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Artificial Intelligence in Astronomy

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Abstract: ***Artificial intelligence (AI) is a domain of computer science that emphasizes the creation of intelligent and smart machines that work and reacts like humans. Artificial Intelligence is a trendy field in computer science and it has been a boon to humans in many areas. A major contribution of AI is in the field of astronomy. With a vast range of data sets in astronomy, it becomes difficult for humans to have correct calculations and predictions. How these vast data sets can be effectively processed and analyzed is a challenging task. Here, Artificial Intelligence promises to deal with this vast data in an efficient and effective manner and provide with the accurate predictions. This paper summarizes the developments of artificial intelligence (AI) techniques, and examines their application to astronomy.***

Keywords: Artificial Intelligence, Astronomy, Machine Learning, Human Intelligence, Intelligence

I. INTRODUCTION

In 21st century, Artificial Intelligence (AI) is playing a vital role in human's life and has changed the life style tremendously. It has benefitted almost all domains, whether in education sector, or medicine or transportation and last but not the least, the astronomy. The big technology tycoons, researchers, and big companies like Yahoo, Google are spending loads of time and are investing to innovate more from this technology. Artificial Intelligence sounds fascinating for some people, but for some it is a mystery. Astronomy is an emerging field that is making the best use of Artificial Intelligence to have more accurate predictions and calculations. By constructing appropriate computer software, researchers in artificial intelligence laboratories around the world attempt to solve a variety of tasks generally considered to require some form and degree of intelligence [1]. A number of attempts to uncover the mysteries in space had been made, but the progress was not that up to their expectations. The pace of the results was very slow and results were not that accurate. What exactly is subsumed under the Al umbrella changes with time, a fact which has nicely been summarised in Tesler's law: "Al is whatever hasn't been done yet."[1]. This paper presents the discoveries that have been made the field of astronomy.

II. HUMAN INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

Human intelligence is a natural process which uses analysis, thoughts, interpretation and past experiences. On the contrary, artificial intelligence works on a system created by humans. Human intelligence is natural and artificial intelligence is man-made. Artificial Intelligence is programmed software but, human intelligence is nothing like this.

III. ARTIFICIAL INTELLIGENCE IN ASTRONOMY

A. A New Technique using Artificial Intelligence was developed to count the craters on moon

When it comes to counting craters on the moon, it's a pretty archaic method," says Mohamad Ali-Dib, a postdoctoral fellow in the Centre for Planetary Sciences (CPS). "Basically we need to manually look at an image, locate and count the craters and then calculate how large they are based off the size of the image. Here we've developed a technique from artificial intelligence that can automate this entire process that saves significant time and effort."[2]. In past also, researchers have tried to develop the algorithms to identify and count the craters, but did not succeed much. But Mohamad Ali-Dib and Ari Silburt along with their colleagues developed an algorithm using AI that helped to identify and count the craters on moon. As Mohamad Ali-Dib also said," It's the first time we have an algorithm that can detect craters really well for not only parts of the moon, but also areas of Mercury," says Ali-Dib, who developed the technique along with Ari Silburt, Chenchong Charles Zhu and a group of researchers at CPS and the Canadian Institute for Theoretical Astrophysics (CITA)[2] .The algorithm was so effective that it was able to identify 6000 unidentified craters on moon. One more interesting fact is that the ages of these craters can also be identified by counting small craters in that. It has been found that some craters on moon are as old as 4 billion years. More improvements in the algorithm are in process to identify more craters on other planets as well. As also said by Ali-Dib the plan is to further improve the algorithm to allow researchers to find more craters, and to also test it on other solar system bodies like Mars, Ceres and the icy moons of Jupiter and Saturn [2].

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B. New Rocky Planet discovered using Artificial Intelligence

In December 2017, with the use of Artificial Intelligence, a new hot rocky planet KEPLER 90i in the Kepler Solar System was discovered and the total number of planets increased to eight. A computer program was developed and trained to examine images, searching for minuscule, previously unnoticed dips in brightness that could indicate a planet [3].

C. Looking inside a star using Artificial Intelligence

Some astronomers have found that with the help of artificial intelligence, some hidden secrets of the stars like their age, composition and many more can be revealed. Using artificial intelligence, researchers have made it possible to look inside the stars. One most amazing fact about the stars is that stars are not solid. They're enormous, vibrating balls of plasma held together by their own gravity and with wildly energetic nuclear reactions at their core [4]. Just like water is heated in a pot, it produces bubbles, similarly sound waves are amplified throughout a star, and the small stars produce higher sound as compared to larger stars. By studying these sound waves of a star, the researchers can analyze the age of the star, its size and what is it made up of. The stellar sound waves are caused by the star quakes, which makes sounds with specific frequencies. From these sounds or tones we conclude the size of a star. To an AI network, Hendriks and Aerts supplied simulations of a star activity, which was made using computer models that can collect the information about stars. This network collected this information and generated the relationships between the internal variables like mass and age of a star, elements contained by a star and the vibration patterns seen on its surface. The AI can then take real-life stellar sound wave data and compare it to the simulations to discern some of the internal characteristics of a star, providing a new tool for researchers studying stars through their sound waves[4].

D. A Study Using Artificial Intelligence to find fast Radio Bursts

A study using artificial intelligence has been recently conducted by researchers to find many fast radio bursts that were unidentified till this point. The fast radio bursts are the energetic pulses which are assumed to driven from distant galaxies. After the analyzing the data set, AI was able to locate the fast radio bursts where as the astronomers could not. "Fast radio bursts are one of the most recently discovered unknown signals in astronomy," Zhang explained. "With new instruments being designed for them coming online, [they're] well-poised to be one of the unknowns that will be solved within the next five to ten years."[5].

E. Face Recognition for Galaxies: A New Tool to Astronomy by Artificial Intelligence

Deep learning, a widely used method of machine learning which is popular in machine learning and speech recognition applications has also been helpful for the astronomers to analyse the images of galaxies and understand how are they formed and evolved. The outcome from these simulations was used to generate the mock images of simulated galaxies. These mock images of galaxies proved to be beneficial for the training of deep learning systems to recognise the key phases of galaxies. The results showed a remarkable level of consistency in the neural network's classifications of simulated and real galaxies [6]. As also said by co-author Joel Primack, professor emeritus of physics and a member of the Santa Cruz Institute for Particle Physics (SCIPP) at UC Santa Cruz," We were not expecting it to be all that successful. I'm amazed at how powerful this is."[6].

F. Study the stars by Artificial Intelligence

In 2007, Kevin Schawinski, an astrophysicist at Oxford University had about 9, 00,000 images of galaxies. He spent his days looking after one image to another to find out the shape of galaxy- spiral or elliptical. He wanted to find out the direction in which the galaxy is spinning. Technical advancements contributed the scientists only in the field of data collection, but they were struggling for this gigantic data to be processed. The pace of this data collection and data processing could not be matched. Schawinski and colleague Chris Lintott decided to find a better way of sorting this. They started with a project named, Galaxy Zoo, which was a project for citizens. Schawinski and Lintott hired volunteers to distinguish between various images online. More than 1,00,000 people gathered and reduced this huge task of years in 6 months. This process continued but the technology took up a high pace. An instrument, The Dark Energy Spectroscopic Instrument, was developed to measure the speed of distant galaxies. With the help algorithms developed using Artificial Intelligence, many astronomical tasks have been executed faster and with more accuracy. In 2017, a research group from Stanford University used machine learning to study images of strong gravitational lensing [7].

G. With Artificial Intelligence, Two new planets discovered

Anne Dattilo, a senior at the University of Texas, Austin, discovered two new exoplanets by using artificial intelligence. She worked on an artificial program named AstroNet-K2 to study the stars having planets. This program detected stars which had planets. The newly discovered planets, officially named K2-293b and K2-294b, orbit stars in the constellation Aquarius and are both slightly

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larger than Earth [8]. Vanderburg said in a statement from the University of Texas McDonald Observatory, “If we want to know how many planets there are in total, we have to know how many planets we've found." “But we also have to know how many planets we missed. That's where this [AI] comes in."[8].

H. Generative Adversarial Network: A Technique of Artificial Intelligence in Astronomy

The GAN or Generative Adversarial Network is a leading technique of Artificial Intelligence being popular in astronomy. The "Computational Plastic Surgery" process changes the disfigured images received from the outer space to clean images. It has also been affirmed that these machine learning or artificial intelligence techniques have been a boon for astronomy. With the help of AI machines, the astronomers are able to detect patterns from the large data sets available from space. AI researchers have contributed to astronomy through new ways. An instrument known as the VAE (Variational Auto-Encoder) is used to generate new images which are more diverse than GAN.

I. Artificial Intelligence : Innovations in Astronomy

Maximum numbers of scientists want to have a grip on artificial intelligence. With minimum human efforts, the AI machines are being developed in such a way that these are able to pull out patterns from the gigantic data available from space. One such AI system is known as artificial neural networks-computer-simulated networks of neurons which works in a similar fashion. It was in the past that the predictions regarding the climate change or any other natural phenomenon was carried out through observations. Today Artificial Intelligence has benefitted every domain through its algorithms. The concept of simulation has been a greatest advancement of science. With the help of this simulation, an astronomer could actually observe the collision of a milky way with its neighbouring galaxy, Andromeda. Thus, observations through simulations have been advantageous for the astronomers to derive the hypothesis for further observations.

J. *Artificial Intelligence: Planets Orbiting Two Stars*

Is it possible for the machines to predict whether planets orbiting binary stars remain in stable orbits? The answer to this is yes. On April 23,2018, the researchers announced that the machines which use deep learning methods can predict the stability of planets in binary star system more accurately than human astronomers[11].

IV. CHALLENGES

With the advancement in the technology, the difficult tasks in the field of science can be done with the few lines of code. No doubt, that in the field of astronomy the use of artificial intelligence has also risen. Can we ever think of that these machines can turn against us ever? Not at all. These machines can be considered as hard working assistants which can work with huge data without complaining or without getting tired or bored[10]. These machines work on the input being fed to them. Still artificial intelligence is a beneficiary for astronomy if it is headed by a human scientist. And Polsterer, a physicist has also said,” oversight by a human scientist remains essential. You’re the one in charge of doing the interpretation.”[10].

V. CONCLUSION

This review paper has highlighted the use of artificial intelligence particularly in the field of astronomy. How the artificial intelligence has proved a boon for astronomy for determining the shapes of galaxies or for discovery of any new planets etc

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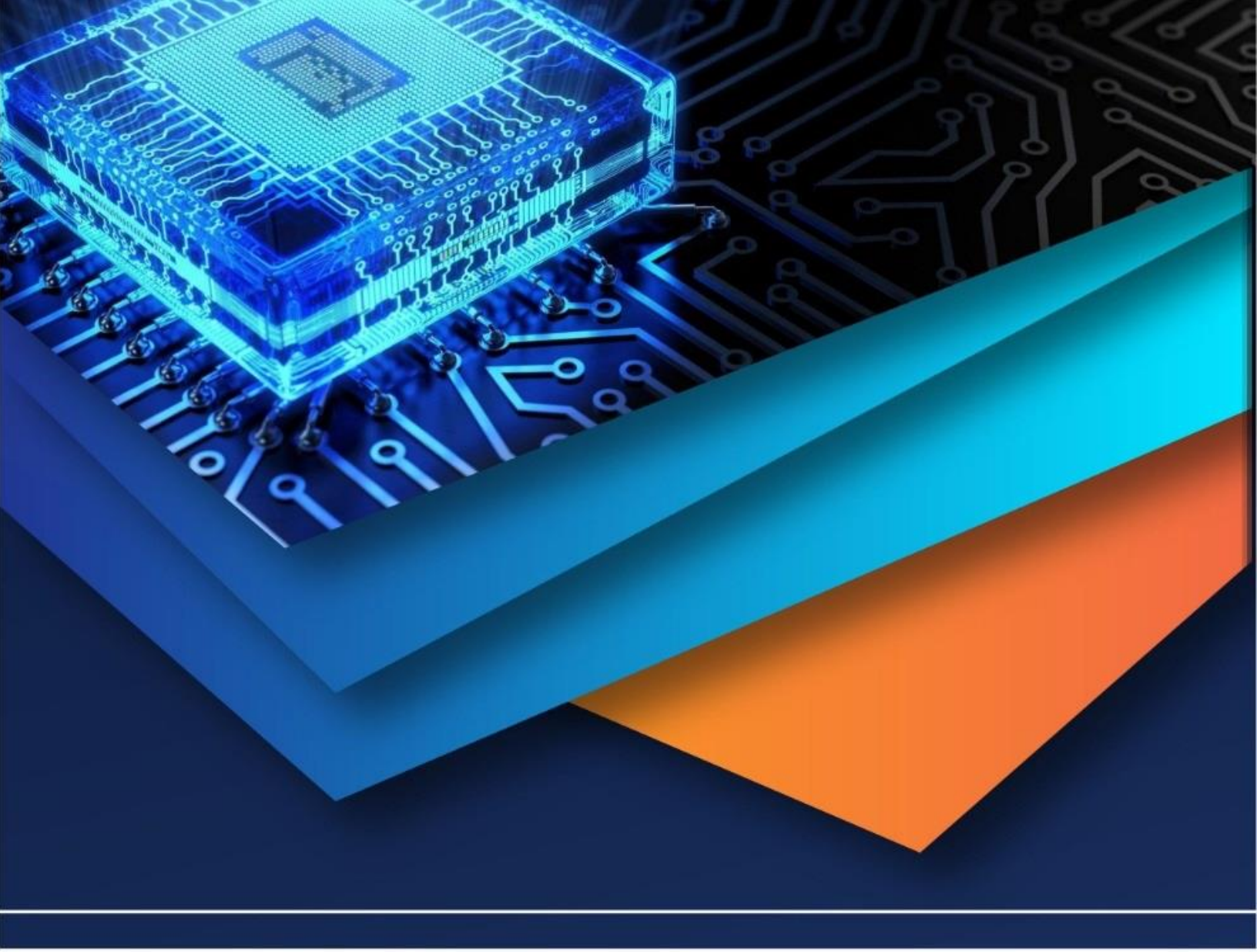

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