RESEARCH ARTICLE

Remote Sensing Technology and Its Application

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Abstract: Aiming at the rapid development of remote sensing technology worldwide and its wide application in various industries, the paper briefly introduces the development and characteristics of remote sensing technology, remote sensing information access, application of remote sensing information, and application of remote sensing technology.

Keywords: Remote sensing technology; Remote sensing information

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1. The Development and Characteristics of Remote Sensing Technology

1.1 The Development of Remote Sensing Technology

The term remote sensing was created in the early 1960s and means remote sensing. Broadly speaking, it is a method of sensing objects or natural phenomena at a distance based on the reflection and radiation characteristics of electromagnetic waves when the objects are not in direct contact. A detection technology, which refers to the use of visible light, infrared, microwave and other sensors (such as photography, scanners, radar, etc.), through photography or scanning, information sensing, data transmission and processing, etc., from remote, high altitude and outside Various platforms in the layer space obtain information on the surface of the earth, so as to realize the study of the shape, size, and location of the earth. The relationship between the natural environment and the ground objects is an application of modern technology.

Remote sensing technology emerged in the 1960s and was promoted by space technology, computer technology, sensor technology, etc. Remote sensing technology has brought revolutionary changes to photography technology, and its wide application in earth sciences and environmental sciences has produced considerable. At present, human beings are faced with the four major problems of population, environment, resources and disasters. Remote sensing technology is one of the best methods to investigate, monitor and analyze these four major problems.

Remote sensing technology includes remote sensing (also known as sensor) technology, information transmission technology, information processing, extraction and application technology, target information analysis and measurement technology, etc. modern remote sensing technology is a new technology integrating space technology, applied optical technology, radio electronic technology and computer technology.

Remote sensing technology can be divided into electromagnetic wave remote sensing technology, acoustic (such as sonar) remote sensing technology and physical field (such as gravity field and magnetic field) remote sensing technology. According to the spectral characteristics selected by its remote sensing instrument, the so-called electromagnetic wave remote sensing technology refers to the use of various objects (substances) to reflect or emit electromagnetic waves with different characteristics to remote sensing, including visible light and infrared, Microwave and other remote sensing technologies. According to the energy function of remote sensing target, active remote sensing technology can be divided into active remote sensing technology and passive remote sensing technology. The so-called active remote sensing technology uses artificial radiation source to emit certain energy and electromagnetic wave of certain wavelength to receive echo in order to achieve the purpose of remote sensing. The so-called passive remote sensing technology is to directly receive the reflection and emission of target. According to the representation of the recorded information, it can be divided into image mode and non image (data or curve) mode. According to the carrier used in remote sensing, it can be divided into: Space Remote Sensing Technology (space), aerial remote sensing technology and ground remote sensing technology. According to the application fields of remote sensing, it can be divided into: Earth Resources Remote Sensing Technology, environmental remote sensing technology, meteorological remote sensing technology, marine remote sensing technology, etc.

1.2 Remote Sensing Technology System

Modern remote sensing technology system is generally composed of four parts: spatial information acquisition system, ground receiving and preprocessing system, ground fact finding system, information analysis and application system.

The space information acquisition system mainly includes remote sensing platform and remote sensing platform. The remote sensing platform is a tool for carrying remote sensing sensors and providing working conditions for them, which can be aircraft or spacecraft. The remote sensor is a kind of acquisition and recording equipment, and transmits the characteristic information of the target (reflected or transmitted electromagnetic wave) to the ground receiving station, Remote sensor is the core of the whole remote sensing technology system, which reflects the level of remote sensing technology.

The information obtained by aerial remote sensing can be directly sent back to the ground and processed to a certain extent. The information obtained by spatial remote sensing is usually transmitted in real-time or non real-time in the form of radio. The main function of preprocessing is to radiometric correction and geometric correction of the noise and error contained in the information, segment and label the image, and provide users with information products.

The ground real-time detection system mainly includes the measurement of the spectral characteristics of ground objects (reflected electromagnetic wave and transmitted electromagnetic wave characteristics) before obtaining space remote sensing information. Collection of various telemetry data related to remote sensing and acquisition of spatial remote sensing information (such as regional environment and meteorological data). It provides a basis for the design of remote sensing sensor and the analysis and application of remote sensing information. The latter is mainly used for the correction and processing of remote sensing information.

Information analysis application system is a variety of technologies used by users to apply remote sensing information for specific purposes, mainly including remote sensing information selection technology, application processing technology, thematic information extraction technology, mapping technology, parameter calculation technology and data statistics technology. The selection technology of remote sensing information refers to the time and conditions required by users according to purpose, task and content (economy, technology, equipment, etc.), and technologies that must be considered when purchasing one or more of the various remote sensing information.

1.3 Characteristics of Remote Sensing Information

Black and white aerial photos have the characteristics of authenticity, intuition, timeliness, image and feature similarity. They can objectively record and reflect human activities and natural landscape within the visible range. Other modern aerial remote sensing instruments can obtain more information than black and white photos.

In addition, space remote sensing information has the following characteristics: ① large detection range; ② New data can quickly reflect dynamic changes; ③ Rapid mapping; ④ Data acquisition is convenient and not limited by terrain.

In short, the development of remote sensing technology has gradually developed from the analysis and application of single band remote sensing data to the comprehensive analysis and application of multi platform, multi band, multispectral and multi temporal remote sensing data, from qualitative investigation and mapping of resources and environment to quantitative analysis, evaluation and prediction, and from the description of surface phenomena of various things and processes, To explore its internal law; From providing basic information for the daily management of various departments to establishing various information databases and geographic information systems for scientific and modern management, practice has proved that remote sensing information application technology has obvious benefits and great potential.

2. Remote Sensing Information Access

The technology of using remote sensing instruments to collect, detect and record target characteristic information is called information acquisition. For the earth resources, the acquisition of remote sensing information generally refers to the acquisition, detection and recording of the electromagnetic characteristics of objects, that is, the emission or reflection of electromagnetic waves.

2.1 Electromagnetic Wave and Electromagnetic Spectrum

According to the electromagnetic field theory, electricity and magnetism are two closely related forms of motion. The changing electric field can cause the change of the surrounding magnetic field. Similarly, the changing magnetic field can also cause the change of the surrounding electric field. This alternating electromagnetic field is called the electromagnetic wave in the process of propagation from near to far in space. Ultraviolet, visible, infrared, microwave and radio waves are electromagnetic waves. These electromagnetic waves are the same in nature, but they have different frequencies (or wavelengths) and different characteristics.

Electromagnetic wave is a kind of shear wave with the characteristics of wave, particle, superposition, coherent and incoherent, diffraction and polarization, Doppler effect and so on.

Various electromagnetic waves are arranged into a chart according to the size (or frequency) of the wavelength. This table is called the electromagnetic spectrum. The order of wavelength from small to large is cosmic ray, 7 ray, X-ray, ultraviolet, visible light, infrared, microwave and radio wave.

2.2 Electromagnetic Wave Emitter

All objects in nature have the characteristics of emitting radiated electromagnetic waves at a certain temperature.

(1) The sun emits radiation. The sun is a huge electromagnetic radiation source. The solar surface temperature is up to 6000K. The heat radiated per second is more than $3.48 * 10^{26}$J. About $1.73x10^{17}$J is sent to the earth. The main source of earth's energy is the sun. The wavelength of solar electromagnetic radiation ranges from less than 10^{-14}m γ Radiation up to radio waves with a wavelength greater than 10km. In the solar electromagnetic radiation, the radiation intensity of visible light is the largest, the radiation flux of visible light and infrared accounts for more than 90% of the total radiation flux, and the proportion of ultraviolet, X-ray and radio wave in the total flux of solar electromagnetic radiation is very small.

(2) Ground objects emit radiation. When the temperature of any object is higher than zero (-273.16 °C) of the absolute temperature, there is thermal motion of molecules. Therefore, it will inevitably radiate certain energy into space. In the infrared band, this radiation is called thermal radiation. According to the STI Boltzmann law of general objects, the radiation emittance of general objects depends on two parameters: temperature and emissivity. It can also be seen that: ① all objects always emit radiation as long as they are not at absolute zero; ② The higher the temperature of the object, the greater the emittance, and the more the maximum wavelength of the maximum emittance moves towards the short wave direction; ③ When the temperature is constant, each object has its own fixed emissivity (that is, the emissivity of objects with different temperatures is different); The emissivity of the same object is also different at different temperatures.

(3) Artificial radiation radio transmitting equipment is the artificial radiation source of electromagnetic wave. The beam with a certain wavelength and frequency can be transmitted manually, and then receive the beam reflection signal encountered by the target, so as to determine the azimuth and distance of the target.

2.3 Reflected Radiation of Objects

In the process of the interaction between electromagnetic radiation and objects, there are three situations: part of the energy is reflected, part of the energy is absorbed and part of the energy is transmitted. The relationship between them follows the law of energy conservation and transformation.

Further discussion shows that the reflected radiation of objects can be divided into four types: mirror reflection, diffuse reflection, directional reflection and mixed reflection.

The characteristic of the mirror is that the reflection energy is concentrated in the direction where the reflection angle is equal to the person's projection angle. Diffuse reflection, also known as Lambert reflection, is characterized by the uniform distribution of reflected energy in all directions, and its reflected radiation (radiation flux per unit area reflected by unit solid angle) and observed direction are directly proportional to the cosine of surface normal angle.

The so-called directional reflection (also known as directional diffuse reflection) refers to the electromagnetic radiation on the object surface. Due to the terrain fluctuation and the complexity of the ground structure, the reflected energy is unevenly distributed in all directions, but there is the strongest reflection in one direction. This reflection is more complex than specular reflection and diffuse reflection.

The so-called mixed reflection is the electromagnetic radiation on the surface of the object. It is one part of the mirror, and the other part is diffuse reflection.

From the brief description of the above four reflective radiation surfaces, it can be seen that mirror reflection is the simplest, but it only occurs in very few cases, and diffusion reflection is of great significance. In space remote sensing, the height of the earth's surface relative to the remote sensor can be approximately regarded as the Lambertian surface. When the solar irradiance is constant (general height angle > 45 °), the radiance of the object recorded by the remote sensor in space is only related to the reflectivity of the object, which not only determines the visibility of the object, but also directly reflects the inherent reflection characteristics of various ground objects, Directional reflection and mixed reflection are common. Their radiation characteristics are different from the emission direction of human body and the observation direction of electromagnetic radiation. They are of great significance in aerial remote sensing.

The reflected radiation of an object is related to the properties of the object. The reflectivity of different objects at the same wavelength is very different, and the reflectivity of similar objects is also different due to their internal differences. Multi band remote sensing technology is mainly based on the reflectivity of different objects with wavelength changes. Through the appropriate selection and combination of spectral cross sections, we can effectively detect and identify different ground objects.

It should be noted that the natural environment and geographical location of the object have a great impact on the reflected radiation of the object. In a large range, the reflectivity of the object increases with the increase of latitude, and the reflectivity of the object changes daily (because the altitude angle of the sun changes every day). It can be seen that when space remote sensing the ground, it is necessary to measure the reflection spectrum of objects in the field.

2.4 Determination of Spectral Characteristics of Ground Features

Ground object spectrum is also called object spectrum. The spectral characteristics of ground objects refer to the electromagnetic wave characteristics of various ground objects (emitted radiation or reflected radiation). It is not only the basis for the selection and design of remote sensing instrument spectrum, but also the basis for user interpretation. The recognition and analysis of remote sensing images have the same significance as the detected fingerprints. In the process of the development of remote sensing technology, countries all over the world attach great importance to the determination of spectral characteristics of ground objects. Soviet scholar krinov tested and disclosed the reflection spectrum of natural objects. It took the United States seven or eight years to test the spectrum of ground objects before launching Landsat.

By indirectly testing the reflected electromagnetic wave characteristics of various ground objects, the characteristics of radiated electromagnetic wave emitted by various ground objects can be obtained. Therefore, the spectral characteristics of ground objects are usually described by reflected radiation electromagnetic spectrum, which actually refers to the variation law of electromagnetic wave reflectivity within a given spectral range.

The principle of measuring the spectral characteristics (reflected radiation) of ground objects is to measure, record and calculate the reflectivity of ground objects to each spectral electromagnetic wave by using a spectrometer (placed at different wavelengths or spectral bands) to detect the measured objects and standard plates. The reflectance law (which can also be drawn as a spectral curve) is the spectral characteristics of an object (reflected radiation).

The instrument for measuring solar reflected radiation is called radiation spectrometer. According to the principle of spectral dispersion, it can be divided into filter spectrometer, prism spectrometer and grating spectrometer.

2.5 Introduction to Remote Sensing Platform

Remote sensing platform is a means to carry remote sensing instruments and provide working conditions for them. Various remote sensing instruments are placed on remote sensing platforms at different heights to obtain various remote sensing information from the ground.

2.6 Overview of Remote Sensing Instruments

According to the corresponding band of remote sensing instrument, it can be divided into visible light remote sensor, infrared remote sensor and microwave remote sensor. Visible light remote sensor and infrared remote sensor are often combined to form multispectral remote sensor.

The image amplitude of conventional aerial frame camera is generally 18cm × 18cm and 23cm × 23cm, the focal length is usually 100 ~ 300mm, and its ground resolution is 0.3 ~ 3M.

There are many kinds of image frames of space frame camera, generally 11.5cm × 11.5cm, 18cm × 18cm, 30cm × 30cm and 23cm × 46cm. The focal length of the camera is generally 140 ~ 1000mm, and its ground resolution is 5 ~ 60m.

The products of frame cameras mainly include black-and-white photos, color films and color infrared films, as well as multi lens multispectral photos and single lens multispectral photos.

It is worth mentioning that in the frame camera, in recent years, the use of light aircraft for small image aerial photography has attracted extensive attention of remote sensing workers. The so-called light aircraft refers to a small aircraft with a single engine, with a maximum lifting limit of 3000 meters, a payload of 200000 kg, a relatively short navigation time, and small image photography refers to an image amplitude of less than 70mm × 70mm camera. Small image aerial photography has the advantages of low cost and strong mobility. It can easily replace the black box of small camera on the plane, and can be processed with ordinary small equipment.

At present, a new remote sensing instrument, imaging spectrometer, has developed rapidly in the world. It is a three-dimensional remote sensing instrument that combines the traditional two-dimensional imaging technology with the ground object spectrum technology. It can obtain the reflection spectrum image of tens to hundreds of bands (reflected solar energy) on the earth's surface at the same time.

3. Application of Remote Sensing Information

3.1 Principles to be Followed in Selecting and Purchasing Remote Sensing Data and Selecting and Purchasing Remote Sensing Data

(1) The purpose and task of remote sensing data application are clarified.

(2) Suit measures to local conditions

(3) Horizontal collaboration and joint development.

When selecting and purchasing remote sensing data, several issues should be considered (including image resolution and ground resolution), the selection of remote sensing spectrum, the temporal phase of remote sensing information, and the definition and scale of remote sensing images.

The main units of China's remote sensing data acquisition include the China Civil Aviation Service Corporation, the Geological Remote Sensing Center of the Ministry of Land and Resources, the National Bureau of Surveying and Mapping, the Aeronautical Remote Sensing Center of the Chinese Academy of Sciences, the National Remote Sensing Information Service Center and the satellite ground receiving station.

3.2 Error Sources of Remote Sensing Images

The errors of remote sensing images can be divided into three categories: internal errors caused by remote sensing itself; external errors caused by external factors; processing errors generated in the process of processing. Among these three kinds of errors, some are systematic errors and some are random errors.

Some errors affect the geometric position of the image, called geometric errors, and some errors affect the density of the image (grayscale, grayscale), called radiation errors. Radiation errors and geometric errors are caused by external factors, among which geometric errors include image distortion caused by the curvature of the earth, atmospheric refraction, and so on. The terrain undulation, earth rotation, orbital position and attitude of the remote sensor.

Due to the existence of these errors, the image is blurred and the geometric distortion is caused, and the remote sensing image needs to be geometrically corrected.

3.3 Visual Interpretation of Remote Sensing Images

(1) The visual interpretation of remote sensing images is based on image features. These image features are the symbols of image interpretation, which can be divided into direct interpretation and indirect interpretation.

The direct interpretation mark is the reflection of the feature attributes on the image, that is, the feature attributes can be directly determined by the image features. These attributes include: shape, size, color and tone, shadow, position, structure, texture, etc.

Indirect interpretation marks infer the category attributes of features through the features reflected on other feature images related to them, such as landform, water system pattern, vegetation distribution of natural landscape features, land use and human history. Most of them use logical reasoning and analogy to quote indirect interpretation marks.

It is worth noting that direct and indirect marks are a relative concept. They are often the same interpretation mark. For object a, it is a direct interpretation mark, and for object B, it may be an indirect interpretation mark. Therefore, it is necessary to make a comprehensive analysis. First, the interpreter finds and identifies the object, then measures the object, and then studies the object according to the expert knowledge and information obtained by the interpreter. The interpreter must have the ability to connect his understanding of the object with the meaning of the object, that is, he must have life and practical experience.

The interpretation marks listed above are the basic symbols commonly used in the visual interpretation of remote sensing images. Due to the wide variety of remote sensing images, there are differences in projection properties, spectral characteristics, hue and scale. Therefore, when using the above interpretation marks, we should distinguish the different characteristics of different remote sensing images, which must be paid attention to in specific applications.

(2) The principles and methods of image interpretation should generally follow the following principles: ① the principle of comprehensive analysis of image interpretation signs and the combination of demonstration and

counter proof; ② The combination of satellite image and aerial image, main image and auxiliary image, image and topographic map, professional map and text data; ③ The principle of combining indoor interpretation with on-site control.

The basic method of image interpretation is from macro to micro, from shallow to deep, from known to unknown. From easy to difficult, it is carried out step by step. From the perspective of analytical reasoning, there are direct judgment method, comparison method, comprehensive judgment identification method and historical comparison method.

(3) The image interpretation process includes: preparation, indoor interpretation, field inspection and result sorting. The preparation includes: collection of aerial photos, satellite films, topographic maps, professional maps, relevant text data, simple equipment (such as magnifying glass, stereoscope, transposer, etc.); Data analysis and necessary processing (such as satellite amplification, pseudo color synthesis, scale domestication, etc.); field investigation; Prepare interpretation schemes and specifications, determine interpretation methods, etc. Indoor interpretation includes establishing interpretation marks, observing and analyzing images according to the requirements of interpretation contents (sometimes with the help of instruments), and drawing the attribute and distribution boundary of features. On site inspection is mainly to check, modify and supplement the results of indoor interpretation. The result arrangement includes the transmission, sorting and marking of photos, as well as text notes.

3.4 Basic Principles and Methods of Computer Automatic Classification of Remote Sensing Images

Computer automatic classification of remote sensing images is to realize the purpose of automatic interpretation of remote sensing images by using computer equipment and pattern recognition theory, so it is often called computer interpretation (classification).

The so-called pattern refers to the standard form of something or the standard form that can do so. For example, the spectral characteristic curve of an object is the reflection characteristic of the object, so this curve is the model of the object characteristic. Pattern recognition is the measurement of a series of objects that need to be identified or classified. Then, the pattern formed by the measurement series of these known classes compares other feature patterns to see which one is the same or very similar, that is, which feature it is considered to belong to.

The purpose of computer interpretation and visual interpretation is the same. Visual interpretation is mainly based on the spatial features of the image (spatial reflection of feature geometric features and spectral features). Computer interpretation is mainly based on the gray level of image pixels (directly reflecting the spectral features of ground objects), that is, the gray level of image pixels is compared and summarized through statistics and operation, Realize the interpretation and classification of features.

Computer interpretation is based on the following points:

① Similar targets have the same (similar) spectral characteristics (spectral mode) and different spectral characteristics of ground objects, and their spectral characteristics are obviously different. Because there are many factors affecting the spectral characteristics of ground objects, the interpretation and classification of images are based on statistical analysis.

② The gray probability of similar features is in single band (one-dimensional space), which conforms to the law of normal distribution.

③ The pixel value (gray level) vector in multi-dimensional image (i.e. multi band) is geometrically equivalent to a point in multi-dimensional space. The pixel values of similar features are not concentrated on one point or randomly distributed, but relatively dense, forming a point group (point group is a kind of feature). Generally, the boundary of point group is not absolute, and it has a small amount of overlap and interleaving.

When using the similarity of computer-based target spectral features for automatic interpretation and classification, the task of interpretation and classification can be completed as long as the position, range and boundary of feature space can be determined.

The computer automatic classification methods of remote sensing images mainly include supervised classification and unsupervised classification. The supervised classification method is also known as the training site method or the first learning method after classification, that is, first select a representative test area (training area), and then train the computer according to the known spectral characteristics of various ground objects to obtain the recognition and classification rules as the standard, This method has many classification methods, such as maximum likelihood classification and tree classification. Unsupervised classification is also called spatial product classification, point group analysis or cluster analysis. Through the analysis of spectral response curve and the comparison of field survey data, the attribution of remote sensing data in unknown areas is determined.

3.5 Thematic Mapping of Remote Sensing

In order to achieve a certain purpose and complete a certain task, the map produced by using remote sensing data for analysis, interpretation and statistics is called remote sensing thematic mapping, and the design and production process is called thematic map. It highlights and improves the content and use of the map, makes it a thematic map, provides comprehensive information of nature, economy, society and environment for economic and national defense construction, and is an important reference for planning, design, management and scientific research.

There are many types of thematic maps. According to the theme of their contents, they can be divided into three types: geological map, geomorphic map, meteorological and climatic map, soil map, vegetation map, administrative division map, resident distribution map, economic map and cultural map; Other thematic maps, such as nautical charts, aeronautical charts and urban planning maps, can also be divided into three types according to the general degree of their contents: analytical (also known as analytical), such as urban population density grade map, pollution source distribution map, green space distribution map, etc; Combined type (also known as compound type), such as land use evaluation map, environmental quality evaluation map, economic development prediction map, etc; Comprehensive type (also known as composite type), such as urban land use status map, comprehensive economic map, etc.

4. Application of Remote Sensing Technology

In the past 40 years, due to the extensive research, experiment and application of remote sensing technology in various countries, as well as the development and integration of other high and new technologies and remote sensing technology, remote sensing technology has developed by leaps and bounds. At the same time, remote sensing technology is also widely used in surveying and mapping, land and resources survey (forest, soil, land), geology, water conservancy, ocean, etc Agricultural production and environmental monitoring, urban and rural planning, military reconnaissance, etc. For example, in 1982, China conducted a national remote sensing survey of land resources using Landsat multispectral images. The yield of Winter Wheat in Shandong Province in 1986 and 1987 was estimated by using meteorological satellite remote sensing data, and the error was less than 2. The comprehensive investigation of agricultural resources in Shanxi Province was carried out by using aerospace and aerial remote sensing data (17 series maps of land use, landform, vegetation, water resources and zoning evaluation were compiled); Based on the eco-environmental system of Inner Mongolia Autonomous Region, the grassland resources were investigated by using remote sensing data (drawing 10 maps, measuring the area of grassland resources, the relationship between livestock load and grassland yield). The former Ministry of coal used thermal infrared aerial remote sensing data and satellite multispectral images to "detect new coal areas" (for example, Wuhan University of Surveying and mapping technology, a promising coal producing area on the west slope of Daxing'an Mountains, using remote sensing technology. Distribution of aquatic plant resources in Honghu Lake, Hubei Province, Research and Exploration on "basic data survey of urban planning and management, urban planning and management survey, grassland Distribution Survey and urban form evolution in Naqu, Tibet".

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