Target characteristic satellite observation modeling and artificial intelligence integrated application

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Abstract: This article focuses on the core key and weak links of artificial intelligence applications in the field of satellite earth observation, carries out satellite reconnaissance modeling and simulation of different objects and different targets, and satellite space-based measurement and optimization of target characteristics, and establishes space-based target characteristics database and services. The platform makes it an infrastructure resource for artificial intelligence applications in the field of domestic satellite earth observation. Through the integrated application of artificial intelligence, the link between the target characteristics and the application is opened to promote the development of the satellite remote sensing application industry.

1. Introduction
The wave of informatization has brought about the rapid growth of global data, and the use of big data to give full play to the leading role of artificial intelligence technology innovation has gradually become the focus of attention in various fields such as science and technology, economy, and society. Many countries have also upgraded big data research to the country. Strategic level. Big data based on artificial intelligence has become another game space for big powers after border defense, coastal defense, and air defense.

In the field of remote sensing and earth observation, mankind has built an earth observation system that integrates the sky and the earth. The imaging methods, number of bands and resolutions of remote sensing images are becoming increasingly diversified, the amount of data is increasing exponentially, the speed of data acquisition is accelerating, and the timeliness is becoming stronger and stronger, and it has clearly shown the characteristics of "big data". However, remote sensing information processing is still at the "data to data" stage, and there are obvious shortcomings in the conversion of "data to knowledge". The utilization rate of remote sensing big data is low, and it falls into the paradox of "big data, little knowledge". What's more serious is that a large amount of accumulated data cannot be effectively used, which will cause a certain degree of "data disaster". Just as the U.S. Congress accused NASA of “95% of the remote sensing data accumulated so far, no one has ever seen it.” The national 973 project researcher also pointed out that “the utilization rate of remote sensing information extraction in my country is less than 5% of the amount obtained, and scientific research is submerged in data. In the ocean, fresh water is eager for information".

Currently, the application of artificial intelligence in the field of satellite earth observation is still in the exploratory stage. The ground scenes and target samples acquired by satellite reconnaissance are
"less data and difficult to obtain", which has become a bottleneck restricting the application of space-based big data artificial intelligence. It is urgent to conduct research on target ground scenarios and target characteristics from the perspective of satellite reconnaissance, establish a space-based target characteristics library, support space-based remote sensing big data mining and integrated application of artificial intelligence, mine the value of stock data, and improve the application efficiency of satellite resources in orbit.

2. Research status at home and abroad

2.1. Status of foreign research

The United States relies on a satellite system covering meteorology, ocean, magnetic field, gravitational field and other environments, and attaches great importance to the accumulation and construction of target data. In addition to satellite reconnaissance and remote sensing, it has continuously sent reconnaissance aircraft to collect data around China for decades, and has established a complete range of types. Target database group with diverse characteristics; at the same time, the United States is far ahead of other countries in basic research on target characteristics. It has built advanced optical and radar characteristics simulation modeling tools and simulation equipment. The U.S. Virtual Target Center has built a virtual target database for the target. Characteristic analysis provides the required high-precision 3D geometric models of real complex targets to support different levels of target characteristic simulation requirements. It played a major supporting role in equipment development and appraisal.

| Table 1. U.S. military target characteristics database |
|-----------------------------------------------|
| **Name database** | **information resource** |
| National Threat Target Characteristics Database (NTSDS) | Various characteristic data of ground vehicles, aircraft, ships, submarines, missiles and other systems and a large amount of description and annotation information about the data |
| US Army Intelligence Database (ARGUS) | Acquisition, analysis and management of target characteristic data |
| U.S. Army Research Laboratory Multimodal Characteristic Database | Provide multiple information queries based on targets, sensors, data sets and meteorological conditions |
| U.S. Navy Hyperspectral Imaging Feature Library | Raw data of airborne infrared hyperspectral imaging reconnaissance for military targets |
| US Air Force Information Warfare Center Database | RCS and IR data of aircraft, missiles and chaff |
| U.S. Department of Defense Missile Data Center | Target and background characteristic data obtained in space-based, ground-based, sea-based and space-based tests |
| American Lincoln Laboratory Target Characteristic Database | Collect ballistic missile radar characteristic data |
| Surface Optical Corporation Material Optical Property Database | Spectral reflectance of materials in the range of 0.3 to 25.0 microns |

Overall, the research on the characteristics of foreign military targets is relatively in-depth, not only serving the construction of their own weapons and equipment, but also playing an important role in supporting military combat applications. The target characteristics of the civilian field are limited to the construction of the ground object spectrum library, and the satellite reconnaissance impact is not considered enough, and it has shown limitations in the classification and recognition of ground objects.

2.2. Current status of domestic research

The research on the characteristics of domestic targets is currently mainly focused on military use, and has mainly served equipment construction. On December 31, 2016, following the instructions of the Chief of the Military Commission, the General Assembly and the General Staff jointly promulgated
the "Outline for the Development of Target Characteristic Engineering Construction of Weapons and Equipment (2016~2030)". Under the organization of the competent department of the Military Commission, the services and arms actively carried out the promotion and study of the "Outline", insisted on demand traction and capability leadership, comprehensively sorted out the needs for target characteristic construction, and systematically demonstrated the construction goals and tasks, completing the "13th Five-Year Plan" "Weapon Equipment Target Characteristic Engineering Construction Project Plan." In accordance with the idea of “focusing on key directions, keeping a close eye on potential opponents, making up for shortcomings, enhancing system integration, and improving application levels”, the service and arms have clarified the construction content of data collection, database system construction, data product development and application, etc., to promote. The target characteristic work has laid a solid foundation for practical, actual combat, systematic and standardized development. In accordance with the general idea of “following requirements, unifying standards, collecting data, and verifying”, the Academy of Military Sciences organized services, arms, and defense industry departments to carry out a pilot project for the construction of foreign military threat target characteristic data, and formed the "Foreign Military Threat Target Requirements List". According to many research results such as "Target Characteristic Description Table", the data filling rate in the database is only about 13%. In addition, there are gaps in the characteristics of space-based targets. Space-based information is only used for detection, and quantified target characteristics data cannot be extracted. Satellite images can only be stored in the form of pictures, and the recognition and application of characteristics are insufficient.

3. Construction content

Focusing on the requirements of land use classification, crop identification, natural resource investigation, and target detection and recognition in military application field. The bottleneck problem of "less data and difficult to obtain" of current target samples restricting the application of artificial intelligence of space-based big data is solved. The satellite reconnaissance modeling and simulation system platform with target characteristics is established, and the atmospheric transmission, satellite platform and phase are comprehensively considered. We will carry out modeling and Simulation of different ground objects, different targets in different orbital altitudes, different shooting angles and different satellite reconnaissance means (visible light, infrared, SAR, hyperspectral, etc.) to obtain high-precision space-based simulation data set of target characteristics, carry out measurement and model optimization of satellites in orbit, and build space-based target characteristic database and space-based objectives. Through the knowledge transfer of target characteristic data, atlas construction, and comprehensive application technology research of space-based target characteristics artificial intelligence, the platform realizes the closed-loop of data, algorithm and application, and builds an artificial intelligence application infrastructure of space-based remote sensing big data for national satellite remote sensing applications, maximizing the application potential of space-based satellite data, and promoting China's satellite remote sensing. The application of satellite remote sensing data in various industries.
3.1. **Target characteristic satellite observation modeling simulation system**

In order to realize the comprehensive application of artificial intelligence to many kinds of military and civilian targets, such as grassland, forestry, agriculture, warship, aircraft carrier, it is necessary to establish a set of satellite observation modeling and simulation system of target characteristics, which can provide high-precision simulation data of target characteristics in different satellite loads, different scenes, different targets and different application environments. The simulation system mainly focuses on the spectral characteristics, geometric characteristics, texture characteristics, temporal characteristics, spatial distribution, space-based imaging conditions and other characteristics of the target, carries out the satellite observation modeling of the target characteristics, simulates the degradation state of different targets in different imaging conditions, different time and different space, so as to build a high-precision target characteristics simulation system.

3.2. **Space-based measurement and optimization of target characteristics**

The main methods to obtain the characteristics of space-based targets include theoretical calculations and experimental measurements. The target characteristic satellite observation modeling simulation system aims to study the modeling technology of the atmosphere, platform, load and other links from the perspective of remote sensing imaging principles. Space-based measurement and optimization of target characteristics aims to verify the correctness of the model from the perspective of experimental measurement and further iteratively optimize the model. The main tasks of space-based measurement and optimization of target characteristics include: 1) Use high-precision spectrum acquisition equipment, geometric reference acquisition equipment, target environment radiation characteristics acquisition equipment, etc. To collect spectral data of typical targets, such as atmosphere, environment, meteorology, ground and other environments. Characteristic data and spatial geometric reference data are used as data sources for simulation image accuracy verification and model iteration optimization. 2) Carry out the on-orbit calibration of the simulated star source and verify the authenticity of the on-orbit data; 3) Use the simulated data to compare and analyze the measured real data and on-orbit data...
to optimize the model parameters; and study the model parameters and image quality, correlation between on-orbit parameters, calibration data, etc.

3.3. Space-based target characteristics database

The construction of the space-based target characteristics database is mainly based on the simulation data of different targets obtained by the simulation of the target characteristics satellite observation modeling simulation system at different times, different spaces, different satellite reconnaissance methods, and different imaging conditions, while integrating existing military and civilian satellites Data, as well as real reference data collected in the field, to build a refined database for space-based targets. Realize storage and management of structured and unstructured data through distributed databases and distributed file systems; realize unified data access services through diversified data access interfaces; through data cleaning, data normalization, data association, and data Integrated governance methods such as maintenance management, data subject screening, realize the improvement of the quality of various space-based big data to meet the requirements of subsequent mining analysis and intelligent processing. The space-based target characteristic database provides data support for the comprehensive utilization of space-based big data, and is a data management and service center for the comprehensive application of space-based big data modeling and artificial intelligence.

3.4. Space-based target characteristic intelligent service platform

The space-based target characteristic intelligent service platform develops common/professional components by building a development/application environment, and develops intelligent services such as military intelligent applications and industrial integrated applications, including three levels: intelligent application platforms, common intelligent components, and professional intelligent components. The intelligent application platform provides a unified application environment and development environment for space-based big data artificial intelligence applications; common intelligent components are a collection of functional modules of space-based big data intelligent applications, providing plug-in implementations of various functions in a unified application environment, Realize update and maintenance through the intelligent development environment; professional intelligent components integrate common intelligent components according to application fields to create professional application function services. The space-based target characteristic intelligent service platform is the main body of the realization of space-based big data intelligence. It provides professional services such as mining analysis, prediction research and judgment, intelligent recommendation, regional change monitoring, and land classification for military aerospace and industrial applications.

3.5. Demonstration of comprehensive application of target characteristics artificial intelligence

The demonstration is mainly based on the space-based target characteristic intelligent service platform. On the basis of the space-based target characteristic database, artificial intelligence technology is used to carry out the commercial production of space-based big data natural ecological classification products in the civil field, and realize massive remote sensing parameter products In order to meet the needs of natural resource supervision business, provide natural resource supervision and planning data support for relevant business departments; for military use, it is developed for various military targets, large-scale fixed facilities, mobile platform targets and other battlefield elements. Efficient and accurate military target recognition technology, a working mode for battlefield command and combat requirements, collects multi-source remote sensing information, locates military target recognition hotspot areas and targets on a "map" of basic military geographic information, and conducts military information fusion and target. Recognition and other tasks, and the ability to provide dynamic results of intelligent and operational military targets, and achieve the purpose of data and information sharing and intercommunication, are urgent and important for improving China's military defense capabilities.
4. Conclusion
This article focuses on the needs of land use classification, crop identification, natural resource surveys in the civilian field, and the needs of target detection and recognition in the military application field, and solves the bottleneck problems that restrict the application of space-based big data artificial intelligence, such as the current target sample "small data and difficult acquisition". Target characteristics satellite reconnaissance modeling and simulation system platform, comprehensively considering factors that affect target characteristics, such as atmospheric transmission, satellite platforms, cameras, carry out different ground objects, different targets at different orbital heights, different shooting angles, and different satellite reconnaissance methods (visible light, Infrared, SAR, hyperspectral, etc.) modeling and simulation, obtain high-precision space-based simulation data sets of target characteristics, carry out measurement and model optimization of satellites in orbit, build a space-based target characteristic database and a space-based target characteristic intelligent service platform, and pass Knowledge transfer of target characteristic data, map construction, and space-based target characteristic artificial intelligence comprehensive application technology research, to achieve a closed loop from data, algorithms to applications, and build a space-based remote sensing big data artificial intelligence application infrastructure for national satellite remote sensing applications. Limit the application potential of space-based satellite data and promote the in-depth integration and application of satellite remote sensing data in various industries in China.

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