

# Celestial Pathways – AI's role in Orbital Safety

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## Introduction

Earth orbits have become increasingly congested with satellites, debris, and other objects, leading to growing concerns about the safety of space operations and potential collisions. According to Space Surveillance & Tracking (SST) report published by Frost & Sullivan (2022), there are more than 130 million space objects between the size 1 mm to 1 cm in size. These debris can orbit the earth for decades, if not centuries, and hence posit a huge threat to the space ecosystem.

Scientists and engineers are exploring Artificial Intelligence (AI) technology to transform space surveillance tracking to overcome these difficulties. AI has the potential to significantly increase our understanding of space dynamics and our capacity to detect and manage objects in orbit by processing enormous volumes of data, identifying patterns, and making predictions in real-time.

## The Challenge of Space Surveillance Tracking

The expanding deployment of satellites for communication, navigation, Earth observation, and scientific research has brought numerous benefits to humanity. However, this proliferation has also led to a crowded and complex environment in space. Race between Starlink (12,000 satellites), Kuiper (Amazon, ~3200 satellites) and OneWeb to provide low-cost, high-speed internet by leveraging large constellations of small satellites is also exponentially increasing the need for effective object tracking.

The tracking of these satellites, along with space debris resulting from defunct spacecraft and collision fragments, is crucial

to avoiding collisions and maintaining the integrity of space infrastructure.

Ground-based radars and telescopes are used in traditional space surveillance technologies to track and predict the paths of objects in orbit. While these methods are useful to some extent, they are constrained by factors such as weather, visibility, data amount, and so on. This is where AI technology can help to transform how we track objects and satellites in space.

## AI-Powered Space Surveillance

Artificial intelligence offers a range of tools and techniques that can significantly enhance space surveillance tracking. Here's how AI is making its mark in this domain:

**Data Processing and Analysis:** AI algorithms are adept at processing vast amounts of data quickly and accurately. In space surveillance, this capability enables real-time monitoring and analysis of objects' positions, velocities, and potential collision risks. AI can sift through complex data sets, identify relevant information, and provide actionable insights to operators.

**Pattern Recognition:** AI excels in identifying patterns and anomalies in data. This ability is crucial for detecting changes in an object's behaviour, such as deviations from predicted trajectories, which could indicate potential collisions or malicious activities.

**Predictive Modelling:** Machine learning algorithms can analyse historical data to create predictive models that forecast the future positions and trajectories of space objects. This helps operators plan orbital adjustments and collision avoidance manoeuvres well in advance.

**Automated Decision-Making:** AI systems can automate decision-making processes, allowing for faster responses to dynamic situations. When AI detects a potential collision risk, it can trigger alerts and even propose mitigation strategies, reducing the human response time and minimizing the chances of a collision.

**Collaborative Space Traffic Management:** AI-powered systems can facilitate information sharing and collaboration between different space agencies and organizations. By aggregating data from various sources and applying advanced algorithms, AI can help create a comprehensive picture of the space environment and enable more effective traffic management.

### Challenges and Considerations

While the potential benefits of integrating AI technology into space surveillance are significant, there are challenges to address:

**Responsible AI:** Principles of Responsible AI must be reflected every step of the way. A system that is not fair, transparent, explainable, and robust cannot be put into operation, since the societal costs far outweigh the technological benefits.

**Geopolitical Complications:** Since space is a common frontier, establishing and enforcing common laws, regulations and practices will require substantial efforts from all global and business leaders. National security concerns will also need to be carefully considered.

**Data Quality:** AI models heavily depend on accurate and up-to-date data. Ensuring the reliability and accuracy of the data used for training and inference is crucial to avoiding incorrect predictions.

**Ethical and Security Concerns:** AI systems in space surveillance must be designed with security and ethical considerations in mind. Unauthorized access to AI-powered space surveillance systems could potentially lead to misuse or tampering with critical data.

### Conclusion

As humanity's presence in space continues to expand, the need for efficient and advanced space surveillance becomes paramount. AI presents an attractive answer to the issues posed by growing congestion in Earth's orbit. AI-powered space surveillance has the potential to increase our understanding of space dynamics and our ability to identify and manoeuvre objects in orbit through data processing, pattern identification, predictive modelling, and automated decision-making.

While there are challenges to overcome, the benefits of adopting AI into space surveillance are clear: **a safer and more secure space environment for current and future generations.**



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