promising results in the identification of diagnosis and prognosis forecasting, despite the current concentration of AI in the area of gastroenterologists on image processing. The limitations of conventional linear statistics can be solved when dealing with complicated datasets by using the ANN. The complicated interplay between demographics, economic, and clinical characteristics may also be represented by the ANN. [3][4]

Artificial Intelligence Applications in the Medical Field

Today, several firms are leveraging AI-based technology to provide medical services and products. The most extensively used AI application in the healthcare business is IBM's "Watson for Oncology," which assists clinicians by proposing appropriate treatment options. Furthermore, Mesko underlined that AI-enabled gadgets, like an executive secretary, might have a substantial impact on patient observation and assistance while team doctors are absent. AI-powered smart robots may also execute surgeries and supplement physicians' labor with groups treated, treatment approaches, time and money savings, and faster reaction to clients' requirements. [5][6]

Real-World Examples of AI Healthcare Applications

Concrete Examples of AI Applications in Healthcare 60 percent of characteristics associated with individual health and well-being correspond with lifestyle choices, like fitness, food, rest, reducing stress, drug and medication misuse, and recreation, according to the World Health Organization [7] [8]. In common knowledge, healthcare professionals are frequently overburdened with documentation throughout the treatment process. This volume of labor has encouraged the sector to switch to AI-assisted digital systems that combine and digitize health records. Moreover, chatbots have been highlighted as a potentially beneficial tool for engaging in discussion to hospital patients and their families [9].

Artificial Intelligence's Place in E-Commerce

More specifically, artificial intelligence software has become an increasingly prevalent efficient tool that can improve e-commerce operations and boost sales and profits. [10]

Assistant with Artificial Intelligence

A natural language processing system-based AI assistant like a chatbot whose major role is to answer accordingly to consumer inquiries, basic voice commands, and product suggestions. Chat conversations on electronic commerce and smartphone websites are built on ML algorithms that are trained to interact with consumers in a tailored way. Chatbots may assist customers in locating relevant items, determining product availability, comparing goods, and paying for their purchases. If clients have concerns or queries, the chatbot may also assist them in contacting the appropriate support professionals. Consumers can pass on robots in different ways like audio, text, and images. Alibaba introduced Shop Xiaomi, an AI service robot, and chatbots for Taobao merchants, in March 2017. After permission and debuggers by vendors, chatbots can change certain customer services, productively reduce labor costs, optimize consumer services, enhance effectiveness, maximize night traffic recovery, and aid customer support in resolving repeated consultation issues. [11]

III. DEEP LEARNING

A deep learning system gains from certain use cases and performs better as it is fed more data. But that doesn't mean you can address every issue by offering a Deep Learning systems using relevant data; have limits, much like machine learning and artificial intelligence. Deep learning algorithms can handle a large number of operations for both structured and unstructured data, and they are crucial for recognizing traits. However, as deep learning algorithms require access to enormous volumes of data in order to function well, they might be overkill for some professions that might include serious problems. [12] [13]

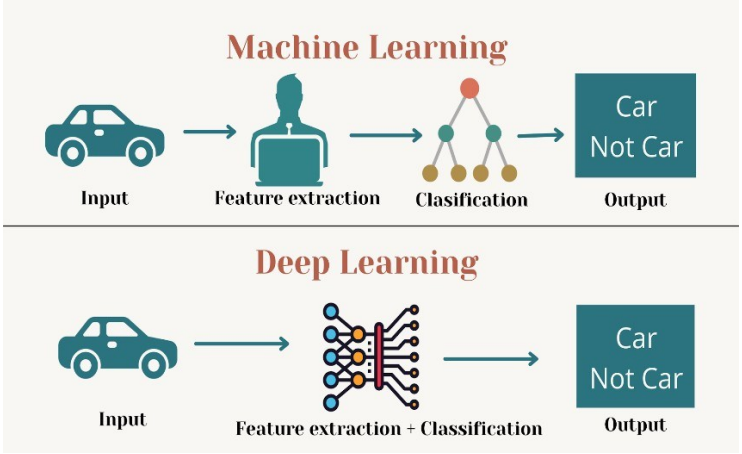

Fig. 2. An illustration of the Machine Learning and Deep Learning

Applications and Techniques of Deep Learning:

A part of machine learning called deep learning aids in giving thoughtful responses to challenging problems. Deep Learning is based on the anatomy and physiology of the human brain. Deep learning uses artificial neural networks to analyze data and make predictions. It is applicable to almost all business sectors. [14] Below is a definition of a few Deep Learning Applications:

Fraud Detection: Another field that gains from deep learning is finance and banking, which is tasked with detecting fraud as more financial transactions take place online. The creation of auto-encoders in Tensorflow and Keras will spare financial institutions from having to pay billions of dollars for credit card theft recovery and insurance. Fraud prevention and detection are based on the identification of abnormal behavior, trends in client transactions and credit ratings, and outliers. [15]

Automatic Machine Translation: When identifying photographs with visible letters, convolutional neural networks are helpful. They can then be translated into text, made as text and a picture utilizing the translated text, after being identified. The name of this procedure is Instant Visual Translation. With a set of provided words, phrases, or sentences in one language, this program will automatically translate them into another language. [16] Although automatic machine translation has been around for a while, deep learning is excelling in two particular fields:

- Translation of any text automatically
- Translation of any image automatically

Automatic Game Playing: In this case, a corpus of text is learned, and new text is generated, either character by character or word by word. This deep learning model is capable of picking up on the spelling, punctuation, and even sentence structure of the corpus texts. Large recurrent neural networks are typically used to train text production through the elements in input string sequences.
[17] Here are some examples of how to apply them:

- Essays by Paul Graham
- Shakespeare
- Wikipedia articles
- Geometric algebra etc.

Sentiment Analysis: it is the process of understanding and analyzing customer sentiments utilizing natural language processing, text analysis, and statistics. Tweets, comments, reviews, and other kinds of social media may be used to get feedback from customers. A company collects these emotions in an organized or unorganized manner from a variety of sources, including Twitter, Facebook, and other social media sites. Data that has been organized and is easy to analyze is known as structured data. Among other things, it might come in the form of a poll, customer reviews, a chat, or data from a contact center. [18]

Fraud news detection and news aggregation: The unpleasant and ugly news may now be removed from your news stream with a filter. Deep learning is being heavily utilized in news aggregation, which is supporting attempts to tailor news to consumers' preferences. Even though it may not appear new, reader personas are being defined at greater degrees of complexity in order to filter out content based on a reader's own interests as well as geographical, social, and economic factors. On the other hand, fraud news identification is a valuable tool in the modern world, where the internet has replaced print media as the main source of all news, real and fraudulent. [19] As false news is routinely replicated across channels by bots, it becomes very difficult to discern it from real news.

Natural Language Processing: Natural language processing (NLP), is a significant area where deep learning is demonstrating promising outcomes. It is the process that enables robots to learn and understand human language. However, bear in mind that robots have a very tough time understanding human language. The alphabet, words, context, accents, handwriting, and other elements all work against machines accurately understanding or producing human language. [20]

Techniques:

Classic neural network: It is differentiated by having a multilayer perceptron connected to the continuous layer and is also referred to as a Fully Connected Neural Network. It was developed in 1958 by American psychologist Fran Rosenblatt. The model is thus condensed to a set of straightforward binary data. [21] The following are the functions of this model a linear function and a Non-linear function. Some other techniques of Deep Learning are:

- Deep Reinforcement Learning
- Self-Organizing Maps
- Auto- Encoders
- Recurrent Neural Networks
- Gradient Decent
- Boltzmann Machine

Machine Learning, the vast area of AI technology attempts to replicate human intellect in computers, gave rise to the field of machine learning. In the topic of computer vision, the crucial problem of how to enable devices to "teach" is taken into consideration. When learning is considered in this perspective, induction inference is the method of drawing conclusions from instances that reflect incomplete knowledge about a "quantitative phenomenon." Unsupervised machine learning often involves trying to find abnormalities in the information or hidden regularities (like clusters for instance some unusual machine function or a network intrusion). Each sample in supervised learning has a label attached to it. It is meant to be the response to a query regarding the example. The task is referred to as classification if the label is discrete. the basic goal of several fields of science is to model the link among a group to make it possible for users (parameters) and another variety of variables that are connected to these outputs. [22]

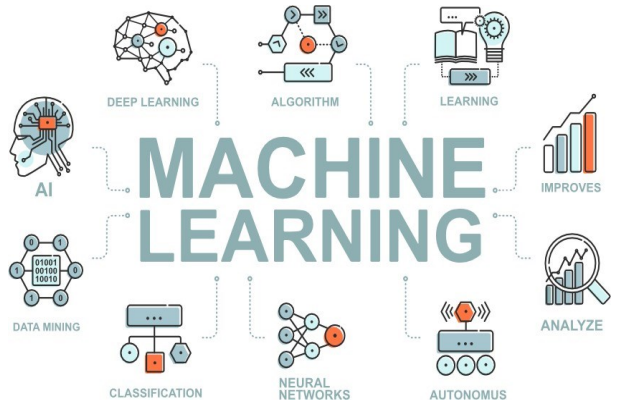

Fig. 3. Techniques of Machine Learning

Once this type of simulation theorem is established, the observables may be used to forecast the frequency of the required factors. However, several actual occurrences are far too complicated to be accurately represented by a closed-form input-output connection. Machine learning approaches can develop a mathematical model of these complicated interactions automatically by analyzing available information and optimizing an issue performance objective. The automatic process of model development is referred to as "retraining," and the information utilized for learning is referred to as "learning algorithm". Algorithms for machine learning frequently require enormous quantities of learning data in order to develop an appropriate model. Current advancements in the digital collection of data, retention, and processing ability have enabled the use of machine learning in a variety of fields, including clinical conditions, biochemistry, chemistry bioinformatics, analysis of social networks share market research, and robots. [23]

For each particular machine-learning task, more than one computational model may often be taught. Consequently, choosing a certain model or method doesn't have a set formula. The effectiveness of a given model is influenced by a variety of elements, including the quantity and quality of training data, the complexity, and structure of the connection between the dependent and independent variables, and computing restrictions like training memory and time. It is sometimes important to test many models and algorithms to determine which ones work best for a given situation. Luckily, there are widely used software programs that integrate several methods into a single framework.

This covers the study of both biology and medicine, whose implications span fields including single-molecule biology, imaging information analysis, and medical care. The very first brain networks were developed in the 1950s, but the principle of machine learning certain abstract ideas people learn continuously evolved since then. Prior to that, similar concepts were applied to other techniques like Markov models and Bayes statistics. The pharmacometrics and clinical pharmacology communities have several names for many of these techniques. [24]

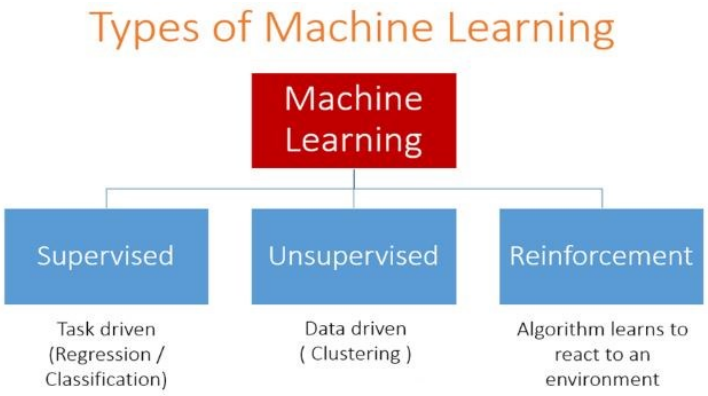

Fig. 4. Types of Machine Learning

The primary difference between them and more traditional approaches is mostly attributable to the two unique statistical modeling traditions. Breiman alluded to this nearly twenty years ago. Here, we expand his notion by including physiological models into one of the communities. [25] The above-described engineering design cycle may be excessively expensive and ineffective for issues where quicker or less expensive solutions are preferred. Using the big datasets of annotated voices, photos, or movies as examples, one may teach common learning computers to do the desired action as a substitute for using humans. Machine learning enables huge volumes of information to dictate methods and conclusions, as opposed to the traditional approach, which depends on domain expertise and layout that is optimal for the task at hand.

To accomplish this, machine learning necessitates the declaration of an aim, of a general model to be trained, and of an optimization approach rather than needing a detailed description of the setup under consideration. [26].

When utilizing a machine-learning technique, such as the first instance over, one might train a general-purpose machine to forecast the results of well-known chemical interactions depending on a sizable set of data, and then use the learned algorithm to investigate how to create more complicated compounds. To achieve compressed representations from which the original input may be retrieved with some distortion, enormous data sets of photographs or videos would be utilized to train a broad sense method. [27]

IV. CONCLUSION

AI is currently engaged in a brand-new endeavor to create computational models of intelligence. The most widely held belief is that intelligence (human or otherwise) is frequently represented by symbol structures and symbolic operations that can be programmed within a scientific discipline system. It is debatable whether a properly programmed computer can be a mind or merely simulate one, but AI researchers do not need to look ahead to the resolution of the current debate or to the hypothetical computer that could model all of human intelligence. Machine learning uses a variety of algorithms to investigate and interpret data, learn from it, and support that learning in order to make the most effective decisions. The system relies on artificial neural network layers in the case of deep learning. Machine learning is now used by everyone, either directly or indirectly. From receiving product recommendations in online shopping to updating photographs on social networking sites, technology is changing the way we live. This indicates that deep learning has an innovative scope with various applications that can produce remarkable results. New architecture may emerge as a result of research, which can be an endless process.

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