The role of Artificial Intelligence in future technology

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Abstract

Artificial Intelligence is the science and engineering of making intelligent machines, aimed at providing machines with the ability to think, reach, and surpass human-level intelligence. In this paper, we begin with an introduction to the general field of artificial intelligence, then progress to the birth, history and the rise of artificial intelligence. We then explore the main streams in the field, along with the advancement, evolution and it's applications for various aspects of our life. The paper will cover central and current research related to artificial intelligence, including reinforcement learning, robotics, computer vision, and symbolic logic. In parallel, we highlight the unique advantages for future technologies, focusing on opportunities, limitations, and ethical questions. To conclude, we describe several current areas of research within the field and recommendations for future research.

***K*eywords** Artificial Intelligence · Machine Learning · Deep Learning · Generative Adversarial Networks · Neuroscience · Symbolic AI · Quantum Machine Learning · Federated Learning · Reinforcement Learning · Affective Computing · Human-Centered AI · Self-Driving Cars · Robotics

1 Introduction

Artificial Intelligence (AI) [1–4] is the science and engineering concerned with the computational understanding of intelligent behavior and therefore the creation of intelligent machines. AI embodies a heterogeneous set of tools, techniques, and algorithms, as shown in Figure 1, including neural networks, genetic algorithms, symbolic AI, and deep learning. These major areas are showing exponential growth and making significant impacts in diverse areas like health care, space, robotics, and military. With the increasing amount of data, ubiquitous connectivity, high-performance computing, and various algorithms present at our disposal, AI is going to add a new level of efficiency and sophistication to future technologies.

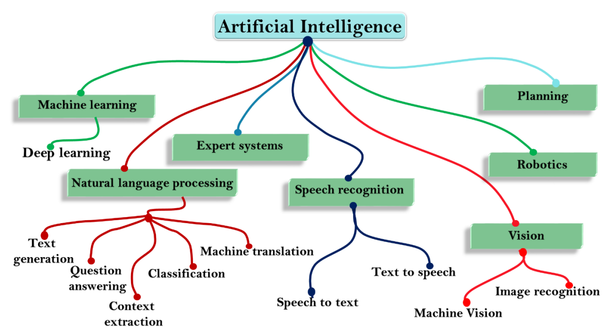

Figure 1: Subfields of Artificial intelligence

One of the primary goals of AI field is to produce fully autonomous intelligent agents that interact with their environments, find out optimal behaviors, improve over time through trial and error almost like humans. It has been a long-standing challenge, ranging from robots, which can sense and react to the world around them, to purely software-based agents, which can interact with natural language and multimedia. Current AI technologies are utilized in driving, aviation, medicine, online advertising, image recognition, and personal assistance.

The recent success of AI has captured the imagination of both the scientific community and the public. An example of this is autonomous cars [5–10] providing the ability to make intelligent decisions on maneuvers in variable, real-traffic road conditions. Another example is the AlphaGo and AlphaZero [11, 12], developed by Google DeepMind, to play the board game Go, and becoming the first machine to beat a professional player. This has led to both the excitement and fear in many that AI will surpass humans in most of the fields.

2 The birth and evolution of AI

The start of AI is believed to be made by Alan Turing with his question "CAN MACHINE THINK?" [1]. The Turing test, developed by Turing in 1950, is a test of a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human. The test set some requirements to build a truly intelligent machine that requires *knowledge representation, natural language, machine learning, automated reasoning, vision, and robotics* for the full test. Since then, the term AI was first introduced by John McCarthy and it was closely associated with the field of "symbolic AI", which was popular until the end of the 1980s. In the 1990s, the new concept of "intelligent agent" [13] emerged. An agent is a system that perceives its environment and undertakes actions that maximize its chances of being successful.

To overcome some of the limitations of symbolic AI, subsymbolic methodologies such as neural networks, fuzzy systems, evolutionary computation, and other computational models started gaining popularity, leading to the term "computational intelligence" emerging as a subfield of AI. Different approaches and methods are being used in AI. Two major methodologies or beliefs are the top-down and bottom-up methods. The top-down theorists believe in mimicking the human brain's behavior with computer programs, whereas the bottom-up theorists believe that the best way to achieve AI is by building electronic replicas similar to the human brain's complex network of neurons. Recently, the term AI encompasses the whole conceptualization of a machine that is intelligent in terms of both operational and social consequences.

3 AI applications and future technology

AI is ubiquitous and is not only limited to computer science but has evolved to include other areas like health [14–17], security [18–21], education [22, 23], music [24–28], art [29, 30], and business [31, 32] application. Many AI applications are deeply embedded in the infrastructure of every industry. AI is expected, in a few years, to touch nearly all the industries [33] and there are plenty of ways AI is and can transform certain industries. AI is currently being utilized for a wide range of activities including medical diagnosis, electronic trading platforms, robot control, and remote sensing. It has been used to develop and advance numerous fields and industries, including finance, healthcare, education, transportation, and robotics.

AI researchers have created many tools to solve the most difficult problems in computer science and other fields. The current AI performance ranges between *sub-human, optimal, and super-human* performance. A wide range of tasks can be solved by AI applications including *facial recognition, speech recognition [34], object recognition [35], images classification [36]* and surpassing human-level intelligence in *The Game of Go [11], Chess [37], Dota 2 [38], and StarCraft II [39–43].*

Another focus of AI technologies lies between the areas of healthcare and privacy with the advancement of federated learning [44] and privacy-perceiving machine learning [45]. AI used as clinical decision support systems for medical diagnosis, computer-aided interpretation of medical images, and companion robots. It can even produce music usable in a medical setting by computer-generated music for stress and pain relief. Moreover, initiatives like Google Magenta [46], conducted by the Google Brain team, want to seek out if AI can be capable of making compelling art and music.

One more active field of AI research is the use of AI to create other AI. This includes Google's AutoML project to evolve a new neural network topologies. with new architectures and topologies exceeding the performance of all previously published ImageNet [47] performance. This is also extended to the current research of Generative Adversarial Networks [48] and the work done by the research team from the visual computing group of the Technical University of Munich and Stanford University developed Face2Face [49], a program which animates the face of a target person, transposing the facial expressions of an exterior source. Since then, other methods have been demonstrated based on deep neural networks, from which the name "DeepFake" [50] was taken.

Recently, new research directions, focus and initiatives have arise including research in quantum machine learning [51], hierarchical reinforcement learning [52], bayesian deep learning [53], affective computing & Human-Centered AI [54, 55], neuroscience [56, 57], self-driving cars [58], and conversational agents [59, 60].

4 Opportunities, Limitations and Ethics of AI

Given the exponential rise of interest in AI, major studies have started on the impact of AI on society, not only in technological but also in legal, and ethical areas. This also includes the speculation that autonomous super AI may at some point supersede the cognitive capabilities of humans.

This future scenario is called the "AI SINGULARITY" [61, 62], defined as the ability of machines to build better machines by themselves. Current AI researchers are more focused on developing systems that are excellent at tasks in a narrow range of applications. This focus is at odds with the idea of the pursuit of artificial general intelligence (AGI) [63, 64] that could mimic all different cognitive abilities related to human intelligence such as self-awareness and emotional knowledge.

Current AI development and the status of our hegemony as the most intelligent species on earth, further societal concerns are raised. However, AI technologies still limited to very specific applications. One limitation of AI is the lack of "common sense" the power to judge information beyond its acquired knowledge. AI is also limited in terms of emotional intelligence. AI can only detect basic human emotional states such as anger, joy, sadness, stress, pain, fear, and neutrality. Emotional intelligence is one of the next frontiers of higher levels of personalization. The computer science principles driving AI forward, are rapidly advancing and it is important to assess its impact, not only from a technological standpoint but also from a social, ethical and legal perspective.

5 Conclusion and recommendations

Many lessons are often learned from the past successes and failures of AI. Rational and harmonic interactions are required between application-specific projects and visionary research ideas to sustain the progress of AI. A clear strategy is required to consider the associated ethical and legal challenges to ensure that the society as a whole will benefit from the evolution of AI and its potential adverse effects are mitigated from early on. Along with the unprecedented enthusiasm of AI, there are also fears about the impact of technology on our society. Such fears should not hinder the progress of AI but motivate the development of a systematic framework on which future AI will flourish. Most crucial of all, it is important to apart science fiction from practical reality. With sustained funding and responsible investment, AI is about to transform the future of our society, our economy, and our life.

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