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# Design and Implementation of Beach Sports Big Data Analysis System Based on Computer Technology

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**ABSTRACT**

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Applying computer technology and data mining technology in sports field plays an important role in improving the training effect and competition level of athletes. This paper focuses on the design and implementation of the beach volleyball big data analysis system based on computer technology. Using computer as the data collection and analysis platform, it adopts the sorting prediction algorithm and the Markov-based data mining algorithm to predict the cooperation success rate in the beach volleyball match and to search for key action transfer processes. The paper designs and implements a beach volleyball big data analysis system based on computer technology, and experimental results have verified the effectiveness of the data mining algorithm in beach volleyball matches. This study provides a scientific basis for coaches to formulate reasonable beach volleyball training programs and tactical decisions, which is of certain practical significance.

**ADDITIONAL INDEX WORDS:** *Beach volleyball, computer technology, data mining, system design and implementation.*

## INTRODUCTION

In recent years, with the gradual improvement of people's material living standards, the national fitness movement has become more popular around the world, and the sports industry has also flourished accordingly. The rapid spread of computer information technology has caused great changes in people's production and lifestyle. The data volume of various sports events is growing rapidly, and only a small part of the data is needed by sports training and development. Therefore, the mining and analyzing of sports big data through computer information technology has become the focus of research and common concern in the computer field and the sports field.

Beach volleyball originated in the United States in the 1920s and then passed to France through the Atlantic Ocean. In the 1950s, beach volleyball had been widely spread (Michalopoulou *et al.,* 2005). The first beach volleyball championship was held in the United States in 1976, and the International Volleyball Federation officially established the World Beach Volleyball Federation in 1988. Since 1993, beach volleyball had been accepted as an event in Olympic Games officially (Yiannis, 2008). Beach volleyball started late in China. It had been included in the National Games since 1997. Chinese men's beach volleyball team won the Asian Games in 1998 (Palao and Ortega, 2015), and Chinese women's beach volleyball team is also among the best in the world. Although the potential of beach volleyball in China is huge and the performance is on the rise, the performance fluctuates greatly and is not stable enough. When encountering new opponents in the game, or their understanding of the opponent's strategy is insufficient, the chance of winning is greatly reduced (Gissane *et al.,* 2002). Using computer to mine and analyze the big data of beach volleyball matches enables us to better grasp the status, changes and laws of the strategies during the match, investigate the advantages and disadvantages of the opponents, understand the technical status of our team members and the effects of the strategies of our team and the opponents, so as to provide important and scientific basis for the coaches to formulate scientific training plans and rational strategies for the game (Koch *et al.,* 2010). The main task of data mining is to discover the patterns hidden in the data. Classification and prediction are the two main contents for the discovery of the patterns. According to different pattern characteristics, they can be divided into classification pattern, association pattern, clustering pattern and regression pattern. The video locating technology can be used to accurately retrieve and locate the game video in real time, and the video frames can be enlarged to observe the event more clearly and to better analyze the tactical actions. The work of using computers to collect and store sports data can be traced back to 1976 (Lames and Hansen, 2001). Sound control ball game field technology statistical system, sound control volleyball statistical computer system, and other speech recognition technologies could collect sports data, but they have higher requirements on environment, the sound of speech, and the speed of the speech, so their practical application has certain limitations (Marques *et al.,* 2016). Currently, in foreign countries, the application of computers in the sport matches and trainings is relatively mature, the Volleyball Information System (VIS) launched by the International Volleyball Federation, and the Swiss-devel-

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oped professional sports video analysis software DartFish have been widely used (Liao, Chen, and Hsu, 2009). Most of China's volleyball technology statistical software were developed based on foreign software, they are mainly used for general technical statistics, and are unadvanced in terms of interface design and use functions (Bonidia, Brancher, and Busto, 2018). Moreover, there's no ready-made software for beach volleyball technical statistics.

Based on the above analysis, this paper takes computer as the data collection and analysis platform, introduces the data mining theory, and studies the design and implementation of the beach volleyball big data analysis system based on computer technology. The application of the sorting prediction algorithm and the Markov data mining algorithm in beach volleyball is analyzed, on this basis, the objectives and the functions of the system are analyzed, and the design and implementation of the main modules of the system is introduced in detail. The experimental results verify that the data mining algorithm is effective and can accurately realize the functions of video retrieving and locating.

## APPLICATION OF DATA MINING ALGORITHM IN BEACH VOLLEYBALL

### Application of Data Mining Algorithm in Beach Volleyball Based On Markov Process

#### (1) System analysis model based on Markov process

Assume a system X is composed of N ($C_1$, $C_2$, ..., $C_N$) components and conform to the Markov process. At different times, T is in different states X(T)=$C_i$, $(X, T) = \{C_i, T_j, i = 0, 1, \cdots N, j = 0, 1, \cdots K\}$ is used to represent the random behavior of the system, and its reliability is (Domínguez-Romero *et al.,* 2013):

$$\begin{pmatrix} R_{1n} \\ R_{2n} \\ \cdots \\ R_{3n} \end{pmatrix} = \begin{pmatrix} Q_{11} & Q_{12} & \cdots & Q_{1n} \\ Q_{21} & Q_{22} & \cdots & Q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ Q_{n1} & Q_{n2} & \cdots & Q_{nn} \end{pmatrix} \begin{pmatrix} R_{1n} \\ R_{2n} \\ \cdots \\ R_{3n} \end{pmatrix}$$

$$or \quad R_{ij} = Q * R_{ij} \tag{1}$$

$$Q_{ij}(t) = P_{ij} * Ri(t) \tag{2}$$

#### (2) Data mining algorithm based on Markov process analysis model

The change of $Q_{ij}$ will affect the reliability of the system. Therefore, data mining is required to determine the influence of the change of the system transfer rate on the reliability of the system, and the sensitivity of reliability to transfer rate can be analyzed by reliability difference (Schnitzler *et al.,* 2013). Therefore, assume the reliability of the system state X(T) is $R_{ij}$, the conversion rate is $Q_{ij}$, and the system reliability difference (Zetou *et al.,* 2008) is:

$$R(Q_{ij})$$

$$\Delta R = R(Q_{ij} + \Delta Q_{ij} - R(Q_{ij})) \tag{3}$$

Assume that the system X(T) satisfies the Markov process, then there is:

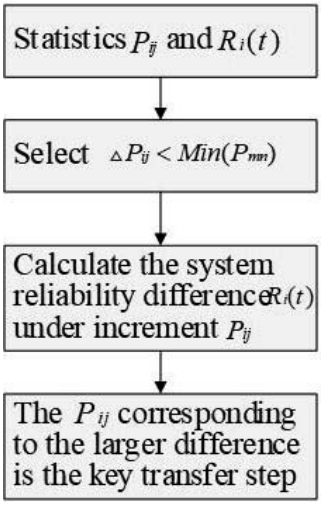


Figure 1. Algorithmic steps for using markov process to mine key transfer probability.

$$\Delta R(Q_{ij}) = A\Delta Q_{ij} \tag{4}$$

A is a constant, according to Formula (2), the transfer increment can be set by adjusting $P_{ij}$ and Ri(t).

Assume the reliability and transfer probability from state i to state j are Ri(t) and $P_{ij}$, respectively; when $P_{ij}$ remains unchanged, $\sum_{i \neq 1}(Q_{ij} \leq R_i(t) \leq 1)$; the transfer increment $P_{ij} \leq Min(P_{mn}), m \neq i, m \neq i$. In addition, assume $F_i(t)$ is the failure probability of state i, and $0 \leq R_i(t) \leq F_i(t)$.

Figure 1 shows the algorithmic steps for using Markov process to mine key transfer probability $P_{ij}$when $R_i(t)$ remains unchanged (Tilp, Wagner, and Müller, 2008).

Figure 2 shows the line graph of the reliability difference obtained via data collection and analysis of 2008 Beijing Olympics beach volleyball matches, it can be seen from the figure that the transfer process from attack to defense is the key link for the scoring of the whole match. If the first passer plays well, the team may win the game. Judging from the actual situation, the prediction results are correct and effective.

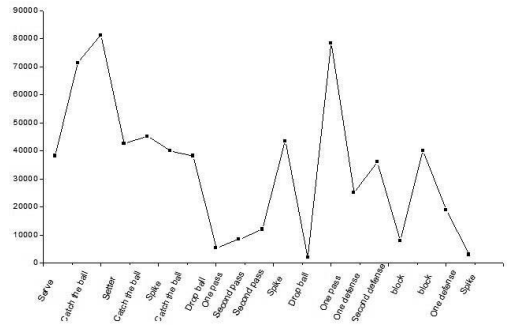


Figure 2. Reliability difference.

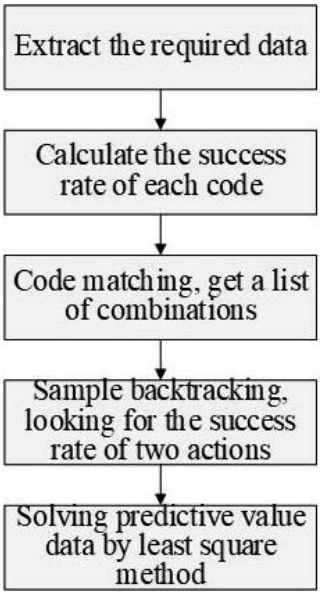


Figure 3. Key steps for applying sorting prediction algorithm in beach volleyball.

### Application of Sorting Prediction Algorithm in Beach Volleyball

The Least Squares (LS) theory was proposed by the French mathematician Legendre in 1806 and is a commonly used method in mathematical statistics. Usually, the LS method is used to measure the adjustment value of the observation data (Giatsis and George, 2003). In a beach volleyball match, the combination of second pass/spike and the combination of spike/block are crucial to the scoring and winning of the game (Gudmundsson and Horton, 2017). The prediction technology could provide relevant technical support for the system users. Figure 3 shows the key steps for applying sorting prediction algorithm in beach volleyball.

## DESIGN AND IMPLEMENTATION OF BEACH VOLLEYBALL BIG DATA ANALYSIS SYSTEM BASED ON COMPUTER TECHNOLOGY

### System Design Objective

This system is a platform constructed for sports data collection, management, statistics and analysis of beach volleyball matches, it provides strategic support for coaches in daily training and matches, and meanwhile, it facilitates the information management of athletes, teams and matches.

### System Module Function Division

According to the system design objective, the system can be divided into four major functional modules: information collection module, information management module, information analysis module and video playback module (Palao Manuel, Valades, and Ortega, 2012), as shown in Figure 4.

The match information collection module mainly collects the match tactics information through script input and mouse click, it provides important data for subsequent information analysis.

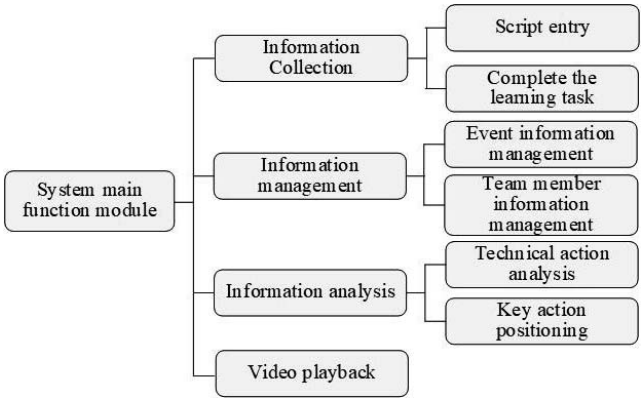


Figure 4. Main system function modules.

The main functions of the information management module include maintaining basic information of matches; adding, modifying and deleting team member information; updating and querying of match results, *etc*.

The main functions of the information analysis module include real-time statistical analysis of the technical information of the match, and locating key actions for analysis.

The main function of video playback module is to provide located playback of the game video. The operator can playback the video according to the key motion locating time provided by the information analysis module.

### Implementation of Main System Functional Modules

#### (1) Information management module

The information management module includes the match basic information management interface, the score management interface, and the player information interface, and it can realize functions of information adding, modifying, and deleting. Figure 5 shows the match information management interface. Users can add, maintain, save or submit the name,

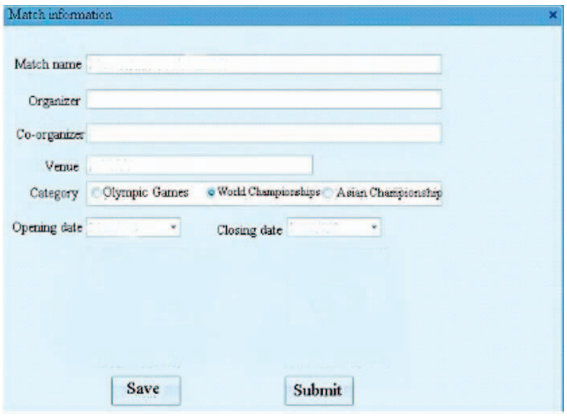


Figure 5. Match basic information management interface.

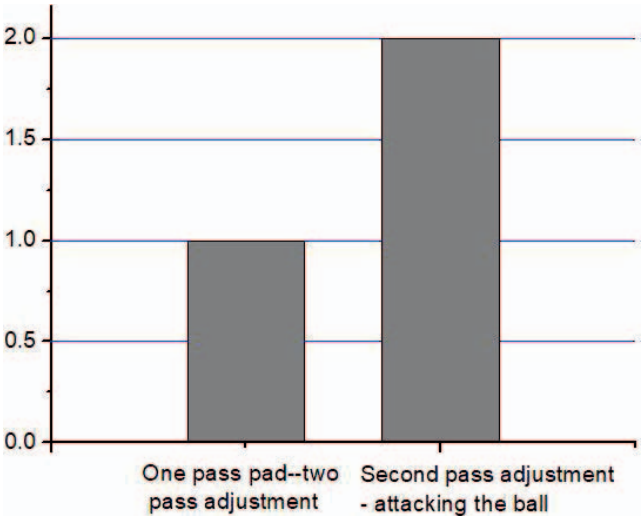


Figure 6. Analysis result of key transfer steps for scoring.

category, venue, opening date, closing date and other information of the match, so that the match information could be queried in the future.

### (2) Information analysis module

The stored and recorded data of the beach volleyball matches will be analyzed by the information analysis module. Through data mining, the data information required by the users will be displayed in different categories, such as the success rate of players, technical analysis, and strategy analysis, etc. Figure 6 shows the analysis results of the key transfer steps for the scoring in a beach volleyball match. From the figure, we can see the key transfer steps of the scoring in a match is the "second pass adjustment => attack and spike". Figure 7 shows the technical statistics of a women's beach volleyball match.

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Spike

Succ. % Limit: 15.00%

| Rk | No | Name | Spikes | Faults | Shots | Total Attempts | Note |
|---|---|---|---|---|---|---|---|
| 1 | 12 | Zeng Chunlei | 20 | 3 | 14 | 37 | 54.05 |
| 2 | 18 | Fan Linlin | 11 | 5 | 6 | 22 | 50.00 |
| 3 | 4 | Hui Ruoqi | 14 | 8 | 13 | 35 | 40.00 |
| - | 9 | Yang Junjing | 5 | 3 | 6 | 14 | |
| - | 11 | Xu Yunli | 7 | - | 4 | 11 | |
| - | 2 | Mi Yang | 3 | - | 1 | 4 | |
| - | 10 | Shan Danna | - | - | 1 | 1 | |
| - | 6 | Chu Jinling | - | - | - | - | |
| - | 7 | Zhang Xian | - | - | - | - | |
| - | 8 | Wei Qiuyue | - | - | - | - | |
| - | 15 | Ma Yunwen | - | - | - | - | |
| - | 17 | Zhang Lei | - | - | - | - | |
| | | Others | - | - | - | - | |
| | | Total Team | 60 | 19 | 45 | 124 | 48.39 |

Block

Avg. by set

| Rk | No | Name | Kill Blocks | Faults | Rebounds | Total Attempts | Note |
|---|---|---|---|---|---|---|---|
| 1 | 11 | Xu Yunli | 7 | 7 | 1 | 15 | 1.40 |
| 2 | 9 | Yang Junjing | 2 | 5 | 6 | 13 | 0.40 |
| 3 | 4 | Hui Ruoqi | 2 | 3 | 1 | 6 | 0.40 |
| 4 | 2 | Mi Yang | 1 | 2 | 1 | 4 | 0.20 |
| - | 6 | Chu Jinling | - | - | - | - | |
| - | 7 | Zhang Xian | - | - | - | - | |
| - | 8 | Wei Qiuyue | - | - | - | - | |
| - | 10 | Shan Danna | - | - | - | - | |
| - | 15 | Ma Yunwen | - | - | - | - | |
| - | 17 | Zhang Lei | - | - | - | - | |
| - | 18 | Fan Linlin | - | - | - | - | |
| - | 12 | Zeng Chunlei | - | 6 | 1 | 7 | |
| | | Others | - | - | - | - | |
| | | Total Team | 12 | 23 | 10 | 45 | 2.40 |

Figure 7. Technical statistics of a women's beach volleyball match.

| Code | Description |
|---|---|
| 15.4yt | The 15th player passed the 4th district |
| 35.8ffh | The 15th player has a good blocking effect from the 3rd district. |
| 59.06rf | The 15th player scored from the 4th area |
| 65.4est | The 15th player has a poor attacking effect from the 4th area. |

Figure 8. Video locating.

### (3) Video playback module

In addition to the normal playing, fast-forward, and slow-motion playback of the match video, the video playback module can also automatically locate the analysis result of the data. For example, it can locate the time of key motions and scoring motions of a specific player during the whole match, as shown in Figure 8, by double clicking, it could realize located playback, as shown in Figure 9.

## CONCLUSION

This paper combined data mining technology with computer technology to study the design and implementation of beach volleyball big data analysis system based on computer technology. The specific conclusions are as follows:

The application of prediction algorithm and data mining algorithm based on Markov process in beach volleyball was analyzed, and its specific application and implementation were illustrated by examples.

Based on the data mining algorithm, this paper took computer as development platform, and divided the beach volleyball big data analysis system into four major functional modules: information collection module, information management module, information analysis module and video playback module.

Figure 9. Located video playback.

The paper analyzed and introduced the design and implementation of the three main functional modules of system information management module, information analysis module and video playback module in detail.

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