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Review Article

The Evolution of Artificial Intelligence: From Supervised to Semi-Supervised and Ultimately Unsupervised Technology Trends

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Abstract

The progression of Artificial Intelligence (AI) technology from supervised learning to semi-supervised methods and ultimately reaching the realm of unsupervised AI marks a remarkable evolution in the field. This article explores this captivating journey, tracing the development of AI from its roots in supervised learning, where models are trained using labeled data, to the innovative semi-supervised approach, which harnesses the power labeled and unlabeled data. The pinnacle of this evolution is unsupervised learning, where AI systems autonomously uncover hidden patterns and relationships within unlabeled data. The implications of this evolution are profound, shaping industries and sparking ethical conversations. This article delves into each stage, revealing the mechanics, applications, and potential societal impact of AI's transformative trajectory. As we peer into the future, we anticipate an era of AI innovation characterized by unprecedented adaptability, creativity, and discovery.

Introduction

Artificial intelligence (AI) has witnessed remarkable growth and transformation over the years, with breakthroughs driving the development of more advanced and sophisticated systems. One of the significant shifts in AI technology trends is the progression from traditional supervised learning approaches to semi-supervised methods and, finally, the intriguing realm of unsupervised AI. This article delves into this fascinating evolution, exploring the nuances of each stage and the implications they hold for the future of AI technology.

Over the years, the field of Artificial Intelligence (AI) has undergone extraordinary technical thriving and growth as well as transition, with innovations spurring the creation of increasingly sophisticated and advanced systems. The shift from conventional Supervised learning approaches to Semi-Supervised techniques, and finally, the fascinating world of Unsupervised AI, is one of the critical changes in AI technological developments. This essay digs into this intriguing progression, examining the subtle differences between each stage and what they mean for future AI technology development.

Artificial Intelligence by Definition

Artificial intelligence (AI) is the ability of a computer program or a machine to think and learn, similar to the way that humans do naturally. It is also a field of study which tries to make computers "SMART." However, there are essential factors to know about AI, and they are briefly listed as follows:

- It is crucial to distinguish different types of Artificial Intelligence and other phases of the evolution of AI when it comes to developing application programs.
- By recognizing the different types of AI and the scope of the related applications, clarity may arise, and expectations may be far from reality.
- The "broad" definition of Artificial Intelligence is "vague" and can cause a misrepresentation of the type of AI we discuss and develop today.

Different Types of Artificial Intelligence

Holistically, definition and scope of different types of AI are explained here and depicted in figure 1 accordingly:

ANI (Artificial Narrow Intelligence)

The Artificial Narrow Intelligence (ANI) is also known as "Weak" AI. This is the first step to designing and applying Artificial Intelligence to our world! On the other hand, what we see today as the result of development by different companies worldwide is ANI. Every sort of Machine Intelligence that surrounds us today is Narrow AI. Google Assistant, Google Translator, Siri, and also Factory Robots are all Narrow AI.

The scope of ANI is to perform only "Single Tasks" on a "specific data set." This can be done offline or on a real-time or near-real-time basis.

Key Note

These systems do not perform outside the single task they are designed to perform. That's why they are called Narrow AI. With that definition in mind, ANI can Analyze big data on weather maps to specify weather patterns and develop predictions, create a political report, create a real-time trend report based on stock patterns, etc.

AGI (Artificial General Intelligence)

Artificial General Intelligence (AGI) is known as “Strong” AI. This is the “Second Phase” to design and apply Artificial Intelligence to our world. The best example of Artificial General Intelligence or “AGI” is what we see in Intelligent Robots who can “interact” with us and learn. “Sophia,” developed by Hansen Robotics, is the best example of AGI; you can see how far we are from human-like intelligent robots! AGI (when fully developed) can successfully perform any intellectual task that a human can. The best example of a developed AGI robot is the (iRobot Movie).

Key Note

Unlike ANI, Artificial General Intelligence allows human interaction with “Conscious Machines” that are “Self-Aware,” “Emotional,” and “Sentient.” Such machines are constantly learning and evolving way faster than us. However, before devices can achieve accurate human-like intelligence, they must understand “Consciousness.” Something that we do not understand yet!

ASI (Artificial Super Intelligence)

Artificial Super Intelligence (ASI) is the Ultimate level of Artificial Intelligence beyond the human brain’s capabilities! This is the “Third and last phase” of designing and applying Artificial Intelligence to our world. Oxford philosopher Nick Bostrom defines Super Intelligence as “Any intellect that greatly exceeds the cognitive performance of humans in virtually all domains of interest.”

Key Note

Unlike ANI and AGI, Artificial Super Intelligence (ASI) has no boundaries. Kurzweil (A futurist) predicts that by 2045, we will be able to multiply our intelligence a billion-fold by linking wirelessly from our neocortex to a synthetic neocortex in the cloud. This will essentially cause a melding of humans and machines called “Singularity.” Not only will we be able to connect with machines via the cloud, but we’ll also be able to connect to another person’s neocortex! This could enhance the overall human experience and allow us to discover various unexplored aspects of humanity.

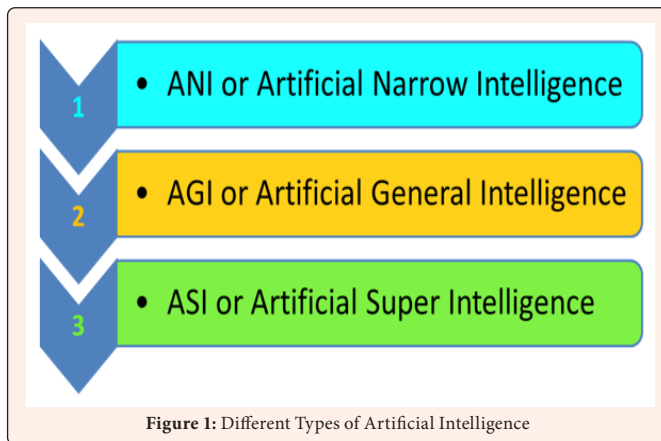


Figure 1: Different Types of Artificial Intelligence

Overall, AI systems, or Artificial Intelligence systems, come with two sub-systems integrated with AI and are computer-based technologies that emulate human cognitive functions, such as learning, reasoning, problem-solving, and decision-making. These systems use algorithms, data, and computational power to perform tasks that traditionally require human intelligence, enabling them to analyze patterns, adapt to changing conditions, and make autonomous decisions [1].

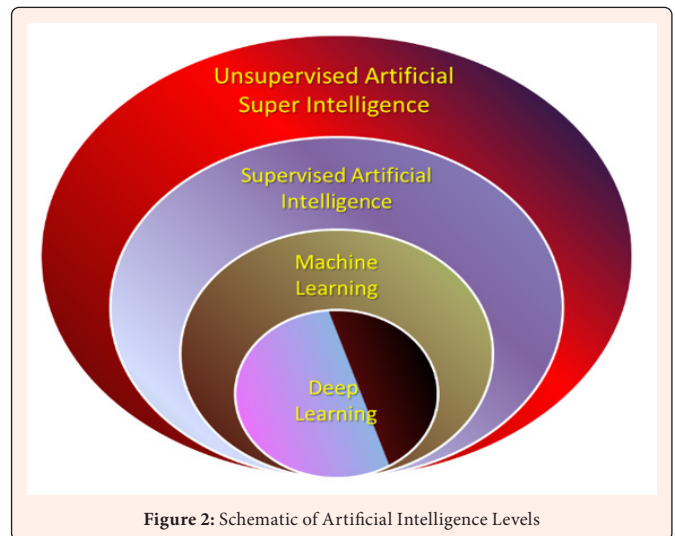


Figure 2: Schematic of Artificial Intelligence Levels

AI sub-systems, namely Machine Learning (ML) and Deep Learning (DL), as depicted in figure 2, are specialized components within artificial intelligence systems that focus on specific tasks or functions. These sub-systems work together to enable the overall AI system to perform complex operations such as data analysis (DL), pattern recognition, language processing (ML), and finally, decision-making [1] capability for (AI).

Each sub-system may have its own algorithms, techniques, and methodologies tailored to its designated task, contributing to the overall capabilities and intelligence of the AI system [2].

From Supervised to Semi-Supervised and Ultimately Unsupervised AI

As we stated, one of the significant shifts in AI technology trends is the progression from traditional supervised learning approaches to semi-supervised methods and, finally, the intriguing realm of unsupervised AI. This article delves into this fascinating evolution, exploring the nuances of each stage and the implications they hold for the future of AI technology [3].

We also quickly introduced you to the holistic aspect of each generation of AI, along with the technology of these AIs from present time to their future existence at different stages and their capacity to technical thrive that they are going through, mainly from supervised to semi-supervised and finally unsupervised progress. Furthermore, again each of these stages from a different perspective is defined here with more granular descriptions:

Supervised Learning: Laying the Foundation Driven Genesis of Learning

Supervised learning serves as the cornerstone of AI development, involving the training of algorithms using labeled data. In this approach, machine learning models are fed with input-output pairs, enabling them to learn patterns and make predictions or classifications on new, unseen data. This method has powered various applications, from image and speech recognition to natural language processing.

While supervised learning has proven highly effective in solving numerous problems, it has inherent limitations. It heavily relies on labeled data, which can be expensive and time-consuming to acquire, especially for complex tasks. Additionally, models trained exclusively using supervised techniques need help adapting to new



or evolving data patterns. The building block of supervised learning that served as the cornerstone for constructing AI emerged. This method uses precisely annotated datasets with supplied inputs and outputs to train AI models. Machines uncover hidden patterns, correlations, and complexities in the data by iteratively learning from these paired examples. We have been gifted with notable accomplishments thanks to supervised learning, like picture recognition, language translation, and virtual personal assistants.

Nevertheless, supervised learning had intrinsic drawbacks even in its successes. Progress was frequently hampered by the voracious need for labeled data, which required much time and money. Additionally, these models could not handle the dynamic nature of real-world data, which limited their capacity to adapt to new situations and contexts.

Semi-Supervised Learning: Bridging the Gap Driven Rise of Learning

Semi-supervised learning emerged as a response to the challenges posed by supervised learning. This approach combines the benefits of supervised and unsupervised techniques, utilizing a small amount of labeled data in conjunction with a larger pool of unlabeled data. By leveraging the vast amounts of unlabeled data available, semi-supervised learning enables models to learn more robust and generalized representations of the data, thereby improving their adaptability and performance on new tasks. One of the key advantages of semi-supervised learning is its potential to reduce the need for extensive labeled datasets, making AI development more cost-effective and efficient. This has significant implications, particularly in domains where labeled data is scarce or difficult to obtain. Semi-supervised techniques have found applications in various fields, including medical image analysis, fraud detection, and language modeling.

Semi-supervised learning is a crucial paradigm that bridges the gap between labeled and unlabeled data due to a natural evolution that followed. This clever strategy combines supervised approaches' strength and unsupervised learning's unbridled potential. Semi-supervised learning gives AI models a richer knowledge of the underlying data distribution by carefully combining labeled and unlabeled data, which enables them to generalize more effectively and adapt to unexplored environments. Semi-supervised learning has been a sign of change in fields with a shortage of labeled data. Its strength has resurrected sectors like healthcare and finance by enabling medical image analysis, predictive modeling, and anomaly identification. The range of possibilities increases exponentially as AI systems get better at gleaning insightful information from a jumble of labeled and unlabeled input.

Unsupervised Learning: the Frontier of AI Driven unleashing the Learning

Unsupervised learning marks a paradigm shift in AI technology, pushing the boundaries of what machines can achieve without explicit labels. Unlike supervised and semi-supervised approaches, unsupervised learning involves training models on unlabeled data, enabling them to independently uncover hidden structures, patterns, and relationships. Clustering, dimensionality reduction, and generative modeling are some of the techniques that fall under the umbrella of unsupervised learning.

One of the most exciting developments in unsupervised learning is the rise of generative adversarial networks (GANs) and variational autoencoders (VAEs). These frameworks enable AI systems to generate highly realistic and creative content, such as images, music, and text, by learning from vast amounts of unlabeled data. Unsupervised learning has also shown promise in anomaly detection, where models can identify rare or abnormal patterns in data without explicit examples. As technology surged ahead, it unlocked the enigmatic realm of unsupervised learning - a paradigm-shattering the shackles of labels and embracing the art of self-discovery. AI models grapple with unannotated data in this landscape, autonomously unraveling hidden patterns, discovering latent structures, and forging intricate connections. The unsupervised juggernaut has manifested in various forms, from clustering algorithms that group similar data points to generative models capable of crafting stunningly realistic synthetic content.

Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) stand as glittering jewels in the crown of unsupervised learning. GANs pit two neural networks against each other in a captivating dance, culminating in the creation of authentic-looking art, music, and even human faces. VAEs, on the other hand, venture into the realm of probabilistic modeling, conjuring vivid imaginations from latent spaces. However, while these artificial intelligences are going through these

revolutionary and evolutionary steps, then question we should entertain would be if their perfection of technologically should be under control and some way of governance role maintained by manufacturer player in this domain [4-6].

Looking Ahead and the Future Implications

The progression of artificial intelligence from supervised to semi-supervised to unsupervised has significant ramifications for both the development of technology and for society at large. AI systems have the potential to completely transform sectors like healthcare, finance, manufacturing, and more as they get better at learning from unlabeled data and spotting intricate patterns on their own.

But these developments also bring up significant ethical and legal questions. Issues with misinformation, privacy, and security become more prominent as AI models develop the capacity to produce highly realistic synthetic content. The direction of AI development will be heavily influenced by finding the ideal balance between innovation and responsible AI deployment. As part of the future implications of AI trajectory from stage to the next stage and the evolution of artificial intelligence (AI) from supervised to semi-supervised and ultimately unsupervised learning heralds a wave of transformative implications that extend across industries, society, and the very nature of human-machine interaction.

As this technological journey unfolds, the future implications of these advancements are both exhilarating and thought-provoking, shaping a new landscape of possibilities and challenges that are discussed here:

- a) **Industries Redefined:** The shift towards semi-supervised and unsupervised AI equips industries with unprecedented tools for data analysis, prediction, and optimization. Sectors such as healthcare, finance, manufacturing, and agriculture stand to benefit from AI systems that can autonomously uncover patterns, forecast trends, and detect anomalies. Decision-making processes become more informed and efficient, contributing to improved patient care, risk management, quality control, and resource allocation.
- b) **Data Accessibility and Cost-Efficiency:** Semi-supervised and unsupervised learning alleviate the burden of data labeling, a resource-intensive process in traditional supervised learning. By extracting insights from a blend of labeled and unlabeled data, AI becomes more accessible to businesses and researchers, particularly in domains where labeled data is scarce or costly to obtain. This democratization of AI has the potential to foster innovation in smaller enterprises and emerging markets.
- c) **Innovation Amplified:** The era of unsupervised AI holds the promise of unlocking novel avenues of innovation. Generative models like GANs and VAEs spark creativity in art, music, design, and content creation. Industries that rely on creativity and imagination, such as entertainment and marketing, could see a revolution in how content is produced and consumed, with AI acting as a co-creator or enhancer of human-driven creativity.
- d) **Ethical and Societal Considerations:** As AI systems delve deeper into unsupervised learning, generating synthetic content that rivals human creations, ethical considerations intensify. The potential for misinformation, deepfakes, and identity theft grows, demanding robust safeguards and regulatory frameworks. Questions about ownership, authenticity, and the blurring lines between human and AI-generated content necessitate careful navigation to ensure responsible AI deployment.
- e) **Human-Machine Collaboration:** Unsupervised AI opens doors to more natural and intuitive human-machine interactions. As AI models become adept at autonomously understanding data structures and relationships, user interfaces could evolve to facilitate seamless collaboration. This could lead to enhanced user experiences, efficient decision support systems, and personalized recommendations that align more closely with human preferences.
- f) **Scientific Discovery:** The power of unsupervised learning extends to scientific research, where AI can assist in identifying hidden patterns in massive datasets, accelerating breakthroughs and discoveries. Fields such as astronomy, particle physics, genomics, and drug discovery could benefit from AI's ability to extract valuable insights from complex and unstructured data.



- g) **Continuous Learning and Adaptation:** The progression towards unsupervised AI implies that systems will become more self-reliant, capable of continuous learning and adaptation without the need for explicit human guidance. This opens avenues for AI systems to autonomously evolve and improve over time, making them valuable partners in addressing dynamic and evolving challenges.

The trajectory of AI, from supervised to semi-supervised and ultimately unsupervised, is a testament to human ingenuity and our perpetual quest for innovation. The implications of this evolution are far-reaching, impacting industries, economies, and societies at large. The healthcare sector could witness earlier disease detection through unsupervised insights, the financial world might predict market fluctuations with uncanny accuracy, and creative endeavors might be revolutionized by AI-generated masterpieces.

However, the ascent to unsupervised AI is not devoid of ethical contemplations. The responsibility of wielding such potent technological tools necessitates a nuanced dialogue about privacy, accountability, and the implications of AI-generated content on our perception of reality. In this article and subjects we have covered in above, we embark on a journey through each stage of AI's evolution, unveiling the mechanics, applications, and implications that define these technological epochs. As we peer into the future, we find ourselves on the precipice of a new era - one where AI, unshackled from the confines of supervision, paves the way for unprecedented innovation, creativity, and exploration.

As a summary, an era of unmatched promise and complexity is being ushered in by the trajectory of AI from supervised to unsupervised learning. As the technology develops, it has transformative effects on a variety of societal dynamics, interactions, and industries. Even such improvements offer innovation and efficiency, they also call for a proactive strategy for resolving sociological, legal, and ethical issues. We can navigate the uncharted waters of this AI evolution and create a future that pushes the limits of human-machine collaboration by wisely utilizing the power of AI.

Conclusion

The development of artificial intelligence (AI) technology from supervised learning to semi-supervised approaches, and finally, unsupervised methods, constitutes a significant shift that has completely changed the potential of human-machine interaction. The progression of AI's role in industries, society, and our collective imagination has been shaped by the new capabilities, difficulties, and discoveries that have emerged at each stage of this journey. AI's capacity to derive insights and make wise judgments has continuously advanced from the early days of supervised learning, where machines learned from precisely labeled data to the ground-breaking semi-supervised method that tapped the value of labeled and unlabeled information. The fascinating potential lies in unsupervised learning, a

frontier of AI where systems autonomously uncover hidden patterns and relationships and transcend the limitations of human-defined labels.

Powered by AI that predicts, detects, and generates, industries are undergoing significant upheavals, and a wave of disruption and creativity is sweeping through several industries. Early disease identification benefits the healthcare industry, financial forecasting skills improve, and the creative industries experience a harmonious synthesis of human creativity and AI-generated brilliance. But this fantastic growth also raises many moral, cultural, and practical questions. The ability of AI to produce synthetic content that is uncannily lifelike prompts concerns about the accuracy of data, individual privacy, and the very nature of human creativity. It becomes crucial to strike the correct balance between innovation and ethical AI use, which calls for strong frameworks and partnerships between engineers, ethicists, and policymakers.

We are on the verge of a time when robots are true collaborators in exploration, discovery, and innovation as we navigate the transition from supervised to unsupervised AI. We must keep pushing the envelope and take advantage of AI's promise of insight, creativity, and flexibility. The development of AI is a monument to human ingenuity as we usher in this new era, guided by our collective wisdom and dedication to ethical advancement; it is a dynamic force that defines the future and inspires us to explore the unknown vistas of possibilities.

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