

# *Construction and analysis of dynamic model of discrete system of physical education teaching based on multi criteria side decision algorithm*

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**Abstract:** Based on the integrated application of intelligent wearable devices, this research obtains multi-dimensional real-time data in the movement process, obtains the human skeleton point data based on Openpose and carries out standardization preprocessing, extracts different posture features of the human body in combination with the geometric features of the skeleton space, and proposes an improved multi criteria decision tree intelligent algorithm theory of motion model and health evaluation system. On this basis, the statistical analysis and advantage comparison of multivariable motion data are carried out. Finally, the evaluation system of sports basic movement teaching based on multi criteria side optimization decision-making algorithm is established, and the functional design of each module is introduced. The research found that boys' upper limb strength and girls' cardiopulmonary endurance are the most important basic physical qualities that affect students' performance. The influence of lower extremity explosive force and cardiopulmonary function on boys' performance is only lower than that of upper extremity strength. The effect of girls' lower limb fast running ability on their performance is only inferior to that of their cardiopulmonary function; While increasing the strength of upper and lower limbs, boys can significantly improve the passing rate by properly improving cardiopulmonary endurance training. Proper improvement of girls' fast running ability and their cardiopulmonary endurance can significantly improve the passing rate of girls. And the motion intelligent recognition system in this study can overcome the self-occlusion of joint points when observing actions from a fixed perspective in a single perspective dataset.

## 1. Introduction

The health of primary and secondary school students has risen to the national level. Primary and secondary school students also have physical problems because of high mental pressure, unreasonable nutrition, and not strict physical exercise. However, the current research projects on the analysis of students' health quality test data have only carried out general research in traditional and conventional ways, such as average, weight, etc., and have not carried out more in-depth mining <sup>[1,2]</sup>. Therefore, it is still an important work in school physical education training to discover

its deeper potential problems. Big data analysis technology has a huge detection function. It has shown great advantages in model construction, basic research, quality and safety detection, disease diagnosis, natural disaster prediction, traffic management and other fields. It can build a comprehensive analysis model for all students' physique test data, and on this basis, conduct a comprehensive evaluation of all students' physique test results, compared with the comprehensive evaluation mode of conventional analysis methods such as mathematical statistics, the big data analysis method can more objectively and effectively study the deep internal relationship between the data results of student body monitoring results<sup>[3,4]</sup>. The biggest disadvantage of acoustic and electromagnetic type is that they are easy to be interfered by the external environment, and the time delay is too large.

With the development of China's modern information technology, the deepening of "Internet + education" and the further development of intelligent sports teaching, sports distance teaching will be one of the directions and trends of China's future education. New technologies such as artificial intelligence, big data analysis and cloud computing not only break through the influence of various factors such as air, time and geography on traditional school sports classes, but also provide guarantee for schools to provide teaching feedback links in extracurricular sports teaching. The educators redesigned the physical education teaching, and made the physical education teaching present a new learning space and environment by changing the traditional way of teacher-student interaction and using new learning evaluation methods. The limited number of physical education teachers cannot objectively and accurately assess the homework of a large number of students, especially the video homework, and give reasonable evaluation scores. Therefore, the lack of intelligent and convenient sports action evaluation guidance in the process of intelligent physical education teaching leads to the failure to give full play to the value of long-distance online physical education teaching<sup>[5-7]</sup>.

In recent years, there is a technology to collect students' sports information through wearable products such as smart bracelets. The collected bracelet information can be used to calculate students' sports load and activity path and analyze intelligent data. Wearable devices can be used to capture and record students' activity information in sports training activities, and further analyze the data to observe whether the actions are standardize.

On the basis of the integrated application of intelligent wearable devices, this research has obtained multivariate and multi-dimensional real-time data in the process of sports, obtained the human skeleton point data based on Openpose and carried out standardized preprocessing, and extracted the different posture features of the human body based on the geometric characteristics of the skeleton space, and proposed a motion model and health evaluation system based on the intelligent algorithm theory of the decision tree. Based on this, the statistical analysis and advantage comparison of multivariate sports data are carried out. Finally, the evaluation system of sports basic action teaching based on decision algorithm is established, and the functional design of each module is introduced. This research can provide some guidance and reference for the construction of discrete system dynamic model of physical education teaching and the analysis of sports health.

## **2. Research on Data Acquisition and Preprocessing in Motion Attitude**

### **2.1 Integrated application of intelligent wearable devices**

As young learners in the new era of the 21st century, students have more flexible ideas and more opportunities to contact high-end sports products. In traditional sports practice classes, a large number of wearable devices have been introduced, which is a creative change to traditional teaching methods. From the perspective of teaching interest, the integration of high-tech industry education and traditional sports practice courses has greatly mobilized the subjective learning motivation of

learners, encourage learners to use familiar life situations to carry out teaching. With big data mining, teachers can observe their learning status at anytime and anywhere, deeply grasp their physical fitness, physical fitness, use skills and other aspects, so that teachers can accurately understand their learning status, and more convenient for them to master self-feedback. The evaluation of intelligent wearable perception effect is shown in Figure 1.

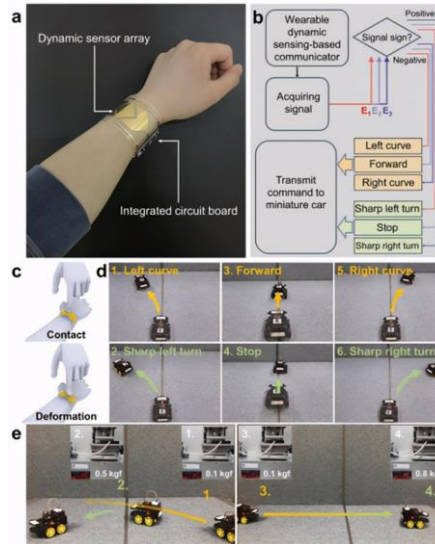


Figure 1: Evaluation of smart wearing perception effect

The intelligent wearable mobile terminal is the carrier of this system, which is mainly based on the intelligent bracelet. It uses the intelligent monitoring, GPS positioning and offline Internet access functions of the smart watch to collect the physiological information, movement status and location information of sports personnel, and has the function of remote information interaction. Due to the complex sports environment, physical education teachers and management personnel cannot directly observe the actual physical health status and changes in their own functions of athletes.

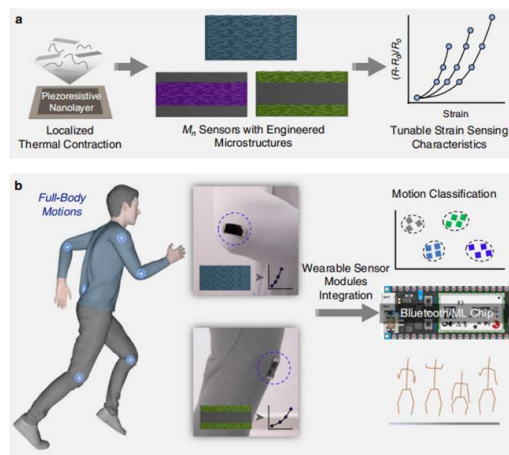


Figure 2: Intelligent Wearing Information Perception Prediction Mode

The perception mode shown in Figure 2 is used to obtain the data information of human skeleton points in the process of motion. Human skeleton points are the joint parts that connect the limbs into a rigid hinge system. The specific state of skeleton points and the action form of each limb can be determined by using the relevance of bone point data. With the development of hardware devices and the breakthrough of visual algorithms, especially the pose estimation algorithm based on depth

learning, it is more convenient to obtain bone point data. The main methods to obtain human bone point data are direct acquisition from devices and pose estimation from images.

## 2.2 Analysis of human motion skeleton posture data

For action recognition based on intelligent algorithms, manual features can better reflect the physical characteristics of the motion itself or the statistical characteristics of the data itself, and then, to a certain extent, characterize the kinematic or statistical characteristics of the action. However, the manual features depend on the prior knowledge of researchers, and the generalization ability is weak. For action recognition based on deep learning method, stacked multilayer perceptron's can gradually learn and extract low-level features, and the network learning performance is good. However, the interpretability of depth features is poor. Combining the advantages of manual features and deep network for action recognition is worth considering. This research tests and analyzes the running speed of Openpose on different hardware, compares the running speed, achieves performance and speed balance, and uses a better configuration to obtain bone points. Finally, the obtained bone point data is standardized and preprocessed, mainly through the reconstruction of skeleton space and scaling processing to eliminate the impact of video size, human body difference and position difference in the video as much as possible. The intelligent recognition system adopts a multi-level CNN architecture ( Figure 3).

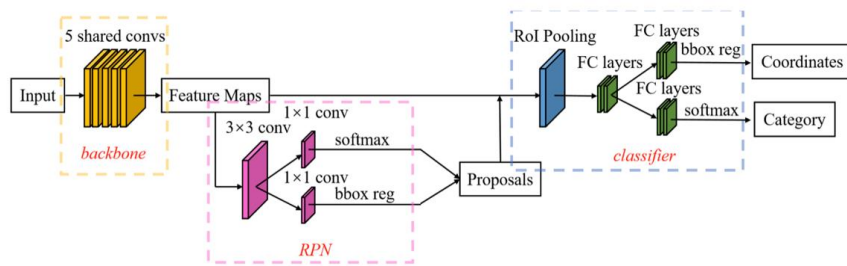


Figure 3: Multilevel CNN architecture

The basic principle of Openpose is to predict the human skeleton points in the image by building a convolutional neural network in stages and output the prediction confidence heat map of the skeleton points. At the same time, it predicts the affinity field area (PFA) between the skeleton points, which is the basis for connecting the skeleton, and participates in the prediction of the skeleton points in the next stage to improve the speed and accuracy of the model.

## 3. Motion model and health evaluation based on decision tree theory

### 3.1 Decision tree algorithm analysis model

The calculation process of decision tree generally includes: attribute selection, decision tree generation and decision tree pruning. Decision tree analysis algorithms generally fall into three categories: ID3, C4.5 and CART. Among them, ID3 calculation cannot directly process the missing values, while C 4-5 calculation adopts the multi tree architecture, while CART algorithm adopts the binary tree architecture. The first two types of calculation adopt the information theory entropy mode, requiring logarithmic calculation with large calculation cost, while CART analysis tree calculation uses Gini coefficient to replace the first two kinds of entropy, that is, to maintain the relative advantage of entropy and reduce the calculation cost. The Gini coefficient represents the purity of the model, that is, the smaller the Gini coefficient, the higher the quality, and the better the characteristics. It is the opposite of the information gain (ratio). CART analysis tree is suitable for discrete statistics, while regression tree is suitable for continuous statistics. The statistical level of

the physical fitness test data indicators of primary and secondary school students is small, with missing values. CART algorithm can be used to re classify the physical fitness test data of primary and secondary school students. At the same time, using a binary tree can simplify the size of the decision tree, thus increasing the time efficiency of forming the decision tree. The algorithm analysis model of the decision tree is shown in Figure 4 below.

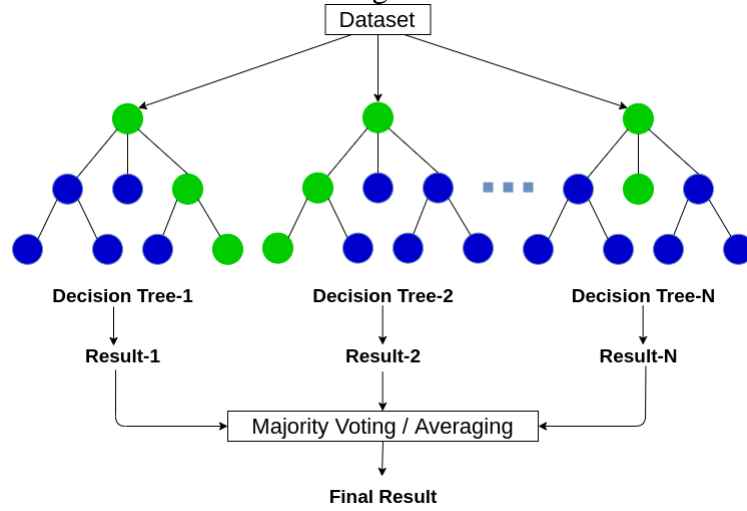


Figure 4: Decision tree algorithm analysis model

During the classification processing of data information by CART classification method, if the sample set has K characteristics, the probability of K characteristics appearing in the sample value is  $p_k$ , and the Gini coefficient of its probability distribution is calculated as follows:

$$\text{Gini}(p) = \sum_{k=1}^m p_k(1 - p_k) = 1 - \sum_{k=1}^k p_k^2 \quad (1)$$

If the number of samples M is  $|M|$ ,  $c_k$  is a subset of function M with k attribute, and the Gini coefficient of function M is calculated as follows:

$$\text{Gini}(M) = 1 - \sum_{k=1}^k \left(\frac{|c_k|}{|M|}\right)^2 \quad (2)$$

Sample M can also obtain  $M_1$  and  $M_2$  by decomposing property A at the value A, so the Gini coefficient of sample M under property A is determined as follows:

$$\text{Gain\_Gini}(M, A) = \frac{|M_1|}{|M|} \text{Gini}(M_1) + \frac{|M_2|}{|M|} \text{Gini}(M_2) \quad (3)$$

### 3.2 Analysis of sports health evaluation

This project is a physical fitness test carried out by an undergraduate school. The process of sports measurement project meets the requirements of the university, the test process is legal, and the test quality is qualified. In the whole experiment process, the team members were all equipped with intelligent wearable instruments according to the scientific research requirements, and except for the player data with incomplete results such as failing to conduct psychological testing and physical examination due to disease and other factors, all the data exceeding  $\pm$  in each dimension were eliminated, and a total of 3562 valid data for men and 65098 valid data for women were screened out. In order to comprehensively analyze the sports information of the players in various competitions, the information data collected in this study are mainly divided into length, weight, BMI, vital capacity, race score (50m), long-distance running (1000m for men and 800m for

women), standing long jump, sitting forward bending, sit ups (women), pull ups (women), scores and grades. Python programming language is used in the decision tree calculation program, which can realize CART decision tree calculation. Through pandas, numpy, matplotlib, seaborn and other libraries, information cleaning, data splitting, statistical results visualization and other calculations are realized respectively. Using the above decision tree calculation method and analysis model, the correctness curves of male and female CART decision trees are given, as shown in Figure 5.

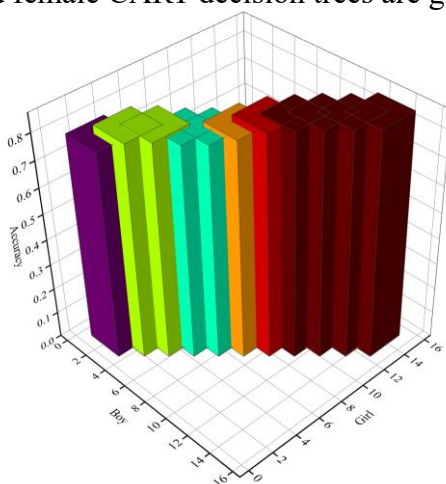


Figure 5: Correct rate of CART decision tree for boys and girls

Figure 6 shows that, after training the training set, in order to achieve better analysis and calculation accuracy, after optimizing the depth, the estimation accuracy is as high as more than 85%, but the estimation accuracy expectation is still insufficient. Moreover, as the depth increases, the accuracy of training, prediction and verification estimation is improved, while the generalization ability will also decline due to the phenomenon of model fitting in its modeling. Therefore, it is also necessary to adjust the pruning method of the decision tree. By training, forecasting and testing the CART decision tree models of various depths, comprehensively investigating the dimensions, accuracy and generalization ability of students' body data, and selecting the depth of five, carry out the visual output of CART decision tree simulation, and continuously optimize the output mode by detecting the impact of each item on the distribution of students' physical performance levels. The results of male and female decision trees are shown in Table 1.

Table 1: Decision tree analysis results of boys and girls

|      |                  |  |  |                |                   |
|------|------------------|--|--|----------------|-------------------|
| Boy  | Pull up movement | Standing long jump (less than 9.5)       | 1000m (less than 1.8m)                 | Pass rate 0.73 | Failure rate 0.56 |
|      |                  |  | 1000m (more than 1.8m)                 | Pass rate 0.86 | Pass rate 0.76    |
|      |                  | 1000m (more than 9.5)                    | Vital capacity (less than 236 seconds) | Pass rate 0.56 | Good rate 0.79    |
|      |                  |  | Vital capacity (less than 236 seconds) | Pass rate 0.81 | Pass rate 0.88    |
| Girl | 800m             | Vital capacity (less than 255.5 seconds) | 75m (less than 3500ml)                 | Pass rate 0.67 | Pass rate 0.69    |
|      |                  |  | 75m (more than 3500ml)                 | Good rate 0.77 | Pass rate 0.56    |
|      |                  | 75 meters (more than 255.5 seconds)      | Long jump (less than 15 seconds)       | Pass rate 0.56 | Good rate 0.86    |
|      |                  |  | 800 meters (more than 15 seconds)      | Pass rate 0.68 | Good rate 0.59    |

Pull up sports and 800 m sports belong to the root nodes of each group of boys and women, respectively. It can be seen that the sports with the highest degree of restriction on achievement levels for boys and women are pull up sports and 800 m sports in turn. When boys' pull up achievements are higher than 9.5 times, the probability of passing the achievement level will also increase significantly. When the same girls' 800 m achievements are lower than 255.5 seconds. The

chance of passing the achievement level will also increase significantly. The pull up and 800m sports events respectively reflect the upper limb sports ability level and cardiopulmonary function of students, which means that the upper limb sports ability level of men and the cardiopulmonary endurance level of women are the most critical basic physical qualities that directly affect the students' grades. (2) The second level nodes of the boys' group include standing long jump and 1000m events. If the score of 1000m is lower than 236s, the probability of good grades will be greatly increased; If, on the contrary, the standing long jump score does not exceed 1.8m, the probability of failing the grade will be greatly increased. However, the standing long jump score and 1000m project reflect the explosive strength quality and cardiorespiratory function of men's lower limbs. Therefore, the strength quality and cardiorespiratory function of men's lower limbs exposed will have a second impact on the score level only to the strength of upper limbs.

The second level nodes of the girls' group include the lung activity rate and 75m. The 800m running result does not exceed 255.5s. However, when the lung activity rate exceeds 3500ml, the possibility of achieving a good grade will be greatly increased. If the 75m result is more than 15 seconds later, the probability of its grade being unqualified is obviously increased. Because vital capacity performance reflects the level of respiratory system function, and 75m reflects the level of fast running of lower limbs, indicating that the level of reflection of girls' fast running of lower limbs on the level of performance is significantly higher than the level of cardiopulmonary capacity. In all sports of female students, the interference range of forward bending in sitting position is smaller than that of other interference factors, which indicates that the flexibility and some human qualities of men and women are higher. As a whole, the male's pull up exercise has the most important effect on the level of physical strength measurement, followed by the standing long jump and 1000m achievement; For women, 800m plays the most important role in physical strength measurement, followed by vital capacity and 75m achievement. The upper limb ability of boys has the greatest impact on the grade, but the cardiopulmonary endurance of girls has the greatest impact on the grade. On the one hand, it may be that in the current stage of sports education, boys and girls have ignored the different innate physical and mental qualities and are implementing the same sports model. On the other hand, it may also be that there are obvious differences between boys and girls in the test content. Boys focus on the strength quality test, while girls focus on the flexibility test, which causes problems. In view of this phenomenon, in the process of sports curriculum development, we must set up a sports curriculum system for male and female students respectively, and implement a sports teaching mode of differentiation between male and female students.

## **4. Intelligent Discrete Motion Analysis System for Physical Education Teaching**

### **4.1 Intelligent Action Recognition Fusion System**

The perspective of motion observation is a problem worthy of consideration in human motion recognition, and it is also one of the challenges in the field of human motion recognition at this stage. The research on motion recognition of bone data in this study has gradually transited from single view dataset to multi view dataset. Single view dataset uses a camera to collect motion data. Its advantages are convenient data collection, low cost, simple processing and small amount of calculation. However, its disadvantage is that there is self-occlusion of joint points when observing actions from a fixed perspective, which is not conducive to accurate collection of action data and affects the effect of action recognition. Multi view dataset is the use of multiple cameras to collect action data at the same time. Its advantage is that the action sequence information obtained by cameras in different directions is complementary, and it can solve the self-occlusion problem of joint points existing in single view observation action to a certain extent. However, its disadvantages are high data acquisition cost, high requirements for acquisition environment, large

amount of data and high computing consumption. In order to integrate action recognition from multiple perspectives, this study proposes the following three view fusion intelligent system for action recognition from a single perspective. The motion attitude data fusion system is shown in Figure 6.

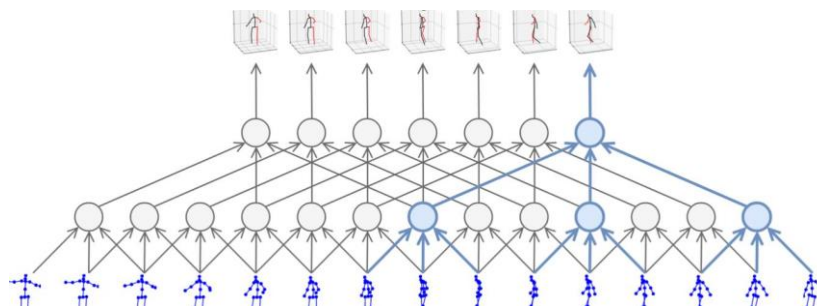


Figure 6: Motion Attitude Data Fusion System

Three field of vision refers to the image drawn by the detector when observing a spatial geometry from three different angles: the front, the left and the top. It can be expressed as the length, width and height of the material, which is an abstract expression of the geometric form of space material in the engineering community. In mechanical engineering manufacturing, 3D rigid body can be reconstructed according to the three views of 3D rigid body. This idea is used for 3D bone data action recognition. 3D action reconstruction is completed according to the three views of 3D action, and action tags are further recognized. The 3D view of 3D motion is to project the motion of objects in 3D space according to the sequence of actions in the front view, left view and top view, so as to obtain the sequence of actions in the front view, left view and top view of 3D motion. Specifically, the front view of an action horizontally projects backward from the front of the action to reflect the motion state in the front of the action. The left view of an action is projected from the left to the right of the action to reflect the movement state of the left side of the action. The top view of an action is projected downward from the positive upward direction of the action to reflect the motion state directly above the action. This 3D action sample is converted into three 2D samples, and the coordinates of joint points are converted from 3D to 2D. The problem of action recognition in high-dimensional space is transformed into the problem of action recognition in multiple low dimensional subspaces, and the computational complexity of data dimension and model is reduced at the same time.

## 4.2 Intelligent perception system of physical education teaching

In order to achieve the evaluation of the standard degree of action through posture matching in the teaching of basic sports actions, a sports teaching system with the basic process as follows is designed. First, students learn from the template action video uploaded by the teacher on the client, practice the basic actions constantly, and imitate the teacher's standard actions in the video as required to achieve the specified actions. At the end of the study, students used their mobile phones to take action learning results videos, upload and submit homework, and wait for the system evaluation. After getting the video uploaded by students, the system further processes the video.

The IntelliSense system includes the following modules:

(1) Preprocessing module: the preprocessing module mainly realizes the task of data acquisition and standardization. The original data is obtained by outputting the coordinate data of human skeleton points in the video through the action video input Openpose. First, standardize the resolution of the input video, mainly by using the Video Capture function in OpenCV to adjust the resolution to 480 \* 360 to standardize the resolution scale. Then, the coordinate data of human skeleton points in the video are obtained. After obtaining the skeleton point coordinates, the



matching skeleton point information is scaled according to the skeleton space proportion of standard actions to eliminate the impact of resolution adjustment on the skeleton space size. For the preprocessing module, it mainly occurs in the earliest stage of the gesture matching process. Students need to preprocess the original bone point data to form standardized coordinate data when they perform action gesture matching and teacher template library formation.

(2) Extraction of bone node information: the feature information extraction module is mainly used to calculate, extract and fuse the different pose features proposed in this paper, and form the human pose feature data available for this pose matching algorithm. This module is mainly divided into four steps. First, the center of gravity information is calculated through the standardized bone point data obtained. According to the principle of torque synthesis method, combined with the inertial coefficients of human limbs, the gravity components of each limb are calculated and stored in an array. Then, the gravity components are divided and accumulated with the cumulative summation function to obtain the center of gravity coordinates. The function is called to calculate the radian of the angle between the center of gravity vector and the spine vector as the first attitude feature. Then, through the coordinate data of bone points, each bone point is classified into each limb block and the included limb angle array. In each array, the function is called to solve the included angle of each limb, and the basic included limb angle features are obtained. Then, the mean value function is defined for the bone points included in the limb block to calculate the center point, and the included angle features of the limb block center point vector and the spine vector are calculated, four limb block orientation features are obtained to constrain limb angle features. Finally, solve the human body orientation feature. According to the bone point data, use the function in the function library to obtain its horizontal axis rotation angle through the two feet combination vector, as the left and right orientation information of the human body, use the definition and change of the positive direction of the shoulder joint and bone marrow joint vector to identify the front and back orientation information of the upper and lower limbs. Finally, each feature is fused into a 21-dimensional array by the splicing method, which can be used as the available human differential posture features. This module is involved in both the process of student gesture matching and the process of teacher template creation. The motion recognition data conversion mode is shown in Figure 7.

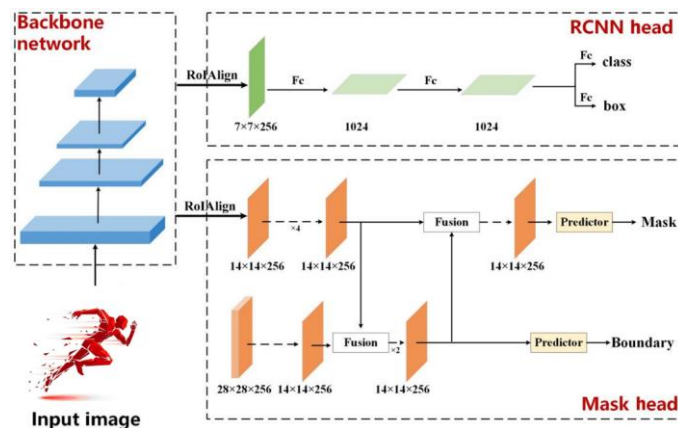


Figure 7: Action recognition data conversion mode

(3) Attitude matching module: the attitude matching module mainly realizes the function of motion evaluation, deviation limb recognition and marking. This module first calculates the similarity between the different human posture features in the student actions and the features in the template library. The definition function uses the power function in the C++ library to solve the feature similarity. After the matching of the most actions is completed, it analyzes the posture standard procedure, takes out the five posture frames that have the greatest impact on the action

standard, that is, the lowest score, and defines the deviation factor function to calculate the deviation degree of the limb features, Get the skeleton points contained in the limb with the largest deviation, use the functions in the OpenCV library to draw the bounding rectangle of the deviation limb in the image of the limb, and mark the deviation limb in the frame image. The posture matching module is only used in the process of matching and evaluating students' actions. The teacher template building module provides the feature information of standard actions and participates in the calculation.

## 5. Conclusion

Based on the integrated application of intelligent wearable devices, this research has obtained multiple multi-dimensional real-time data in the process of sports, and proposed a motion model and health evaluation system based on the intelligent algorithm theory of decision tree, and conducted statistical analysis and advantage comparison on the multiple motion data. Finally, the evaluation system of sports basic action teaching based on decision algorithm is established, and the functional design of each module is introduced.

(1) Men's upper limb ability and women's cardiopulmonary endurance are the most important basic physical qualities that affect students' grades. However, the male lower limb explosive ability and cardio pulmonary ability have a second effect on the students' grade, only inferior to the upper limb ability. The interference degree of female lower limb fast running function on the score ranking is only inferior to the cardiopulmonary capacity. In all competitions between male and female students, the interference range of long jumpers is relatively small compared with other interference factors in other competitions, which also shows that the level of flexibility of men and women is better than other physical qualities.

(2) As a whole, in all indicators, the male's pull up movement has the most significant impact on the body measurement grade, followed by the standing long jump and 1000 m performance; Girls' 800 m achievement had the most significant impact on their physical test grades, followed by their vital capacity and 75 m achievement. The upper limb ability level of boys has the most significant impact on the grade. In contrast, the cardiopulmonary endurance level of girls has the most significant impact on the grade.

(3) Based on the information collection of intelligent sensors and the analysis of decision tree model, it is concluded that the most critical basic psychological factor for students to achieve the test level is the ability of male forebody and the tolerance of female heart. When strengthening the ability of upper and lower limbs, college students should appropriately strengthen the cultivation of concomitant tolerance to further significantly improve the passing rate. When girls strengthen the cardiorespiratory endurance level exercise, they can increase the passing rate obviously by strengthening the fast-running strength exercise appropriately. Moreover, from the analysis results of each group of male and female students, the cardiopulmonary endurance level has a great influence on the performance level in both groups, and the cardiopulmonary endurance level and speed running strength complement each other.

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