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Intelligent Remote Sensing: Applications and Techniques

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Abstract: ***The development of remote sensing technologies over the last several decades has resulted in considerable improvements, which have made it possible for us to gather data of a high quality about the surface of the Earth and the characteristics it has. Yet, in terms of data processing and interpretation, the enormous volumes of data that are created by remote sensing devices provide a tremendous problem. The purpose of this paper is to provide a review of the most recent and cutting-edge techniques and applications of intelligent remote sensing. These techniques and applications aim to address these challenges by integrating machine learning, artificial intelligence, and other advanced computing techniques into the processing and analysis of remote sensing data. In this article, we will go through the fundamental components of intelligent remote sensing. These components include data collecting, data preprocessing, feature extraction, classification, and prediction. We also emphasize the potential of intelligent remote sensing in the management of real-world issues such as environmental monitoring, mapping land use and land cover, disaster management, and the mitigation of climate change.***

Keywords: Remote Sensing, Data Acquisition, Machine Learning, Data Pre-Processing.

1. INTRODUCTION

The study of the surface of the Earth and the objects on it now often makes use of remote sensing as an instrument. The utilization of remote sensing technologies such as satellites, drones, and ground-based sensors has provided us with valuable data for a variety of applications. These applications include environmental monitoring, mapping of land use and land cover, disaster management, and climate change mitigation. On the other hand, the enormous volumes of data that are produced by these remote sensing systems provide

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considerable hurdles when it comes to the processing and interpretation of the data. This has resulted in the creation of a technology known as intelligent remote sensing, the purpose of which is to combine machine learning, artificial intelligence, and other sophisticated computing techniques into the processing and analysis of remote sensing data.

One of the scientific approaches that may be used to determine the many physical characteristics of a region is called remote sensing. This procedure is carried out without making any kind of direct physical contact with the items that are being targeted. The primary purpose of this method is to collect information on the many planets in the solar system, including Earth. The technique of remote sensing has been used in a variety of scientific disciplines, including geology, ecology, meteorology, hydrology, geography, and glaciology. This type of sensing was also applied in a wide variety of other domains, including the military, planning, economics, and intelligence.

The Meaning of the Term "Remote Sensing"

The primary purpose of the technique known as remote sensing is to collect data on the surface of the Earth without having to make any kind of direct physical contact with the subject being studied. This procedure is an example of a technical approach that is used in a variety of disciplines, including geography, ecology, and hydrology (Researchgate.net, 2022). This is a form of instrument that can identify a variety of characteristics and critically evaluate those aspects. One of the most important things that this technology has accomplished is the detection of flames in the forest. For the identification and investigation of a wide range of issues, this platform requires essential components. The procedure focuses mostly on an item that serves as a target.

For the procedure to be successful, a platform that can hold the necessary instrument is required. A sensor or an instrument is an additional component of this technology that is necessary. The development of this particular technology can be traced back to the invention of cameras in more recent times (Kattenborn et al. 2021). This technology is put to use for a variety of research endeavours across a wide range of areas. Figure 1 is showing advancement of it.

Figure 1: The next phases in the advancement of the digital remote sensing platform for AI.

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Intelligent remote sensing monitoring to obtain image sequence frames:

The technologies of remote sensing monitoring and visual imaging have made significant strides forward in recent years, thanks in large part to the ongoing development of related theories. These technologies are now being used to conduct surveys of the atmosphere, water quality, marine oil pollution, thermal environment, and ecological environment in society. At this time, the technology of remote sensing is being used in a wide variety of facets of society, such as the survey of the atmosphere, the water quality, the marine oil pollution, the thermal environment, and the ecological environment in society. The technique of remote sensing may be broken down into three distinct categories: hyper spectral remote sensing, visible light remote sensing, and microwave remote sensing. These categories are based on the different bands of the electromagnetic spectrum that are used. Visual interpretation is the traditional approach to change monitoring. This means that the interpreter observes with their bare eyes, and then with the assistance of some auxiliary materials, the interpreter makes logical reasoning, and then conducts a methodical and comprehensive analysis of the image. The use of visual interpretation comes with a number of drawbacks, including a low degree of automation, a high level of time consumption, and the need of a significant amount of financial and human assistance. In addition to that, there is some subjectivity involved, which is a shortcoming of this method. For instance, it is not able to carry out automated learning iteration based on the outcomes of the monitoring that was carried out in the past; rather, it must be manually updated. Because the traditional methods of monitoring changes have been unable to meet the needs of society, this paper has adopted a variety of methods to analyze remote sensing images in order to quickly and efficiently monitor the changes in the target area. This was done in order to meet the objectives of the project. Figure 2 provides an illustration of the construction of the intelligent remote sensing monitoring technology.

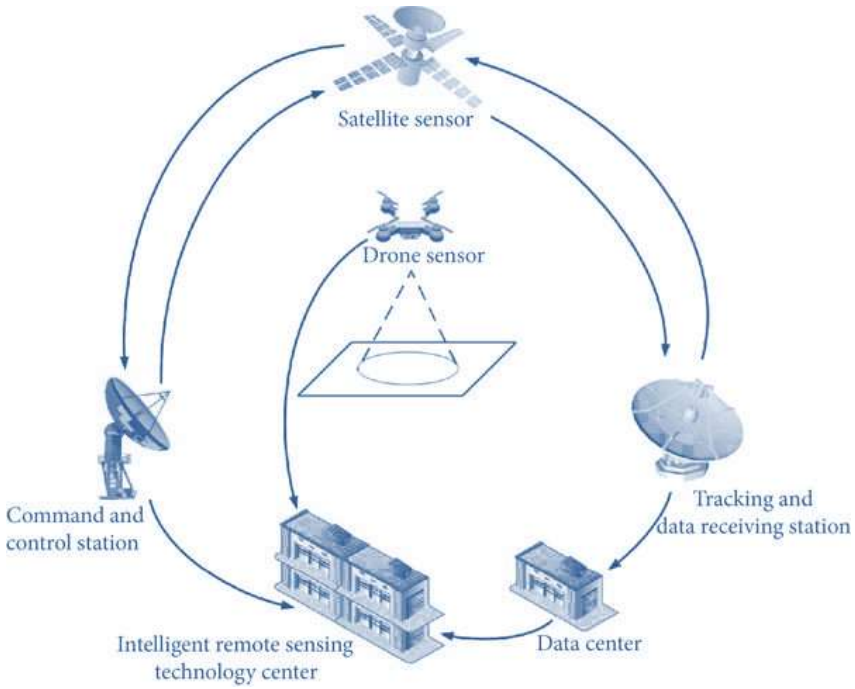

Figure 2: Structure of the technology for intelligent remote sensing and monitoring.

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Advantages of Remote Sensing

The following are some of the benefits that come with using remote sensing:

a. The images that are obtained through the use of remote sensing satellites are used as permanent records because they offer helpful information in a variety of wavelengths.
b. It may be used for both repeated coverage analysis as well as coverage analysis of huge areas (e.g. water and agriculture etc.).
c. The collection of data at a variety of sizes and resolutions may be accomplished with relative simplicity, and this data can be analyzed in a relatively short amount of time utilizing a computer in the laboratory.
d. Passive remote sensing does not interfere with the phenomena of interest because it creates records based on the electromagnetic radiation that is received from those phenomena.
e. It is able to detect natural disasters such as floods, forest fires, or volcanic eruptions in order to facilitate immediate rescue operations and planning.

Disadvantages of Remote Sensing

The following is a list of the drawbacks associated with remote sensing:

a. The method has a high cost for use in relatively limited regions that need just a single analysis.
b. In order to evaluate the picture data, one has to have received specialized training.
c. It is challenging to create detailed maps using data collected from satellites when working on a wide scale.
d. The examination of dynamic characteristics necessitates the taking of many aerial images at different angles. This results in an increase in the system's total cost.
e. The selection of sensors, the installation of sensors, the gathering of data and its timings are all decided by human people, which means that mistakes are possible if proper precautions are not followed.
f. Equipment used for remote sensing has to be calibrated on a regular basis; failure to do so will result in data from remote sensing that has not been calibrated.
g. Active systems, such as radar and laser, that is in close proximity to the remote sensing system cause interference. This has an impact on the phenomena that is being examined.
h. There are certain scenarios in which the sensor has a difficult time differentiating between them, such as fake grass and genuine grass. They are easily distinguished by infrared light.

Data Acquisition

Acquiring Data Is the First Step in Intelligent Remote Sensing The first stage in intelligent remote sensing is obtaining data. The platforms used for remote sensing produce vast volumes of data, which may take the form of pictures, spectra, and other sorts of data. The accuracy of the processing and analysis that comes after acquiring data is directly correlated to the quality of the data that is obtained. The rapid development of technology used for remote sensing has made it possible for us to capture data with great spatial, spectral, and temporal resolutions. For instance, hyper spectral sensors are able to collect data with

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hundreds of spectral bands, which enables us to get specific information on the characteristics of the Earth's surface.

Data Pre-processing
The second phase in intelligent remote sensing is data pre-processing, which entails preparing the data for further processing and analysis. This step also involves preparing the data for use. Among them are the elimination of noise, the correction of geometric distortions, and the improvement of the data's quality. The accuracy and dependability of the following processing and analysis depend heavily on the results of the pre-processing step, which is why this stage is so important.

Feature Extraction
The substantial amounts of data that are produced by remote sensing systems make this a difficult process to complete. Automating this process and identifying traits that are pertinent to the issue at hand may be accomplished via the use of methods from machine learning and artificial intelligence.

Classification
A number of different machine learning techniques, including as support vector machines, decision trees, and neural networks, may be used to accomplish this goal. When it comes to establishing the dependability of the future forecasts, the correctness of the categorization is really essential.

Prediction
The last phase of intelligent remote sensing is called prediction, and it entails utilizing the data that has been previously categorized in order to produce forecasts about the physical characteristics of the Earth's surface. Many methods, like as clustering and regression analysis, are among those that may be used to accomplish this goal. The accuracy of the predictions is absolutely necessary in order to guarantee that the application of remote sensing will be successful.

Applications
For instance, remote sensing may be used to keep an eye on the state of the nation's woodlands, monitor the progression of wildfires, and identify changes in the way land is utilized. It is also possible to use it to monitor the influence that climate change is having on the environment and to forecast how things will change in the future.
The following are some of the intelligent remote sensing approaches that are discussed in the paper:

A. Machine learning algorithms
Algorithms for machine learning Machine learning algorithms are utilized in the process of extracting features from remote sensing data and classifying it into a variety of different categories. Decision trees, random forests, support vector machines (SVM), artificial neural

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networks (ANN), and deep learning algorithms are all examples of typical machine learning techniques that are utilized in remote sensing.

B. Techniques of image processing

Techniques of image processing are used in the preprocessing of the remote sensing data prior to the feature extraction and classification processes. These approaches include picture enhancement, image fusion, and image segmentation.
These approaches include picture enhancement, image fusion, and image segmentation.

C. Object-based image analysis (OBIA)

OBIA is an image analysis approach that includes segmenting an image into regions depending on the spatial and spectral features of those areas. C. Object-based image analysis (OBIA): OBIA is an image analysis technique that involves segmenting an image into regions. With this method, one may extract information about the individual items in the picture as well as the connections **between those objects and other things.**

D. Spectral Indices

The Normalized Difference Vegetation Index (NDVI), the Soil Adjusted Vegetation Index (SAVI), and the Improved Vegetation Index are some examples of spectral indices (EVI).

E. Techniques for the extraction of features

Analyses such as principal component analysis (PCA), independent component analysis (ICA), and wavelet transform are examples of these methods.

F. Data fusion

The act of merging data from various sources to produce a single dataset that has more information than the individual sources combined, data fusion is known as "data fusion." The accuracy of classification findings may be improved by the use of data fusion, which can also be utilized to lessen the impact of noise and mistakes in the data.

2. CONCLUSION

Intelligent remote sensing is a burgeoning subject that has the potential to revolutionize the ways in which we acquire, process, and evaluate data obtained through remote sensing technologies. The integration of machine learning, artificial intelligence, and other advanced computing methods into the processing and analysis of remote sensing data may assist overcome the issues that are presented by the huge volumes of data that are created by remote sensing systems. Intelligent remote sensing may assist us in solving real-world issues such as environmental monitoring, mapping land use and land cover, managing disasters, and mitigating the effects of climate change. It is also able to give useful insights into the properties of the Earth's surface, which enables us to make choices regarding the future of our planet that are based on accurate information. Intelligent remote sensing is set to play an increasingly significant role in solving global concerns and improving scientific research as technology related to remote sensing continue to progress.

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