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Multi-Sensor Data Fusion Technology for the Single Bamboo Drifting

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Based on the multi-sensor data fusion technology, we design the monitoring system for the single bamboo drift. The system can collect the sports information and generate the monitoring process chart of sports training parameters in real time without affecting the normal training of athletes by using 4G network transmission, oar frequency calculation, embedded system and GPS et al., which is convenient for coaches to monitor the speed of athletes, oar frequency, acceleration, heart rate and other kinematic and physiological indicators during training. The system has been applied to the daily training of the single bamboo drift team of Hechi University, which provides a scientific basis for coaches to diagnose the training effect in real time, improve the efficiency of athletes' special training and carry out targeted training.

Keywords: sensor; data fusion; water training; monitoring; sports information collection

1. INTRODUCTION

Duzhu drifting activity has a long history. It is a unique folk skill of Miao people in Chishui River Basin in northern Guizhou Province [1–3]. It is a folk activity that local bamboo farmers have extracted from their long-term productive labor and evolved through thousands of years of inheritance and development. According to records, because Nanzhu is abundant in the area, tall Nanzhu is one of the better building materials in ancient times [4–6]. Transportation has become a problem after logging. Later, bamboo farmers plunged the cut bamboo into the Chishui River, drifting down with the buoyancy and thrust of the water [7,8]. In order to catch up with the floating bamboo, bamboo farmers jumped up and down on the floating bamboo. Over time, they practiced this unique skill in the process of collecting and transporting bamboo. The local people called it "single bamboo drifting". Duzhu drift was eventually included in the competition item of the Ninth National Games (held in 2011), which was popularized throughout the country [9–11]. At the same time, it was widely concerned by many social activists, scientific and technological workers and educators. About the history of Duzhu drifting, cultural connotation, sports characteristics, social value and university sports curriculum resources results abundant but directly related results not yet, so this research has certain innovation [12,13].

In the literature [9–12], the conclusions drawn by scholars are far from being able to understand the complex characteristics of the Duzhu drifting movement. At present, no one studied single bamboo drift from the experimental view, and the conclusions obtained from the experimental study are often more reliable [14,15]. the single bamboo drifting race is a water sport with complex movement technology. It involves balance mechanics, fluid mechanics, biomechanics and other principles [16,17]. There are many influencing factors. The athlete's speed performance depends on the perfect combination of various techniques.

Duzhu drift belongs to the water sports project, which is mainly dominated by physical fitness and has high requirements for technology [18]. The law of victory lies in

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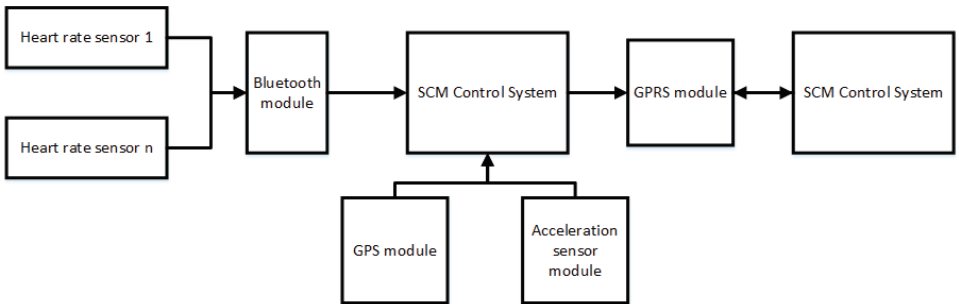

Figure 1 Schematic diagram of Duzhu drift training monitoring system

the perfect combination of technology and physical fitness [19]. Around the law of winning the water sports, domestic and foreign scholars have carried out a lot of research, mainly in the field of competition strategy, competitive ability, physiological and biochemical indicators detection and monitoring, sports technical analysis of special technical movements, and juvenile selection [20,21]. With the development of science and technology, many electronic and intelligent sports training devices are gradually applied to the field of training and monitoring of water sports. In June 1989, China introduced the kayak dynamometer for the first time [22]. Although it is still used today, it is still the main training equipment for the kayak project. Zhang Junyou and others have successfully developed the on-board visual and intelligent simulation test training system for the first time in the domestic sports industry [23]. It can be used to simulate and test athletes' skills and conduct special strength training. Ouyang Bo et al. chose the magnetic powder brake as the system resistance source, and used the rotary encoder to detect the pitch angle signal [24]. The special strength training system for the onshore rowing was also designed.

There is a common problem in land-based test equipment: that is, there is a significant difference between the actual paddle feeling on the water and the complete water technology cannot be implemented. In order to combine athletes' water practice and monitor training more realistically and effectively, many domestic scholars have carried out research. Zheng Weitao and others: developed a new multi-parameter dynamics test and evaluation system for rowing strength and acceleration [22,24]. The system was successfully applied in the preparation of the national rowing team for the 2000 Sydney Olympic Games [24,25]; Du Fu and Yang Haiying developed kayaking The video monitoring system of the Slalom Project, the coach can analyze and evaluate the athlete's training level and the game state by analyzing the massive video data of the Slalom training [26,27]; Li Yuan developed a multi-parameter telemetry device for the canoe training state, which can be used in athletes. In the normal training of the launching water, the coaches are assisted in real-time comprehensive understanding of the athletes' motion parameters on the boat, but the actual application results have not been reported [28,29].

The above studies are only for rowing and other projects. As the bamboo drifting movement is just emerging, there is currently no motion monitoring equipment for the Duzhu drift project.

According to the training requirement of ability evaluation of single bamboo drifting project, this research developed a monitoring system for single bamboo drifting training based on multi-sensor data fusion technology. The system can provide the kinematic and physiological indicators of bamboo speed, bamboo frequency, acceleration and heart rate for coaches on the spot, facilitate the monitoring of coaches and athletes, and provide the corresponding means and scientific basis for the test and evaluation of athletes' individual abilities.

2. OVERALL CONSTRUCTION OF SYSTEM

Duzhu drift training monitoring system is divided into two parts: hardware and software. The hardware is embedded data acquisition module, which includes acceleration sensor module, heart rate band module, 4G module, Bluetooth module and microprocessor. In software, SOCKET programming is used to realize data communication for TCP/IP protocol, acceleration sensor and GPS module on experimental board are programmed to realize data acquisition, multiple heart rate measurement nodes are programmed to realize heart rate acquisition, and data analysis system of upper computer is implemented. The schematic diagram is shown in Figure 1.

3. HARDWARE SYSTEM DESIGN

Multiple heart rate bands are connected with Bluetooth host module on the minimal system of single-chip computer through Bluetooth respectively. The minimal system of single-chip computer controls Bluetooth host module, acceleration sensor and GPS module. The processed data is transmitted to the 4G module through serial port. The 4G module transmits these data to the remote computer. Because the data is transmitted through GPRS network, the system works. There is no distance limit. The hardware system framework is shown in Figure 2.

3.1 Design of Main Control Circuit System

The hardware of the system includes three sensor acquisition modules and two wireless data transmission modules. Considering that the hardware equipment will be used on the

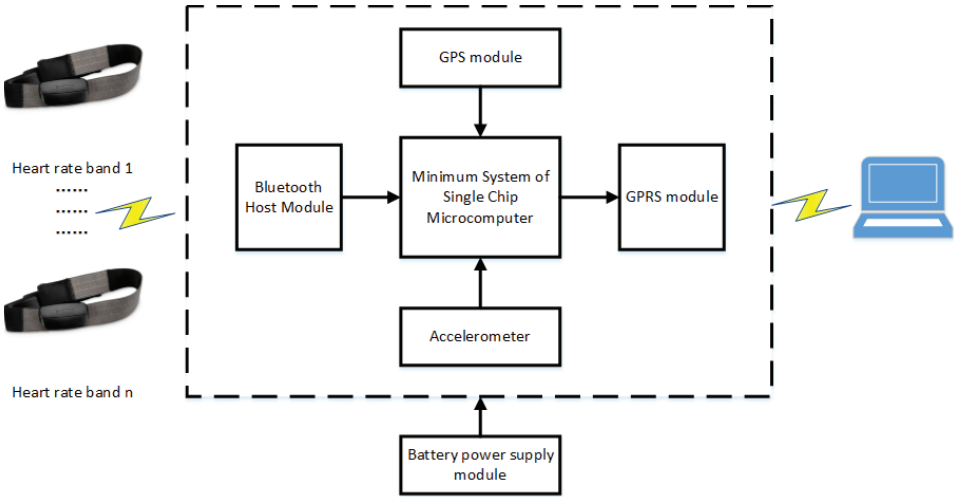

Figure 2 Hardware System Framework

water, the core controller must have stable performance and low power consumption, we choose MSP430 MCU.

3.2 Design of 4G Data Transfer Module

Starting from the training needs of coaches and athletes, we require the system to monitor the athlete's heart rate in real time. In order to ensure the real-time transmission of data, the system design needs to understand the factors affecting the wireless communication distance, mainly: 1) geographical environment; 2) electromagnetic environment; 3) climate conditions; 4) transmitter RF output power; 5) receiver receiving sensitivity; 6) system anti-interference ability; 7) antenna type and its gain. Considering these factors, we choose 4G module for data transmission. The design of peripheral circuit of 4G module refers to the hardware design guide of Huawei Company, and deals with the power protection and anti-interference of the circuit. The power supply adopts TVS as voltage protection and a large capacity tantalum capacitor as energy storage device; standard 232 interface also has interface protection circuit, which can resist environmental interference; TTL interface supports 3–5V level interface; SIM card has ESD electrostatic protection circuit to prevent human electrostatic damage to the module.

3.3 Selection of Heart Rate Band

In order to collect athletes' heart rate, the Italian Armor-XGO_HRM Bluetooth 4.0 wireless heart rate band is selected as the heart rate band. The heart rate band is paired by its own Bluetooth module and the host Bluetooth module connected to the minimal system of single chip computer to realize data transmission.

3.4 Design of Bluetooth Data Transfer Module for Host

In the process of training, because of the real-time monitoring of heart rate, this study uses heart rate band to measure the heart rate of athletes, and then heart rate data is transmitted to the host Bluetooth module connected to the minimal system board of single chip computer through Bluetooth. HC05 is chosen as the host Bluetooth module. HC05 is a high-performance master-slave integrated Bluetooth serial module. At the same time, when multi-person heart rate is measured, Bluetooth heart rate band and Bluetooth host module are networked, that is, Bluetooth one-to-many networking mode.

3.5 Design of GPS Module

The speed of bamboo in sports is one of the most concerned kinematics parameters for coaches and athletes. In competition, the speed of boat determines the distribution of sport performance and physical strength. In training, speed parameters can be used to control the intensity of training and help coaches formulate scientific training plans. In this study, GPS is used to measure the hull speed. GPS module uses NEO-5Q as the main chip. This chip is a multi-functional independent GPS module. It is based on ROM. It has many characteristics, such as low cost, small size and so on.

3.6 Design of Acceleration Sensor

In this study, bamboo paddle frequency is calculated and acceleration sensor is selected to monitor the paddle frequency. As the main component of the system, the selection of sensors has a significant relationship with their performance indicators. According to the system design requirements, the acceleration module GY-52 of XYZ three-axis gyroscope (±2g, ±4g, ±8g, ±16g) is selected. It has comprehensive functions, stable performance, low cost, signal conditioning, low-pass filtering, temperature compensation, self-test and other functions. It also provides I2C interface mode to facilitate communication with MCU.

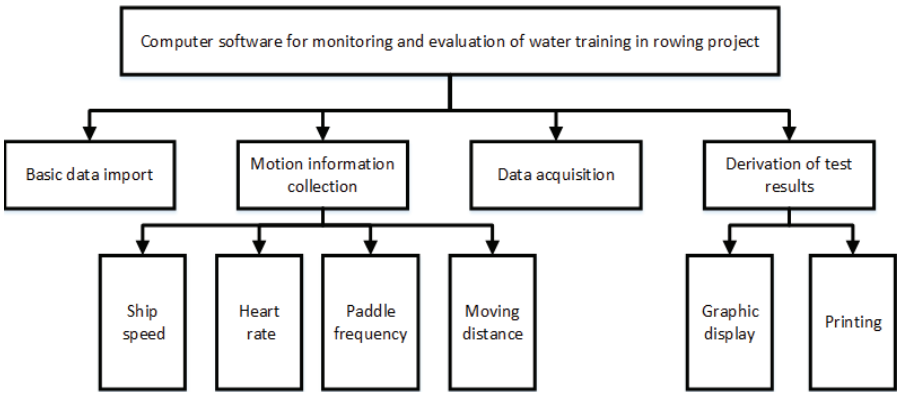

Figure 3 Software System Architecture

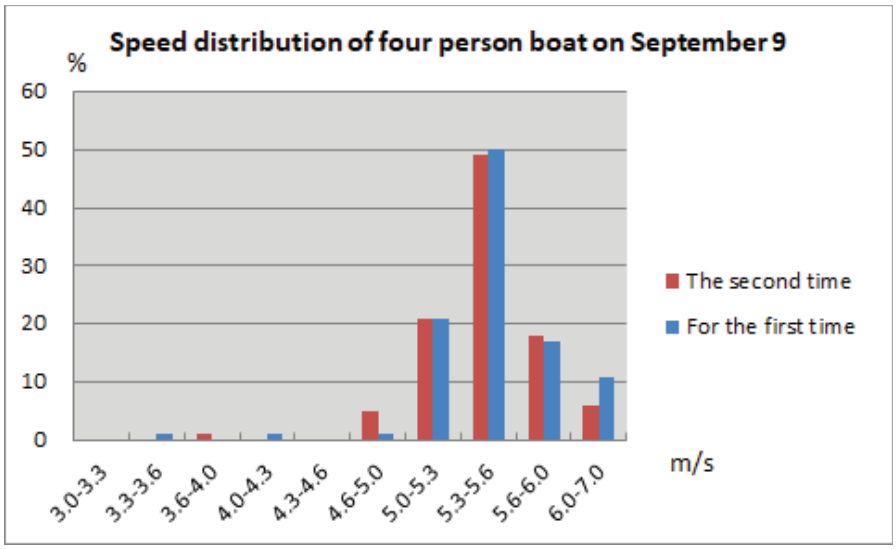

Figure 4 Distribution Chart of 1000m Training Speed for Four-Man Boat

4. SOFTWARE SYSTEM DESIGN

The software system consists of four functional modules: human-computer interaction interface, serial data reception, data storage, graphic display and printing. The structure of the software system is shown in Figure 3. In the human-computer interaction system, the computer communicates with the MCU main control system through serial port to obtain the motion parameters and physiological data such as ship speed, propeller frequency, moving examples and heart rate. Coaches and athletes can log in and check relevant data curves and historical training records according to their needs, which provides objective basis for scientific training and timely discovery of training problems.

5. SYSTEM APPLICATIONS AND TEST ANALYSIS

5.1 Application Test of Duzhu Drifting Team

On the morning of September 9, 2018, the system was applied to the Duzhu Drifting Team of Hechi University. The 60m training of Four people was tested and analyzed. The training speed distribution is shown in Fig. 4.

As can be seen from Fig. 4, in the 60m training of Four people, the following conclusions can be drawn from the comparison of the two training sessions:

1) The main speed interval of 60m training is 2 m/s or more. The lower speed zone belongs to the low speed zone. The effect of two training sessions is basically the same in the 1.7–1.9m/s zone, but the second training is a little more important in the 1.9–2.1m/s zone.

2) 2.1–2.3m/s is a high-speed area. The bigger the proportion of this speed range, the better the training effect. From the graph, the first time is better.

3) 2.0–2.1m/s is the high speed in training. The larger the proportion, the better the second time can be seen from the figure.

4) 1.9–2.0m/s is the normal speed of training. The larger the proportion, the more normal the training is. It can be seen from the figure that the two times are almost the same. To sum up, the speed range of men's single bamboo drifting over 1.9m/s in 60m training is the key to improve the athletes' special ability of 60m. The distance ratio of

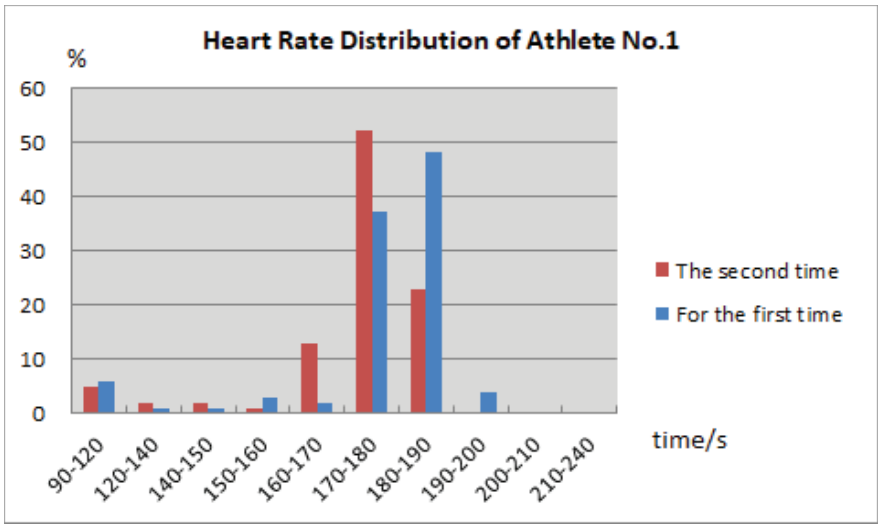

Figure 5 Heart Rate Distribution of Athlete No. 1

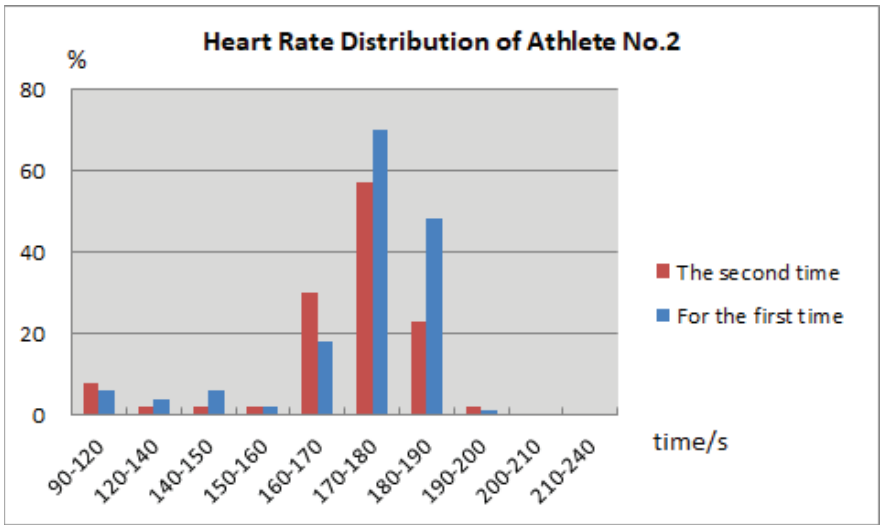

Figure 6 Heart Rate Distribution of Athlete No. 2

60m is more endurance, so the short-time high speed is useful in the sprint stage and the start stage, so it is more important to maintain the speed of 2.0–2.1m/s. It is hoped that through the later training, the ratio of the speed range of 2.0–2.1m/s will be continuously increased, and the low speed range below 1.9m/s will be avoided as far as possible. Therefore, through the above data analysis, we can see that in the first 60 meters rowing, athletes' physical distribution tends to be more reasonable.

The heart rate distribution of the No. 1 athlete is shown in Figure 5. The first training is mainly 180–190, and the second training is mainly 170–180. In comparison, the first heart rate is higher, and such a gap occurs. It may not be restored before the second row; the heart rate distribution of athlete No. 2 is shown in Figure 6, with 160–170 and 170–180 as the main interval, the first time is 170–180 more, the second The interval of 160–170 is more than that of the first time; the heart rate distribution of athlete No. 3 is shown in Figure 7. It can be seen that the first training of the No. 3 athletes is similar in the distribution of 170–180 and 180–190. The second 160–170 accounted for a larger proportion; the heart rate distribution of the No. 4 athlete is shown in Figure 8. For the first time, the interval between 160–170 and 170–180 is the main one. The heart rate of the second training is mainly at 160–170 and 150–160 two intervals. In summary, it can be seen that the heart rate of this person is generally better than the second time for the first time. The training of 60m is the endurance, so the second time may be the reason for not recovering.

5.2 Application Test of Duzhu Drifting Alone

6. CONCLUSIONS

Based on multi-sensor data fusion technology, Duzhu drift training monitoring system has the characteristics of high sampling frequency and strong processing ability. It can convert the collected heart rate, speed and acceleration data into real-time image display, and monitor and analyze

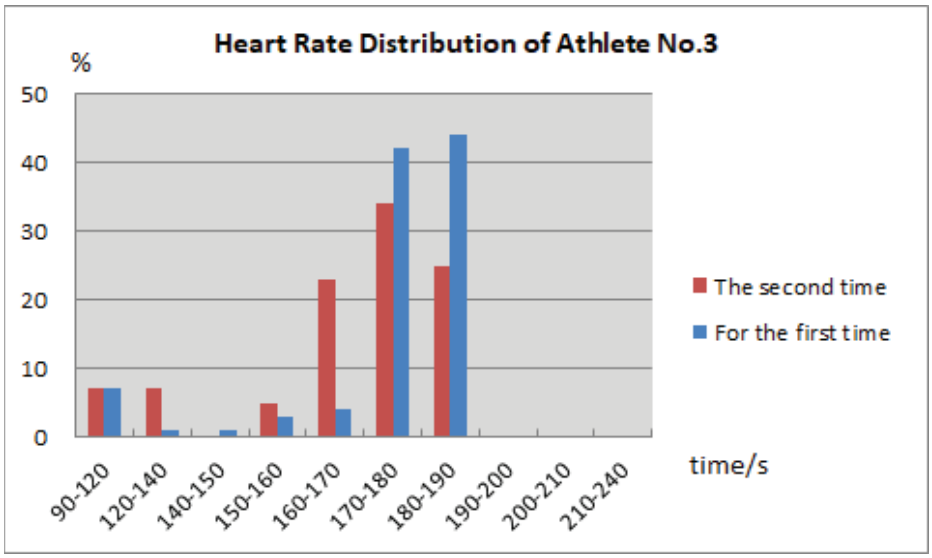

Figure 7 Heart Rate Distribution of Athlete No. 3

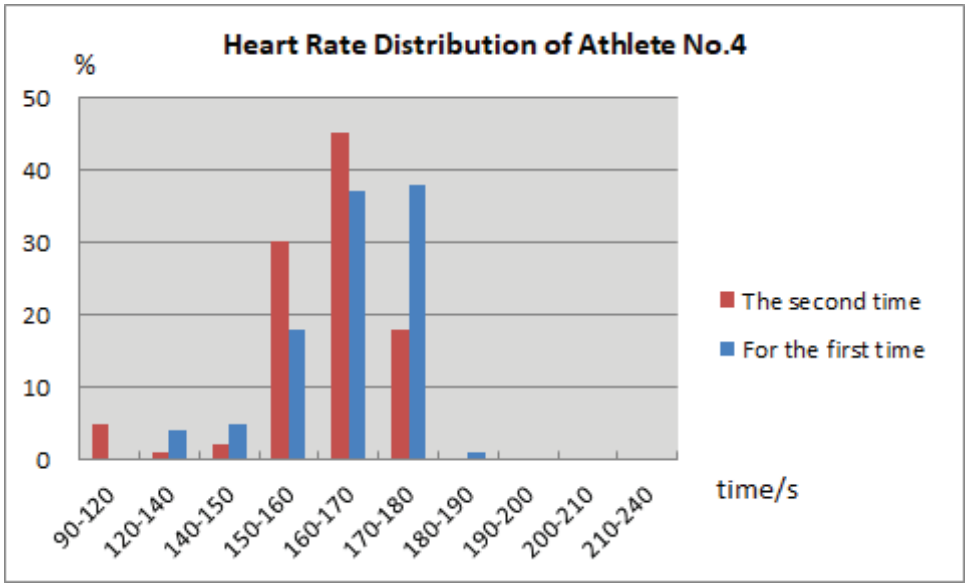

Figure 8 Heart Rate Distribution of Athlete No. 4

the training effect. The system can use the 4G network transmission, the paddle frequency calculation, the embedded system, the GPS and other modern science and technology to collect the motion information and generate the monitoring process diagram of the sports training parameters without affecting the athlete training. Clearly understand the real-time kinematics parameter information during the training process; the system has been applied to the Hechi University Duzhu drift team to provide real-time diagnosis of training effects for coaches, improve the efficiency of athletes' special training, and provide a scientific basis for targeted training. The coaches and athletes clearly understand the real-time kinematics parameters during the training process. The system has been applied to the Hechi University Duzhu drift team to train the trainers in real time to improve the training effect, improve the efficiency of the athletes' special training, and provide the basis of science for targeted training.

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AUTHORS' CONTRIBUTIONS

All authors contributed equally and significantly in writing this article. All authors read and approved the final manuscript. Jianzhuo Lan is corresponding author.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

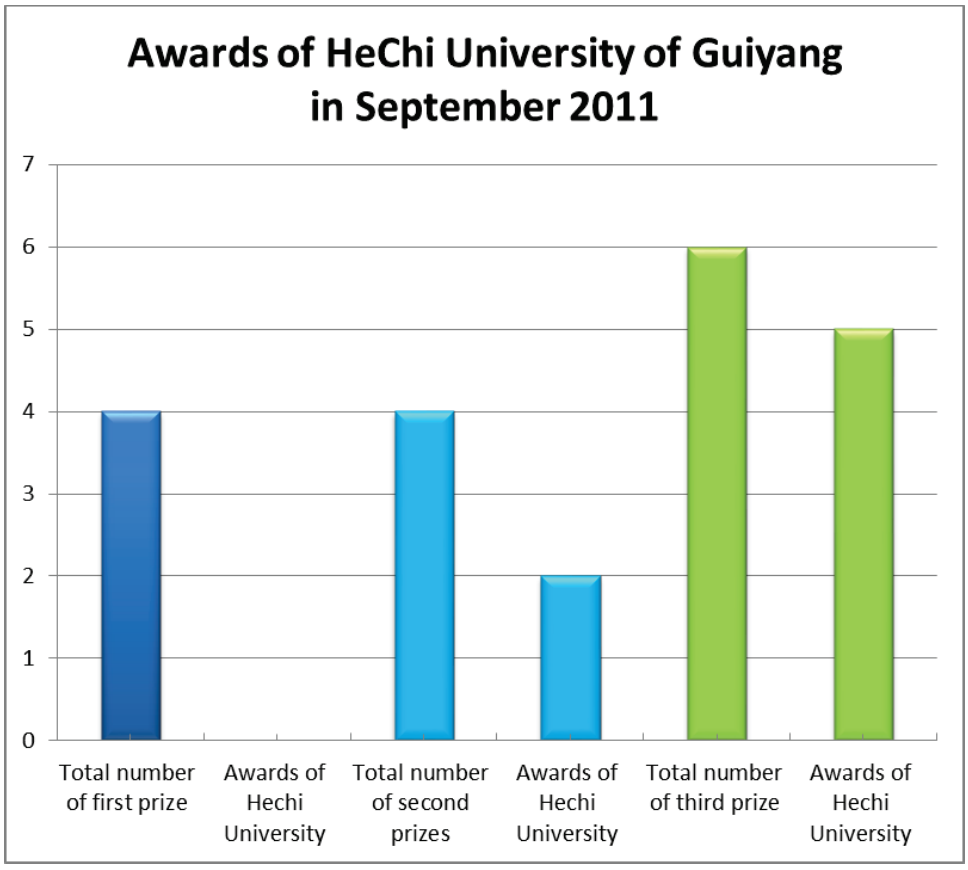

Figure 9 Awards of Hechi University of Guiyang in September 2015

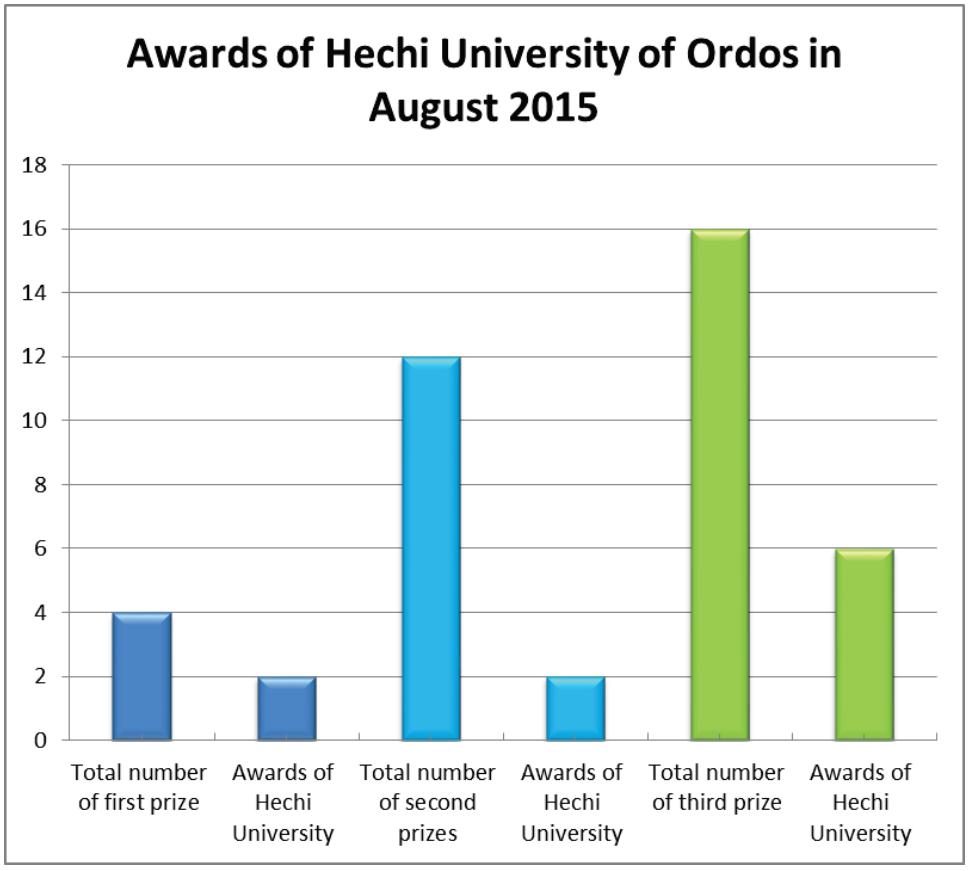

Figure 10 Awards of Hechi University of Ordos in August 2015

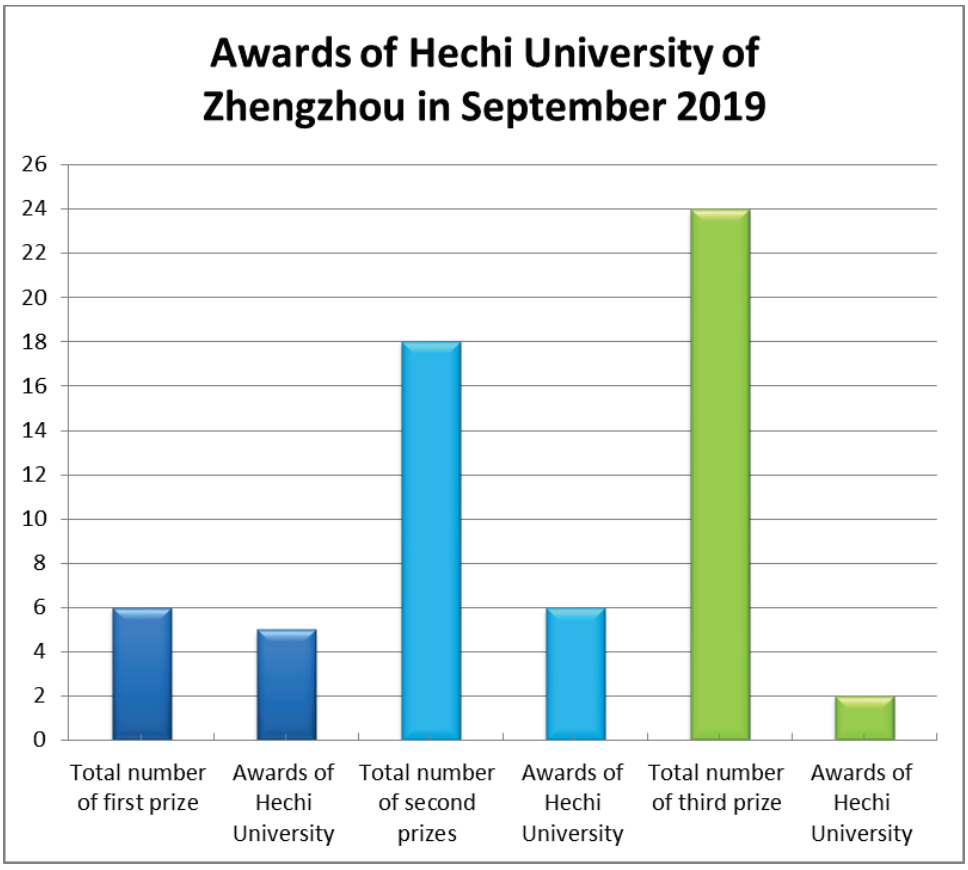

Figure 11 Awards of Hechi University of Zhengzhou in September 2019

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