International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Impact Factor: 6.882, Volume 05, No. 01(II), January - March, 2023, pp. 11-17

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN PHYSICS

Mr. Amarjeet*

ABSTRACT

Artificial intelligence (AI) is a branch of computer science capable of analyzing complex medical data. Their potential to exploit meaningful relationship with a data set can be used in the diagnosis, treatment and so on. This article explains the main concepts of the artificial intelligence especially deep learning method, and focusing on its history and applications in different fields including physics, industry, etc. Deep learning method employs non-linear functions to adjust the weight of the data wanted from the data background. By extracting meaningful data and fitting its shape with parametrized functions, deep learning method can capture main rules of the rude data, and make reliable predictions based on the tendency of the available data. Further more, this article focus on the applications of deep learning in solving physical problems with many concrete examples, and compare with the traditional methods to show the benefits and advantages of the artificial intelligence.

Keywords: *Artificial Intelligence, Physics, Applications.*

Introduction

Artificial Intelligence (AI) is a subject that studies theories, methods, and applications with respect to simulation and extension of human intelligence for different questions. AI, as a branch of computer science, aims to understand the essence of intelligence and design intelligent machines acting like human behaviors. Programs which enable computers to function in these ways are called artificial intelligent systems. The field of AI comprises a diverse range of methods stemming from computer science or statistics and addressing problems related to knowledge presentation, search and optimization, planning, pattern recognition, learning, creativity or interaction [1]. AI is the method applied in projects related to a broader field of scientific computation. AI methods often involve creating data-based approximative models that replace exact physical models and it can be used for reasoning purposes. It offers unexpected perspectives on how to think about ourselves and the world around us [2].

The History of AI

Application domains of AI include robotics, voice recognition, image recognition and natural language processing. Artificial Intelligence is a field that has along history and it is still very active and developing today. The field of Artificial Intelligence (AI) really came into existence with the birth of computers around the 1940s and 1950s. At the earlier period of its development, attention was clearly focused on getting computers to do things like humans. Essentially, this just makes computers study humans in some or all aspects of their behaviors. In the 1960s and 1970s, this opened up a philosophical discussion about the connections between human brains and the computer, and whether these differences were really important. This period – referred to as 'classical AI' in this book – was, however, rather limited in its potential. In the 1980s and 1990s there was a whole new approach, a sort of bottom-up attack on the problem, which effectively builds artificial brains to bring about AI. This completely opened up the possibilities and created a whole set of questions. AI wasn't restricted to merely copying

* Assistant Professor, Department of Physics, Chhotu Ram Arya College, Sonepat, Haryana, India.

human intelligence any longer – now it could be intelligent in its own way. In some cases it could still be brought about by mimicking a human brain but now it has the potential to be bigger, faster and better. The philosophical consequence is that an artificial brain could potentially outperform a human brain. In more recent years the field has really taken off. Real-world applications of AI, particularly in the finance, manufacturing and military sectors, are performing in ways the human brain simply cannot compete with. Artificial brains are now being equipped with their bodies, with which to perceive the world in their own ways, to move around and modify it in the way they see fit. They viii PREFACE are being given the ability to learn, adapt and carry out their wishes with regard to humans. This raises all sorts of issues for the future [3].

Applications in Life

AI is applied in the field of intelligent manufacturing through the intelligent manufacturing system. The application of AI which is beyond the intelligent manufacturing system does not make any sense. Against the background of 'Internet plus AI', the intelligent manufacturing system is characterized by autonomous intelligent sensing, interconnection, collaboration, learning, analysis, cognition, decision-making, control, and execution of human, machine, material, environment, and information in the whole system and life cycle. The system consists of a resources/capacities layer, a ubiquitous network layer, a service platform, an intelligent cloud service

From the beginning of the artificial intelligence there was a desire for a fully automated intelligent car. Numbers of experiments have been done and some of them were very much fruitful. Now there are intelligent smart cars which can make some decisions by their own.

Google modified Toyota prius by using an array of sensors to navigate a public road without human involvement. It includes different types of sensors like:

- **GPS:** The Global Positioning System (GPS) [1] is a space-based global navigation satellite system that provides reliable location and time information in all weather conditions at all time and anywhere on the Earth when and where there is an unobstructed line of sight to four or more GPS satellites.
- **Motion Sensor:** This one is used for monitoring the speed of the car.
- **LIDAR:** A rotating sensor on the roof which scans around 200 feet in all the directions of the car to generate a precise three dimensional map on the car's surrounding.
- **Position estimator:** A sensor mounted on the left rear wheel which measures the small movement made by the car and accurately locates its position on the map.
- **Video Camera:** A camera near the rear view mirror deflects traffic lights and helps the car`s onboard computer recognize moving obstacles like pedestrian and bicyclists.
- **Radar:** Four standard automotive radar sensors, three in front and one in the rear, help to determine the position of the distant objects [5].

Types of Artificial Intelligence

The following will explain artificial intelligence and its main categories. There are three types of artificial intelligence: artificial narrow intelligence, artificial general intelligence, artificial super intelligence [6].

- **Artificial Narrow Intelligence (ANI)**

ANI is the first type that can make a decade only in one sphere. Sometimes it's referred to as Weak AI, which is the most limited form of AI and currently possible in 2016. ANI can carry out specific tasks brilliantly, using a combination of advanced algorithms, deep learning and various techniques depending on the usage. What's more, ANI is narrow because it is incapable of carrying out any task outside of its specific purpose. For example, there's AI that can beat the world chess champion, but that's the only thing it does. Alpha Go may be impressive at playing Go but it would be flummoxed if you asked it for restaurant recommendations [7].

- **Artificial General Intelligence (AGI)**

GI is AI that reaches and surpasses the intelligence level of a human, meaning it can reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience. Sometimes it is referred to as Strong AI or Human-Level AI. At this level, AI would be capable of performing any task up to the standard of a human. The time when AGI will be achieved is a subject of debate and most AI specialists predict it will occur around 2040.

To reach AGI requires hardware should be comparable to the human brain, which can process AI approximately 10 quadrillion calculations per second on just 20 watts of power. Such a computer already exists in China's Tianhe-2 actually, which can handle 34 quadrillion calculations per second. Spreading across 720 square meters, costing USD 390 million, and requiring 24 megawatts of power, Tianhe-2 is clearly inappropriate for the consumer market. However, it does demonstrate that hardware is unlikely to be the biggest block on the development of AGI. Other than this, developing software that is as advanced as the human mind poses a greater challenge. While such software does not currently exist, most computer scientists believe the most promising approach could be to build an AI that can code changes into itself —enabling it to develop improvements based on its own AI. This would enable it to become progressively smarter and constantly build upon its own intelligence with an exponential increase in gains [7].

After approximately knowing what AGI is, there is a question: what is the goal of AGI? Determining and codifying these goals are both in terms of AGI researchers' own goals in creating AGI and the goals enabling us to finally know the direction. It has been the observation that, at the most abstract level, there are two primary views of the potential goals of an AGI, one positive and one negative. The positive view generally seems to regard intelligence as a universal problem-solver and expects an AGI to contribute to solving the problems of the world. The negative view sees the power of intelligence and fears that humanity will be one of the problems that is solved. So, more than anything else, One needs an AGI that will not be inimical to human beings or one's chosen way of life. Eliezer Yudkowsky claims [8] that the only way to sufficiently mitigate the risk to humanity is to ensure that machines always have an explicit and inalterable top-level goal to fulfill the "perfected" goals of humanity. People believe, however, that humanity is so endlessly diverse that will never find a coherent, non-conflicting set of ordered goals. What's more, the presence of functioning human society makes it clear that people should be able to find some common ground that people can all co-exist. People contend that it is the overly abstract Principle-AI view of intelligence as "just" a problem-solver that is the true source of risk and re-introducing more similarity with humans can cleanly avoid it. For example, Frans de Waal, the noted primatologist, points out [9] that any zoologist would classify humans as obligatorily gregarious since people "come from a long lineage of hierarchical animals for which life in groups is not an option but a survival strategy". If one, therefore, extended the definition of intelligence to "The ability and desire to live and work together in an inclusive community to solve problems and improve life for all", there would be no existential risk to humans or anyone else. At earlier time, people think that acting ethically is an attractor in the state space of intelligent behavior for goal-driven systems and humans are basically moral and deviations from ethical behavior on the part of humans are merely the result of shortcomings in people's own foresight and intelligence. As pointed out by James Q. Wilson, the real questions about human behaviors are not why people are so bad but "how and why most of us, most of the time, restrain one's basic appetites for food, status, and sex within legal limits, and expect others to do the same." Of course, extending the definition of intelligence in this way should also impact the view of people's stated goal for AGI that one should promote. The goal of AGI cannot be to produce slaves solving the problems of the world ethically but must be to create companions with different capabilities and desires who will journey with us to create a better world [10].

- **Artificial Super Intelligence (ASI)**

ASI is an intellect that is much smarter than the best human brain in practically every field, including scientific creativity, general wisdom and social skills. So when will people see the first machine with ASI? All surveys show speculative results and they're only representative of the median opinion of the AI expert community, but it tells us that a large portion of the people who know the most about this topic would agree that 2060 is a very reasonable estimate for the arrival of potentially world-altering ASI, which is only 45 years from now [11]. Once ASI exists, any human attempt to constrain it will be unreasonable. People would be thinking on human-level, and the ASI would be thinking on ASI-level. A monkey couldn't ever figure out how to communicate by phone or Wi-Fi like us, neither can people conceive of all the ways an ASI could achieve its goal or expand its reach. It could, let's say, shift its own electrons around in patterns and create all different kinds of outgoing waves. But that's just what a human brain can think of – ASI would inevitably come up with something superior [12]. If ASI really does happen this century and the outcome is really as extreme and permanent as most experts think, people will have an enormous responsibility on people's shoulders. Human lives in the next millions of years are all quietly looking at us, hoping as hard as they can that people don't mess this up. So, with new technologies people can give a chance for a better life, or people can bring all humanity to an unhappy ending [13].

Application of Artificial Intelligence in Physics

The development of artificial intelligence and physics has always shown a close connection. On the one hand new methods and theories in physics have contributed to the development of artificial intelligence. On the other hand, applying machine learning techniques to the power physics research can boost numerical calculation efficiency. The following sections will be divided into seven sections to cover some areas of physics where artificial intelligence has been applied.

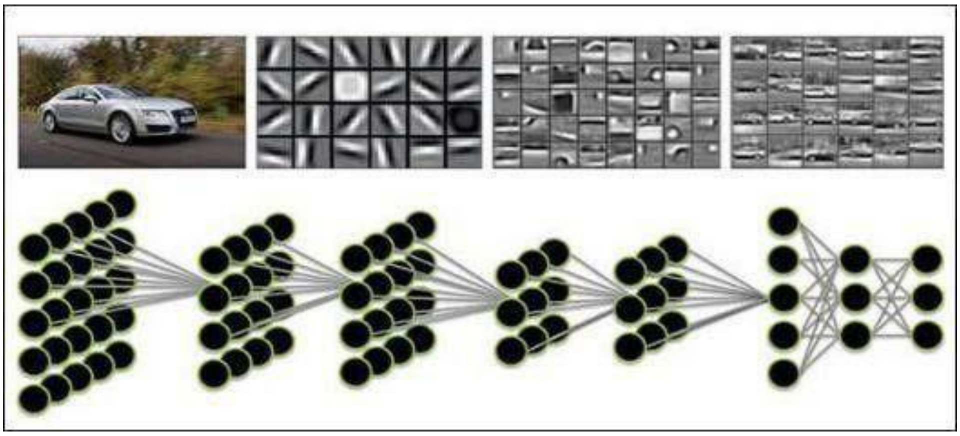

Figure 1: ***Schematic figure for deep learning method, trying to analyze the car.***

- **Particle Physics**

Particle physics needs to process large amounts of data from large particle colliders. The huge amount of datais beyond the ability of human calculations by hand. However, the computer is undoubtedly efficient and accurate, which allows to do this work.

Nowadays, AI is used in high-energy physics problems. One of the biggest physics discoveries, the Higgs boson particle was discovered using the neural network. Researches at the Large Hadron Collider (LHC) have to deal with millions of data each day and go through and analyse them manually, which is a very tedious process. Also, particles like the Higgs boson, or any other particles of a great discovery, lies in the noise of this data. A processor of quantum computer called the annealer helped the LHC to detect this particle. This processor, along with the neural network helps to detect patterns in particle collisions. Without AI the discovery was completely impossible because the lifetimes of these particles are very small, and so they decay very quickly. Feynman diagram calculations and gauge theory calculations also benefit from the AI [14].

- **Statistical Physics**

Bose-Einstein condensate, the experiment for which a Nobel Prize was won in 2001, was repeated in 2016, but this time with the aid of AI. The research team cooled the gas to around 1 microkelvin and gave the control of the lasers to the AI system which was supposed to cool the trapped gas to orders of nanokelvin. The AI could do the whole experiment in a span of less than an hour [14].

- **Astrophysics**

By using images as training sets, neural networks can be taught to distinguish between gravitational lenses and other objects, and the application of artificial intelligence in this area can alleviate the tedium of researchers.

Nord’s group is using AI to discover gravitational lenses, massive celestial objects — such as galaxies — whose gravity bends light. These objects leave signature distortions in telescope images that AI can help quick identification. Understanding those distortions could help to answer questions about dark matter, dark energy, and the expansion of the universe. Neural networks alleviate the tedium of conventional techniques used in the hunt for gravitational lenses. This architecture had presented 761 candidates for gravitational lensing. This research can also answer questions on one of the most mystifying phenomena of dark matter [15].

Figure 2: ***Schematic figures for artificial intelligence to capture the Lens and Non-Lens.***

- **Nuclear Physics**

Neural networks are also capable of representing ground state wavefunctions. Machine learning tools are used in condensed matter and statistical physics to implement various algorithms.

AI algorithms such as artificial neural networks have been developed with nuclear physics properties like atomic mass number, neutron separation energies, ground state spin and parities, neutron capture rates, branching probabilities in different decay channels and beta-decay, to determine the properties of exotic and halo nuclear systems. Neural networks have also helped to identify electrons and determine heavy quarks [14].

- **Quantum Mechanics**

Schrodinger equation, to find the ground state energy, which is the lowest energy of a particle in a one- dimensional box, can also be solved with deep learning. Quantum state is a wavefunction showing the probability of different states for particles. Quantum computer is another breakthrough that the Physics and AI have been able to achieve together, bringing the world the most powerful computers ever. Neural networks are also capable of representing ground state wavefunctions. One of a successful examples is Giuseppe Carleo who introduces artificial intelligence techniques into the realm of many-body quantum systems. In the recent Science publication [15] Carleo introduces an innovative idea into condensed matter physics. By making the simple observation that a quantum state may be regarded as a kind of computational “black box”, mapping configurations of a system’s degrees of freedom to complex numbers, he proposes to obtain an approximate representation of quantum state by making use of techniques developed in the artificial intelligence community.

More specifically, Carleo has shown how it is possible to take the notion of a Restricted Boltzmann Machine (RBM), a type of neural network commonly used to learn probability distributions, and couple it together with traditional techniques from quantum Monte Carlo methods to assemble what he has dubbed a Neural Network Quantum State (NQS). The class of NQS embodies a type of computational machine designed to employ a custom form of reinforcement learning, specifically tuned to enable the machine to learn the complex features present in strongly-correlated quantum states. By employing NQS to simulate standard benchmark problems, Carleo has managed to provide compelling evidence that this approach can achieve higher accuracies than algorithms based on Tensor Network States (TNS), currently considered to be among the state-of-the-art methods in the simulation of strongly-correlated systems, which make use of subtle observations regarding the entanglement properties of typical ground states of local hamiltonians. Remarkably, the work has spurred a chain of efforts, both in obtaining explicit connections between TNS and NQS [18] as well as in the study of the entanglement properties of NQS [19], paving the way to a novel path towards the understanding of the processes involved in machine learning, using inputs from recent development in quantum information theory.

Carleo introduces an innovative idea into the realm of condensed matter physics. By making the seemingly simple, yet crucial, observation that a quantum state may be regarded as a kind of computational "black box", mapping configurations of a system's degrees of freedom to complex numbers, he proposes to obtain an approximate representation of quantum states by making use of techniques developed in the artificial intelligence community [16].

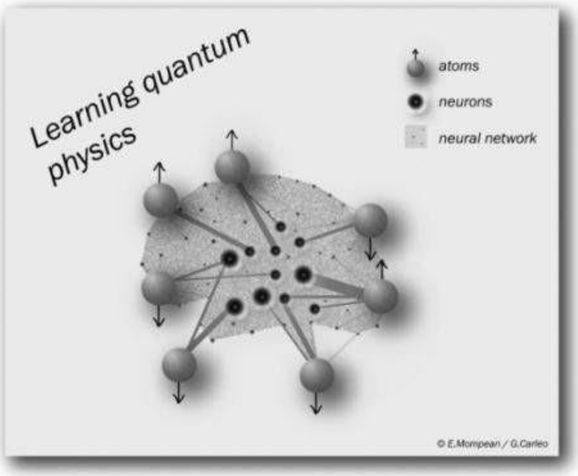

Figure 3: ***Deep learning method to learn quantum physics, show the evolutions of quantum states.***

- **Material Science**

Research at the Northwestern University discovered three new glass-forming systems using AI. Performing experiments for this would have taken them a lot of hours. With the use of AI algorithms, they could come up with the glass-forming systems in no time. This can speed up the process of detecting new particles, saving a lot of time of the experiments involved. Similar algorithms will also help NanoScience. With the help of tools from UNSILO, Springer Nature has made a number of data available for NanoScience for discovering new material [14].

- **Atmospheric Physics**

The application of AI in Atmospheric Physics involves the use of algorithms like neural networks, Decision trees and Fuzzy logic. A subset of AI is largely used in this area. Problems like understanding the mechanism of pollution, identifying cyclones, can be addressed using algorithms of AI like Self Organizing Maps and Clustering. It is difficult for humans to identify these challenges on their own. AI in quicker and more reliable weather forecasts can give better weather forecasts [14].

Conclusion

This article presents a review about AI employed in different aspects of science. With new calculation methods and strong computer power, artificial intelligence (AI) drives many aspects of people’s lives. It powers Google and Facebook, and it’s even found a foothold in medicine to help doctors make diagnoses. But despite its budding ubiquity everywhere, AI has been a hard sell in physics, because their fundamental mechanisms are still unclear and deserve abundant attention [15]. People can't deny that it is very easy to use, and have shown great power in researches. Therefore, the application of artificial intelligence in physics is important and deserves people’s attention.

References

1. Academy Programme 2018–2021. Novel Applications of Artificial Intelligence in Physical Sciences and Engineering Research (AIPSE). 30 June 2017.
2. AN Ramesh, C Kambhampati, JRT Monson, Artificial intelligence in medicine [J] Ann R Coll Surg Engl 2004; 86: 334–338.
3. Kevin Warwick. Artificial Intelligence The Basics. Routledge 711 Third Avenue, New York, NY 10017. 2012.
4. Bo-hu LI, Bao-cun HOU, Wen-tao Yuetal. Applications of artificial intelligence in intelligent manufacturing: a review [J]. Frontiers of Information Technology & Electronic Engineering. 2017 18 (1):86-96.
5. Md. Nazmul Hasan, S. M Didar-Al-Alam, Sikder Rezwanul Huq. Intelligent Car Control for a Smart Car [J]. International Journal of Computer Applications (0975 – 8887) Volume 14– No. 3, January 2011.

6. Anjali UJ. UNDERSTANDING THREE TYPES OF ARTIFICIAL INTELLIGENCE [EB/OL]. [April 28, 2018]. https://www.analyticsinsight.net/understanding- three-types-of-artificial-intelligence/.

7. Springwise Artificial Intelligence Innovation Report 2016 [R]. United Kingdom. Springwise Intelligence Ltd. 2016.

8. Yudkowsky, E. 2004. Coherent Extrapolated Volition. Available at http://www.singinst.org/ upload/CEV.html.

9. de Waal, F. 2006. Primates and Philosophers: How Morality Evolved. Princeton University Press.

10. Mark R. Waser. What Is Artificial General Intelligence? Clarifying The Goal For Engineering And Evaluation. Books International 22883 Quicksilver Drive, Dulles, VA 20166.

11. Tim Urban The AI Revolution: Our Immortality or Extiction / Tim Urban. - [Electronic resource]. URL: http://waitbutwhy.com/2015/01/artificial- intelligencerevolution-2.html (last access: 03.04.2017).

12. Pawel Sysiak AI Revolution 101 / Pawel Sysiak // medium.com: electronic magazine, 2007. [Electronic resource].

13. URL:https://medium.com/ai- revolution/airevolution-101-8dce1d9cb62d (last access: 03.04.2017).

14. O. Strelkova, BSc Student. THREE TYPES OF ARTIFICIAL INTELLIGENCE. O. Pasichnyk, PhD in Education, As. Prof., language advisor Khmelnitsky National University.

15. Anjali UJ. How Artificial Intelligence Is Addressing Real World Physics Problems [EB/OL]. [AUG 25, 2018]. https://www.analyticsindiamag.com/how- artificial-intelligence-is-addressing-real-world- physics-problems/.

16. Sophia Chen. AI Makes Inroads in Physics [J]. American Physical Society Sites, 2018, 27 (6).

17. Giuseppe Carleo. Artificial intelligence meets the quantum world [EB/OL]. [10.02.2017]. https://www.ethz.ch/content/specialinterest/phy s/theoretical-physics/computational-physics/en/news-and- events/nc/2017/02/artificial-intelligence-meets- the-quantum-world.html.

18. Solving the quantum any-body problem with artificial neural networks-Science 355 (6325), 602-606.

19. On the Equivalence of Restricted Boltzmann Machines and Tensor Network - arXiv: 1701.04831v1.

20. Quantum Entanglement in Neural Network States-arXiv: 1701.04844v1.

❖◆❖