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Image-Based Fitness Guidance and Recording System

Shuyue Xu*

Fuzhou University, Fuzhou, Fujian, 350108, China
* **Corresponding author Email:** SHUYUE.XU.2021@MUMAIL.IE

Abstract: This study proposes a fitness guidance and recording system design based on computer vision, aiming to provide users with personalized, real-time and efficient fitness guidance and training, as well as dietary record services through advanced computer vision algorithms. The system integrates a variety of technologies such as image processing, action recognition and body analysis, which can automatically capture the movement posture of users in the process of fitness, and compare it with the standard action library, so as to accurately evaluate the accuracy of action and provide immediate feedback and suggestions. At the same time, the system can feed back the user's diet and nutrition matching suggestions according to the user's dietary records, body data and training goals, and develop a personalized diet plan for the user. The development of this system can solve the problems existing in the traditional way of fitness guidance, and increase dietary guidance and record module, fitness is to provide a full range of support. At the same time, the research and development of this system can provide new ideas and methods for the research in the field of fitness, and promote the development and innovation of related technologies.

Keywords: Fitness; Dietary Guidance; Computer Vision; Deep Learning; Action Recognition and Correction.

1. Introduction

With the continuous development of modern society and the steady improvement of economic level, the quality of life of the people has been improved unprecedented. The people's growing health consciousness, and gradually will exercise into their daily lives of planning, become an indispensable part of. In order to shape the ideal figure, or in order to improve the body quality, the pursuit of healthy lifestyle, fitness has become a popular way of life.

The health concept of fundamental shift, is one of the important factors affecting people incorporate fitness life. According to the latest data released by the National Health Commission, the health literacy level of Chinese residents has been increasing year by year in recent years. From figure 1, according to data from the residents' health literacy level of 8.80% growth in 2012 to 29.70% in 2023. This remarkable growth reflects the increasing public attention to health. Under this background, the fitness as a positive means of promoting physical and mental health, has become a universal participation in fashion trends.

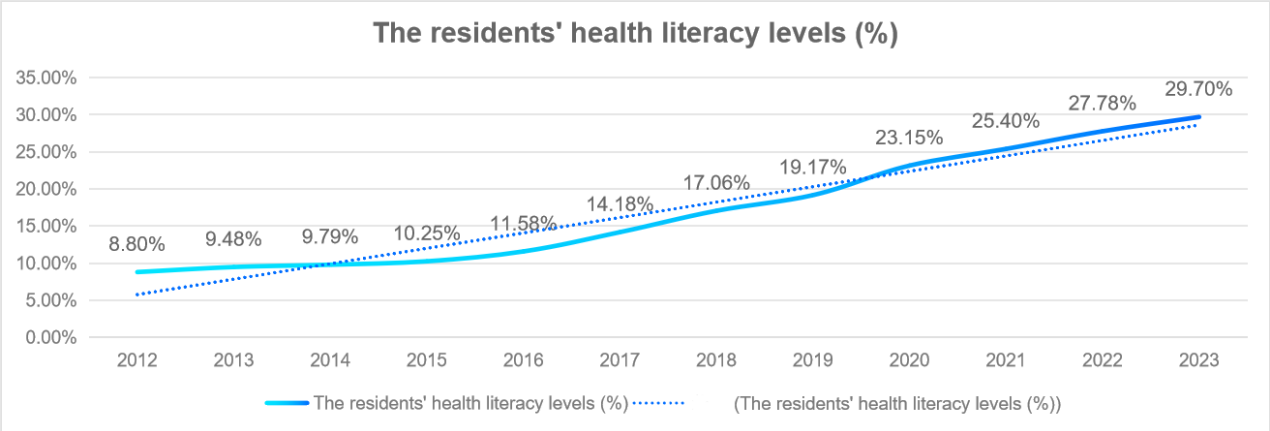


Figure 1. Trend of National Residents' Health Literacy Levels from 2012 to 2023

However, despite the popularity of the fitness degree unceasing enhancement, but many people still faces many difficulties and challenges in the process of exercise, such as the lack of professional guidance, gym fitness coach and hire the high cost of professional fitness coaches, Internet information overload, can't use the fragment time efficient fitness, such as the concept of cultural differences and differences of different countries. At the same time, due to the diversity of user needs, it is difficult to meet the individual fitness needs of bodybuilders. And because of the lack of effective means of record and monitoring, many people are hard to continue to adhere to develop fitness plan, or not according to oneself circumstance timely adjust their own training program. For example, these problems not only affect the effect of fitness, but also waste a lot of time and energy, and may even lead to different degrees of damage to the body.

In recent years, the fitness industry scale data and overall fitness venues business data is on the decline. On the one hand, the high cost of gym membership and private education has undoubtedly become one of the important factors hindering many people from persisting in fitness for a long time. According to statistics, the average annual card fee in first-tier cities is more than 5,000 yuan, and the class fee of hiring a professional fitness coach is hundreds to thousands of yuan.

On the other hand, the collapse of some big health club chains has also caused unhappiness among members. Compared with the indoor fitness venues, now users have more choice movement scene, especially outdoors.

In the face of these problems, the Internet fitness platform arises at the historic moment. With the prosperous development of science and technology, computer vision technology developed on deep learning and neural networks has become a popular research field [1]. However, in the era of Internet information explosion, users are often troubled by massive fitness tutorials and fragmented information, and it is difficult to screen out the content that is really suitable for them. According to the 2023 Internet Fitness User Behavior Research Report, more than 70% of online fitness users want more personalized and systematic fitness guidance programs, as well as scientific and effective recording and supervision methods. At the same time, as people life rhythm speeding up, how to use the fragment time efficient fitness has become the new demand point. According to a survey, more than 60 percent of professionals say they prefer to exercise for short periods of time after busy work.

Therefore, in order to solve the above problems and difficulties, we developed a fitness instructor and record system based on image, can well solve the problem of traditional fitness, and increase the diet records and guidance function, meet the exercisers at present different aspects of the demand of motion process, to improve the training effectiveness and scientific nature to provide comprehensive support.

2. Literature Review

2.1. Collection of Fitness Data

One is the system based on traditional data acquisition and analysis. In 2017, and the horse alone led the team to design the national physique monitoring, direct bodybuilding science system[3], the system at all levels of physical fitness center to collect user data constitution; And in 2020 the issue of automation technology and application, based on Internet + Chen mobile terminal physique monitoring and fitness guidance system design[6], the system USES mobile terminals to collect user data. These systems mainly rely on traditional data collection methods, such as the use of specialized monitoring equipment or data collection at monitoring centers, followed by processing and analysis in the cloud or on servers.

The other is systems based on smart devices and advanced technologies. In 2018, the fitness running guidance system based on smart phones[4] and the fitness guidance system based on Android mobile platform[5] were proposed by scholars. Both systems use smart phones or Android devices to collect exercise data and physiological data. In 2021, the design of the national fitness information service system[7] and the virtual fitness system[8] will make fitness activities full of unprecedented vitality and convenience. The system user movement data gathered through the virtual reality technology, let users can enjoy the immersion in the home fitness experience. In the electronic design engineering journal, 2023, Wen scholars put forward by 3D - ResNet model fitness gesture recognition, and build a professional action data comparison, implement action to correct opinion[1]. That same year, Joe Zhou put forward by the national fitness information service platform is the key technology research and use of AI recognition fitness hazardous events, solve our country set up the service platform of informatization for the national fitness lack key technologies and products, and to build a new generation of national fitness information service platform provides the support of new and high technology[2]. These systems usually rely on smart devices, mobile platforms, virtual reality technology, or advanced image recognition technology to collect and analyze motion image data, so as to provide more advanced and personalized fitness guidance services.

2.2. Fitness Data Processing

In terms of data processing, traditional data processing is mainly to analyze user data on the cloud service platform, issue scientific exercise prescriptions, and collect exercise prescription execution results[3]. And with the progress of science and technology, the data processing in recent years mainly by constructing fitness guidance model, using 3D - ResNet model for gesture recognition and compares them with professional action data, or build a virtual environment, so as to provide more advanced, more personalized fitness guidance service.

3. Argument and Analysis

3.1. System Introduction

This project aims to design an image-based fitness guidance and recording system to provide users with a convenient and efficient fitness guidance and recording platform. It solves the guidance problem under the traditional fitness mode and the individual demand problem, and adds the diet guidance record module to assist users to carry out high-quality fitness exercises in different time periods and different Spaces.

Users can at home or other suitable place for fitness training, and through the mobile phone camera real-time image capture their own actions. These images will be uploaded to the system server and analyzed by advanced image processing and machine learning algorithms. Based on the image uploaded by the user, the system will identify the user's action type, posture and other key information, and compare it with the preset standard action model. By comparing the results, the system can judge whether the user's action is correct and whether the posture is standard, and give corresponding guidance and correction suggestions.

In addition, the system will provide users with personalized dietary advice and supervision based on their body data and training goals. By collecting the user's body data such as height, weight, and body fat percentage, as well as the user's training goals and dietary preferences, the system can develop personalized meal plans for the user and provide nutrition matching suggestions. At the same time, the system will also push messages, set reminders and other ways to urge users to train and eat according to the plan to ensure that users can adhere to the fitness plan and achieve good training results.

3.2. Research Content

3.2.1. Fitness Guidance Module

For the fitness guidance module, the system needs to process the images uploaded by the users in real time, use the posture detection algorithm to accurately identify and analyze the user's actions, compare them with the calibrated actions in the database, ensure the accuracy and effectiveness of the guidance, and give timely feedback. This flow chart shown in figure 2. By using the fitness guidance of the system, users

can get scientific action guidance and correction when performing fitness training, and adjust their movements and postures in time.

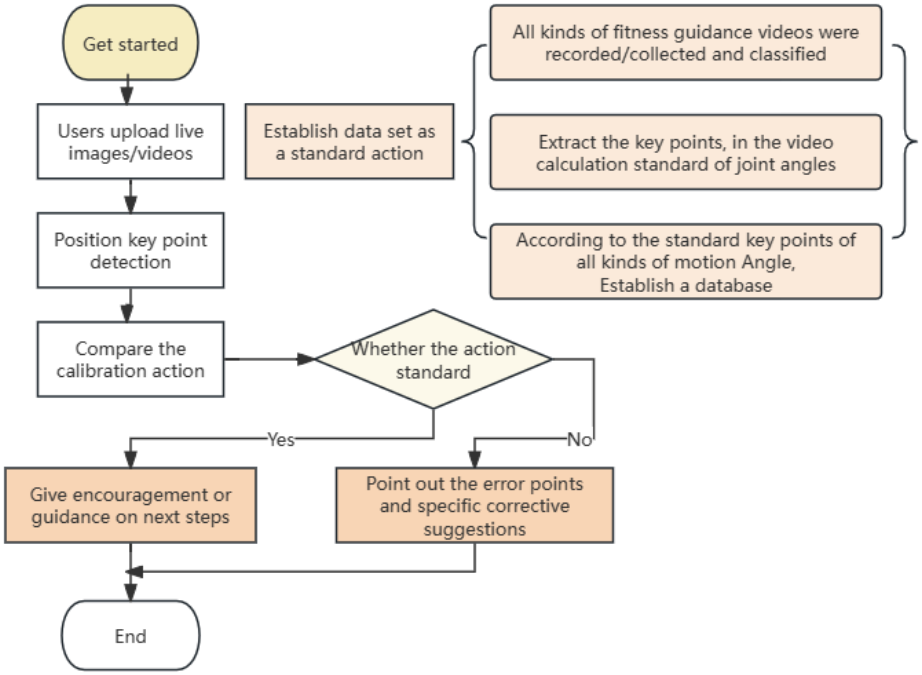


Figure 2. Flow Chart of Design Scheme of Fitness Guidance Module

3.2.2. Dietary Guidance Module

System need to be able to according to the user's body and the target of training, provide personalized guidance and advice. Different users have different physical conditions and training needs, and the system needs to tailor the appropriate training plan and dietary advice for the user. At the same time, the system needs to have good interactivity and be able to communicate and exchange effectively with users. So that users can get timely feedback, better understanding and application of the system.

According to the food pictures uploaded by the user, the system uses computer vision processing to construct a three-dimensional model of food, to estimate the volume of food, calculate the composition and calories, and then connect the user's personal body data to provide personalized advice and guidance. Processes are shown in figure 3 below:

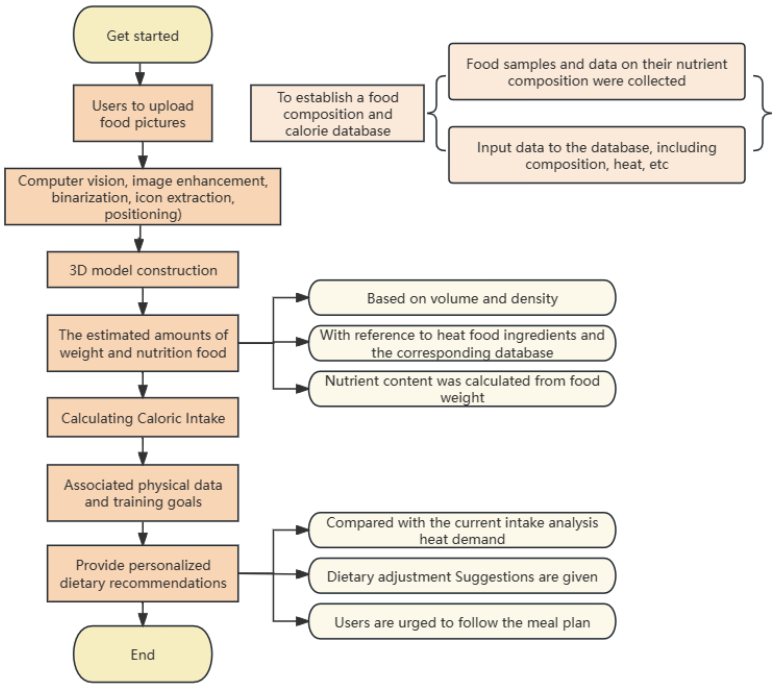


Figure 3. Dietary Record Module Design Flow Chart

3.3. Technology Application

Due to the complexity and diversity of human movements, image-based fitness guidance and recording systems need to use image processing techniques and deep learning algorithms to improve the accuracy and robustness of recognition. Online collection professional fitness guidance to each type of action video or image data, extract the bones

of the standard action sequence information, to obtain video or image bodybuilders in the human body each joint point of spatial coordinates, to establish a standard action, the data set.

Users upload live images or videos of themselves using the front-facing camera of their phone while performing a workout. The system uses the pose key point detection algorithm, such as PP-TinyPose model or OpenCV vision library, to obtain the position information and coordinates of each joint node, and can calculate the eight joint angles of the human body through the cosine theorem, as shown in Equation (1). And the data set with the action of standard data Angle were compared. By comparing the results, the user's posture is judged to be correct, and the corresponding guidance and correction suggestions are given.

$$\theta_i = \frac{\arccos\left(\frac{l_{ij}^2 + l_{ik}^2 - l_{jk}^2}{2 \times l_{ij} \times l_{ik}}\right)}{\pi} \times 180^\circ \quad (1)$$

In Formula (3-1), $\theta_i$represents the joint Angle of joint i, and $l_{ij}$is the coordinate point distance from joint i to joint j.

For the dietary guidance module of the system, it is also necessary to establish a database of food components and calories. System according to the user uploaded to the food pictures, using computer vision technology to identify types of food, and the image enhancement and binarization, target detection precision, area and the height of the food. Based on multi-angle object image, the 3 d model can be used to build the target, the target volume calculation, the weight of the estimate the roughly. To calculate the intake of nutrients in the food, with reference to food ingredients and heat corresponding concrete numerical value in the database, heat conversion of each meal. In addition, personalized dietary advice and supervision are provided to users by linking physical data and training goals.

3.4. Key Issues

3.4.1. The Problem of Low Speed Model Reasoning

System can be used in a mainstream model pruning algorithm to optimize the model. Model pruning, also known as model sparsity, is a technique to reduce the number of parameters and computation by removing "unimportant" weights from the model. Usually these unimportant weights to the model output contribution is small, it can keep basic model precision is not affected under the premise of gaining model inference speed significantly. Pruning algorithm can be divided into global pruning and local pruning, according to the specific structure of the model and the demand to choose the appropriate method. After pruning model not only more lightweight, more suitable for deployment on mobile devices, realize rapid and accurate fitness position detection.

3.4.2. Shade Problem

In the process of gesture detection, complex environmental conditions such as crowded, object shelter and so on, tend to cause the camera could not capture the full user profile, which affects the accuracy of the test results. This cover is especially true in today's fitness scenario, because the user may need to be performed in various environment fitness exercise.

The designed model needs to be able to access pictures or images uploaded by multiple cameras and perform fusion analysis. Through multiple points of view, the data fusion of cameras, access to a more comprehensive user profile information, reduce the error resulting from a single perspective shade. This approach can significantly improve the robustness and accuracy of pose detection. At the same time, using the perspectives of learning technology of deep learning, can be training model and integrated features extracted from multiple perspectives, further enhance the detection effect.

3.4.3. Personalized Guidance Questions

In order to provide personalized guidance and recommendations, the system can refer to the healthy diet recommendations of the World Health Organization (WHO) or authoritative guidelines such as the Guidelines for Diet and Nutrition for Adult Obesity (2024 edition). First of all, through the user input or equipment measuring the user's body data (such as height, weight, body fat rate, etc.) and the training objectives (e.g., lose fat and increase muscle, shaping, etc.). These data and goals are then combined to develop an individualized diet and exercise plan. In terms of diet, the types and intake of nutrient-rich foods can be recommended according to the WHO recommendations. In sports, it can according to user's physical condition and exercise capacity design appropriate training intensity and frequency. In addition, still can use machine learning techniques to continue to track and analyze user's data, dynamic adjustment Suggestions, in order to satisfy the user's changing needs.

4. Conclusions

The development of this system has the important project significance. First, it solves the problems that exist in the traditional way of fitness guidance, such as lack of coaching, raised the efficiency and effect of fitness guidance. Secondly, the system uses the attitude key point detection algorithm to realize the automatic recognition and correctness analysis of the user's action, and improve the accuracy and scientific guidance. At the same time, compared with the traditional fitness software, this system considering the importance of diet in the process of fitness, joined the dietary guidelines and record module in particular, through the establishment of the computer vision technology and 3 d model, designed to provide users with a full range of health support, further expand the application of audience. Finally, this system can also provide new ideas and methods for research in the field of fitness, and promote the development and innovation of related technologies.

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