STM JOURNALS

International Journal of
Satellite Remote Sensing

Volume 3, Issue 1, 2025
January–June
DOI (Journal): 10.37591/IJSRS

https://journals.stmjournals.com/ijsrs

Review IJSRS

AI-Based Software-Defined Satellite in Decision Making: A Study

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Abstract

For decades, satellites have been a vital infrastructure, relaying communication signals, observing Earth's climate, and providing critical navigation data. However, the traditional model of satellite operation is often rigid and reactive, relying heavily on pre-programmed instructions and ground-based control. This limits their flexibility and responsiveness in a rapidly changing environment. Enter software-defined satellites (SDS), and now, the game-changer: artificial intelligence (AI). Imagine a satellite that can independently analyze its surroundings, anticipate potential problems, and reconfigure itself to adapt to evolving mission objectives – that is the promise of AI-based SDS. This fusion of advanced technologies is poised to revolutionize space operations, ushering in an era of autonomous decision-making and unprecedented efficiency. AI-based SDS represent a paradigm shift in space operations, promising to unlock unprecedented levels of autonomy, efficiency, and resilience. By combining the flexibility of SDS with the intelligence of AI, we are paving the way for a new era of space exploration and utilization, one where satellites can truly think for themselves and contribute to a more connected and sustainable future. The journey towards fully autonomous space systems is just beginning, but the potential rewards are well worth the effort.

Keywords: Satellite, software-defined satellite (SDS), decision making, artificial intelligence

INTRODUCTION

For decades, satellite technology has been defined by rigid hardware, built for specific tasks and largely inflexible once launched. But a new paradigm is emerging, promising to revolutionize the space industry: software-defined satellites (SDS). These intelligent spacecraft leverage the power of software to dynamically adapt to changing mission requirements, optimize performance, and even extend their lifespan, offering unprecedented flexibility and efficiency [1–5].

Think of it like comparing a traditional cell phone to a smartphone. The traditional phone could only make calls and send texts, while a smartphone, powered by software, can perform a vast array of functions through downloadable applications. SDS operate on a similar principle.

At their core, SDS are satellites where critical functions, traditionally implemented in dedicated hardware, are instead handled by software. This means that key components like communication payloads, data processing units, and even attitude control systems can be reconfigured, upgraded, and even reprogrammed remotely while in orbit [6–12].

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Received Date: March 28, 2025
Accepted Date: March 29, 2025
Published Date: April 08, 2025

Citation: Sanika Anil Bhosale, Kazi Kutubuddin Sayyad Liyakat. AI-Based Software-Defined Satellite in Decision Making: A Study. International Journal of Satellite Remote Sensing. 2025; 3(1): 63–72p.

Key benefits of SDS:

- *Flexibility and adaptability:* This is the cornerstone of SDS. Missions evolve, requirements change, and unforeseen circumstances arise. SDS can adapt to new challenges by deploying different software configurations, enabling them to repurpose their capabilities in real time.
- *Extended lifespan:* By updating software to optimize power consumption, adjust performance parameters, or even repair minor glitches, SDS can significantly extend their operational lifespan, leading to cost savings and increased return on investment.
- *Enhanced performance:* Software updates can improve the performance of existing hardware, making it possible to push the limits of the satellite's capabilities and extract maximum value from its resources. This includes optimizing data processing speed, improving communication bandwidth, and enhancing image resolution [13–17].
- *Reduced development costs:* While the initial investment in software development might be higher, SDS can ultimately reduce development costs by leveraging common hardware platforms and adapting them to different mission requirements through software configurations. This also allows for a more iterative and agile development process.
- *New business opportunities:* The adaptability of SDS paves the way for creative and groundbreaking business models. Imagine a satellite that can be reprogrammed to serve different customers or provide different services on demand, creating new revenue streams and maximizing asset utilization.
- *Improved disaster response:* In the event of a natural disaster, SDS can be rapidly reconfigured to provide critical communication and imaging capabilities to support relief efforts. Their adaptability ensures they can be deployed where and when they are needed most [18–23].

Although SDS has great potential, certain challenges still need to be overcome. Some of these are:

- *Security:* Ensuring the security of software-defined systems in space is paramount. Protecting against cyberattacks and unauthorized access is crucial to prevent disruption or compromise of satellite operations [24–28].
- *Software validation and testing:* Thorough testing and verification are crucial to guaranteeing the dependability and precision of software updates in the challenging conditions of space.
- *Standardization:* The lack of standardized interfaces and software frameworks can hinder interoperability and increase development costs. Developing industry standards will be critical for the widespread adoption of SDS.

The future of satellite technology is clearly moving towards a software-defined approach. In the coming years, we can anticipate advancements in this direction:

- *Increased adoption of artificial intelligence (AI) and machine learning:* AI algorithms will be used to automate satellite operations, optimize resource allocation, and even predict and prevent potential problems [29–48].
- *Development of more robust and secure software platforms:* New security measures and development practices will be implemented to protect against cyber threats and ensure the reliability of software-defined systems.
- *Growing collaboration between hardware and software developers:* A closer integration between hardware and software teams will be essential to fully leverage the capabilities of SDS.

SDS are poised to transform the space industry, offering unprecedented flexibility, adaptability, and performance. By embracing the power of software, we can unlock new possibilities in space exploration, communication, and Earth observation, driving innovation and creating a more connected and sustainable future. As the technology matures and challenges are overcome, SDS will undoubtedly become the dominant paradigm for future satellite missions, shaping the future of space for decades to come.

ARTIFICIAL INTELLIGENCE–POWERED SOFTWARE-DEFINED SATELLITES

For decades, satellites have been largely static, pre-programmed behemoths orbiting the Earth. They served their purpose, but their functionality was fixed upon launch, making them inflexible and slow to adapt to changing needs. But a revolution is underway. Enter the era of AI-based SDS, poised to redefine space technology and unlock unprecedented possibilities [30–35].

SDS, in their initial form, offered a significant leap forward by allowing post-launch configuration via software updates. This meant changes to frequency bands, beam shaping, and even the onboard processing capabilities could be made remotely. However, the incorporation of AI is elevating this idea to an entirely new dimension, enabling space assets to become genuinely intelligent and adaptable.

AI's strength comes from its capability to process large amounts of data, adapt based on past experiences, and make instant decisions independently of human input. When applied to SDS, this translates into a multitude of benefits (Figure 1):

- *Adaptive resource allocation:* AI can dynamically allocate onboard resources like bandwidth, power, and processing power based on real-time demand. Imagine a satellite automatically shifting bandwidth to disaster-stricken areas experiencing communication outages or prioritizing data processing based on the urgency of the information. This responsiveness is crucial for applications like disaster relief, military operations, and dynamic traffic management.
- *Optimized performance:* AI algorithms can continuously monitor and optimize satellite performance, identifying and addressing anomalies before they escalate into major issues. By analyzing telemetry data, AI can predict potential failures, adjust operational parameters to extend lifespan, and even optimize orbital trajectories to reduce fuel consumption.
- *Enhanced earth observation:* AI can significantly enhance Earth observation capabilities by automatically identifying and classifying objects and events. This allows for faster and more accurate monitoring of deforestation, illegal fishing, natural disasters, and other critical environmental and security concerns. Imagine a satellite autonomously identifying an oil spill and alerting the relevant authorities in real time.
- *Autonomous operations:* AI enables satellites to function more independently, minimizing the necessity for continuous human supervision. This is particularly important for missions in deep space or in constellations where managing a large number of satellites becomes increasingly complex. AI can handle routine tasks, navigate autonomously, and even make decisions in response to unforeseen events, freeing up human operators to focus on higher-level tasks.
- *Improved security:* As cyberattacks on satellites become more prevalent, AI can serve as a key defense mechanism. AI-driven security systems can identify and counter intrusion attempts instantly, safeguarding critical data and maintaining the reliability of satellite functions.

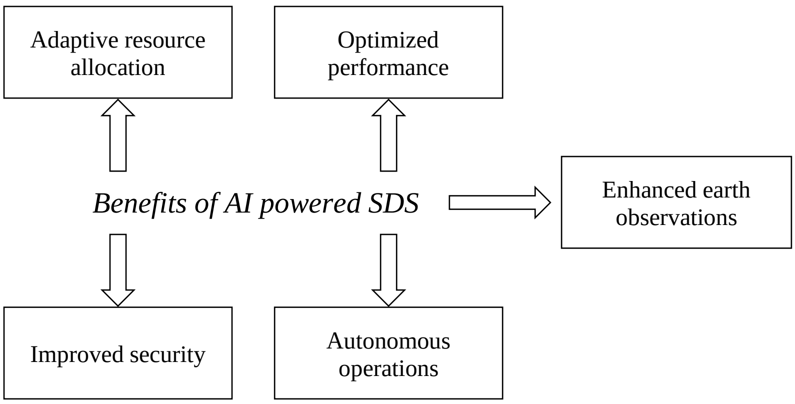

Figure 1. Benefits of artificial intelligence (AI)-based software-defined satellites (SDS).

While the potential of AI-based SDS is immense, there are also challenges that need to be addressed:

- *Computational power:* Implementing AI on satellites requires significant onboard processing power, which can be limited by size, weight, and power constraints. The development of edge computing and compact AI hardware plays a vital role in addressing this challenge.
- *Data security:* It is crucial to protect and maintain the accuracy of data utilized by AI algorithms. Robust encryption and data handling protocols are necessary to prevent manipulation and misuse.
- *Algorithm validation:* Thorough testing and verification of AI algorithms are crucial to guarantee their dependable and precise performance in the challenging conditions of space.
- *Regulation and ethics:* As AI-based SDS become more prevalent, it is important to establish clear ethical guidelines and regulations to ensure responsible use and prevent unintended consequences.

Thorough testing and validation of AI algorithms are crucial to guarantee their dependable and precise performance in the challenging conditions of space. From revolutionizing communications and Earth observation to enabling new scientific discoveries and space exploration missions, these intelligent satellites are poised to transform the way we interact with and understand our planet and the universe beyond.

The integration of AI into SDS is not just a technological advancement; it is a paradigm shift. It represents a move towards smarter, more responsive, and more sustainable space operations. As AI advances, we will witness even more groundbreaking applications of AI-driven SDS, paving the way for a new era of smart orbits and maximizing the potential of space technology to benefit humanity [36–42].

AUTONOMOUSLY ARTIFICIAL INTELLIGENCE–POWERED SOFTWARE-DEFINED SATELLITES

For decades, satellites have been the unsung heroes of modern life, enabling everything from global communication and weather forecasting to GPS (global positioning system) navigation and scientific research. However, their operation has traditionally been a complex and labor-intensive process, requiring constant monitoring and control from ground stations. Now, a new generation of satellites, powered by AI and built on SDS architecture, is promising to revolutionize space operations, ushering in an era of unprecedented autonomy and efficiency.

Traditional satellites are largely static systems. Their functionality is pre-determined during the design phase and hardwired into their hardware. This inflexibility makes them difficult to adapt to changing mission requirements, unexpected events, or new technological advancements. They are heavily reliant on ground station commands for tasks like sensor calibration, data processing, and orbit adjustments. This dependence not only causes delays but also demands substantial resources for ground infrastructure and staffing. SDS offers a paradigm shift. By abstracting the hardware layer and relying on software-based configuration, SDS allows for greater flexibility and adaptability. Imagine a satellite that can be reprogrammed in orbit to perform different tasks, optimize resource allocation, or even recover from unexpected failures. This is the promise of SDS [43–48].

Think of it like a smartphone versus a landline. A landline has a single, fixed function. A smartphone, with its software-driven architecture, can be constantly updated with new apps and functionalities, making it far more versatile and adaptable.

While SDS provides the foundation for flexibility, AI provides the intelligence to automate operations and make informed decisions in real time (Figure 2). By integrating AI algorithms into SDS, satellites can:

- *Autonomous Decision Making:* Analyze onboard data, predict potential problems, and take corrective actions without human intervention. This is crucial for tasks like collision avoidance, power management, and thermal control.

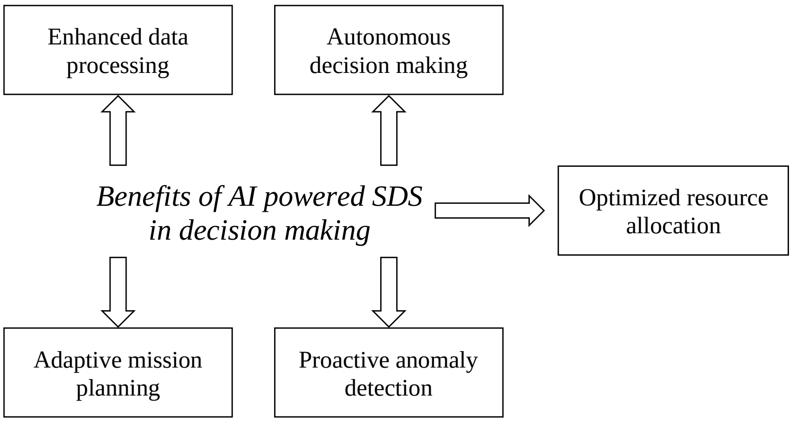

Figure 2. Decision-making benefits of artificial intelligence (AI)-based software-defined satellites (SDS).

- *Optimized resource allocation:* Intelligently allocate resources like power, bandwidth, and processing power based on mission priorities and current conditions. This maximizes efficiency and allows for more effective data collection and transmission.
- *Adaptive mission planning:* Dynamically adjust mission parameters and observation schedules based on real-time data and evolving objectives. This enables a quicker and more effective way to explore space and monitor Earth.
- *Proactive anomaly detection:* Detect and address possible issues at an early stage to allow for preventive maintenance and reduce downtime. This greatly enhances the longevity and dependability of satellites.
- *Enhanced data processing:* Analyze data directly on the satellite to minimize the volume of information that must be sent back to Earth. This lowers communication bandwidth requirements and speeds up data delivery.

The combination of AI and SDS offers a multitude of benefits:

- *Reduced operational costs:* Autonomous operations significantly reduce the need for ground station support, lowering operational costs.
- *Increased mission efficiency:* Optimized resource allocation and adaptive mission planning lead to more efficient data collection and utilization.
- *Improved reliability and resilience:* Proactive anomaly detection and autonomous fault recovery mechanisms enhance the reliability and resilience of satellites.
- *Faster response times:* Onboard data processing and autonomous decision-making enable faster response times to critical events.
- *Greater flexibility and adaptability:* Satellites can be easily reprogrammed to perform new tasks and adapt to changing mission requirements.

Although AI-driven SDS holds great promise, there are several obstacles that need to be addressed. These consist of:

- *Developing robust and reliable AI algorithms for space environments:* Space is a harsh environment with radiation, extreme temperatures, and limited resources. AI algorithms need to be specifically designed to withstand these challenges.
- *Ensuring cybersecurity:* Protecting satellites from cyberattacks is crucial, especially as they become more autonomous and interconnected.
- *Developing efficient onboard processing capabilities:* Processing data onboard requires powerful and energy-efficient processing units.
- *Addressing regulatory issues:* The increasing autonomy of satellites raises new regulatory questions about liability and control.

Despite these challenges, the future of space operations is undoubtedly being shaped by AI-based SDS. As technology continues to advance and costs continue to decline, we can expect to see a growing number of these intelligent satellites populating our skies, ushering in a new era of efficient, autonomous, and adaptable space exploration and utilization. They represent a significant step towards a future where satellites can not only collect data but also understand, interpret, and act upon it, making them truly intelligent partners in our quest to understand and protect our planet.

ARTIFICIAL INTELLIGENCE–POWERED SOFTWARE-DEFINED SATELLITES OF AUTONOMOUS DECISION-MAKING IN SPACE

For decades, satellites have served as critical infrastructure, enabling everything from global communication and weather forecasting to GPS navigation and remote sensing. However, traditional satellite operations are heavily reliant on ground control, requiring constant communication and manual intervention for even minor adjustments. Now, a new generation of satellites –SDS leveraging the power of AI – are poised to revolutionize the space industry, ushering in an era of autonomous decision making and unprecedented adaptability.

Unlike traditional satellites with fixed hardware configurations, SDS are highly flexible platforms whose functionalities can be reconfigured in orbit through software updates. This programmability allows them to adapt to changing mission requirements, respond to unexpected events, and even fix anomalies remotely. Imagine a satellite designed for communication that can, on demand, transition to atmospheric monitoring simply by uploading a new software module. This is the promise of SDS. While SDS provide the foundation for flexibility, AI is the key to unlocking true autonomous decision-making. By incorporating AI algorithms, SDS acquire the capability to:

- *Analyze real-time data:* AI can process vast amounts of data gathered by onboard sensors and external sources, identifying patterns, predicting trends, and detecting anomalies in real time.
- *Make autonomous decisions:* Based on the analyzed data, AI algorithms can make informed decisions about resource allocation, power management, orbit adjustments, and even payload operation, all without human intervention.
- *Adapt to changing environments:* AI enables SDS to adapt their behavior to changing environmental conditions, such as space weather events or increased orbital debris, ensuring mission continuity and maximizing efficiency.
- *Optimize performance:* AI can continuously learn from past performance and optimize resource utilization, improving the overall efficiency and lifespan of the satellite.
- *Respond to anomalies:* AI can detect and diagnose anomalies in onboard systems and, in many cases, autonomously implement corrective actions, reducing downtime and preventing mission failures.

The combination of SDS and AI offers a multitude of benefits, transforming the way we operate in space:

- *Increased responsiveness and agility:* AI-powered SDS can react to events and adapt to changing mission requirements much faster than traditional satellites, enabling quicker responses to emergencies and more efficient data collection.
- *Reduced operational costs:* AI-driven SDS can greatly cut operational costs by automating repetitive tasks and minimizing the reliance on continuous ground control.
- *Improved resilience:* The ability to autonomously diagnose and repair problems makes AI-powered SDS more resilient to anomalies and environmental hazards, ensuring mission continuity even in challenging conditions.
- *Enhanced data quality:* AI can optimize data collection and processing, leading to more accurate and reliable data for downstream applications.
- *New mission possibilities:* AI-powered SDS open up new possibilities for complex and dynamic missions, such as on-orbit servicing, space debris removal, and autonomous exploration.

Although AI-driven SDS holds great promise, there are still challenges that need to be addressed:

- *Computational power limitations:* Space environments are harsh and resource-constrained, making it difficult to deploy powerful AI algorithms onboard satellites.
- *Data security and cybersecurity:* Safeguarding sensitive information and ensuring unauthorized individuals cannot access onboard systems is essential for the security of the mission.
- *Algorithm validation and verification:* Ensuring the reliability and safety of AI algorithms in unpredictable space environments is paramount.
- *Regulatory framework:* There is a need for clear regulations to oversee the creation and use of autonomous space systems.

Although there are challenges, the future of AI-driven SDS looks promising, with continuous research and development efforts dedicated to advancements:

- Creating more effective and resilient AI algorithms for use in space applications.
- Improving onboard computing capabilities through advanced hardware and software solutions.
- Establishing strong cybersecurity protocols to safeguard against online threats.
- Establishing international standards and best practices for autonomous space operations.

CONCLUSION

AI-driven SDS mark a revolutionary change in space technology. By combining the flexibility of SDS with the intelligence of AI, we can unlock a new era of autonomous decision-making in orbit, leading to more efficient, resilient, and adaptable space missions. As technology advances and the challenges are addressed, AI-powered SDS will play an increasingly important role in shaping the future of space exploration, communications, and our understanding of the universe.

REFERENCES

1. Mulani AO, Bang AV, Birajadar GB, Deshmukh AB, Jadhav HM, Liyakat KK. IoT-based air, water, and soil monitoring system for pomegranate farming. Ann Agri-Bio Res. 2024; 29 (2): 71–86.
2. Parihar B, Kiran A, Valaboju S, Rashid SZ, Liyakat KK, DR AS. Enhancing data security in distributed systems using homomorphic encryption and secure computation techniques. In: ITM Web of Conferences. 2025; 76: 02010.
3. Veena C, Sridevi M, Liyakat KK, Saha B, Reddy SR, Shirisha N. HEECCNB: an efficient IoT-cloud architecture for secure patient data transmission and accurate disease prediction in healthcare systems. In: 2023 Seventh International Conference on Image Information Processing (ICIIP), Solan, India, November 22–24, 2023. pp. 407–410.
4. Liyakat KK, Khadake SB, Tamboli DA, Sawant VA, HM M, Sathe S. AI-driven-IoT (AIIoT) based decision-making-KSK approach in drones for climate change study. In: 2024 4th International Conference on Ubiquitous Computing and Intelligent Information Systems (ICUIS), Gobichettipalayam, India, December 12–13, 2024. pp. 1735–1744.
5. Prasad KR, Karanam SR, Ganesh D, Liyakat KK, Talasila V, Purushotham P. AI in public-private partnership for IT infrastructure development. J High Technol Manage Res. 2024; 35 (1): 100496.
6. Liyakat KK. Detecting malicious nodes in IoT networks using machine learning and artificial neural networks. In: 2023 International Conference on Emerging Smart Computing and Informatics (ESCI), Pune, India, March 1–3, 2023. pp. 1–5).
7. Kasat K, Shaikh N, Rayabharapu VK, Nayak M, Liyakat KK. Implementation and recognition of waste management system with mobility solution in smart cities using internet of things. In: 2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), Trichy, India, August 23–25, 2023. pp. 1661–1665.
8. Kazi K. AI-driven IoT (AIIoT) in healthcare monitoring. In: Nguyen TVT, Vo NTM, editors. Using Traditional Design Methods to Enhance AI-Driven Decision Making. Hershey, PA, USA: IGI Global; 2024. pp. 77–101.

9. Kazi K. Modelling and simulation of electric vehicle for performance analysis: BEV and HEV electrical vehicle implementation using Simulink for E-mobility ecosystems. In: Lakshmi D, Nagpal N, Kassarwani N, Vishnu Varthanan G, Siano P, editors. E-Mobility in Electrical Energy Systems for Sustainability. Hershey, OA, USA: IGI Global; 2024. pp. 295–320.
10. Yang S, Song Y, Tong S. Sustainable retailing in the fashion industry: a systematic literature review. Sustainability. 2017; 9 (7): 1266.
11. Kazi KS. Braille-Lippi numbers and characters detection and announcement system for blind children using KSK approach: AI-driven decision-making approach. In: Murugan T, Karthikeyan P, Abirami AM, editors. Driving Quality Education Through AI and Data Science. Hershey, PA, USA: IGI Global; 2025. pp. 531–556.
12. Kazi KS. AI-driven IoT (AIIoT)-based decision-making system for high BP patient healthcare monitoring: KSK1 approach for BP patient healthcare monitoring. In: Mzili T, Arya AK, Pamucar D, Shaheen M, editors. Optimization, Machine Learning, and Fuzzy Logic: Theory, Algorithms, and Applications. Hershey, PA, USA: IGI Global; 2025. pp. 71–102.
13. Kazi KS. Advancing towards sustainable energy with hydrogen solutions: adaptation and challenges. In: Özsungur F, Semsari MC, Bayraktar HK, editors. Geopolitical Landscapes of Renewable Energy and Urban Growth. Hershey, PA, USA: IGI Global; 2025. pp. 357–394.
14. Kazi KS. Machine learning-based pomegranate disease detection and treatment. In: Zia Ul Haq M, Ali I, editors. Revolutionizing Pest Management for Sustainable Agriculture. Hershey, PA, USA: IGI Global; 2024. pp. 469–498.
15. Kazi KS. Computer-aided diagnosis in ophthalmology: a technical review of deep learning applications. In: Garcia MB, de Almeida RPP, editors. Transformative Approaches to Patient Literacy and Healthcare Innovation. Hershey, PA, USA: IGI Global; 2024. pp. 112–135.
16. Kazi KS. IoT driven by machine learning (MLIoT) for the retail apparel sector. In: Tarnanidis TK, Papachristou E, Karypidis M, Ismyrlis V, editors. Driving Green Marketing in Fashion and Retail. Hershey, PA, USA: IGI Global; 2024. pp. 63–81.
17. Kazi KS. AI-driven-IoT (AIIoT)-based decision making in kidney diseases patient healthcare monitoring: KSK approach for kidney monitoring. In: Polat LÖ, Polat O, editors. AI-Driven Innovation in Healthcare Data Analytics. Hershey, PA, USA: IGI Global; 2025. pp. 277–306.
18. Kazi KS. Artificial intelligence (AI)-driven IoT (AIIoT)-based agriculture automation. In: Satapathy S, Muduli K, editors. Advanced Computational Methods for Agri-Business Sustainability. Hershey, PA, USA: IGI Global; 2024. pp. 72–94.
19. Kazi KS. Machine learning-driven internet of medical things (ML-IoMT)-based healthcare monitoring system. In: Soufiene BO, Chakraborty C, editors. Responsible AI for Digital Health and Medical Analytics. Hershey, PA, USA: IGI Global; 2025. pp. 49–86.
20. Kazi KS. Transformation of agriculture effectuated by artificial intelligence-driven internet of things (AIIoT). In: Garwi J, Dzingirai M, Masengu R, editors. Integrating Agriculture, Green Marketing Strategies, and Artificial Intelligence. Hershey, PA, USA: IGI Global; 2025. pp. 449–484.
21. Sayyad Liyakat KK, Konnur RG. Vehicle health monitoring system (VHMS) by employing IoT and sensors. Grenze Int J Eng Technol.. 2024; 10: 5367–5374.
22. Liyakat KK, Kutubuddin K. IoT based boiler health monitoring for sugar industries. In: 15th International Conference on Advances in Computing, Control, and Telecommunication Technologies, ACT 2024, Hyderabad, India, June 21–22, 2024. Vol. 2, pp. 5178–5185.
23. Dong Y, Wang C, Wang L, Yang Y, Hu M, Peng K, Cai C, Xiong Z. Robust software defined multicast in broadband LEO constellations. IEEE Trans Vehic Technol. 2025. Early access. doi: 10.1109/TVT.2025.3542596.
24. Keerthana R, Bhagyalakshmi K, Papinaidu M, Liyakat KK. Machine learning based risk assessment for financial management in big data IoT credit. In: Proceedings of the 3rd International Conference on Optimization Techniques in the Field of Engineering (ICOFE-2024), November 15, 2024.

25. Väänänen A, Haataja K, Vehviläinen-Julkunen K, Toivanen P. AI in healthcare: a narrative review. F1000Research. 2021; 10: 6.
26. Kazi KS. Machine learning (ML)-based Braille Lippi characters and numbers detection and announcement system for blind children in learning. In: Sart G, editor. Social Reflections of Human-Computer Interaction in Education, Management, and Economics. Hershey, PA, USA: IGI Global; 2024. pp. 16–39.
27. Liyakat KK. Machine learning approach using artificial neural networks to detect malicious nodes in IoT networks. In: Shukla PK, Mittal H, Engelbrecht A, editors. International Conference on Machine Learning, IoT and Big Data 2023. Singapore: Springer Nature; 2023. pp. 123–134.
28. Kazi KS. IoT technologies for the intelligent dairy industry: a new challenge. In: Thandekattu SG, Vajjhala NR, editors. Designing Sustainable Internet of Things Solutions for Smart Industries. Hershey PA, USA: IGI Global; 2025. pp. 321–350.
29. Zhang Y, Zhang Q, Zhang L, Li J, Li M, Liu Y, Shi Y. Progress of machine vision technologies in intelligent dairy farming. Appl Sci. 2023; 13 (12): 7052.
30. Liyakat KK. Heart health monitoring using IoT and machine learning methods. In: Shaikh A, editor. AI-Powered Advances in Pharmacology. Hershey, PA, USA: IGI Global; 2025. pp. 257–282.
31. Mishra SB, Liyakat KK. AI-driven-IoT (AIIoT) based decision-making in molten metal processing. J Indus Mech. 2024; 9 (2): 45–56.
32. Choi RY, Coyner AS, Kalpathy–Cramer J, Chiang MF, Campbell JP. Introduction to machine learning, neural networks, and deep learning. Transl Vision Sci Technol. 2020; 9 (2): 14.
33. Biradar PK, Pardeshi YS, Bagwan IA, Kazi TI, Ganji SS. Remotely operated video enhanced receiver. Int J Adv Res Sci Commun Technol. 2025; 5 (2): 696–707.
34. Fourati F, Alouini MS. Artificial intelligence for satellite communication: a review. Intell Converged Netw. 2021; 2 (3): 213–243.
35. Yuan S, Peng M, Sun Y, Liu X. Software defined intelligent satellite-terrestrial integrated networks: Insights and challenges. Digital Commun Netw. 2023; 9 (6): 1331–1339.
36. Fontanesi G, Ortíz F, Lagunas E, Garcés-Socarrás LM, Baeza VM, Vázquez MÁ, Vásquez-Peralvo JA, Minardi M, Vu HN, Honnaiah PJ, Lacoste C. Artificial intelligence for satellite communication: a survey. IEEE Commun Surveys Tutorials. 2025. Early access. doi: 10.1109/COMST.2025.3534617.
37. Siddique IM. Detection and analysis of anomalous behavior in on-orbit satellites using AI algorithms. J Firewall Softw Netw. 2024; 2 (2): 226-17.
38. Thangavel K, Spiller D, Sabatini R, Amici S, Longepe N, Servidia P, Marzocca P, Fayek H, Ansalone L. Trusted autonomous operations of distributed satellite systems using optical sensors. Sensors. 2023; 23 (6): 3344.
39. Abdulwahid MM, Kurnaz S. The utilization of different AI methods-based satellite communications: a survey. AIP Conf Proc. 2024; 3051 (1): 040013.
40. Turkmanović H, Vajs I, Cica Z, El Mezeni D, Ivaniš P, Saranovac L. Distributed AI-driven simulation framework for performance evaluation of hybrid satellite–terrestrial network access. Electronics. 2025; 14 (7): 1239.
41. Mahboob S, Liu L. Revolutionizing future connectivity: a contemporary survey on AI-empowered satellite-based non-terrestrial networks in 6G. IEEE Commun Surveys Tutorials. 2024; 26 (2): 1279–1321.
42. Ali J, Shan G, Mohsin AR, Khalid M, Chandroth J, Roh BH. Software-defined space-air-ground IoT: motivation, architecture and research challenges. In: Jamshed MA, Nauman A, editors. Integrated Terrestrial and Non-Terrestrial Networks. Cham, Switzerland: Springer; 2024. pp. 59–76.
43. Haldorai A, Lincy RB, Suriya M, Balakrishnan M. Satellite-terrestrial integrated computing and artificial intelligence as a means of achieving handover management. In: 2024 IEEE International Conference on Computing, Power and Communication Technologies (IC2PCT), Greater Noida, India, February 9–10, 2024. Vol. 5, pp. 874–877.

44. Ismoilova S. Revolutionizing connectivity: Unraveling the wonders of 5G technology. Sci Educ (Engl). 2023;4(7):88–91.
45. Chintalapati B, Precht A, Hanra S, Laufer R, Liwicki M, Eickhoff J. Opportunities and challenges of on-board AI-based image recognition for small satellite Earth observation missions. Adv Space Res. 2024. In press. doi: 10.1016/j.asr.2024.03.053.
46. Novák A, Kováčiková K, Kandera B, Sedláčková AN. Global navigation satellite systems signal vulnerabilities in unmanned aerial vehicle operations: impact of affordable software-defined radio. Drones. 2024; 8 (3): 109.
47. Hua H, Li Y, Wang T, Dong N, Li W, Cao J. Edge computing with artificial intelligence: A machine learning perspective. ACM Comput Surv. 2023;55(9):1–35. DOI: 10.1145/3555802.
48. Saifaldawla A, Ortiz F, Lagunas E, Adam AB, Chatzinotas S. GenAI-based models for NGSO satellites interference detection. IEEE Trans Mach Learn Commun Netw. 2024; 2: 904–924.

