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Article

Research on the Application of Intelligent Computing Methods in the Analysis of Sports Competitive Tactics in an Interdisciplinary Collaborative Environment

Hexia Wang *

School of Education, China University of Petroleum (Beijing), Beijing, 100049, China;
wang20252222025@163.com

Abstract: Traditional tactical analysis in competitive sports relies heavily on individual experience and event sensitivity, and lacks the full utilization of competitive event data. Relying on the inspiration of interdisciplinary synergistic ideas, tactical knowledge base and gray situation decision-making methods are mined in this study. Among them, the construction of the tactical knowledge base for sports and athletics is mainly accomplished through knowledge learning based on state space representation, and the acquired tactical knowledge representation states are presented into the tactical knowledge relationship knowledge base in a complete way with the help of mapping of domain ontology. The gray situation decision-making method, on the other hand, decides the theoretically optimal tactics for each tournament stage by abstracting the decision-making events in the knowledge states, and decides the tactics through situation measurement, measurement unification, and optimal ordering. In the study of a women's volleyball tournament, it was found that the frequency of "one attack" tactics in each stage of the tournament was as follows: strong attack (66.64%) > fast attack (18.53%) > three-dimensional attack (11.86%) > two attacks (2.97%). Gray decision-making calculates the effect measure of strong attack tactics corresponding to the win or loss in the previous game as (0.55875, 0.5085), which provides a visual reference for selecting tactics in each offensive round. The gray situation decision-making method built on a tactical knowledge base is powerful as an interdisciplinary and synergistic tool for strategic analysis of competitive tactics in sports.

Keywords: competitive tactical analysis; tactical knowledge base; gray situation decision making; state space representation; situation measurement

1. Introduction

Sports competition is a highly technical and tactical activity, and teams will adopt different tactical strategies. For athletes and coaches involved in athletics, it is important to better understand the rules of the game and the tactics of the opponents by deeply analyzing the tactics of sports competition, analyzing the strengths and weaknesses of the opponents as well as the main tactical ideas, and assisting the team in formulating countermeasures and adjusting tactics [1-4]. The flexible use of tactics can play a decisive role in the game, assisting participants to improve self-confidence and ease anxiety, make up for their own technical deficiencies, thus improving their own and team's competitiveness, and thus obtaining a higher winning rate and athletic performance [5-8]. In recent years, the increasingly intense competition in the sports arena and the diversified development of competitive tactics have urged the innovation of tactical analysis methods in order to accelerate the efficiency and effectiveness of analysis.

With the rapid development of science and technology, the field of sports competition has also ushered in unprecedented changes, from athlete training, game equipment to event broadcasting



technology, technological innovation is constantly promoting the digital transformation of the sports industry [9-11]. And tactical analysis, as an important part of sports competition, has become an important development direction of sports science and technology innovation. Intelligent computing, as a new type of computing technology, integrates computer vision, natural language processing, intelligent control, machine learning and other technologies to promote the development of technology to realize a new direction [12-13]. It is based on statistical knowledge and algorithms, simulating the method of human thinking to abstract and effectively express the characteristics of arithmetic, the limited information and buffer space to simulate the complex computing process, so as to realize intelligent computing [14]. Intelligent computing can effectively solve complex real-world problems, and in an effective way to improve the flexibility and reliability of computers in practical applications, improve the system's responsiveness to decision-making, provide more accurate information, more effective applications, and is widely used in various fields, the field of sports is one of them [15-18].

In modern society, in the face of complex and changing problems, single-discipline research and solutions are no longer sufficient to cope with them, and in order to adapt to new needs, interdisciplinary synergy has become an important trend in academic research and practice [19-21]. Interdisciplinary synergy aims to combine the knowledge and methods of different disciplinary fields to realize the integration and crossover between disciplines, so as to provide new solutions and innovative thinking. By integrating the knowledge and methods of different disciplinary fields with each other, interdisciplinary synergy can provide a new comprehensive research thinking and innovative methods, complement the shortcomings of single-disciplinary research, broaden research horizons, and enhance problem-solving capabilities and effects [22-25]. Literature [26] explored interdisciplinary research for the understanding of elite athletes' competitive performance and concluded that this approach is a promising method for exploring athletes' performance. Whereas literature [27] examined athletes through a multivariate interdisciplinary approach and found that interdisciplinary sport research was able to more accurately and comprehensively understand athlete game performance, identify individual differences, and quantify task performance from physiological-psychological and perceptual-cognitive motor test data. In the analysis of sports and athletic tactics, it involves the fields of athletic training, human science, kinesiology, psychology, and computer science, and the powerful comprehension of intelligent computational analytics has injected new momentum into tactical analysis.

Currently, intelligent computing-driven tactical analysis research is focused on various ball sports and has shown amazing results. In the field of soccer and basketball athletics, the soccer tactical analysis system proposed in literature [28] is enabled by intelligent computing, which can collect, query, and visually display tactical information with incomplete game information, and identify passing patterns to effectively analyze the dynamic evolution of soccer tactics. Literature [29] designed strategic analysis algorithms and visual recognition algorithms based on YOLOv5 and Markov chain model, which were realized based on a virtual reality platform, the platform through real-time monitoring of soccer players and the ball, analyzing the correlation between players' positions and movements, obtaining soccer tactical information, and combining tactical knowledge to assist players and coaches in generating confrontation tactics. Literature [30] analyzes soccer players and their tactics using an intelligent multi-criteria decision-making algorithm with fuzzy information. The algorithm analyzes team dynamics and overall tactical planning by identifying the roles, positions, and techniques of the players on the field of play. Literature [31] provides a machine learning model-driven model for analyzing and classifying one-on-one tactics in basketball, where the model automatically identifies changes in an athlete's defensive tactics and classifies defensive strategies for pass and cut plays. Literature [32] constructed a basketball defensive tactics analysis based on long and short-term memory networks and convolutional neural networks, respectively, using two network models to identify the characteristics of athletes' movements in time and space to classify basketball tactics such as switching and trapping.

In the field of table tennis competition, literature [33] designed a table tennis tactics recognition model using a back propagation neural network algorithm by calculating athlete tactics-related metrics and predicting athletes' scores in matches using the recognized tactics. Literature [34] shared a visual analysis system based on interactive graphics, embedding and dimensionality reduction algorithms, which can be used to analyze the tactics of multiple table tennis matches and compare these tactics to achieve a comprehensive tactical analysis of athletes. Literature [35] proposed an analysis system for table tennis techniques and tactics, which contains a module for collecting and managing match information based on MySQL database, a data processing module based on multi-conditional filtering and multi-conditional sorting, and a module for analyzing tactics based on data mining. Literature [36] combined image fuzzy edge recognition algorithm, target tracking and trajectory estimation methods to create a table tennis video tactical analysis platform, the platform based on the algorithm to effectively identify the characteristics of the players and the ball in the video, and based on the ball's speed of movement and the point of landing for tactical development.

In the field of tennis, badminton, and volleyball competition, literature [37] mined multivariate patterns from a large number of sequences by multivariate sequence pattern mining algorithms and introduced Saint-Gobain diagrams to achieve visual analysis of changing tactics and tactical processes in tennis competition. Literature [38] analyzed the tactics of two athletes in badminton sparring matches with the help of game tree, analyzed the strengths and weaknesses of the athletes, and predicted the tactics, and the introduction of Nash equilibrium could obtain the most favorable tactical strategy for the athletes. Literature [39] used an improved association rule mining algorithm to mine the tactical association rules of the athletes in the videos of multiple badminton matches, and obtained the tactical strategies of the athletes, which provided a reference for the athletes and coaches. Literature [40] designed a technical and tactical analysis system for volleyball matches under computer information technology, combining volleyball professional knowledge and related tournament data to conduct post-match tactical analysis as a way to optimize tactical strategies. Literature [41] designed a three-layer volleyball technical and tactical recognition model through artificial neural network, and the tactical analysis results of the modified model can achieve extremely close accuracy to the expert analysis results, and the average error is only less than 1%, which is in line with the training requirements.

In addition, literature [42] used deep learning for sprinting competitive training and competition data mining to extract data features and key information for evaluating sprinting tactics and improving sprinting skill performance based on tactical evaluation results. Literature [43] contributes a spatio-temporal relationship dynamic modeling method based on adaptive graph convolutional network and attention time convolutional network for extracting athlete interaction information of competitive tactics and team dynamics over long distances in sports videos for comprehensive tactical evolution analysis. Literature [44] points out that AI techniques are efficient and comprehensive for tactical analysis in sports, but emphasizes that AI-driven tactical analysis faces issues such as high analysis costs, dependence on large amounts of data for training, and technical ethics and privacy.

Interdisciplinary synergy breaks the pre-existing framework of tactical analysis in sports and various intelligent computational methods are introduced to provide more possible research ideas. In this paper, a gray situation decision-making method applicable to the analysis of incomplete information systems is selected to explore the feasibility of intelligent information computing in the study of sports event tactics. The research is prepared by first building a knowledge base for analyzing sports and athletic tactics. Collecting and organizing various index data of sports events, using state space representation to describe each tactical knowledge, constructing a domain ontology, and realizing the mapping of the tactical knowledge base. The tactical knowledge ontology is further extracted to form the event description of the situation. Based on the gray theory, measure the effect of each situation event, unify the measurements and finally filter out the optimal situation decision.

2. Construction of a knowledge base for tactical analysis of sports competitions

With the development of competitive sports, the research of technical and tactical analysis of competitive sports programs has been deepening, and the knowledge of technical and tactical analysis has been increasing and diversifying. The effective management of knowledge has become a bottleneck in the research of technical and tactical analysis. Before proposing an intelligent computing method applicable to the analysis of sports tactics, this paper first needs to build a relevant knowledge base of sports tactics based on the knowledge representation method.

2.1. State Space Representation

2.1.1. Status

A state is an ordered set of the least numbered set of variables q_0, q_1, q_2, \dots introduced to describe the differences between things in a given class. It is often expressed in vector form as follows:

$$Q = \begin{bmatrix} q_0 \\ q_1 \\ q_2 \\ \vdots \end{bmatrix} = [q_0, q_1, q_2, \dots]^T \quad (1)$$

It can also be expressed in the form of a multivariate group:

$$Q = (q_0, q_1, q_2, \dots, q_n, \dots) \quad (2)$$

Each of these elements q_i is a component of the set, called a state variable, and they all have a range

of values $[a_i, b_i]$. The number of components is called the dimension of the state, which can be finite or infinite. When a definite value is assigned to each component, a specific state is obtained.

2.1.2. Operations

The action that causes a change in state is called an operation. An operation can be a walk, a program, an action, a mathematical operator, etc., as long as it causes a change in the components of the state.

2.1.3. State space

The set consisting of all the states of a problem and all the operations that can be used is called the state space of the problem. It generally consists of three parts: the set S of possible initial states of the problem, the set F of operations, and the set G of goal states. It is expressed in terms of triples as follows:

$$ZT = \langle S, F, G \rangle \quad (3)$$

The graphical form of a state space is called a state space graph, where nodes represent states and directed edges (arcs) represent operators.

2.1.4. Solution of the problem

A sequence of operations α passed on this pathway is called a solution of the problem if it can reach the goal state G after a series of operations starting from the initial state S of the problem.

After understanding the above definition of state space, the general steps for solving a problem using a state space representation are as follows:

(1) Define the form of the description of the problem state, i.e., determine the components of the state, an independent component that represents the nature of a particular aspect of the problem.

(2) Represent all possible states of the problem and determine the initial and goal state set descriptions of the problem. Note that not all states are logically justified, and take care to remove those that are not.

(3) Define a set of operations such that the problem can be transformed from one state to another using this set of operations.

(4) Solve the problem by starting from the initial state, choosing an appropriate operation to act on it to produce a new state, choosing another appropriate operation to act on the new state,....., and so on until the resulting state is the target state. At this point, a solution to the problem is obtained, this solution is from the initial state to the target state through the sequence of operations; if the target state can not be reached, it means that the problem has no solution.

Thus, the problem solution can be formalized as a triple sequence element $\langle Q_s, \alpha, Q_g \rangle$. where Q_s denotes some initial state, Q_g denotes some goal state, and α denotes a finite sequence of operations that turn Q_s into Q_g . As:

$$\alpha = f_1, f_2, \dots, f_n \quad (4)$$

Then the problem is solved as:

$$Q_g = f_n \left(\dots \left(f_2 \left(f_1 \left(Q_s \right) \right) \right) \dots \right) \quad (5)$$

2.2. *Ontological mapping of competitive tactical knowledge in sport*

In the technical and tactical analysis of competitive sports, we often compare, analyze, and statistic according to various index data of sports, so as to derive some valuable information, which comes from the actual competition monitoring data, training monitoring data, and some physiological and biochemical test reports, etc. In order to facilitate the unified management and maintenance of the data, we have established a knowledge source system based on a database. In this system, data are available in various forms, such as WORD, EXCEL, PPT, PDF, and audio/video files. Although these original database systems can facilitate the collection and storage of knowledge documents, but there is a database system common deficiencies and shortcomings, that is, through a large number of knowledge documents to find out the intrinsic links embedded in the knowledge documents, but also through some of the cyclical factual data to get a certain law and predict the results, in a word, is the lack of existing

knowledge again extracted and utilized functions, and these But our knowledge document researchers are the most important things, so the proposed knowledge base system. Knowledge base is a collection of structured and easy-to-use knowledge pieces in knowledge engineering, which is used to store, organize, manage and use the knowledge pieces in computer by adopting knowledge representation for the solution of a domain problem. These knowledge slices include theoretical knowledge related to the domain, factual data, and heuristic knowledge based on the experience of domain experts, such as relevant definitions, theorems, and common sense of a domain. The management and storage of all these knowledge slices require a unified format, which should be conducive to both knowledge expression and knowledge extraction and reasoning, which is a major difficulty in the establishment of knowledge base - knowledge representation.

Domain ontology puts forward a set of vocabularies that can be used to express and communicate domain knowledge at the domain conceptual level, as well as the relationship between the vocabularies, which has strong conceptual semantic expression and knowledge expression ability. Knowledge representation based on domain ontology can be a good solution to the problem of unified expression and semantic analysis of domain knowledge. Here, we will continue to study how to associate the knowledge sources stored in the database with the domain ontology, i.e., use the ontology to unify the knowledge representation.

Relational database is mainly divided into two main parts, i.e., relational schema and relational data, relational data adopts two-dimensional relations to represent schema and data, and describes the association rules between data through the database's paradigm design, integrity constraints and so on. Domain ontology contains ontology classes and ontology instances, and describes relationships between data through relationships between ontology classes and class attributes and value domain constraints, and adding attribute constraints does not follow a paradigm like the database schema. We categorize the database ontology mapping process into two main processes, namely, ontology class and attribute mapping for the relational schema and ontology mapping process for the database instances. The processes are shown in Figure 1.

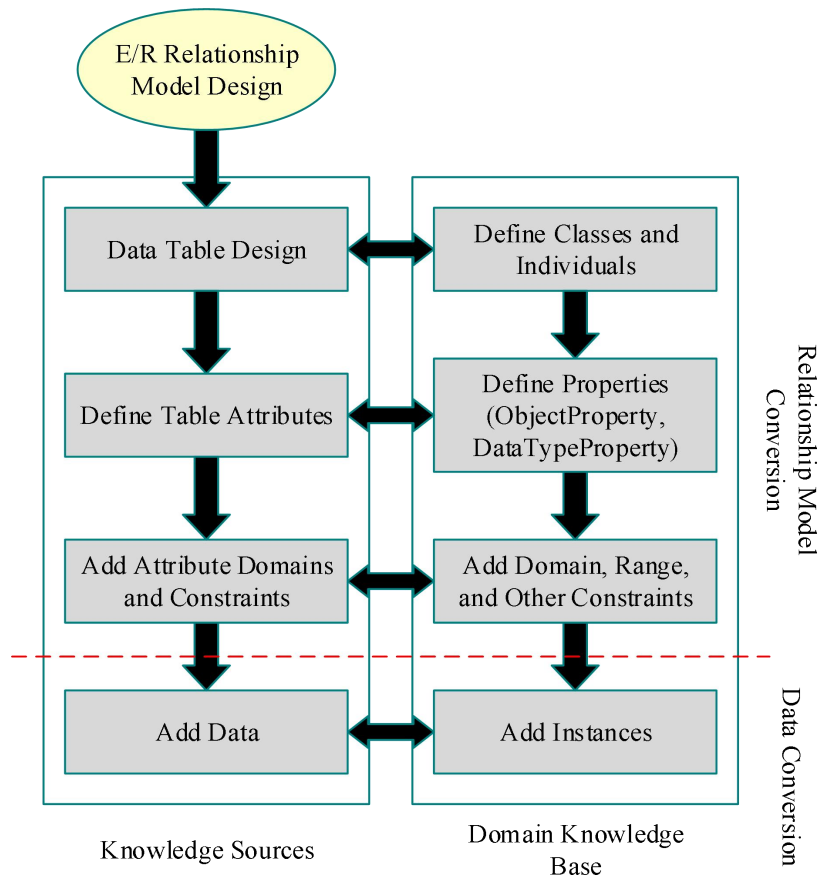


Figure 1. The correspondence between relational databases and domains.

3. Tactical analysis of competitive sports based on gray situation decision-making

The above completes the design and construction of a knowledge base of competitive sport tactics, on which the core of this research can be developed. That is, to explore the application of gray situation decision analysis method in tactical planning in competitive sports.

3.1. Basic framework for decision-making in gray situations

Decision making means: an event occurs, many responses are considered to deal with it, different responses have different effects, and then some kind of objective (or objectives) is used to measure them. From these responses, the one with the best effect is selected. The four elements of decision making are:

- (1) Event a_i , something that needs to be dealt with.
- (2) Response b_j , a measure to deal with something.
- (3) Effect r_{ij} , the result of dealing with an event with a certain response.
- (4) The goal p_i , the criterion for evaluating the effect in terms of events.

The binary combination of events and countermeasures is called a situation, noted as $S_{ij} = (a_i, b_j)$, and each situation has one or more effects r_{ij} , and the situation decision-making is the decision-making under the premise of the unity of the events, countermeasures and effects. When the event, countermeasures quantified, according to the event topology and countermeasure topology constitutes an even pair of decision-making, known as gray situation decision-making. When making countermeasures, the decision that has multiple objectives to be considered is called multi-objective decision-making.

Gray situation decision-making can generally be carried out in the following steps:

- (1) Synthesize events and countermeasures.
- (2) Compose the situation.
- (3) Give the objectives.
- (4) Give the whitening values for different targets.
- (5) Calculate situation effect measures for different goals.
- (6) Reduce the many-goal problem to a single-goal problem.
- (7) Select the best situation according to the best effect and make a decision.

3.2. Process steps for decision-making in gray situations

Gray situation decision-making method is an important part of the gray theory system, which is a scientific decision-making under multiple countermeasures, multiple objectives and multiple times, and refers to the decision-making model that contains gray elements, or the decision-making under the condition of the combination of ordinary decision-making model and gray model. Decision-making is the process of selecting the optimal among many measures based on a specific event, generally containing four objectives: event, countermeasure, effect and process, where the binary combination of event and countermeasure is defined as a situation. Taking the gray environment as the background is the premise of the gray situation decision-making method, and according to the gray generation method, the optimal decision is finally obtained by analyzing the effect measurement of the data columns containing randomness.

3.2.1. Effectiveness measurement

Definition: let M_{eff} be the transformation, u_{ij}^p be the sample of the effect of the situation s_{ij} under the P goal, and r_{ij}^p be the image of u_{ij}^p under M_{eff} .

$M_{eff} : u_{ij}^p \rightarrow r_{ij}^p$, M_{eff} is said to be an effect measure transformation or effect transformation when r_{ij}^p has positive polarity and is in the interval $[0, 1]$ and r_{ij}^p is the situation s_{ij} out of the effect measure under the target P . If u_{ij}^p exhibits positive polarity, M_{eff} is called the upper limit effect measure transformation; if u_{ij}^p exhibits negative polarity, M_{eff} is called the lower limit effect measure transformation; and if it exhibits median polarity, M_{eff} is called the moderate effect measure Transformation.

Let M_{eff} be the effect measure transformation, u_{ij}^p be the positive polarity effect sample, and r_{ij}^p be the image of u_{ij}^p under M_{eff} , then the formula for the maximal value target transformation is:

$$M_{eff}(u_{ij}^p) = r_{ij}^p = \frac{u_{ij}^p}{\max_{ij} \max u_{ij}^p} \quad (6)$$

Let M_{eff} be the effect measure transformation, u_{ij}^p be the negative polarity effect sample, and r_{ij}^p be the image of u_{ij}^p under M_{eff} , then the minimal-value target transformation formula is:

$$M_{eff}(u_{ij}^p) = r_{ij}^p = \frac{\min_{ij} \min u_{ij}^p}{u_{ij}^p} \quad (7)$$

Let M_{eff} be the effect measure transformation, u_{ij}^p be the mid-polarity effect sample, and r_{ij}^p be the image of u_{ij}^p under M_{eff} , then the median target transformation formula is:

$$M_{eff}(u_{ij}^p) = r_{ij}^p = \frac{\min\{u_0, u_{ij}^p\}}{\max\{u_0, u_{ij}^p\}} \quad (8)$$

Where: u_0 is the moderate value.

3.2.2. Harmonization of measurement

One of the effect transformation functions is the transformation that unifies effect samples u_{ij}^p of different polarities into r_{ij}^p having the same polarity. The totality of r_{ij}^p is defined as a polarity-consistent space, and, moreover, effect measures of the same situation are arithmetically operable in the polarity-consistent space.

Let r_{ij}^p be the effect measure of the situation s_{ij} under the objective. If $P = 1, 2, \dots, l$, then r_{ij}^Σ is said to be a uniform effect measure for s_{ij} :

$$r_{ij}^\Sigma = \frac{1}{l} \sum_{p=1}^l r_{ij}^p \quad (9)$$

3.2.3. Optimal situation

If $r_{ij}^{\Sigma*} = \max_j r_{ij}^\Sigma$, $r_{ij}^{\Sigma*} \Rightarrow s_{ij}^* = (a_i, b_j^*)$, then s_{ij}^* is said to be a satisfactory situation for a_i and b_j^* is a satisfactory response for a_i .

4. Tactical Knowledge Base Testing and Gray Decision Making Practice in Competitive Sports

4.1. Learning Validation of Tactical Knowledge Base

In this section, information is provided on the FB15K-237 and WN18RR datasets used in the experiments. The FB15K-237 dataset information is mainly derived from entities and relations from Freebase, a classical knowledge graph with an extremely large source of information, whereas FB15K-237 is a pruned version of the FB15K dataset that removes duplicates and inverse relations to prevent direct prediction. In addition, FB15K-237 also ensures that the triples (H, R, T) in each valid and test set do not have any direct connections (H, R, T) in the training set, making prediction more challenging. WN18RR is derived from Word-Net, a lexical database of semantic relations between words. Similar to FB15K-237, WN18RR is a pruned dataset from WN18 by removing duplicates and inverse relationships, whereas there is no direct linkage restriction in WN18RR. Since the same dataset is

used, the experimental results of several baseline models are directly replicated here for comparison, and the comparison results are shown in Table 1.

The comparison models were chosen from two categories that were translational distance models: the TransE, RotatE, and PaiRE. Semantic matching models: DistMult, ComplEx, TuckER, ConvE. And the results of the five indicators of MRR, MR, H@1, H@3 and H@10 of different models were obtained respectively to compare and analyze with the model designed in this paper. The following conclusions can be obtained through the comparison:

(1) Given the five metrics for both datasets, the model in this paper achieves 7 out of 10 SOTAs, which is the best performance overall compared to the baseline. And for the exceptions in the MR report of WN18RR, the model designed in this paper still achieves competitive results on most baselines.

(2) Our model is compared to CopGCN, which is a typical GNN-based KGE model. This suggests that the semantic information and the aggregation function of graph neural networks are a more adequate approach for modeling the three levels of semantic information, allowing more precise access to the embedding information.

Table 1. Performance Comparison of Knowledge Representation Models.

Model	FB15K-237					WN18RR				
	MRR	MR	H@1	H@3	H@10	MRR	MR	H@1	H@3	H@10
TransE	0.353	210	0.194	0.334	0.497	0.266	5542	0.136	0.454	0.519
RotatE	0.421	151	0.238	0.222	0.525	0.102	3107	0.057	0.291	0.481
PaiRE	0.29	143	0.206	0.291	0.43	0.149	3162	0.217	0.519	0.403
DistMult	0.437	168	0.272	0.232	0.488	0.199	3075	0.137	0.344	0.422
ComplEx	0.441	161	0.248	0.38	0.517	0.276	2252	0.212	0.349	0.436
TuckER	0.39	192	0.285	0.347	0.431	0.128	2658	0.045	0.402	0.511
ConvE	0.187	212	0.299	0.422	0.611	0.187	4126	0.064	0.46	0.508
CopCGN	0.412	146	0.252	0.315	0.425	0.18	4457	0.295	0.414	0.613
Ours	0.486	180	0.298	0.472	0.658	0.279	3892	0.293	0.524	0.62

4.2. Gray Situation Decision Making Use of Tactics in Competitive Sports

This paper selects the data of women's volleyball matches in various stages of an official tournament to build a tactical knowledge base. This chapter takes the "first attack" tactics in women's volleyball games as the research object, and explores the effect of the gray situation decision-making method in practice.

4.2.1. Tactical utilization statistics

This paper analyzes and researches the game according to different stages of the game, and strives to come up with the optimal first attack tactics in different stages of the game. The statistics of "first attack" tactics in different stages of the tournament are shown in Table 2. The results of the chi-square test for the utilization rate of different tactics are shown in Table 3. As the most common attacking tactic, "strong attack" was the most frequently used tactic in all stages of the tournament. The order of the frequency of the use of each competitive tactic in the four tournament stages was as follows: strong attack (66.64%) > fast attack (18.53%) > three-dimensional attack (11.86%) > two attacks (2.97%).

Table 2. "one-on-one attack" tactic at different stages.

	Assault		Quick attack		Two attacks		Three-dimensional attack	
	N	%	N	%	N	%	N	%
Group stage	2136	62.46	342	65.64	152	67.86	144	70.59

Quarter-finals	745	21.78	95	18.23	38	16.96	35	17.16
Semifinals	58	1.7	21	4.03	5	2.23	8	3.92
Finals	481	14.06	63	12.09	29	12.95	17	8.33

Table 3. Chi-square test for the usage rates of different tactics.

	Assault	Quick attack	Two attacks	Three-dimensional attack
Group stage-Quarter-finals	0.541	0.287	0.388	0.127
Group stage-Semifinals	0.613	0.118	0.742	0.54
Group stage-Finals	0.525	0.382	0.578	0.519
Quarter-finals-Semifinals	0.342	0.382	0.406	0.524
Quarter-finals-Finals	0.452	0.265	0.278	0.646
Semifinals-Finals	0.213	0.292	0.202	0.497

Even though the proportion of “one attack” tactics used varies in different stages of the game, the chi-square test shows that there is no significant difference in the utilization rate of strong attack, fast attack, two attacks and three-dimensional attack among the four stages of the women's volleyball game, indicating that there is no significant difference in the selection of “one attack” tactics between different stages of the game. This indicates that the tactical choices of “one attack” between different stages of the game are relatively stable and there is no significant difference in the choice of tactical play.

4.2.2. Case Study on the Effectiveness of Individual Tactical Utilization

A case study was conducted to analyze the most frequently used “power play” tactics in different phases. The statistics of the effectiveness of the power play in each stage of “one attack” are shown in Table 4. In the group stage, a total of 2273 strong attack tactics were used, of which the proportion of the effect of being prevented was the highest, and the rest of the effect of the proportion of the following in descending order: buckle dead > hitter out of bounds > buckle lost > blocked back > blocked dead. In the quarter-final stage, a total of 368 strong attack tactics were used, in which the proportion of effect of being prevented was the highest, and the rest of the proportion of effect, in descending order, was as follows: death by deduction > out of bounds by the batter > loss of deduction > blocked back > blocked to death. In the semi-final stage, the proportion of the effect of being defended up was the highest, and in the final stage, the proportion of the effect of being defended up was still the highest among all the indicators of the effect of offense.

Table 4. The application of strong offensive tactics in each stage of "one attack".

		Group stage	Quarter-finals	Semifinals	Finals
Lock down	N	545	98	33	25
	%	23.98	26.63	20.63	18.52
Foul out of bounds	N	358	44	26	20
	%	15.75	11.96	16.25	14.81
Blocked up	N	918	144	53	50
	%	40.39	39.13	33.13	37.04

Fouled back	N	163	26	19	21
	%	7.17	7.07	11.88	15.56
Foul lost	N	176	35	22	16
	%	7.74	9.51	13.75	11.85
Blocked dead	N	113	21	7	3
	%	4.97	5.71	4.38	2.22

The chi-square test for the effect of using the power play in the “first down” is shown in Table 5. After the chi-square test, there is no significant difference between the group stage, quarterfinals, semifinals and finals in the same effect of the use of strong offense tactics in the “one attack”, which can be shown that the four stages of the game with each other in the “one attack” in the use of the strong offensive effect is comparable, there is no significant difference. There is no significant difference between the four stages of the tournament in terms of the same effect of using the power play in the “first down”.

Table 5. Chi-square test for evaluating the effectiveness of aggressive tactics.

	Lock down	Foul out of bounds	Blocked upv	Fouled back	Foul lost	Blocked dead
Group stage-Quarter-finals	0.328	0.227	0.791	0.411	0.654	0.449
Group stage-Semifinals	0.386	0.52	0.619	0.461	0.798	0.355
Group stage-Finals	0.298	0.573	0.234	0.556	0.299	0.341
Quarter-finals-Semifinals	0.49	0.215	0.42	0.574	0.875	0.817
Quarter-finals-Finals	0.632	0.293	0.432	0.383	0.669	0.73
Semifinals-Finals	0.242	0.871	0.412	0.381	0.808	0.812

4.2.3. Effectiveness of decision-making in gray situations

The above data results show the characteristics of the situation in the women's volleyball game, and next, the gray situation is used to calculate the whitening value under the decision-making goal of the sample. The whitening values of each attack method in the “first attack” phase are shown in Table 6. The values in the table represent the expected values of the application effect under different attack methods. For example, in the current situation, the expected whitening value for the application of the strong attack tactic is 415, which is a certain risk.

Table 6. The white-out values of each attack method in the "attack" stage.

	Assault	Quick attack	Two attacks	Three-dimensional attack
Lock down	415	662	-89	1067
Foul out of bounds	1133	695	665	148
Blocked up	463	776	123	1054

Fouled back	710	690	558	670
Foul lost	217	197	271	258
Blocked dead	734	634	1018	1063

Accordingly, the gray situational decision-making method was applied to the calculation of the final tactical effects, and the measures of the effects of different tactical uses were obtained as shown in Table 7. Table 7 gives the situation effect measures of using the corresponding tactics again after the last attack victory or defeat, and each number reflects the predicted effect of executing the offensive tactics at different stages of the tournament. Further calculations show that the situational effects of performing a strong, fast, secondary, and three-dimensional offense in the case of an overhand win or loss are, in order, (0.55875,0.5085), (0.56125,0.606), (0.66825,0.454), and (0.831,0.55225). The optimal tactics for each phase in real time can be determined by combining the measurement spaces.

Table 7. Measurement of the effectiveness of different tactics.

	Assault		Quick attack		Two attacks		Three-dimensional attack	
	Win	Loss	Win	Loss	Win	Loss	Win	Loss
Group stage	0.138	0.34	0.523	1	1	1	0.899	0.165
Quarter-finals	0.395	1	0.604	0.411	0.275	0.566	1	0.694
Semifinals	1	0.363	1	0.703	0.871	0.117	0.604	1
Finals	0.702	0.331	0.118	0.31	0.527	0.133	0.821	0.35

5. Conclusion

This paper constructs a complete scheme for analyzing and making decisions on sports and athletics tactics by integrating tactical knowledge base and gray situation decision-making. In practical application, it is found to have a clear and concise analysis process and significant and effective decision-making effect. The tactical knowledge base can fully explore the full range of data of sports training and competition, and realize the integration of unstructured data into domain ontology knowledge, providing the basis for scientific quantitative analysis. Gray situation decision-making effectively abstracts the complex data and builds a set of explicit tactical analysis and decision-making process through intelligent calculation methods.

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