

Evolution of artificial intelligence and hybrid methods for modeling and optimization in complex systems

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Abstract. Artificial intelligence (AI) has rapidly evolved to become an integral part of our daily lives, with its absence potentially causing significant disruptions. This paper examines the current trajectory of AI development and its projected impact on society in the near future. We explore the fundamental aspects of AI technology, its applications across various sectors, and the associated challenges and opportunities. The study also investigates the integration of hybrid methods for modeling and optimization in complex systems, highlighting their synergistic relationship with AI advancements. By combining analytical and data-driven approaches, these hybrid methods enhance AI's capabilities in addressing multifaceted problems across diverse domains. Our analysis encompasses the potential societal implications of AI, including job market transformations, ethical considerations, and the need for regulatory frameworks. Through this comprehensive examination, we aim to provide insights into the possible future states of AI technology and its far-reaching effects on human society.

1 Introduction

Algorithmic advancement has a drastic impact on every field that it has been introduced to. Any field of industry is eager to be well established in terms of its improvement. Nonstop development of processes is an essential part of any industry and field to compete and adapt to the changing realities and challenges. It is a well-known fact that artificial intelligence is capable of automating complex processes in various fields, including agriculture, manufacturing, medicine, education, and other sectors. Due to its capabilities, this technology is welcomed in many processes as it can elevate them to unimaginable heights.

From one angle, the technology is elevating the visible parts. However, there are other sides of the technology that can be questioned. For instance, its impact on mass job displacement and their complete elimination. The autonomy of the technology could lead to unprecedented events. Its intelligence has the potential to displace human beings and overshadow accumulated knowledge. The ability of the technology to mimic different

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aspects of human life is noteworthy. The technology can generate realistic images, videos, and audios. Some of the aforementioned are so well done that it is hard to distinguish them from real ones. Of course, the technology can be used for good deeds, but it is essential to understand that there is another side to the technology [1,2].

Therefore, one of the main aspects of this work will be the influence of the technology on humans and the environment. Also, it will cover the tendency of the technology and how it will look in the nearest future. It is obvious that the technology has already had a great influence on the way we live, and its future state will affect us severely [3].

Furthermore, this work examines the role of hybrid methods in modeling and optimization of complex systems, and how they complement AI advancements to address increasingly sophisticated challenges in various fields.

2 Methods and materials

With the advancement of artificial intelligence, many useful tools have occurred. In addition, this technology helped old methods and technologies to reshape themselves for the best possible outcomes. Each leap of the technology slightly reshapes everything, and these leaps are occurring frequently. In the nearest future, the technology will be able to program itself, which means it will improve itself at an unimaginable rate for humankind and hence introduce some issues [4].

However, the technology in its present state can benefit us in various ways. The greatest gift of the technology to humanity is the automation of almost every process that used to be manual or required partial involvement of people. Modern tools that it established are so powerful that some of them can provide results in a matter of time. For instance, tools powered by artificial intelligence can generate text of any format and style. Then it can be easily altered with simple or complex prompts depending on the tasks. Images, videos, and audios can be generated with results that cannot be distinguished from real ones. This technology can introduce precision where it was previously lacking and quality to the end product. All of this can be achieved due to algorithmic advancements that perform better at analyzing and acting on certain tasks than humans. Therefore, it brings many beneficial influences that put it above all when describing automation [5,6].

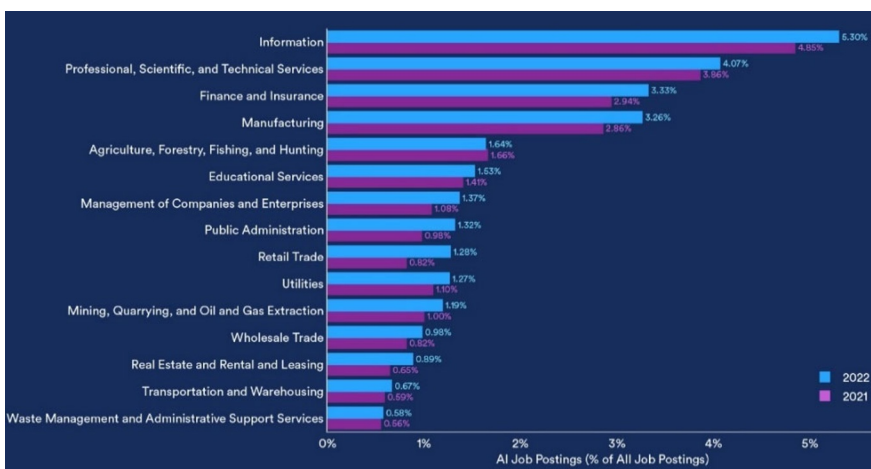


Fig. 1. Increasing AI Labor Demand.

Nonetheless, this technology is also bringing some issues that need to be handled before getting out of reach. One of the main issues that this technology gives to humans is its power,

which puts humans aside when dealing with, at the moment, certain tasks. This technology performs some given tasks more productively than humans and hence makes their presence in the workplace unnecessary. This side of the technology is responsible for job displacement and their elimination. Of course, it can also introduce new jobs (Figure 1) [7], but compared to those that it phases out, they can, at the moment, be neglected from the general equation [8,9]. Figure 1 illustrates the data of Artificial intelligence related job's posting in the US (by % of all postings).

The other side of the technology that gives shivers to people is its end state. How this technology will look in the nearest future with its nonstop and nonlinear improvement. There are some theories that this technology could dominate as it is already more intelligent in some of the tasks it performs. Also, it is believed that there must be some regulation upon its autonomy as this could lead to unprecedented events. Many people are questioning the ultimate outcome of this technology and pondering humanity's role in its development and future applications.

3 Results and discussion

3.1 Future state of the technology

The most anticipated thing right now is the next step of artificial intelligence. Will it be a leap that changes everything we know or a gradual change that we will barely notice? In both cases, the new stage of this technology will be achieved in the nearest future. However, the question is: what will it personify and how will it influence us? There are many different possible outcomes, but the most realistic one is, as stated in this work, the move from the first stage to the second stage. In this stage, the technology will be able to function more or less similarly to a brain. This will push all other technologies further in their development.

This is fraught with uncertainties, even if we know the stage of the technology. The first uncertainty is related to its uncontrolled improvement. With the ability to function similar to the human brain and the technology's breakthroughs in the computational field, it is possible that this technology can or will improve itself in an unprecedented manner. Hence, the leaps of improvement can occur in a matter of seconds, which we humans will not be able to take full advantage of immediately. Nonetheless, we will have ready theoretical data that we can use for our benefit [10-11].

Again, it does not illustrate the end state of the technology. If we look to nature, we can find endless changes to adapt to new challenges. With artificial intelligence, what type of challenges will it face for improvement? So, it is obvious that there will be no end state to this technology as it will exponentially improve. But its speed of development can slow down or increase [12].

The second question arises from the first one. If the technology will improve endlessly, what is the role of humans in this game? Will humans still be in control of the technology and direct it in the right direction, or lose control? In reality, some control over the technology will be achieved through various approaches, such as built-in code that prevents it from doing so, energy control, viruses, and so on.

Here arises another dilemma with this technology. It is related to variation. When we talk about artificial intelligence, one could see it as one entity, but in reality, there are millions of different algorithms that can be as powerful as possible. This realization can make it harder to predict the future of this technology as we have not one branch of the technology that can possibly outsmart humans, but millions that are waiting for their time to show their capabilities.

3.2 Potential challenges and opportunities

One of the most intriguing aspects of this technology is its balance between challenges and opportunities. It is clear that there will always be some issues with the technology in the form of large or small scales. However, positivity must always dominate or remain balanced; otherwise, the use of the technology is not practical. The most obvious opportunity from this technology is its direct influence on major sectors and fields such as healthcare, environmental monitoring, education, and others. These sectors and fields will greatly benefit from the technology in various ways. Nonetheless, there will be some dilemmas with the technology that demand careful consideration. For instance, with its unprecedented power and knowledge, the technology can easily mimic human thought processes, which will directly threaten our dominance. There is a great chance that, with the autonomy of the technology, it will conflict with human values. With its advancement, socio-economic gaps will widen, creating disparities between those who control the technology and those who rely on it. It is hard to correctly predict the technology's paths in various states, and hence it is on us to decide what it will look like in the future.

3.3 Hybrid methods for modeling and optimization in complex systems

The integration of hybrid methods with AI has opened new avenues for addressing complex systems. These approaches combine different modeling techniques and optimization algorithms to leverage their individual strengths and overcome limitations.

Key aspects of hybrid methods include:

1. Combining analytical and data-driven approaches: Hybrid methods often merge mathematical models with machine learning techniques to capture both theoretical understanding and empirical patterns in complex systems.
2. Multi-scale modeling: These methods can address systems with interactions across different scales, from micro-level behaviors to macro-level properties.
3. Integrating top-down and bottom-up perspectives: Hybrid approaches link system-level dynamics with individual component behaviors, allowing for more comprehensive modeling of disturbed or non-equilibrium systems.
4. Improved computational efficiency: By combining different optimization algorithms, hybrid methods can reduce computation time and improve solution quality for complex problems.

The synergy between AI and hybrid methods has led to significant advancements in various fields, including:

- Novel combinations of evolutionary algorithms with mathematical modeling for solving complex optimization problems in engineering and environmental sciences.
- Hybrid deep learning models that integrate different neural network architectures for improved performance in modeling complex biological systems.
- Advanced approaches that link system dynamics simulations with ranking algorithms to analyze complex network behaviors in social and economic systems.

3.4 Hybrid methods and ai: shaping the future of complex systems analysis

The integration of hybrid methods with AI is poised to play a crucial role in the future development of both fields. As AI continues to evolve, hybrid methods offer a way to enhance its capabilities in dealing with complex, real-world systems. This synergy is likely to lead to more robust and adaptable solutions for challenges in areas such as climate modeling, urban planning, and healthcare systems optimization.

The combination of AI's pattern recognition and learning capabilities with the structured approach of hybrid methods creates a powerful toolset for tackling multifaceted problems. This integration allows for more nuanced modeling of complex systems, taking into account various interacting factors and scales that might be overlooked by traditional approaches.

As we look to the future, the continued development of hybrid methods in conjunction with AI advancements promises to unlock new possibilities in understanding and optimizing complex systems across various domains.

4 Conclusion

This study has explored the potential future trajectories of artificial intelligence and its implications for human society. One of the primary concerns highlighted is the displacement of human workers as AI continues to advance. We have observed that certain jobs have already been eliminated due to AI automation, raising questions about the future of employment.

The increasing autonomy of AI systems presents unprecedented challenges for human oversight and control. Our reliance on these autonomous processes has reached levels never before seen in human history. This work has aimed to elucidate the current trends in AI development and provide insights into what we can expect in the near future.

Furthermore, we have examined the integration of hybrid methods for modeling and optimization with AI technologies. This combination offers enhanced capabilities for addressing complex systems challenges across various domains. The synergy between AI and hybrid methods promises more robust and adaptable solutions for future problems in areas such as climate modeling, urban planning, and healthcare systems optimization.

As AI continues to evolve, it is crucial to maintain a balance between harnessing its potential benefits and mitigating potential risks. The future development of AI will likely be shaped by our ability to effectively integrate it with hybrid methods, ethical considerations, and regulatory frameworks. This interdisciplinary approach will be key to unlocking new possibilities in understanding and optimizing complex systems while ensuring that AI remains aligned with human values and societal needs.

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