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ATHLETES' PHYSICAL FITNESS EVALUATION MODEL BASED ON DATA MINING

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Abstract. This study firstly introduces the design and implementation of a physical health monitoring bracelet and describes in detail how the bracelet collects multi-dimensional physiological data such as heart rate, step number and sleep quality of athletes. This paper then discusses the application of data mining algorithms in processing these data, including cluster analysis, classification and prediction models, to identify the key influencing factors of athletes' physical fitness. This paper uses the RFID anti-collision algorithm to improve the accuracy and efficiency of data acquisition, avoiding the error and delay that may occur in traditional methods. The practicability and validity of the model are verified by system simulation. The simulation results show that the model can accurately evaluate the athletes' physical fitness and provide real-time feedback and personalized training suggestions for the coaching team. This not only helps athletes improve their competitive performance but also prevents sports injuries during daily training.

Key words: Athletes' physical health; Physical health monitoring bracelet; Data mining; RFID anti-collision algorithm; System simulation

1. Introduction. With the rapid development of information technology, wearable devices have gradually integrated into People's Daily life. Especially in sports, they have provided unprecedented convenience for athletes' training and competition. In recent years, the physical health of athletes has become one of the hot spots of sports research, and wearable bracelets, as a convenient data collection tool, have played an essential role in this aspect. Previous studies have explored various ways to assess athletes' physical fitness. For example, literature [1] proposes an athlete fatigue evaluation method based on heart rate variability, which determines the fatigue state of athletes by analyzing their heart rate data, thus providing a basis for training adjustment for coaches. However, this method mainly focuses on a single heart rate index and fails to reflect the athlete's physical condition fully. With the progress of science and technology, physical health monitoring bracelets came into being. These bracelets can monitor several physiological parameters of athletes in real time, such as heart rate, blood oxygen saturation, sleep quality and so on. Literature [2] introduces the design and implementation of a multi-functional physical health monitoring bracelet, which integrates various sensors and can monitor the physiological indicators of athletes in real time. It transmits it via Bluetooth to a mobile device for analysis. The appearance of this bracelet provides convenience for the real-time monitoring of athletes' physical health. However, relying solely on the wristband to collect data is not enough. How to effectively process and analyze these data is the key. This requires the use of data mining technology. Data mining is a process of extracting useful information from large amounts of data, which can help us discover the patterns and trends behind the data. In athletes' physical health, data mining technology has many application prospects. For example, literature [3] used data mining technology to analyze the training data of athletes and found the key factors affecting athletes' performance, providing valuable reference information for coaches. Accuracy and completeness are critical when dealing with large amounts of data. Some scholars have introduced the RFID anti-collision algorithm. RFID is a wireless communication technology that can identify a specific target through radio waves and read the relevant data. The integration of RFID technology in the physical health monitoring bracelet can realize the simultaneous reading and data exchange of multiple bracelets, thus avoiding the problem of data conflict and loss. Literature [4] proposes an anti-collision algorithm based on RFID technology, which can effectively solve the collision problem in the process of multi-tag identification and improve the accuracy and efficiency of data reading. In addition to the above literature, many scholars have

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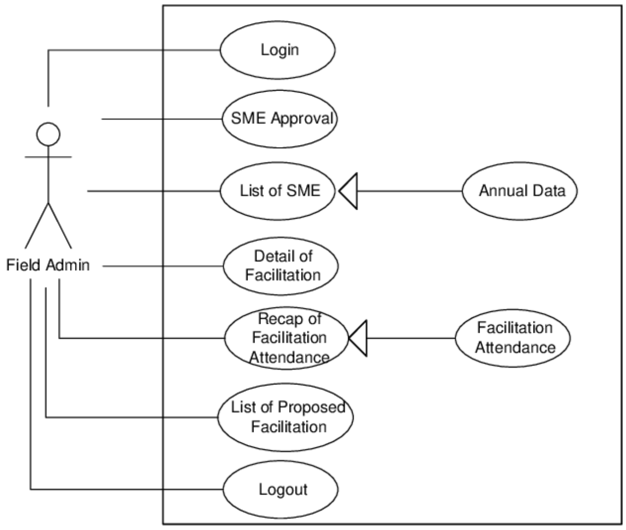

Fig. 2.1: Super Administrator function diagram.

conducted in-depth research on athletes' physical health, physical health monitoring bracelets, data mining and RFID anti-collision algorithms. For example, literature [5] discussed the relationship between athletes' physical health and sports injuries and put forward targeted preventive measures; Literature [6] studied the application of data mining technology in athletes' mental health assessment; Literature [7] gives a comprehensive review on the application of RFID technology in the field of sports.

This paper will start with the actual needs of athletes' physical health, combined with wearable bracelets, data mining and RFID anti-collision algorithms and other advanced technologies, to build a complete set of athletes' physical fitness data mining evaluation models [8]. The model will realize real-time monitoring, scientific evaluation, and personalized guidance of athletes' physical conditions, positively contributing to sports development in China.

2. Demand analysis and model architecture. The information network management model of physical education quality monitoring in colleges and universities is proposed based on data and network support. This paper introduces the computer-aided instruction system in the computer-aided instruction system. It includes test comparison, dynamic student interaction information collection and other functional modules [9]. The construction, release, implementation and feedback of the results of the system are introduced into the specific management mode. This provides a solid basis for formulating school sports plans and related policies.

2.1. Requirement Analysis.

2.1.1. Super Administrator. The super administrator has the most rights and is responsible for managing and assigning work to all administrators. Usually, the developer of the system is personally responsible. As shown in Figure 2.1, the super administrator's job is relatively easy, just adding, adjusting, and delegating tasks to lower administrators.

2.1.2. System Administrator. Since there are many job types of system administrators, there should be more people with system administrator rights. The system administrator is responsible for daily system maintenance, bug repair, student data proofreading, data backup, student file management, examination and statistics [10]. It can be manually repaired when an exception occurs or recovered if the student's login information is lost or forgotten.

2.1.3. Student users. This study takes students as the primary research object. It includes system login, test booking, personal information filling and modification, examination score inquiry, feedback verification, information submission and other modules.

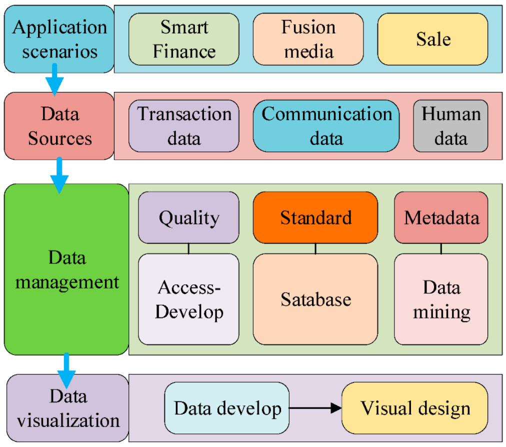

Fig. 2.2: Detailed architecture of the system.

2.2. System Architecture. The system adds a front end of physical fitness detection and acquisition devices. The three modules cooperate to complete the collection and storage of the module. The front end of the physical fitness testing device takes the measuring device as the main body to realize the field collection of students' physical fitness [11]. When the data is returned to the server, it is based on the specifications for body recognition [12]. The corresponding logical parsing is performed on the server, and then the parsing results are stored in the system's database. Publish information through the web in a unified standard. Its construction relationship is shown in Figure 2.2.

2.3. System hardware design. The bus control unit is the system's center, and other functional units are connected to the bus control unit. Each control unit works together to complete the functions required by the system. The MAX30100 microcontroller is used to detect human health. The LIS3DH three-way accelerometer is used as the communication module to obtain the acceleration. The communication module has 13.56Mhz passive RF electronic marking [13]. This machine adopts a 2.2V lithium-ion battery and a BQ24040 charger that can be charged with 5V. The screen uses organic light-emitting diodes to bend the screen. The Buzzer module adopts an active buzzer with an alarm function. P0.26 and P0.27 in the primary control component circuit U1 are connected to the XC1 pin, and the XC2 pin is connected to the 16/32 MHZ crystal oscillator to generate oscillation. U2 module, U4 module, U5 module, U8 module is the physical monitoring module, communication module, display module, buzzer module: power modules U6 and U7 supply power to the control module U1 through a voltage stabilization circuit. The pins SPC, SDI, SDO, and CS arranged by the mobile component U3 are successively connected with the pins P0.10, P0.11, P0.12, and P0.13 of the main control component UI so that information can be exchanged between the two components [14]. The communication component U4 is configured with different pins; pin 2 uses RF pins, and the output impedance is 50 ohms. No.1 and No. 11 are digital power supply pins that can be directly connected to the 3.3V working power supply, 27/28 is connected to the crystal oscillator circuit, which can stimulate the vibration frequency, 25,26,32 is connected to the central control module pins P0.14, P0.152, P0.16. This line realizes the data communication between the student's wristband and the teacher's terminal. This paper provides a contactless intelligent RFID identification tag, S50, which can improve the security of module operation and effectively resist external disturbance. The type S50 electronic marking comprises an RF interface and a digital controller [15]. Its memory is 1 KB. Each section has 16 blocks, and each block is 16 bytes. The buzzer module uses a Tereski-type integrated circuit connected to the central control component through the input and output pins. Under the adjustment of the central control unit through the low-level switch, the S8550 triode drives the internal oscillation source to achieve the purpose of alarm.

3. RFID anti-collision algorithm. Given the shortcomings of the existing monitoring methods, such as poor stability and poor real-time performance, this project intends to introduce the RFID collision avoidance method of equal partition to achieve optimal control of the human body and embed it into the smartwatch to improve its practicality [16]. Divide A picture into A segment with B as the number of marks to be identified. The matching probability is:

$$F(R=r)=Z_n^r\cdot\left(\frac{1}{\tau}\right)^r\cdot\left(1-\frac{1}{\tau}\right)^{n-r} \tag{3.1}$$

r is an integer and its value interval is $r\in[0,n]$. If it's $r=1$, then you get the odds of a match. The calculation formula for setting the initial time slot value $\delta_h^{\tau,n}$, $\delta_s^{\tau,n}$ and conflicting truth value $\delta_e^{\tau,n}$ is as follows:

$$\delta_h^{\tau,n}=\tau\cdot F_h=n\cdot\left(1-\frac{1}{\tau}\right)^{n-1} \tag{3.2}$$

$$\delta_s^{\tau,n}=\tau\cdot F_s=\tau\cdot\left(1-\frac{1}{\tau}\right)^{n} \tag{3.3}$$

$$\delta_\varepsilon^{\tau,n}=\tau\cdot F_e=\tau-\delta_h^{\tau,n}-\delta_s^{\tau,n} \tag{3.4}$$

Set the throughput rate of the system to D_{RFID} , and the ratio of the marks recognized by a frame identifier to the total number of time slots is:

$$D_{RFID}=\frac{\delta_h^{\tau,n}}{\tau}=\frac{n}{\tau}\cdot\left(1-\frac{1}{\tau}\right)^{n-1} \tag{3.5}$$

Figure 3.1 describes in detail the specific implementation process of the anticollision algorithm of the RFID system (the picture is quoted in Thinking about the Strategy and Practice Path of Modern Agricultural Industry Development in the context of Big Data).

If the number of marks is more than 354, grouping the marks into N groups by equal area is necessary. The signal is randomly selected in a specific time slot. The number of multiple labels was predicted by the DFSAC-II method. Optimize the time slot based on accurate data. When the tag is identified, the following tag identification process starts after the "+1" group, and the method does not end until all the tags have been tagged.

4. Experimental results and analysis.

4.1. Checking System Performance. The value range of the number of markers is set to [50,1500], and the initial value of the method is set to 256. Set the value of the method to 1500. The resulting average is the result [17]. The total number of time slots of the proposed algorithm, FSA_256 and DFSA algorithms change with increasing the number of tags (fig.4.1). The delay of the proposed algorithm increases with the increase in the number of tags. When the number of tags is 4912, it is reduced by 83.23% and 84.21% compared with FSA_256 and DFSA, respectively, which proves that the algorithm can effectively shorten the collision time and save the system identification time [18]. The change trend of system throughput is shown in Figure 4.2. The algorithm's delay increases with the increase in the number of tags. When the number of tags is 4912, it decreases by 83.12% and 84.32% compared with FSA_256 and DFSA, respectively, which proves that the algorithm can effectively reduce the conflict slot and save the system identification time [19]. The results show that the network traffic changes under various methods with increased markers.

4.2. Physical monitoring module software debugging. The memory of the MAX30100 is accessed using the IIC interface. First, it is initialized. When the red light is on, it is serial debugging so that it can be measured in real-time. The data is sent to the PC through the serial port and compared with the physiological indicators obtained by the red light and infrared LED. The MAX30100 transmits the collected information

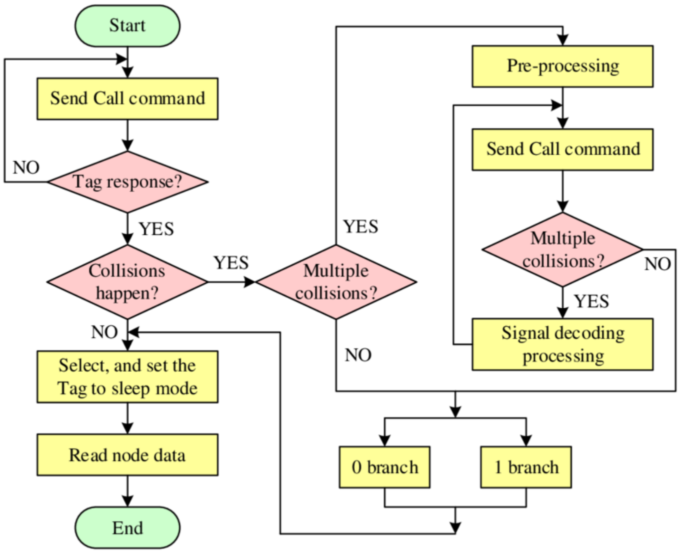

Fig. 3.1: Flow of RFID anti-collision algorithm.

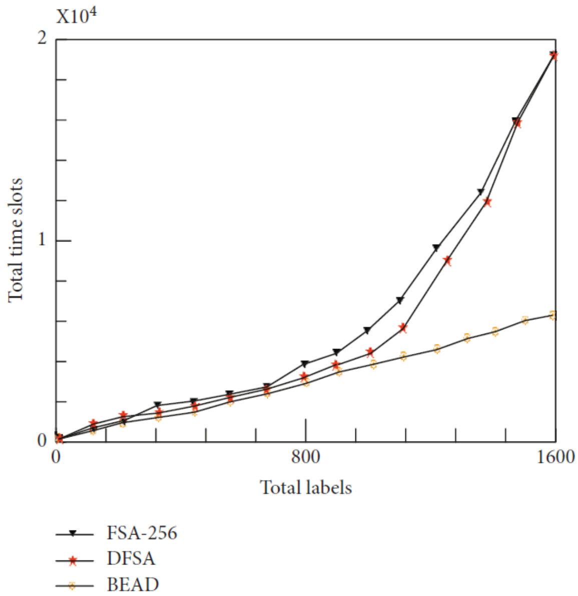

Fig. 4.1: Comparison results of total time slots of the proposed algorithm, FSA_256 and DFSA algorithms.

to the master controller and stores it in memory. The electrical signal is converted into parameters such as blood oxygen saturation and heart rate through calculations. The developed physical fitness monitoring module can accurately display the athlete's heartbeat, blood oxygen concentration and other indicators to reflect the athlete's physical fitness better. Through the motion control of the hand ring, the monitored motion information can be accurately displayed on the OLED screen, which further verifies that the design of the motion module is correct.

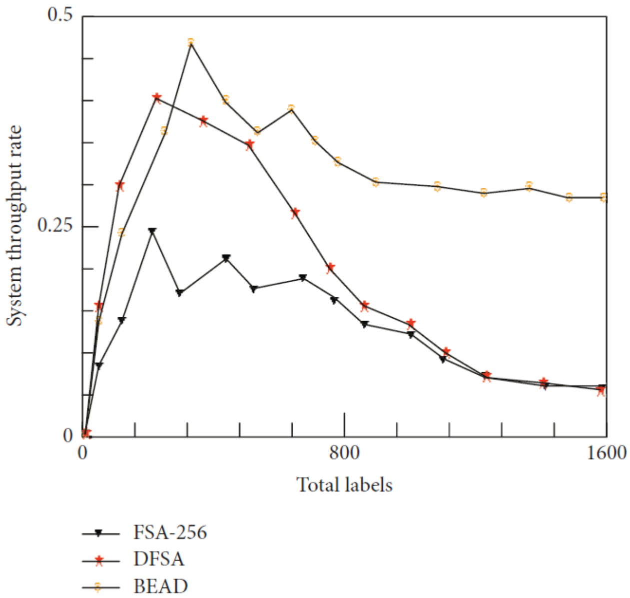

Fig. 4.2: Comparison of total time slots.

5. Conclusion. This study successfully constructed a data mining evaluation model of athletes' physical fitness based on wearable bracelets. Through the in-depth analysis of a large number of physiological data collected by physical health monitoring bracelet, we find that data mining technology has great application potential in this field. In particular, the combination of RFID anti-collision algorithms improves the accuracy and efficiency of data acquisition and enhances the model's robustness and practicability. The establishment of this model provides a new technical means for real-time monitoring and scientific evaluation of athletes' physical health. It can accurately identify the key indicators of athletes' physical fitness and provide scientific and comprehensive training guidance for the coaching team. At the same time, the model can also prevent sports injuries in daily training and improve athletes' competitive performance.

REFERENCES

[1] Yuliandra, R., & Fahrizqi, E. B. (2020). Development of endurance with the ball exercise model in basketball games. Jp. Jok (Jurnal Pendidikan Jasmani, Olahraga Dan Kesehatan), 4(1), 61-72.
[2] Kalkhoven, J. T., Watsford, M. L., & Impellizzeri, F. M. (2020). A conceptual model and detailed framework for stress-related, strain-related, and overuse athletic injury. Journal of science and medicine in sport, 23(8), 726-734.
[3] Stoyel, H., Slee, A., Meyer, C., & Serpell, L. (2020). Systematic review of risk factors for eating psychopathology in athletes: a critique of an etiological model. European Eating Disorders Review, 28(1), 3-25.
[4] Rozali, M. Z., Puteh, S., Yunus, F. A. N., Hamdan, N. H., & Latif, F. M. (2022). Reliability and validity of instrument on academic enhancement support for student-athlete using Rasch Measurement Model. Asian Journal of University Education, 18(1), 290-299.
[5] Lee, J., & Zhang, X. L. (2021). Physiological determinants of VO2max and the methods to evaluate it: A critical review. Science & Sports, 36(4), 259-271.
[6] Ramirez-Campillo, R., García-Hermoso, A., Moran, J., Chaabene, H., Negra, Y., & Scanlan, A. T. (2022). The effects of plyometric jump training on physical fitness attributes in basketball players: A meta-analysis. Journal of sport and health science, 11(6), 656-670.
[7] Li, B., & Xu, X. (2021). Application of artificial intelligence in basketball sport. Journal of Education, Health and Sport, 11(7), 54-67.
[8] Yuliandra, R., Nugroho, R. A., & Gumantan, A. (2020). The Effect of Circuit Training Method on Leg Muscle Explosive Power. Active: Journal of Physical Education, Sport, Health and Recreation, 9(3), 157-161.
[9] Malikov, N., Konoh, A., Korobeynikov, G., Korobeynikova, L. E. S. I. A., Dudnyk, O., & Ivaschenko, E. (2020). Physical condition improvement in elite volleyball players. Journal of Physical Education and Sport, 20(5), 2686-2694.

[10] Paquette, M. R., Napier, C., Willy, R. W., & Stellingwerff, T. (2020). Moving beyond weekly ”distance”: optimizing quantification of training load in runners. journal of orthopaedic & sports physical therapy, 50(10), 564-569.
[11] Mossman, L. H., Slemp, G. R., Lewis, K. J., Colla, R. H., & O’Halloran, P. (2024). Autonomy support in sport and exercise settings: A systematic review and meta-analysis. International Review of Sport and Exercise Psychology, 17(1), 540-563.
[12] Kim, M., Do Kim, Y., & Lee, H. W. (2020). It is time to consider athletes’ well-being and performance satisfaction: The roles of authentic leadership and psychological capital. Sport Management Review, 23(5), 964-977.
[13] Upadhyay, A. K., & Khandelwal, K. (2022). Metaverse: the future of immersive training. Strategic HR Review, 21(3), 83-86.
[14] Ekstrand, J., Spreco, A., Windt, J., & Khan, K. M. (2020). Are elite soccer teams’ preseason training sessions associated with fewer in-season injuries? A 15-year analysis from the Union of European Football Associations (UEFA) elite club injury study. The American journal of sports medicine, 48(3), 723-729.
[15] Towlson, C., Salter, J., Ade, J. D., Enright, K., Harper, L. D., Page, R. M., & Malone, J. J. (2021). Maturity-associated considerations for training load, injury risk, and physical performance in youth soccer: One size does not fit all. Journal of sport and health science, 10(4), 403-412.
[16] Broglio, S. P., McAllister, T., Katz, B. P., LaPradd, M., Zhou, W., & McCrea, M. A. (2022). The natural history of sport-related concussion in collegiate athletes: findings from the NCAA-DoD CARE Consortium. Sports medicine, 52(2), 403-415.
[17] Luczak, T., Burch, R., Lewis, E., Chander, H., & Ball, J. (2020). State-of-the-art review of athletic wearable technology: What 113 strength and conditioning coaches and athletic trainers from the USA said about technology in sports. International Journal of Sports Science & Coaching, 15(1), 26-40.
[18] Impellizzeri, F. M., Menaspà, P., Coutts, A. J., Kalkhoven, J., & Menaspà, M. J. (2020). Training load and its role in injury prevention, part I: back to the future. Journal of athletic training, 55(9), 885-892.
[19] Flockhart, M., Nilsson, L. C., Tais, S., Ekblom, B., Apró, W., & Larsen, F. J. (2021). Excessive exercise training causes mitochondrial functional impairment and decreases glucose tolerance in healthy volunteers. Cell metabolism, 33(5), 957-970.

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