[1] **Xin Liu**

[1] * **Jun Guo**

A Systematic Study on the Application of Computer Big Data Analysis to Improve the Accuracy of Referee Decision in Sports Events

JES

Journal of Electrical Systems

Abstract: - Due to the complex working environment, long communication distance and high reliability requirements of referees in weightlifting events, this project uses TI's MSP430F5299 as its core processing chip. RS485 for long-distance communication. This system realizes a variety of judgments, arbitration supervision, system function setting, LED large screen display, PC data real-time transmission and other functions. Then, Fourier pyramid filtering method is used to extract human skeleton information, and SVM is used to classify human behavior to complete the construction of human behavior recognition model. The findings from the study indicate that the architectural approach detailed within this manuscript yields a higher degree of precision in identification, thereby offering judges an enhanced instrument for assessment.

Keywords: Depth Characteristics; Skeletal Characteristics; Support Vector Machine; A Decision Organ; LED Large Screen Display.

I. INTRODUCTION

The extraction, recognition, tracking, three-dimensional reconstruction of human motion features and the analysis and expression of motion are the focus of current imaging and machine vision research. It can observe the instantaneous posture, joint position and motion path of players in real time, and can quantitatively analyze motion parameters such as displacement, velocity and angular velocity at any point in time. Combined with the principles of human physiology and physics, people explore a perfect way to promote competitive sports from simply relying on experience to the scientific digital age [1]. It can also capture the actions of poor athletes and good athletes, and correct non-standard actions by comparing their actions, so as to make their actions more correct, which is conducive to smooth training, improve the level of sports, and play an auxiliary role in smooth training [2]. For example, the pool wall of the Sydney Olympic swimming pool is installed with high-performance high-speed cameras, which can track and record the whole process of the players, and conduct real-time analysis, thus laying the foundation for the diagnosis of technical actions, the optimization of technical solutions, the optimization of actions and the simulation of actions. The accuracy of testing equipment has reached astonishing levels, and technology is continuously allowing people to exceed the limits of the human body [3]. The recognition of human posture is a very important research direction, which has a broad development space in machine vision. Therefore, methods based on 3D human pose estimation and behavior recognition are widely used. In recent ten years, the research on human motion capture, human modeling, pose estimation and motion recognition has achieved fruitful results. A new human behavior recognition algorithm based on local characteristics has been proposed, which is characterized by the explicit description of human behavior using an extensible graph model, so as to improve the recognition efficiency of human behavior. Some scholars, when studying various parts of the human body, give an overall characteristic [4]. In order to achieve this goal, a 3D model is first established in the 3D space of the human body, and then the model is used to identify the human behavior. Aiming at the motion features in RGBD images, a new image feature extraction method is presented. The method can identify the behavior by extracting the spatial orientation of the space with equal space spacing. Prominent areas of inquiry encompass: sophisticated man-machine interfaces, facilitated lifestyles, motion-sensing gameplay, smart vehicular support technology, cinematic arts, stereoscopic television and cartoons, rehabilitation techniques, self-governing cognitive evolution. Intelligent environment, motor behavior analysis, video surveillance, video annotation, etc. Especially in the study of physical activity, there are many items, such as aerobic dance, which have high requirements on the posture and movement of the human body [5]. Therefore, the attitude estimation method can be used in the study of sports performance and training in physical education. In the process of competition, it can also provide some help for judges to score. Therefore, the author has researched and designed the referee system to adapt to the world standard of weightlifting. The

[1] School of Taishan University, Taian 271000, China
*Corresponding author: Jun Guo

system consists of four-sided digital LED display module, single-sided digital LED display module, core control system module, timing display module, peripheral keys and display control module. The main idea of the system is to use RS485 bus to realize various display and digital communication. Due to the many hardware connection points, higher requirements for I/O ports, and including the competition timing display system, the 16-bit hybrid signal processor with rich I/O resources, low power consumption and strong anti-interference ability is selected as the core for the control of various logical decisions and arbitration monitoring. When completed, the scheme will replace the current judging system in the market and can be upgraded as the competition rules change [6]. By collecting 3D data of movements, the system uses the extended standard database to identify movements based on bone features and depth local features, and assists judges to give more accurate difficulty scores according to the accurate recognition results.

II. DESIGN OF REFEREE SYSTEM

A. System structure framework

The overall architecture of the system is shown in Figure 1 (image cited in Application Analysis of Data Mining Technology in Oil Painting Course Resource Management). With MSP430F5529 as the core, it will be the decision signal of the three judge controllers, the prompt signal of the arbitration controller and the keying signal of the timing setting board, and the received signal is transmitted to the display control board through the 485 bus, on the display control panel, another MSP430F5529 and the drive circuit [7]. The time display of the LED display and the decision display of the RESULT display can be controlled, and the electronic speaker can also be prompted for segmented time and decision results.
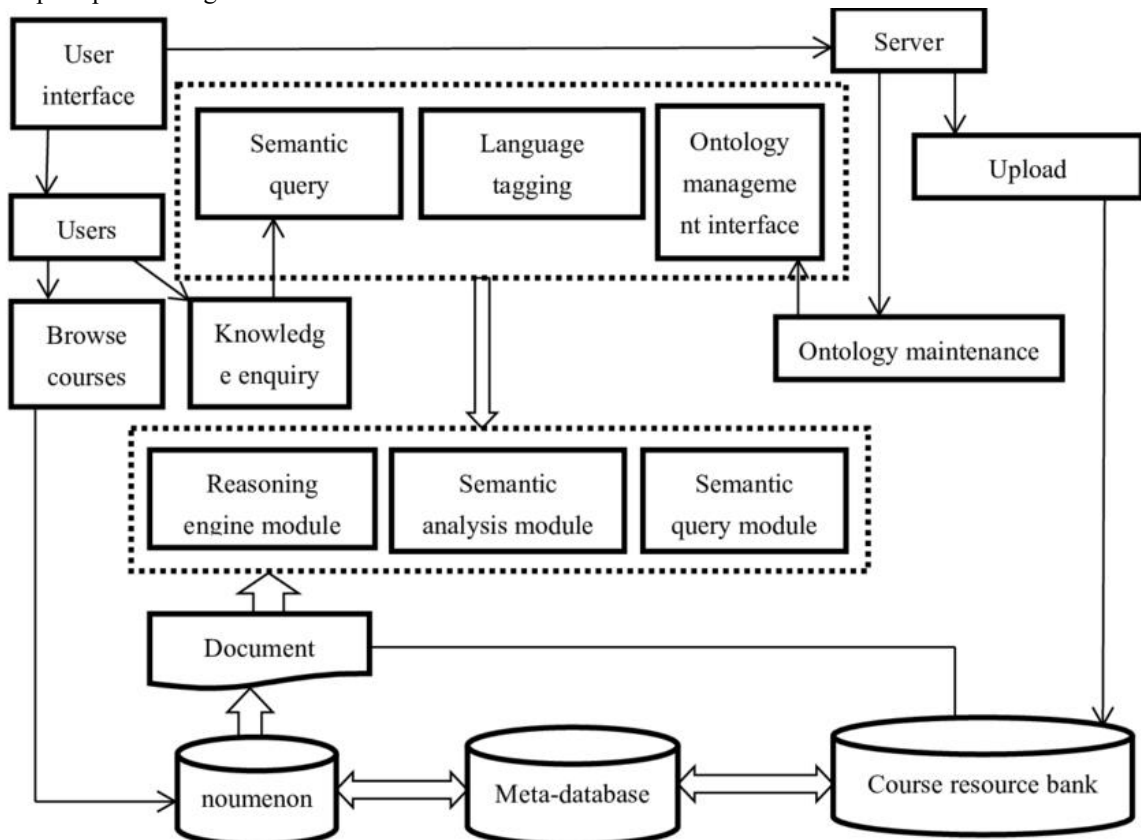

Fig.1 Frame diagram of the referee system

B. Hardware implementation of the transmitting end of the kernel controller

The system consists of three main peripherals: referee controller, arbitration controller and timing board. The control panel of the center is responsible for the logical judgment of the three judges, and the judgment results of the three judges with the corresponding "victory" or "failure" words LED as arbitration supervision. In addition, in the program, there are also three prompt buttons to allow the three judges to make judgments in time [8]. There is an alarm in each of the three vice judges, and whenever there is a referee's prompt, the corresponding alarm will sound "beep" to play a warning role. This paper focuses on the design of court control system and 485 communication system.

1)   Circuit of referee controller

The decision button and buzzer of the external device are provided by the +12 V power supply, and the control of each input /O port is built on the MCU +5 V power supply, so the photoelectric coupler is used here to isolate, here, the MCU input /O port will output a lower level for control, so it has high reliability. Similarly, this type of decision key and timing controller also use this line [9]. As you can see from Figure 2, in addition to the keyboard control lines, the diagram also contains the lines for the alarm speaker.
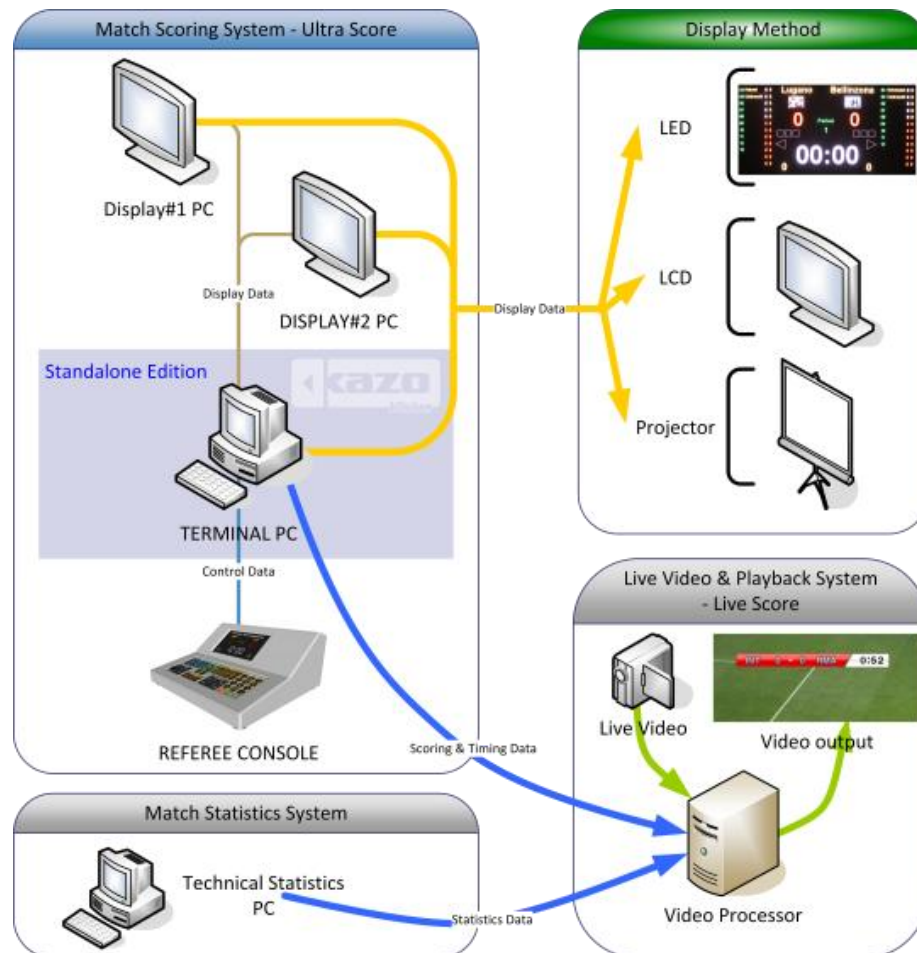
Fig.2 Referee controller

2)   Communication circuit

485 communication as the communication mode of the whole system, the reliability of its work has a very important impact on the performance of the whole system. MAXIM MAX485ESA is used as the main control module, and power isolation and optocoupler drive are adopted to ensure the safe and reliable transmission of system data [10]. The maximum communication capacity of RS485 communication is 1200 m. It can well meet the application requirements of the scheme (Figure 3 is quoted in the Design and Fabrication of a High Precision Constant Current Source Current Generator).
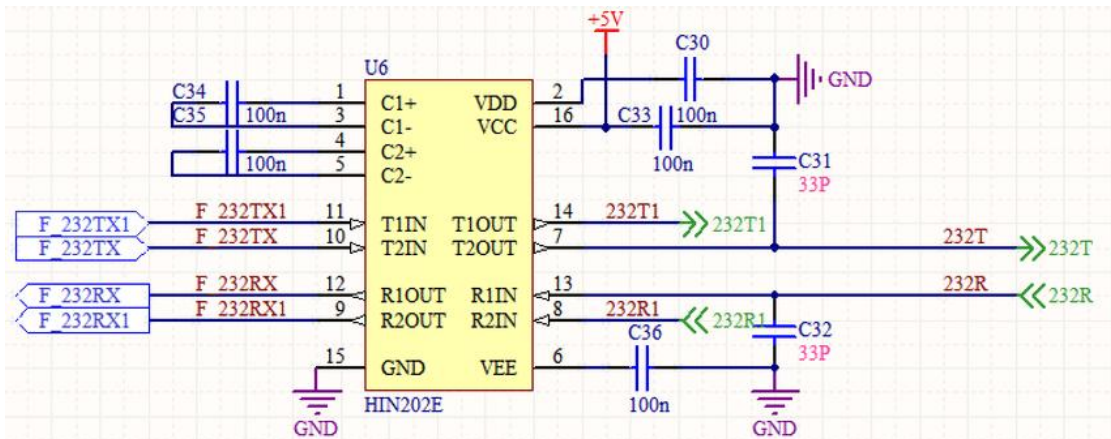
Fig.3 Communication circuit

C.   Display the hardware design of the receiving part

The device consists of a backward timer and a red and white LED result display panel. The timing display board displays the corresponding time according to the timing Settings on the timing device, and counts backwards after startup. Red and white LED display is used to show the corresponding results generated after a number of judgments, if the judgment is correct, it is white, if the judgment is incorrect, it is red [11]. The work of this system is to complete the judgment of time and judgment through 485 bus communication.

1)   Digital kinescope display

After receiving the first display signal from the 485 bus of the receiver, the MSP430 microcontroller makes the corresponding time be represented in the LED digital tube by controlling the four CD4094 blocks, which is represented by the timing display board driver circuit in Figure 4. Each display position on the system display is provided with 7 leds, marked with the word "8", each "8" section is a section, each section is 8 mm LED, the current limiting resistance is 240 OHMs, the current is about 20 mA, the use of high power transistor to drive the LED, to ensure long-term stable operation. In practical applications, LED shows high brightness, and through a long time of testing, is not easy to damage.
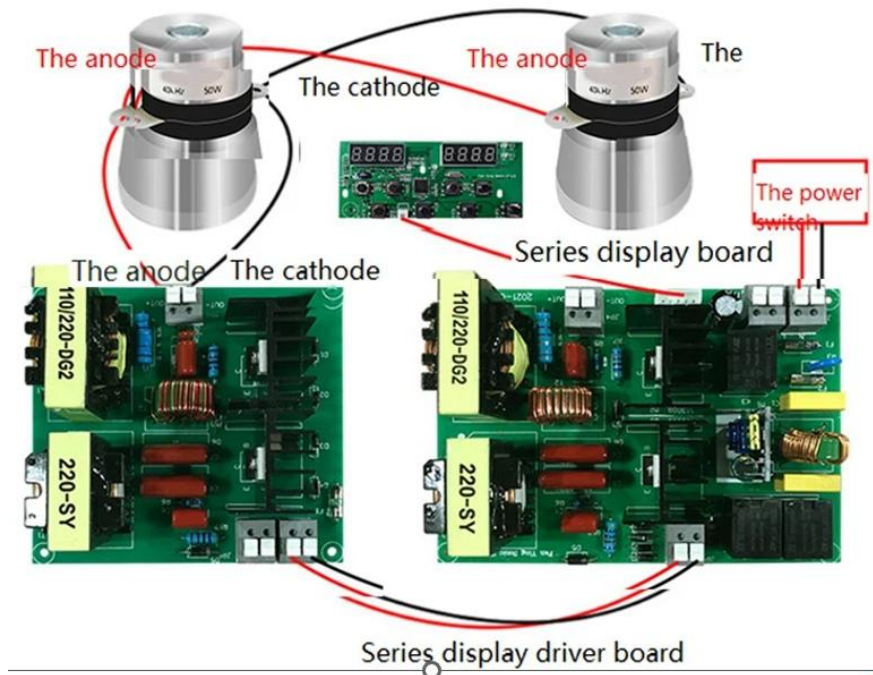

Fig.4 Time display board driver

2)   RESULT Result display board

Figure 5 shows one of the three red lights in the red and white display panel as an example (image cited in Design and Validation of a Low Cost Programmable Controlled Environment for Study and Study) Production of

Plants, Mushroom, and Insect Larvae). This circuit uses a connection mode of 3 leds in series and 18 groups in parallel, so that the test results can be displayed in a large range on the screen, and it is very convenient and intuitive to watch [12]. Due to the LED parallel more, according to the actual calculation, $P = U^2 / R$. The actual calculation P=3.6W, so here people take a 10Ω5W high-power resistor, this LED can also use high-power patch LED instead.
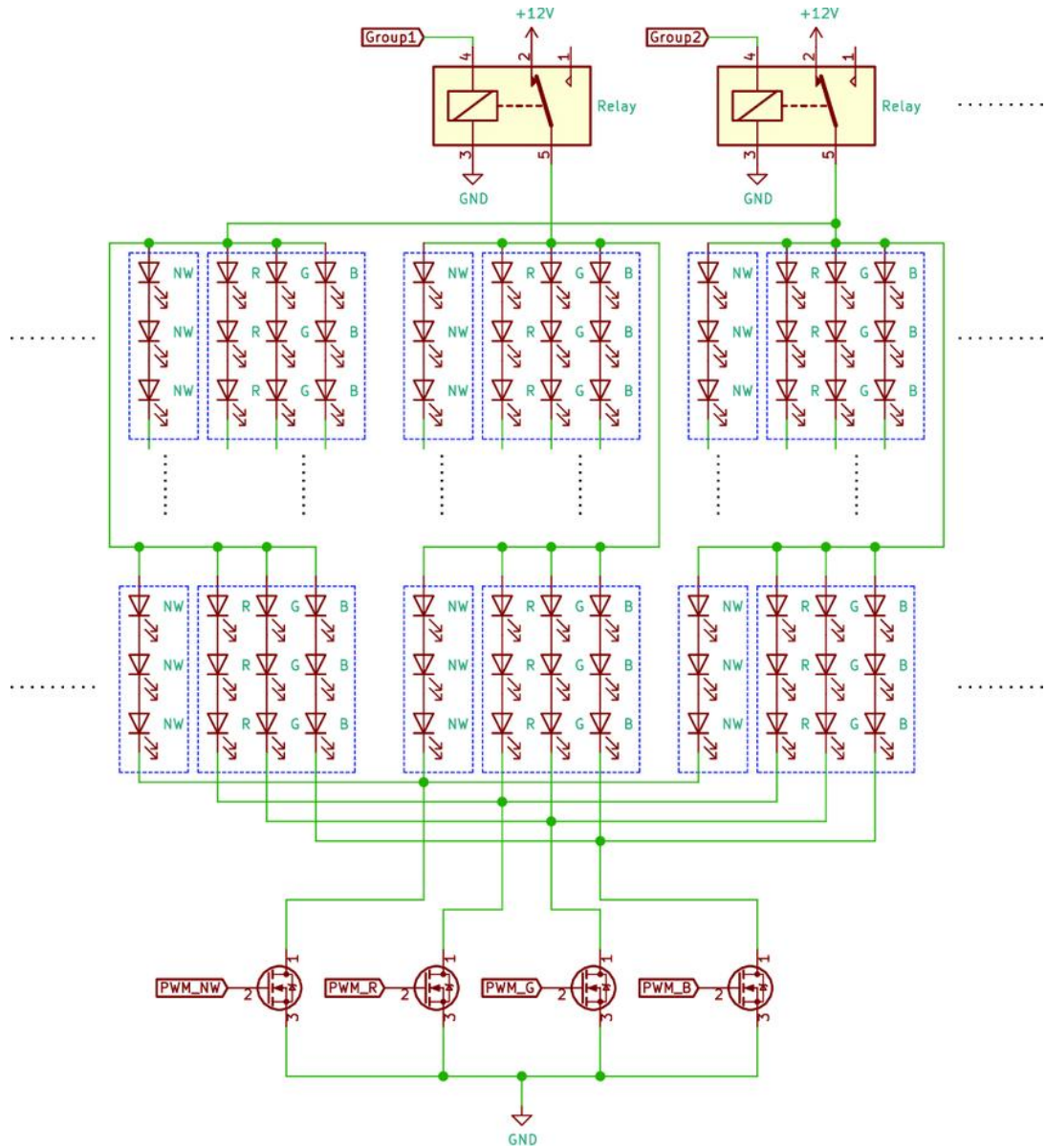

Fig.5 Red LED series circuit diagram of red and white display panel

D. Software Design

in Figure 6, a flowchart for the part of the program is shown (the image is referenced in the Application of Virtual Reality Based on Computer Vision in Sports Posture Correction). After starting the program, the hardware is initialized first to realize the function of timing and timing [13]. When the game enters the countdown, the MCU will collect the results of the decision of the various deputy judges, if there is no judgment, it will give a hint, and the arbitration will also give a hint of the judgment, according to this rule of reasoning, you can get the final decision. After 485 communication, the measured results will be displayed on the LED screen, and the measured results will be communicated with the PC in real time, so that it can carry out real-time data processing and display.
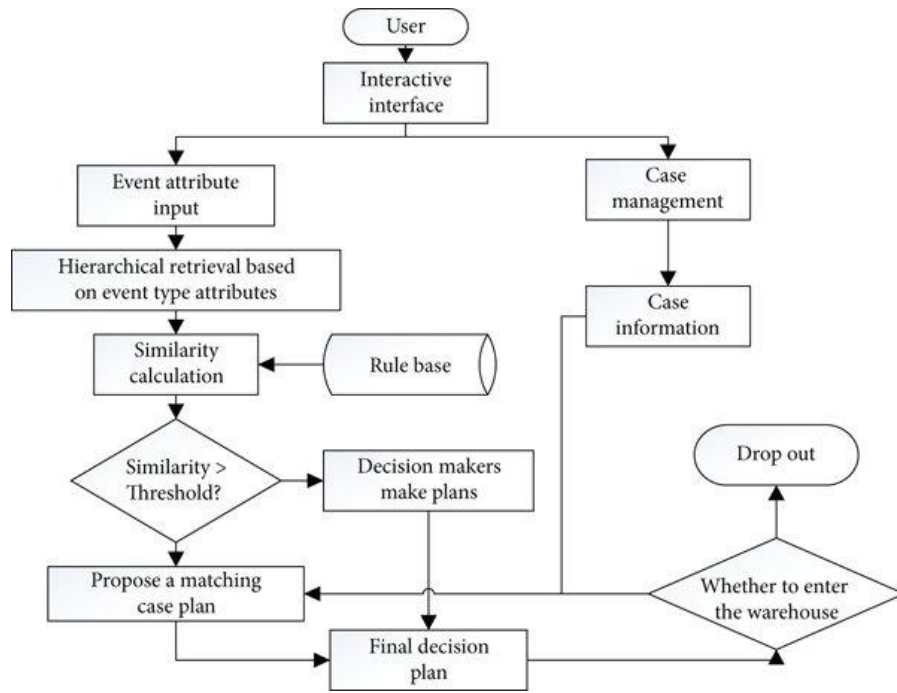
Fig.6 Partial process flow chart

E. Network Security Design

The competition network is a dedicated space that is completely separated from the competition field on one side of the field, and ensures the safety of the competition field through measures such as partition and isolation protection, equipment and line redundancy, guaranteed performance redundancy and wireless access control [14]. The competition network of the stadium is divided into five sections: special exit area, security maintenance management area, business system area, business system protection area and special terminal area based on the layout of the system and the characteristics of the activity. The overall network architecture is shown in Figure 7 (image cited in Applied Sciences, 2019, 9(23): 5166):
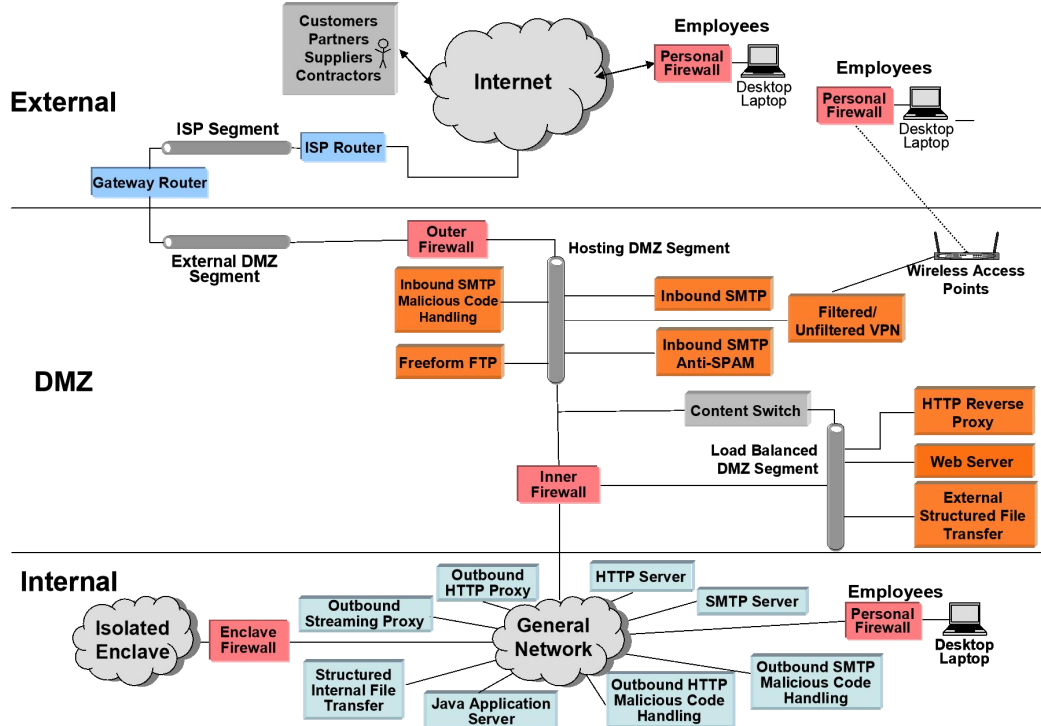

Fig.7 Network security architecture diagram

The exit area of the dedicated channel is the peripheral area of the dedicated channel of the competition, which is responsible for external networking and border management, mainly for the egress router, the egress

firewall and the core switch. Security maintenance management area through the external management of the competition network, and its security maintenance and maintenance, including APT analysis, business security reinforcement and control center and other security management core equipment, such as fortress machine, database audit, log audit; Among them, the operation system area, as the central area of the competition network, is equipped with the competition system server at the field level, which is an important place to ensure the security of the competition information. Commercial system protection area protects the boundary of commercial system area;

The dedicated terminal area is a place for accessing the timing and scoring equipment, the office terminal dedicated to the competition and the score system, and is equipped with an access switch, a timing and scoring device, a video capture device, a office terminal dedicated to the competition and a special terminal dedicated to the score system. Dual routing and redundancy scheme In order to ensure the high reliability of the private network link in the competition field, the redundant mode of two routes is adopted in the competition port on one side of the competition field. At the same time, the egress router, egress firewall, core switch, and service firewall all use two pieces of hardware for backup [15]. In the export area and service system protection area of the dedicated communication system, the security access control device is installed in the security operation management area, and the protective device such as APT analysis device is installed in the security operation area to achieve the functions of access control, intrusion prevention, malicious code prevention and other functions of cross-border access and data flow.

1)   Access Control

Through the configuration of the access control device of the private network outlet and the service system protection area, the corresponding access control criteria are set according to the principle of cross-regional access control [16]. In the protection area of the entrance and exit of the dedicated communication system and the service system, the firewall with intrusion detection capability is configured to detect the network attacks initiated by the outside world or by the inside. The APT analysis device is deployed in off-line mode on the core switch to implement in-depth detection and analysis of external to internal, internal to external, and internal horizontal network attacks.

2)   Preventing malicious code

Firewalls are configured in the private network egress zone and service system protection zone to enable the antivirus function. Using the virus Trojan detection function in APT technology, the input and output data in the network can be analyzed effectively.

3)   Security protection of servers and terminals

In order to protect access control, intrusion and malicious code, commercial system security protection software is configured on each server and terminal. Various protection measures based on access control, intrusion prevention and malicious code prevention are proposed, and integrated with APT attacks, a network-based terminal security collaborative protection mechanism is constructed. APT technology is used to detect the attacks in the operation monitoring area, and alarm them according to their danger level, and describe the attack source IP, attack type, attack target, attack time and other information in detail [17]. The "detection + protection" mechanism of the edge peer end based on APT technology is studied to realize the detection and positioning of known or unknown threats, and the security protection of the terminal to achieve collaborative protection.

4)   Security Coordination Office

The security management department detects network traffic, user behavior, and security events by means of integrated logs, security operation and maintenance, and data communication behavior analysis. The specific tasks are as follows: In the security operation and maintenance management area, logs of key security events and behavior events such as network devices, security devices, hosts, and service systems are statistically analyzed. and compared it to A log audit system (Figure 8 cited in a Blockchain based and GDPR-compliant design of a system for digital education certificates).
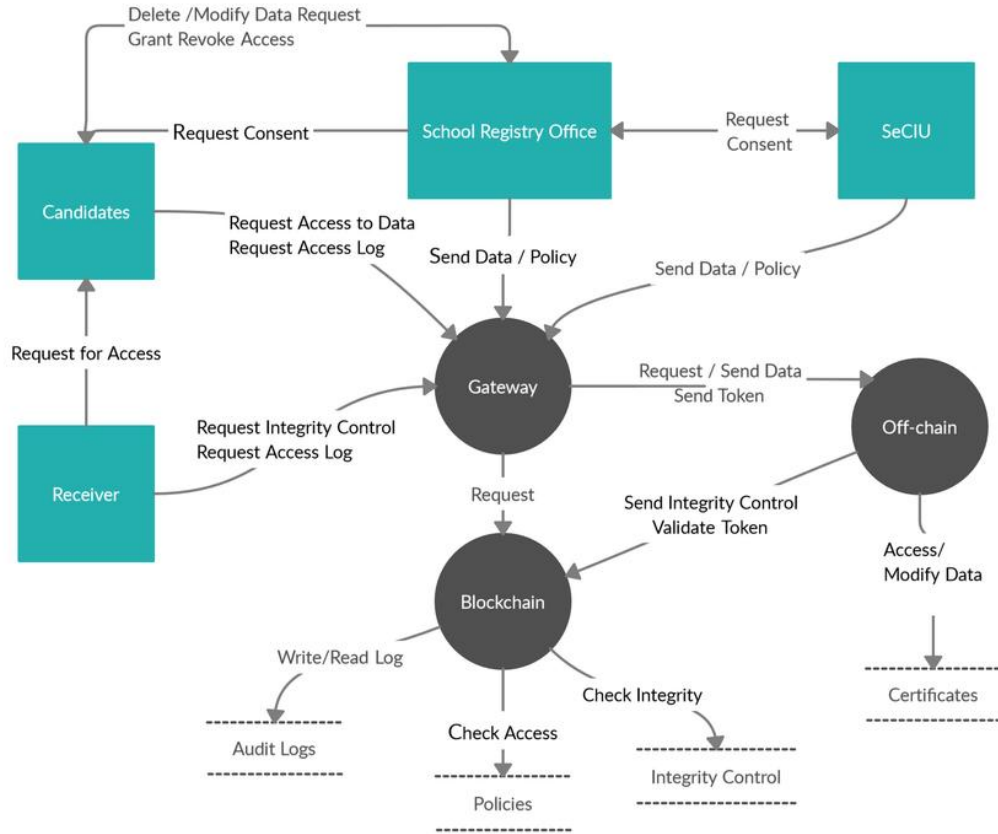
Fig.8 Log audit data flow

In the security maintenance management area, you can remotely maintain and audit network devices, security devices, hosts, and service systems to achieve unified account management, authentication and authorization, single sign-on, and process audit. In the security operation management area, the traffic and traffic in the edge network are deeply probed and analyzed, and their transmission process is monitored.

III. COLLECTION OF ACTION DATA

Machine vision is the study of how to use computers to complete human visual tasks, that is, to use computers to depict the 3D world. Since the computer can only obtain 2D 2D images, compared with the real 3D scene, there will inevitably be some missing, so when using 2D images for 3D reconstruction, there will inevitably be a "pathological" problem. Therefore, in practice, it is more about imaging the same object from different perspectives and then analyzing it to maximize the 3D image of the subject, which is the origin of computer vision. A new binocular stereo vision system is established to simulate the imaging principle of human eyes based on the principle of binocular imaging. This paper introduces a computer-aided binocular stereo imaging method. The reason why the depth of the subject cannot be restored from a photograph is that every point of the subject has a projected ray, and all points on this ray are flat, so the true position of the target cannot be judged from a photograph [18]. If you know two images taken from different angles of the same object, the projected rays of the two images will meet in the air, and the value of this position is the 3-D coordinate of the object. An image-based 3D reconstruction method is proposed. Among them, image acquisition refers to taking photos of the subject from different angles, so as to obtain multiple images of the subject. Camera modeling determines the corresponding positions of the camera surfaces of the two cameras in a certain 3-D coordinate system, that is, the camera calibration work mentioned before. By establishing the spatial position relation of two camera image surfaces and the coordinate information of the same image point, the spatial coordinate of the subject is obtained by means of spatial analysis geometry, and the spatial positioning of the target is realized.

This project intends to abstract human movements into a 3D human body model composed of rigid movements connected by multiple joints, and realize 3D stereoscopic pose reconstruction by acquiring the position information of human joints. Camera shooting is a relatively simple means to obtain the position of human joints. This project intends to use dual cameras to synchronize acquisition of human movements under

two perspectives, obtain their 2D coordinates, and calculate their 3D coordinate values. In order to meet the demand for accurate acquisition of 3D image data, people calibrated the camera in the early stage, which is to establish the conversion relationship between the 3D target and the 2D image coordinate system of the camera [19]. The accuracy of camera calibration has a great influence on the accuracy of its measurement results. According to the needs of human behavior, there are many research results, mainly including tag type, laser ranging type, structured light sensor, Microsoft Kinect sensor and multi-camera. Through the motion information acquisition of Microsoft Kinect, get more motion information, so as to get more motion information. The acquisition process is shown in Figure 9 (image cited in Crowdsourced mobile data collection: lessons learned from a new study methodology). The method is mainly divided into three aspects: depth map, human body parts and 3D joint modeling.
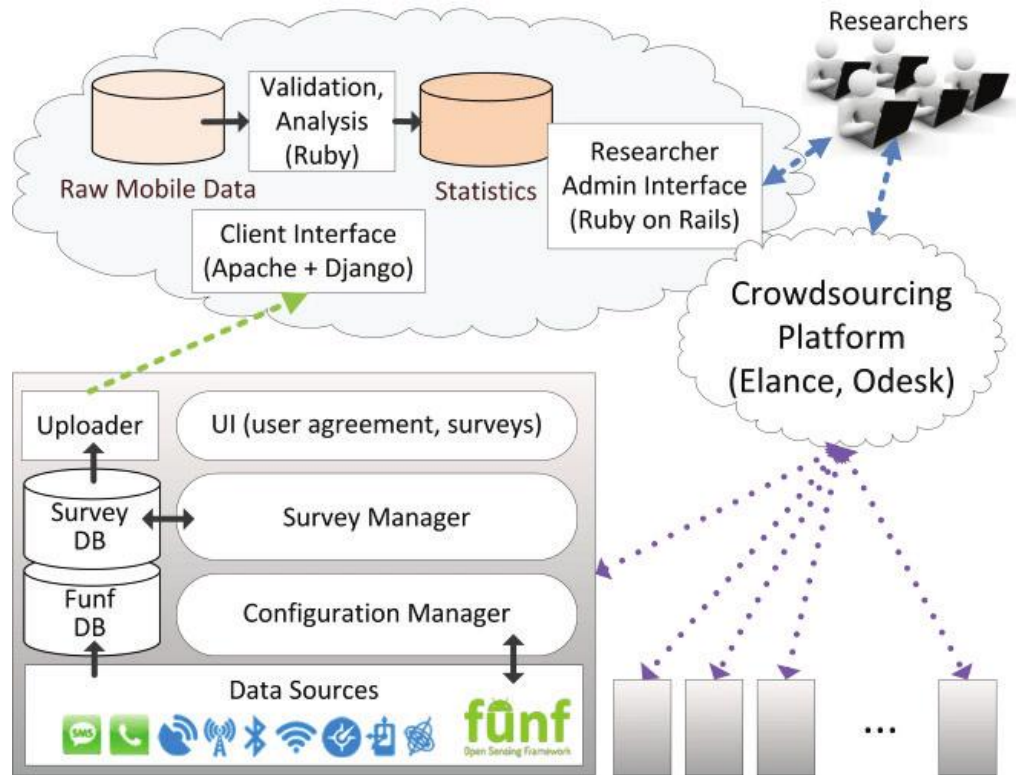

Fig.9 Action data acquisition architecture diagram

A new image region search algorithm based on Gaussian function is proposed. The density of each part of the human body is estimated as follows:

$$g_z(\hat{u}) \in \sum_{i=1}^{N} \lambda_{iz} \exp(-\| (\hat{u} - \hat{u}_i)/\varepsilon_z \|) \quad (1)$$

A method based on mean shift is proposed, which can quickly and accurately identify each mode value in this region, and obtain the weighted sum of each mode value, so as to obtain a high confidence. The recognized patterns are distributed on the surface of the target, and finally a three-dimensional three-dimensional model is obtained [20]. In these sports, the movement characteristics of the skeleton are the key to distinguish aerobic exercise, but also the requirement for Angle robustness. This paper selects the body part characteristics and define them as:

$$f_{i,k}^t = U_i^t - U_k^t \quad (2)$$

A method based on two-dimensional planar graph is proposed, that is, it is projected onto a two-dimensional plane first, and then treated as 1, if not, then 0 is obtained. Because in general, the number of 1s is much less than the number of 0s, the paper can think of it as a sparse phenomenon. The three-dimensional data of each node is divided into blocks, and the statistics of each pixel on each node are carried out.

$$B_{xyz} = 1\left(1 + e^{-\gamma \sum_i p_i}\right) \quad (3)$$

In view of the great influence of external influences in the process of human movement obtained by Kinect, a three-level Fourier-time-space cone method was proposed to accurately identify aerobic exercise [21]. The first level obtains the low frequency coefficient of the data frame through FFT; The low frequency component of half image is obtained by FFT processing of half frame in middle layer.

$$corr(P,Q) = \mathrm{cov}(P,Q)/(\eta_P \eta_Q) \ (4)$$

$$\Xi = \mathrm{var}\left(\begin{bmatrix} u \\ v \end{bmatrix}\right) = \begin{bmatrix} \Xi_{11} & \Xi_{12} \\ \Xi_{21} & \Xi_{22} \end{bmatrix} (5)$$

Where Ξ_{11}, Ξ_{22} represents the autocovariance matrix and Ξ_{12}, Ξ_{21} represents the covariance matrix.

$$\Xi_{11}^{-1}\Xi_{12}\Xi_{22}^{-1}\Xi_{21}x = \varphi^2 x \ (6)$$

$$\Xi_{22}^{-1}\Xi_{21}\Xi_{11}^{-1}\Xi_{12}y = \varphi^2 y \ (7)$$

Feature matrix is used for feature fusion, and the specific fusion method is expressed as follows:

$$C = \begin{bmatrix} P \\ Q \end{bmatrix} = \begin{bmatrix} x^T & \\ & y^T \end{bmatrix}^T \begin{bmatrix} u \\ v \end{bmatrix} (8)$$

u, v represents the feature vector and the action label respectively.

$$\eta_i = v_i(\lambda u_i + \varepsilon) \ (9)$$

$$\min \frac{1}{2}\|\lambda\|^2 + C\sum_{i=1}^{l}\xi_i \quad (10)$$

$$s.t. v_i[(\lambda u_i) + \varepsilon] \geq 1 - \xi_i$$

Where l is the number of samples, and C is the penalty factor used to represent the importance of outliers. When its value is large, the loss to the optimal problem will also increase. Here, people set only one relaxed variable for the outlier, and the larger its value, the greater the deviation of the variable. The characteristics of calisthenics were classified and distinguished by SVM method, and the corresponding difficulty and completion degree were scored with the corresponding database.

IV. Conclusion

After hardware circuit design, software programming, assembly technology design, and finally debugging, all the design indicators are fully satisfied, and the work is stable and reliable. In the programming, for the different rules of the game, a lot of adjustments and amendments have been made to adapt to the change of the rules of the game. At the same time, in the research of this topic, the LED flicker instability, hardware connection point is not reliable, reliable transmission and other problems are studied.

V. References

[1] Kubayi, A., Larkin, P., & Toriola, A. (2022). The impact of video assistant referee (VAR) on match performance variables at men's FIFA World Cup tournaments. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 236(3), 187-191.

[2] Lago-Peñas, C., Gómez, M. A., & Pollard, R. (2021). The effect of the Video Assistant Referee on referee's decisions in the Spanish LaLiga. International Journal of Sports Science & Coaching, 16(3), 824-829.

[3] Dawson, P., Massey, P., & Downward, P. (2020). Television match officials, referees, and home advantage: Evidence from the European Rugby Cup. Sport Management Review, 23(3), 443-454.

[4] Russell, S., Renshaw, I., & Davids, K. (2022). Sport arbitration as an emergent process in a complex system: Decision-making variability is a marker of expertise in national-level football referees. Journal of Applied Sport Psychology, 34(3), 539-563.

[5] Webb, T., Dicks, M., Thelwell, R., van Der Kamp, J., & Rix-Lievre, G. (2020). An analysis of soccer referee experiences in France and the Netherlands: Abuse, conflict, and level of support. Sport Management Review, 23(1), 52-65.

[6] Han, B., Chen, Q., Lago-Peñas, C., Wang, C., & Liu, T. (2020). The influence of the video assistant referee on the Chinese Super League. International Journal of Sports Science & Coaching, 15(5-6), 662-668.

[7] Samuel, R. D., Tenenbaum, G., & Galily, Y. (2021). An integrated conceptual framework of decision-making in soccer refereeing. International Journal of Sport and Exercise Psychology, 19(5), 738-760.

[8] García-Santos, D., Gómez-Ruano, M. A., Vaquera, A., & Ibáñez, S. J. (2020). Systematic review of basketball referees' performances. International Journal of Performance Analysis in Sport, 20(3), 495-533.

[9] Chen, R., & Davidson, N. P. (2022). English Premier League manager perceptions of video assistant referee (VAR) decisions during the 2019-2020 season. Soccer & Society, 23(1), 44-55.

[10] Tzeng, C. C., & Lee, P. C. (2021). Understanding match-fixing from the perspective of social capital: A case study of Taiwan's professional baseball system. International Review for the Sociology of Sport, 56(4), 558-577.

[11] Abdikadirova, N. S., Nurillaeva, D. S., Ganijanovna, M., Azamova, S. R. J., Bobomuradov, B. K., & Kutlimuratov, I. K. (2021). Football in Uzbekistan: Law, Leisure and Sociology. PSYCHOLOGY AND EDUCATION, 58(1), 1995-2002.

[12] Pan, T. Y., Tsai, W. L., Chang, C. Y., Yeh, C. W., & Hu, M. C. (2020). A hierarchical hand gesture recognition framework for sports referee training-based EMG and accelerometer sensors. IEEE Transactions on cybernetics, 52(5), 3172-3183.

[13] Loyens, K., Claringbould, I., Rossem, L. H. V., & van Eekeren, F. (2022). The social construction of integrity: A qualitative case study in Dutch football. Sport in Society, 25(9), 1714-1733.

[14] Buhari, M. R., Nurjamal, N., Huda, M. S., Cahyono, D., Jufri, J., & Ruslan, R. (2021). Human Resource Management in Sports Judging from the Sports Development Index on Increasing Sports Achievement in Samarinda City. Kinestetik: Jurnal Ilmiah Pendidikan Jasmani, 5(4), 736-746.

[15] Spitz, J., Wagemans, J., Memmert, D., Williams, A. M., & Helsen, W. F. (2021). Video assistant referees (VAR): The impact of technology on decision making in association football referees. Journal of Sports Sciences, 39(2), 147-153.

[16] Jacobs, B. L., Tingle, J. K., Oja, B. D., & Smith, M. A. (2020). Exploring referee abuse through the lens of the collegiate rugby coach. Sport Management Review, 23(1), 39-51.

[17] Zglinski, J. (2022). Rules, standards, and the video assistant referee in football. Sport, Ethics and Philosophy, 16(1), 3-19.