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Retraction

Retracted: Computational Technologies for the Wearable Sports Training System Based on Sensor Acquisition

Security and Communication Networks

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Security and Communication Networks has retracted the article titled "Computational Technologies for the Wearable Sports Training System Based on Sensor Acquisition" [1] due to concerns that the peer review process has been compromised.

Following an investigation conducted by the Hindawi Research Integrity team [2], significant concerns were identified with the peer reviewers assigned to this article; the investigation has concluded that the peer review process was compromised. We therefore can no longer trust the peer review process, and the article is being retracted with the agreement of the Editorial Board.

References

[1] G. Wang, Q. Meng, and W. Xu, "Computational Technologies for the Wearable Sports Training System Based on Sensor Acquisition," *Security and Communication Networks*, vol. 2022, Article ID 4443834, 7 pages, 2022.

[2] L. Ferguson, "Advancing Research Integrity Collaboratively and with Vigour," 2022, https://www.hindawi.com/post/advancing-research-integrity-collaboratively-and-vigour/.

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Research Article

Computational Technologies for the Wearable Sports Training System Based on Sensor Acquisition

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Aiming at the problems of long time-consuming and low precision in traditional training system, a wearable sports training system based on data mining is proposed and designed. According to the overall structure of the system, the hardware and software of the system are designed respectively. The hardware part is mainly composed of attitude measurement unit, power supply unit, main control unit, clock circuit, and reset circuit. The software part introduces the data mining method of mining sports training information data. The experimental results show that the system designed in this study effectively shortens the time-consuming time, improves the accuracy, and has certain advantages.

1. Introduction

Wearable devices are the general name of wearable devices that apply wearable technology to intelligently design daily wear and develop wearable devices, including bracelets, watches, glasses, and clothing products [1]. Its purpose is to explore a scientific and boundary human-computer interaction mode to provide more personalized and intelligent services for people's life, work, study, and entertainment. Under the influence of the concept of man-machine integration, wearable technology continues to break through and develop, the connection between devices and people is becoming closer and closer, and the wearable device industry is booming. Some information industry experts predict that with the rapid development of intelligent wearable industry, wearable devices have forgotten to become a new growth point of the global information industry after smartphones and tablets [2]. The sports training system is mostly accomplished by wearable technology, according to authoritative literature inquiry and research. Advanced science and technology, such as functional software technology and high-density integration technology, are used to create wearable technology. It mostly refers to electronics that are physically worn on the body or incorporated into users' clothing or accessories and are not only simple to use but also to transport [3]. People's rising physical health demand has prompted the sports business to restructure, thanks to the fast growth of Internet technology and somatosensory technology. The sports sector has been touched by the newest science and technology, which has had a steady effect on conventional sports equipment [4]. However, the technological scheme of conventional sports equipment in colleges and universities is now unsuitable, and the sports training management mode is outdated, making it impossible to properly lead students' sports, resulting in the current condition of bad overall sports impact. Therefore, a wearable sports training system based on data mining is proposed and designed.

2. Overall Structure Design of the Wearable Sports Training System

The system is mainly composed of camera, PC host, display, cloud server, main control unit, power supply, attitude measurement unit, IMU [5], single-chip microcomputer, clock circuit, and reset circuit [6]. It also contains student campus card data equipment. The overall structure is shown in Figure 1.

In order to achieve a more reasonable and efficient sports training system design and strive to bring users a more humanized body feeling sports experience, it is necessary to meet the following requirements for sports training system:

A motion recognition terminal with multiple functions is needed [7]. This system will address the problem of a large number of college sports students and the need for all-round development of students' physical quality, design and realize the simultaneous training function of multiple users, solve congestion during peak sports periods, improve the efficiency of sports training [8], and realize the integration of a variety of different sports with the same training [9].

So, there is a need to create a scientific sports training plan based on the physique of the pupils. The "one size fits all" sports norm of conventional training equipment cannot be implemented due to the varied physical quality growth of college students. Some training mode is needed, which can customize personalized sports training plans according to students' different physical conditions [9], scientifically and efficiently improve the effect of sports training, standardize users' training, and prevent physical damage to students due to improper training or training transition.

In order to quickly adapt to the development of Internet of things technology, it is necessary to timely understand the detailed status of each terminal, design an efficient cloud server, monitor the operation of sports training equipment in the system in real time, and achieve the goal of unified management [10].

It is necessary to realize the process of efficient real-time wearable sports training system. Users can independently choose the type of sports in the sports money or fully consider the user's training experience according to the sports training content customized by the system [11]. The system needs to feedback the sports content in time for real-time human-computer interaction, and meet the smooth data transmission flow of the training system [12].

3. Hardware Design

3.1. Attitude Measurement Unit. The attitude measurement unit is the most important part of the sports training system. It is mainly composed of MEMS accelerometer, MEMS gyroscope, and MEMS magnetometer. In addition, the device contains a built-in microprocessor chip that can solve attitude and motion information in real time, reducing data transmission pressure and increasing system reliability [13].

In real time, a MEMS accelerometer can monitor the carrier's acceleration and linear motion condition. A MEMS gyroscope can detect the carrier's angular rate and measure the carrier's angular motion status in real time. MEMS magnetometers can detect information about the magnetic field surrounding the carrier, and the carrier's attitude and motion state can be determined using the measurement data from these three MEMS sensors [14]. It may be customized to meet a variety of capacity, wearing position, and measurement accuracy needs. It primarily consists of two types of wearable attitude measurement equipment, namely the micro attitude measurement unit and the multifunctional attitude measurement unit [15].

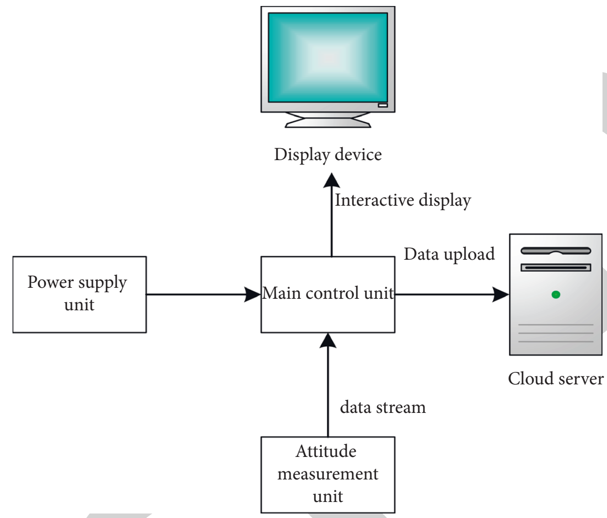

Figure 1: Overall structure of the system.

The reference and weight requirements for the micro attitude measuring unit are greater. In hardware design, this trait necessitates the selection of suitable MEMS sensors and microprocessors. The chosen MEMS sensor and microprocessor chip should have smaller chip packaging due to volume and quality requirements, which is more favourable to the overall design of the circuit and micro attitude measuring unit [16].

The capacity and importance requirements for the multifunctional attitude measuring unit are flexible, but measurement accuracy is critical. Different from micro and tiny attitude measuring units, MEMS sensors with improved measurement accuracy and microprocessor chips with stronger computation capability are needed when choosing MEMS sensors and microprocessor chips. The unit can also add auxiliary measurement chips such as air pressure sensor and airspeed sensor according to different functional requirements. Therefore, better scalability is required when designing the unit [17].

3.1.1. Micro Attitude Measurement Unit. In view of the strict volume and weight requirements of the micro attitude measurement unit, the nine-axis motion sensor mpu9250 integrating the three-axis MEMS accelerometer, three-axis MEMS gyroscope, and three-axis MEMS magnetometer are selected when selecting the MEMS sensor. Considering the low accuracy of the MEMS magnetometer in the nine-axis motion sensor mpu9250, the three-axis MEMS magnetometer hmc5983 is selected to replace its built-in magnetometer [18], the microprocessor chip stm32f401ceu6 is selected, and the design structure block diagram of the micro attitude measurement unit is shown in Figure 2.

Following the above nine-axis motion sensor and microprocessor selection, the minimum system circuit meeting its requirements is designed for the selected microprocessor chip stm32f401ceu6, and the relevant MEMS sensor circuits

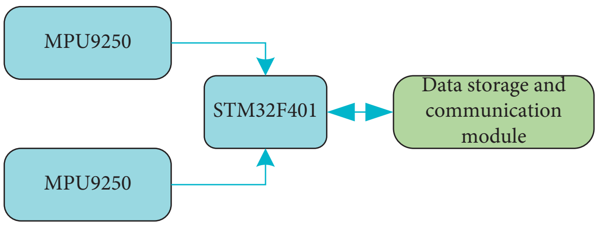

Figure 2: Hardware design diagram of the micro attitude unit.

are then designed under the condition that the microprocessor chip can function normally [19]. MEMS sensors were chosen as the attitude measuring sensors in this scheme because they have a tiny volume and can be easily incorporated onto a compact circuit board. At the same time, the nine-axis motion sensor mpu9250 and three-axis magnetometer hmc5983 support SPI communication mode, and the selected two MEMS sensors have the same communication timing and phase. Therefore, the communication function between the microprocessor chip and each sensor can be realized by time-sharing multiplexing directly through the pin selection, that is, the microprocessor chip can change the sensor range by sending instructions and receiving the measurement data of each sensor in real time [20].

3.1.2. Multifunctional Attitude Measurement Unit. The multifunctional attitude measurement unit has low volume requirements, so MEMS sensors with better accuracy can be selected. At the same time, in order to achieve better expansion functions, microprocessor chips with stronger computing power, larger flash storage space, and more peripheral interfaces can be selected. In this case, The MEMS sensor of the multifunctional attitude measurement unit adopts three-axis accelerometer adxl355, three single-axis gyroscopes adxrs453, and three-axis magnetometer ak09979n, while the processor chip adopts stm32f407vgt6. The hardware design diagram of the scheme is shown in Figure 3.

The three MEMS sensors selected in the unit support SPI communication, and the three-axis accelerometer adxl355 and single-axis gyroscope adxr453 have the same communication timing and phase. The two MEMS sensors can be directly connected to the SPI interface on the microprocessor chip. However, the timing of the three-axis magnetometer ak09979n is exactly opposite to that of the above two sensors, so it is necessary to reverse process the signal in the formula given by the microprocessor with the help of the logic circuit. Therefore, in the actual design of the circuit, the SCLK pin of the microprocessor chip shall reverse process the signal through the sn74lvc1g00 chip and then connect it with the SCLK pin of the chip. At this time, the three MEMS sensors are connected to the same SPI bus of the microprocessor. The time-sharing multiplexing function of the three MEMS sensors to the SPI bus can be realized by using the chip selection signal, so as to realize the high-speed acquisition function of the output of the three MEMS sensors, so that the microprocessor chip can process the data in real time [21].

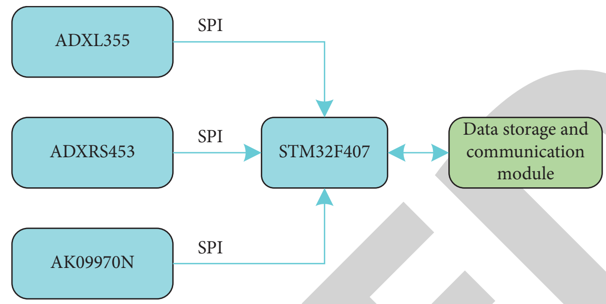

Figure 3: Hardware design diagram of the multifunctional attitude unit.

In order to ensure the stability of the multifunctional attitude measurement unit, the unit can select the nine-axis motion sensor icm20948 as the supplement of the three-axis accelerometer adxl355, gyroscope adxrs453, and magnetometer ak09970n to realize the redundant backup function. The nine-axis motion sensor icm20948 also has SPI high-speed communication function, and the communication timing of the chip is the same as that of the three-axis accelerometer adxl355 and the three-axis gyroscope adxrs453, but its voltage standard is different from that of other MEMS sensors [22]. When using the same SPI bus, signal level conversion is required, so it needs to be specially considered when designing the circuit. In order to solve this problem, max3378eeud chip is selected to convert the 3.3 V level signal output by microprocessor into the 1.8 V level signal used by icm20948, which can realize the connection of four MEMS sensors on the same SPI bus. The microprocessor chip adopts the time-sharing multiplex SPI bus through the chip selection pin to read the measurement data of each MEMS sensor one by one [23–25].

3.1.3. Inertial Measurement Unit. Considering the wearable requirements, MEMS sensors with small volume and weight should be selected. In addition, the accuracy and stability of the sensor should be considered. In this regard, mpu9250 nine-axis inertial sensor is selected, which integrates three-axis accelerometer, three-axis magnetometer, and three-axis gyroscope, can output quaternion, gravity acceleration, linear acceleration, gyroscope, and other information, and has attitude calculation function. The specific output type of the acceleration sensor is optional, and the overall acceleration data, linear acceleration data, and gravity acceleration data can be output [24]. The sensor is packaged in qfn24 with a size of $4 \times$ four $\times 1$ mm, small volume, and lightweight, fully meeting the requirements of portability. Mno055 has a built-in programmable digital low-pass filter, its acceleration measurement range is ±16 g, ±8 g, ±4 G, ±2 G, and the gyroscope range is ±2000, ±1000, ±500, ±250°/sec, which can be set by programming. It has a built-in 16-bit ADC, I2C/SPI interface, etc. The electrical schematic design of the bno055 is shown in Figure 4 The circuit selects the IMU's I2C communication interface, which can be directly linked to the microprocessor's I2C, and the IMU's equipment geology may be controlled via hardware. It has a built-in 16-bit ADC, I2C/SPI interface, etc.

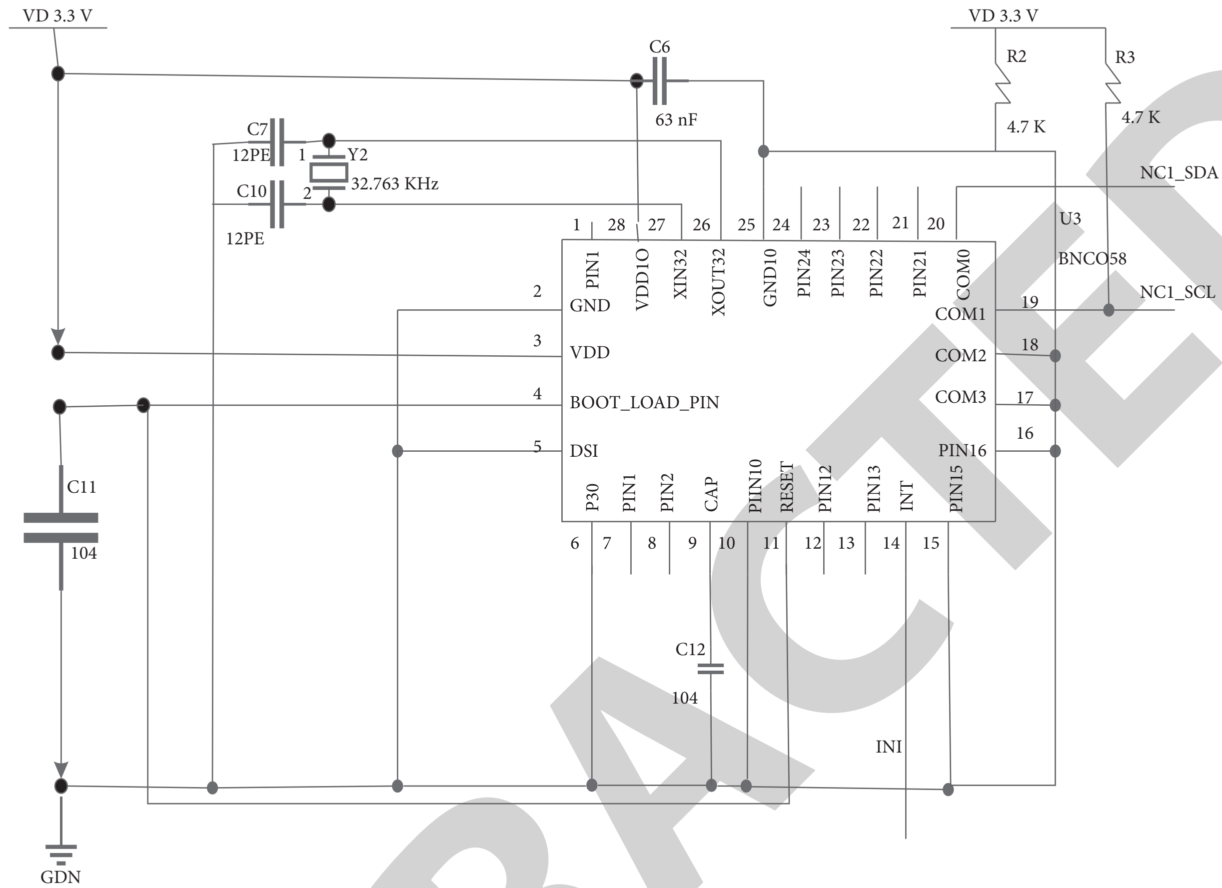

Figure 4: Circuit diagram of the inertial measurement unit.

3.2. Power Supply Unit. The wearable method is used to measure the attitude to ensure that it is light enough, and there are strict requirements on the endurance time. Related to the power supply, it has a battery unit, charging unit, and power management unit.

Battery unit: rechargeable lithium-ion polymer battery is used, with a battery capacity of 250 mah, weight of 10 G, discharge rate of 2 C, effective power supply voltage range of 3.5 V–4.2 V, and rated power supply voltage of 3.7 V.

Charging unit: tp4054 charging chip encapsulated in SOT23-5 is used as the core device. The chip is a single lithium-ion battery charging chip that may be used to charge USB devices as well as power adapters. The chip has an anti-back charging circuit and a thermal feedback component that may effectively safeguard the charging circuit. The chip fixes the charging voltage at 4.2 V. When the battery voltage reaches 4.2 V, the charging process will stop automatically. During this period, the charging current will be automatically adjusted according to the difference between the charging voltage and the battery voltage to charge safely. When the external charging power supply is removed, the chip will automatically enter the low-power state, and the leakage rate of the whole chip is 2 μA。 VCC pin is an external power input pin, which is used for an external power supply to supply power to the charger. Prog is the charging current setting pin. Since the battery capacity of lithium battery is 250 mah and the discharge rate is 2 C, the charging and discharging current is 500 mA, the charging current setting resistance is 2 kΩ, and the charging current is 500 mA.

Power management unit: the power supply is used to output 3.3 V after stabilizing the 3.5 V–3.7 V power supply voltage of lithium-ion battery, and supply power to the main control unit, built-in unit, and wireless communication unit circuit [25]. The core chip used by the power management unit is the pl3500-662k low-voltage differential voltage regulator chip encapsulated in sot23-3. The chip can convert the input voltage of 3.5 V–6.5 V into a stable output voltage of 3.3 V and provide the maximum output current of 500 mA. Because the wireless communication unit consumes very fast power at the time of data transmission, a large capacity capacitor is connected in parallel at the 662 k output terminal supplying power to the wireless communication unit to provide instantaneous high current for the wireless communication chip to ensure that normal power supply voltage is provided for the chip.

3.3. Main Control Unit. The main control unit is used to control the original attitude data reading of the attitude measurement unit, the data transmission of the wireless communication unit, the data receiving and processing of the configuration unit, and the real-time solution of the attitude data. The core chip of the unit is a stm32f4ceu6 microprocessor chip encapsulated in qfn48.

The core of the MCU includes DSP, FPU, 512kbytes flash, and 128kbytes SRAM, and the main frequency of the core can reach 100 MHz; MCU peripherals include psi communication interface, IIC communication interface, 12-bit ADC, and complete USB2.0 full-speed controller. In this node, the IIC communication interface is used to communicate with the attitude measurement unit, the SPI communication interface is used to communicate with the wireless communication unit, and the USB2.0 full-speed slave is used as the communication interface of the configuration unit; the 12-bit ADC is used to detect the power supply voltage of lithium-ion battery in real time. When the battery voltage is lower than 3.7 V, it will remind that charging operation should be carried out.

3.4. Clock Circuit. The clock circuit provides the running time standard for the single-chip microcomputer system. The minimum system circuit of STM32 series products is generally configured with two circuits in the formula, as shown in Figure 5. An external resonator with a selection of 4 to 16 MHz generates an external clock to tell the HSE to provide an accurate master clock for the main control chip. Another option is a 32.768 kHz crystal/ceramic resonator to generate a low-speed external clock LSE for system standby or low power consumption. When drawing PCB for component layout, it is best to place the resonant load capacitor around the oscillator pin of the main control chip to ensure the accurate output of clock signal.

3.5. Reset Circuit. The reset circuit will return each part of the MCU to the initial state and make the MCU work again. The reset circuit designed in this study is mainly composed of reset key S1, resistor R2, and capacitor C2. The reset pin pulls down 3.3 V through resistor R2. In the working state, after pressing the key S1, the capacitor C2 begins to discharge, and the reset pin level is pulled down to complete the reset of the single-chip microcomputer system. The circuit diagram is shown in Figure 6.

4. Software Design

The information acquired by the sports catenary system would always be mixed with noise throughout the actual data processing process owing to the effect of the external environment and the status of the sensor itself. Thus, not all signals are helpful to the end outcome in the signal propagation process. The signal may be combined with additional noise or altered by the environment throughout each phase of production, transformation, and transmission. The noise or distortion introduced into the signal will obstruct further data processing and have an impact on the final outcome. As a result, the signal gathered must be processed to limit the impact of noise or distortion. As a result, the sports training data are processed using the data mining approach. Assuming that the average value of N sampling points, rather than the current sample value, can successfully suppress the random interference signal, then the sensor's action sequence is as follows:

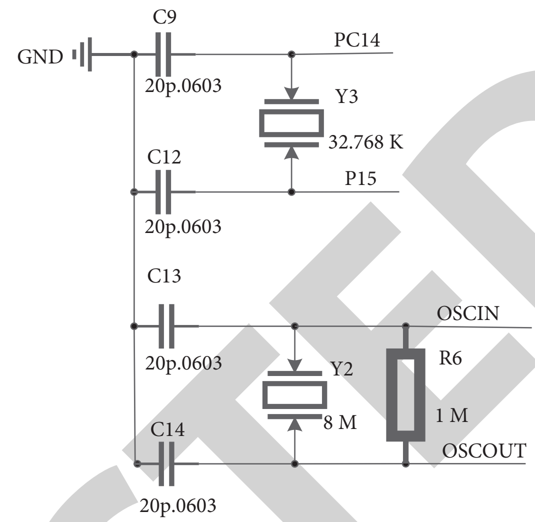

Figure 5: Clock circuit diagram.

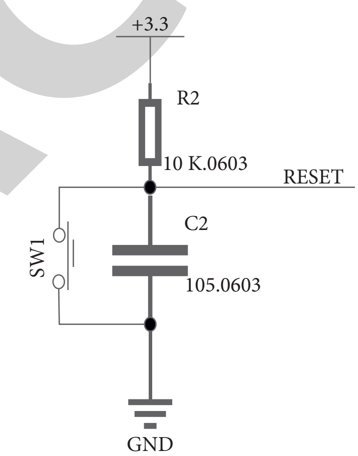

Figure 6: Reset circuit.

$$x = (x_1, x_2, \ldots, x_l). \quad (1)$$

The filtered sequence is as follows:

$$y = (y_1, y_2, \ldots, y_l). \quad (2)$$

Then, the formula of the filtered sequence obtained from the original sequence is as follows:

$$y_n = \frac{x_n + x_{n-1} + x_{n-2} + \cdots + x_{n-N}}{N}, \quad (3)$$

where the selection of N has a direct impact on the filtering effect. When the value of n is the smallest, the sensitivity is higher, but the smoothing effect is poor. When the value of n is large, the smoothing effect is good, but the sensitivity will be low.

The data mining method is used to mine the sports training information. Assuming that there are M class sports training information, and the probability that some information is m class is p_m, then the Gini index of the whole data set is as follows:

Table 1: Comparison and analysis results of time consumption of different systems.

Number of iterations	System designed in this study	System described in [4]	System described in [5]
100	10.24	35.94	50.36
200	11.64	37.58	51.62
300	11.89	38.69	52.36
400	12.69	39.66	53.94
500	13.66	40.91	54.88

Table 2: Comparison of accuracy of different systems.

Number of iterations	System designed in this study	System described in [4]	System described in [5]
100	89.68	36.99	40.36
200	90.33	40.98	45.62
300	91.67	41.32	57.46
400	92.68	42.68	48.94
500	96.99	43.69	64.87

$$\text{Gini}(p) = \sum_{i=1}^{M} p_m (1 - p_m) = \sum_{i=1}^{M} \left(1 - p_m^2\right). \tag{4}$$

Suppose that $S_t = \{S_{t1}, S_{t2}, S_{t3}\}$ represents the sports training information data in dimension m, $p_{s\,dr}{}'$ represents the integrity of the target sports training information data formed by a single sports training information data source, and $F_{\text{ser}}{}'$ represents the similarity of multiple target sports training information data. In this way, the following formula is used for data mining:

$$M_{\text{llp}}{}' = \frac{F_{\text{ser}}{}' \pm S_t}{p_{\text{sdr}}{}' \times \text{Gini}(p) \pm p_{ru}{}'}. \tag{5}$$

In the above formula, $p_{ru}{}'$ is the number of data elements generated by the sports training information data source.

5. Analysis of Experimental Results

In order to verify the effectiveness of the improved wearable sports training system, the system designed in this study is compared with the system described in [4, 5], and the system operation time and accuracy are taken as indicators for experimental comparative analysis. The results are listed in Tables 1 and 2, respectively.

Table 1 shows that the time consumption of the system described in this study grows as the number of iterations increases, while the total time consumption is roughly 12.14 s on average. Its general growth rate is sluggish, despite the fact that the number of repetitions is growing. The total time-consuming while utilising the system in reference [4] is 38.56 s on average, and it grows as the number of repetitions increases, which is 26.42 s longer than the method developed in this study. The total time-consuming while utilising the system in reference [5] is 52.63 s on average, which grows significantly with the number of repeats, and is around 40.49 s greater than the method developed in this study. As a result, the method proposed in this research may efficiently minimise the time-consuming process and offers a number of benefits.

Table 2 lists that the accuracy of the system described in this research grows as the number of iterations increases, with an average overall accuracy of roughly 92.27%. Its general growth rate is quick, despite the fact that the number of repetitions is growing. The total accuracy of the system described in reference [4] is 41.13% on average, and it grows as the number of iteration times increases, which is 51.14% less than the system described in this study. The overall accuracy of the system in reference [5] is 51.45% on average, which increases rapidly as iteration times increase, which is about 40.82% lower than the system designed in this study; thus, the system designed in this study can effectively improve the accuracy and has certain advantages.

6. Conclusion

Aiming at the problems of long time-consuming and low accuracy in the traditional training system, a wearable sports training system based on data mining is proposed and designed. The research shows that the system designed in this study can effectively shorten the time-consuming and improve the accuracy, which has certain advantages.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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