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Introduction

Artificial Intelligence (AI). From word-wide coverage to massive amounts of funding, this piece of technology is at the centre of the spotlight for media, technological innovations, and various other applications. While it may seem that this technology is new due to the attention that generative AI tools such as GhatGPT and Google Bard have been receiving, this technology has in fact been around since the mid-20th century. Various tools and applications are already utilizing AI and machine learning to make informative and real-time decisions that influence the behaviour of a program. However, as the investments in AI technology continues to grow, the potential and capabilities of these tools are becoming increasingly intricate and advanced. In fact, over the past decade or so, global startup funding for artificial intelligence has exponentially grown from 670 million U.S dollars in 2011 to an impressive 36 billion in 2020 [1]. This goes to show how much interest AI has been able to accumulate in recent years, and just how much research is ongoing to provide even more sophisticated tools, similar to ChatGPT. However, such as with every technological craze, there comes many burdens and limitations before world-wide adoption can be observed. For example, AI programs and tools require extensive amounts of large and high-quality datasets that can be very computationally expensive. Furthermore, training an AI model can be prone to many biases, which could propagate into more drastic reliability issues when the program is being utilized. Privacy concerns and risks are also major setback for the development and adoption of AI technology. Due to the need for storing and collecting data, AI systems can be a target for potential data breaches, leading to significant harm to individuals whose data are compromised.

Background

In general, new technologies that emerge in the market follow a sigmoid curve [2]. At the start, there is a rather slow takeoff as the technology is invented, developed, and tested. At this stage, the technology is only being used for research purposes and have not yet been fully released to the public. After that, an explosion of growth and interest as the public begin finding these tools useful and the technology becomes more sophisticated. Competitors begin entering the market that sets off a massive race in which the technology becomes even more accessible and cheaper. Eventually, the

technological craze and rate of progress flattens, as people become more accustomed to the new technology. This technological behaviour was observed with the smartphone releases, social media, and even e-commerce.

Currently the adoption of Artificial Intelligence is also on a similar path, however the critical question is where exactly this new technology on the sigmoid curve is. As interest in the Artificial Intelligence world builds up, more and more sophisticated tools will become available that will effectively make many tedious tasks more automated. Most importantly, technologies are much more likely to "takeoff" when they become usable for the general public. For example, the primary reason why generative AI tools such as ChatGPT have become such prominent topics in recent media is solely due to its usefulness and usability. In fact, ChatGPT has recently set a world record for the fastest user growth after reaching 100 million active users in just 2 months after launch [3]. The fact that anyone can easily use ChatGPT to accomplish a simple task has greatly enhanced its presence and helped attract this many users. Tools that are overly complex which can only be used by a specific technical or research group have less chance of becoming major points of attraction for the general public.

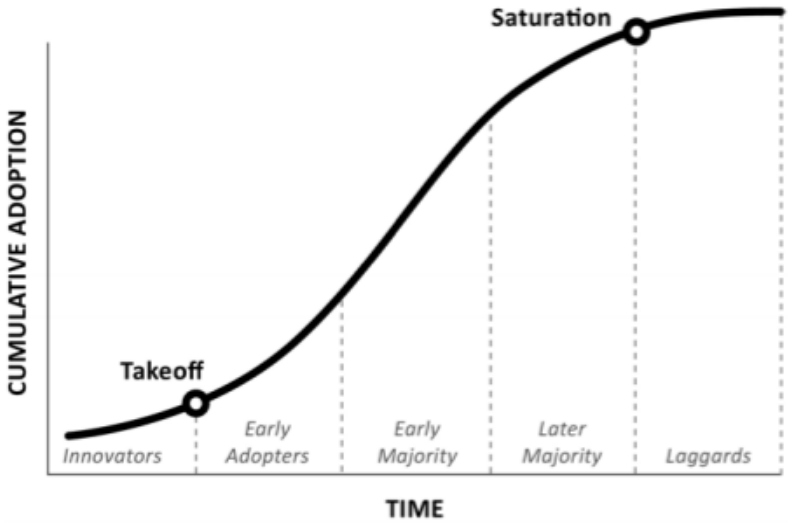


Figure 1: general progress curve for new technologies [2].

Opportunities

The global adoption of AI tools will most certainly put many areas of work in jeopardy. While the adoption of such technology can improve efficiency and productivity in many industries, it will also lead to automation that can replace repetitive and labour-intensive work. According to a study by McKinsey, about 15% of the global workforce could be displaced by automation in the period 2016 to 2030. This alarming number depends on multiple factors including AI technological advancements, worldwide adoption rate, and feasibility. Furthermore, it is predicted that countries that have higher wage levels, primarily developed countries like France, Japan and U.S, will see an even bigger job displacement figures compared to poorer countries such as India [4].

However, the automation and artificial intelligence industry will also contribute to economic growth and transforming businesses through advancements in productivity and efficiency. First of all, the AI technological advancements have significantly contributed to rapid technological progress, ranging from autonomous self-driving vehicles to automated computer programs and tools. These technologies generate increasing values for the companies that use them for personalization, tracking, and forecasting. This increase in economic growth is very much needed, especially in ties where labour productivity growths have dropped to an average of 0.5% in 2010-2014 compared to 2.4% a decade earlier in the U.S [4]. The increase in automation and productivity could be the key driver to lifting up productivity and setting up an economic boom. IT is predicted that productivity growth could reach 2% again in the next decade due to the contributions from the artificial intelligence industry [4].

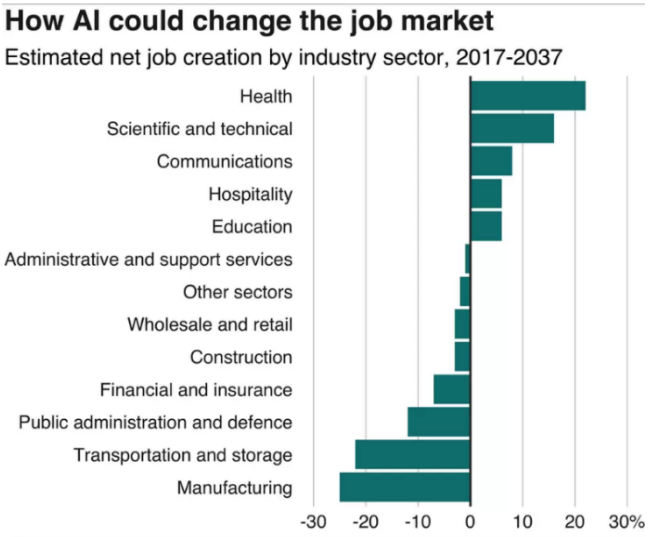


Figure 2: Job displacement and opportunities impact [7].

As with just about every new technology, the risk of job displacement is very much a real threat to the economy, however, there is a plethora of new opportunities and industries that will emerge, ranging from research on new AI tools to data collection and maintenance. These opportunities will require a significant shift in the skills of workers. Reskilling and upskilling programs will need to be implemented to train new generations to acquire those skills. For example, large companies like Google and Tesla are investing millions into self-driving cars and trucks [5]. While this will replace many driver's jobs, it will also create higher demand for skilled labour such as engineers, software developers, and AI maintenance workers. Essentially, the worldwide adoption of artificial intelligence will create a shift in job opportunities that will focus on higher skilled forms of labour that will require higher forms of education [6]. This could potentially widen the wealth gap in many countries and creating a bigger divide between the wealthy and poor. The graph below by PwC shows that while AI will create just about the same number of new opportunities as it displaces, the key point of concern is that the type of jobs requires higher levels of education which will contribute to the wealth gap [7]. As can be seen by the second graph, higher educational requirement jobs are at less risk of job displacement than lower educational careers [7].

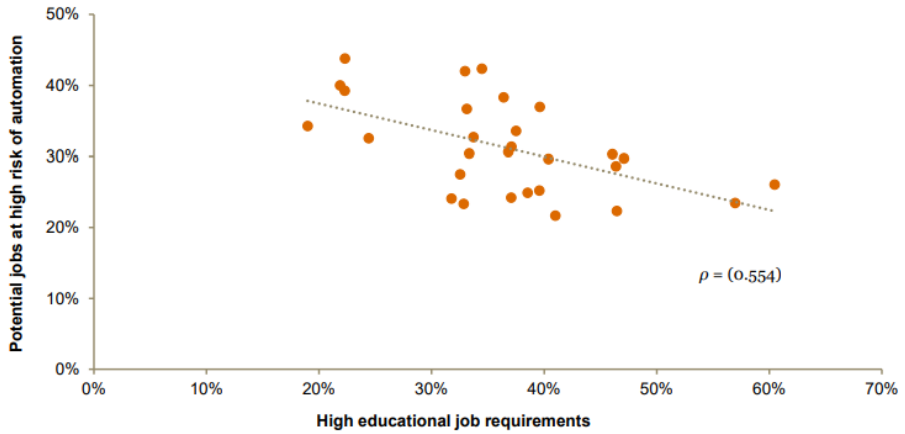


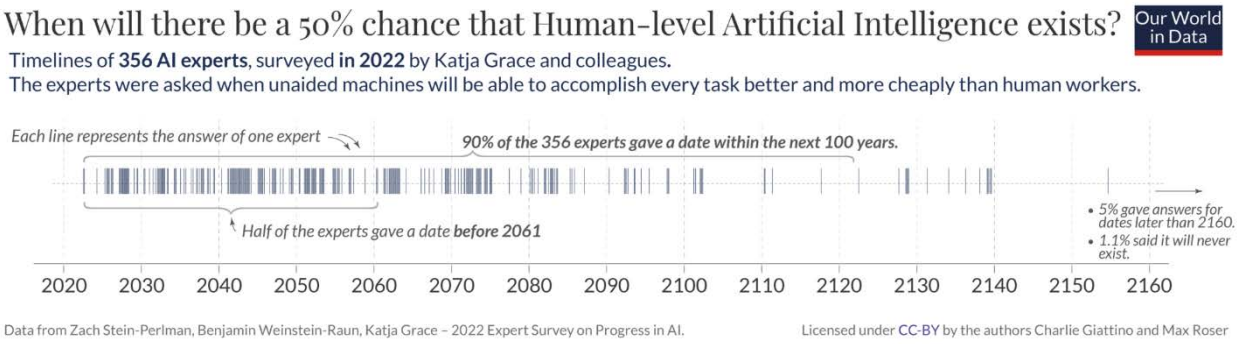
Figure 3: Relative impact from automation of jobs based on educational requirements [7].

Timelines

It is often extremely difficult to predict the exact timeline of when new technological innovations become widely adopted. For example, it took several decades (1960s to 1990s) before internet became widely accessible to the general public. Similarly, the use of machine learning and artificial intelligence has been around for quite some time, but it has only recently received such rapid increase in adoption and attention.

The creation of AI tools is not an easy task. Many months of research, machine learning, AI training, and data monitoring needs to take place before AI tools can become usable. While media attention and competitors jumping on the technological bandwagon are certainly hastening the process of developing new AI tools, it will take some time before the day-to-day lives of many people will truly change. As stated earlier, according to McKinsey, AI related job displacement will be observed mainly around 2030. However, a more interesting question is when AI will be smart enough to outsmart human intelligence. While machines can already excel at specific tasks and be able to outperform humans in specific situations, there is much more to human level intelligence than simply solving algorithms. Without the use of extensive amounts of historic data, machines can often fail to make even the simplest of decisions. A recent study by Katja Grace asked AI experts about the timeline of when Artificial Intelligence could likely surpass human intelligence [9]. About half of the experts gave a date before 2061.

Figure 4: Expert answers about human level intelligence for AI [9].



The figure above shows how even experts are not able to reach a consensus on the progress timeline of AI development. The wide range of results represents the many factors that play into the development of this technology. Factors such as costs, competition, and even public acceptance all play a very major role into this technology's adoption.

Current Technologies

As mentioned earlier, AI is a rapidly evolving field that has gained widespread attention due to its potential to transform various industries. The field of AI mainly encompasses three technologies: natural language processing (NLP), computer vision, and machine learning. As the demand for AI-powered solutions continues to grow, developers and researchers are constantly developing and refining new tools to support the deployment of AI models.

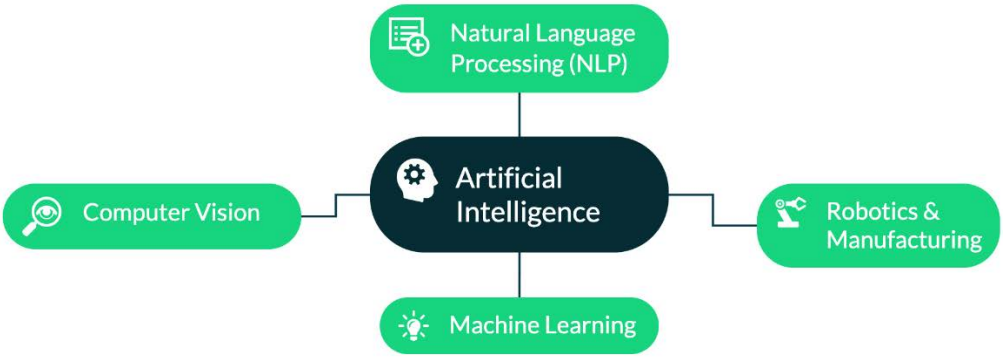


Figure 5: Categories of AI [10].

Natural Language Processing (NLP)

One of the most widely known tools in the realm of AI is natural language processing (NLP), which has been implemented in various applications, such as chatbots, virtual assistants, sentiment analysis, and language translation. The emergence of social media has made it possible for NLP researchers to access unprecedented amounts of data. For instance, product reviews can be analyzed to predict pricing trends and assess advertising campaigns. Social networks can be examined to find indicators of power and influence among different groups. Medical forums can be studied to discover common questions and misconceptions about medical conditions. ChatGPT is a type of NLP model developed by Open AI.

Computer Vision

Another AI tool that shows great promise is computer vision, which analyzes and interprets visual data, such as images and videos. One of the most significant applications of computer vision is in autonomous vehicles, where cameras and sensors are used to detect objects and navigate roads. Additionally, computer vision is used in security systems for facial recognition and tracking, as well as in medical imaging for diagnostics and treatment planning. It has also been applied in agriculture for crop monitoring and yield prediction. Also, in retail for inventory management and customer analytics. Amazon Go is a chain of emerging convenience stores developed by Amazon that uses computer vision to eliminate the need for cashiers and checkout lines.

Robotics and Manufacturing (Robotic Process Automation, RPA)

In robotics, AI is used to develop systems that can perceive their environment and make decisions based on the data they collect. For instance, autonomous robots can be trained to perform sorting, packing, and transporting items in warehouses and factories. AI can also be used to optimize processes and improve quality control, detect anomalies, and predict equipment failures. AI-powered robots can also adapt to changing production demands and reducing waste and improving productivity.

Machine Learning and Deep Learning (ML & DL)

Machine learning is a branch of artificial intelligence that allows algorithms to adjust their own parameters based on feedback loops, without the need for explicit programming. Deep learning is a subset of machine learning that utilizes artificial neural networks inspired by the structure and function of the human brain to solve complex problems. Both machine learning and deep learning models can learn from large datasets and automatically extract meaningful features, allowing them to achieve state-of-the-art performance when combined with NLP or computer vision. This technology has led to significant advancements in areas such as image recognition, speech recognition, predictive maintenance, and more.

Corporate Investments

The increasing integration of AI into the economy makes it necessary to monitor corporate investment in AI. Figure 6 displays the various global corporate investment (Mergers/Acquisitions, Minority Stakes, Private Investments, Public Offerings) in AI between 2013 and 2022. Interestingly, global investment in AI has declined for the first time in 2022. Despite this, AI-related investment has grown 1200 % over the past decade.

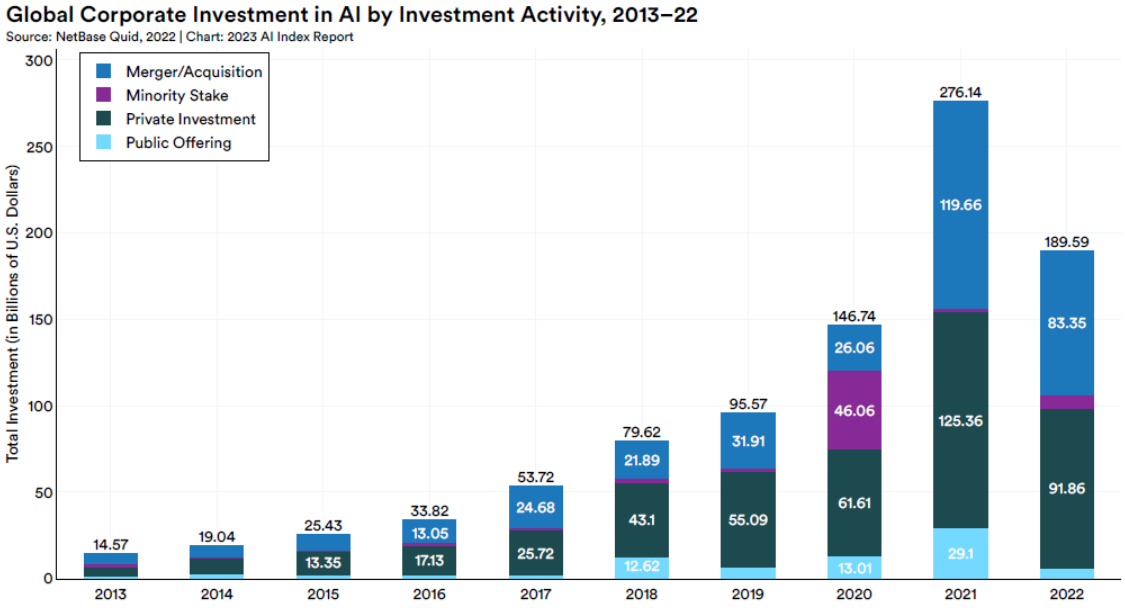


Figure 6. Global Investment in AI by Different Activities [11]

In 2022, the most substantial investments in mergers and acquisitions were made in Nuance Communications, a US-based company specializing in enterprise software, healthcare, and machine learning. The deal was valued at 19.8 billion. The larges minority stake investment was found in a UK-based company Aveva Group, valued at 4.7 billion. Aveva's business spans a wide range of industries, including chemical, data mining, electronics, manufacturing, and software technology. The most significant private investment was made in GAC Aion New Energy Automobile, a Chinese company specializing in automotive, clean energy, and EV manufacturing, with a value of 2.5 billion. Lastly, the biggest public offering event was ASR Microelectronics (1.1 billion), a Chinese company focused on semiconductors.

There could be several reasons why AI investment has decreased. One could be the economic slowdown caused by rising interest rates, which may have led companies to re-evaluate their spending priorities and reduce their R&D investments. The US is the biggest AI partitioner, after all. It is also possible that some investors have become more skeptical about the potential returns of AI investments, particularly in light of the increasing competition and growing complexity of the

technology. The AI market may be reaching a level of maturity where growth rates are expected to slow down, leading some investors to shift their focus to other emerging technologies. Finally, the lack of clear and consistent regulations governing the use of AI in various industries could cause some investors to become more hesitant about investing in the field. An analysis of the limitations of AI is provided in the next section.

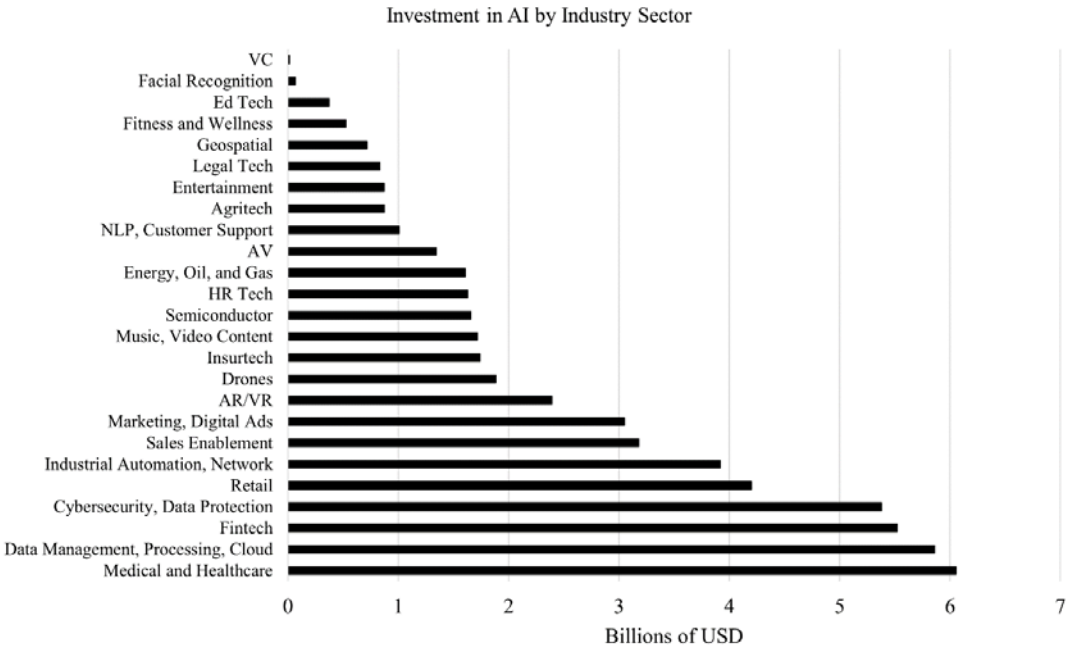


Figure 7. Investment in AI by Industry Sector, 2022 [11].

In terms of industry sectors, the medical and health care industry received the largest investment during 2022, with a total of 5.22 billion. This was followed by data management, processing, and cloud computing, with 5.21 billion, and Fintech, with 4.2 billion.

Investors are hopeful that AI can bring significant advancements to health care . The consensus is that AI is capable of aiding healthcare personnel in various areas, including administrative tasks, clinical documentation, patient communication, and specialized tasks such as medical image analysis, diagnostic equipment automation, and vital signs monitoring [12].

Data management, processing, and cloud computing technologies are primitive targets for AI implementation, and the significant investments in this sector are self-explanatory.

The effectiveness of machine learning as a data processing technique has attracted the attention of the Fintech community, as this industry often responds to volatility, uncertainty, complexity, and ambiguity. Although algorithmic trading has been in practice for several decades, the ability of machine learning to analyze vast amounts of data and identify patterns that would be challenging for humans to discern has led to its widespread adoption. In addition, ML algorithms are utilized in macroeconomic and price prediction, enabling organizations to anticipate market trends and make strategic decisions. ML algorithms can also be found in banking, where it assesses default risk and customers' creditworthiness, assisting financial institutions in making informed lending decisions [13].

Although there is a global downward trend, investment has increased in several sectors such as semiconductors, industrial automation, drones, digital marketing, and HR tech. Table 1 summarizes the possible reasons for increased investment.

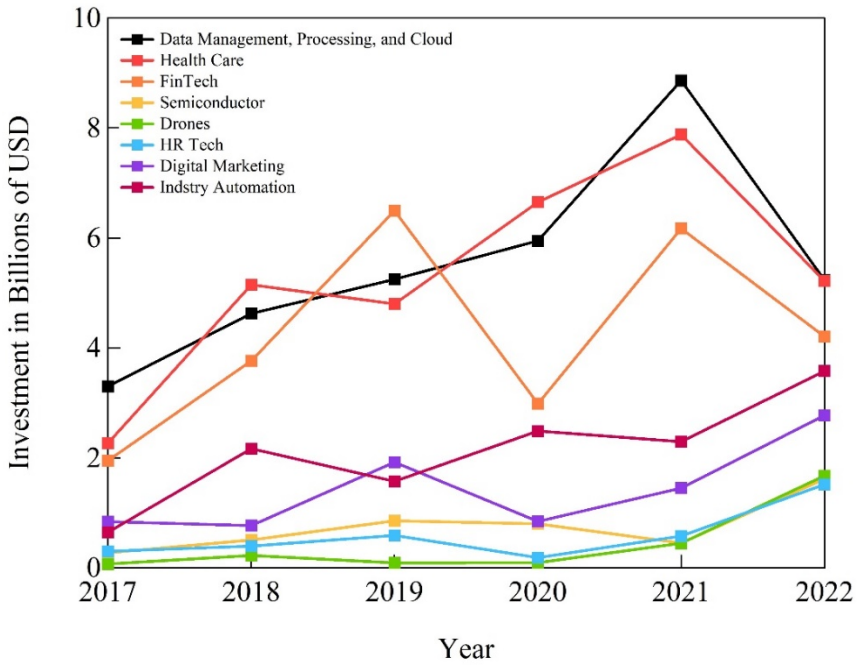


Figure 8. Selected Investment in AI by Industry Sector, from 2017 to 2022 [11].

Table 1. Reasons for Increased Investment on Several Industry Sectors

Industry Sector	Reason for Increased Investment
Semiconductors	▪ Increasing demand for products that rely on semiconductors (smart phones, tablets, sensors … etc.) ▪ Growing trend towards the localization of semiconductor manufacturing to reduce rely on foreign suppliers.
Industry Automation	▪ Growing trend towards Industry 4.0 (Smart Factories), which refers to the integration of advanced technologies such as big data analytics and autonomous operation into manufacturing processes. ▪ Promotion of workforce development and training to keep pace with the technology change.
Drones	▪ Increasing use of drones in agriculture, construction, infrastructure inspection, search and rescue, and delivery services. ▪ Regulatory environment has become more favorable.
Digital Marketing	▪ Increasing use of digital channels, such as social media, search engines, and email, for marketing purposes. ▪ The demand for predictive analytics to optimize customer segmentation, ad targeting, product recommendations/promotions.
HR Tech	▪ HR Tech solutions can automate tasks such as payroll processing, employee onboarding, and performance management. ▪ HR Tech helps companies make data-driven decisions related to the workforce, such as identifying talent gaps, forecasting future needs, and optimizing recruitment efforts.

Limitations and Threats

Data Limitations

The effectiveness of AI algorithms heavily depends on the quality and quantity of data used to train and test them. In this context, data limitations pose challenges for AI developers and researchers. Firstly, AI algorithms require large and high-quality data sets to learn and make accurate predictions. Collecting and labeling data can be an expensive and time-consuming process, which can hinder the development of AI applications [14]. In addition, some domains, such as healthcare, cutting-edge research, military, or finance, have strict regulations and privacy concerns that limit the availability of data for AI development. This can make it challenging to build accurate AI models in these domains, as the available data may not be sufficient or representative of real-world scenarios.

Bias and Interpretability

Bias in AI is a result of the fact that AI relies on data generated, annotated by humans, or collected via systems created by humans. Therefore, the biases that exist in humans can influence the decision-making process of AI systems, and maybe even amplified due to complex sociotechnical systems [15].

Frequently occurring biases include selection bias (certain individuals are more likely to be selected for study), often as self-selection bias, and the reverse exclusion bias; reporting bias (observations of a certain kind are more likely to be reported, which leads to a sort of selection bias on observations); and detection bias (a phenomenon is more likely to be observed for a particular set of subjects) [16]. Sensitive characteristics that identify grounds of discrimination or bias may be present or not. Removing or ignoring such sensitive features does not prevent learning biased models because other correlated features may be used as proxies for them. For example, a minority's preference for bright-colored cars may induce bias against the minority in predicting accident rate if bright-colored cars are also preferred by aggressive drivers. Such a simple correlation between apparently neutral features can then lead to biased decisions. Discovering and understanding causal influences among variables is fundamental for dealing with bias. Hence, emphasizing the fact that statistical inferences require the data from which the model was learned be representative of the data on which it is applied.

Computational Power

The computational power required to train and run AI algorithms has increased dramatically in recent years. This is due in part to the increasing complexity of algorithms, as well as the massive datasets that they are trained on. The demand of computational power is also reflected both in terms of financial resources and environmental impact.

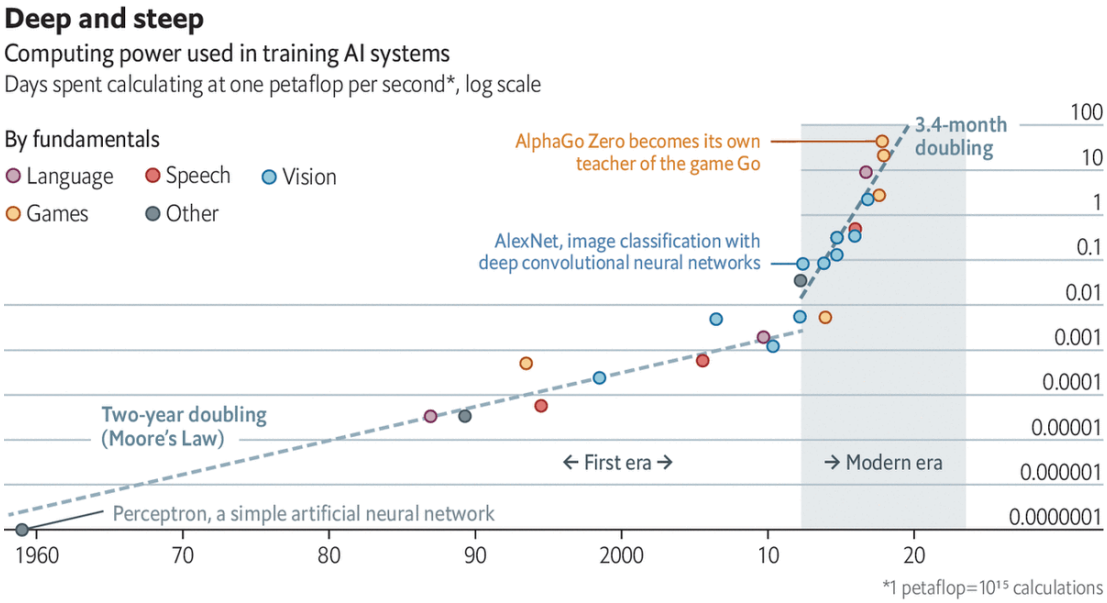


Figure 9. The amount of computations in AI training is increasing with 3.4 month doubling time [17].

Figure 9 shows the rate of increase in calculations is much faster than the doubling time of Moore's Law, which had a two-year doubling period (Currently, CPU performance is down to approximately 30% increase annually). As long as such a trend persists, it is essential to be prepared for the implications of systems that are far beyond the current capabilities of processors. Not to mention the demand for networks and storage.

Figure 10. Transistor Counts for Microprocessors against Dates of Introduction [18].

The energy consumption of AI algorithms is also significant, with estimates (Training of GPT-3 requires *1.3 gigawatt hours [19]*) suggesting that the energy required to train a single deep learning model can be equivalent to the energy consumption of hundreds of households for a year [20]. This has led to concerns over both the financial and environmental impact of AI and the need for more sustainable computing practices.

Threats

According to a report by Goldman Sachs, Artificial intelligence (AI) could replace the equivalent of 300 million full-time jobs though it could replace a quarter of work tasks in the US and Europe but may also mean new jobs and a productivity boom including eventually increasing the total annual value of goods and services produced globally by 7%. The report said that Generative AI, able to create content indistinguishable from human work, is "a major advancement" .

Geoffrey Hinton, often called the Godfather left Google citing the dangers. He claims the immediate danger, was A.I.'s ability to create convincing false photos, videos and audio — showing things that didn't happen or weren't done by the people seen or heard in the generated content and most people will "not be able to know what is true anymore." He further warned with A.I. systems consuming so much data and reaching some unexpected conclusions, mixed with the ability of an A.I. machine to write its own computer code, it can lead to a "nightmare scenario,".

Discussion

Advantages:

AI is a versatile tool that can be applied across various industries. It has the potential to enhance productivity, reduce costs, increase the accessibility of products and services, and improve accuracy and precision. Both private and public institutions could explore ways to utilize AI to their advantage and may need to hire / train staff with the necessary expertise to do so.

Research and Collaboration

It is important to increase investment in AI research, particularly in basic research that may not have immediate commercial applications. In such instances, countries could work together and combine resources and knowledge to enhance their research efforts. Moreover, collaboration between government labs, universities, and industries can provide additional insights and support.

Ethics

In order to effectively put ethical principles into practice, AI education should not only cover ethics but also provide a code of standard actions to follow. This is crucial to ensure that good intentions are put into action. Aspects such as security, privacy and safety can be prioritized.

Accountability

At present, obtaining explanations from AI programs, especially those based on deep learning algorithms, can be difficult. This poses a significant issue in various fields such as finance and healthcare, where professionals are responsible for their decisions and cannot solely depend on AI-generated decisions without comprehending the rationale behind them. In response to this challenge, Explainable AI (XAI) has been developed as a collection of tools to tackle the "black box" problem.

Regulations

It is recommended to make regulatory changes gradually, particularly when the shortcomings of current regulations become apparent. To do this, regulatory agencies could seek the input of AI specialists in order to anticipate necessary changes.

Employment

AI has the ability to decrease wages or even eliminate “low-skilled” occupations, therefore it is crucial to take steps to ensure fairness and distribute the economic advantages more broadly. The dilemma lies in the mismatch between the speed at which AI-driven changes occur and the time it takes for society to adjust to them. In the early stages, the number of unemployed might surpass the number of new jobs created. Even if the effect is short-term, there may be a turbulent period of widespread unemployment. In addition, some argue that not only low-skilled jobs, but also professional and knowledge-based jobs will be impacted.

Opportunities Ahead – General Artificial Intelligence System

The ultimate form of intelligent systems is to have diverse capabilities rather than being limited to a single task. For instance, a system may not only excel in playing chess but also be competent in driving a car. However, current narrow AI systems are not capable of such versatility, and research in this area is still limited.

Furthermore, human imagination plays a key role in tasks that involve problem-solving, ideation, and decision-making in complex and uncertain situations. While AI can imitate human imagination and assist in idea generation, it has not been able to supplant or exceed it. Hence at the current stage, AI systems can be developed to collaborate with human creativity and imagination, resulting in the most favorable outcomes.

Conclusion

The adoption of Artificial Intelligence is at a critical stage where its capabilities are becoming more complex and sophisticated as more funding is made available. While there is a potential for AI to automate tedious tasks and significantly improve the productivity and efficiency of many industries, there are also several limitations such as the need for large and high-quality datasets, training biases, and privacy concerns as highlighted in this article. As with every new technology, there is also a risk of job displacement, but the AI industry will also create new opportunities and specialized fields that will mostly require reskilling and upskilling programs.

However, the challenges and limitations brought about from the utilization of AI technology must be addressed before world-wide adoption can be considered safe. As discussed earlier, data limitations, bias and interpretability, and computational power are some of the key issues. It is essential to take steps to ensure that AI is developed ethically and transparently, and that its benefits are distributed fairly. To effectively address many of these issues, collaboration between different stakeholders, such as governments, academia, and industry will tremendously help.

Additionally, the development and implementation of Explainable AI as mentioned earlier will also go a very long way in helping address the issues of accountability in AI systems. While AI can significantly aid humanity, it is important to approach this technology with caution to ensure that ethical and safety concerns are carefully considered. In conclusion, it is crucial for society to continue to navigate the impacts of AI while making sure that it benefits humanity as a whole.

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