Write Up

Artificial Intelligence

By:

Tanishq Tanwar
Shiva Tripathi
Srishti Sharma
Aditya Binukumar

17th October, 2021

Introduction

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to the natural intelligence displayed by animals including humans. AI applications include advanced web search engines (i.e. Google), recommendation systems (used by YouTube, Amazon and Netflix), understanding human speech (such as Siri or Alexa), self-driving cars (e.g. Tesla), automated decision-making and competing at the highest level in strategic game systems (such as chess and Go).

As machines become increasingly capable, tasks considered to require "intelligence" are often removed from the definition of AI, a phenomenon known as the AI effect. For instance, optical character recognition is frequently excluded from things considered to be AI, having become a routine technology.

The various subfields of AI research are centered around particular goals and the use of particular tools. The traditional goals of AI research include reasoning, knowledge representation, planning, learning, natural language processing, perception and the ability to move and manipulate objects. General intelligence (the ability to solve an arbitrary problem) is among the field's long-term goals. To solve these problems, AI researchers have adapted and integrated a wide range of problem-solving techniques -- including search and mathematical optimization, formal logic, artificial neural networks, and methods based on statistics, probability and economics. AI also draws upon computer science, psychology, linguistics, philosophy, and many other fields.

History

In the first half of the 20th century, science fiction familiarized the world with the concept of artificially intelligent robots. It began with the “heartless” Tin man from the Wizard of Oz and continued with the humanoid robot that impersonated Maria in Metropolis. By the 1950s, we had a generation of scientists, mathematicians, and philosophers with the concept of artificial intelligence (or AI) culturally assimilated in their minds. One such person was Alan Turing, a young British polymath who explored the mathematical possibility of artificial intelligence. Turing suggested that machines, just like humans, can use available information as well as reason in order to solve problems and make decisions This was the logical framework of his 1950 paper, Computing Machinery and Intelligence in which he discussed how to build intelligent machines and how to test their intelligence.

Unfortunately, Turing faced a plethora of challenges in implementing it.

- First, computers needed to fundamentally change. Before 1949 computers lacked a key prerequisite for intelligence: they couldn’t store commands, only execute them. In other words, computers could be told what to do but couldn’t remember what they did.
- Second, computing was extremely expensive. In the early 1950s, the cost of leasing a computer ran up to $200,000 a month. Only prestigious universities and big technology companies could afford to experiment with this concept. A proof of concept as well as advocacy from high profile people were needed to persuade funding sources that machine intelligence was worth pursuing.

Five years later, the proof of concept was initialized through Allen Newell, Cliff Shaw, and Herbert Simon’s, Logic Theorist. The Logic Theorist was a program designed to mimic the problem solving skills of a human and was funded by Research and Development (RAND) Corporation. It’s considered by many to be the first artificial intelligence program and was presented at the Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) hosted by John McCarthy and Marvin Minsky in 1956. In this historic conference, McCarthy, imagining a great collaborative effort, brought together top researchers from various fields for an open ended discussion on artificial intelligence, the term which he coined at the very event. Sadly, the conference fell short of McCarthy’s expectations; people came and went as they pleased, and there was failure to agree on standard methods for the field. Despite this, everyone whole-heartedly aligned with the sentiment that AI was achievable. This event catalyzed the next twenty years of AI research.

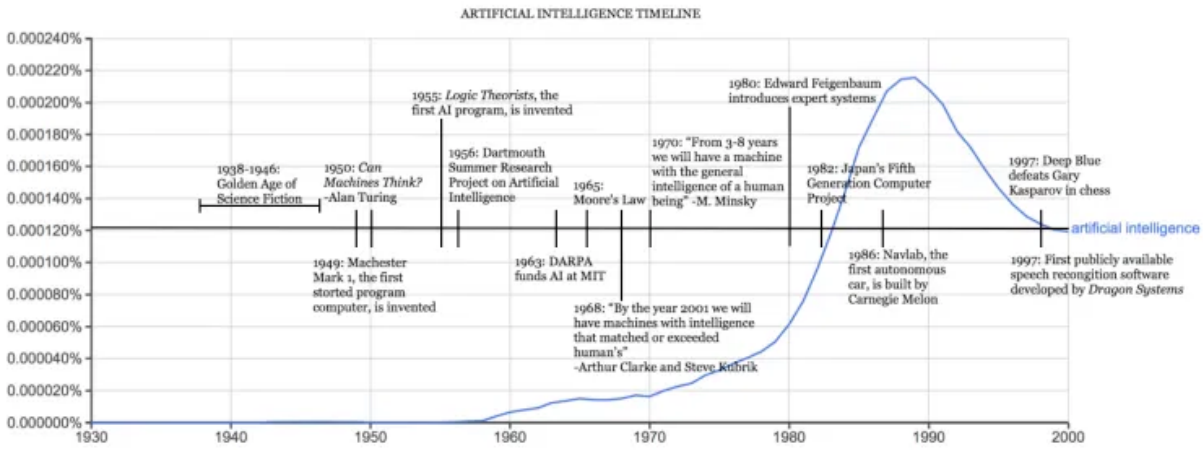
From 1957 to 1974, AI flourished. Computers could store more information and became faster, cheaper, and more accessible. Machine learning algorithms also improved and people got better at knowing which algorithm to apply to their problem. Early demonstrations such as Newell and Simon's General Problem Solver and Joseph Weizenbaum's ELIZA showed promise toward the goals of problem solving and the interpretation of spoken language respectively. These successes, as well as the advocacy of leading researchers (namely the attendees of the DSRPAI) convinced government agencies such as the Defense Advanced Research Projects Agency (DARPA) to fund AI research at several institutions. The government was particularly interested in a machine that could transcribe and translate spoken language as well as high throughput data processing. Optimism was high and expectations were even higher.

In 1970 Marvin Minsky told Life Magazine, "from three to eight years we will have a machine with the general intelligence of an average human being." However, while the basic proof of principle was there, there was still a long way to go before the end goals of natural language processing, abstract thinking, and self-recognition could be achieved.

Breaching the initial fog of AI revealed a mountain of obstacles. The biggest was the lack of computational power to do anything substantial: computers simply couldn't store enough information or process it fast enough. In order to communicate, for example, one needs to know the meanings of many words and understand them in many combinations. Hans Moravec, a doctoral student of McCarthy at the time, stated that "computers were still millions of times too weak to exhibit intelligence." As patience dwindled so did the funding, and research came to a slow roll for ten years.

In the 1980's, AI was reignited by two sources: an expansion of the algorithmic toolkit, and a boost of funds. John Hopfield and David Rumelhart popularized "deep learning" techniques which allowed computers to learn using experience. On the other hand Edward Feigenbaum introduced expert systems which mimicked the decision making process of a human expert. The program would ask an expert in a field how to respond in a given situation, and once this was learned for virtually every situation, non-experts could receive advice from that program. Expert systems were widely used in industries. The Japanese government heavily funded expert systems and other AI related endeavors as part of their Fifth Generation Computer Project (FGCP). From 1982-1990, they invested $400 million dollars with the goals of revolutionizing computer processing, implementing logic programming, and improving artificial intelligence. Unfortunately, most of the ambitious goals were not met. However, it could be argued that the indirect effects of the FGCP inspired a talented young generation of engineers and scientists. Regardless, funding of the FGCP ceased, and AI fell out of the limelight. Despite this, in the absence of government funding and public attention, AI began to thrive.

During the 1990s and 2000s, many of the landmark goals of artificial intelligence had been achieved. In 1997, reigning world chess champion and grandmaster Gary Kasparov was defeated by IBM's Deep Blue, a chess playing computer program. This highly publicized match was the first time a reigning world chess champion lost to a computer and served as a huge step towards an artificially intelligent decision making program. In the same year, speech recognition software, developed by Dragon Systems, was implemented on Windows. This was another great step forward but in the direction of the spoken language interpretation endeavor. It seemed that there wasn't a problem machines couldn't handle. Even human emotion was fair game as evidenced by Kismet, a robot developed by Cynthia Breazeal that could recognize and display emotions.



The Inner Workings of AI

As the hype around AI has accelerated, vendors have been scrambling to promote how their products and services use AI. Often what they refer to as AI is simply one component of AI, such as machine learning. AI requires a foundation of specialized hardware and software for writing and training machine learning algorithms. No one programming language is synonymous with AI, but a few, including Python, R and Java, are popular.

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 chats can learn to produce lifelike exchanges with people, or an image recognition tool can learn to identify and describe objects in images by reviewing millions of examples.

AI programming focuses on three cognitive skills: learning, reasoning and self-correction.

- **Learning processes:**

  This aspect of AI programming focuses on acquiring data and creating rules for how to turn the data into actionable information. The rules, which are called algorithms, provide computing devices with step-by-step instructions for how to complete a specific task.

- **Reasoning processes:**

  This aspect of AI programming focuses on choosing the right algorithm to reach a desired outcome.

- **Self-correction processes:**

  This aspect of AI programming is designed to continually fine-tune algorithms and ensure they provide the most accurate results possible.

The Significance of AI

AI is important because it can give enterprises insights into their operations that they may not have been aware of previously and because, in some cases, AI can perform tasks better than humans. Particularly when it comes to repetitive, detail-oriented tasks like analyzing large numbers of legal documents to ensure relevant fields are filled in properly, AI tools often complete jobs quickly and with relatively few errors.

This has helped fuel an explosion in efficiency and opened the door to entirely new business opportunities for some larger enterprises. Prior to the current wave of AI, it would have been hard to imagine using computer software to connect riders to taxis, but today Uber has become one of the largest companies in the world by doing just that. It utilizes sophisticated machine learning algorithms to predict when people are likely to need rides in certain areas, which helps proactively get drivers on the road before they're needed. As another example, Google has become one of the largest players for a range of online services by using machine learning to understand how people use their services and then improving them. In 2017, the company's CEO, Sundar Pichai, pronounced that Google would operate as an "AI first" company.

Today's largest and most successful enterprises have used AI to improve their operations and gain advantage on their competitors.

The Advantages and Disadvantages of AI

Artificial neural networks and deep learning artificial intelligence technologies are quickly evolving, primarily because AI processes large amounts of data much faster and makes predictions more accurately than humanly possible.

While the huge volume of data being created on a daily basis would bury a human researcher, AI applications that use machine learning can take that data and quickly turn it into actionable information. As of this writing, the primary disadvantage of using AI is that it is expensive to process the large amounts of data that AI programming requires.

Advantages:

- Good at detail-oriented jobs
- Reduced time for data-heavy tasks
- Delivers consistent results
- AI-powered virtual agents are always available

Disadvantages:

- Expensive
- Requires deep technical expertise
- Limited supply of qualified workers to build AI tools
- Only knows what it's been shown
- Lack of ability to generalize from one task to another

Strong and Weak AI

AI can be categorized as either weak or strong.

Weak AI, also known as narrow AI, is an AI system that 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 test.

Types of AI

Arend Hintze, an assistant professor of integrative biology and computer science and engineering at Michigan State University, explained in a 2016 article that AI can be categorized into four types, beginning with the task-specific intelligent systems in wide use today and progressing to sentient systems, which do not yet exist. The categories are as follows:

- **Type 1: Reactive machines**

  These AI systems have no memory and are task specific. An example is Deep Blue, the IBM chess program that beat Garry Kasparov in the 1990s. Deep Blue can identify pieces on the chessboard and make predictions, but because it has no memory, it cannot use past experiences to inform future ones.

- **Type 2: Limited memory**

  These AI systems have memory, so they can use past experiences to inform future decisions. Some of the decision-making functions in self-driving cars are designed this way.

- **Type 3: Theory of mind**

  Theory of mind is a psychological term. When applied to AI, it means that the system would have the social intelligence to understand emotions. This type of AI will be able to infer human intentions and predict behavior, a necessary skill for AI systems to become integral members of human teams.

- **Type 4: Self-awareness**

  In this category, AI systems have a sense of self, which gives them consciousness. Machines with self-awareness understand their own current state. This type of AI does not yet exist.

Incorporation of AI

AI is incorporated into a variety of different types of technology. Here are six examples:

- **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 learning**

  This is the science of getting a computer to act without programming. Deep learning is a subset of machine learning that, in very simple terms, can be thought of as the automation of predictive analytics. There are three types of machine learning algorithms:
  - **Supervised learning:**
    Data sets are labeled so that patterns can be detected and used to label new sets.
  - **Unsupervised learning:**
    Data sets aren't labeled and are sorted according to similarities or differences.
  - **Reinforcement learning:**
    Data sets aren't labeled but, after performing an action or several actions, the AI system is given feedback.

- **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 assembly lines for car production or by NASA to move large objects in space. Researchers are also using 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 skill at piloting a vehicle while staying in a given lane and avoiding unexpected obstructions, such as pedestrians.

Application of AI

Artificial intelligence has made its way into a wide variety of markets. Here are nine examples.

- **AI in healthcare**

  The biggest bets are on improving patient outcomes and reducing costs. Companies are applying machine learning to make better and faster diagnoses than humans. One of the best-known healthcare technologies is IBM Watson. It understands natural language and can respond to questions asked of it. The system mines patient data and other available data sources to form a hypothesis, which it then presents with a confidence scoring schema. Other AI applications include using online virtual health assistants and chatbots to help patients and healthcare customers find medical information, schedule appointments, understand the billing process and complete other administrative processes. An array of AI technologies is also being used to predict, fight and understand pandemics such as COVID-19.

- **AI in business**

  Machine learning algorithms are being integrated into analytics and customer relationship management (CRM) platforms to uncover information on how to better serve customers. Chatbots have been incorporated into websites to provide immediate service to customers. Automation of job positions has also become a talking point among academics and IT analysts.

- **AI in education**

  AI can automate grading, giving educators more time. It can assess students and adapt to their needs, helping them work at their own pace. AI tutors can provide additional support to students, ensuring they stay on track. And it could change where and how students learn, perhaps even replacing some teachers.

- **AI in finance**

  AI in personal finance applications, such as Intuit Mint or TurboTax, is disrupting financial institutions. Applications such as these collect personal data and provide financial advice. Other programs, such as IBM Watson, have been applied to the process of buying a home. Today, artificial intelligence software performs much of the trading on Wall Street.

- **AI in law**

  The discovery process -- sifting through documents -- in law is often overwhelming for humans. Using AI to help automate the legal industry's labor-intensive processes is saving time and improving client service. Law firms are using machine learning to describe data and predict outcomes, computer vision to classify and extract information from documents and natural language processing to interpret requests for information.

- **AI in manufacturing**

  Manufacturing has been at the forefront of incorporating robots into the workflow. For example, the industrial robots that were at one time programmed to perform single tasks and separated from human workers, increasingly function as cobots: Smaller, multitasking robots that collaborate with humans and take on responsibility for more parts of the job in warehouses, factory floors and other workspaces.

- **AI in banking**

Banks are successfully employing chatbots to make their customers aware of services and offerings and to handle transactions that don't require human intervention. AI virtual assistants are being used to improve and cut the costs of compliance with banking regulations. Banking organizations are also using AI to improve their decision-making for loans, and to set credit limits and identify investment opportunities.

- **AI in transportation**

  In addition to AI's fundamental role in operating autonomous vehicles, AI technologies are used in transportation to manage traffic, predict flight delays, and make ocean shipping safer and more efficient.

- **AI in Security**

  AI and machine learning are at the top of the buzzword list security vendors use today to differentiate their offerings. Those terms also represent truly viable technologies. Organizations use machine learning in security information and event management (SIEM) software and related areas to detect anomalies and identify suspicious activities that indicate threats. By analyzing data and using logic to identify similarities to known malicious code, AI can provide alerts to new and emerging attacks much sooner than human employees and previous technology iterations. The maturing technology is playing a big role in helping organizations fight off cyber attacks.

Future of AI

So what is in store for the future? In the immediate future, AI language is looking like the next big thing. In fact, it’s already underway. I can’t remember the last time I called a company and directly

spoke with a human. These days, machines are even calling me! One could imagine interacting with an expert system in a fluid conversation, or having a conversation in two different languages being translated in real time. We can also expect to see driverless cars on the road in the next twenty years (and that is conservative). In the long term, the goal is general intelligence, that is a machine that surpasses human cognitive abilities in all tasks. This is along the lines of the sentient robot we are used to seeing in movies. To me, it seems inconceivable that this would be accomplished in the next 50 years. Even if the capability is there, the ethical questions would serve as a strong barrier against fruition. When that time comes (but better even before the time comes), we will need to have a serious conversation about machine policy and ethics (ironically both fundamentally human subjects), but for now, we'll allow AI to steadily improve and run amok in society.

Conclusion

The creation of a machine with human-level intelligence that can be applied to any task is the Holy Grail for many AI researchers, but the quest for AGI has been fraught with difficulty.

The search for a "universal algorithm for learning and acting in any environment," (Russel and Norvig 27) isn't new, but time hasn't eased the difficulty of essentially creating a machine with a full set of cognitive abilities.

AGI has long been the muse of dystopian science fiction, in which super-intelligent robots overrun humanity, but experts agree it's not something we need to worry about anytime soon.