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A Comprehensive Analysis of Machine Learning and Deep Learning Integration within Functional Areas

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Abstract— ***Machine learning is one area of modern technology. The topic of creating intelligent machines has been the subject of numerous investigations. As humans already possess this ability, machines can now learn. Various strategies have been devised for the same objective. Traditional machine learning approaches have been applied in many sectors of applications. These days, machine learning algorithms are far more accurate. Deep learning evolved as more components were taken into account. Deep learning is element/part of machine learning. In fact, not many deep learning applications have been researched thus far. It is likely that deep learning will become easier to apply in many more subdomains and application areas to solve issues. This paper provides a summary of the machine learning and deep learning application areas, sub-domains, and applications. This paper also discusses the process of selecting the most suitable approach for a given set of circumstances through research and understanding of whether learning technique (deep learning or machine learning) is most suited for a given field.***

Keywords— ***Deep Learning, Machine learning, Artificial Intelligence, Data Science.***

I. INTRODUCTION

Through the use of deep learning and machine learning, artificial intelligence seeks to give computers human intelligence in the age of data sciences. Machine learning is a branch of artificial intelligence that teaches computers how to learn. Deep learning cannot be completely utilised by machine learning. It helps sustain the strict requirements of the educational environment. Deep learning and machine learning are both necessary for computers to develop into intelligent systems that can judge and predict the future without human input.

Artificial intelligence has made it possible for computers to make decisions and display intellect.[1] The system uses machine learning to develop artificial intelligence, and deep learning makes it easier for the system to consistently achieve its machine learning objectives[2][3]. For the sake of clarity, Figure 1 illustrates it.

There paper discusses about machine learning, its methods and applications, it also discuses about deep learning approaches, their methodology, applications, etc. and it also provides the comparison between both learning techniques and factors to be taken into consideration while choosing options between machine learning and deep learning techniques for mapping it to appropriate functional areas.

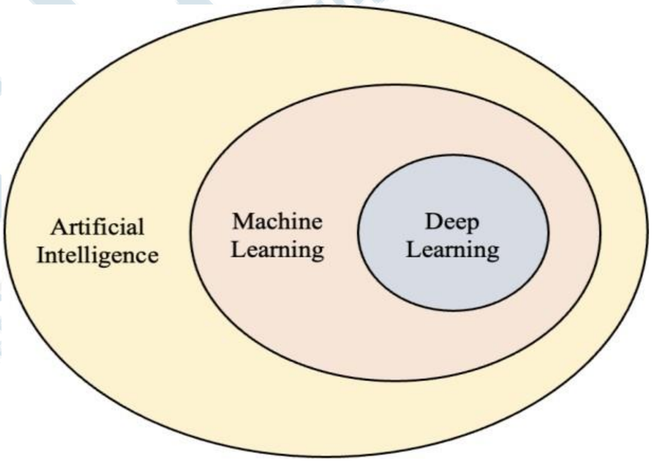

Fig 1. Artificial Intelligence, Machine Learning, Deep Learning paradigm

II. MACHINE LEARNING

Artificial intelligence (AI) has a subfield called machine learning. The main objectives of machine learning are to comprehend data structures and incorporate them into user-friendly frameworks. Even though machine learning is a branch of computer science, it differs from more conventional computational approaches. In conventional computing, computers perform calculations and solve problems using algorithms, which are collections of precisely created instructions. Instead, using data inputs and statistical analysis, computers may now be taught to produce numbers that fall inside a given range using machine learning techniques. Machine learning, which speeds up the decision-making process based on data inputs, can be used by computers to construct models.[4]

Machine learning addresses the problem of not wanting to build new code for each new application. By using machine learning, we can focus on issues that are more likely to arise. Making computer programmes that can execute certain tasks and automatically learn from experience when provided with data is the primary objective of machine learning (performance).

Machine learning has following subcategories:

Supervised machine learning: On labelled data sets, supervised machine learning models are trained, which enables them to grow and learn over time. A computer programme can be trained to automatically recognise images of dogs using, for example, images of various items and dogs that have all been recognised by humans. Nowadays, supervised learning is the machine learning technique that is most often used. [5]

Unsupervised machine learning: Unlabelled data is scanned by software to hunt for patterns. Unsupervised machine learning can identify patterns or trends even when they are not actively being searched after. Unsupervised machine learning algorithms, for instance, may identify the various consumer groups making purchases by looking at online sales data.[5]

Reinforcement learning: In this despite the algorithm's lack of training on sample data, is equivalent to supervised learning. This model learns by trial and error. It will be strengthened to generate the best idea or solution for a certain issue after a string of favourable outcomes.[5]

Algorithms under Machine learning

The algorithms of machine learning are [4]:

Neural networks: In order to mimic the way the human brain operates, neural networks—which are made up of a significant number of interconnected processing nodes—were developed. A few uses for neural networks' capacity to recognise patterns include spoken language translation, image creation, and photo recognition.

Linear regression: Based on a linear relationship between numerous factors, this technique is used to predict numerical outputs. The technique could be used, for instance, to predict home values in the neighbourhood using historical data.

Logistic regression: We can predict categorical response variables, such "yes" or "no" responses to questions, by using supervised learning. It can be used for a variety of activities, including as determining how well production processes operate and classifying spam.

Clustering: Clustering algorithms can organise data by identifying patterns through unsupervised learning. Computers' capacity to identify differences between data pieces that people have missed is advantageous to problem researcher.

Decision trees: It can be used to categorise data and forecast figures (regression). A tree diagram can visually depict the branching pattern of connected decisions used in decision trees. Compared to neural networks, which are a "black box," decision trees have the advantage of being easy to verify and check.

Random forests: Using a combination of the findings from various decision trees, this machine learning technique forecasts a value or category.

Machine Learning Applications

The list of some of examples of machine learning that we may see on a daily basis[7]:

- Speech recognition
- Customer service
- Computer vision
- Recommendation engines
- Automated stock trading
- Fraud detection and many more

III. DEEP LEARNING

These days, intelligent software or systems are frequently referred to by the words artificial intelligence (AI), machine learning, and deep learning interchangeably. Complex neural networks that can learn from data or experience to generate analytical models are used in deep learning, a subset of both machine learning (ML) and more general artificial intelligence (AI). Unlike AI, which often involves integrating human behavior and intellect into systems, ML focuses on data-driven techniques. Deep learning, also known as data-driven learning (DL), utilizes computation- and multi-layer neural network-based approaches. The term "deep" in "deep learning" signifies that data processing occurs across multiple layers or stages before model formation.[8]

Deep learning uses multi-layered artificial neural networks to accomplish tasks. Artificial Neural Networks (ANNs) draw much of their inspiration from the biological connections among neurons in the human brain. The human brain processes incoming data through neural connections and identifies it by referencing previously learned knowledge that has been stored in memory. The brain uses recognition and organisation to do this in a couple of nanoseconds.

Deep learning techniques educate artificial neurons to recognise patterns and classify data in the same way that humans do. Unlike the real brain, artificial neural networks make use of several layers, connections, and data propagation directions. Deep learning (DL) is ultimately just another statistical learning methodology that takes raw data sets and extracts features or qualities from them, despite its complex methodologies. The primary distinction between machine learning and deep learning is that the former requires manual feature insertion.

Deep learning (DL), a frontier in the science and a technique for building automated, intelligent systems, is one of the key components of artificial intelligence (AI). It also takes AI to a whole new level known as "Smarter AI." Since

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DL can learn from data, "Data Science" and "DL" are closely related concepts. In its widest definition, data science encompasses the entire process of finding patterns or insights in data within a specific problem area, where DL approaches may be essential for sophisticated analysis and well-informed decision-making.

Deep learning approaches

DL algorithms extract classification-relevant features automatically. It takes a large amount of data to develop the algorithms for this capability. The amount of data required for deep learning influences the accuracy of the result. Because of the sophisticated algorithms used, deep learning necessitates the utilisation of extremely powerful computational resources. These are specialised computers, typically cloud-based, with high-performance CPUs or GPUs.

Deep learning approaches fall into three basic categories: supervised, semi-supervised, and unsupervised. Deep reinforcement learning, or RL, is another strategy that is widely acknowledged to belong to the class of partially supervised (and occasionally unsupervised) learning strategies.[9]

Deep supervised learning

This approach relies on labeled data. Convolutional, recurrent, and deep neural networks are instances of supervised learning methods within deep learning (DL) (DNNs). LSTM and GRU algorithms fall into the RNN category as well. The significant advantage of this technology lies in its capability to collect data or generate output based on previously acquired data. However, a drawback of this approach is that if the trained model lacks samples from a specific class, it may overly rely on certain decision boundaries. Ultimately, this learning technique is considered more user-friendly compared to others.

Deep semi-supervised learning

Semi-labelled datasets are utilised in this method to construct the learning process. DRL and generative adversarial networks are occasionally paired with this method (GANs). For unsupervised learning, partial supervision is used with RNNs, which also include GRUs and LSTMs. The advantage of this approach is that it requires the least number of tags in the data. However, this strategy has a number of disadvantages, including the potential for judgements to be incorrect as a result of irrelevant input features present in training data.

Deep unsupervised learning

This approach allows for learning to proceed even in situations when tagged data is not easily accessible. Now, the agent looks for underlying patterns or relationships in the input data by learning from fundamental traits or intrinsic representations. Methods like generative networks, clustering, and dimensionality reduction are frequently used in unsupervised learning. GANs, auto-encoders, and limited Boltzmann machines have demonstrated encouraging performance in tasks including as clustering and non-linear dimensionality reduction. RNNs have been used in many unsupervised learning applications, such as GRUs and LSTMs. Nonetheless, unsupervised learning encounters obstacles such intricate processing and a lack of accurate data classification information.

Deep reinforcement learning

Unlike supervised learning, which uses sample data that has already been provided, reinforcement learning operates by interacting with the environment. Another name for this approach is semi- supervised learning. The size or scope of the problem determines the kind of reinforcement learning needed to complete a task. The primary flaw in reinforcement learning is that environment can affect learning rates.

Deep Learning applications

Different DL applications are currently widely adopted worldwide. These applications include health, social media network analysis, multimodal data analysis, acoustic and sound processing, and visual information processing methods. Using natural language processing (NLP) for phrase classification and translation is one of these. These applications have been divided into five categories: classification, localization, detection, segmentation, and registration. The medical field is one of DL's most significant and varied applications. Additionally, DL has achieved success in the medical field.

IV. DEEP LEARNING VS. MACHINE LEARNING

The deep learning architecture uses many neurons in each hidden layer. It is simpler to map the input to higher level representations thanks to the layered design. Here, we contrast and compare the key variations between two learning approaches: -

- Unlike deep learning, which uses multiple levels of algorithms to build an artificial neural network that can learn and make decisions on its own, machine learning relies on methods to analyse data, acquire knowledge/information from that data, and then construct the informed conclusions.
- Machine learning just requires a little quantity of data to function, whereas deep learning requires a vast number of data.
- High-performance hardware is needed for deep learning.
- Deep learning creates new aspects using its own methods and approaches, in contrary to machine learning, where users precisely and accurately recognise features.
- Deep learning resolves the issue from start to finish, in comparison to machine learning, that splits the task into smaller jobs and then integrates the results.

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- Deep networks are "black box" networks, and understanding how they function is highly challenging due to their complicated network architecture and high number of hyperparameters.
- Deep learning requires a lot more training time than machine learning does.
- Machine learning techniques demonstrate transparency better than deep learning techniques.
- The accuracy rate obtained by deep learning is pretty acceptable when matched to machine learning.
- Deep learning eliminates the challenging and complex feature extraction process that seems to be present in machine learning.
- Deep networks require pricey, high-end graphics processing processors that can quickly process large amounts of data.

The way data is provided to the system is just where deep learning and machine learning differ the most. While deep learning networks rely on ANN layers, machine learning techniques nearly universally demand structured data (artificial neural networks).

V. CONSIDERATION FOR CHOOSING MACHINE LEARNING VS. DEEP LEARNING

In order to produce new outputs utilising different sets of data, machine learning algorithms must first "learn" how to fulfil tasks by comprehending tagged data. But if the results aren't what was expected, they must be retrained by people. Deep learning networks use numerous layers of neural networks to accept input through hierarchies of different concepts, and they finally train from their own mistakes. Deep learning systems don't need human engagement as a result. But if the quality of the data isn't good enough, even they might produce inaccurate findings. Here, data is in charge. The outcome's quality is ultimately determined by the data's quality.

Machine learning algorithms can never be utilised to solve difficult queries involving massive amounts of data since they require tagged data. Deep learning neural networks are actually used far more frequently. In fact, because these networks analyse so many levels, hierarchies, and concepts, they are more suited to perform complex calculations than simple ones. The fact that deep learning needs far more data than a conventional machine learning algorithm should be emphasised. This is because it requires exposure to over a million data points in order to recognise edges (concepts, differences) among layers of neural networks. On the other hand, machine learning algorithms have the capacity to learn using pre-programmed, pre-defined criteria.

More details about the two methods are compared below:

a. Factor Considered: **Number of data points**

Machine Learning: can create predictions using a **small amount of data**. **Deep Learning:** needs to generate predictions using **a lot of training data**.

b. Factor Considered: **Hardware dependencies**

Machine Learning: can create predictions using a **small amount of data**. **Deep Learning:** needs to generate predictions using **a lot of training data**.

c. Factor Considered: **Featurization process**

Machine Learning: demands that users accurately identify and build features.

Deep Learning: develops new features on its own while learning high-level features from the data.

d. Factor Considered: **Learning approach**

Machine Learning: divides learning into more manageable steps. The outcomes of each phase are then combined to create one output.

Deep Learning: works through the process of learning by working through the issue from beginning to end

e. Factor Considered: **Execution time**

Machine Learning: training just requires a little amount of time, from a few seconds to a few hours.

Deep Learning: Due to the several layers of a deep learning system, training typically takes a long time.

f. Factor Considered: **Data Output**

Machine Learning: Typically, the result is a number, such as a score or a classification.

Deep Learning: The output might come in a variety of media, such as text, music, or sound.

VI. CONCLUSION

Artificial intelligence requires deep learning as well as machine learning. In both processes, test and training data are used to train a learning model, which is then optimised to determine the weights that will best enable the model to match the data. Deep learning models, as opposed to machine learning models, are a better fit for some machine learning applications, such as object identification and language translation. For problems involving regression and classification, both deep learning and machine learning work well. Whether deep learning or machine learning is superior for a given data project depends on the task at hand.

This article also compares deep learning with traditional machine learning techniques to assist new researchers in determining which approach is best to use in a given situation. For instance, if one is working with a small training data set, machine learning algorithms should be used instead of deep learning; likewise, if one needs to select features from the dataset, machine learning techniques should be used; in the case of deep learning, the feature selection process is automated, so the researcher need not worry about it.

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