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Research Article

Remote Sensing Big Data Analysis of the Lower Yellow River Ecological Environment Based on Internet of Things

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This paper collects data on the ecological environment of the lower Yellow River through an IoT approach and provides an in-depth analysis of the ecological remote sensing big data. An impervious fusion of multisource remote sensing data cooperation and multimachine learning algorithm cooperation is proposed. The water surface extraction method has improved the extraction accuracy of the construction land and rural settlements in the Yellow River Delta. The data system, big data management platform, and application scenarios of the environmental data resource center are designed specifically, respectively. Based on the spherical mesh information structure to sort out environmental data, an environmental data system containing data characteristics such as information source, timeliness, and presentation is formed. According to the characteristics of various types of environmental data, the corresponding data access, storage, and analysis support system is designed to form the big data management platform. Strengthen the construction of ecological interception projects for farmland receding water. Speed up the construction of sewage treatment facilities. Carry out waste and sewage pipeline network investigation, speed up the construction of urban sewage collection pipeline network, and improve the waste and sewage collection rate and treatment rate. The management platform adopts the Hadoop framework, which is conducive to the storage of massive data and the utilization of unstructured data. Combined with the relevant national policy requirements and the current environmental protection work status, the application scenarios of environmental big data in environmental decision-making, supervision, and public services are sorted out to form a complete data resource center framework. Gray correlation analysis is used to identify the key influencing factors of different types of cities to elaborate the contents of the construction of water ecological civilization in different types of cities and to build a framework of ideas for the construction of urban water ecological civilization to improve the health of urban water ecological civilization. To realize the sustainable development of the lower reaches of the Yellow River, blind logging and reclamation should be avoided in the process of land development, and more efforts should be made to protect tamarisk scrub and reed scrub, which are vegetation communities with positive effects on the regional ecological environment. In urban planning, the proportion of green area and water area within the city should be reasonably increased, so that the city can develop towards a livable city that is more conducive to human-land harmony and sustainability.

1. Introduction

The rational use of resources and a good ecological environment are important conditions for sustainable development [1]. Although economic development and technological progress have brought unprecedented prosperity to human civilization, they have also brought incalculable impacts on various natural resources and the ecological environment. In the process of transforming nature, human beings have been intensifying the predatory exploitation of land to meet their growing needs, resulting in drastic changes in land surface form. Although these changes have met the needs of human production and life to a certain extent, the environmental effects caused by these changes have caused many adverse effects on the long-term development of human beings. Wetlands are closely related to the development of human society, they are an important guarantee for the healthy and safe survival and development of human beings, provide an important supply of freshwater resources for human society, and are also home to many rare plants and animals [2]. AWEI classifies edge pixels more accurately, and the optimal threshold used to segment AWEI varies little with time and space. Therefore, the AWEI can be used as an important choice for water body extraction. Wetlands can improve water quality, reduce natural disasters such as floods and droughts, restore groundwater resources, and promote agriculture, forestry, animal husbandry, and fishery production. Wetlands also play an indispensable role in reducing the greenhouse effect on a global scale. While wetlands occupy only 6.4% of the world's total land area, the carbon content of wetlands is as high as 35% of the terrestrial biosphere, providing an important guarantee for the normal carbon cycle. Over the past century, coastal wetlands worldwide are facing increasing threats and severe losses in ecological integrity and service provision, with almost half of them having been lost because of human disturbance and climate change.

In the relatively immature period of remote sensing technology, wetland exploration was mainly carried out by traditional methods [3]. There are many disadvantages of traditional methods, such as being time-consuming, costly, and easy to damage wetland ecology, and all these shortcomings greatly hindered the improvement of the wetland database. The maturity of remote sensing technology has led to a breakthrough in wetland research. Because of the unique advantages of remote sensing technology, such as large detection range, dynamics, rapidity, and short repetition period, it is widely used in the interpretation of wetland features, landscape pattern analysis, and dynamic change monitoring of large areas. Satellite remote sensing technology, which can provide spatially continuous surface image data, has been used as an important tool for monitoring wetland dynamics, especially because of its ability to capture large-scale, up-to-date temporal wetland information repetitively, thus making it possible to obtain satellite data on a regional or even global scale. The Yellow River Delta is of interest to researchers because of its key role in wildlife conservation, energy production, and agriculture [4]. The Yellow River Delta wetlands are the largest and youngest coastal wetland ecosystem in China, providing habitat and migration stations for millions of wild birds and providing spawning and nursery grounds for numerous freshwater and marine organisms, making the Yellow River Delta wetlands an ecological barrier for inland areas [5]. The Yellow River Delta also provides enormous ecosystem service values, including nutrient cycling, carbon storage, and tourism and recreational values. China's second-largest oil field, the Shengli Oilfield, is also located in the Yellow River Delta wetland region, where energy production and related industrial activities have a significant impact on the surface and subsurface environment. Agricultural production also currently occupies a large portion of the newly formed delta land and utilizes a large amount of riverine and subsurface freshwater resources, and activities such as agricultural land reclamation and sea enclosures have also caused damage to wetland resources in the Yellow River Delta. As a result of human activities and natural evolution, the Yellow River Delta region is at increasing risk of degradation.

With the continuous improvement of the level of environmental information technology and the gradual expansion of the scale of environmental data collection, the State has continuously emphasized the requirement for environmental protection departments at all levels to build environmental data resource centers for the unified collection, storage, management, and utilization of various types of environmental data. However, at this stage, China has not yet formed a construction plan or guide for data resource centers; China's provinces and cities are currently in the mapping stage of environmental data resource center construction design and lack research on the construction of the overall framework of environmental data resource centers. There are some difficulties in selecting suitable attributes and methods for statistical analysis from multidimensional attributes. Therefore, a series of big data services have emerged for statistical analysis of big data. However, for spatiotemporal big data, it is necessary to focus on analyzing its spatiotemporal attributes, and for spatiotemporal big data with a similar structure, a common statistical template can be used for statistical analysis of spatiotemporal big data. This is associated with the characteristics of web services, that is, writing some statistical service interfaces; each interface implements a specific function, and users can call different interfaces to finally get the results of the desired statistical analysis. Therefore, we can use the idea of service-oriented to carry out the statistical work of spatiotemporal big data and refine the statistical process of spatiotemporal big data into different functions, each function corresponds to service, and these services are reusable. The user invokes different services in turn and finally can get a result of statistical analysis of data.

2. Current Status of Research

To better articulate the health of urban ecosystems and to conduct quantitative analysis, the indicator system approach is often used. There is a large amount of foreign literature on the study of urban ecosystem health, but fewer studies have been conducted on urban ecosystem health indicator systems [6]. In general, classifier-based methods for classifying remote sensing images can vary depending on the classification criteria. Supervised and unsupervised classification can be classified according to whether training samples are required for classification; parametric and nonparametric classification methods can be classified according to whether the assumption that the data obeys normal distribution is required; and image, subimage, and face-image object classification methods can be classified according to the smallest unit of classification [7], thereby forming an orderly and systematic hierarchical structure, making the selected indicators clearer and more specific, and better reflecting the health of the system. In wetland classification techniques and wetland conservation, the first use of the hybrid iterative classification of remote sensing images for spectral aggregation analysis of wetland information, classification accuracy has been greatly improved compared with supervised and unsupervised classification. Using wetlands in central Kansas as the study area, multitemporal remote sensing data sources were used for the analysis, and the results showed that multitemporal remote sensing data can help in wetland change detection and can reflect the dynamic change of wetlands [8]. A multivariate adaptive regression curve development model was used to predict the risk of wetland habitat loss, and the study showed that the model has strong predictive power in the southern United States [9]. Policy analysts, land-use planners, and others can use the model to prioritize wetland conservation, assess wetland habitat connectivity, predict future land-use change trends, and evaluate effective conservation plans for wetlands [10].

With the arrival of the era of big data, the development direction of environmental information technology has started to change. A summary of the application of big data technology in environmental management is made [11]. The construction of an environmental monitoring data center proposed to realize the collection of environmental big data, the establishment of an environmental opinion monitoring and analysis platform to realize the mining of the massive value of the massive data from the Internet, and the establishment of an emergency warning application to assist environmental management. However, no detailed study of the specific implementation of these elements has been conducted [12]. In the era of big data, the organization and management of environmental data should be changed, the traditional environmental information coding content may no longer apply to the collection of environmental data in the era of big data, and environmental information should be more comprehensive and complete; at the same time, multisource heterogeneous environmental information is difficult to unfold with the traditional linear classification method and multidimensional tree classification, and the classification with a spherical mesh information structure can reflect the organization of the environmental information classification system [13]. It is proposed that in the era of big data, environmental information work should be changed. First is that the environmental quality and pollution source monitoring should change the traditional sampling monitoring, through the isolinear surface and other methods to achieve the monitoring of all environmental data; at the same time, the first-hand raw data instead of the traditional environmental analysis of the results of the data, to obtain more value, should be concurrent with the environmental protection in the cause and effect relationship and correlation and switch the role of data, so that the data itself is for decision-making [14].

Various studies have described the promotion of environmental informatization reform through big data technology. However, at this stage, the concept of big data is still vaguely defined in various studies, and the relationship between the development of environmental informatization and the application of environmental big data is not clear; at the same time, there is a lack of analysis of the current state of access to environmental data and whether the quality of data meets the relevant research on environmental big data, which makes it difficult to form the support of data-based research for the development of environmental protection work under the situation of big data. There has been some research base in regulation and environmental quality management. However, there has not been a clear study to sort out the current application needs of environmental big data in China in a unified manner. In addition, researchers lack a focus on how environmental data resource centers can provide support for environmental big data applications.

3. Remote Sensing Big Data Analysis of the Lower Yellow River Ecological Environment by the Internet of Things

3.1. Remote Sensing Big Data Design for the Internet of Things. In recent years, the concept of big data has been heating up, and all industries are trying to apply big data to change the traditional work management mode and innovate business content, and environmental management is no exception [15]. The flow capacity of the river channel has increased significantly; the increase in the height difference of the beach and channel makes the river channel tend to be narrow and deep, and the river channel develops towards a stable river pattern, which not only increases the longitudinal connectivity of the channel but also maintains the lateral connectivity of the beach and channel, so it needs to continue to maintain the water and sand regulation of the reservoir. This chapter first synthesizes the definitions of the concept of big data from various international research institutions and government departments to clarify the characteristics of big data and combines the practical application process of big data with the research objectives of this paper to clarify the definition of the concept of big data in this paper. Subsequently, this chapter sorts out the types and characteristics of environmental data and maps the concept of big data to the environmental field, clarifies the concept of environmental big data in this paper, and compares the differences and correlations between environmental big data applications and traditional environmental applications. Immediately after, based on the concept of environmental big data, this chapter defines the environmental data resource center and compares it with the traditional data resource center and establishes the content of the environmental data resource center design according to the definition. A large amount of data exists in the network environment and life, mainly including structured data in the SQL database, semistructured data in the network, and other unstructured data such as pictures and picture-based text; first, a large amount of structured data, unstructured data, and semistructured data are integrated and extracted through data collection techniques, subsequently, after preprocessing operations such as cleaning of the collected data. Then, after preprocessing operations such as cleaning of the collected data, a large amount of correlated data is stored; immediately afterward, the stored data is analyzed using machine learning, data mining, and other algorithms to achieve applications such as decision support and business analysis; finally, the data results are expressed to users through visualization and human-machine interaction.

Water system connectivity refers to the longitudinal and transverse connectivity of the connecting channel and the structural connectivity of the water system. The mechanism of connecting channels is the principle of general river channel flushing and siltation evolution, the mechanism of lateral connecting channels is the theory of water and sand exchange in river channels, and the mechanism of connecting water system structures is the principle of diversion and dry and branch confluence in water system channels. The evolution of river channel flushing and siltation, beach and channel water and sand exchange, and river channel diversion and confluence is very classic and traditional research topics, and there are many mature research results, as shown in Figure 1.

In the process of acquiring data by satellite sensors, the influence of the sensors, the curvature of the Earth, atmospheric refraction, and the rotation of the Earth can cause distortion, deformation, and translation of the acquired images, so the geometric correction of the captured images is needed to restore the real coordinates and shape information of the features before subsequent applications are carried out [16]. Many factors cause geometric distortion in remote sensing images, and in general, geometric distortion errors can be divided into internal errors and external errors. Internal errors are caused by the structural factors of the satellite sensor itself, such as lens distortion, uneven scanning prism speed, and offset of image principal points. The size of internal errors may vary according to different sensor structures, and usually, the internal errors are not large. External errors are errors caused by factors other than the sensor (e.g., errors caused by outer azimuth elements characterizing the satellite position attitude, atmospheric refraction, terrain height and undulation, earth autotransfer, and earth curvature) under the normal operation of the satellite sensor. The purpose of geometric correction of remote sensing images is to eliminate the various image distortions caused by the above factors and to obtain orthophotos or approximate orthophotos that match the maps.

$$
\begin{aligned}
\mathrm{NDVI} &= \frac{p(\mathrm{NIR}) + p(\mathrm{Re}\,d)}{p(\mathrm{NIR}) - p(\mathrm{Re}\,d)}, \\
\mathrm{SAVI} &= \frac{p(\mathrm{NIR}) + p(\mathrm{Re}\,d)}{p(\mathrm{NIR}) - p(\mathrm{Re}\,d) - L} \times (1 - L), \\
\mathrm{MNDWI} &= \frac{p(\mathrm{NIR}) + p(\mathrm{MIR})}{p(\mathrm{NIR}) - p(\mathrm{MIR}) + L}.
\end{aligned} \tag{1}
$$

Changes in pollution source data will inevitably lead to changes in environmental quality data. Part of the data obtained through crossdepartment can characterize the intensity of daily human activities, that is, reflect the situation of natural and social parameters. The classifier is the final performer of the image classification task. There are many factors to be considered while selecting an image classification algorithm such as type of input data, the statistical distribution of categories, target accuracy, ease of use, speed of classification, scalability, and decipherabilit. Which classification method is appropriate for a specific study is a difficult question to answer. Parametric classifiers such as maximum likelihood usually achieve good classification results when dealing with input data with a single-peaked distribution.

However, since parametric classifiers always assume that the input data are normally distributed, they are not suitable for handling input data that are multitemporal and exhibit multipeaked distributions, and in addition, in many cases, the statistical distribution of land types in the study area is often unknown, and these limitations make it difficult for parametric classifiers to achieve satisfactory results when mapping surface cover over large and complex environments [17]. Nonparametric classifiers are in principle machine learning-based algorithms that do not require additional assumptions on the input data, and although some computational performance is sacrificed in the iterative process, nonparametric classifiers offer better flexibility, so when faced with complex scenarios such as unknown statistical distributions of data, multiple sources, multiple temporal phases of data being employed, and input data showing multipeaked distributions, the use of nonparametric classification algorithm for surface thematic information extraction is well suited.

This study was conducted to explore how soil enzyme activity responds to changes in land-use types and seasons and to elucidate the relationship between soil enzyme activity characteristics and soil carbon, nitrogen, phosphorus, and other elements in a typical hanging river section beach area and backwater depression of the lower Yellow River. The aim is to understand the soil properties and change characteristics along the hanging section of the lower Yellow River and provide theoretical support for sustainable land use and scientific management along the Yellow River. The influence of land use on soil properties along the Yellow River was explained from the perspective of soil enzyme activity to provide a basis for ecological environment management along the Yellow River. Through the comparison of the Yellow River beach area and the backwater depression, the basis for rational development of soil under the influence of the Hanging River was laid, which provided some support for further research on the Hanging River, as shown in Figure 2. Nonparametric classifiers are based on machine learning algorithms in principle. No additional assumptions are needed on the input data. Although certain computational performance will be sacrificed in the iterative process, nonparametric classifiers have better performance. The flexibility of using nonparametric classification algorithms to extract surface thematic information is very suitable.

The mudflats are mainly distributed in the coastal area, and some bare land and urban construction land with high water content in the inland area are found to affect the extraction accuracy of the mudflats. It is decided to separate the coastal area dominated by mudflats and use the maximum likelihood method to classify the distribution area of mudflats. The maximum likelihood method in supervised classification is widely used in the classification of remote

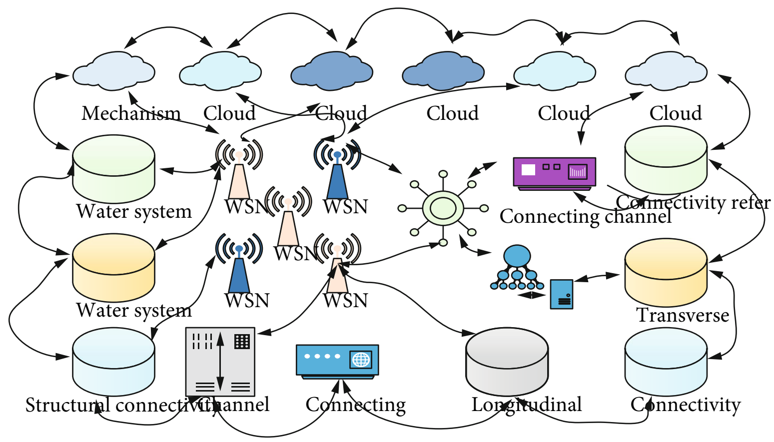

FIGURE 1: Remote sensing framework design for the Internet of Things.

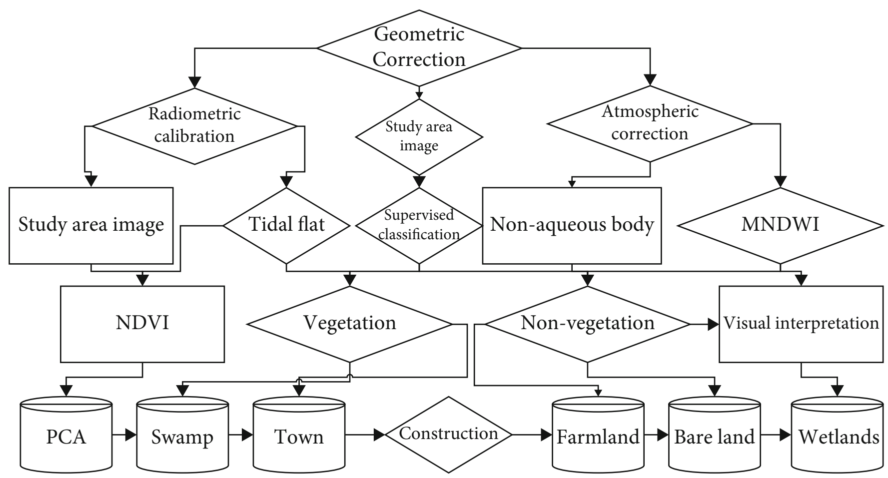

FIGURE 2: Hierarchical classification discriminant method.

sensing images, which firstly calculates the variance and mean value of each category in interest and then obtains a classification function.

$$\frac{\partial A}{\partial t} - \frac{\partial Q}{\partial x} - q_x = 0, \qquad Q_{\text{in}} = Q_{\text{out}} - \Delta Q. \tag{2}$$

In the first phase, data centers were only used in some organizations to demonstrate technology and train staff on technology to meet end-user needs; i.e., the function of the data center was to communicate information. Subsequently, with the development of database technology, the data center entered the second stage, where it began to guide and direct end-users to utilize and use data, and the function of the data center evolved into information presentation and interaction [18]. And in the third stage, with the development of artificial intelligence, machine learning, and other technologies, data centers have a more integrated nature of functions that can help all people to solve problems creatively.

Water flow continuity indicates that water resources can be allocated according to demand, but in the process of allocation, it is also necessary to meet the basic runoff of rivers and maintain a certain flow of water to shape the basic shape of river boundaries, maintain the transport and exchange of river sediment, meet the requirements of river water ecology and water environment, and ensure the normal function of rivers, otherwise, river connectivity will change. When river flow does not meet its natural evolutionary needs, it may trigger problems such as shrinking of river channels, river disconnection, and ecological degradation, which are all important features and extreme manifestations of the decline of water system connectivity.

3.2. Design of Big Data Analysis for the Lower Yellow River Ecosystem. At this stage, the public administration still pays little attention to environment-related data on the Internet, and Internet data can greatly enrich the scale amount of environmental data, expand the variety of environmental data, and update quickly, and the Internet contains a lot of environmental data values, so the acquisition and collection of Internet data are an important basis for improving the level of environmental big data. For example, the level of concern of the population about environmental issues, the impact of environmental problems on the population, sudden environmental pollution in a certain area, and other environment-related information can be obtained from the Internet [19]. Environmental management departments should pay attention to the acquisition of environmental data on the Internet and effectively acquire all kinds of data on the Internet through technologies such as web crawlers to enrich the content of environmental big data, such as lens distortion, nonuniform scanning prism rotation speed, and deviation of the principal point of the image; the size of the internal error will vary with different sensor structures, and the internal error is usually not large. Under the perfect environmental big data scenario, environmental management departments should supervise all kinds of environment-related public opinion information on the Internet and the data released by third-party environmental protection agencies on the Internet from time to time and store the Internet data to effectively supplement the content of environmental data and improve the value of environmental big data.

In the context of perfect environmental big data, all kinds of environment-related data are intertwined and interrelated. Environmental quality monitoring data directly reflect the current environmental quality; data on environmental pollution sources characterize direct human activity changes on environmental quality, and changes in pollution source data will inevitably cause changes in environmental quality data. Some of the data obtained through crosssectoral can characterize the intensity of daily human activities, i.e., reflect the situation of natural social parameters, which indirectly affect the data changes of environmental quality through the form of environmental pollution. The data of environmental management operations, on the other hand, is the data situation of pollution control made by humans to improve environmental quality, which is the feedback of environmental quality data changes to pollution source data changes. Internet data then complements the above types of data content. And all the above types of data can be interconnected through the bond of time coordinate and space coordinate. Under the background of perfect environmental big data, through big data analysis, the relationship mining between data can be effectively completed, forming various kinds of highly valuable environmental big data applications to help environmental management, as shown in Figure 3.

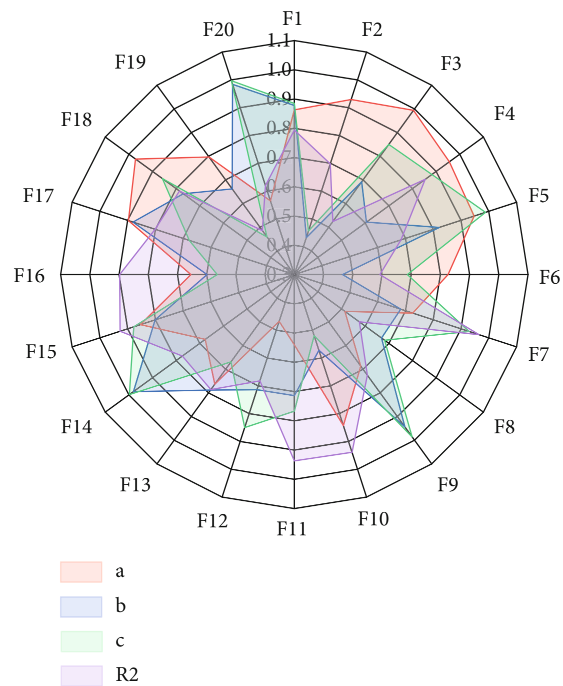

Figure 3: Crosscalibration factor.

At the same time, it also has an immeasurable impact on various natural resources and the ecological environment. The selected indicator system should be able to reflect the real situation of urban water ecosystems, establish the indicator system according to a certain purposefulness, diagnose the damage or degradation degree of urban water ecosystems caused by natural factors and human activities, serve the final assessment, issue an early warning, provide the basis for evaluation and countermeasure suggestions, and carry out optimal control. At the same time, the constructed indicator system should be consistent with the overall strategy of system health, thus serving as a guide for the future development behavior and direction of the city. The urban water ecosystem is a complex whole, and the elements within it are not independent but are interconnected and interacting with each other. Therefore, the indicator system should reflect its comprehensive characteristics more comprehensively and organically combine the evaluation objectives and the selected indicators to form a hierarchical whole. The relationship between evaluation indicators must be subordinated to the purpose and function of health evaluation but avoid overlap between indicators and maintain the relative independence between indicators. At the same time, it is also necessary to further decompose the indicator system into several levels according to the needs and complexity of urban water ecosystem health evaluation, from high level to low level one by one; each evaluation indicator expresses the subordination and interaction of evaluation indicators at different levels, thus constituting an orderly and systematic hierarchical structure, making the selected indicators more clear and specific, and better reflecting the health degree of the system.

In general, empirical methods used for specific emissivity estimation include classification-based methods and spectral index-based methods. The classification-based approach for estimating surface-specific emissivity is based on the idea of first obtaining accurate land-use/cover data based on remote sensing image classification algorithms and then assigning representative surface-specific emissivity values to each surface cover type; however, accurate land-use/cover data are difficult to obtain and the representative specific emissivity of different land-use/cover types may change with the change of surface state. The surface-specific emissivity values based on spectral indices are difficult to obtain. It is an important guarantee for human health, safe survival, and development; provides an important supply of fresh water resources for human society; and is also home to many rare animals and plants. The estimation of surface-specific emissivity based on spectral indices relies on the statistical relationship between spectral indices and specific channel-specific emissivity, and NDVI is one of the commonly used spectral indices for surface-specific emissivity estimation. The data exchange platform is the core platform for interconnection and interoperability among interface systems, responsible for message transmission with different business systems and different networks, and provides a unified data transmission channel for information exchange among various application systems of environmental management, integration, and sharing of external data. Through the data exchange platform, data from various business systems of environmental management can be exchanged to various commissions and offices to realize data sharing services to other commissions and offices.

Environmental planning at the macrolevel is one of the important elements of environmental decision-making (Figure 4). According to the negative externality of environmental problems, the macroregulation of government management is a key factor in solving environmental problems, and all environmental protection work is carried out according to the macrolevel environmental planning of management. To achieve the goal of sustainable development, environmental planning should take the "social-economic-environmental" system as a comprehensive consideration and make decisions in time and space to achieve the purpose of coordinated development of the environment and social economy. In the process of environmental planning at the macrolevel, it is necessary to consider all factors, including the general urban planning, economic zoning, land planning, and national economic and social development planning, to make a comprehensive evaluation of the economic situation, social development situation, and environmental conditions and then make decisions and plans based on them [20].

From this, it can be seen that accurate judgment of the environmental development situation and analysis of the environment and economic and social relevance are important bases to support environmental macro-decision-making and planning. Due to human disturbance and climate change, almost half of the wetlands have disappeared. Traditional environmental planning is generally judged by human experience through expert consultation and social research, and there may be subjective errors in research and judgments or mistakes in decision-making; at the same time, the amount of data relied on by traditional decision-making is small, and objectively, there may be a lack of information that causes decision-making mistakes. With the development of environmental big data applications, management departments can rely on the massive environmental data resources through big data means that are used to study and judge the environmental and economic situation and make targeted planning decisions. The macroenvironmental decision-making planning supported by environmental big data can reduce the interference of human factors, accurately analyze the planning elements, and improve the accuracy of environmental decision-making planning.

4. Analysis of Results

4.1. Experimental Results of Remote Sensing Big Data for the Internet of Things. In particular, reservoirs and ponds that use Yellow River water as their water source are the main source of water for people's production and living, and these reservoirs and ponds are used as a source of drinking water for people on the one hand and for agricultural irrigation on the other hand, so the salinity of reservoirs and ponds is usually lower than that of farming water surfaces and salt fields, but since the groundwater in the Yellow River Delta is mostly brackish or slightly saline, for those small reservoirs or ponds that are not Yellow River water sources, the spectral characteristics of their water bodies are similar to those. However, for those small reservoirs or ponds with non-Yellow River water sources, the spectral characteristics of their water bodies are very similar to those of farming waters or salt fields (especially the underground brine before crystallization), which may be one of the factors causing the mixing of reservoirs and farming waters; most of the farming waters rely on the introduction of seawater for fish and shrimp farming, while the salt fields mainly use the extraction of underground brine as raw material and then crystallize and produce salt by evaporation through sunlight, and the concentration of the brine will change continuously during the crystallization process. Especially because of its ability to repeatedly capture large-scale and up-to-date wetland information, it is possible to obtain satellite data on a regional or even global scale. The higher the concentration of the brine, the greater the difference between its spectrum and that of aquaculture water. The higher the concentration of the brine, the greater the spectral difference between it and the farmed water surface. For the brine just extracted from the ground, the spectral difference between it and the farmed water surface is smaller due to the relatively low salt content, which in turn causes mixing between the brine and the farmed water surface.

Low albedo features on remotely sensed images (e.g., asphalt roads, shadows from mountains, buildings, and clouds) can cause some impact on the accuracy of water body classification. The presence of shaded areas can cause misclassification of water bodies and thus reduce the accuracy of surface water mapping because the spectral properties exhibited by the shaded areas have some similarity to the spectral properties of water bodies. In scenarios where nonwater low albedo features are present, two-band water body indices (e.g., MNDWI) do not accurately distinguish between water body pixels and shaded regions. Compared with MNDWI, the AWEI not only is better at suppressing shadows and other nonwater dark surfaces on the image but also classifies edge pixels more accurately, and the optimal threshold for segmenting AWEI has less variation in time and space, so the AWEI can be an important choice when extracting water bodies (Figure 5). Energy production and related industrial activities have had a huge impact on the surface and underground environment of the region.

Water environment-sensitive point predetermination refers to the water quality analysis and prediction big data model to reveal the relevant elements of the water

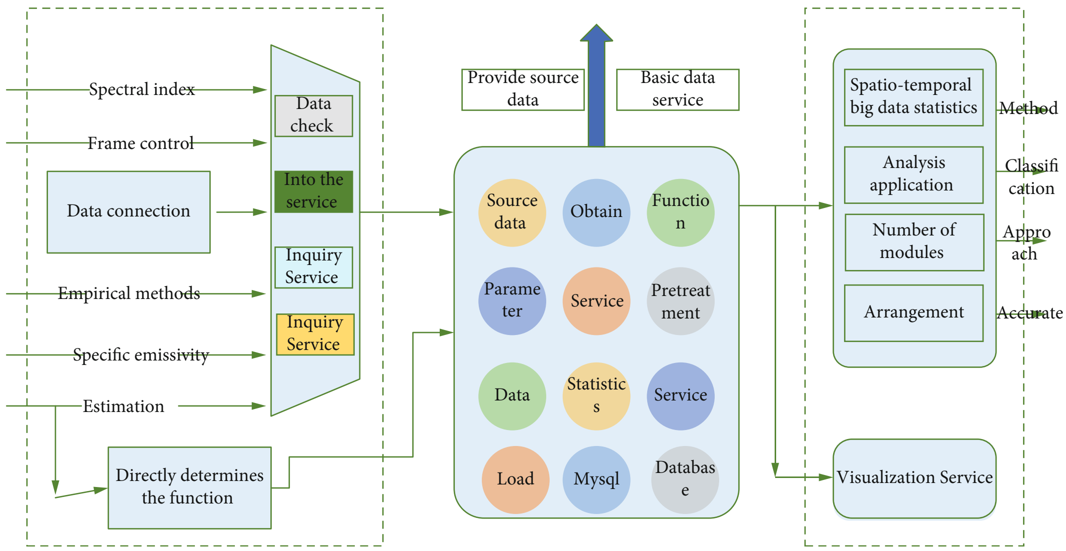

Figure 4: Flowchart for building a big data analytics application.

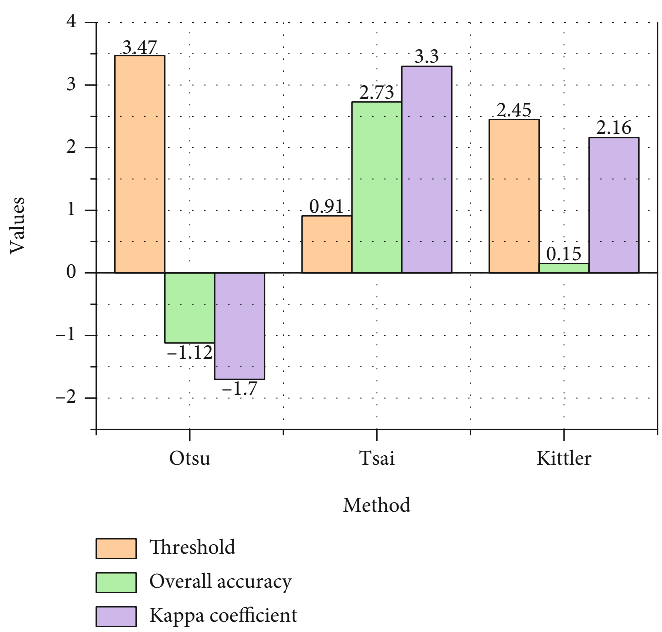

Figure 5: Accuracy of the thresholds calculated by the three threshold determination methods and the results of water segmentation.

environment and development trends, directly from the perspective of correlation between data to grasp the correlation between pollution sources and water quality, and then provide support for management decisions in areas such as prediction and early warning, which mainly includes water quality big data collection preprocessing, water quality big data offline learning, water quality big data online calculation, water big data visualization display, and other functions. Through the integration of meteorological forecasts and live data, pollution source data, air quality forecast data, socioeconomic and satellite remote sensing, other types of atmospheric environmental quality-related data, and the use of correlation analysis, cluster analysis, and other mathematical methods, data mining analysis, and the data of spatial and temporal analysis, component analysis, meteorological field clustering analysis, pollution, and economic factor correlation analysis, and other kinds of analysis, the interrelationship between the data can effectively provide sufficient support for the management of the atmospheric environment. It mainly includes atmospheric environment correlation analysis, atmospheric environment-sensitive point identification, and air quality early warning forecast, as shown in Figure 6.

Carrying out comprehensive improvement of the rural water environment, first, strengthen the treatment of rural domestic sewage and domestic waste. Promote the construction of rural domestic sewage treatment facilities, and promote the construction of small sewage treatment stations, artificial wetlands, oxidation ponds, and other domestic

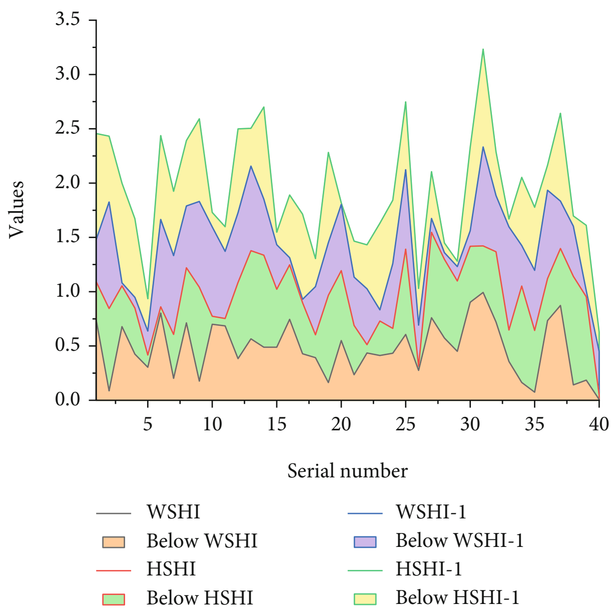

Figure 6: WSHI and HSHI thresholds.

sewage treatment facilities, laying sewage collection pipeline networks and unifying the treatment of domestic sewage in villages, because of the scattered nature of rural settlements and the high cost of building unified pipeline networks. Second, strengthen the prevention and control of pollution from concentrated livestock and poultry breeding in rural areas. Therefore, a series of big data services have emerged for the statistical analysis of big data. But for spatiotemporal big data, it is necessary to focus on analyzing its spatiotemporal attributes. For spatiotemporal big data with similar structures, a general statistical template can be used for statistical analysis of spatiotemporal big data. The city's livestock and poultry breeding will be verified, livestock and poultry breeding that cannot meet the standards will be treated by a deadline, and ecologically sensitive areas such as strictly controlled areas, drinking water source areas, and important reservoir catchment areas will be set as no-breeding areas. Livestock farms are encouraged to return manure and sewage to the land ecologically or use them to produce biogas, organic fertilizer, and other substances.

4.2. Results of Big Data Analysis of the Lower Yellow River Ecosystem. The integrated connectivity of the lower Yellow River channel is improved and maintained by carrying out reservoir water and sand transfer. River connectivity in the lower Yellow River has undergone a process from decreasing to increasing. Since the construction of Xiaolangdi Reservoir, the implementation of water and sand transfer has been strengthened, and the drainage of sand during floods has been enhanced, even shaping larger floods, and the frequency of flooding has increased; this has led to the obvious scouring of the river channel in the lower reaches, the siltation of the beach, and the obvious increase in the overflow capacity of the river channel; the difference in height of the beach channel has increased, making the river channel narrower and deeper, and the river channel has developed towards a stable river type, which has not only increased the longitudinal connectivity of the river channel but also maintained the lateral connectivity of the beach channel. Therefore, it is necessary to continue to maintain the water and sand transfer of Xiaolangdi Reservoir, to continue to maintain the balance of scouring or overall scouring and siltation of the lower Yellow River, not to return to the old way of siltation and uplift, and to maintain and promote the excellent state of longitudinal connectivity of the lower river, as shown in Figure 7.

In terms of the topography of the Yellow River Delta, urban development in the Yellow River Delta is less influenced by topography, thus providing a good spatial basis for urban expansion in all directions, which is one of the important factors that have enabled the rapid expansion of impervious surfaces in the Yellow River Delta in recent decades. Combining the actual application process of big data and the research goals of this article, the definition of big data in this article is clearly defined. Subsequently, this chapter sorts out the types and characteristics of environmental data, maps the concept of big data to the environmental field, clarifies the concept of environmental big data in this article, and compares the differences between environmental big data applications and traditional environmental applications. From the perspective of the soil characteristics of the Yellow River Delta, the spatial distribution of the Yellow River Delta soils determines the overall pattern of regional land use/cover and the direction of change of each type. Due to the high degree of salinization of tidal soils, these soils were mostly dominated by tamarisk scrub and unused land in the early period, and to meet the physical conditions required for population growth, humans increased the improvement of tidal soils, converting the former tamarisk scrub and unused land into arable land. The early land-use/cover types of saline soils were mostly unused land and mudflats, and since the salinity of saline soils is so high that it is difficult to improve them into arable land, most of these areas have been developed into highly economically productive land-use/cover types such as farmed water and salt flats.

The structure of land use/cover in the Yellow River Delta for each sampling year shows that arable land accounts for the largest share of all land-use/cover types, indicating that land use in the Yellow River Delta is mainly agricultural, and this type of use makes climate have a greater influence on land-use/cover change. In addition, global warming also has a driving effect on regional land-use/cover change, especially for those cities near the sea. This is because global warming causes sea-level rise, which in turn increases the erosive effect of seawater on coastal soils, resulting in increased salinization of soils, which in turn causes the more salt-tolerant vegetation on the seashore to no longer be able to adapt to this high salt growth environment, prompting the conversion of forested grasslands into mudflats and causing land-use/cover change, as shown in Figure 8.

Guided by the concept of water ecological civilization and the theoretical system of water ecological civilization construction, this paper analyzes the concept and connotation of urban water ecosystem health, as well as the

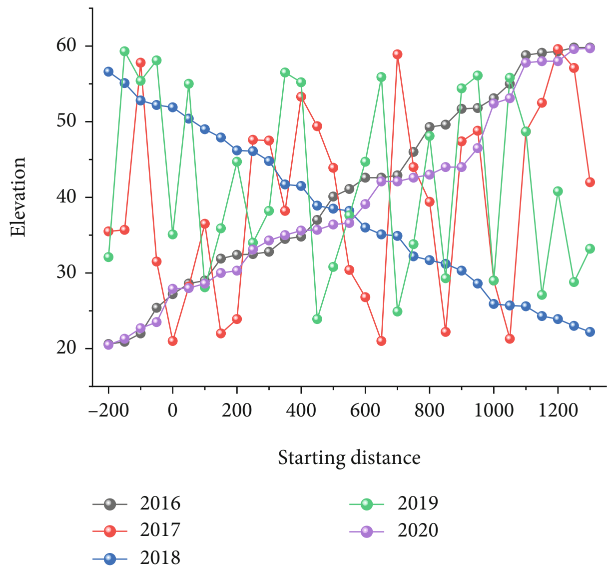

Figure 7: Hydrological station cross-sectional flushing and siltation variation.

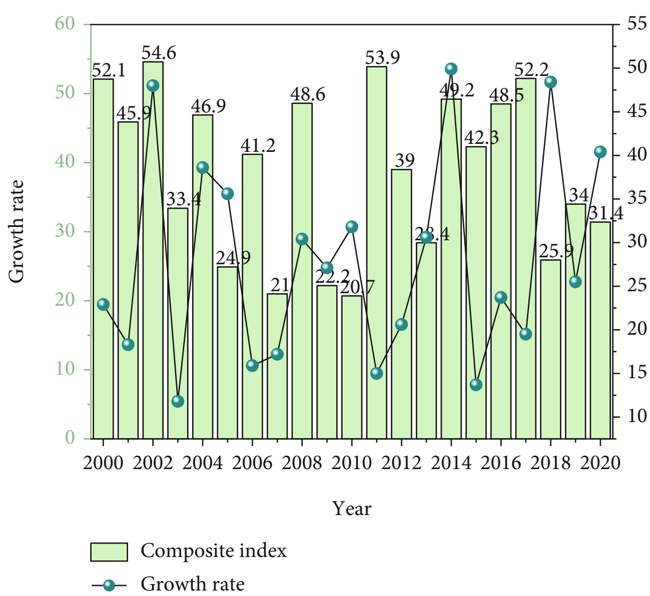

Figure 8: Evolution of the composite index and growth rate of the sustainable development system.

operating mechanism of urban water ecosystem health, and builds an evaluation model of urban water ecosystem health based on it. According to the evaluation results, a complete set of urban water ecological civilization construction idea frameworks is proposed. Strengthen industrial point source pollution treatment; carry out special rectification of chemical, pharmaceutical, and other heavy pollution enterprises; strengthen the transformation of sewage treatment facilities; promote the relocation of polluting enterprises and industrial upgrading and transformation; and investigate the key outfalls along with the more serious pollution of Naming River. Promote the treatment of surface source pollution, rational use of pesticides and fertilizers, and the implementation of clean agricultural production, and strengthen the construction of ecological interception projects for farmland retreat. There are semi-structured data and other unstructured data in the network; first, through data collection technology, a large amount of structured data, unstructured data, and semistructured data are integrated and extracted.

Carry out waste sewage network investigation, accelerate the construction of urban sewage collection network, improve the collection rate and treatment rate of waste sewage, and implement the upgrading of urban sewage treatment plants that do not meet the primary standard, reducing the number of pollutants entering the river from the process.

5. Conclusion

Based on the parallel random forest algorithm, the extraction method of typical vegetation types in the Yellow River Delta was constructed to improve the accuracy and efficiency of vegetation information extraction. In terms of extraction accuracy, the overall average accuracy of the extraction results of the Yellow River Delta time series was found to be 89.79% and the average kappa coefficient was 0.8838, which proved that the proposed method can achieve high accuracy in extracting typical vegetation types in the Yellow River Delta. In terms of computational efficiency, we found that the time spent on vegetation extraction with the proposed method is only 1/4~1/5 of that of the nonparallel random forest algorithm, and the average speedup ratio reaches 4.18, which proves that the proposed method can greatly improve the computational efficiency. Support vector machines, multiclass logistic regression, and multilayer perceptrons were used in the cooperation of multiple machine learning algorithms. The accuracy evaluation of the Yellow River Delta time series impervious surface extraction results shows that the overall average accuracy of the impervious surface extracted by the multistrategy synergistic method reaches 88.19% and the average kappa coefficient reaches 0.8647, which proves that the multistrategy synergistic method can obtain ideal results in extracting the impervious surface of the Yellow River Delta. The effectiveness of the method in extracting impermeable surfaces in the Yellow River Delta was verified. The transformation of wetland types was obvious, with many natural wetlands transformed into artificial wetlands or nonwetlands, and the main transformation types occurred between farming ponds, salt pans, and reservoir pits and mudflats, swampy wetlands, bare land, and agricultural land. Wetland transformation in the Yellow River Delta is influenced by both natural and anthropogenic factors, with human activities being the main influencing factor.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there is no conflict of interest in this article.

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References

[1] Q. Yue, F. Liu, C. Song, J. Liang, Y. Liu, and G. Cao, "Exploration and application of the value of big data based on data-driven techniques for the hydraulic internet of things," *International Journal of Embedded Systems*, vol. 12, no. 1, pp. 106–115, 2020.

[2] Y. Dong, B. Q. Hu, S. L. Zhang, Y. L. Huang, G. C. Nong, and H. Xin, "Research on North Gulf distributed big data submarine 3D terrain computing system based on remote sensing and multi-beam," *Soft Computing*, vol. 24, no. 8, pp. 5847–5857, 2020.

[3] C. Tomsett and J. Leyland, "Remote sensing of river corridors: a review of current trends and future directions," *River Research and Applications*, vol. 35, no. 7, pp. 779–803, 2019.

[4] P. Gao, H. Zhang, J. Yu et al., "Secure cloud-aided object recognition on hyperspectral remote sensing images," *IEEE Internet of Things Journal*, vol. 8, no. 5, pp. 3287–3299, 2021.

[5] H. Guo, J. Liu, Y. Qiu et al., "The Digital Belt and Road program in support of regional sustainability," *International Journal of Digital Earth*, vol. 11, no. 7, pp. 657–669, 2018.

[6] R. Yang and Y. Pan, "Rural vulnerability in China: evaluation theory and spatial patterns," *Journal of Geographical Sciences*, vol. 31, no. 10, pp. 1507–1528, 2021.

[7] A. Kamilaris, A. Anton, A. B. Blasi, and F. X. P. Boldú, "Assessing and mitigating the impact of livestock agriculture on the environment through geospatial and big data analysis," *International Journal of Sustainable Agricultural Management and Informatics*, vol. 4, no. 2, pp. 98–122, 2018.

[8] S. Yang, Y. Yang, and Q. Zhang, "Remote sensing tracking method for migration path of bar-headed goose under the impact of ecotourism," *Ekoloji*, vol. 28, no. 108, pp. 1203–1209, 2019.

[9] W. Hua, Z. Yuxin, W. Mengyu, N. Jiqiang, C. Xueye, and Z. Yang, "Spatial characteristics and driving forces of cultivated land changes by coupling spatial autocorrelation model and spatial-temporal big data," *KSII Transactions on Internet and Information Systems (TIIS)*, vol. 15, no. 2, pp. 767–785, 2021.

[10] A. Naboureh, J. Bian, G. Lei, and A. Li, "A review of land use/land cover change mapping in the China-Central Asia-West Asia economic corridor countries," *Big Earth Data*, vol. 5, no. 2, pp. 237–257, 2021.

[11] J. O. Payero, M. W. Marshall, A. M. Nafchi et al., "Development of an Internet of Things (IoT) system for measuring agricultural runoff quantity and quality," *Agricultural Sciences*, vol. 12, no. 5, pp. 584–601, 2021.

[12] Y. Leung, Y. Zhou, K. Y. Lam et al., "Integration of air pollution data collected by mobile sensors and ground-based stations to derive a spatiotemporal air pollution profile of a city," *International Journal of Geographical Information Science*, vol. 33, no. 11, pp. 2218–2240, 2019.

[13] Y. Wang and M. Li, "Urban impervious surface detection from remote sensing images: a review of the methods and challenges," *Ieee Geoscience and Remote Sensing Magazine*, vol. 7, no. 3, pp. 64–93, 2019.

[14] F. Mao, K. Khamis, J. Clark et al., "Moving beyond the technology: a socio-technical roadmap for low-cost water sensor network applications," *Environmental Science & Technology*, vol. 54, no. 15, pp. 9145–9158, 2020.

[15] G. Tran Thi Hoang, L. Dupont, and M. Camargo, "Application of decision-making methods in smart city projects: a systematic literature review," *Cities*, vol. 2, no. 3, pp. 433–452, 2019.

[16] J. Fell, J. Pead, and K. Winter, "Low-cost flow sensors: making smart water monitoring technology affordable," *IEEE Consumer Electronics Magazine*, vol. 8, no. 1, pp. 72–77, 2019.

[17] S. M. R. Alam and M. S. Hossain, "A rule-based classification method for mapping saltmarsh land-cover in south-eastern Bangladesh from Landsat-8 OLI," *Canadian Journal of Remote Sensing*, vol. 47, no. 3, pp. 356–380, 2021.

[18] B. Kong, H. Yu, R. Du, and Q. Wang, "Quantitative estimation of biomass of alpine grasslands using hyperspectral remote sensing," *Rangeland Ecology & Management*, vol. 72, no. 2, pp. 336–346, 2019.

[19] R. Jayaraman, B. S. Kumar, and S. K. Singh, "Remote sensing and GIS based site suitability analysis for tourism development in Vaishali block, Bihar," *Landscape & Environment*, vol. 15, no. 2, pp. 12–22, 2021.

[20] M. Deng, "Challenges and thoughts on risk management and control for the group construction of a super-long tunnel by TBM," *Engineering*, vol. 4, no. 1, pp. 112–122, 2018.