HiLCoE

School of Computer Science & Technology

Artificial Intelligence & Machine Learning

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Abbreviations

AI ---------- Artificial Intelligence
ML ---------- Machine Learning

I. Abstract

The purpose of this seminar is to give information and some knowledge about artificial intelligence and machine learning. It explains about artificial intelligence, how it works, its history, how it can be applied in our day-to-day life and the consequences that come along when using it. And with regards to machine learning it tries to cover ideas like what machine learning is, its relationship to other fields like artificial intelligence and the limitations it is facing. In general, it tries to cover the above emerging technologies that are on the way of changing how we live. We hope by the end of our paper you gain some knowledge on the topics.

II. Introduction

The effect of Artificial Intelligence (AI) and Machine Learning (ML) has grown significantly in recent years, with applications in a variety of industries, including healthcare, finance, transportation, and many more. Machine learning (ML), a subset of artificial intelligence (AI), is the use of algorithms to evaluate and learn from data in order to make predictions or judgments without being explicitly programmed. AI refers to the ability of machines to accomplish tasks that traditionally require human intelligence. These technologies are reshaping sectors, bringing about fresh opportunities and difficulties, and posing significant moral and societal issues. In order to give an overview of AI and ML, this paper will look at their definitions, uses, and difficulties as well as their effects on society and possibilities in the future.

Artificial Intelligence (AI)

Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems. Specific applications of AI include expert systems, natural language processing, speech recognition and machine vision. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience.The goal of AI is to replicate human intelligence, create systems which can exhibit intelligent behavior, learn things by itself, and can advise to its user. AI is accomplished by studying how the human brain thinks, and how humans learn, decide, and work while trying to solve a problem.

History of AI

In today's world, technology is also growing very fast, and we are getting in touch with different new technologies day by day. Artificial Intelligence is a field that originally was founded by computer scientists in the 1950s but has since become a field with applications in nearly every aspect of human life.

In 1955: An Allen Newell and Herbert A. Simon created the "first artificial intelligence program" Which was named "Logic Theorist". This program had proved 38 of 52 Mathematics theorems.

1956 The term “artificial intelligence” is coined by John McCarty at a Dartmouth conference and AI is founded as an academic discipline.-The golden years-Early enthusiasm (1956-1974)

In 1966 the first chatbot Eliza and in 1972 the first humanoid robot in Japan WABOT-1

-A boom of AI (1980-1987): Expert systems The 1st and 2nd AI winter: was a period where there was shortage of funding from the government.The emergence of intelligent agents **(1993-2011)**

The year 1997: IBM Deep Blue beats world chess champion

The year 2002: AI entered the home in the form of Roomba, a vacuum cleaner.

The year 2006: AI came into the Business world. Facebook, Twitter, and Netflix started using AI. - Deep learning, big data and artificial general intelligence **(2011-present)**

The year 2014: Chatbot "Eugene Goostman" won a competition in the "Turing test."

How does AI work?

As the hype around AI has accelerated, vendors have been scrambling to promote how their products and services use it. Often, what they refer to as AI is simply a component of the technology, such as machine learning. AI requires a foundation of specialized hardware and software for writing and training machine learning algorithms. No single programming language is synonymous with AI, but Python, R, Java, C++ and Julia have features popular with AI developers.In general, AI systems work by ingesting large amounts of labeled training data, analyzing the data for correlations and patterns, and using these patterns to make predictions about future states. In this way, a chatbot that is fed examples of text can learn to generate lifelike exchanges with people, or an image recognition tool can learn to identify and describe objects in images by reviewing millions of examples. New, rapidly improving generative AI techniques can create realistic text, images, music and other media.

Types of AI

Artificial intelligence is classified based on capability and functionality.

Based on capability:

1.Narrow AI

Narrow AI is a type of AI which is able to perform a dedicated task with intelligence. Narrow AI is only trained for one specific task in which it can fail if pushed beyond its limits. It is designed to perform a single task, and any knowledge gained from performing that task will not automatically be applied to other tasks. Google Assistant, Google Translate, Siri, e-commerce site, speech and other.

2.General AI

General AI is a type of intelligence which could perform any intellectual task with efficiency like a human. The main goal of general AI is to make such a system that could be smarter and think like a human on its own. Although such system doesn't exist now it is predicted to arrive within the next 20 or so years. This is a concept of the machine with general intelligence that mimics human intelligence, with the ability to think, understand, learn and apply its intelligence to solve any problem as humans do in any given situation.

3.Super AI

Super AI is a type of intelligence in which machines could surpass human intelligence, and can perform any task better than human with cognitive properties. Super include cognition, general intelligence, problem-solving abilities, social skills and creativity.

Based on functionality AI is divided into four.

1. Reactive Machines

These machines only focus on current scenarios and do not store memories or past experiences for future actions. Machine learning models tend to be reactive machines because they take customer data, such as purchase or search history, and use it to deliver recommendations to the same customers. Other examples can be IBM's Deep Blue, Spam filters and the Netflix recommendation engine. s can store past experiences or some data for a short period of time.

2.Limited memory

Unlike reactive machines can store past experiences or some data for a short period of time. They use stored data for a limited time period only. Self-driving cars are usually stated as one of the examples of limited memory. It stores recent speed of nearby cars, the distance of other

cars, speed limit, and other information to navigate the road.

3.Theory of mind

Although this type of AI machines is still not developed, but researchers are making lots of efforts and improvement for developing such machines. It is thought to understand human feelings and emotions and should be able to interact like humans. One famous example is Sophia which is a humanoid robot in which many Ethiopians have contributed for its development.

4.Self Awareness

Self-Awareness machines are perceived to be smarter than human mind. It is still a hypothetical concept. These machines will be intelligent and will have consciousness and self-awareness. It is considered to be the future of AI.

Strong AI vs. weak AI

AI can be categorized as weak or strong.

● Weak AI, also known as narrow AI, is designed and trained to complete a specific task. Industrial robots and virtual personal assistants, such as Apple's Siri, use weak AI.

● Strong AI, also known as artificial general intelligence (AGI), describes programming that can replicate the cognitive abilities of the human brain. When presented with an unfamiliar task, a strong AI system can use fuzzy logic to apply knowledge from one domain to another and find a solution autonomously. In theory, a strong AI program should be able to pass both a Turing test and the Chinese Room argument.

Advantages of AI

- **Decreases human error and risk:** using AI to complete particularly difficult or dangerous tasks can help prevent the risk of injury or harm to humans for example in places that have radiation effects implementing AI can be good solution.
- **Unbiased decision making**: Humans are known to make biased decisions but by implementing AI the program will be able to make decisions without the influence of bias.
- **For Repetitive jobs**: Using an AI program can save humans from the boredom of repetitive tasks, and it helps save their energy for work that requires more creative energy rather than wasting time on those repetitive tasks.
- **Cost reduction:** AI can help to take over manual and tedious tasks, and frees up workers for more important tasks.

Disadvantages of AI

- **Lack of feelings and emotion:** AI does not have any emotion so it makes no attachment with humans which may sometimes be harmful for users if the proper care is not taken.
- **Increase dependence on machines:** Nowadays people are becoming more and more dependent on machines which is causing them to lose their mental capabilities and creativity.
- **No improvement with experience**: AI can't naturally learn from its own experience and mistakes and try to improve those mistakes like humans.
- **Reduced jobs for humans**: It might decrease available jobs, since AI can easily handle repetitive tasks that were previously done by workers, there won't enough work for people.
- **High Cost:** AI hardware and software requirement is very costly as it requires a lot of maintenance to meet current requirements.
- **No Original Creativity:** AI can't create new solutions to problems, it cannot be imaginative and intelligent.

Technologies that use AI

- **Cloud computing**: it is the delivery of on-demand services, usually through the internet, on a pay-per-use basis. Cloud Computing involves delivering hosted services over the Internet.
- **Internet Of Things (IoT):** describes the network of physical objects that are embedded with sensors, software, and other technologies for the purpose exchanging data with other devices and systems over the internet.
- **Machine Learning**: is a branch of artificial intelligence which focuses on the use of data and algorithms to imitate the way that humans learn. It is where the machine can learn as it goes rather than having every action programmed by humans.
- **Virtual Reality**: is the use of computer technology to create a simulated environment. It creates a totally artificial environment. VR is fully immersive, which tricks you into thinking you're in a different environment or world apart from the real world.
- **Automation**: When paired with AI technologies, automation tools can expand the volume and types of tasks performed. An example is robotic process automation (RPA), a type of software that automates repetitive, rules-based data processing tasks traditionally done by humans. When combined with machine learning and emerging AI tools, RPA can automate

bigger portions of enterprise jobs, enabling RPA's tactical bots to pass along intelligence from AI and respond to process changes.

- Machine vision: This technology gives a machine the ability to see. Machine vision captures and analyzes visual information using a camera, analog-to-digital conversion and digital signal processing. It is often compared to human eyesight, but machine vision isn't bound by biology and can be programmed to see through walls, for example. It is used in a range of applications from signature identification to medical image analysis. Computer vision, which is focused on machine-based image processing, is often conflated with machine vision.

- Natural language processing (NLP): This is the processing of human language by a computer program. One of the older and best-known examples of NLP is spam detection, which looks at the subject line and text of an email and decides if it's junk. Current approaches to NLP are based on machine learning. NLP tasks include text translation, sentiment analysis and speech recognition.

- Robotics: This field of engineering focuses on the design and manufacturing of robots. Robots are often used to perform tasks that are difficult for humans to perform or perform consistently. For example, robots are used in car production assembly lines or by NASA to move large objects in space. Researchers also use machine learning to build robots that can interact in social settings.

- Self-driving cars: Autonomous vehicles use a combination of computer vision, image recognition and deep learning to build automated skills to pilot a vehicle while staying in a given lane and avoiding unexpected obstructions, such as pedestrians.

- Text, image and audio generation: Generative AI techniques, which create various types of media from text prompts, are being applied extensively across businesses to create a seemingly limitless range of content types from photorealistic art to email responses and screenplays.

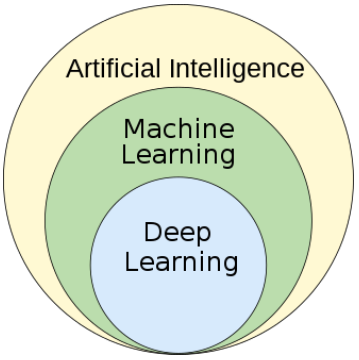
Future of AI

Though it is not yet known how far artificial intelligence technology will be heading, it is also clear that it is becoming an essential part of our life.Nowadays, the use of AI in marketing and sales, in product research and development, and in service operations are becoming more popular. But still the development of artificial intelligence is still ongoing. Researchers and developers are continuing to improve artificial intelligence to make it more

adaptable and user-friendly.The productivity of artificial intelligence may improve our workplaces, which will benefit people by enabling them to do more work. The algorithm found in artificial intelligence technology allows programmers to work and process more variables in a much simpler way.Some upcoming trends of AI include: Delivering 5G with AI, AI to Predict IT Issues, Expansion of natural language processing, Quantum Artificial Intelligence, Edge Artificial Intelligence, Machine learning and Automation (AutoML), Artificial Intelligence and health, Cyber security AI, Generative AI in the Art and Creative Space, Introduction of Virtual Agents, Augmented Process and AI, Small and Wide Data Analytics

What is Machine Learning?

Machine learning is a subfield of artificial intelligence, which is broadly defined as the capability of a machine to imitate intelligent human behavior. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems. The term machine learning was coined in 1959 by Arthur Samuel, an IBM employee and pioneer in the field of computer gaming and artificial intelligence. The synonym self-teaching computers was also used in this time period.Machine learning (ML) algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so. Machine learning algorithms are used in a wide variety of applications, such as in medicine, email filtering, speech recognition, agriculture, and computer vision, where it is difficult or unfeasible to develop conventional algorithms to perform the needed tasks.



Machine Learning's relationship with other fields

Machine learning has a broad range of applications across various fields and is rapidly changing the way we interact with technology and the world around us.
Some of the relationships are listed below.

Artificial Intelligence

Even though the difference between Artificial Intelligence and Machine Learning is subtle, there are few things that differ them. Generally, ML is considered to be a sub-set of Artificial Intelligence.

An “intelligent” computer uses AI to think like a human and perform tasks on its own. Machine learning is how a computer system develops its intelligence.
While ML focuses on teaching machines to learn from data, AI focuses on creating machines that can perform tasks that would typically require human intelligence, such as recognizing speech, identifying objects, and making decisions.

Data mining

Data Mining relates to extracting information from a large quantity of data. Data mining is a technique of discovering different kinds of patterns that are inherited in the data set and which are precise, new, and useful data. Data Mining's origins are databases, statistics.
While Machine learning includes an algorithm that automatically improves through data-based experience. Machine learning is a way to find a new algorithm from experience. Machine learning utilizes data mining techniques and another learning algorithm to construct models of what is happening behind certain information so that it can predict future results.

Theory

Machine Learning Theory, also known as Computational Learning Theory, aims to understand the fundamental principles of learning as a computational process. This field seeks to understand at a precise mathematical level what capabilities and information are fundamentally needed to learn different kinds of tasks successfully, and to understand the basic algorithmic principles involved in getting computers to learn from data and to improve performance with feedback. The goals of this theory are both to aid in the design of better automated learning methods and to understand fundamental issues in the learning process itself.Machine Learning Theory draws elements from both the Theory of Computation and Statistics and involves tasks such as:

• Creating mathematical models that capture key aspects of machine learning, in which one can analyze the inherent ease or difficulty of different types of learning problems.
• Proving guarantees for algorithms (under what conditions will they succeed, how much data and computation time is needed) and developing machine learning algorithms that provably meet desired criteria.
• Mathematically analyzing general issues, such as: “Why is Occam’s Razor a good idea?”, “When can one be confident about predictions made from limited data?”, and “How much power does active participation add over passive observation for learning?”

Approaches towards Machine Learning

Machine learning approaches are traditionally divided into three broad categories, which correspond to learning paradigms, depending on the nature of the "signal" or "feedback" available to the learning system:

Supervised Machine Learning (Supervised Learning)

Supervised learning is one type of machine learning in which machines are trained using well "labelled" training data, and on basis of that data, machines predict the output. The labelled data means some input data is already tagged with the correct output.

In supervised learning, the training data provided to the machines work as the supervisor that teaches the machines to predict the output correctly.The aim of a supervised learning algorithm is to find a mapping function to map the input variable (x) with the output variable (y).In the real-world, supervised learning can be used for Risk Assessment, Image classification, Fraud Detection, spam filtering, etc.

How Supervised Learning Works?

In supervised learning, models are trained using labelled dataset, where the model learns about each type of data. Once the training process is completed, the model is tested on the basis of test data (a subset of the training set), and then it predicts the output.

The working of Supervised learning can be easily understood by the below example and diagram:

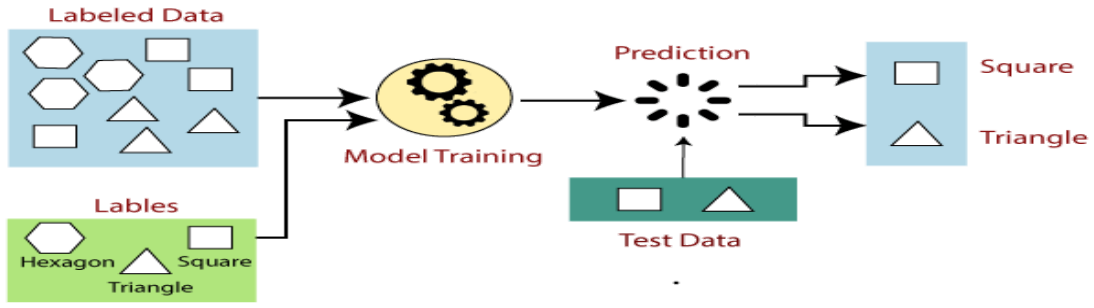


Figure 2. Working mechanism of a supervised learning with an example

Suppose we have a dataset of different types of shapes which includes square, rectangle, triangle, and Polygon. Now the first step is that we need to train the model for each shape. If the given shape has four sides, and all the sides are equal, then it will be labelled as a Square.If the given shape has three sides, then it will be labelled as a triangle.If the given shape has six equal sides then it will be labelled as hexagon.Now, after training, we test our model using the test set, and the task of the model is to identify the shape.The machine is already trained on all types of shapes, and when it finds a new shape, it classifies the shape on

the bases of a number of sides, and predicts the output.

Steps Involved in Supervised Learning:

- First, choose the training dataset type (the kind of data we want to use).
- Compile the labelled training data.
- Create training, test, and validation datasets from the training dataset.
- Identify the training dataset's input features, which should have sufficient details to enable effective output prediction.
- Choose the best algorithm for the model, such as a decision tree or a support vector machine.
- Apply the algorithm to the practice data. Validation sets, a subset of training datasets, are occasionally required as control parameters.
- Use the test set to judge how accurate the model is. If the model correctly predicts the outcome, then it is accurate.

Advantages of Supervised learning:

- With the help of supervised learning, the model can predict the output on the basis of prior experiences.
- In supervised learning, we can have an exact idea about the classes of objects.
- Supervised learning model helps us to solve various real-world problems such as fraud detection, spam filtering, etc.

Disadvantages of supervised learning:

- Models of supervised learning are inadequate for dealing with complicated tasks.
- If the test data and training dataset are not the same, supervised learning cannot predict the right result.
- Training involved lengthy computations.

Unsupervised Machine Learning (Unsupervised Learning)

Unsupervised learning is a machine learning technique in which models are not supervised using training dataset. Instead, models itself find the hidden patterns and insights from the given data. It can be compared to learning which takes place in the human brain while learning new things. It can be defined as:

Unsupervised learning is a type of machine learning in which models are trained using an

unlabeled dataset and are allowed to act on that data without any supervision.
Unsupervised learning cannot be directly applied to a regression or classification problem because unlike supervised learning, we have the input data but no corresponding output data. The goal of unsupervised learning is to find the underlying structure of dataset, group that data according to similarities, and represent that dataset in a compressed format.
Example: Suppose the unsupervised learning algorithm is given an input dataset containing images of different types of cats and dogs. The algorithm is never trained upon the given dataset, which means it does not have any idea about the features of the dataset. The task of the unsupervised learning algorithm is to identify the image features on their own. Unsupervised learning algorithm will perform this task by clustering the image dataset into the groups according to similarities between images.

How Unsupervised Learning Works?

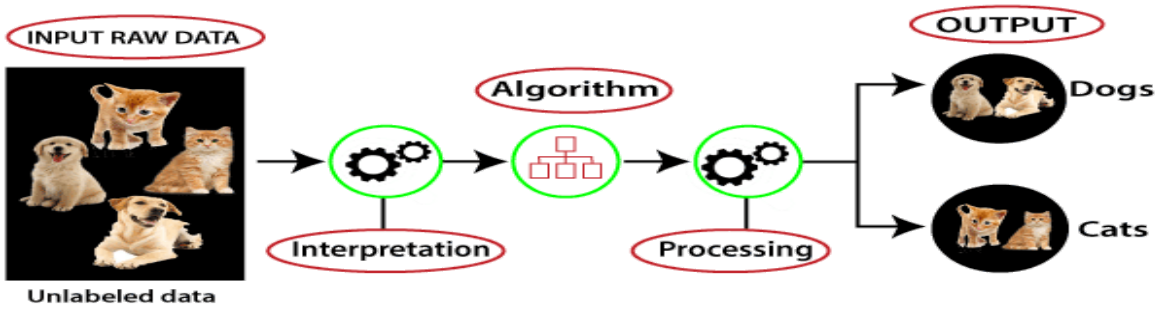


Figure 3. Working method of unsupervised learning by example

Here, we have taken an unlabeled input data, which means it is not categorized and corresponding outputs are also not given. Now, this unlabeled input data is fed to the machine learning model in order to train it. Firstly, it will interpret the raw data to find the hidden patterns from the data and then will apply suitable algorithms such as k-means clustering, Decision tree, etc.Once it applies the suitable algorithm, the algorithm divides the data objects into groups according to the similarities and differences between the objects.
Unsupervised learning is further subcategorized into two: Clustering and Assosiation.
Clustering is a method of grouping the objects into clusters such that objects with most similarities remains into a group and has less or no similarities with the objects of another group while Assosiation is an unsupervised learning method which is used for finding the relationships between variables in the large database. It determines the set of items that occurs together in the dataset.

Unsupervised Learning algorithms:

The following is the list of some popular unsupervised learning algorithms: K-means clustering, KNN (k-nearest neighbors), Hierarchical clustering, Anomaly detection, Neural Networks, Principal Component Analysis, Independent Component Analysis, Apriori algorithm, Singular value decomposition.

Advantages of unsupervised learning:

- Unsupervised learning is helpful for finding useful insights from the data.
- Unsupervised learning is much similar as a human learns to think by their own experiences, which makes it closer to the real AI.
- Unsupervised learning works on unlabeled and uncategorized data which make unsupervised learning more important.
- In real-world, we do not always have input data with the corresponding output so to solve such cases, we need unsupervised learning.

Disadvantages of unsupervised learning:

- Unsupervised learning is intrinsically more difficult than supervised learning as it does not have corresponding output.
- The result of the unsupervised learning algorithm might be less accurate as input data is not labeled, and algorithms do not know the exact output in advance.

Semi-supervised learning

Semi-supervised learning falls between unsupervised learning (without any labeled training data) and supervised learning (with completely labeled training data). Some of the training examples are missing training labels, yet many machine-learning researchers have found that unlabeled data, when used in conjunction with a small amount of labeled data, can produce a considerable improvement in learning accuracy.

Reinforcement learning

Reinforcement learning is an area of machine learning concerned with how software agents ought to take actions in an environment so as to maximize some notion of cumulative reward. Due to its generality, the field is studied in many other disciplines, such as game theory, control theory, operations research, information theory, simulation-based optimization, multi-agent systems, swarm intelligence, statistics and genetic algorithms.

Models

In machine learning, a model is a mathematical or computational representation of a system or process that can learn and make predictions based on input data.A model is typically

created by training it on a dataset, which involves using an algorithm to optimize the model's parameters in order to minimize its prediction errors on that data. Once the model has been trained, it can be used to make predictions on new, unseen data.Examples of machine learning models include linear regression, decision trees, random forests, support vector machines, neural networks, Bayesian networks, Gaussian processes, Genetic algorithms and many others. The choice of model depends on the nature of the problem being solved, the size and complexity of the dataset, and the desired level of accuracy and interpretability.

Applications of Machine Learning

Together with Artificial Intelligence, Machine Learning has various growing applications in our day-to-day lives. Some of them are: Agriculture, Affective computing, Automated decision-making, Banking, Climate Science, Computer networks, Computer vision, Credit-card fraud detection, Data quality, DNA sequence classification, Economics, Financial market analysis, General game playing, Handwriting recognition, Information retrieval, Insurance, Internet fraud detection, Knowledge graph embedding, Linguistics, Machine learning control, Machine perception, Machine translation, Marketing, Medical diagnosis, Natural language processing,Structural health monitoring, Syntactic pattern recognition, Telecommunication, Theorem proving, Time-series forecasting, User behavior analytics etc.

Limitations of Machine Learning

Although machine learning has been transformative in some fields, machine-learning programs often fail to deliver expected results. Reasons for this are numerous: lack of (suitable) data, lack of access to the data, data bias, privacy problems, badly chosen tasks and algorithms, wrong tools and people, lack of resources, and evaluation problems.
In 2018, a self-driving car from Uber failed to detect a pedestrian, who was killed after a collision. Attempts to use machine learning in healthcare with the IBM Watson system failed to deliver even after years of time and billions of dollars invested.Some other limitations of ML include bias on the data the model is trained on and overfitting.

Ethics

Machine learning poses a host of ethical questions. Systems that are trained on datasets collected with biases may exhibit these biases upon use (algorithmic bias), thus digitizing cultural prejudices. For example, in 1988, the UK's Commission for Racial Equality found

that St. George's Medical School had been using a computer program trained from data of previous admissions staff and this program had denied nearly 60 candidates who were found to be either women or had non-European sounding names.

Hardware and Software used in Machine Learning

Hardware

Since the 2010s, advances in both machine learning algorithms and computer hardware have led to more efficient methods for training deep neural networks (a particular narrow subdomain of machine learning) that contain many layers of non-linear hidden units.[127] By 2019, graphic processing units (GPUs), often with AI-specific enhancements, had displaced CPUs as the dominant method of training large-scale commercial cloud AI.

Software

Several open-source and proprietary softwares are used in Machine Learning, some of them are: Google JAX, Kubeflow, Microsoft Cognitive Toolkit, ML.NET, MLFlow, Shogun, Spark MLlib, SystemML, TensorFlow, Torch / PyTorch, Amazon Machine Learning, Azure Machine Learning, Ayasdi, IBM Watson Studio, Google Cloud Vertex AI, Google Prediction API, MATLAB, Oracle Data Mining, Oracle AI Platform Cloud Service.

Summary

To briefly summarize the aforementioned topics, AI is the simulation of human intelligence processes by machines, originally founded back in the 1950s and currently has advanced greatly where it could assist humans in different day to day activities and even replace them in certain fields of work. AI works by ingesting large amounts of labeled training data, analyzing the data for correlations and patterns, and using these patterns to make predictions about future states. It can be classified based on capability as Narrow, General, and Super AI and based on functionality as Reactive Machines, Limited Memory, Theory of Mind, and Self Awareness, can also be classified as Strong and weak AI based on its functionality. Machine learning is a subfield of artificial intelligence, defined as the capability of a machine to imitate intelligent human behavior. Machine Learning Theory aims to understand the fundamental principles of learning as a computational process. ML approaches can be classified as Supervised, Unupervised, Semi-Supervised, and Reinforcement Learning. Its application includes AI itself, Data Mining, Agriculture, Banking, Economics, Computer Vision and so much more. Limitation to ML include but not limited to data it requires,

privacy issues, data bias and so on.

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