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Article

Visualization and analysis of the integration mechanism of artificial intelligence-enabled sports development and ecological environment protection

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Abstract: The development of all sports requires a competent sports ecological environment. Pollution of the sports ecological environment greatly restricts people's enthusiasm and interest in taking part in sports activities, and at the same time greatly affects people's physical and mental health and hinders the development of sports. As people's awareness of environmental pollution protection increases, it will certainly curb and alleviate the environmental pollution problem. Promote social harmony and sustainable development. Therefore, this paper will intuitively analyze the integration mechanism of sports development and ecological environmental protection based on artificial intelligence. After analysis, China's research in related fields, sports and environmental engineering disciplines accounted for the largest proportion of 74.46%, and with the progress of sports events and environmental protection, the number of international publications in 2017 reached a maximum of 134. To a certain extent, this is linked to the Rio Olympics in Brazil the previous year. However, in the global research in this field, the number of published papers in the United States reached a maximum of 159, which opened a large gap with other countries.

Keywords: sports and ecological environment; visual analysis; artificial intelligence; artificial neural networks

1. Introduction

All sports need a good ecological environment for their development. The ecological environment is the basis and carrier for people to perform sports. Without the ecological environment, there would be no sports and sports culture. When people carry out daily physical exercise and outdoor activities, they must rely on the surrounding sports ecological environment and social environment, and are affected and restricted by the surrounding ecological environment throughout the process. An important factor for the success of the application city for hosting the Modern Olympic Games is the quality of the ecological environment of the applicant city. The basis and premise of people's exercise and sports is a decent sports ecological environment. A fine sports ecological environment can effectively help people to enjoy sports and improve their health in the usual physical exercise. However, at present, many bodily exercises are seriously polluted by the ecological environment. People's participation in normal campus physical exercise is not merely greatly restricted and restricted, but also poses serious challenges and threats to physical and mental health, which has caused huge obstacles to the development of sports. It is imminent to solve and deal with the problem of ecological environment pollution in the development of sports.

With the continuous development and innovation of science and technology, many intelligent technologies are employed in all aspects of life. This paper would use artificial intelligence technology to integrate sports development and ecological environmental protection. Because visual analysis can convey and communicate operational information clearly and intuitively, the technology that data is finally presented in the form of graphics by means of visualization is currently widely used in various fields of knowledge. Therefore, this paper used the visualization method to systematically analyze the integration mechanism, so as to foster the harmonious development of sports development and ecological environment protection.

2. Literature review

In the research of sports development and ecological environmental protection, many scholars have organically integrated the two. Peng [1] suggested to promote the construction of sports and leisure towns by relying on the rich local agricultural resources and sports and leisure resources. Wu [2] submit suggestions for the development of water sports by analyzing the carrying capacity of water resources. Rosevear and Cassidy [3] based on an ecosystem development model to understand how character in the New Zealand Rugby (NZR) ecology is understood. One of the proposed tour routes tested in the research reserve by Ilies was completed in four modes of walking, running, cycling and Nordic walking, and believed that the proposed tour route for physical activity and recreational activities in the reserve is suitable for ordinary people use [4]. These studies are all targeted and not abundant enough in the connection between sports and ecology.

In the research of visual analysis, countless scholars have various applications for it. Ming [5] used the spectrometric software CiteSpace by mapping keyword co-occurrences, time zones, scholarly collaborative networks and research institution collaborative networks. Lu et al. [6] proposed TMNVis, an interactive visualization system for exploring the evolution of temporally multivariate networks. Ben-Shalom et al. [7] conducted a visual analytical study of a sample of special cases. Chen et al. [8] conducted a photographic analysis of the state of application of network meta-analysis in the field of traditional Chinese medicine. Gotz et al. [9] proposed a new visual analysis method for dynamic hierarchical dimensional aggregation. Based on collaboration with historians, linguists, and statisticians, Ha et al. [10] proposed a method for creating and analyzing interpersonal visualizations using data from Kwon's family tree and the Joseon Dynasty yearbook. Graphical analysis can be used in various fields, but no one has carried out visual analysis of sports development and ecological environmental protection.

Recent advances in artificial intelligence for sports and environmental protection recent research has seen significant advancements in the application of artificial intelligence in sports and environmental protection. For instance, a study by Zhang and Liu [11] assessed the ecological impact of sports events using artificial intelligence, highlighting the potential of AI in enhancing sustainable sports development and ecological balance.

3. Introduction of artificial intelligence and the visual evaluation of the integration mechanism

3.1. Introduction of artificial intelligence technology

Aiming at the problems and deficiencies in the development of sports and the protection of ecological environment, this paper introduces various advanced artificial intelligence technologies. These technologies are selected based on their ability to address specific research questions and their potential to provide insights into the integration mechanism of sports development and ecological environmental protection.

The selection of artificial intelligence technologies is driven by several criteria:

1) Relevance to research questions: The technologies must be of interest to the research questions, capable of analyzing complex data sets and providing actionable insights.

2) Data handling capabilities: Given the vast amount of data generated in sports and environmental studies, the technologies should have solid data preprocessing and pattern recognition capabilities.

3) Predictive analytics: The ability to predict trends and provide foresight into potential impacts on ecological environments.

Conducts the modeling research of the integrated decision support system, establishes the comprehensive model, and improves the existing methods. Numerous artificial intelligence technologies and methodologies are applied to solve practical problems one by one [12]. The methods of pre-processing, data outlier resolution and correlation coefficient analysis are used to evaluate the statistics, and applicable factors are screened. At the same time, the signal decomposition algorithm and clustering intelligent algorithm are utilized to improve the accuracy of the model [13].

(1) Artificial neural network

1) BP neural network (BPNN)

BPNN is a case in multi-layer feed-forward neural network, which is responsible for processing the information hidden sequentially from the input layer to the output layer [14]. If the predicted output value exceeds the expected output value, the inverter is executed and the network parameters are adjusted. The prediction error approximates the prediction output through an iterative process.

2) Radial basis function network

Radial basis function (RBF) is a local response function [15]. Its structure and calculation formula read as follows Equation (1):

$$x_j = \sum_{i=1}^{h} u_{ij}\, exp(-\frac{1}{2\sigma^2}\|y - c_i\|^2) \rightleftarrows \ j = 1,2,\dots,n \tag{1}$$

In the formula: x_j is the output; u_{ij} is the connection weight between the hidden layer and the output layer; σ is the variance of the basis function; $y = (y_1, y_2, \dots, y_m)^T$ is the input sample; c_i is the center of the hidden layer node; m, h, n are the number of nodes in the input layer, hidden layer and output layer, respectively.

3) Generalized regression neural network

General regression neural network (GRNN) is a distortion of the RBF network that combines radial basal and linear nerves [16,17]. The learning ability and speed of GRNN is better than that of RBF function, and the accuracy is better. The structure and calculation formula of GRNN are as follows Equations (2)–(5):

$$q_i = exp[-\frac{(y-y_i)^T(y-y_i)}{2\sigma^2}] \quad i = 1,2,\dots,n \tag{2}$$

$$S_C = \sum_{i=1}^{n} q_i \tag{3}$$

$$S_{Nj} = \sum_{i=1}^{n} x_{ij} q_i \quad j = 1,2,\dots,k \tag{4}$$

$$x_j = \frac{S_{Nj}}{S_C} \quad j = 1,2,\dots,k \tag{5}$$

q_i—pattern layer output;

S_C, S_{Nj}—Summation layer output;

x_{ij}—the j element of the i output sample;

x_j—output the j element.

4) Deep belief networks

Deep belief network (DBN) plays a major role in the development of deep learning [18]. The energy function of RBM is equivalent to Equation (6). After determining the modulus, the coupling distribution Equation (7) can be generated according to the energy function. The principle of DBN is to train in RBM to complete the initialization of BPNN factors, which overcomes the shortcomings of local optimization.

$$\varepsilon(u,l|\vartheta) = -\sum_{i=1}^{n}\sum_{j=1}^{m} \omega_{ij} l_i u_j - \sum_{j=1}^{m} a_j u_j - \sum_{i=1}^{n} b_i l_i \tag{6}$$

$$q(u,l|\vartheta) = \frac{1}{Z(\vartheta)} e^{-\varepsilon(u,l|\vartheta)} = \frac{1}{Z(\vartheta)} exp(-\varepsilon(u,l|\vartheta)) \tag{7}$$

In the formula: u_j is the input of the visible node j; l_i is the output of the hidden node i; ω_{ij} is the weight of both; a_j, b_i is the bias of u_j, l_i; $\vartheta = \{\omega_{ij}, a_j, b_i\}$ is the parameter.

5) Elman neural network

Elman neural network is a classic recurrent neural network [19]. Its structure is the same as the multilayer feedforward neural network, and its calculation formula is as follows Equations (8) and (9).

$$h(x) = f(Vy(x) + Wh(x-1) + a) \tag{8}$$

$$o(x) = g(h(x)) = g(Uh(t) + b \tag{9}$$

In the formula: $h(x), o(x)$ are the input vector, the hidden vector and the output vector respectively; V, W, U are the connection weight of the input layer and the hidden layer, the connection weight of the hidden layer and the hidden layer, and the connection weight of the hidden layer and the output layer; f, g are the activation functions of the hidden layer (commonly used Tansig function) and the output layer (commonly used Purelin function).

(2) Correlation coefficient analysis method

The correlation coefficient generally uses the value range to judge the degree of correlation between the indicators, and the relationship is shown in **Table 1**:

Table 1. Value range and meaning of correlation coefficient.

The absolute value of the correlation coefficient	Relevance
0–0.1	Very weak correlation
0.1–0.35	Weak correlation
0.35–0.6	Moderately relevant
0.6–0.85	Strong correlation
0.85–1	Very strong correlation

Correlation coefficients have different forms according to the research variables. Three commonly used correlation coefficients are as follows:

1) Pearson correlation coefficient

The Pearson correlation coefficient was utilized to quantitatively analyze the linear relationship between two variables [20]. The formula for the calculation is reproduced below Equation (10):

$$r = \frac{\sum_{j=1}^{m}(x_j - \overline{x})(y_j - \overline{y})}{\sqrt{\sum_{j=1}^{m}(x_j - \overline{x})^2}\sqrt{\sum_{j=1}^{m}(y_j - \overline{y})^2}} \tag{10}$$

In the formula: x_j and y_j are the correlated variables of the j sample pair; $\overline{x}$ and $\overline{y}$ are the mean values of x and y, respectively.

2) Spearman rank correlation coefficient

The Spearman's rank correlation coefficient uses the rank of variables instead of statistical values to calculate rank correlation coefficient, which can be said to be a special form of Pearson's correlation coefficient [21]. Features: non-statistical does not require data distribution and is more widely used than Pearson's correlation coefficient. The calculation is as follows Equation (11):

$$r_s = \frac{\sum_{j=1}^{m}(a_j - \overline{a})(b_j - \overline{b})}{\sqrt{\sum_{j=1}^{m}(a_j - \overline{a})^2}\sqrt{\sum_{j=1}^{m}(b_j - \overline{b})^2}} = 1 - \frac{6\sum_{j=1}^{m} d_j^2}{m(m^2-1)} \tag{11}$$

In the formula: a_j and b_j are the grades of the j sample on the relevant variables; $\overline{a}$ and $\overline{b}$ are the averages of a and b, respectively; $d_j = a_j - b_j$ is the grade difference.

3) Kendall rank correlation coefficient

The Kendall rank correlation coefficient was used to reflect the correlation of

categorical variables [22]. The formula for the calculation is as follows Equation (12):

$$\lambda = \frac{m_c - m_d}{m(m-1)/2} \tag{12}$$

In the formula: for two sample pairs (x_i, y_i) and (x_j, y_j), if $x_i < y_i$ and $x_j < y_j$, or $x_i > y_i$ and $x_j > y_j$, it is a homologous pair, otherwise it is a heterologous pair; m_c is the homologous log; m_d is the heterologous; m is the heterologous total logarithms.

(3) Whale optimization algorithm

1) The prey is surrounded

Humpback whales can identify and surround their prey. This behavior is represented by the following Equations (13) and (14):

$$\vec{B} = \left|\vec{C} \cdot \vec{Y}(t) - \vec{Y}(t)\right| \tag{13}$$

$$\vec{Y}(t+1) = \vec{Y}^{*}(t) - \vec{A} \cdot \vec{B} \tag{14}$$

In the formula: t is the current iteration; $\vec{Y}^{*}$ is the position vector that currently obtains the optimal solution, which needs to be updated in each iteration if there is a better solution; $\vec{Y}$ is the position vector; $\vec{A}$ and $\vec{C}$ are the coefficient vectors, and the formula is as follows Equations (15) and (16):

$$\vec{A} = 2\vec{a} \cdot \vec{x} - \vec{a} \tag{15}$$

$$\vec{C} = 2 \cdot \vec{x} \tag{16}$$

In the formula: $\vec{x}$ is a random vector in [0,1]; $\vec{a}$ decreases linearly from 2 to 0 in the iterative process (exploration, utilization).

2) Attack method of "bubble net" (exploitation stage)

Shrink wrapping mechanism:

By reducing the value of $\vec{a}$ in Equation (15) to meet this behavior, the fluctuation range of $\vec{A}$ is also reduced.

Spiral update position:

A spiral equation established between the whale and prey positions to simulate the spiral movement of a humpback whale, see Equation (17):

$$\vec{Y}(t+1) = \vec{B} \cdot e^{bl} \cdot cos(2\pi l) + \vec{Y}^{*}(t) \tag{17}$$

In the formula: $\vec{B} = \left|\vec{Y}^{*}(t) - \vec{Y}(t)\right|$ is the distance from the i whale to the prey (the current optimal solution is obtained); b is a constant that defines the shape of the logarithmic spiral; l is a random number in $[-1, 1]$.

Humpback whales circle their prey along a spiral path. In order to simulate simultaneous movement, the position of the whale is refreshed with a 50% probability, assuming a shrink-wound mechanism or a helical model is chosen during the optimization, see Equation (18):

$$\vec{Y}(t+1) = \begin{cases} \vec{Y}^{*}(t) - \vec{A} \cdot \vec{D} & ifp < 0.5 \\ \vec{B} \cdot e^{bl} \cdot cos(2\pi l) + \vec{Y}^{*}(t) & ifp \geq 0.5 \end{cases} \tag{18}$$

In the formula: p is a random number in [0, 1].

3) Search of prey (exploration phase)

Humpback whales can search randomly depending on each other's position. When $\vec{A}$ is greater than 1 or less than −1, the search agent would move away from the reference search agent. The mathematical model is as follows Equations (19) and (20):

$$\vec{B} = \left| \vec{C} \cdot \vec{Y}_{rand} - \vec{Y} \right| \tag{19}$$

$$\vec{Y}(t+1) = \vec{Y}_{ramd} - \vec{A} \cdot \vec{B} \tag{20}$$

In the formula: $\vec{Y}_{rand}$ is a random position vector in the current population.

The WOA algorithm starts with a set of random solutions, and during each iteration, the search agent updates its position based on the randomly selected search agent or the currently obtained optimal solution. The parameter a is reduced from 2 to 0 to ensure exploration and utilization, and the optimal solution is selected when $\left|\vec{A}\right| < 1$. According to the p -value WOA algorithm, we are able convert between spiral and circular movements. The iteration stops when the termination condition is satisfied.

Construction of a prediction model for the impact of sports events on the ecological environment

In this study, we utilize artificial intelligence techniques to construct a prediction model of the impact of sports events on the ecological environment to predict the impact of sports events on the urban ecological environment. Historical data of sports events, including event size, number of participants, duration, and environmental monitoring data during the events (e.g., air quality index, noise level, and waste generation), are collected and used to predict the potential impact of future sports events on the ecological environment. To predict the trends of urban ecological indicators under different event sizes and durations.

3.2. Integration mechanism of sports development and ecological environment protection

(1) Conflict between sports development and ecological environment

Sports play a major role in modern society. As an integral part of a healthy human lifestyle, it offers opportunities to increase human physical activity and social interactions, stimulating economic and social development. The contents of the ecological environment are illustrated in **Figure 1**.

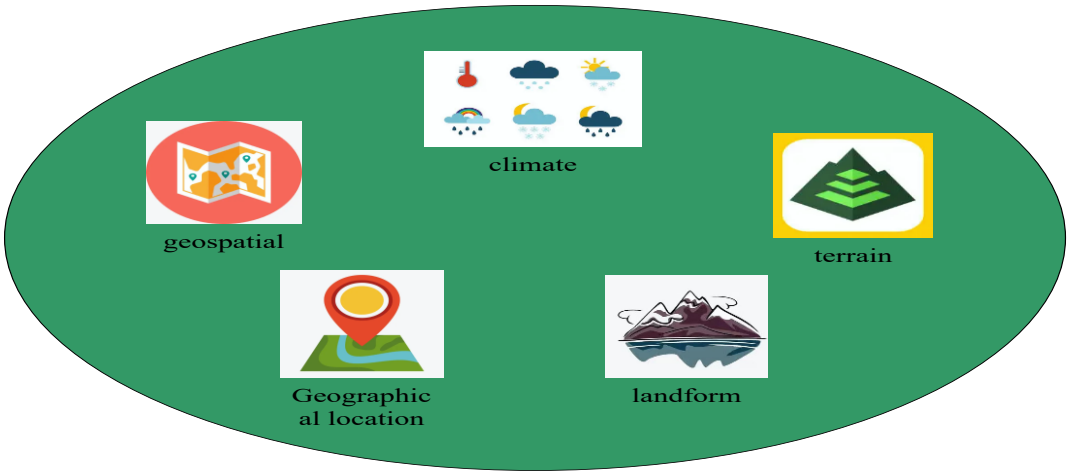

Figure 1. Contents of the ecological environment.

The development of sports, especially the holding of large-scale sports events, has also had some negative impacts on the environment. The negative impacts of large-scale sports events on the environment are shown in **Figure 2**.

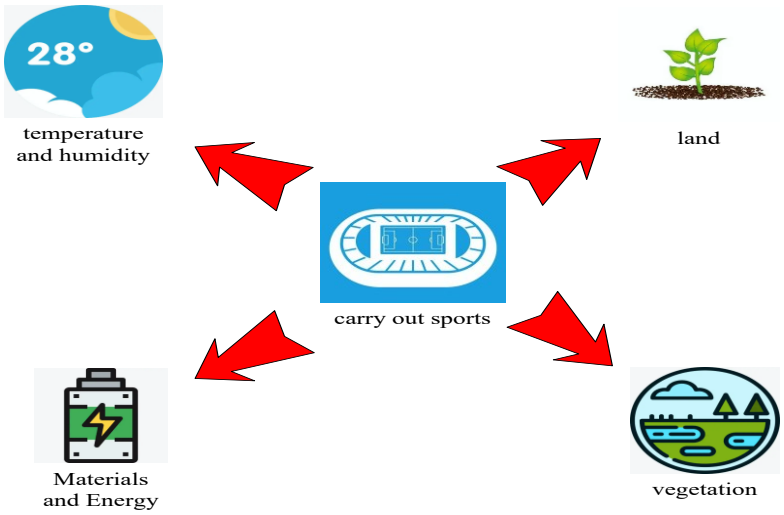

Figure 2. Various aspects of the environment affected by the development of sports.

First, it is taken into account in the extensive use of the natural environment. The construction of stadiums and their facilities requires a lot of land, and the existing natural environment is inevitably destroyed. Different roads, parking lots and other facilities further pollute and damage the existing natural environment. Competition organizers often forgo existing venues and build large numbers of permanent venues, wasting a lot of material and energy. On the other hand, geological factors such as local vegetation and soil are also damaged, and this damage is long-term.

During competitions, a series of environmental problems still arise, such as car rally, motocross and powerboat racing, as illustrated in **Figure 3**.

(a) Motocross. **(b)** Powerboat racing.

Figure 3. Motocross and powerboat racing scene.

These items consume a lot of fuel during the race. This would rapidly increase exhaust emissions. Water sports such as water skiing and jet skiing can contaminate water bodies. Winter sports destroy vegetation, and natural landscapes damage vegetation.

Sports would not only affect the natural environment, but also damage other ecological environments, such as the use of non-renewable resources, the discharge of harmful substances during the construction and operation of stadiums, etc. In order to solve the contradiction between sports and ecological environment, sports development and ecological protection must be combined.

(2) Integration of sports development and ecological environment

Sports and the ecological environment each exist as an independent and complete system, so the construction goal of the integration mechanism of the two is essential to enhance the coordinated operation and function of the system itself. On the other hand, as the existence of two different fields, the exchange and transmission of energy and information occur between the two, so the construction goal of integrating wit is secondly to maintain the stability of the system and promote the overall health and harmony of the sports ecology, as shown in the **Figure 4**.

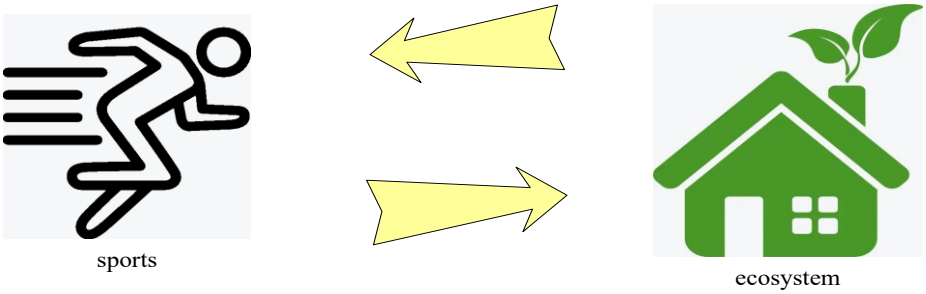

Figure 4. Integration of sports and ecological environment.

1) Exploration period: preparation for “idea point”

Thought is the guide of action, so it is necessary to lead in thought to lead in action, and to be prepared in considered to guide the implementation of action. The construction of an integration mechanism for sports development and ecological environmental protection requires a multi-angle grasp of this unprecedented complex ecological environment. Driven by the continuous development of technology and the uninterrupted progress of society, there has never been a situation where such diverse

forms coexist and are intertwined as today. Therefore, it is necessary in order to fully understand the close connection between sports and the ecological environment. According to the characteristics and trends of sports development, combined with the objective laws of the ecological environment, the preparation for the integration of the two cognitive transformations and the establishment and cultivation of scientific, correct and reasonable cognitive and thinking methods are the core tasks of the exploration stage of sports development and ecological environment integration.

2) Collision period: exclusion of "obstacle points"

At present, on the one hand, the two fields are intertwined with each other, and there are fierce conflicts in value orientation and ideological concept. At the same time, in order to win a larger living space, win a wider audience, and gain a stronger influence, they continue to absorb, learn from, exclude and resist each other; on the other hand, there are also contradictions or struggles between the components in the two systems. In order to maintain its constitutive position in the system and exist for a long time, it constantly transforms, replaces, and assimilates other heterogeneous elements. Therefore, it is a necessary measure in the stage of integration and collision to treat and optimize the diseases that affect the two systems themselves, and to continuously eliminate or even eliminate the key factors that hinder the integration.

3) Run-in period: the search for a "neutral point"

After monitoring and investigating the main obstacles to the integration of sports development and ecological environmental protection, it is necessary to actively seek the "neutral point" between the two fields, and to promote the continuous running-in and mutual recognition between the two fields through equal and conscious communication and dialogue. Based on these differences or distances, and guided by the principles of the unity of individuality and identity, as well as specificity and universality, mutual companionability and intelligibility are found, and a "common understanding" is found, so as to promote a good form of pluralistic coexistence and harmonious coexistence.

4) Expansion period: mating of "gene points"

Due to the differences in geographical environment, historical development, political economy and many other conditions, many ecological environments have formed their own unique and stable cultural genes during their long-term social evolution. The valuable and long-standing cultural genes inherent in various artistic forms are deeply dissected and explored. They meet and merge into the ecosystem in a certain way, and then set up form. It is a major advance and innovation process for the integration of the two in the multicultural field, and it is also the mission of the integration of sports development and ecological environment.

5) The whole process: avoidance of "risk points"

The development of sports and the ecological environment are complicated, and the integration of the two in this environment would inevitably have numerous risk points. In order to promote the smooth development of the integration of the two, and effectively achieve the goal and expectation of the integration, it is necessary to monitor the whole process of the integration from the exploration stage, to the collision stage, and to the running-in stage. Finally, in the whole process of integration in the expansion stage, the whole process of monitoring and risk avoidance is carried out, and the warning line is always grasped to prevent the serious consequences of system

collapse and disintegration and ecological damage.

From the above construction scheme, this paper designs the corresponding exact mechanism, forming a relatively complete integration framework, as shown in **Figure 5**.

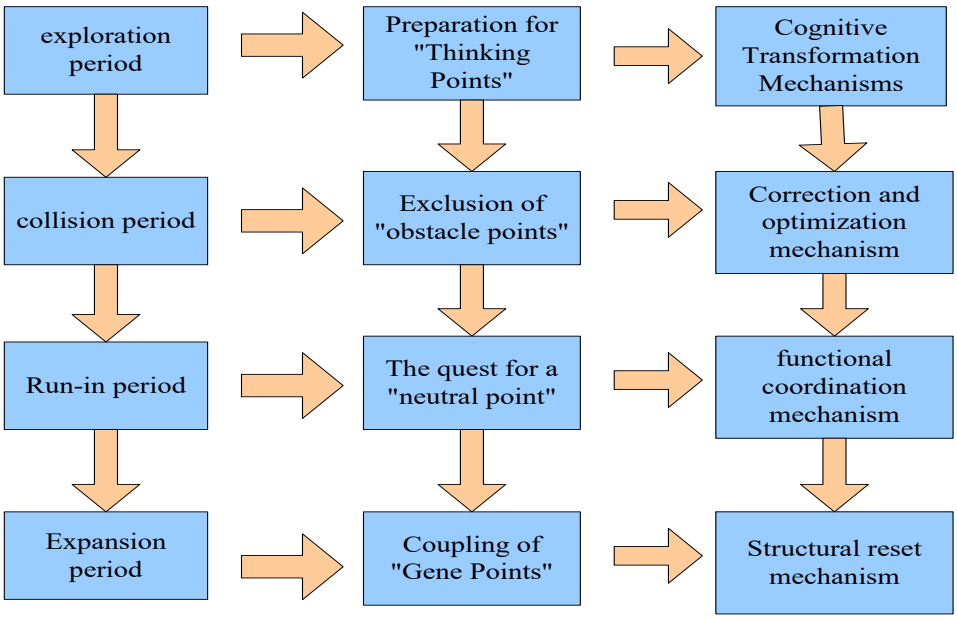

Figure 5. The basic framework of the administrative culture integration mechanism in the multicultural field.

Five stages of integration of sports development and ecological environmental protection: the initial exploration stage, which establishes the basic framework and principles for the integration of sports development and ecological environmental protection; the collision stage, in which conflicts of interests and difficulties in coordination increase, and a balance needs to be found to resolve the contradictions between sports activities and environmental protection; the integration stage, in which policy adjustments and technological innovations are made with the aim of finding the best ways to promote sports development and protect the environment at the same time In this period, relevant policies and standards are optimized and improved, environmental protection technologies and management models are promoted, and the environmental friendliness of sports facilities and activities is enhanced; in the expansion period, a win-win situation is formed, where sports activities not only do not damage the environment, but instead become a driving force for environmental protection; in the whole process, comprehensiveness and systematization, environmental protection requirements are taken into account in every link of sports activities, and the results achieved in the early stage are consolidated and developed to ensure that the integration of sports development and environmental protection becomes indispensable. The integration of sports development and environmental protection has become an irreversible trend.

These five stages are not isolated, but are interrelated and gradually evolving processes. Each stage has its own specific tasks and challenges, but lays the foundation for the next stage of progress.

3.3. Design of visual evaluation system

(1) Demand analysis of visualization system

When an information platform has a large amount of data and visualization requirements, system users need to process different types of business data and visualize them. A very common visualization method at this time is the digital cockpit. When processing a certain data, the business process of the visual analysis engine is shown in **Figure 6**:

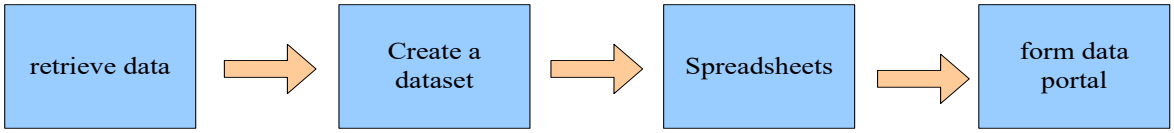

Figure 6. Visual analytics engine business process.

The custom visual analysis engine includes three main functions. The first is the data management function corresponding to the steps of adding data sources and acquiring data, creating datasets. The second is the creation of the cockpit building function analogous to the dashboard or spreadsheet step. The third one is to form the cockpit management function conforming to the data portal or cockpit application steps. The business details of different businesses of the custom graphic analysis engine are shown in **Table 2**.

Table 2. Visual analysis engine business function description.

Business name	Business function description
Data management function	Realize adding and selecting data sources to obtain data, after having data sources, display all data in our data sources, provide field selection, filtering and other functions for users to choose, and create data sets through the selection of cockpit managers.
Cockpit management functions	Manage the construction information of the cockpit, and support the viewing, editing and deletion of the built cockpit view, and manage multiple cockpits
Cockpit Build Features	It mainly completes the view drawing work, selects and displays the data, and manages the interface style.

Data integration is the first stage in data analysis. The data management function can easily and quickly centralize the required data to solve the problems of scattered data and different types. It simplifies the data acquisition process and helps users in data management and data analysis. The system offers a variety of flexible ways to help users complete data access, from the local MySQL database to the Hive database. The data management function mainly includes four functions: data source selection, data set creation, data source management, and data set management, as shown in **Figure 7**.

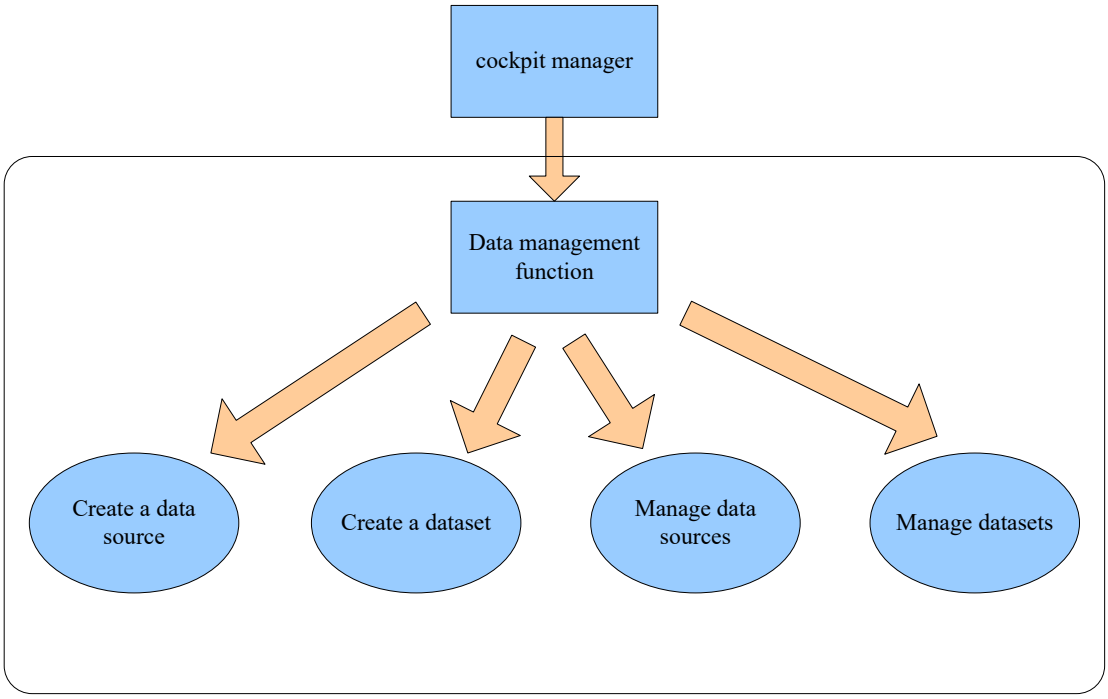

Figure 7. Data management function use case diagram.

The function of creating data source would realize the creation of MySQL database type data source, and the function of managing data source can realize the management of the obtained data source list. This function includes operations such as editing, deleting, etc. The function of making a data set is performed after the data source is obtained. The data source can be seen through the data source list, and after selecting the data source, the system matches all the data and fields of this table.

(2) Design of visual analysis system

According to the boundaries of different functions and actual business needs, the massive data-based custom visual analysis engine is divided into data management modules, cockpit building modules, and cockpit functions. The module diagram is shown in **Figure 8**. These three modules not only perform their specific functions and are responsible for the business and calculation of this module, but also share and transfer data with each other.

The function of each module would be discussed in detail below.

1) Data management module

The data management module is an important part of data analysis. The job of the data management module is to collect the data needed by the cockpit managers from different data sources into the system to solve the problems of scattered data and diverse types to form a data set. It simplifies the data acquisition process and saves a lot of time in integrating and cleaning data, and allows users to conveniently store and manage data and analyze data.

2) Cockpit building blocks

Cockpit building blocks are core modules for building visualization applications. The cockpit consists of various cards. The position and size of each card in the cockpit can be free to set, and finally these cards together form the cockpit page. Users can adjust the position by dragging the header area of the chart, or set the chart size to

zoom in or out through the small arrow in the lower right corner of the chart, or directly edit a card to control its data, style, and other attributes. The cockpit building module includes four parts: cockpit viewing, view editing, card management, and layout management.

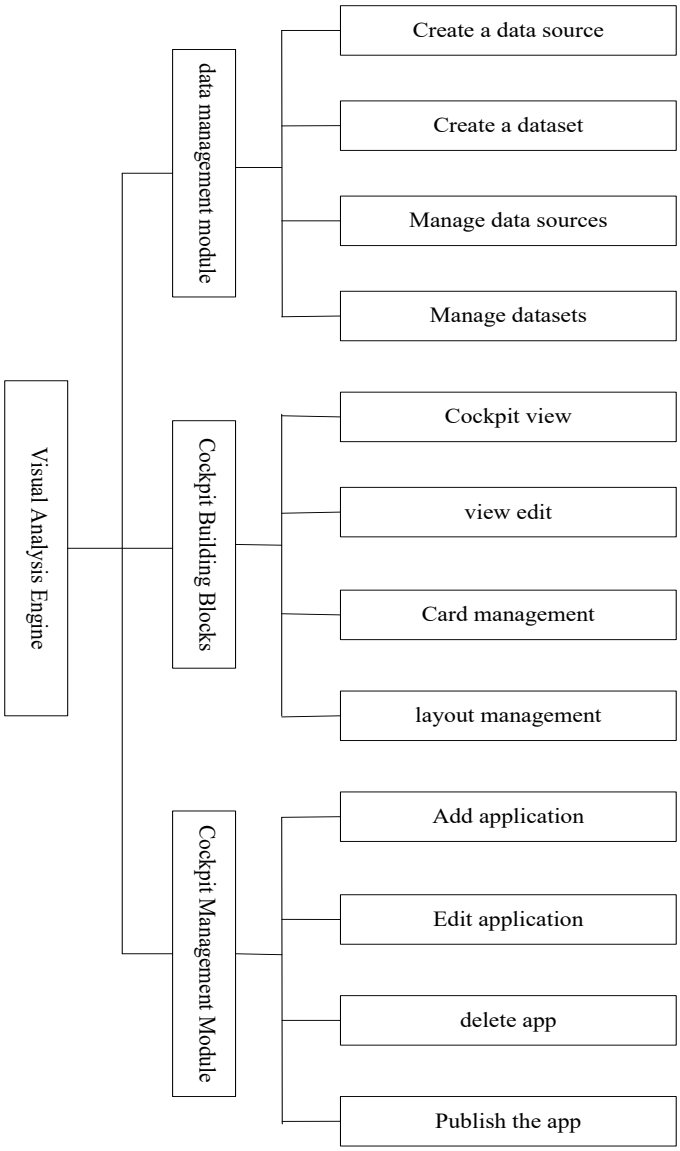

Figure 8. Visual analysis engine functional block diagram.

3) Cockpit management module

Cockpit management module includes cockpit application management and publishing application functions. The page structure of this module is the same as a directory, which is composed of folders and specific cockpits. The analysis framework of each business is formed through folders and cockpits. This module includes the four operation functions of adding, publishing, deleting and editing the cockpit application by the cockpit manager.

(3) Design and implementation of functional modules of visual analysis engine

1) Detailed design and implementation of data source

The cockpit manager clicks data management in the system menu to enter the

data management interface. The cockpit manager then clicks the new data source button. In the data source type list, the MySQL database data source option is selected, and the create data origin method of the data origin Service class is called, and a pop-up box prompts to input configuration items including server, port number, user name, password, database name, etc. The get connection method of java data base connectivity (JDBC) connects to the database.

The connection is retained, and a data source data is added through the data origin create method of the data access object (DAO) layer. Generator both reads and displays the tables of the database for data preview. The parameters of the create data source method are shown in **Table 3**:

Table 3. JDBC is used to create dataset method parameters.

Parameter	Type	Describe	Note
Id	Int	The data source ID	
Name	String	Database Name	
Table Name	String	The name of the table	
Columns	String	Data Source Description	
Amount	Int	Number of fields	Field is the column name and type is the sort type. ASC and DESC are supported
Base Info	Map<String, List>	field	The selected column, key is the table, vale is the table selected
Address	String	Server Address	
Port	Int	The port number	
Username	String	The user's name	
Password	String	password	

2) Detailed design and implementation of the dataset

The dataset function comprises the following steps. The first step is tantamount to access the data source and obtain the data source list through the get data origin list method of the data origin service class, and display it on the front end page data management view for users to choose.

The definition of the indicator is identified and the indicator is added. In the worksheet list box, the worksheet to be processed is selected and the add field in the upper right corner is clicked, and the field name and field type to be added are set. According to the needs of business and analysis, the corresponding indicators are formulated, and the Chinese naming operation is carried out to facilitate the subsequent data analysis. This step is tantamount to defining the columns object of the interface on the front-end. There is data selection. The selection of data is controlled by filtering columns, data volume restrictions, whether to join, etc. This step defines the filters attribute, order by attribute, and amount attribute when passing parameters.

Finally, the data set is newly created through the create dataset method of the data origin service class, and the data is added through the dataset create method of the DAO layer accessed through sql Generator. This step generates the data table and adds entries to the dataset table, where the dataset is generated. After the added fields are generated, the accuracy of the field values and whether they meet the expectations are previewed on the data verification page of the worksheet. The parameters of the method of creating a dataset are shown in **Table 4**:

Table 4. Creation of dataset method parameters.

Parameter	Type	Describe	Note
Table Names	List	Table name to read	
Table Names CN	List	Contents in the table to be read	
Target Table Name	String	Table name after importing MySQL	
Columns	Map<String. List>	field	The selected column, key is the table, vale is the table selected
Amount	int	Limit the amount of data	
Filters	Map<String. List>	Filter conditions	Where field is the column name, filter is the condition, which supports greater than, less than, equal to, included in, equal to, and val is the value
Order By	Order By	Sort columns	Where field is the column name, type is the sort type, and ASC and desc are supported
Base Info	Base Info	user data	Where id is the user ID and token is the user token
Join Col	Map<String. List>	Join selected columns	Where col is the join column name and table is the join table name

Among them, the concept of field type is defined for the columns parameter. The field can be simply understood as the row or column title when using the EXCEL table, and the value of each column or row below the title is the value of the field. Field is a concept introduced by database table, which is inherited here. There are three types of fields in the worksheet: date, text, and value. The following would introduce the three field types mentioned above:

Date type field: the field type is date, indicating that the value of the field is a date or time, and an icon would be displayed in front of it. Date type fields support further processing using calculation functions and data analysis as dimensions or values in charts.

Text type field: the field type is text, indicating that the value of the field is a string and records some text information. For example, if an order data table is accessed, the receiving address of the order, the recipient and other field types are all text.

Numeric type field: the field type is numeric, indicating that the value of the field is a numeric value or a number, including int, numeric and other types. For example, a field type in a table in the database that stores business data in the enterprise is int type, and then the system is directly connected to the database for synchronization. After synchronizing to the system, this field type corresponds to a value.

4. Visual experiment and evaluation of the integration mechanism of sports development and ecological environment protection

4.1. Visualization experiment of the integration mechanism of sports development and ecological environment protection

(1) Visualization experiment of Chinese sports development and ecological environmental protection research

Generally speaking, the publication volume and changing trend of research

literature in a certain field in different time periods can reflect the academic level or development trend of experts and scholars in this research field to some extent. The research object selected in this paper is the literature in China that conformed to all standard formats during the period from 2010 to 2018, and the valid data were screened and retained, with a total of 640 articles, and the change trend is shown in **Figure 9**.

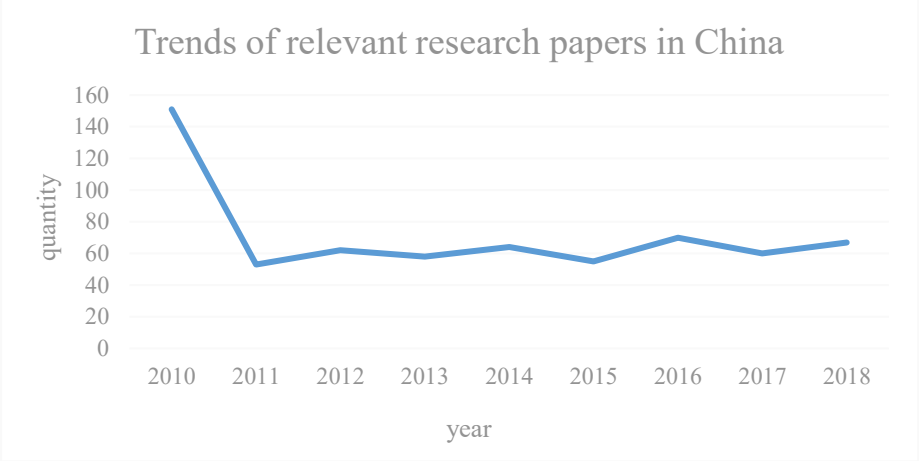

Figure 9. Line chart of the publication trend of Chinese sports development and ecological environmental protection research literature from 2010 to 2018.

As can be observed in **Figure 9**, the trend of published articles fluctuated greatly during the period from 2010 to 2011. The reason is that before 2010, to a certain extent, it was linked to the positive impact of the "Olympic Fever". Compared with previous years, the changes in the number of published papers from 2013 to 2018 showed a fluctuating trend. To a certain extent, the cause is related to factors such as the increase in the difficulty of reviewing academic journal publications and the increase in review thresholds in recent years.

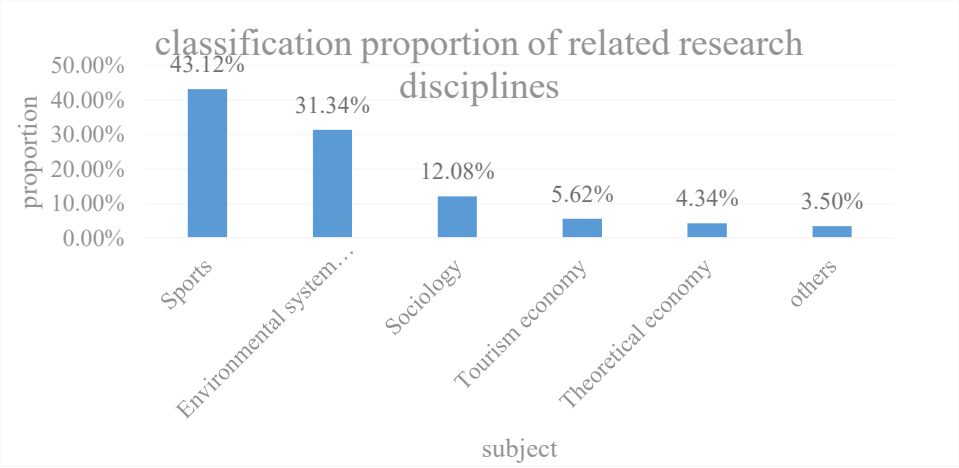

Figure 10. The proportion of China's sports development and ecological environmental protection disciplines.

However, there are many disciplines that study the development of sports and ecological environmental protection in China, and relevant literature has made definite

contributions to the progress and development of this direction. **Figure 10** shows the classification proportions of China's sports development and ecological environment protection disciplines.

China holds the largest proportion of the distribution of disciplines studied in this field, followed by environmental systems engineering. However, on the whole, it has got out of the two disciplines of sports and environment, and the scope of research has expanded, involving sociology, tourism economics, theoretical economics and other disciplines. At the same time, the development of sports and ecological environment protection, as an emerging interdisciplinary subject, has a certain role in enriching and improving the speculative system by examining and understanding the application of multidisciplinary literature behind it.

(2) Visualization experiment of international sports development and ecological environmental protection research

The research object selected in this paper is the literature from countries other than China that conformed to all standard formats from 2010 to 2018. Valid data were screened and retained, with a total of 656 papers. The number of published papers from 2010 to 2018 is illustrated in **Figure 11**.

Figure 11. The number of international publications from 2010 to 2018.

As can be seen from **Figure 11**, the overall trend of international sports development and ecological environmental protection has fluctuated greatly. From 2010 to 2012, this stage belonged to the "small peak" of the number of publications; from 2013 to 2018, during the five-year period of this stage, the tendency of publishing articles showed an obvious upward trend. Especially after 2015, the trend of publishing articles has reached a peak, and is greatly influenced by factors such as the Olympic Games and large-scale events.

At the same time, according to statistics, the national distribution of worldwide sports development and ecological environmental protection research is shown in **Figure 12**.

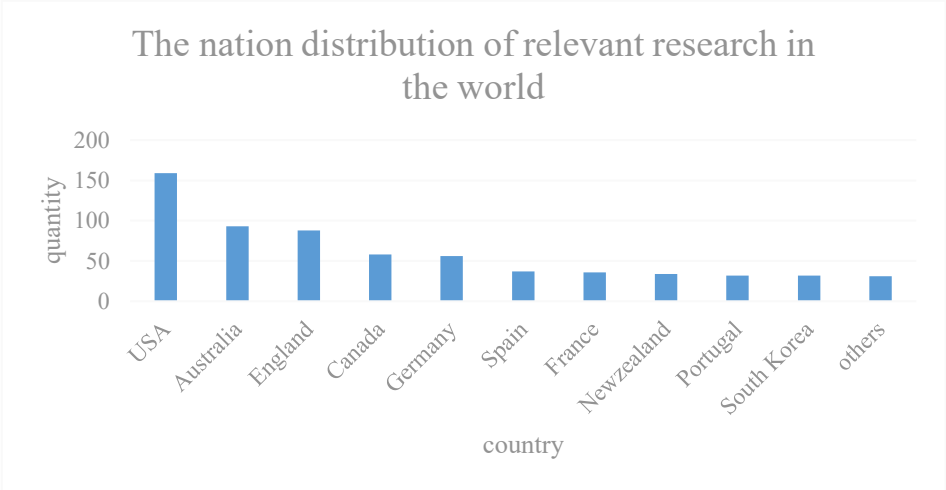

Figure 12. National distribution of international sports development and ecological environmental protection research.

As can be observed in **Figure 12**, the USA (the United States), Australia, and England (the United Kingdom) are among the top three countries in which the international sports development and ecological environmental protection research literature is published. Among them, the United States has the largest number of publications, which has opened a huge gap with Australia and the United Kingdom, showing strong research strength. It is worth mentioning that European countries represented by France, Germany and Spain and American countries dominated by Canada and Brazil are affected to a certain extent by national geographical conditions, sports resources and environment and other factors.

Visualization research helps researchers understand and analyze data more intuitively through charts, graphs and other visual means, which is important for exploring the complex relationship between sports development and ecological and environmental protection. Through visualization research, the impact of sports activities on the environment and the importance of environmental protection to the sustainable development of sports can be clearly demonstrated.

4.2. Visual evaluation of sports development and ecological environmental protection evaluation

Through the data visualization analysis and comparison in the past ten years, the development of sports and related issues of ecological environmental protection have gradually attracted the attention and attention of the public. Scholars in various fields are deeply concerned about ecological environmental protection. Only by carrying out environmental protection can the sustainable development of human society be realized. The concept of sustainable development is assessed by more and more people, and there are more and more studies on this topic. Whether it is in the fields of sports, environment, sociology or economics, a large number of scholars have focused on research and discussion on its progress. At the same time, relevant factual hotspots would also affect people's enthusiasm for the research, such as the holding of the Olympic Games and the applicable policies promulgated by various countries. Under the visual analysis, a clear understanding and judgment of the pertinent data

and situations can be made. Due to the 2008 Beijing Olympic Games, the number of related studies in China has increased significantly in the following two years, and in the field of research, the proportion of sports and environmental engineering disciplines has reached as much as 70%, which has opened a large gap with other countries.

In-depth Statistical Analysis and Interpretation To further substantiate the preliminary visualization results, additional statistical analyses have been carried out. These analyses include regression models to understand the relationship between sports development and ecological outcomes, as well as time-series analysis to track changes over time. For instance, the correlation between the number of sports events and environmental impact indicators has been quantified using Pearson's correlation coefficient, revealing significant relationships that can inform future policy and management strategies.

The application of artificial intelligence technologies in sports development and ecological environmental protection brings many opportunities and is accompanied by some challenges. Through the rational use of these technologies, we can improve the effectiveness of sports training and competition, optimize the management of physical education, as well as protect our natural environment more effectively. However, we also need to face issues such as the high cost of technology application, personal privacy protection, and technological challenges such as algorithm optimization and updating. Only then will be unable to take full advantage of the benefits of AI technology while minimizing its potential negative impacts.

5. Conclusions

Through the visual research on the integration mechanism of sports development and ecological environmental protection, it can be understood that the distribution trend of hotspots from surface to point and from the whole to the part is developmental. The emergence of hot spots in different periods is closely linked to the development needs of the country and society. The evolution path of sports development and ecological environment protection mainly focused on development strategy research, sports tourism research, and sports environment research. From the perspective of economics, the research on the integrated development of sports culture and sports tourism was divided into four knowledge groups. This paper has the characteristics of multiple topics, multiple contents, multiple research perspectives, complex research methods, and refined research content. The stratification of research perspectives is becoming ever more prominent. The proportion of empirical and multicultural research is increasing. Research hotspots in different periods are closely related to domestic macro policies and major social events. Through the comparative analysis of sports development and ecological environment research hotspots, it can be seen that there are still some deficiencies in related research, including a single disciplinary perspective, a lot of repetitive research, lack of comparative research, insufficient argumentation, less specific research, insufficient research depth and breadth, insufficient research content, lack of systematic research content, lack of systematic research methods, etc. Therefore, this field still needs in-depth research and discussion.

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