



Design and Implementation of College Physical Fitness Test Management System based on the Identification of Key Points of the Human Body

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Abstract. At present, physical fitness test, as a course that must be completed by students in major colleges and universities across the country, the problem of insufficient manpower, material resources and inaccurate measurement accuracy caused by manual measurement methods is a thorny problem faced by major universities. This system mainly analyzes the functional needs of physical fitness test in major universities, and develops a physical fitness test management system for colleges and universities by applying human body key point identification technology, SSM technology, and front-end and back-end separation technology. The score collection of this system is based on the pose detection technology of key points of the human body, and the design by the top-down is used to directly realize the performance detection function of the physical fitness test project, and equip WEB system which is used to improve the efficiency of the physical fitness test. The front end of the WEB system is developed based on the B/S architecture, through Vue + Element UI to build pages, the back end uses Spring+Springboot+MybatisPlus to build, the front and back end communicate through the Restful API interface, Shiro+Jwt technology is used to verify user identity and permission management, Echarts is used to achieve data visualization, and real-time data display is realized through WebSocket technology. In a real sense, it realizes efficient physical fitness test and fully meets the physical fitness test needs of college students.

Keywords: key point identification; physical fitness test for college students; WEB system

1 Introduction

According to the data of eight times large-scale national surveys on student physique and health since 1985, the physical fitness of college students has shown a slow decline^[1]. As the core evaluation method of physical quality, physical fitness test currently mostly adopts manual assessment, but the accuracy of manual assessment based on human eye observation needs to be considered. There are also some studies is to obtain human movement-assisted physical education by wearing human joint marking devices to identify human joints. However, this kind of human joint recognition device requires the user to wear a special recognition device, which will interfere and affect the user's sports process. For the wearing of the identification device, it is also necessary to operate manually, and it is easy to cause damage to the instrument during exercise, or the final measurement result is inaccurate due to incorrect wearing. Therefore, there is an urgent need for a college physical fitness test management system, which can obtain the video through the camera, analyze the data in the system, and determine the human posture, so as to obtain the physical fitness test results and manage the physical fitness test results.

2 System design scheme

2.1 System architecture design

From the consideration of high performance and data security, the system uses the action camera to transmit back the body test video data in real time during the test process, identifies the number of students and the 21 key points of each student's human body through top-down design according to the human body key point recognition technology, generates point data through multi-directional observation technology, combines recurrent neural network to regression analysis of video data, and makes standard judgments on body measurement actions.

The front end of the WEB system is developed based on the B/S architecture, through Vue + Element UI to build pages^[2], back end uses Spring+Springboot+MybatisPlus to build^[3], front and back end communicate through the Realful API interface, Shiro+Jwt technology is used to verify user identity and permission management, Echarts is used to achieve data visualization, and real-time data display is realized through WebSocket technology^[4]. a real sense, it realizes efficient physical fitness test and fully meets the physical fitness test needs of college students.

At the same time, Webpack packaging technology is used to compress the front-end project, so as to convert it into static files, and Nginx's reverse proxy technology is used to achieve load balancing of multiple servers, which greatly improves the loading speed of front-end pages under high concurrency. At the same time, the Docker containerization technology is used to deploy the backend, which can make different schools deploy separately, and the main architecture design is as follows, as shown in Fig.1. system architecture diagram.

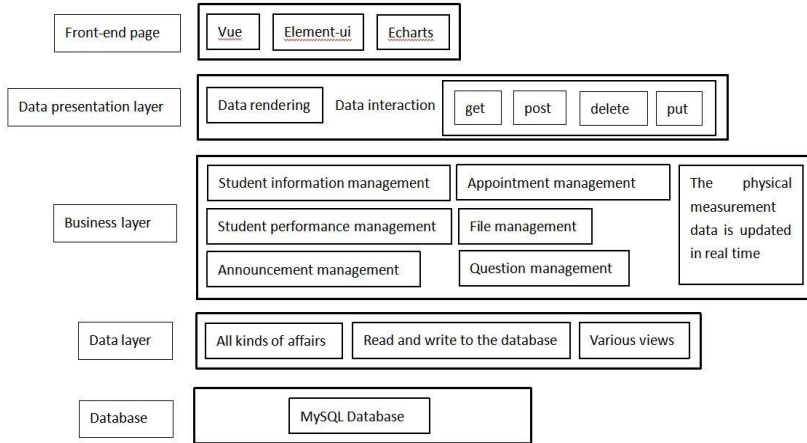


Fig. 1. architecture diagram[self-drawn]

2.2 Main tasks of system development

This design is mainly carried out from three aspects: student system, teacher system and monitoring system, and uses human body key point recognition technology, computer vision technology and SSM technology to realize the functions of physical fitness test activity testing, project appointment, performance monitoring, score entry, score query, performance management, performance analysis, and develop a simple operation, friendly interface and rich functions suitable for the majority of college users of the physical fitness test management system. The implemented functions are roughly summarized as follows:

- (1) Face recognition confirms the identity of the student;
- (2) Video real-time monitoring of physical fitness test information and upload;
- (3) Judge students' movements based on the recognition technology of key points of the human body;
- (4) There are two ways of user registration: student registration and teacher batch import of students;
- (5) Modification of student information;
- (6) The teacher manages the physical fitness test results of the students in the class;
- (7) Administrator management teacher information;
- (8) Large screen visualization of high-performance body measurement data;
- (9) High-performance student physical fitness test appointment function;
- (10) Students initiate the physical fitness test questioning function;
- (11) Student performance inquiry function;
- (12) Student information management function;
- (13) Daily updated sports news feed;
- (14) The teacher's management of the announcement, and the student's reading of the announcement;
- (15) Email score push function;

- (16) The teacher's management of the carousel image;
- (17) Realize the function of batch information entry through file upload;

2.3 System Development Environment

The data collection of this system is based on the key point recognition technology of the human body, the database adopts MySQL8^[5], mainly developed by Idea, Vscod and other development tools, the back-end server is built using Springboot, the deployment uses Docker containerization technology, and the front-end is built using Vue and deployed using Nginx reverse proxy.

3 The key point recognition function of the human body is realized

This system is a college physical fitness test management system based on the identification of key points of the human body, monitors the physical fitness test process of students through video, and uploads video data to the computer at the same time, obtains 21 key bone joint points of the human body with the help of human key point technology, obtains the posture data of key points, determines the posture of the human body, and obtains the results of physical fitness test, as shown in Fig.2. of the identification charts of key points of the human body. At the same time, it supports the identification of key points of the human body by multiple people, as shown in Fig.3. of the key point recognition diagram of multiple people. The use of Top-down design in the identification of key points of the human body is a top-down design idea, that is, a top-down, step-by-step design process from the overall layout, overall structure, component structure to component parts ^[6].

The system first records the physical fitness test video of the students participating in the physical fitness test through the regional camera, and at the same time performs human body detection according to the top-down design, judges the number of students participating in the physical fitness test, and then detects the key points of each person, identifies and analyzes the human body movements in the video, transmits the analysis results back to the computer, and the computer performs regression analysis and prediction based on a large number of experimental pictures and video information through the deep convolutional neural network of machine learning. Return the required information to the cloud data center of the project's physical fitness test platform, and finally obtain the physical fitness test results, and upload the physical fitness test results to the WEB system after confirmation by the teacher, which provides convenience for teachers and students to manage the physical fitness test results later ^[7].

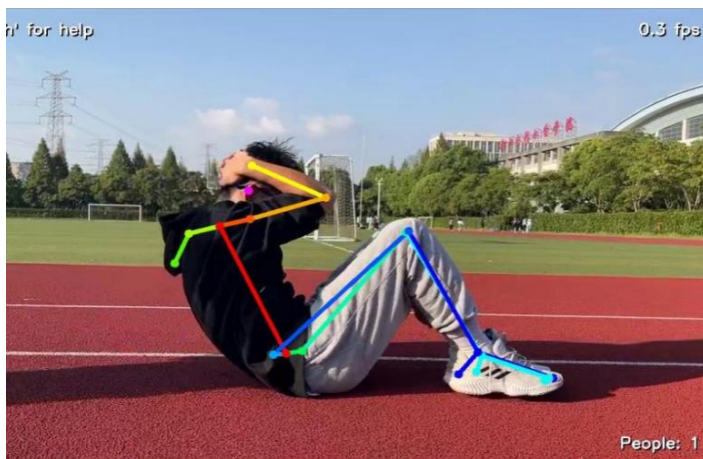


Fig. 2. of the identification chart of key points of the human body[self-drawn]

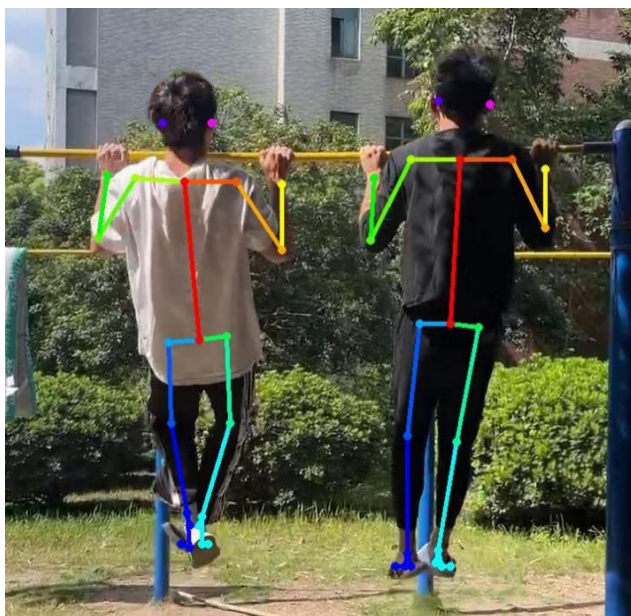


Fig. 3. of the key point recognition diagram of multiple people[self-drawn]

4 WEB system design

4.1 Authentication and authorization function implementation

The design of the cloud measurement system adopts a typical way that users have roles and roles have permissions. The system adopts a before and after separated approach, and the front end interacts with the back end through the Restful interface for

data interaction and business processing. The backend is stateless access, so it must be verified and authorized with the help of Jwt and Shiro, otherwise the data security is not high, as long as the interface is found, anyone can manipulate the data. After the user logs in successfully, the system will encapsulate the user ID and roles into the JwtToken and return it to the frontend, and then no matter what operation the frontend performs, it will carry the JwtToken to the backend, and the backend will distinguish who is accessing by parsing the token. It is impossible to achieve authentication only by using Jwt, so Shiro is introduced to replace Shiro's UsernamePasswordToken with JwtToken, and the user information encapsulated in JwtToken is called in the core authentication part to authenticate.

4.2 Student system function implementation

There are three most important functions of the student side: score query, booking physical fitness tests, and submitting questions. The system adopts a drawer-type page, and the button that triggers the drawer to open is integrated in the navigation bar.

First of all, you need to determine whether the user is logged in, which is implemented using the Vuex plug-in, which encapsulates the Info object to access information such as name, student number, legal token, and gender. However, because Vuex refresh data will cause data loss, data persistence is required, and after the homepage rendering DOM is completed, determine whether there is a token in Vuex, and when the token exists, it means that the user has logged in.

The system grade query is divided into two types: total grade query and single query, the front-end requests back-end data through Axios technology, the request data is written in the Created life cycle, that is, the basic elements of the page are loaded after the request data is requested, the requested data is saved in the data of the current page, and the Element UI list gets the data that needs to be displayed from the total data. Grade inquiry can be divided into detailed grade inquiry and total grade inquiry, in the detailed grade inquiry can query the previous results of each item, and the total score inquiry can check the total score of the physical fitness test of the current year.

Fig. 4. Student Achievement Query Chart.

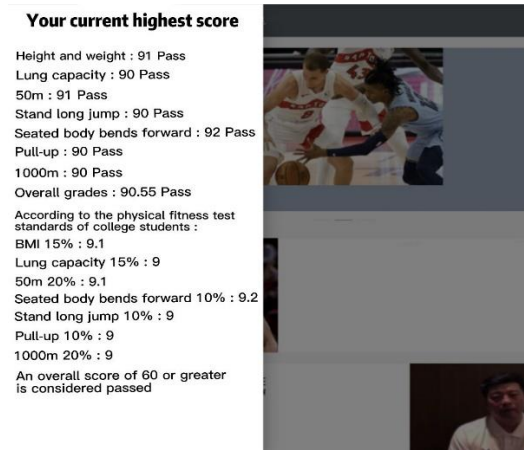


Fig. 4. Student Achievement Query Chart[self-drawn]

Physical fitness test booking is one of the core functions of the student side, and the system integrates "bookable items" and "reserved items" on the same page. Among them, the details of each project include "Project Category", "Start Time", "End Time", "Open Quantity", "Scheduled Quantity", "Test Address" and "Test Time", which is convenient for students to view the physical fitness test item information in time and comprehensively after the appointment is completed, as shown in Fig.5. Student physical fitness test Appointment Interface.

Projects								
<input type="checkbox"/>	Project category	Start time	Finish time	Quantity	Quantity ordered	Exam address	Exam time	Operation
<input type="checkbox"/>	1000m	2021-05-10 17:24:00	2021-05-10 20:00:00	100	1	Southeast of the gymnasium	2021-05-12 17:23:19	Book
<input type="checkbox"/>	All	2021-05-09 23:22:00	2021-05-09 23:59:00	10	1	Southwest of the gymnasium	2021-05-09 23:21:12	Book
<input type="checkbox"/>	Lung capacity	2021-05-09 23:06:00	2021-05-09 23:20:00	10	0	Southwest of the gymnasium	2021-05-09 23:21:12	Book
<input type="checkbox"/>	Lung capacity	2021-05-06 20:52:00	2021-05-05 20:54:00	100	0	Southeast of the gymnasium	2021-05-09 23:21:12	Book
<input type="checkbox"/>	All	2021-04-15 03:00:00	2021-04-15 06:00:00	100	0	Southwest of the gymnasium	2021-05-09 23:21:12	Book
<input type="checkbox"/>	Height and weight	2021-04-15 03:00:00	2021-04-15 06:00:00	0	0	Southwest of the gymnasium	2021-05-09 23:21:12	Book

My appointments					
Project category	Exam address	Order creation time	Responsible teacher	Project time	Operation
All	Southwest of the gymnasium	2021-05-09T22:21:33	00001	2021-05-09 23:21:12	Cancel
1000m	Southeast of the gymnasium	2021-05-12T17:25:09	00002	2021-05-12 17:23:19	Cancel

Fig. 5. Student physical fitness test Appointment Interface[self-drawn]

The physical fitness test project booking module first uses the token bucket algorithm to limit the flow, each request must obtain the token given by the system to be executed normally, and the system issues tokens at a constant speed, setting 1000 tokens per second, when the request fails to get the token, the waiting time of 3s is set, if it exceeds 3s or fails to get the token, the request is abandoned, preventing too many requests from the source from processing at the same time and causing the system to

crash. The second is the single-user throttling measure, which saves the number of visits within 5s of users in the Redis database, allowing users to access up to 5 times^[8]. the same time, the system adopts optimistic locking to solve the oversold problem, adding a version field to the database field, and the database will continue to execute only if the query and modification functions consistently indicate that no other transactions have been operated during the period. The isEqual(), isBefore(), and isAfter() methods were used to compare whether the appointment time was sent in conflict and whether the current time was within the course selection time, as shown in Fig. 6. Physical fitness test reservation order.

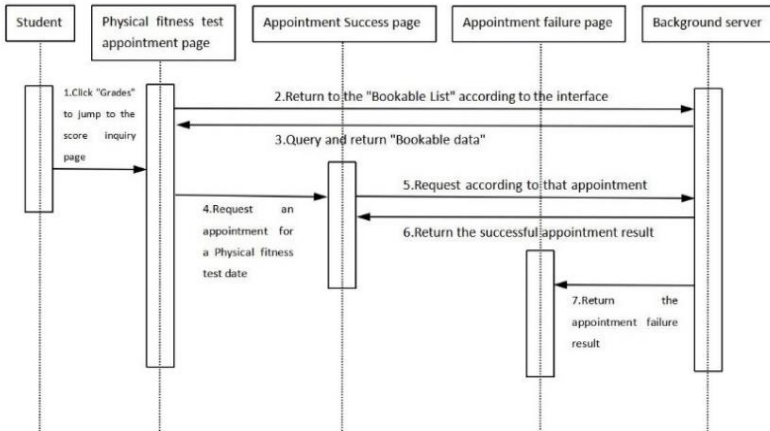


Fig. 6. Physical fitness test reservation order[self-drawn]

In the process of physical fitness test, cannot ensure that all equipment is in normal use, so there may be due to machine failure caused by student performance error, in this case, students can through "question handling" to report questions to solve the problem, question handling includes 3 processes, namely "question submission", "question processing" "question solving", students can view the question processing process in real time through the system, as shown in Fig. 7. question processing process interface.

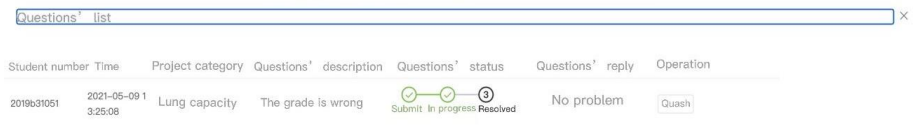


Fig. 7. question processing process interface[self-drawn]

4.3 Teacher system function implementation

The teacher-side functional modules are mainly divided into five modules: student management, score management, physical fitness test's activities management, document management, and intelligent monitoring, which mainly realize the functions of

opening appointments for physical fitness test, entering student information, and grades, announcement management, document management, and real-time visualization of physical fitness test data [9]. At the same time, the body measurement cloud system adopts the left sidebar design, integrates the button to switch the page into the sidebar, when the user clicks the sidebar button, the right window part sends the switch, and the overall Ajax local refresh technology page switching is used to prevent the situation of the screen flash back.

The student management module mainly realizes the functions of viewing student information, adding student information, adding student information in batches, deleting student information, modifying student information, and exporting student information, among which, student information can be viewed through student numbers and classes, student information can be added and exported in batches, and all batch import and export are unified by uploading excel files.

The score management module mainly realizes the functions of student grade query, batch import of grades, total grade management, various grade management, modification of grades, and deletion of student grades, which can not only view students' total grades, but also manage students' individual physical fitness test scores, as shown in Fig. 8. Grade Management Page.

The screenshot shows a web interface for grade management. On the left is a sidebar with a tree view containing: Grade management, Import grades, Overall grades, Seated body bends forward (highlighted), Lung capacity, 50m, 800m, and 1000m. The main area has a search bar for 'Student number' and buttons for 'Inquire', 'delete', 'Export', and 'Send messages'. Below is a table with columns: Student number, Time, Overall grade, Lung capacity, 50m, 800m/1000m, Pull-up/sit-up, Seated body bends forward, Height and weight, Stand long jump, and Operation. The table contains three rows of data for students with IDs 2019b31054, 2019b31051, and 2019b31052. Each row has 'Send' and 'Delete' buttons in the Operation column. At the bottom of the table is a pagination control showing '1'.

Student number	Time	Overall grade	Lung capacity	50m	800m/1000m	Pull-up/sit-up	Seated body bends forward	Height and weight	Stand long jump	Operation
2019b31054	2021	72.65	60	60	800m: 65	仰卧起坐: 80	100	88	80	Send Delete
2019b31051	2021	90.55	90	91	1000m: 90	引体向上: 90	92	91	90	Send Delete
2019b31052	2021	50	50	50	1000m: 50	引体向上: 50	50	50	50	Send Delete

Fig. 8. Grade Management Page[self-drawn]

The physical fitness test's activities management module mainly realizes the functions of issuing announcements, managing announcements, publishing appointments, and managing appointments, and can delete or process separately for students' physical fitness test appointments and announcements.

File management is mainly used to realize batch import of student information, student grades, etc., and realize batch import of information by selecting files and uploading files. The file upload frontend uses the Element-Ui file upload template, which encapsulates various methods required to upload files, including callback functions for successful and failed file uploads. Since the action here does not go through Axios, the address does not have a preset base prefix, and it does not carry token, but it is pointed out that the headers attribute is used to modify the request header to achieve the purpose of carrying token.

4.4 Realization of body measurement data visualization function

Data visualization is one of the cores of BI, physical fitness test data reflects the overall physical quality of a school student, but real-time data is very resource-intensive, http protocol is a one-way protocol, after the execution and the server will be disconnected, set up a scheduled task to send frequent and repeated requests to update data, in the case of multi-user simultaneous use is bound to bring serious pressure to the background. The system adopts Websocket two-way communication technology, the background setting timing task pushes new data to the front-end every 10s, and the front-end monitoring data re-renders the chart if it is sent to change. The data query is also optimized, and the database is divided into tables and only the required data is queried to avoid querying unnecessary data, as shown in Fig. 9. Data visualization effect chart.

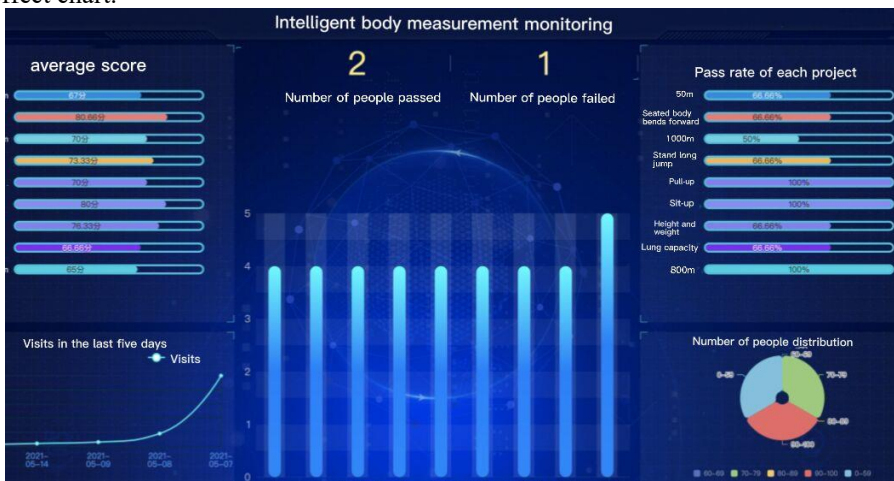


Fig. 9. Data visualization effect chart[self-drawn]

5 Conclusions

Under the background of the current sports and health more and more attention, artificial intelligence and B/S architecture are more and more sought after due to their own convenience, short development cycle and complete functions, based on the human body key point recognition technology and SSM development, to achieve the mainstream front-end and back-end separation of a body measurement information management system. The recognition of key points of the human body adopts a top-down design to identify the number of students and the 21 key points of the human body. The front end of the web system uses Vue and Element UI to quickly build it, which improves the speed of development while ensuring the efficiency of development quality, and realizes partial refresh of the whole page. Use Axios for data requests, quickly implement the implementation of adding global request headers, and carrying tokens to access the backend and pre-request and post-request interceptors. The

backend uses Jwt+Shiro to authenticate authorization, where Jwt contains the Payload part, which can save data in the form of key-value pairs. At the same time, replacing Shiro's original UsernamePasswordToken with JwtToken allows the system to obtain user information during authentication, and writing a Jwt filter to accumulate and configure it into Shiro to achieve authentication authorization. This system realizes the core functions such as physical fitness test reservation, physical fitness test score inquiry, student management, announcement management, document management, and physical fitness test data visualization, which is helpful for the management of students' physical fitness test scores.

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