Earth Observation (EO) refers to the gathering and analysis of data about the Earth's physical, chemical, and biological systems.

The EO field has its roots in the early 1960s, when the TIROS-1 satellite (Television Infrared Observation Satellite) was used for weather observation and ushered in a new era of environmental monitoring. While only a handful of satellites existed then, there are more than 12,000 satellites on-orbit today, with more than 300 devoted to EO.

The field plays a vital role in applications such as environmental monitoring, urban planning, agricultural management, and disaster response. For example, EO enables scientists and policymakers to track deforestation and land use changes, assess the impact of climate change, and monitor natural disasters. By providing valuable insights into the Earth's dynamics, EO supports informed decision-making and promotes sustainability, making it an essential tool for addressing some of the most pressing global challenges.

Artificial intelligence (AI) is revolutionizing EO by enhancing data processing capabilities, improving analysis accuracy, and enabling real-time insights. This article highlights three areas at the intersection of AI and EO...

The use of AI for object detection in satellite imagery
The development of foundation models permitting researchers to build custom applications without the need for training AI models from scratch
Autonomous AI-powered detection in orbit to reduce the volume of data that needs to be transferred to Earth.

AI-Powered Object Detection

Satellites generate vast amounts of data. AI algorithms can efficiently analyze this information using Machine Learning (ML) techniques, such as image classification and object detection. Deep learning models further enhance feature extraction, enabling more nuanced interpretations of environmental data, such as assessing vegetation health. Furthermore,

AI-driven predictive analytics empower researchers and decision makers to forecast environmental events. By automating data interpretation and improving analytical precision, AI is transforming EO into a more proactive and responsive tool for managing the Earth's resources and addressing global challenges.

For example, a recent article in the journal *Scientific Data* highlights the application of AI object detection for accurately identifying solar panel installations using high-resolution satellite imagery. These AI algorithms employ specialized techniques that focus on the unique bird's-eye perspective of satellites, where objects can appear at various angles and rotations, and which makes detection more challenging than in traditional images taken on Earth. The article underscores the crucial role of AI in improving detection accuracy of small objects, which is not limited to solar applications but extends to other objects of interest as well.

Foundation Models for EO

The AI detection models discussed previously are a first step in enabling new use cases for EO. Foundation models are the next step and permit researchers to use newly developed algorithms as well as provide pre-trained AI models that can generalize to new applications by performing limited fine-tuning, rather than training from scratch.

Foundation models are large-scale AI systems that are pre-trained on vast amounts of data and can be fine-tuned for various specific tasks with little additional training. By capturing complex patterns and relationships in the data, foundation models can facilitate advanced applications, including land-use classification, environmental monitoring, and disaster response. Their versatility and power make them a pivotal tool for transforming raw satellite data into actionable insights for researchers and policymakers.

In example, NASA recently made available foundation models based on the Harmonized Landsat and Sentinel dataset, which merges data from the Landsat program and the European Space Agency's Sentinel missions. By harmonizing the two sources of satellite imagery, the dataset enhances temporal and spatial resolution, allowing researchers to analyze land use, vegetation health, and urban development with greater accuracy.

The integration of this extensive dataset into NASA's foundation models enables advanced AI algorithms to leverage consistent and high-quality data, improving their ability to detect patterns, monitor changes, and make predictions. This is especially valuable for applications such as climate monitoring, where understanding long-term trends is crucial. Additionally, the availability of harmonized data helps to bridge gaps in coverage and ensures that users can access a robust, unified resource for their analyses, ultimately leading to more informed and timely decision-making.

Foundation models have important use cases in disaster response and recovery. For example, in the wake of natural disasters such as floods, wildfires, or hurricanes, foundation models can rapidly analyze satellite imagery to assess damage and inform response strategies.

By processing real-time data, these models can identify affected areas, evaluate infrastructure damage, and track changes in landscape features. This information is crucial for emergency responders, enabling them to allocate resources effectively and prioritize recovery efforts. Furthermore, the predictive capabilities of these models can help in anticipating the impacts of future disasters, contributing to better preparedness and resilience planning.

Alleviating the Edge-Computing Problem

The limitation of downlink bandwidth poses significant challenges for EO applications, particularly given the vast amounts of data generated by modern satellites. With hundreds of satellites continuously capturing high-resolution imagery, the ability to transmit this information back to Earth is constrained by bandwidth restrictions. This limitation can result in delays in data availability, reduced frequency of updates, and the inability to transmit all collected data, which can hinder timely decision-making in critical applications such as disaster response.

AI can help to mitigate these challenges by optimizing data handling and transmission processes. For instance, AI algorithms can prioritize data by analyzing which images or datasets are most relevant based on current conditions or specific user needs, allowing satellites to downlink only the most critical information. Additionally, AI can be employed to preprocess and compress data onboard satellites, reducing its size before transmission without significant loss of quality. By leveraging AI in this manner, EO applications can achieve more efficient bandwidth usage, ensuring that vital information is delivered promptly and effectively.

Legal Considerations

The integration of AI in EO raises important legal considerations that stakeholders must navigate carefully. Key issues include data ownership and intellectual property rights, particularly with respect to the vast amounts of satellite imagery and the models developed from this data. Stakeholders should carefully analyze who owns data used in their systems and any applicable license rights and restrictions. For example, some datasets may be licensed for academic use only, which would preclude their use in commercial applications. Similarly, it is important to understand the ownership of derivative works and improvements.

The use of AI in EO also raises issues relating to data leakage and model hallucination. Data leakage refers to the unintentional exposure of sensitive information, which can occur when AI systems inadvertently incorporate or reveal proprietary data during analysis. This is particularly concerning in applications where satellite imagery may capture identifiable structures or activities.

Model hallucination and false positive results also pose risks in interpreting satellite data. For instance, if an AI system incorrectly raises alarm and such decisions are made autonomously in orbit, without the ability to analyze the data on Earth using more sophisticated computing resources, it could lead to misguided policy decisions with legal ramifications for stakeholders relying on this flawed information. Consequently, organizations using AI in EO must implement robust data governance frameworks, ensure rigorous model validation, and establish clear accountability mechanisms.

wsgr.com

Author Curt Blake co-founded and was CEO of Spaceflight Inc., the largest provider of integrated launch services for small satellites. He established Spaceflight's global network of launch providers, which included SpaceX, Rocket Lab, Orbital, JAXA, Arianespace, and NSIL (the commercial arm of the Indian Space Agency). Curt was one of the first attorneys on-site at Microsoft, general counsel at Aldus, and COO at Starwave, giving him a solid combination of practical business experience and an intimate understanding of the legal risks involved in running companies. Curt has negotiated numerous launch contracts with companies all over the world, including India, Japan, Russia, New Zealand, Australia, France, Germany, Italy, the UK, Kazakhstan, Israel, Brazil, Luxembourg, Korea, and Canada, among others.

Author Stefan Geirhofer assists leading technology companies with their most complex and strategic IP and commercial transactions. Industry Expertise. Before his law practice, Stefan worked in the R&D department of a leading semiconductor company and served as a delegate in a large technical standardization group. Stefan is experienced in navigating intellectual property disputes and his litigation background helps him to evaluate risks and negotiate favorable outcomes for his clients.

WILSON SONSINI

The views expressed in this article reflect those of the authors themselves and do not necessarily reflect the views of their employer or their clients.