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AI's Potential to Solve Problems And Challenges In Space

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Abstract - The benefits of artificial intelligence may be seen in a wide variety of important applications and research fields, including robots, autonomous vehicles, intelligent data processing, and natural language processing, to name just a few. The use of artificial intelligence across a variety of sectors has been the subject of investigation in a great number of scholarly works. However, in recent times, there has been a lot of interest in the field of space travel about artificial intelligence. In this research, an effort is made to investigate the most significant problems in the field of space applications that have been handled by using strategies based on artificial intelligence. We provide a taxonomy of the challenges that are currently being faced and focus on applications that are related to mission planning, space exploration, and Earth observation. In addition, we provide an explanation of the current solutions that have been offered for each problem in order to make it possible for scholars to identify and compare the state of the art in regard to this circumstance.

Keywords: space exploration; mission design; Earth observation; machine learning; deep learning; reinforcement learning

1. INTRODUCTION

During the last 60 years, artificial intelligence (AI) has been used in a variety of applications, some of the most well-known examples of which include automated reasoning, intelligent systems, knowledge representation, and game theory. However, recent advancements in computing power, the amount of data that is readily available, and the development of new algorithms have proved that AI can play a big role in the digital transformation of society and that it should be a priority for any government. Because of this, the academic community has devoted a substantial amount of time and effort to the development of innovative AI methodologies in a range of key sectors, such as smart cities, e-Health, cyber security, and military applications, amongst others.

The relevance of artificial intelligence is shown by the abundance of survey papers that report recent advances in AI in almost all fields of study. Space

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applications, on the other hand, have shown a significant amount of interest in artificial intelligence, which is a critical field that has not been properly researched in recent years. This sector encompasses the technology used for spacecraft, satellites, and other types of spacecrafts, in addition to the communications between them and the services they provide for use on Earth (such as weather forecasting and remote sensing).

Background on AI

The second kind of learning is known as unsupervised learning, and it refers to the process by which computers may learn from unlabeled data and may discover hidden patterns in data categorization without the assistance of a human [8]. Clustering is a kind of unsupervised learning in which the goal is to find groups or clusters of a feature based on the degree to which the features are alike or distinct to one another. There are a few different approaches to clustering, one of which is called K-means clustering, which is used often for document clustering, market segmentation, and compressed image segmentation, among other applications. This approach arranges the data points into K clusters, with K being the number of groups that is dependent on the distance from each cluster. Another noteworthy unsupervised learning strategy is dimensionality reduction, which works to simplify a problem by reducing the number of dimensions it has. It is used to decrease the amount of random elements taken into consideration while maximizing the usable qualities of the original data by converting the data from a high-dimensional space into a low-dimensional space. This is accomplished by converting the data from a high-dimensional space into a low-dimensional space.

In these approaches, just a small bit of the data is tagged, while a significant quantity of the data is left unlabeled. They get knowledge from the data that has not been classified and education from the data that has been labeled. Consider, for instance, a document classifier that is incapable of locating a great number of text documents that have labels attached to them. A limited amount of labeled training data is used to train the model, and then, after training is complete, an unlabeled training dataset is used to make predictions about the outcomes. The paradigms that were outlined before are fundamentally different from reinforcement learning. This is due to the fact that reinforcement learning does not need a labeled dataset or a supervisor. Instead, it is made up of an agent that is able to conduct experiments and make observations in a complicated environment. This agent learns the most effective course of action via interactions with other elements of the environment so that it may maximize its benefits. As a consequence of this, reinforcement learning has the potential to be used to the resolution of any problem in which an agent must interact with an unpredictable environment in order to accomplish a particular goal. Therefore, robots and the technology behind autonomous vehicles often make use of this strategy.

Neural networks are a sort of machine learning that are designed to emulate the way biological neurons communicate with one another in a manner that is supposed to be mirrored by biological neurons. Learning from vast quantities of data and illuminating intricacies are the primary goals of neural networks, which are designed to function similarly to the

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human brain. Using the backpropagation method, the model makes adjustments to its internal parameters. These parameters are what are used to construct the representation in each layer, and they are derived from the representation in the layer that came before it.

The analysis of visual images is the most common use of convolutional neural networks, often known as CNNs. CNNs are constructed via a series of steps, the first few of which are composed of two distinct types of layers known as convolutional layers and pooling layers. These layers serve as a tool for feature extraction, and they are used to pull the fundamental characteristics from the images that are input into the model. The output from the feature extraction layers is then utilized by the fully connected layer and the output layer, which are the last phases, to predict a class for the image based on the features that were derived from it. These networks are designed to assess data from a wide variety of arrays, such as language, spectrograms of images or sounds, video, or volumetric imagery.

Decoding temporal and sequential data is accomplished with the assistance of recurrent neural networks, often known as RNNs. Because these networks have a more in-depth understanding of sequences, they are able to analyze time series, audio, text, and spoken language. RNNs carry out the processing of an input sequence one item at a time while maintaining a record of all of the items that have been processed earlier [13]. A short-term memory may also be created via recurrent networks, and the whole of history may be compressed into a very tiny area [14].

Deep learning is a branch of artificial intelligence that makes use of computer models with several processing layers that are able to learn representations of input with varying degrees of abstraction [13]. Natural language processing, voice recognition, and image identification are all areas in which neural networks and deep learning are making strides in improving the state of the art.

Fuzzy logic is a kind of logic that contains all of the intermediate possibilities that are available between the digital values of yes or no, representing how humans make decisions. For the purpose of communicating confusing information, this approach involves quantifying the extent to which the hypothesis is true. Important applications for the use of fuzzy logic include the systems found in automobiles, as well as electronic and environmental equipment.

2. Challenges in Space Applications

Over the course of human history, several attempts have been made to find answers to a variety of questions pertaining to space and its use. Collaboration between humans and machines, as well as the development of new technology, has been a crucial component of this process and has facilitated both the discovery of new things and the introduction of innovative new ideas. If on the one side extending the human presence in space is something that must be done, then on the other, it is up to individuals to figure out how to manage the resource constraints in space.

Therefore, all of the work is focused on achieving two primary goals: (i) making progress in the exploration of space and the advancement of scientific research, and (ii) improving the quality of life for those living on Earth. People play an important role in all of this, including experts who work on the aims of space missions, astronauts who suffer tough situations in space, and normal people who take part in the settlement of these challenges, particularly those that are aimed at improving life on Earth. People play an important role in all of this.

Within the context of our study, we have investigated the aforementioned difficulties, starting with the degree of mission execution. When things are linked to one another in the age of the Internet of Everything, services may be delivered, and processes may be enhanced. In point of fact, the planning and execution of a space mission involves the collaboration of a number of distinct but interrelated organizations. These entities include robots in space, wearable technology, apps, and smart buildings.

These systems generate enormous volumes of data in addition to relying on data for their operation. Because these data, for example, correspond to the essential and life-sustaining qualities of satellites, it is critical to build systems that are able to deliver precise replies to the parameters that describe these qualities. During the phases of mission design and planning, it is essential to build technologies that will allow for increased access to information in order to facilitate the management of the information that is essential to the accomplishment of the goal. Design engineering assistants are tools that may aid with challenging engineering decision-making by giving new design possibilities, estimating beginning input, and assisting experts by replying to inquiries concerning earlier design choices. Design engineering assistants may help provide new design possibilities, estimate initial input, and provide support.

It is imperative that the astronauts maintain both their mental and physical health in order for the mission to be successful. The employment of intelligent assistants that can boost astronaut performance in space or supply astronauts with vital information about their health is one solution to some of the challenges. This solution is aimed at lessening the harmful effects of space circumstances on human physical and mental health. We have now arrived at the challenging stage of reducing the threat presented to spacecraft by both naturally occurring and intentionally generated space trash, as well as enhancing our ability to recognize and lessen the likelihood of these objects causing catastrophic threats to Earth. It is very necessary to identify solutions in order to improve the accuracy and reliability of space situational awareness (SSA) and space surveillance and tracking (SST) systems.

In the context of space exploration, the scientific community need more trustworthy and accurate approaches to the processes of data collection, analysis, and dissemination. For instance, technologies are essential for enhancing robot exploration and producing more accurate surface mapping of planets. In addition to this, the accuracy of the equipment used to observe planetary bodies may be improved using these approaches.

Applications developed for space have the potential to improve both the current status of life on Earth and its future possibilities. The most significant challenge is the development of methods and tools that are able to make use of information or images obtained from satellites in order to recognize, evaluate, and provide assistance with decision-making in high-pressure situations on Earth, such as emergencies and disasters. The applications are quite diverse and span all of the Sustainable Development Goals that need to be met in order for the 2030 Agenda to be successful. Some examples of these goals include increasing agricultural production, estimating and reducing the effect of climate change, protecting Earth's biodiversity, and promoting clean air and water.

These problems may essentially be broken down into three basic categories, which are outlined in more detail in the following sections.

Mission Design and Planning

During the whole of a space trip, AI may be able to aid in the management of information, knowledge, procedures, and operations. The idea behind a goal and the strategy behind executing it call for an amazing level of knowledge and expertise from all of the human and technological resources involved.

The early application of AI in mission design and planning refers to the knowledge obtained during previous missions, which is often not totally accessible. This information was gathered via the use of AI. As a consequence of this, researchers are working on the development of an engineering assistant that will be able to gather, assess, and give correct data while saving a significant amount of time compared to manual labor. An intelligent assistant known as Daphne is used in the process of designing Earth observation satellite systems. Daphne is able to analyze the advantages and disadvantages of various designs proposed by engineers and offer responses to specific questions about design via the use of natural language processing. This system takes use of information that was discovered via the process of data mining in the current design space, as well as domain-specific expert knowledge associated with this topic and a historical database of all Earth-observing satellite missions.

Another challenging task is keeping tabs on the state of the satellites. The vehicle is equipped with artificial intelligence capabilities that can solve this challenge. In point of fact, a system monitoring that constantly controls the operation of tools and sensors and may offer helpful information such as warnings is responsible for monitoring. Artificial intelligence (AI) systems are utilized by scientists to solve problems on their own and warn ground control to any problems that may arise. An example of this may be seen in the satellites produced by SpaceX. These satellites are equipped with a collection of sensors that can determine their position and make modifications as necessary to avoid colliding with other spacecraft. In addition, the Italian start-up company AIKO developed an artificial intelligence for mission autonomy with the use of their MiRAGE library. The AIKO technology can identify events and make it possible for satellites to engage in autonomous replanning and reaction, so removing delays caused by decision-making loops that are dependent on the ground. In addition to performing a great number of other scientific tasks, artificial intelligence is aiding the Mars rover

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Perseverance with landing [24] and navigating on the planet.

Additionally, AI algorithms have the potential to be applied to improve the manufacturing of satellites and other spacecraft. Because they include a number of iterative procedures that need a high level of precision and accuracy, these activities need to be carried out in clean rooms to avoid the introduction of biological contamination. In addition, collaborative robots, also known as cobots, could make industrial processes that are prone to error caused by humans more reliable. As a consequence of this, the use of AI may significantly accelerate the processes involved in manufacturing while simultaneously reducing the amount of human touch, which is essential for increasing overall productivity. In addition, a personal assistant in orbit might give prompt help and support during normal duties carried out by astronauts on their missions or in the case of an emergency on board, therefore reducing communication delays with ground control. This would be beneficial for a number of reasons. For instance, IBM worked with the German space agency DLR and Airbus to build CIMON, which stands for the Crew Interactive Mobile Companion. A conversational artificial intelligence robot known as CIMON is able to interact with astronauts on the International Space Station and react to any questions they may have.

Space Exploration

Important is how artificial intelligence will shape and develop space exploration in the future. There are many different applications for artificial intelligence, some of which include astronomical body finding in deep space, robot exploration, and planetary navigation. For example, a Bayesian approach was used to do deconvolution on photos obtained in radio astronomy, and the end result was the very first image of a black hole. This was accomplished by using the images to study how radio waves interact with matter. Researchers are now working on constructing more advanced AI systems in order to take images of black holes that are more precise. These methodologies will unquestionably be of assistance to researchers in the process of categorizing and recognizing a wide variety of deep-space objects. Take, for instance, the discovery of the two extrasolar planets discovered by Kepler. These planets, Kepler 80g and Kepler 90i, orbit the star systems Kepler 80 and Kepler 90, respectively. An automated and objective way of detecting exoplanets is required for information retrieval in this field, which presents a challenge for astronomers as they attempt to learn more about the population of exoplanets.

In the field of space situational awareness (SSA), one of the most difficult problems to solve is the problem of managing space debris, which includes things like fragmentation debris and abandoned launch vehicle stages. In point of fact, academics place a strong emphasis on the need of keeping a resident space object database since SSA is necessary for the effective operation of a future Space Traffic Management system. The most significant concern in relation to space debris is the persistent possibility of collisions with satellites or other spacecraft, which may lead to negative events occurring in space. Deep learning strategies might be used to increase the accuracy of the laser-range technology that has traditionally been used in this context to find a solution to this problem. An further challenge is presented by the construction of more accurate maps of the planet's surface. One such instance is the collaboration between NASA and Intel to develop an artificial intelligence system that would enable explorers to navigate their way across planets. The software was originally used to explore the surface of the moon, and then it was transferred over to the Mars exploration mission. The challenges associated with space flight could one day be conquered thanks to the collaborative efforts of human beings and swarms of robots. In point of fact, humans are able to educate multi-robot systems using AI methodologies. More efforts have been done in the realm of autonomous and intelligent space guidance challenges with the assistance of deep learning and reinforcement learning.

Earth Observation

Satellites take hundreds of photographs and collect terabytes of data in each and every minute of each and every day. Earth observation, often known as EO, may be put to a number of different purposes, some of which include environmental and disaster management, forestry, urban and rural planning, water and ocean resources, mineral exploration, and agricultural management. In the past, humans were responsible for interpreting this data and gaining relevant information for the application that was wanted. This was done without the assistance of a data analysis tool. As a direct result of this attempt, selecting, filtering, polishing, and analyzing a very large number of images required a significant amount of time. The advancement of AI has allowed for great strides to be made in the examination and analysis of millions of photographs taken by satellites. In addition, since they speed up the process of collecting images, these algorithms may detect any issues that may exist with the photographs.

Attempts to mitigate the effects of natural disasters sometimes include the use of satellites. These images, for example, may be of assistance to ground people in estimating the course of the catastrophe or the number of victims, as well as the level of damage to the environment and to buildings. Additionally, thanks to EO satellites, first responders are provided with geographical information on the affected area of the occurrence in a very timely manner. The use of satellite data may, in point of fact, facilitate the reduction of catastrophe risk assessments and the preparation of post-disaster responses. Both the population's exposure to air pollution and demographic statistics have been analyzed in order to determine which regions have the highest risk of being exposed to harmful levels of pollution. As a consequence of this, EO could investigate a variety of the physical, chemical, and biological aspects of Earth in order to get a deeper understanding of the environment of the planet and provide suggestions on how to improve the quality of life there.

3. STATEOFTHEART

Following an explanation of the challenges that space applications must overcome and an analysis of the basic approaches, this section will investigate the most recent suggestions that have been made to address each challenge. In addition, we present a mind map in Figure 1 that connects each challenge with the solutions that are provided by the research

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in the relevant field. In addition, we classify these solutions in Figure 2 according to the kind of AI approach that was used.

Works on Space Exploration

In the not-too-distant future, advancements in artificial intelligence will help space exploration. In point of fact, each and every component of a space colony will consist of highly developed algorithms that examine data and make projections about potential outcomes. Robotics and automation have been critical components of space exploration from the very beginning, assisting in the discovery of new phenomena and facilitating the advancement of existing technologies. Utilizing AI makes it simpler to construct self-sufficient, intelligent robots that are able to acquire new skills while they are in space. Methods from the field of artificial intelligence might potentially be used to assist ground controllers in the management of space traffic. The authors created prediction models by performing several regression analyses and then training those models. They wanted to improve space traffic management and come up with collision avoidance solutions before anybody else.

It may be possible to employ AI systems to increase the level of autonomy possessed by robots, spaceships, and other types of machinery. The authors of explore how artificial intelligence is affecting the dynamics and control of spacecraft steering. They focus on evolutionary optimization, tree searches, and machine learning employing deep learning and reinforcement learning as they examine exciting application situations where these methods enhanced the performance of guidance and control of well-known issues. In addition, they look at how these methods may be used to increase the performance of machine learning. When it comes to the safety and dependability of space operations, the authors discuss the benefits that may be gained by using a multi-agent system. The strategic incorporation of many robots with a human-to-loop strategy helps to reduce not only the costs associated with the mission but also the demands placed on the available human resources. In this study, a design and control approach for elastic computing self-organization for artificial intelligence space exploration is presented.

Any situation involving space travel presents a wide range of difficulties, which humans and swarm robots may work together to overcome. The authors of this study take into consideration a hypothetical situation that takes place on Mars and involves human researchers instructing robots and multi-robot systems on how to carry out essential duties. When a group of individuals cooperate to transport an item via artificially manufactured difficult terrain, the efficiency of the method may be measured based on the level of success achieved by the group as a whole. The strategy makes use of a fuzzy genetic algorithm, which is an optimization method for genetic algorithms that sets a fuzzy inference system as its primary objective.

The fields of astronomy and astrophysics both stand to gain a great deal from the use of AI methods. the use of artificial intelligence (AI) to the examination of planets, the monitoring of instruments in real time, the study of star clusters, and the analysis of non-stellar components of the Milky Way. Deep learning and neural networks have the

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potential to improve the efficiency of future exploration missions in a number of different ways. One of them is the automation of the process of locating celestial objects. The authors of NASA Starlight and Breakthrough Starshot provide artificial intelligence simulator-based ways for capturing images during deep space missions by applying an unsupervised methodology known as a Grow When Required Network. These methods can be found in each of their respective books. Numerous photos of Mars have been obtained and will need to be analyzed in order to get a deeper understanding of the planet.

For the purpose of developing a vision-based navigation system that can ensure an accurate lunar landing, convolutional neural networks and recurrent neural networks are used. While a convolutional neural network (CNN) is used to extract and evaluate the features, an LSTM recurrent neural network is responsible for the regression. In order to train a CNN, a series of manufactured photos of the landing area are used. These images are captured using a variety of perspectives and degrees of light. In point of fact, CNN-LSTM has previously shown good performance in delivering image processing and model prediction inside an application that does not need any space.

Deep learning and reinforcement learning are two AI approaches that are often employed in the area of spaceship guiding dynamics and control to increase the autonomy of space equipment, spacecraft, and space robotics. This is one of the main takeaways from our research, which can be summed up by saying that deep learning and reinforcement learning are two AI techniques. The primary objective of these systems is to create an environment in which humans and several robots may successfully work together. Using approaches based on neural networks to automate the process of doing research in deep space detection of astronomical bodies and the accessibility to better maps of planets' surfaces.

Works on Earth Observation

In the study, artificial intelligence (AI) models that are used to foresee and grasp different parts of the Earth observation system are investigated, and the survey categorizes the issues that it seeks to resolve into the following four categories: (1) the categorization of different forms of land cover, (2) the modeling of land-atmosphere and ocean-atmosphere interactions, (3) the identification of anomalies and extreme occurrences, and (4) the identification of causal relationships. Artificial intelligence (AI) and Earth observations (EO) may play an important role in helping to achieve the sustainable development goals (SDGs). The comprehensive utilization of real-time sensing data collected by several satellites operating as part of a smart constellation is the fundamental impetus behind this approach. This utilization ultimately results in on-the-edge data processing and benefits for the picture product value.

It may be possible to utilize AI algorithms to consume data closer to its source rather than on the ground. This would lessen the burden that is placed on the downlink and make it possible to develop value-added applications in space.

In recent years, deep neural networks, which include both convolutional and recurrent neural networks, have become

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more popular for use in the classification of hyperspectral images. Using convolutional layers in order to glean information from a non-local graph, the authors develop a network that is capable of evaluating the whole situation. The use of semi-supervised learning makes it feasible to develop a map classification method of excellent quality. On the other hand, the authors of investigate the adverse effect that minute material mixtures have on the processing of hyperspectral images. Another essential quality is the non-local smoothness of this data, which can be found in and has been investigated there. A brand new spectral mixing model has been introduced once again into the public domain. The authors demonstrate that using their approaches might result in more accurate abundance calculations as well as improved reconstructions of abundance maps.

Another area where there is a significant interest in using AI is in the field of disaster management. The study gathered numerous strategies that make use of AI approaches to aid with the issues of the multiple phases of disaster management. These stages include mitigating the effects of the catastrophe, being prepared for it, responding to it, and recovering from it. These stages are broken down and categorized using the information provided.

The findings provide evidence for the many benefits that may be derived from using AI to catastrophe planning and response, and they encourage both the public and private sectors to do so. The authors of investigated how people responded to various situations on social media during the 2017 Atlantic Hurricane season with the intention of developing a system that might improve both situational awareness and the ability of assistance groups to respond to catastrophes. The information that was retrieved includes both the textual and visual content of a large number of tweets that were posted during the event in question. A framework known as random forest learning was used in order to classify the tweets that were collected. Additionally, using the K-means approach, we were able to identify high-level categories that were shared by related texts. In conclusion, it was proposed that methodologies based on deep learning should be used in order to extract useful information from images shared on social media. Information from social messaging systems like Twitter was evaluated in a model for disaster prediction that was based on machine learning. This allowed for the detection of potential catastrophic occurrences. Classifiers such as Multinomial Naive Bayes and XGB can separate tweets into two categories: those that are relevant to a flood and those that are not relevant to a flood. These classifiers have an accuracy of above 90%.

Our research has shown that despite the many contributions, there is still a need for the categorization and analysis of hyperspectral images. This requirement emerges and converges on a number of different fields, such as land use, agriculture, food supply systems, and the cleaning of water and the atmosphere. Nevertheless, the vast majority of solutions take into consideration the value of imaging systems that are powered by AI. The use of deep learning in conjunction with semi-supervised learning is included in several of the ideas. In addition, both generative and convolutional neural networks are used in order to increase the accuracy of the hyperspectral pictures.

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Discussion

The challenges that are now being faced by the space sector have an impact, maybe more than we are aware of, not only on our day-to-day lives but also on our perspectives of the future. Nevertheless, AI is also fostering growth and innovation across a wide variety of business sectors. Artificial intelligence is supporting academics and companies, particularly in the space sector, in developing concrete solutions to the most urgent concerns; nonetheless, AI's primary function is to enable discoveries. The following are some of the problems that artificial intelligence (AI) attempts to solve: developing strategies for and creating missions, space exploration, and

Results of observations made of the Earth, as shown in Figure1. Because we found a lot of studies that support the use of AI in innovative, convergent, and disruptive sectors, it is crucial to point out that we did not perceive these categories as impenetrable compartments when we were doing our study. In point of fact, a significant number of the advances that are beneficial to one industry also affect the results and prospects of other industries. The creation of health satellite monitoring systems, for instance, is beneficial to both the observation of Earth and the exploration of space. the disclosed challenges and discoveries that we provide here are all connected to one another. Because of the diverse reinforcement learning methodology, a multi-robot system on Mars or an internet-connected space object may be taught to accomplish fundamental tasks by adapting to the challenging environment as needed by the method. This would allow the system to fulfill the requirements of the method.

In the past, unsupervised learning has been used with satellite telemetry data for the same objectives, namely to develop an improved health monitoring system and prevent unplanned failures. It is necessary to develop a design engineering assistant in order to plan a space mission, which is another challenge that is connected to the process of information retrieval and the reuse of knowledge in space missions. Expert systems and semi-supervised approaches are two of the numerous approaches that have been developed to address this challenge.

In addition, semi-supervised learning has been used in remote sensing, namely for high-resolution EO photographs and the classification of Mars pictures. This is a very recent development. Supervised learning may be used to the largest variety of problems, ranging from dealing with the challenges of disaster management stages to satellite fault diagnostics, agricultural automation, and environmental concerns such as predicting water quality and reducing the consequences of climate change. Supervised learning can be applied to all of these problems and more. In addition, fuzzy logic offers solutions to issues that arise while monitoring the quality of water, the environment, and the climate, as well as when conducting space exploration with a number of different robot systems.

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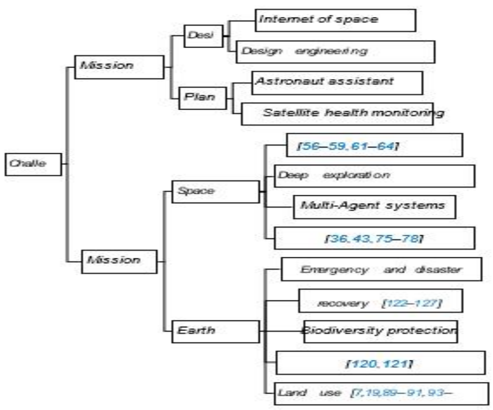

Figure 1. Challenges in Space Applications.

4. CONCLUSIONS

Artificial intelligence (AI) is used in a variety of contexts to carry out operations in a way that is analogous to that of humans, and it plays a vital part in the process of digitally transforming society. Survey articles detailing innovative AI-based solutions for the most challenging engineering challenges have been published in nearly all application areas, with the exception of space applications. As is customary, members of the scientific community contribute significantly in the development of these responses.

This study presents a framework that reviews all recently suggested AI-based solutions used in space applications and categorizes them according to (1) the particular issue to which they are applied and (2) the typology of the AI method that is used to address the problem. The purpose of this framework is to fill the vacuum that has been created as a result of the absence of such a framework. A classification system for newly presented solutions has been generated using this framework. We meticulously organized and arranged over one hundred articles by categorizing them according to a system based on two fundamental hurdles (mission execution and mission goal) and thirteen secondary obstacles.

As a result of the classification that has been provided, the reader will be able to discover the most recent techniques that are being used to solve specific challenges, as well as the most critical issues that arise in space-based applications that AI-based methods may assist in addressing.

Our research has provided some insight into potential future paths. Utilizing technology that is related to artificial intelligence is one of the key directions that is being taken in satellite communication. This is being done primarily with the goal of improving the efficiency and safety of communication systems. The creation of an even more advanced kind of artificial intelligence that can be used for satellite navigation is another exciting prospect.

REFERENCES:

[1] Gao, Y.; Chien, S. Review on space robotics: Toward top-level science through space exploration. Sci. Robot. 2017, 2, eaan5074.

[2] Fourati, F.; Alouini, M.S. Artificial intelligence for satellite communication: A review. Intell. Converg. Netw. 2021, 2, 213–243.

[3] Meß, J.G.; Dannemann, F.; Greif, F. Techniques of artificial intelligence for space applications—A survey. In European Workshop on On-Board Data Processing

(OBDP2019); European Space Agency: Paris, France, 2019.

[4] Saravanan, R.; Sujatha, P. A state of art techniques on machine learning algorithms: A perspective of supervised learning approaches in data classification. In Proceedings of the 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 14–15 June 2018; pp. 945–949.

[5] Cervantes, J.; Garcia-Lamont, F.; Rodríguez- Mazahua, L.; Lopez, A. A comprehensive survey on support vector machine classificati on: Applications, challenges and trends. Neurocomputing 2020, 408, 189–215.

[6] Speiser, J.L.; Miller, M.E.; Tooze, J.; Ip, E. A comparison of random forest variable selection methods for classification prediction modeling. Expert Syst. Appl. 2019, 134, 93–101.

[7] Sheykhmousa, M.; Mahdianpari, M.; Ghanbari, H.; Mohamma dimanesh, F.; Ghamisi, P.; Homayouni, S. Support vector machine versus random forest for remote sensing image classification: A meta-analysis and systematic review. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens. 2020, 13, 6308–6325.

[8] Berry, M.W.; Mohamed, A.; Yap, B.W. Supervised and Unsupervised Learning for Data Science; Springer: Cham, Switzerland, 2019.

[9] Sinaga, K.P.; Yang, M.S. Unsupervised K-means clustering algorithm. IEEE Access 2020, 8, 80716–80727.

[10] Van Engelen, J.E.; Hoos, H.H. A survey on semi-supervised learning. Mach. Learn. 2020, 109, 373–440.

[11] Botvinick, M.; Ritter, S.; Wang, J.X.; Kurth-Nelson, Z.; Blundell, C.; Hassabis, D. Reinforcement learning, fast and slow. Trends Cogn. Sci. 2019, 23, 408–422.

[12] Kelleher, J.D. Deep Learning; MIT Press: Cambridge, MA, USA, 2019.

[13] LeCun, Y.; Bengio, Y.; Hinton, G. Deep learning. Nature 2015, 521, 436–444.

[14] Mikolov, T.; Karafiát, M.; Burget, L.; Cernocky`, J.; Khudanpur, S. Recurrent neural network based language model. In Proceedings of the Interspeech, Makuhari, Japan, 26–30 September 2010; Volume 2, pp. 1045–1048.

[15] Chowdhary, K. Natural language processing. In Fundamentals of Artificial Intelligence; Springer: New Delhi, India, 2020;pp. 603–649.

[16] Zadeh, L.A.; Klir, G.J.; Yuan, B. Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems: Selected Papers; World Scientific: Singapore, 1996; Volume 6.

[17] Liebowitz, J. The Handbook of Applied Expert Systems; CRC

ISSN: 2057-5688

Press: Boca Raton, FL, USA, 2019.

[18] Kua, J.; Loke, S.W.; Arora, C.; Fernando, N.; Ranaweera, C. Internet of Things in Space: A Review of Opportunities and Challenges from Satellite-Aided Computing to Digitally-Enhanced Space Living. Sensors 2021, 21, 8117.

[19] Dumitru, C.O.; Schwarz, G.; Castel, F.; Lorenzo, J.; Datcu, M. Artificial intelligence data science methodology for Earth Observation. In Advanced Analy- tics and Artificial Intelligence Applications; InTech Publishing: London, UK, 2019; pp. 1–20.

[20] Bang, H.; Virós Martin, A.; Prat, A.; Selva, D. Daphne: An intelligent assistant for architecting earth observing satellite systems. In Proceedings of the 2018 AIAA Information Systems-AIAA Info- tech@ Aerospace, Kissimmee, FL, USA, 8–12 January 2018; p. 1366.