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Emergence in Space Technologies with Nanosatellites, Exploring the Applications of AI in Space Development, and Future Trends

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Abstract: Since, the first satellite was launched years ago, more than 6000 have been flown into orbit. Space science is the most fascinating field of study and research in the twenty-first century. The satellites are objects that travel in an elliptical orbit around the planet. Artificial satellites are being produced in large numbers. One of the most important aspects of modernizing science and communication technology, including space technology, mobile and radio communication, is satellite communication. The focus of the research work is on nanosatellites like cube sats, which are becoming increasingly well-known because to their wide-ranging applications in the field of radio transmission. This review paper explains some recent developments and the importance of nanosatellites in advancing space technology, highlight the recent development of space technologies in developing Asian nations and presents the future prospects of satellites development. Also, study is done in the role of AI in space technologies enhancement and space industries development its applications and future trends are discussed in this paper.

Keywords: Nanosatellite, Space Technology, Artificial Intelligence, Elliptical Orbit, Internet of Things

Introduction

In recent years, the landscape of space exploration and satellite technology has undergone a paradigm shift, catalyzed by the emergence of nanosatellites. These miniaturized, spacecraft, weighing no more than a few kilograms, have ushered in a new era of accessibility and affordability in space technology, particularly for developing nations. Nanosatellites are considered easy-made technology due to their low cost, modular design, and off-the-shelf components which makes them an accessible technology capable of disrupting the spacecraft industry (Loisel 2022). Compared to traditional satellites, nanosatellites retain the same or similar capabilities, while costing significantly less, making them cheap and convenient. The potential of nanosatellites to democratize space exploration is immense, offering a viable means for resource-constrained countries to participate in the global space community and harness the myriad benefits of space-based applications. The nanosatellites are the satellites weighing approximately below 10 kilograms. The cube-sat are good example of nano satellites. The newest technologies allow development of mini satellites with specific scientific research focused goals. The cube-sats are based and designed on the standard CubeSat Unit. Nanosatellites are fundamental in space research and rocket science field today. It makes sure for the low-cost access to space. The nanosatellites have light weight, and has short time period of development. It accompanies the bigger satellites and it is put into its orbit by the help of rockets. A number of nanosatellites are developed for gathering weather report, atmospheric characteristics and behaviours. The nanosatellites find their application in the atmospheric research purposes as well as space research so are revolutionising the space technology at peak.

Artificial Intelligence (AI) plays a significant role in space development, impacting various aspects of space exploration and technology. AI is used to solve space challenges, enhance innovation, accuracy, and responsiveness in space endeavors, and support the development of new technologies and life support systems needed to establish human settlements in space (Russo and Lax, 2022; Richards et al. 2023). It also creates efficiencies in mission planning and operations, provides scientists with the ability to explore the far reaches of space (Daniel 2022). Additionally, AI is seen as a key technology for space education, enabling students to complete more advanced space experiments and will play a vital role in furthering space exploration. The use of AI in space development is a rapidly evolving field with the potential to unlock new potentials in space technology development (Davidian 2023).

Therefore, the primary objectives of this review study are to examine current satellite and space technology advances and advancements. In addition, the information about nanosatellites aids in advancing science and technology in underdeveloped economies, and the development patterns for nanosatellites in the future are also discussed.

Literature Review

Research and development on nanosatellites has increased dramatically, demonstrating the wide range of applications that they can be used for. In addition to offering a thorough overview of tiny satellite research and its various applications, Wayne A. and colleagues (2010) also shed light on the prospects for nanosatellites in the future. Their efforts highlight how important nanosatellites are to the advancement of space research. There is a lot of debate about the possible missions for these cutting-edge satellite bodies, which envision a future in which satellites become highly specialized for certain purposes. Meftah et al. (2014) explored the fascinating prospect of researching Earth-sun connections, predicting a significant interest in this field in the years to come. According to their research, nanosatellites present a viable way to carry out tasks that traditional satellites would typically accomplish. This offers a rare chance to study, especially for those who want to work in aerospace. Moreover, a wide range of tasks for nanosatellite development, including communications, astronomy, planetary research, and remote sensing, were highlighted by Natalia L. and colleagues (2016). Their study emphasizes how adaptable nanosatellites are and how much they might potentially add to many areas of space exploration. Regarding lunar missions, Andrea B. et al. (2021) emphasized the critical function that nanosatellites fulfill in space-related research and development projects. Their work demonstrated the critical role that nanosatellites play in expanding our understanding of the universe by highlighting the use of cameras and infrared spectrometers on Earth to get insights into star histories. A great deal of research has gone into the creation of nanosatellites, which were created with OpenCosmos' OpenKit and examined by SSPI specialists. This includes a thorough assessment of the quality of the search in Lunar CubeSat missions as well as the state of small objects. Furthermore, a feasibility study has been carried out to evaluate the potential and viability of these cube satellites.

Giovanni S. et al. (2022) have presented a novel idea that involves the use of laser-powered nanosatellites that are fitted with collision-optimized light sails. The goal of their research is to develop a reliable system for sending several spacecraft into orbit. Positioned in particular orbits, these laser-guided nanosatellites can support heliospheric surveys, earth observation, and customized communication missions with the appropriate sensors. Nanosatellites can be placed in hyperbolic orbits with respect to Earth and travel quickly to their destinations by adjusting important variables like sail area-to-cloud ratio and laser power.

Recent years have seen a spectacular rise in the field of nanosatellites, revolutionizing space technology and expanding its applications across multiple sectors. Wayne et al. (2010) outlined the bright future prospects for nanosatellites and gave a thorough overview of small satellites and their various applications. These little but mighty spacecraft have become essential tools for space exploration and are ready to assume more specialized roles in upcoming missions. Among these upcoming missions, Meftah et al. (2014) envisions an intriguing prospect to research the complex link between the sun and Earth. Their research suggests a thorough investigation of the sun-earth dynamic, opening up a very interesting scientific direction. By bridging the gap between theory and practical experience, the deployment of nanosatellites presents a unique opportunity for aerospace enthusiasts and learners to participate in satellite-based activities.

According to Natalia et al. (2016), nanosatellites have found a home in a variety of missions covering communications, astronomy, planetary science, and remote sensing. Specifically, moon missions are now essential to the advancement of space research and development. According to Andrea et al. (2021), cameras and infrared spectrometers play a crucial part in revealing the cosmic history of stars from Earth-based vantage points. The development and approval of creative concepts utilizing OpenKit for Lunar CubeSat missions is the result of the joint efforts of OpenCosmos and SSPI experts. This program has made significant progress in satellite technology possible by providing priceless insights on the condition and nature of tiny objects in orbit. Furthermore, Giovanni et al. (2022) have made noteworthy progress in investigating the possibilities of nanosatellites outfitted with laser-driven, collision-optimized light sails. This innovative study offers a practical way to launch several spacecraft into the solar system. Laser-guided nanosatellites show promise for heliospheric surveys, Earth observation, and customized communication applications in certain orbits when equipped with the right sensors. Through accurate positioning in various hyperbolic orbits with respect to Earth, these nano-satellites can quickly and efficiently arrive at their intended destinations by varying the area-to-cloud ratio and laser intensity. The work of Giovanni et al. (2022) highlights the ongoing potential for innovation in this emerging sector and represents a significant advancement in the optimization and deployment of nanosatellites for a variety of space missions.

But even with the remarkable advancements in nanosatellite technology, there is still a research gap that has to be filled. Even though the body of current literature is rich in accomplishments and possible uses, more in-depth research is still needed to fully address some problems and unrealized promise in this rapidly evolving field. This research gap highlights the ongoing need for comprehensive studies that could advance nanosatellite technology and its revolutionary effects on space exploration and technology. Future trends in the development of the space sector as well as the impacts of artificial intelligence are also included in this study. The study as a whole addresses the functions of nanosatellites in space development and connects them to the function of AI in this field.

Methodology

The types and structures of nanosatellites are important to understand in order to track their progress in science and technology. We categorize them according to similar features, break them down into their type, examine their structure, and then analyze how they have advanced and contributed to the most recent technical advancements.

1.1. Classification of nanosatellites

We aim to find the major impacts and roles of nano-satellites in space technologies development. We are focusing on recent advancements and the sectors which the nanosatellites benefits. The nanosatellites can be classified to different types depending upon operation, capacity and their size.

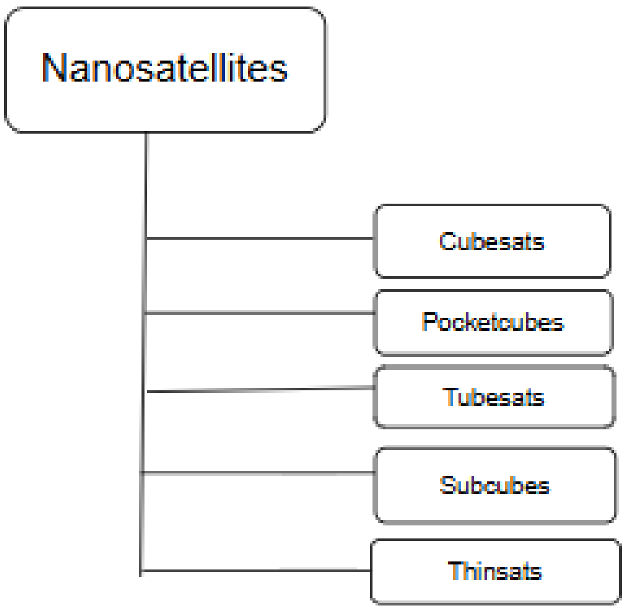

Figure 1. Nanosatellites versions & types

Compact, extremely specialized spacecraft with a wide range of mission-specific designs are collectively referred to as nanosatellites. One of the most common varieties are CubeSats, which are standardized nanosatellites that are usually constructed in cubic units of 10 cm, however they can also be produced in 1U, 2U, or 3U designs. They are adaptable and frequently used for scientific, teaching, or technology demonstration. Even smaller, weighing less than 0.1 kg, femtosatellites are primarily employed in particular types of scientific research. Slightly bigger than femtosatellites, picosatellites can support more sophisticated functions including communications and Earth observation. They weigh between 0.1 and 1 kilogram.

Finally, microsatellites are larger than nanosatellites, although they are still classified as the same size and have a weight between 10 and 100 kg. They provide more sophisticated features including telecommunications, remote sensing, and intricate scientific missions. Because each kind of nanosatellite meets particular mission requirements, they are vital instruments for space exploration and research.

Figure 2. Nanosatellite in space

1.2. Nanosatellite structure

It is essential that we examine the satellite technologies' structure and construction while learning about their importance. Understanding the satellite's features, size, capabilities, and applications requires a thorough understanding of its construction.

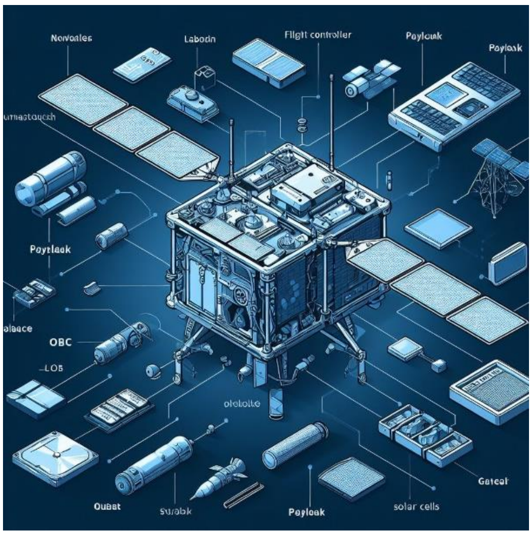

Figure 3. A nanosatellite structure

a. Payload

The satellite tv for pc's payload makes it best for its project. This is largely why satellites had been positioned into orbit within the first place. In this regard, miniaturization is specifically good for nano satellites, as payloads which include cameras may be scaled down in many instances, which saves costs while keeping extremely good pix. As opposition for new area grows, so does the incentive for cargo system to be worthwhile and green. COTS components isn't necessarily economical. This is same case for satellite softwares. There are pre validated software components available for such purpose.

b. Attitude Determination and Control System (ADCS)

The ADCS is a crucial subsystem in a satellite responsible for accurately determining its orientation in space and controlling its attitude (i.e., its orientation with respect to a reference frame). This system typically includes sensors like sun sensors, star trackers, magnetometers, and gyroscopes to provide data on the satellite's attitude. It also includes actuators such as reaction wheels, magnetic torquers, and thrusters to control and adjust the satellite's orientation.

c. Payload Board

The payload board is a specialized circuit board within the satellite that is dedicated to managing and interfacing with the primary payload or scientific instruments. It contains components like data acquisition systems, signal conditioning circuits, and interfaces to ensure proper communication and operation of the payload.

d. Transceiver

The transceiver is a critical communication component responsible for both transmitting and receiving signals to and from the satellite. It typically operates in specific frequency bands allocated for satellite communication. The transceiver enables the satellite to establish links with ground stations, other satellites, or networks, allowing it to transmit data collected by its payload and receive commands from Earth.

e. Solar Cells

Solar cells, also known as photovoltaic cells, are used to convert sunlight into electrical power. They are a primary source of power for most satellites, especially those in low Earth orbit (LEO). The solar cells are mounted on the satellite's surface and arranged in arrays to capture as much sunlight as possible. The generated electricity is then stored in rechargeable batteries or used to power the satellite's systems directly.

f. OBC

The On-Board Computer (OBC), which controls numerous operations relating to spacecraft management, data handling, and communication, is a crucial part of nanosatellite systems. The OBC is essential to the smooth operation and coordination of onboard systems in the setting of nanosatellites, which stand out for their small size and scarce resources.

The onboard computer (OBC) of the satellite carries out tasks like malfunction detection, onboard time synchronization, command control, and telemetry. An onboard computer necessitates onboard software, which manages the nano satellite's mission. The same off-the-shelf (COTS) products that nanosatellites employ can also be used for COTS software solutions. Nano satellite flight software can be designed utilizing commercial hardware based on mission requirements thanks to creative methods like flight hardware development software.

In the end, this means that nanosatellites can be combined with real-world and digital tools, cutting down on complexity and development time while accelerating project completion. Its superior performance is due to the satellite. This is essentially why satellites were put into orbit in the first place.

In this sense, miniaturization is particularly advantageous for nano satellites since it allows payloads like cameras to be scaled down several times while still producing high-quality images. The incentive for cargo equipment to be lucrative and efficient is growing as competition for new space increases.

1.3. Nanosatellites properties

A comparative study can help learners identify the traits and aims of nanosatellites, one of their primary distinguishing characteristics. Understanding these attributes is essential to appreciating their capabilities and features for space-related tasks.

Table 1. Size comparision table of satellites

Type	Satellite size in kg	Comparable size
Extra large	8000+	
Very large	4000-8000	
Large	1,501-4000	
Medium	501-1500	
Minisatellites	100-500	Oven

Microsatellites	10-100	A small cupboard
Nanosatellites	1-10	Rubic cube
Picosatellites	0.1-1	Palm of hand
Femtosatellites	Less than 100gm	Dice

Previously, only wealthy countries could purchase satellites, which are categorized from smallest to largest. Most often constructed by private enterprises, nanosatellites give developing nations the capacity to quickly deploy spacecraft from conception to launch (Table 1).

Smaller-sized nanosatellites are widely used, whereas femtosatellites, which resemble dice in shape, are less frequently employed in space-related research projects but are nonetheless widely used. A comparative analysis of the satellites can help to understand the kinds of roles that they play similarly, as well as the complexity of their development and payload capacity.

1.4. Technological innovations and advancements

The nanosatellite assists other spacecraft in operating and is employed in space research and related tasks. In less developed nations, the development of nanosatellites is also progressing. In south Asian poor nations, nanosatellites are quickly rising to the top of the development priority list. We can examine recently built satellites from underdeveloped and developing countries. Consider Bhutan, Nepal, and Sri Lanka as instances of recent advancements. Their nanosatellites have recently been launched through space missions.

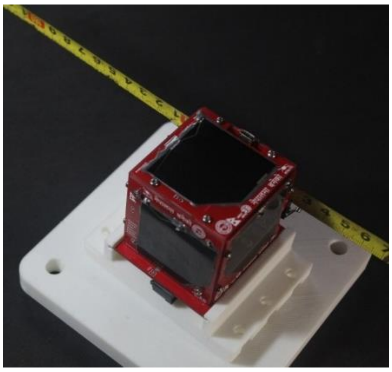

Figure 4. sanosat-I developed in Nepal

The brokerage service for the PocketQube is provided by FOSSA Systems, a premier aerospace firm specializing in constructing picosatellites for Internet of Things communications. The PocketQube is being developed by ORION Space in partnership with AMSAT-Nepal and AMSAT-EA. SanoSat-1 is a 1P-sized PocketQube that was built using easily available commercial components (COTS) to detect space radiation while in orbit and occasionally send the results to Earth. In an amateur band, the satellite will serve as a digital repeater. In remote areas that are prone to disasters, the store and forward idea can be applied. The same idea can be used to gather data from sensors on the ground, store it on board, and send it to the main station on Earth [8].

The best time of small satellites hasonly a few years ago. On November 19, 2013, Orbital Sciences Corporation (now Orbital ATK) launched a rocket from the Wallops Fli ght Facility in Virginia. It carries 29 satellites and places them in low Earth orbit for a mi ssion. Thirty hours later, the Russian joint venture Kosmotras launched 32 satellites into a similar orbit. Then, in January 2014, Orbital Sciences sent 33 satellites to the Internatio nal Space Station, where they were launched a month later.

Figure 5. Bhutan – I nanosatellite

The first nanosatellite from Bhutan to be sent into space was named BHUTAN-1. The satellite was created as part of the Birds-2 program at the Kyushu Institute of Technology. The Birds program aids nations in launching their initial satellite. On June 29, 2018, BHUTAN-1 was put into orbit by the SpaceX CRS-15 mission. On August 10, 2018, it was released from the International Space Station's (ISS) Kib module. The Earth was captured by the satellite's cameras.

Figure 6. Nanosatellite RAAVANA-1

After being given to the Japan Aerospace Exploration Agency (JAXA) on February 18, the satellite was launched from the International Space Station on April 17 at 2:16 a.m. Sri Lanka Standard Time. The satellite was launched alongside NepaliSat-1, the country of Nepal's first satellite. The satellite had five missions to accomplish while in orbit at a 400-kilometer altitude. Along with satellites from Nepal and Japan, Raavana 1 was a part of the third batch of satellites known as BIRDS-3. Raavana 1 set a goal of fifteen photos per day.

Investment in satellite technology makes sense for developing nations, and the creation of nanosatellites has many advantages. Enhancing communication infrastructure has the potential to be one of the main benefits. Nanosatellites in particular offer cost-effective ways to close the digital divide, improve connectivity in distant or underserved areas, and improve access to telecommunications and the internet. Nanosatellites are also essential for disaster response and management. They provide real-time information on natural disasters like hurricanes, floods, and wildfires since they are equipped with the ability to observe the Earth.

A prompt and focused response is made possible by this vital information, potentially saving lives and reducing damage. Additionally, nanosatellites have a big impact on industries like agriculture. They provide farmers with crucial insights for making wise decisions by keeping an eye on agricultural activities, evaluating crop health, and forecasting weather trends. This can therefore result in higher agricultural output, enhancing food security and local economies in these areas. Overall, the creation of nanosatellites is an investment that can help developing nations achieve sustainable development. It offers a variety of socio-economic and technological advantages.

2. Results and Discussions

Space research and development is a subject that is home to numerous noteworthy projects. Because they work on low-cost projects for space technology research introduction in their nations, research efforts related to nanosatellites are also extremely popular in developing nations. Studying the developments in nations like the United States, Russia, and China is essential.

Fig.7. Satellite technology

Additionally, we have investigated satellite missions and have discovered some significant data. Studying the contributions and functions of satellite technologies in developing countries is quite intriguing, and the findings align with our goal of investigating how space technology is changing.

2.1.Advancements in satellite missions

As we see in figure 8. below, for various interrelated reasons, developed nations typically have more satellites in orbit. First and foremost, developed countries have the financial means and technological know-how necessary to plan, manufacture, and launch satellites. These nations are able to take the lead in satellite technology and space exploration because to significant investments in R&D and well-established aerospace sectors. Furthermore, industrialized countries frequently have strong space agencies or organizations, like NASA in the United States or ESA in Europe, which receive a lot of funding and resources from their respective governments. These organizations are in charge of organizing, planning, and carrying out space missions, such as satellite placements.

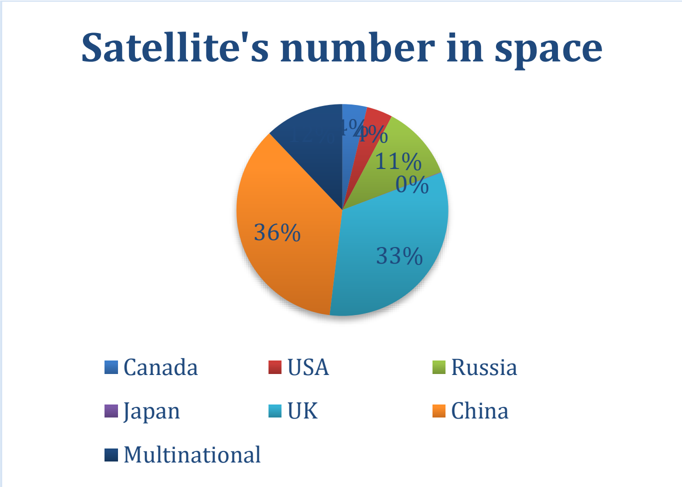

Fig.8. Countries with most satellites in space

The nanosatellites play a vital role for space research support. The nanosatellites have a specific research-oriented role and it is cheaper, portable. As of March 7th, 2024, the satellite tracking website "Orbiting Now" reported 9,494 active satellites in various Earth orbits. A detailed look at the number of satellites in space demonstrates how small satellites have come to dominate low Earth orbit [21]. It therefore, has a vast application's related to the field of space-oriented research. An economically backward country too needs a substantial improvement in the field of aerospace and avionics research, a footstep for a low budget space-oriented research has been contributed by the development of nanosatellites.

2.2.Satellites in developing nations

Economical and lower budget-oriented technology can help the economically unstable countries to invest on such technologies. This can enhance their nations technological development and cause to make advancement in space-oriented research. This can build a confidence for students and researchers in such countries to enhance the field of space science and technologies and we illustrate in fig.9. its essential applications.

Fig.9. Nanosatellites applications illustration

i. Space Research assistance

With sensors built for atmospheric studies, nanosatellites are able to gather vital information about temperature, humidity, rainfall, air pollution, ocean currents, and other environmental factors. In order to process and analyze this massive amount of data and provide insightful information about atmospheric conditions and climate patterns, artificial intelligence (AI) algorithms are used. For example, machine learning models can help researchers make decisions about climate change, weather patterns, and potential environmental hazards by identifying trends, anomalies, and correlations within the collected data.

ii. GIS

Geographic Information Systems (GIS) are made more capable through the integration of artificial intelligence (AI) technologies and nanosatellites, which offer sophisticated tools for data interpretation and analysis. Large volumes of high-resolution imagery are captured by imaging-equipped nanosatellites, which can be difficult to manually analyze. AI is essential for automating and streamlining GIS processes related to nanosatellite data. Applying machine learning algorithms to the obtained imagery allows for the automatic classification of land cover, recognizing and classifying various terrain and land use types. GIS mapping and analysis are made more effective by this automated classification.

iii. Signal Intelligence (SIGINT)

The integration of artificial intelligence (AI) further enhances the role of these satellites in disaster response and planning when used in Signal Intelligence (SIGINT) applications with nanosatellites monitoring radio transmissions from Earth. Because of their ability to intercept and analyze radio signals, nanosatellites can be very helpful in determining how a disaster will affect human activity and communication infrastructure. The enormous volume of signal data that these nanosatellite instruments gather is efficiently processed and interpreted in large part thanks to artificial intelligence (AI) technologies.

iv. Agriculture

In order to increase farmer earnings, sustainable agriculture must balance the need for decreased exploitation of natural resources and agronomic inputs with high production standards [27]. And, relating to AI researchers have recently employed deep learning extensively to address the myriad problems facing the space industry. Neural networks, for instance, are utilized to enhance agricultural land utilization [28].

By enabling effective monitoring, automation, and seamless data communication across enormous agricultural landscapes, the convergence of Internet of Things (IoT) technologies and nanosatellites presents a game-changing opportunity for expanding agricultural capabilities. For the purpose of transferring data over large distances and enabling more advanced agricultural research and automation, nanosatellites are an essential medium. Making use of Internet of Things sensors spread throughout agricultural fields is a crucial component of this synergy. Real-time data on multiple parameters, including soil moisture, temperature, humidity, crop health, and environmental conditions, is gathered by these sensors. Because they act as a communication link, nanosatellites are essential in enabling these Internet of Things devices to send data to centralized systems for analysis. providing insights into crop performance, pest infestations, and general farm conditions by automating the analysis of massive datasets.

Another field that has been significantly impacted by IoT and nanosatellites is agricultural automation. Nanosatellites' remote sensing capabilities make it possible to monitor crop health, growth patterns, and possible problems in real time, enabling timely intervention. Based on real-time data from IoT sensors, automated systems guided by AI algorithms can then carry out tasks like pest control, fertilization, and precision irrigation. This degree of automation promotes sustainable farming methods and improves resource efficiency.

v. Environmental conditions

The use of nanosatellites can help in analysis of environmental conditions. The atmospheric data like pressure, humidity and temperature can be easily obtained by use of nano-satellites and this mat open new opportunities in development in the field of sanitation and health in the people of that area.

vi. Internet Of Things (IoT)

A major obstacle for Internet of Things implementations is maintaining connectivity and communication over large and distant areas. These difficulties are addressed by nanosatellites, which offer a dependable method of data transfer across wide geographic areas. The deployment of constellations is made possible by the small size and low cost of nanosatellites, which guarantee extensive coverage and connectivity for IoT devices in even the most remote locations. The data consumption rate is lower and the data acquisition from the satellite has a longer delay because of the current on-board processing capability and the intersatellite connection rate constraint. Satellites are becoming a more vital component of 5G/6G and IoT communications as their number keeps rising [31].

The Internet of Things (IoT) has sparked widespread interest in the scientific community as a result of previously inconceivable applications that have become commonplace. The most difficult IoT scenarios include installations of low-power devices distributed across large geographic areas. In such cases, satellites will play an important role in bridging the gap to a pervasive IoT capable of readily handling disaster recovery scenarios (earthquakes, tsunamis, and flash floods, for example), where the presence of a resilient backhauling communications infrastructure is critical. Direct-to-Satellite IoT (DtS-IoT) connectivity is favored in these cases because it eliminates the need for an intermediate ground gateway, making it easier and faster to construct wide-coverage IoT infrastructure [22]. In some geographically tough places (such as deserts, seas, and forests) where direct connecting to a terrestrial network is impossible, space communication is the sole option. In these remote places, Internet of Things (IoST) applications can also be successfully used [23].

The requirements for a worldwide network connection are supported by the incorporation of nanosatellites into the Internet of Things ecosystem. By gathering data from Internet of Things (IoT) devices on the ground and sending it to centralized servers for processing and analysis, these satellites serve as communication relays. Nanosatellites enable real-time monitoring, control, and data exchange between Internet of Things devices and applications worldwide through two-way communication.

Additionally, the scalability and flexibility of Internet of Things networks are enhanced by nanosatellites. Nanosatellite constellations are easily expandable to accommodate growing device deployments as the demand for IoT connectivity grows. IoT applications can grow easily to satisfy the changing demands of a variety of industries, such as agriculture, environmental monitoring, logistics, and more, thanks to this scalability.

AI in Satellite industries and Space Development

Nanosatellites and more general space development projects benefit greatly from artificial intelligence (AI). AI has the potential to revolutionize the field of nanosatellites, which are smaller and less expensive spacecraft. From improving onboard processing and communication efficiency to independently controlling navigation and propulsion systems, AI algorithms aid in the optimization of nanosatellite systems. Because of their small size, nanosatellites frequently need creative ways to maximize mission capabilities while using minimal resources. Nanosatellites can process and interpret data gathered during missions, such as Earth observation or scientific research, with the help of machine learning algorithms.

Furthermore, AI-driven automation makes autonomous operations easier, enabling nanosatellites to execute tasks more precisely and adapt to changing space environments. The integration of artificial intelligence (AI) technologies accelerates space development by providing affordable, flexible, and intelligent solutions for a range of applications, from Earth monitoring to interplanetary exploration, as nanosatellites become essential parts of satellite constellations and space exploration [32].

AI's influence on shaping and enhancing space exploration's future is essential. There are numerous uses for artificial intelligence, ranging from deep space investigation of celestial bodies to robot navigation on planets. For instance, a Bayesian technique used for deconvolution of images produced in radio astronomy produced the first image of a black hole [24].

2.3.Future trends

The past ten years have seen a more adventurous approach to space innovation and a proliferation of inexpensive small satellites, which have prompted commercialization and sped up the development of technology that can be downsized and significantly lowered the cost of CubeSats. CubeSats are being viewed more and more in this perspective as platforms for cutting-edge missions that go beyond low-Earth orbit [26]. The benefits of satellite communications and space technology, in particular, are widespread and apply to a variety of development sectors. These benefits include bettering people's lives by facilitating information exchange between first responders and relief agencies in disaster zones, decreasing illicit fishing and enhancing safety and livelihood security, and boosting connectivity to improve patient access to healthcare providers in remote and rural areas [25]. Space technology has undergone a radical transformation thanks to the quick development of automated, robotic, function-centered, and compact equipment. This has made it possible to pursue intensive near-Earth space research and the most ambitious interplanetary missions [26].

Nanosatellites have a wide range of uses in several industries, and as technology advances and space research continues, we may see a marked rise in space missions and, correspondingly, in the characteristics and capabilities of these flexible nanosats and also the Artificial Intelligence has major areas to cover in space development.

Fig.10. Future trend of nanosatellites

The field of nanosatellites is continuously evolving, and several future trends are anticipated to shape the development and applications of these miniature satellites. Here are some anticipated future trends of nanosatellites:

Nanosatellites will likely see a dramatic transformation in the near future, characterized by increased complexity and capability [29]. These satellites' improved sensors, communication capabilities, and processing capacity will enable them to carry out increasingly complex missions and collect higher-quality data. Furthermore, the precise creation of nanosatellite constellations promises increased coverage, redundancy, and effective execution of coordinated activities. These developments not only represent a quantum increase in technological power but also have the potential to completely transform a range of industries, from business to science, and bring in a new age of space exploration and use. To put it briefly, there are a plethora of amazing new technologies still in the works that could lead to the development of space-based satellite communications systems, more potent processors, new encoding capabilities, and new user terminal features that could increase the mobility, versatility, and personal responsiveness of user systems while also lowering their cost [30].

In addition, the path of nanosatellite development includes a number of exciting opportunities, such as service and maintenance while in orbit and interplanetary missions. Improved communication systems will enable quick data transfer, while advancements in propulsion and AI integration will boost agility and autonomy. Regulations will change as the sector grows, driven by business and educational endeavors, to guarantee appropriate use of space resources and allay environmental worries. Nanosatellites are positioned to influence how humans will interact with space in the future by acting as catalysts for innovation, teaching, and sustainable space exploration in this ever-changing environment [3].

2.4.AI in Space missions

Space agencies and organizations hope to increase the scope and complexity of space exploration projects while lowering dependency on ground-based control and increasing mission efficiency by integrating autonomous AI robotics into space missions.

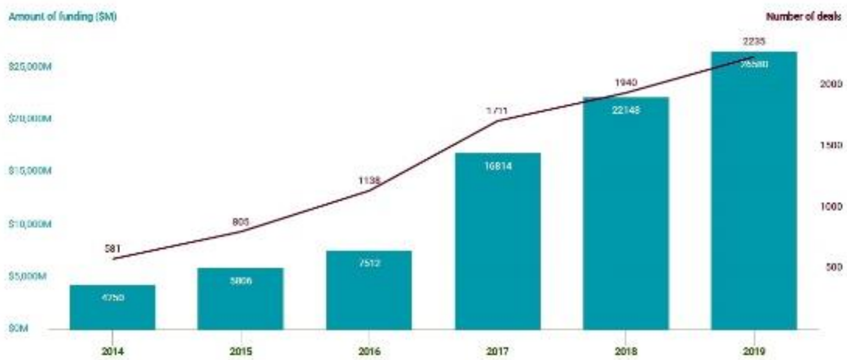

Fig.11. Geospatial world data on impact of AI on space investment [20]

According to CB Insights, AI was one of the most popular industries for VC investment in 2019, and the trend is still going strong. In terms of space, pioneers in artificial intelligence and edge computing are even forming divisions dedicated to the space sector, with a geospatial emphasis. For instance, the UAE-based AI powerhouse G42 recently revealed that

it has hired Talal Al-Kaissi, a former special advisor to the UAE Space Agency and a superstar in the industry.
These systems allow for more complex and adaptable missions beyond Earth, which advances both space technology and our understanding of the universe.

Fig.12. Robot in space mission

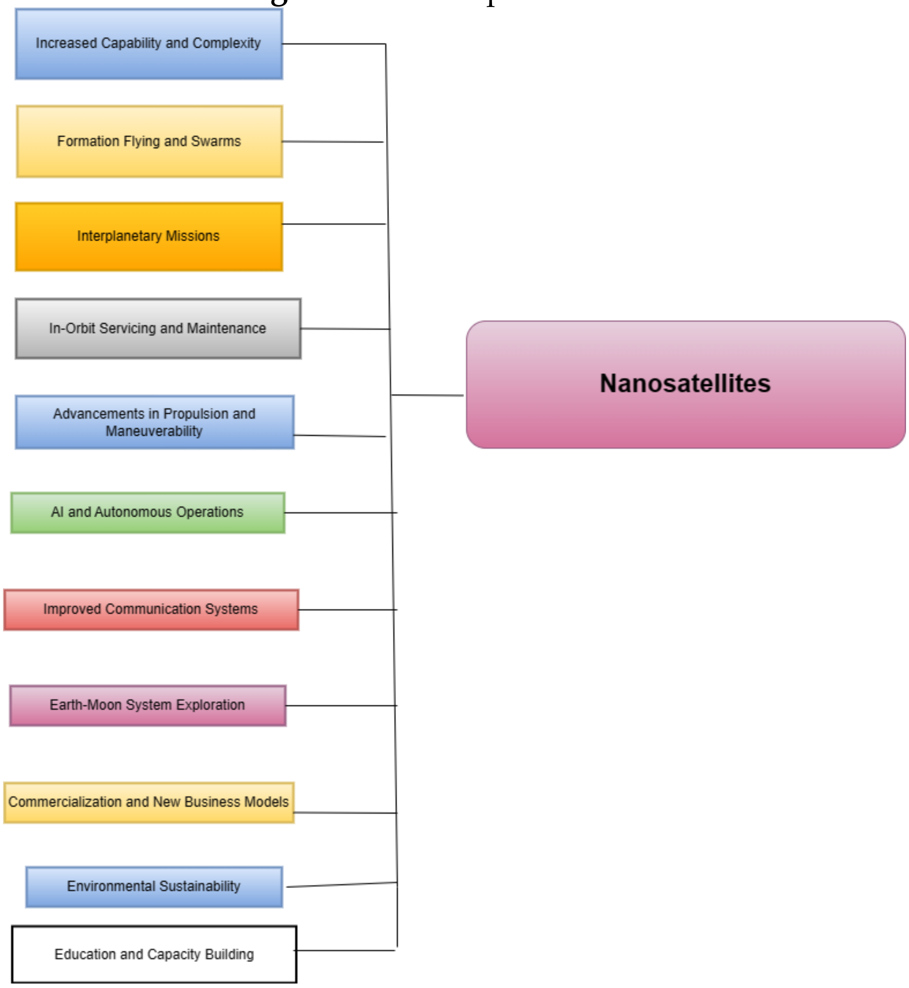

Fig 13. Nanosatellites scopes and applications

i. Autonomous Navigation and maneuvering

Robotic systems with AI capabilities are able to navigate through space on their own, modifying their course and orientation in response to mission objectives and real-time data. This independence is necessary to stay clear of pitfalls, choose the best course, and adjust to unanticipated difficulties.

ii. Robotic Space Exploration

Robots with autonomous AI are essential for planetary exploration. Intelligent artificial intelligence (AI) systems enable rovers and landers to conduct scientific experiments autonomously, analyze the terrain, and decide where to go. Trips to far-off planets and moons require this capability.

iii. Satellite Maintenance and servicing

Robots with autonomous AI are essential for planetary exploration. Intelligent artificial intelligence (AI) systems enable rovers and landers to conduct scientific experiments autonomously, analyze the terrain, and decide where to go. Trips to far-off planets and moons require this capability.

iv. Adaptive mission planning

Autonomous systems can modify their mission plans in reaction to unforeseen circumstances or shifting conditions thanks to AI algorithms. This flexibility is essential to the success of extended missions where real-time human intervention is impractical due to communication delays.

v. Spacecraft assembly and construction

Autonomous AI robotics may be used to assemble and build space structures in future space exploration scenarios. Building habitats, telescopes, or other infrastructure needed for long-term space missions could fall under this category.
A new era of innovation in many scientific and technological sectors has been brought about by advances in nanosatellites, with communication being one of its key benefactors. This study is extremely important and makes a significant contribution to our understanding of how such innovative technologies came to be and what uses they serve. Through the utilization of the fundamentals and requirements present in this domain, it encompasses the entire range needed for a multitude of industries, such as IoT [31], mobile communication, radar communication, and many more. Because of their small size and improved capabilities, nanosatellites have completely changed communication systems by providing affordable, flexible, and globally covered options. They are perfect for a wide range of applications, from scientific study to Earth observation, thanks to their modular architecture and small form factor. Within the domain of the Internet of Things,

nanosatellites are essential in providing smooth communication for a wide range of networked devices, allowing for effective data gathering, processing, and sharing.

Furthermore, in the field of mobile communication, nanosatellites present innovative ways to close the digital divide, cover isolated and neglected regions, and provide communities with access to basic services. Their capacity to convey communications in real time improves disaster management initiatives by permitting prompt action and collaboration in times of emergency.

Nanosatellite technology also greatly helps radar communication, since these tiny satellites may be arranged in constellations to supplement current radar systems, improving surveillance capabilities for a range of uses such as defense, weather monitoring, and maritime surveillance.

Looking ahead, space exploration and tackling the difficulties involved with human missions beyond Earth have a great deal of potential thanks to the convergence of nanosatellite technology and artificial intelligence (AI). Artificial Intelligence (AI) algorithms have the potential to enhance mission planning, navigation, and resource management, hence expanding spacecraft capabilities and improving autonomy in complex and uncertain situations [31]. [32]. Moreover, from the massive volume of data gathered by nanosatellites, AI-powered data analytics can derive actionable insights, facilitating better decision-making and hastening scientific advancements.

Fundamentally, the combination of AI technologies and nanosatellites signifies a paradigm change in space development, opening up new avenues for creativity, cooperation, and exploration. Humanity may overcome the difficulties of space travel and open the door to a future in which the limits of our cosmic voyage are only our imagination by utilizing these state-of-the-art technologies. Subsequent satellite communications are unable to withdraw from the [16For the purpose of utilizing cooperative diversity in wireless networks, distributed space-time coded systems typically align with terrestrial communication protocols. This results in a full integration between the two networks, enabling the provision of high data rates and high quality of service implementing interference reduction strategies anytime, anywhere in the context of broadband multimedia satellite systems [33].

Conclusion

Thus, the space technology and nanosatellites are most essential in research perspective in 21st century. The rapid research works are carried out to create newer technologies to get new findings on space. There are as many as 10,000 objects launched into space through the earth surface. These satellites are relatively smaller and conventional but has been supporting the field of communication and data & information exchange. With smaller size they support vast applications and supports earth observations. The development of such satellites is one of primary steps being carried out by the underdeveloped nations for broadening the space technology related research and development. As, they support huge missions related to space with smaller capital requirements they are gaining higher demand of development in every nation. The main challenge to be solved now is the security of the nano satellite. That's because exi sting satellites don't last long before they disappear into the earth's atmosphere. Many spa ce launch projects are underway and many R&D projects will be conducted to upgrade sp ace science using nano satellites.

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