The Design and Implementation of Kinect-Based College Sports Auxiliary Evaluation Training System

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Abstract. Based on Kinect equipment, the construction of college sports auxiliary evaluation training system was completed with the core of motion capture technology and ASP.NET architecture. Aiming at the problem of lack of scientific evaluation and feedback of teaching effect in the current physical education teaching process in colleges and universities, the system proposed to acquire the data information such as color data flow, depth information data flow and bone data flow under different movements of students in the process of physical training by using motion capture technology. And movement characteristic according to the standard training on students' sports training in technology, and identification of action skills, judgment, and ratings, forming students training database, with accurate data comparison results, convenient students informed of their own technology, the problems existing in the action skills, also facilitate teachers to give students targeted help and guidance. The system can not only achieve the purpose of auxiliary training, but also improve the situation of single teaching content and outdated teaching form. By virtue of the application advantages of intelligent motion measurement technology and network information technology, the digital reform of physical training is effectively promoted.

Keywords: Kinect · Motion capture technology · Auxiliary evaluation · Physical training skills movement

1 Introduction

At the present stage, China's economic development has made tremendous achievements, the economic development is unprecedented prosperity, the overall national strength is constantly increasing, all sectors of society have ushered in a golden era of accelerated development. Among them, various undertakings in the field of sports have also been comprehensively promoted. Competitive sports, school sports and social sports have all achieved vigorous development, which has made sports culture more prosperous and sports spirit more popular among people.

With the vigorous development of physical education, the shortage of physical education professionals has gradually become the focus of current attention, which puts

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forward certain requirements and challenges for the training of physical education professionals in colleges and universities. In 2020, the General Administration of Sport of China and the Ministry of Education jointly issued a notice emphasizing the inclusion of sports talent training in colleges and universities into the category of deepening reform of sports and education integration in the new era.

Colleges and universities should integrate sports with the national strategy of "building a strong country in sports", carry out work around sports personnel training, science and technology assisted sports training, and sports humanities integration, and improve the quality of sports personnel training. [1] In view of this, colleges and universities should conduct detailed research and analysis on the current situation of sports professional talent training, sort out the problems, and build a diversified sports professional compound talent training mechanism based on teaching reform, aiming at market demand and centered on quality education under the value concept of sports and education integration.

According to the survey, there are problems such as single teaching content, outdated teaching form, and lack of scientific teaching effect evaluation and feedback in the current education and teaching process of physical education majors in colleges and universities. For example, teaching content mostly relies on textbooks or teachers' teaching techniques and experience, and the depth and breadth of teaching are limited. The teaching form also adopts classroom theoretical teaching and after-class practical teaching, the teaching thinking is solidified, and the teaching atmosphere is dull. The teaching effect assessment mostly follows the examination or the actual measurement of the project, and it is difficult to directly perceive and evaluate the students' daily training progress, the details of the technical skills and movements in the training process, their own physical defects or habitual omissions. Targeted guidance also relies more on experience and estimates, and is not precise and scientific. In view of this, this paper believes that Kinect equipment will be used in combination with motion capture technology to complete the collection, processing and analysis of data during students' physical training. Through comparison with standard training data, effective assessment and accurate feedback of students' physical training effects will be completed.

At the same time, combined with the ASP.NET framework, a college sports auxiliary evaluation and training system with online teaching function was developed, which realized the improvement of the theoretical knowledge education effect and professional sports training effect for college physical education students, and adhered to the concept of integration of sports and education. Complete the network and digital reform of physical education teaching content, teaching form and teaching evaluation in colleges and universities.

2 Introduction of Key Technologies

2.1 Motion Capture Technology

Motion capture technology is defined as the process of recording and capturing object motion information by tracking special markers within a certain spatial range, and then converting it into motion that can be expressed mathematically. [2] For the tracking and recording of marked points, sensor equipment is often used, and the movements,

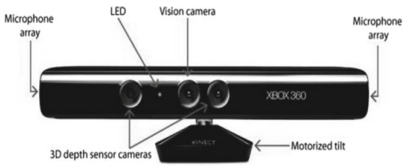

Fig. 1. Schematic diagram of the hardware structure of the Kinect device (Source: http://www.962.net/html/12336.html)

displacements, expressions, sounds, etc. of the captured objects are mapped to the computer for processing and transformation, and virtual and abstract data information is formed to construct the corresponding data model. In the actual application process, based on motion capture technology, combined with sensors, signal capture equipment, data transmission equipment, and data processing equipment, a motion capture system is used to complete motion capture in various situations.

According to different information principles, motion capture systems can be divided into two categories: computer vision and depth information recognition. The motion capture technology under computer vision belongs to the traditional method, and can be divided into four types: mechanical, acoustic, electromagnetic and optical according to the different sensor devices. The motion capture technology under traditional computer vision has more prominent shortcomings, that is, the price of sensors and signal capture equipment is expensive, and the captured objects need to be installed and worn with a large number of auxiliary equipment, and there are more stringent requirements for the capture and test environment. Data processing is also more complex. The motion capture technology based on video images can make good use of distance and depth information to complete human motion recognition and capture, overcome the shortcomings of motion capture under computer vision, eliminate environmental interference, and improve the freedom of movement of the captured object. It effectively improves the implementation convenience of the motion capture system and greatly improves the work efficiency of motion capture. In this paper, the college sports auxiliary evaluation and training system will also use the deep information recognition motion capture technology, and rely on the Kinect device to complete the motion capture.

Kinect is a somatosensory device designed and developed by Microsoft in 2010. At first, Kinect was designed as an external connection device for the Xbox 360 game console. Its core function is a 3D somatosensory camera, which uses motion capture, image recognition, audio input, voice recognition and other functions to help Game players control the game with body movements or voice interaction. Figure 1 is a schematic diagram of the hardware structure of the Kinect device. The Kinect includes many components, including a motor, a USB interface, an infrared transmitter, an infrared receiver, an RGB camera, a microphone array, and a chip.

2.1.1 Equipment Structure

Kinect has a total of 3 cameras. The Vision camera in the middle is an RGB color camera. Through this camera, you can directly obtain images with a maximum resolution of 1280*960, and the shooting frame rate is 24–30 frames per second. There are two depth

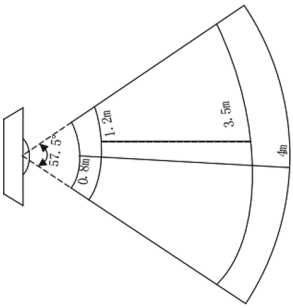

Fig. 2. Kinect interaction distance in default mode (Source: https://gameinstitute.qq.com/community/detail/119584)

sensors on both sides of the Vision camera, the infrared transmitter on the left and the infrared receiver on the right. The two cooperate with each other to form a depth camera to accurately obtain the distance between the Kinect device and the object to be measured, as shown in Fig. 2, the interactive depth limit of the Kinect device is 4m, and the optimal depth distance is 1.2–3.5 m. There is a set of microphone arrays on the two outer sides of the Kinect, which can obtain audio signals in time to realize the functions of voice recognition control and sound source localization. A transmission motor is installed at the lower end of the Kinect to obtain test data at the best test angle. In addition, Kinect has two different versions, Kinect for Xbox360 and Kinect for Windows. According to the functional requirements of this system, Kinect for Windows, which is supported by more advanced technology, will be used to complete related design and development.

The test data that Kinect can collect includes color video stream, depth data stream, and audio data stream. The three data information corresponds to the three data processing processes of person identification, motion skeleton tracking, and speech recognition. At the same time, the Kinect device will complete data transmission through USB3.0, and save the collected data information in time for subsequent application development and analysis calls.

2.1.2 Working Principle

Kinect's measurement of depth distance relies on optical coding theory technology. When the laser light emitted by the infrared transmitter on the left side, the marking of the area to be measured is completed. When the measured object appears in the area or moves and displaces in the area, the laser light will form unique reflection speckles on the surface of the object, and the infrared receiver will acquire these laser speckles as a test image. After the positioning algorithm, the correlation coefficient between the laser speckle and the area marking can be compared to estimate the position of the object. Kinect normalizes the obtained distance results into gray value images, and finally outputs a depth image of the distance of the measured object, and can repeat the above process multiple times to form a continuous depth image data stream. [9].

The core function of Kinect is to identify the movement of bones and joint point positions in human depth images, and to represent a complete set of human skeleton diagrams with corresponding points and lines. Its implementation process relies on image

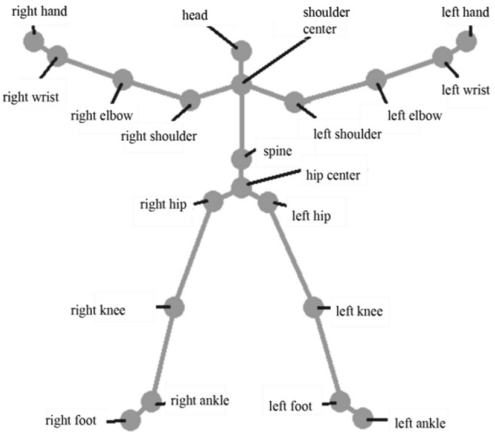

Fig. 3. Human skeleton joint point labeling diagram (Source: https://www.jianshu.com/p/1e532727a1c8?utm_campaign=maleskine&utm_content=note&utm_medium=seo_notes&utm_source=recommendation)

processing technology, machine learning, matrix changes and other complex algorithms. The main workflow is: human body contour segmentation, human body part recognition, and joint point positioning. The realization of human body contour segmentation relies on the built-in image processing technology of Kinect. After scanning and analyzing the depth pixels of the area to be tested, it is determined whether it belongs to the human body part, and then edge detection is used to extract the human body pixels from the depth image and filter out the contour. Friday's noise points to complete the human silhouette segmentation. [3] For the recognition of human body parts, it will rely on the human body recognition model under Kinect. The model uses pixel category labeling technology to identify 32 body parts such as human head, shoulders, hands, and feet. Finally, for joint point positioning, after the human body parts are identified, the possible pixel points are combined into a joint point, and the determination of the joint point is completed. Kinect divides human skeletal joints into 20 joints, as shown in Fig. 3, and uses this to form a human skeleton system.

2.2 ASP Technology and ASP.NET Framework

ASP, Active Server Pages, is a web server-side scripting environment developed by Microsoft, which can be used to create dynamic interactive web pages and build powerful web applications. [4] In the development of Web applications and the realization of dynamic interaction between users and Web interfaces, ASP technology and JSP technology have formed a situation of competition between the two powers. ASP technology is easy to learn, easy to modify and test, and has the advantages of powerful integrated development tools, which can provide developers with certain convenience. The working principle of ASP technology is shown in Fig. 4. When the user sends a.asp page request through the client browser, the Web server will identify the corresponding ASP file according to the extension.asp, and send the ASP file to the script engine asp. In the

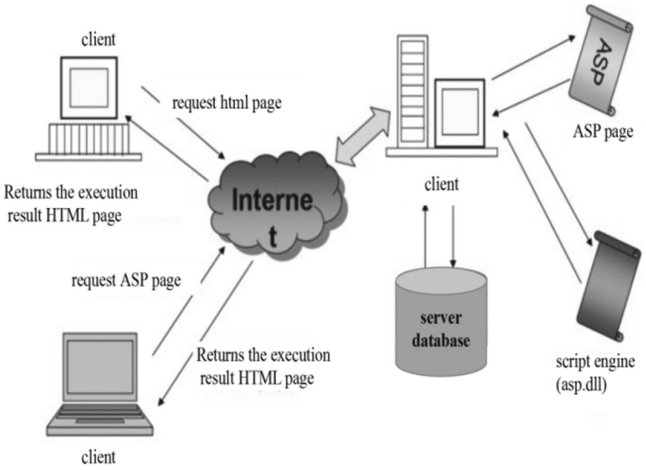

Fig. 4. The working principle of ASP technology (Source: https://www.ejaket.com/2016102303023.html)

dll file, the script command is returned to the client to produce the corresponding HTML page after interpretation processing.

ASP.NET builds an open source web application development framework based on.NET Framework. Compared with ASP technology, it can achieve powerful, Standardized Web service support capabilities. [8] Under the ASP.NET framework, developers can use HTML, CSS and JavaScript to build powerful Web sites, and also support the use of C#, VB, J# and other object-oriented languages to complete the construction of Web applications. ASP.NET provides three basic frameworks for creating Web applications, namely Web Forms, ASP.NET MVC, and ASP.NET Web Pages. In view of the scope of application and the difficulty of development and design of this system, ASP.NET MVC will be selected as the development framework, which has realized the efficient and flexible development of the system.

2.3 Development Environment

Complete the construction and deployment of the development environment according to the use requirements of the above related application technologies. The development environment of this system is divided into two parts, one is the hardware equipment configuration based on Kinect; the other is the system design and development of the Kinect data analysis and application and the actual sports auxiliary evaluation training function.

For the hardware configuration of the Kinect device application, first the Kinect device selects the version as Kinect for Windows sensor V1. The supporting computer system is Windows 7, 64-bit operating system, 8-core 2.9 GHz Intel Core i7-10700 processor. Kinect completes data transfer through the USB 3.0 interface.

```
using System.Data;
using System.Data.SqlClient;
using System.Configuration;
public class MainController : Controller
    {
        // GET: Main
        public ActionResult Index()
        {
            SqlConnection conn = new
SqlConnection(ConfigurationManager.ConnectionStrings["DefaultConnection"].ConnectionString)
;
            conn.Open();
            SqlCommand cmd = new SqlCommand("select * from student", conn);
            cmd.CommandType = CommandType.Text;
            SqlDataReader sqldr = cmd.ExecuteReader();
            while(sqldr.Read())
            {
                ViewBag.sno = sqldr["sno"];
                ViewBag.spwd = sqldr["spwd"];
            }
            conn.Close();
            return View();
        }
    }
```

Fig. 5. The key code for ASP.NET MVC to implement database connection calls (Original)

The analysis application of Kinect data needs to rely on the support of Kinect for Windows SDK, Visual Studio 2017,.NET Framework 4.7 and C# language. Under the computer system, first complete the download and installation of the Kinect for Windows SDK and Developer Toolkit (supporting development tool kit) to realize the connection between the Kinect device and the computer system. Afterwards, according to the ASP.NET MVC framework under Visual Studio 2017, the development of the corresponding functions of the system is completed, and the encapsulation of the corresponding Web application program is completed to form a Web website, which is published through the Microsoft IIS Web server. In addition, the system will use SQL Server 2016 as the database server, as shown in Fig. 5, under the ASP.NET MVC framework, the data connection is completed by declaring the SqlConnection conn() method, and SqlCommand cmd() completes the detailed content in the database Operation, and output results to realize the management and storage of data analysis results. [7] Through the introduction of the above key technical theory, the overall environment for system development, the configuration of related software and tools are determined, and the technical feasibility of the overall project of the college sports auxiliary evaluation training system is also clarified.

3 Demand Analysis

3.1 System Requirements Analysis

Based on Kinect equipment, with motion capture technology as the core college sports auxiliary evaluation and training system, it will meet the different needs of students and physical education teachers. The design requirements of this system are to improve the deficiencies in the current physical education in colleges and universities, take into

account students' professional physical education and physical training, and provide auxiliary evaluation functions for physical education teachers in the daily teaching process, so that teachers can grasp the training situation of students in time., and give students targeted guidance and help to effectively improve the effect of students' physical training.

The system can support users of different roles to complete user registration and authentication through the client browser, and complete the login and use of the system with a unique account. According to the system requirements, there will be two subsystems, the student side and the teacher side, under the college sports auxiliary assessment and training system. Among them, the student terminal system can satisfy the online learning of sports-related knowledge and the viewing of self-training evaluation results. On the teacher side, it can complete the analysis and evaluation of different training subjects for different students, adjust or revise the training plan according to the corresponding results, correct students' mistakes, and form corresponding data analysis reports, so as to achieve the improvement of education and teaching work efficiency and management control level.

3.2 Overall Design

The college sports auxiliary evaluation and training system will use B/S architecture, based on ASP technology, and use ASP.NET MVC framework to complete the overall design and development of the system. ASP.NET MVC will effectively separate the tasks of the system, that is, the input logic, business control logic, and output display logic are separately developed and designed to enhance the flexibility and usability of each functional page. A large number of nested template pages, user controls, and page tags can easily implement functions such as declaring server space, templates, data binding, and positioning, which greatly improves the development efficiency of the system. [5] The functional structure of the system is shown in Fig. 6. The system will use Kinect equipment to complete the collection, analysis, processing, storage and other operations of data information such as movement, displacement, and attitude of students during physical training. And the corresponding data is implemented through the NUI API interface to realize the call of the data information by the Web server. At the same time, the system will set up a database of standard movements for sports training. After comparing and analyzing the skeleton angle characteristics and skeleton movement speed characteristics of students' training movements and standard movements, the similarity score will be completed, and the results will be saved. When student users and teacher users send requests through the web client browser, the web server will respond and return the corresponding data results or file contents to the client for display.

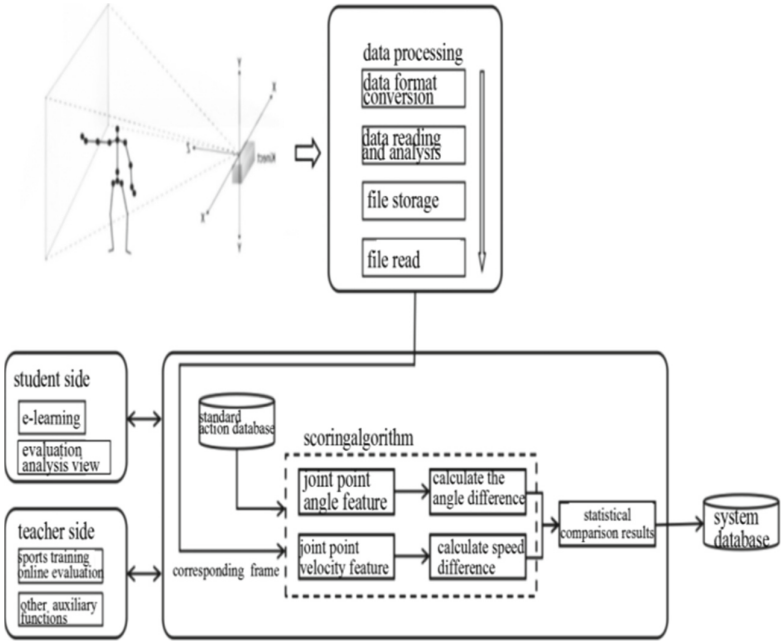

Fig. 6. System Functional Structure Diagram (Original)

4 Detailed Function Realization

4.1 Teacher Side

4.1.1 Online Evaluation of Sports Training

When teachers use the college sports auxiliary evaluation training system, they need to complete the motion capture of students' sports training at the training site to obtain the corresponding data information. First, the Kinect equipment is installed and arranged, and the test area is set. When students complete training actions or move positions in the area, the Kinect equipment will automatically complete the data collection, analysis and processing of students' training actions. The depth data stream will automatically form the human skeleton system diagram through operations such as human body contour segmentation, human body part identification, joint point positioning, etc., and write it into a file to complete the preservation. The color video stream will be superimposed frame by frame with the human skeleton system diagram to complete the annotation of the character's movements, postures and joints on each frame.

Secondly, when the teacher selects the training data of the students under this function module for evaluation, the system will start the automatic scoring function to extract the sports training action features from the human skeleton system diagram stored in the Kinect device. That is, according to the change characteristics of the eight joint points of the shoulder, elbow, hip, and knee in the process of physical training, the rotation angle feature extraction is performed. In addition, the human skeleton system diagram relies on the depth data stream to form a skeleton sequence. When the human body is

in the process of continuous sports, each frame collected by Kinect has the same time interval, so that the joint points of the human skeleton will be reflected in each frame. The instantaneous speed can be obtained, and then the difference in motion speed of the same joint point in two adjacent frames can be calculated as the speed feature of the joint point of the human skeleton at this time. [6] After obtaining the rotation angle feature and speed feature, the skeleton sequence of the student sports training is forcibly aligned with the skeleton sequence in the standard action database, that is, each frame forms a correspondence and unity, and the rotation angle features and motion of the joint points are compared.

Speed characteristics, get the corresponding difference score. The scores are comprehensively calculated according to different weight values to obtain the final training action standard score.

Finally, the system stores the calculated final score in the database and saves it. When teachers choose to view and retrieve data, they can directly obtain the evaluation scores of different students and different training subjects from the database, and can directly form corresponding data analysis reports, and support multi-format file export.

4.1.2 Other Functions

After completing the student training evaluation, the teacher can obtain the training effect of the students and the inspection results of the details of each movement in time, which is convenient for discovering the habitual deficiencies or congenital defects of the students in the training process, and can adjust the follow-up physical training plan., to give students targeted guidance and help to improve students' physical training level. In addition, teachers also take into account the production, uploading, and maintenance of physical education resources in the system, and provide students with different forms of teaching content and extracurricular expansion content through the Internet, so that students can broaden their horizons, increase knowledge, and improve their knowledge in their spare time. Own comprehensive quality, and effectively realize the integration of sports and education.

4.2 Student Side

Under the student terminal, student users can complete online learning by themselves through the learning resources provided in the system. To achieve the purpose of enriching the content of classroom teaching, and the form of online teaching is more in line with the "online learning" habits of students in the new era, which can not only stimulate students' interest in learning, improve learning effects, but also complete the reform of teaching forms.

For the evaluation of physical training, students can also more clearly identify various problems existing in the training process, activate students' initiative in self-examination and self-examination, and complete physical training with more scientific and data-based means. Evaluating and evaluating effects.

5 Conclusions

Based on Kinect equipment, with motion capture technology as the core and ASP.NET framework to complete the construction of college sports auxiliary evaluation and training system, it can improve the various deficiencies in current college sports education and professional training with the help of various advantages of current high-tech. Under the educational concept of "integration of sports and education", it has realized the auxiliary function of physical education teaching in colleges and universities, effectively improved the management and control of the physical education teaching process, and provided scientific and accurate analysis data for the adjustment and implementation of teaching plans. The necessary basis has realized the improvement of the current college physical education teaching mode, which not only improves the work efficiency of teachers, but also further improves the college physical education teaching system, and further promotes the reform process of college education network and digitalization.

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