Analysis of computational power as a potential breakthrough in advancing AI technology

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Abstract. The term Artificial Intelligence(AI) has become more common in view recently. The performance and fame of ChatGPT brought a new AI fever to present industries with multiple big companies announcing their upcoming "AI plans". People are arguing about whether AI will help them or steal their jobs. It seems that AI will be, if not have been, walking into people's daily lives. As a result, this article analyzes the current challenges and potential future breakthroughs of Artificial intelligence by focusing on one of the most fundamental factors that support the development and operation of AI—computational power. This article analyzes the relationship between AI performance and computer performance from different eras particularly. It summarizes and analyzes several sources published in related fields. The primary purpose of this article is to provide people with a better overview of present AI technology by taking a close look at the history, present difficulties, and potential solutions of AI and computational power and concludes with possibilities of each solution and expected futures of the AI industry. This paper concludes that the development of AI relies on the computer performance acquired by the industry. Finding a way to obtain better computer performance at a lower cost might be the next breakthrough in the AI industry.

Keywords: Artificial intelligence, Computational power, History, Deep learning.

1. Introduction

Artificial intelligence may appear to be a complex and mysterious concept despite the truth that it is indeed a complicated topic, however, understanding its core is not so challenging. The word Artificial intelligence (AI) commonly refers to a system that has the ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation [1]. While computational power is defined as the ability of a computer system to calculate and process data. When talking about the future of AI, most envision and worry about the possible legal and ethical impacts AI will bring but seldom talk about the next breakthrough and related factors such as hardware or computational power. However, the path leading to the imaginary future is still blocked by many barriers waiting to be solved and this is why analyzing the next significant achievement is important. Because the invention and development of AI are closely connected to the body bearing them, the computers, looking at and analyzing their histories and current development may provide a unique point of view. The article used document analysis to analyze several famous AI over history and their carriers' computing performance, successfully proving that the performance of a carrier can significantly

influence the performance of its AI. The article focused on document reports talking about the AIs and official hardware reports provided by their manufactures like IBM. In the hope of providing a new perspective to look at possible turning points the AI industry will experience, this article intends to offer the public a more detailed and complete near future the society may be walking into. This article explores several historical breakthroughs in computer performance and AI industry, analyzing their relationship and influence cast upon each other from multiple resources. This article will provide a general outlook of the past and present artificial intelligence and computer industry, informing current AI industry practitioners and the public about the importance of computer performance and pointing out the next possible breakthroughs in artificial intelligence.

2. The history of artificial intelligence

2.1. The birth of artificial intelligence

Although the figure of AI has been around within scientific fiction for a long time, the concept was not proposed officially until 1950 by the famous mathematician Alan Turing [1]. By then, Turing was working on a code-breaking machine called The Bombe, which was used to decipher code from Germans in WWII [1]. The Bombe was a electro-mechanical computer and it was first invented in the 1940s. The deciphering job could not be done by any human mathematician by then, so a question came to Turing's mind whether computational machines could develop and have their own intelligence. By then The Bombe was a massive monster weighing about a ton and it brought the idea of artificial intelligence into Turing's mind. A paper was soon published by Turing named "Computational Machinery and Intelligence" and it was like a rock being thrown into a still pond. Six years later, the first group of AI researchers gathered at Dartmouth College. Many people who attended the conference became founding fathers of computer and artificial intelligence such as John McCarthy and Terry Winograd [2].

2.2. The development history of artificial intelligence in the 20th century: ELIZA & Deep Blue

Significant achievements in the AI field were made after the birth of the idea such as ELIZA, one of the first natural language processing AI that passed the Turing test [1-3]. ELIZA was built and ran on IBM7094, a 1962 computer and it was far more modern than the Bombe Turing was working with. IBM7094 could run twice as fast as IBM7090, which was announced in 1959. The IBM7090 series achieved a much higher computational power than the former ones, with the IBM7090 being six times faster than its last predecessor [4]. What's more, IBM7090 was equipped with seven index registers instead of its predecessor's three or less, meaning that it can store and read data much quicker.

There were many other successful AI programs passing the Turing test around that age like the General Problem Solver program. However, the high expense put into the AI industry gained attention from governments and soon the support was cut down. There were also sounds criticizing the AIs not being intelligent enough while playing chess and talking because they can only reach the level of an amateur. Some even started to doubt the outlook of AI is too idealized. With the support from the government and the public leaving the industry, AI researchers were facing their winter [1].

The prejudice was broken into pieces by an artificial intelligence made by IBM called Deep Blue. Deep Blue was a chess-playing program that was able to beat the world champion, Garry Kasparov, in 1997. However, the success and excellent performance of Deep Blue was not born with it. Deep Blue was first launched in 1995 and upgraded along with the IBM RS/6000 series and finally impressed the public in 1997. The Deep Blue quickly lost the first game it had with Kasparov. The computational power of the series was increasing drastically with the latest improvement making RS/6000 58% faster than the previous edition. Also, Deep Blue was trained to understand and tackle Kasparov's style. After training with the most advanced computer in the industry, Deep Blue successfully brought more hope and funding to its industry [5].

2.3. The present AI: ChatGPT & AlphaGo

Many insisted that Deep Blue was still far from a real intelligent being. It is true that many of these early AIs ran on hard-coded if statements [3]. In order to make artificial intelligence think more like real people, artificial neural networks came into place. Today, many famous and outstanding AIs such as ChatGPT and AlphaGo are all equipped with deep neural networks and trained through deep learning. The structure of neural networks mimics how neural units are in a human's brain and its intention is to make machines think more like humans.

Just like Deep Blue, AlphaGo is another expert system, meaning that the AI is trained to conquer specific tasks [1]. Deep Blue was trained to become the best chess player while AlphaGo also beat the chess game Go's world champion. Go is a much more complex game than chess. Because AlphaGo was able to calculate so many possibilities and figure out the best step at a fast speed, it was able to win the competition. In contrast, ChatGPT was designed to become an AI much more similar to a real person. The excellent computational power provided by modern Graphics Processing Unit(GPU) allows AIs to be trained more efficiently than ever. Google developed a hardware called Tensor Processing Unit(TPU) specifically to help with machine learning and training artificial intelligence in 2016, which was also used by AlphaGo[6]. The IBM 6000/RS used to train and run the first prototype of Deep Blue only had 2 gigabytes of memory while computers in modern days have at least 8 gigabytes [7]. Cloud also plays an important role in modern AI training. TPU released by Google can be accessed and used for AI training through cloud service.

3. The future of computational power and its influence on artificial intelligence

3.1. computational power and AI development

It is obvious that computational power develops along with artificial intelligence and it is a critical cornerstone of the AI industry. However, they come in an order. The most elegant and complex algorithms and models could not run in the air. The progress of artificial intelligence relies on the development of hardware and computational power of its carrier. Whenever the hardware and computational power are still developing, researchers and programmers can train and improve their AI. It would be impossible to train an AI if there is not enough memory or it takes too long to process data.

Despite the fact that the computational power of present computers is developing at a steady speed, it is still likely to encounter a bottleneck in the near future. If the computational power slows down or even stops improving, the future of AI will also dim. Training an AI involves multiple computer hardware including memory, disk, CPU, etc. However, the efficiency of these components relies on the amount of electric circuits or structures that can be put into a fixed amount of space. The better the photolithography technology is acquired, the more elegant and effective chips and hardware pieces can be made.

Funding has become a pain in the AI industry's neck for a long time. The industry experienced its first winter around the 1960s due to the low support and funding given[1]. The price to create the most advanced hardware is not cheap at all. OpenAI spent at least 8 years on ChatGPT before it was released in 2022[3]. Because hardware is not the whole story of an AI, the majority of money may not go toward the hardware carrier. What's more, with the heat brought by modern AI, many people started to train their own AI using their personal computers. There are supercomputers such as quantum computers already being used in other fields, however, the price is still too high for the AI industry to.

3.2. Future possible breakthroughs in computational power

The goal is simple: being able to access computers and hardware with better computational power at a cheaper price. When computers first came out in the early 20th century, there weren't a lot of them. People came in and rented computers to calculate their problems because there was no technology to produce massive amounts of computers at a low price. Computer producers tackle this problem by finding a way to put more content into a smaller box by increasing the precision and amount of detail in

each unit. Finding better materials, designing more effective circuits, and even having a brand new theory coming into the field can promote computational performance and reduce costs.

3.3. The future of artificial intelligence

However, the current AI industry still faces many more challenges. Content generative AI such as ChatGPT have been criticized due to the biased and incorrect information they give to the public. Many still doubt whether these AIs can be counted as intelligent beings just like AI was doubted to reach the best human intelligence in one field in the 20th century. It seems that the future of artificial intelligence is still blurry and filled with questions. With the fame earned by modern AI these days, more and more funding will flow toward this industry. As long as the hardware and computational power given to AI is making progress, it can be believed that better artificial intelligence will appear in the future.

4. Conclusion

In conclusion, this article talked about the close relationship between computational power and artificial intelligence and stated that economic hardware and computational power are critical supplies to the industry. However, this article does not dive deep into the theory and data behind these aspects and analyze their relationship in more detail. What's more, surrounding topics of artificial intelligence such as machine learning and social impacts can be mentioned more in the future to provide background information. It can be helpful to dive deeper into present and past hardware details, theories, and manufacturing technology like how GPU is made and used to train an AI since the breakthroughs of computational power can be the next breakthrough of artificial intelligence. What's more, taking a closer look at the current challenges supercomputers are facing may provide some clues to potential breakthroughs.

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