Artificial Intelligence in Astronomy

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Abstract— **Artificial Intelligence (AI) is a greatest technology which created by human in the world. At present, every field use AI for to make things easier. Because AI can automate any typical task a person can do. Specially, AI use for more advance and complex subject area to do more difficult tasks. Astronomy is also very complex field which explore the universe and difficult to use human involvement every time. Around the Earth, the universe is a mysterious region filled with many secrets. What's happening in some of the areas is even more dangerous than ever. Therefore, using human for universal exploration is quite ambitious. This paper describes usage of Artificial Intelligence, applications current issues, future directions in the astronomy.**

Keywords— *Artificial Intelligence, AI, Universe, Exploration, Space.*

I. INTRODUCTION

Universe is a most wonderful creation. It contains so many stars, Planets, Galaxies, Black holes, different rays, Nebula, and etc. The study and explore this universe called Astronomy. From another word, study the universe under the multilayer subject, called as Astronomy [16]. Astronomy is mainly based on observations. At past, astronomy based on mainly observations and knowledge systems [08] and old scientists try to find secrets using simple tools and they found some new things about the universe. But today with the development of the technology, AI has attacked this field and has given more support for more explorations of universe. There can see so many AI developments and techniques use in space. AI robots, automatic vehicles, Satellites, Telescopes and many more advance tools use for explorations. All of these things are based on Artificial Intelligence technology. Worldwide Telescope at central China is wonderful tool for learning astronomy [08]. Not only that this technology can use to visualize the data of universe [04].

The structure of this paper can mention as below. In section 2 describe overview of astronomy, and how Artificial Intelligence related to astronomy. Section 3 show major researchers related to AI in astronomy. Section 4 describe about current issues and section 5 is about future directions of the AI in space exploration.

II. OVERVIEW OF ARTIFICIAL INTELLIGENCE IN ASTRONOMY

A. Astronomy

The Earth is not the only object in the universe. And humans are not the only creatures in the considering universe. There cannot see any limitation, border for this universe. Since ancient time, human curious about the sky. Therefore, Astronomy has a long history too [16]. In traditional astronomy, people used knowledge systems and observations [8]. Nicolaus Copernicus, Tycho Brahe, Johannes Kepler, Galileo Galilei, Sir Isaac Newton are some of highlighted scientists who founders of modern astronomy [16]. Today with the development of the technology, astronomy goes through an advance way with the increased technologies and find more thing in sky day by day.

Today there is more associations, organizations related to astronomy field. Such as the National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Indian Space Research Organization and so on [03,12]. All of these agencies, organizations try to explore universe.

B. Artificial Intelligence

Artificial Intelligence (Machine Learning) is the most advance technology in the modern world. In some cases, there is nothing without AI. So much so today we can see AI from smart phone to universe explorations.

Artificial Intelligence can define as below. "AI is the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making and translation between languages." In other word, it is a simulating for human brain.

This technology was proposed and introduced by John McCarthy in his first academic conference on 1956 [17]. Alan Turing who is a mathematician did testing series to prove that machines have an ability to exhibit intelligent behavior equivalent to human and he proved that logic. After that, those testing series has named as Turing test and it uses to identify whether machine can respond like human. With this begin, at today, AI is increasing day bay day and touch every field in the current world.

C. AI in Astronomy

With the advent of Artificial Intelligence, Space agencies identified that AI is the way to achieve their short-term and long-term goals. After that, scientist who expert in AI suggest AI Approaches for complete and reduce problems in astronomy field [01].

According NASA's "Human research program" space is unfriendly and dangerous place for human body [22]. They have identified several risks and grouped into five categories as problem of Gravity, isolation, hostile environment, space radiation and distance from Earth. In this case Ai can automate any tasks less than a second of thought and complete task correctly [02]. Therefore, space agencies could use AI agents instead of sending human for long-term explorations. For develop these machines scientists use more methodologies of AI. Fuzzy logic, Expert System, Neural network, AI Galaxy recognition are the example for that [10,11,13,14]. As this, by joining AI to space exploration, it has become more advance and because of that explorations, have got more benefits that improve the quality of life on Earth [23].

III. MAJOR RESEARCHES IN ARTIFICIAL INTELLIGENCE

There can see more situations that used AI techniques in astronomy field.

Artificial intelligence techniques have been used to spacecraft scheduling [11,12,20]. Scheduling is very important to achieve maximum benefits from high expensive spacecraft. For that AI approaches have used for scheduling astronomical observations for NASA/ESA Hubble Space Telescope [12, 20]. Hubble Space Telescope is one of the largest vital research tool for astronomy. For that, they have developed a system called "Spike scheduling system" for astronomical observations of Hubble Space Telescope (HST). This Spike is an activity based Artificial intelligence technique [12]. Mark D. Johnston also   has mentioned AI techniques which have been implemented in the HTS SPIKE scheduling tool [20]. Furthermore, he has mentioned three implemented

mechanisms in the SPIKE tool. Those are procedural search, Rule-based heuristic search and Neural network [20].

According to Kerry Taylor-Smith, there have been used AI for discover Kepler 90i in 2007 [02]. Using AI have found it is a hot rockey planet and computer program was trained to explore images, searching minuscule, unnoticed dips in brightness. As well as the neural network was accurate to 96% and spotted a second in the Kepler 80 system [02].

AI techniques have used to detect Radio Frequency Interference (RFI) for the Karoo Array Telescope data [05]. The radio signals which unwanted to astronomically named as Radio Frequency Interference(RFI). With the increased of the technology, Radio astronomy community has face for a deluge of data. Therefore, to detect and excision the RFI, need to be automated the KAT-7. In this case, at first, they have used tree AI algorithms to analyze the data. They are "K-Nearest Neighbour (K-NN)", "Random Forest Classifier(RFC)" and "Naïve Bayesian(NB)" [05]. But during the investigations, the have realized that above all features might night be need and identified 3 general classes of feature selection algorithms as wrapper methods, filter methods and embedded method. As well as, by further investigations they have identified that, time domain is more important than spectral information for detection RFI.

In MER Surface Operations system, has used AI in different ways [15,21]. In this case, NASA has landed two vehicles(Rovers) on Mars surface named "Spirit" and "Opportunity" on 2004. The purpose of these rovers to achieve mission objectives by working as surrogate geologists for a science team on Earth. In this operation, Rovers should work in collaboration with scientist and flight control engineers on Earth and represent a distributed human-robot system for semi-autonomous planetary exploration. For this mission, NASA has used AI technology to achieve their tasks on Mars. Therefore, they have used mobility and robotic arm software to perform different tasks on Mars. To control mobility and navigation, has used wheel encoders, some stereo camera for sensing for heading determination and potentiometers for articulated suspension kinematic state and etc [15]. These Rovers have 6 wheels for each and using commands, Rovers move automatically on surface. For robotic arm used to check and clash with soil and rocks. It is also used in underground digging when needed. The robotic arm consists of a microscopic imager for capture extreme close-up images, a Mössbauer spectrometer to detect composition and abundance of iron-bearing minerals, an Alpha-Particle-X-Ray Spectrometer to determine the elemental chemistry of surface

materials and a Rock Abrasion Tool for exposing fresh material beneath dusty or weathered rock surface layers via controlled-force loading and physical abrasive action. The arm is also used to position the spectrometers for physical placement on an instrument calibration target and science-related magnets mounted at different locations on the rover body. The underline algorithms can found in [18]. As well as, Robert R. Sim has mentioned about a system named AEGIS (Autonomous Exploration for Gathering increased science) [18]. This system used for target selecting, enables space bots to point on Mars, and initial follow-up measurements. This system has use to Curiosity Rover for Mars mission.

In addition, "Feedforward Neural Networks(FNN)" is a technology which used to forecast the sunspot number's data. Because of the emission of solar particles and electromagnetic radiation effects, solar activity forecasting become as important thing in astronomy field. The reason is it is effect to the electric power transmission lines, space activities, satellites, weather and other ionosphere parameters. Therefore, it is important to know about future behavior of solar activities. For the best inflated FNN used to forecast the sunspot data, use models, algorithms and function and try to do as "Mean Square Error(MSE)" and correlation analysis by using different algorithms, models and transfer function [06].

IV. IDENTIFYING CURRENT ISSUES OF ARTIFICIAL INTELLIGENCE IN ASTRONOMY

Artificial Intelligence is a complex and autonomous technology. Therefore, while explorations, scientists have to face some issues in using this technique.

A. Limmited Mobility

For explore the surface of other planets, asteroids, comets or any other physical thing, use mobility systems. But traveling on surface is limited for these vehicles. Therefore, most of the time these robots only can investigate limited area which the original landing area.

B. Limited Power

To do explorations and scientific discoveries the universe, spacecraft need more energy, power and capacity. But with the limited lifetime and power availability, explorations become as limited progresses and have to complete tasks efficiently.

C. Lack of ability to avoid desasters from the environment

In space explorations, there is a problem regarding to survival. Because these autonomous machines land on unsafe environment. There have been gravity problems, propulsive forces, chemical issues and many more things. Like human, it effects to machine too. But there cannot see any ability to avoid that type of disasters.

D. High cost

Developing spacecraft with complex and autonomous facility is a very expensive task [01]. Specially some models are very expensive to produce such as expert system and so on. Further, outer planet exploration is higher than other developments. Because spacecraft have to travel long distance during a long-time period [24]. As example, according to James Andrew Lewis cost for mars exploration is higher than moon exploration. As this, high cost is a current issue in this field.

E. Self-Awareness Issue

There is another issue, as spacecraft cannot get autonomous action for their own health status. It depends on the ground segment and flight engineers who monitor the telemetry data during the mission [01]. But it is hard, wasting time and requires more human experts. In some situations, it takes more days to processed, make decisions and upload commands to spacecraft… Sometimes human cannot recognize situations when mission involves for advance relationship among large number of variables. In this case, spacecraft should be able to get decision for their status within few seconds and get autonomous action for efficiency of the operation [01].

F. Human involvement

Artificial intelligence is good at filling the blanks of universe. AI machines get actions according to commands of engineers.
As well as the better way to study about universe by direct observations. Therefore, it still need human engineers to validate the findings of Artificial Intelligence machines [02]

G. Risk of Artificial Intelligence

With the new innovations in the world, human curiosity is increased to find and innovate more and more things. Specially, with the limitation of the space exploration to human, they always try to us AI to overcome exploration tasks. As a result, machines have become as more advance as well as autonomous. So, with these situation, there is a warning that AI machines will develop and build itself. Further, there also can see the increasing of AI is accelerating with technologies which use to develop AI machines, and researches predict that it is increasing fast. So, there is a risk that machine will be uncontrollable to human. It is more

dangerous for whole world and can be destroy with the human being too [19]. As a human creation, still AI obey to human. So that, in the creation of machines in the future, we should be careful to make it obedient to us.

V. APPLICATIONS OF ARTIFICIAL INTELLIGENCE

There can see more applications of Artificial Intelligence in various field. Such as, Virtual agent, Voice recognition, Virtual assistance, machine learning platform, Biomatters, Robotic process automation, Text analytics automation and etc [17].

According to the Remi Challamel, Thibaud Calmettes and Charlotee Neyret Nigot the Automatic Identification System(AIS) is a most development tracking system for ships based on satellite [07]. This system based on use of satellites and multiple antennas and beamforming techniques. Furthermore, optimize AIS link between ships and satellite is another approach. In here, under the reason of AIS protocol is frozen, additional VHF frequencies support to links to ships towards satellite. Further, high performance and safe are main advantages by using this system [07].

"Siri" is a one of best virtual assistance which use typed command and voice recognition to perform it's tasks. In here, user can use his voice or texts to give command to Siri and it respond it from both text and voice [17]. Further, Google assistance is another example for a virtual assistance.

In medical field, there can see more tools, machines based on AI technology [09]. People always expect highest services health care. Therefore, doctors or any other officials should be fast and give solutions. But as human, they have some limitations and problems as with the limited time they cannot gather all details related to diseases, human limited memory and etc. AI has become as a solution for all those problems and medical field have become more smart and friendly. In this field, AI use for managing and record data, Digital consultation, Virtual Nurse, Health monitoring, Precision medicine any more thing. Predicting ICU Transfers, Medical Testing, Improving Clinical Workflow, Claims Fraud Detection are some of example tools for this. Therefore, with these improvements, medical field has become as more professional field.

VI. CONCLUSION

With the day by day discoveries about apace, AI has become as a major role in explorations. As well as with the development of the world with technology, there can see a competition for the space explorations too [24]. This paper we have discussed about involvement of AI for space explorations. In here we identified current applications of AI, what are the current issues by using AI and future directions. For this paper, we have researched 24 research papers.

VII. FUTURE DIRECTIONS OF ARTIFICIAL INTELLIGENCE IN ASTRONOMY

With the current usage achievements of AI techniques in astronomy, scientists are planning and thinking about future space exploration in advance level that present level.

A. Outer planet application

With onboard decision-making spacecraft, as a further work, scientists have plan a mission to study about Jupiter moon which contain volcanically active body on surface. Because by face explorations, there has some questions about nature of their volcanic activities [03]. As well as, have proposed a mission for investigate surface ocean of Europa moon. In this case, scientists hope to land the machine on icy cap on the moon and investigate the subsurface. Further, Titan is another moon of Jupiter. According to previous mission, have showed about complex and diverse surface on Titan. Therefore, with onboard advance technologies, explore the Titan moon is another mission under the outer planet exploration [03].

B. Earth science application

With the onboard Earth Observing One(EO-1), autonomous Science Experiment(ASE) has developed nodes which autonomous decision-making nodes for study Earth science events. In here, by developing AI based advance machines and tools in Earth orbit will convert to future Sensorwebs in another planetary orbit [03].

C. AI for human space application

According to vision of the NASA's explorations, they have emphasis about human involvement for space exploration. For that they proposed an advance vehicle named "The CEW". According to their ideas, it's duty is back to moos with astronauts and explore the surface, travel to Mars and support continued low-Earth-orbit flight. The motivation of this mission is, the increased complexity of spacecraft will be required advance handing for the longer mission [03]. Because with increased intelligent, manage from ground will not be sustainable [03].

Furthermore, human are very flexible explorers than machines. But their physical capabilities, human exploration have been limited. Therefore, as future explorations, scientist

plant to use robots as assistance of human during explorations. As examples, robots can do activities which human cannot do under some dangerous situations of another planets environment, construction and setup tasks, gathering data and etc.

D. Space weather

Usually, many explorations are managing and planning by space agencies. Because of that, get to know about weather of space is more important for explorations. Therefore, by NASA and other space agencies have several spacecraft monitoring procedure using AI in different events [03].

E. Find Aliens

Scientist are predicted that we are not the only creature in this whole universe. Therefore, under that idea, more Scientist believe that Artificial Intelligence technology can use to search about Aliens [02]. Mainly scientist predict that Aliens are also can be human like or advance than human. Therefore, scientist think that AI can categorize this organically and investigate this and find differ from norm.

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