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Artificial Intelligence And Its Applications

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Abstract

Artificial Intelligence (AI) represents a transformative domain within computer science that focuses on the creation of intelligent systems capable of performing tasks that typically require human cognition. It encompasses a wide range of computational techniques designed to enable perception, reasoning, learning, and autonomous decision-making. As the volume of data generated by both humans and machines continues to expand exponentially, AI provides the computational framework necessary to interpret, analyze, and act upon this data in ways that exceed human cognitive capacity. From machine learning and neural networks to natural language processing and intelligent automation, AI has become the cornerstone of modern computational advancement and digital transformation. This paper explores the foundational concepts, methodologies, and diverse applications of artificial intelligence across multiple sectors, including healthcare, finance, robotics, education, and cybersecurity. Furthermore, it discusses the current developments and future potential of AI as a catalyst for innovation and socio-economic progress.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Natural Language Processing, Knowledge-Based Systems

Introduction

Artificial Intelligence (AI) is a rapidly evolving branch of computer science dedicated to the design and development of systems that exhibit intelligent behavior comparable to human cognition. An intelligent agent—the core operational unit in AI—can be defined as a system capable of perceiving its environment and undertaking actions that maximize its probability of achieving specified goals (Russell & Norvig, 2021). The central pursuit of AI lies in enabling machines to perform tasks that typically require human intelligence, such as reasoning, learning, problem-solving, perception, and language understanding.

The fundamental objectives of AI research encompass several domains: reasoning, which involves deriving logical conclusions from available data; knowledge representation, which focuses on storing and organizing information efficiently; planning, which facilitates goal-directed actions; learning, which enhances performance through experience; and communication, which allows interaction using natural human language. Together, these capabilities contribute to the broader goal of constructing systems that can adapt dynamically and act autonomously in complex environments.

The advancement of AI has been made possible through interdisciplinary integration—drawing insights from computer science, mathematics, linguistics, psychology, and neuroscience. Unlike traditional computational paradigms, AI emphasizes adaptive and self-improving mechanisms rather than explicit programming instructions. Consequently, AI represents both the science and engineering of intelligent behavior and the foundation for next-generation computing systems.

In this paper, a comprehensive exploration of AI's methods, components, and applications is presented. The discussion highlights key methodologies such as machine learning, deep learning, natural language

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processing, robotics, and knowledge-based systems. Furthermore, the paper examines contemporary applications of AI across multiple domains and concludes with reflections on its future implications for society and technology.

Artificial Intelligence Methods

Artificial Intelligence encompasses a variety of methodologies and computational frameworks that enable machines to mimic, enhance, or extend human intelligence. These methods allow systems to learn from data, interpret complex patterns, and perform cognitive functions autonomously. The principal AI methods include Machine Learning, Natural Language Processing, Automation and Robotics, Machine Vision, Knowledge-Based Systems, and Neural Networks.

1. Machine Learning (ML)

Machine Learning is a subfield of AI that focuses on developing algorithms capable of learning from experience and improving performance without explicit programming. It enables systems to automatically detect patterns within large datasets and make data-driven predictions or decisions (Goodfellow, Bengio, & Courville, 2016).

Machine learning algorithms are typically categorized into three primary types:

Supervised Learning: The model is trained on labeled data, enabling it to learn the relationship between input variables and the desired output.

Unsupervised Learning: The system identifies hidden structures or relationships in unlabeled data, allowing pattern recognition and clustering.

Reinforcement Learning: The algorithm learns optimal actions through trial and error by receiving rewards or penalties based on outcomes.

Deep Learning, a subset of machine learning, employs artificial neural networks with multiple layers to analyze complex data structures such as images, speech, and text. These models are particularly effective for predictive analytics and cognitive automation.

2. Natural Language Processing (NLP)

Natural Language Processing is a multidisciplinary area that enables machines to understand, interpret, and generate human language. By integrating linguistics, computer science, and AI, NLP allows seamless interaction between humans and computers through text or speech (Jurafsky & Martin, 2023).

The process of NLP typically involves converting audio input into text, analyzing its syntactic and semantic meaning, and then generating an appropriate response. Applications of NLP are widespread, including speech recognition systems, chatbots, language translation tools (e.g., Google Translate), and grammar-checking applications like Microsoft Word.

However, the inherent complexity of human language—due to ambiguity, context dependence, and cultural variation—poses significant challenges for computational modeling. Consequently, NLP systems utilize machine learning algorithms and statistical models to extract rules and patterns that allow them to handle unstructured linguistic data effectively.

3. Automation and Robotics

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Automation focuses on performing repetitive and monotonous tasks using machines to enhance efficiency, accuracy, and cost-effectiveness. When combined with AI, automation evolves into intelligent automation, capable of adaptive decision-making and self-correction (Brynjolfsson & McAfee, 2017).

Robotic Process Automation (RPA) uses AI algorithms to manage high-volume, rule-based operations—such as transaction processing or data entry—across dynamic environments. AI-driven automation also plays a critical role in cybersecurity through mechanisms like CAPTCHA verification and fraud detection during financial transactions.

Intelligent robotics integrates AI into robotic systems, enabling them to perform complex functions such as navigation, manipulation, and interaction with human users. These systems are increasingly deployed in manufacturing, healthcare, and service industries.

4. Machine Vision

Machine Vision refers to the ability of computers to capture and interpret visual information from the environment. It involves a sequence of processes: capturing visual input through cameras, converting analog signals into digital form, and applying digital signal processing to analyze the data. The analyzed information is then utilized by AI models for decision-making (Szeliski, 2022).

Key parameters of machine vision include sensitivity—the capacity to detect low-intensity stimuli—and resolution, which determines the system's ability to differentiate between objects. Applications of machine vision range from medical image analysis and biometric recognition to industrial inspection and pattern recognition.

5. Knowledge-Based Systems (KBS)

A Knowledge-Based System is an intelligent computer application designed to emulate the decision-making ability of human experts in specific domains. It relies on a knowledge base, which stores domain-specific rules or cases, and an inference engine, which applies logical reasoning to generate conclusions or recommendations (Liebowitz, 1998).

KBS are widely used in areas such as medical diagnosis, financial advising, and technical troubleshooting, where structured reasoning and expert judgment are essential.

6. Neural Networks (NNs)

Neural Networks are computational models inspired by the structure and functioning of the human brain. They consist of interconnected processing units, or "neurons," arranged in layers that collectively perform complex mappings between inputs and outputs. Through training—often using backpropagation algorithms—neural networks can approximate nonlinear functions with high accuracy (LeCun, Bengio, & Hinton, 2015).

Depending on architecture, neural networks can be categorized into various forms such as Convolutional Neural Networks (CNNs) for image recognition, Recurrent Neural Networks (RNNs) for sequential data, and Generative Adversarial Networks (GANs) for creative data synthesis. These systems form the foundation of modern deep learning and cognitive computing applications.

Applications of Artificial Intelligence

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Artificial Intelligence has become an indispensable element of contemporary society, shaping the operational and strategic frameworks of multiple industries. Through data-driven modeling, adaptive learning, and cognitive automation, AI offers transformative potential across diverse sectors. The following subsections highlight major application domains of AI and their evolving impact.

1. AI in Astronomy

AI plays a pivotal role in addressing the complexity of astronomical data analysis. Modern telescopes and space missions generate vast quantities of data that exceed manual processing capabilities. Machine learning algorithms assist in identifying celestial bodies, predicting stellar behavior, and classifying cosmic events. For instance, convolutional neural networks are employed to detect exoplanets and analyze galactic formations, significantly accelerating astronomical discovery (Smith & Geach, 2020).

2. AI in Healthcare

The healthcare sector has witnessed remarkable transformation through AI-driven technologies. Machine learning algorithms are employed in medical imaging, drug discovery, disease prediction, and patient monitoring. AI systems can analyze radiological images for early detection of conditions such as cancer or cardiovascular disease with precision comparable to, or even surpassing, that of human experts (Esteva et al., 2019). Furthermore, predictive analytics models assist clinicians in anticipating patient deterioration, facilitating timely intervention. AI-powered virtual assistants and diagnostic tools have also improved healthcare accessibility and efficiency globally.

3. AI in Gaming

In the gaming industry, AI enables dynamic and adaptive gameplay through intelligent agents capable of learning from user behavior. These systems use reinforcement learning and pathfinding algorithms to simulate realistic environments and strategic decision-making. Games such as Chess and Go exemplify the success of AI algorithms like DeepMind's AlphaGo, which achieved human-competitive performance by combining deep neural networks with Monte Carlo tree search (Silver et al., 2017).

4. AI in Finance

AI has revolutionized the financial industry by enhancing efficiency, risk assessment, and customer engagement. Financial institutions employ AI for algorithmic trading, credit risk evaluation, fraud detection, and customer service automation. Machine learning models analyze historical and real-time market data to optimize investment strategies, while chatbots and natural language interfaces streamline client interactions. Moreover, anomaly detection systems strengthen cybersecurity by identifying irregular transactional patterns indicative of fraud (Bussmann, 2020).

5. AI in Data Security

The escalating sophistication of cyber threats has necessitated AI-driven security systems capable of real-time threat detection and response. Machine learning algorithms are used to recognize behavioral anomalies and predict potential breaches. Platforms such as the AI2 cybersecurity framework utilize deep learning for malware classification and intrusion detection, thereby strengthening organizational resilience against cyberattacks (Sommer & Paxson, 2019).

6. AI in Social Media

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Social media platforms leverage AI for content recommendation, trend analysis, and moderation. AI algorithms analyze user behavior to personalize news feeds and advertisements, enhancing engagement and user experience. Sentiment analysis and natural language understanding further enable platforms to identify emerging social trends and public opinions. However, this integration also raises ethical considerations concerning data privacy, algorithmic bias, and misinformation dissemination (Kapoor et al., 2018).

7. AI in Travel and Transportation

AI applications in the travel and transport sectors enhance route optimization, demand forecasting, and customer experience. AI-powered chatbots assist travelers with itinerary planning, hotel bookings, and flight recommendations. In logistics, predictive models optimize delivery routes and fleet management, minimizing operational costs and environmental impact (Zhang et al., 2021). Autonomous vehicles represent one of the most significant advancements, utilizing AI for real-time perception, decision-making, and navigation.

8. AI in the Automotive Industry

Automotive manufacturers are integrating AI into vehicles to improve safety, efficiency, and user convenience. Advanced Driver Assistance Systems (ADAS) employ computer vision and deep learning to detect obstacles, manage lane control, and enable partial automation. Companies such as Tesla and Waymo have pioneered the development of self-driving cars, utilizing AI for environmental mapping, object recognition, and adaptive control systems. Additionally, virtual assistants within vehicles provide intelligent, voice-activated support for drivers.

9. AI in Robotics

AI enhances robotic systems by enabling them to perceive their surroundings, make decisions, and learn from interaction. Unlike traditional robots limited to pre-programmed actions, AI-driven robots can adapt to new situations autonomously. Humanoid robots, such as Sophia and Erica, exemplify this capability by demonstrating human-like communication and emotional expression (Sharkey, 2016). In industrial contexts, collaborative robots (“cobots”) operate alongside humans, performing precision tasks in manufacturing, logistics, and healthcare environments.

10. AI in Entertainment

The entertainment industry increasingly relies on AI for content creation, personalization, and audience engagement. Recommendation systems used by streaming platforms like Netflix and Spotify analyze user preferences to suggest relevant media content. Furthermore, generative AI models can produce music, visual art, and video effects, expanding creative boundaries and production efficiency (McCormack et al., 2019).

11. AI in Agriculture

AI is transforming agriculture by optimizing resource utilization and improving crop yields. Machine learning algorithms are used for predictive analytics in weather forecasting, soil health assessment, and pest detection. AI-powered drones and robotic systems assist in precision farming by monitoring crop conditions and automating irrigation. These technologies contribute to sustainable agricultural practices and reduced environmental impact (Kamilaris & Prenafeta-Boldú, 2018).

12. AI in E-Commerce

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AI has become central to the e-commerce ecosystem, offering enhanced personalization, product recommendations, and customer support. Recommendation engines analyze customer data to suggest products based on browsing and purchasing patterns. Chatbots, powered by NLP, provide instant assistance and improve customer satisfaction. Moreover, AI supports demand forecasting, inventory management, and dynamic pricing, ensuring operational efficiency (Davenport et al., 2020).

13. AI in Education

In education, AI facilitates personalized learning, automated grading, and intelligent tutoring systems. Adaptive learning platforms analyze student performance data to tailor instructional content to individual learning styles. Virtual teaching assistants and chatbots offer continuous academic support, making learning more accessible and engaging (Zawacki-Richter et al., 2019). Future developments in AI are expected to further democratize education through scalable, data-driven teaching models.

Future of Artificial Intelligence

The rapid evolution of Artificial Intelligence is fundamentally reshaping the trajectory of technological and societal development. As AI systems continue to mature, they are increasingly influencing economic models, labor structures, security frameworks, and human interaction paradigms. The future of AI, therefore, lies not merely in enhancing computational efficiency but in redefining the relationship between humans and intelligent machines.

Biological intelligence, although remarkable, is inherently limited by neural capacity and biological constraints. In contrast, artificial intelligence possesses scalable, non-biological computation, enabling exponential growth in data processing and knowledge synthesis (Kurzweil, 2016). While the human brain is estimated to store around ten billion binary digits of information, much of this capacity is devoted to visual and sensory memory. AI systems, however, can store, retrieve, and analyze information with virtually unlimited capacity, facilitating decision-making processes beyond the threshold of human cognitive endurance.

The increasing integration of AI across all sectors brings both unprecedented opportunities and substantial challenges. On one hand, AI promises to revolutionize healthcare, education, finance, and infrastructure by enhancing predictive capabilities and automating complex tasks. On the other hand, it introduces ethical dilemmas concerning data privacy, algorithmic transparency, job displacement, and autonomous decision-making. These issues necessitate robust governance frameworks to ensure that AI technologies are developed and deployed responsibly (Floridi & Cowls, 2019).

From a global perspective, AI is emerging as a central instrument in cyber defense and security. As cyber threats become more sophisticated, AI will be utilized both defensively—to detect, prevent, and respond to attacks—and offensively—to counteract adversarial AI systems. The rise of adversarial machine learning presents new vulnerabilities, requiring innovative strategies for safeguarding data integrity and system reliability (Brundage et al., 2020).

The importance of data governance is expected to grow exponentially as AI's reliance on large datasets intensifies. Data will not only serve as fuel for AI models but also as a strategic asset influencing economic and political power dynamics. Ensuring equitable access to data and protecting individuals' rights within AI ecosystems will be essential for maintaining public trust and social welfare.

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Ultimately, the future of AI is not a question of technological capability but of ethical direction and collective intent. Responsible innovation, guided by transparency, accountability, and inclusivity, will determine whether AI becomes a tool for universal progress or a source of inequality and disruption. Global collaboration among governments, researchers, and industry stakeholders is imperative to ensure that AI development leads to sustainable growth and human-centered outcomes.

NetApp and Artificial Intelligence

As organizations increasingly transition toward digital ecosystems, the effective management and utilization of data have become central to operational success. NetApp, a global leader in data management and cloud computing solutions, plays a pivotal role in facilitating artificial intelligence (AI) development through its robust data infrastructure and hybrid cloud technologies. The company's data fabric architecture provides an integrated environment for data storage, access, and processing, enabling organizations to manage information seamlessly across on-premises and cloud-based systems (NetApp, 2023).

The NetApp Data Fabric offers a unified platform that enhances data visibility, mobility, and governance, all of which are essential for scaling AI workloads. By ensuring consistent access to structured and unstructured datasets, it supports the efficient training and deployment of machine learning and deep learning models. This integration allows enterprises to accelerate innovation while maintaining data security and compliance standards.

NetApp's AI solutions are built on several foundational components:

ONTAP Software: Facilitates efficient data management and storage optimization for AI and deep learning workloads in both on-premises and hybrid cloud environments.

AFF All-Flash Systems: Deliver high-performance data access and reduced latency, eliminating processing bottlenecks commonly associated with intensive AI computation.

ONTAP Select: Enables data collection and aggregation at the network edge using Internet of Things (IoT) devices, streamlining the preprocessing of large, distributed data streams.

Cloud Volumes: Support rapid prototyping and flexible scaling of AI projects by enabling dynamic data movement between private and public cloud environments.

Through these integrated systems, NetApp empowers enterprises to leverage the full potential of AI for business transformation. By enhancing data accessibility and computational agility, NetApp's AI infrastructure aligns with the broader objective of achieving intelligent data-driven decision-making. Moreover, its hybrid cloud architecture addresses one of the most critical challenges in modern AI—balancing data security with scalability and operational efficiency.

In essence, NetApp's contributions extend beyond infrastructure; they embody a strategic approach to enabling AI-driven innovation. The company's emphasis on sustainable data ecosystems positions it as a crucial enabler in the global AI landscape, supporting applications ranging from autonomous systems to predictive analytics and digital twin technologies.

Conclusion

Artificial Intelligence (AI) has emerged as a transformative force that continues to redefine the boundaries of human capability and technological advancement. By enabling machines to learn, reason, and make

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autonomous decisions, AI has evolved from a theoretical construct to a practical reality influencing nearly every domain of modern life. From healthcare and education to finance, agriculture, and cybersecurity, AI-driven innovations are reshaping how data is analyzed, decisions are made, and services are delivered (Esteva et al., 2019; Zawacki-Richter et al., 2019; Sommer & Paxson, 2019).

The interdisciplinary nature of AI—drawing from computer science, mathematics, linguistics, and cognitive science—underscores its vast potential as both a scientific discipline and an enabler of global progress (Russell & Norvig, 2021; Jurafsky & Martin, 2023). As demonstrated throughout this paper, the diverse applications of AI illustrate not only its technical sophistication but also its socio-economic impact in improving efficiency, accuracy, and personalization across industries (Davenport et al., 2020; Bussmann, 2020).

However, the growing ubiquity of AI also presents challenges that demand ethical foresight and responsible governance. Issues related to data privacy, algorithmic transparency, employment displacement, and decision accountability necessitate a balanced approach to innovation—one that prioritizes human welfare alongside technological growth (Floridi & Cowls, 2019). Sustainable and inclusive AI development must therefore rest on the pillars of fairness, explainability, and accountability.

Looking ahead, the future trajectory of AI will depend on global collaboration among governments, academia, and industry leaders to ensure equitable access to AI resources and ethical deployment. With responsible integration, AI holds the potential to augment human intelligence rather than replace it, leading to a future characterized by enhanced problem-solving, innovation, and societal well-being (Brundage et al., 2020; Kurzweil, 2016).

In conclusion, Artificial Intelligence is not merely a technological evolution but a paradigm shift that offers boundless opportunities for human advancement—provided it is guided by the principles of ethics, inclusivity, and sustainability (Brynjolfsson & McAfee, 2017; Floridi & Cowls, 2019).

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