Study on badminton system with auxiliary training based on Kinect motion capture

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Abstract

First, the paper studies the algorithm to repair self-occlusion body joint information. Due to the existence of human self-occlusion, the motion capture data is not credible. According to the invariance of the length of human body skeleton and the continuity of human movement, this paper proposes a quick geometric method to repair the skeleton information. The experiments show that the algorithm can real-time repair more than half of the obscured joints information, especially the end of the joint information. Then, study the movement redirection based on constraints of terminal effectors. Different human motions are assigned to another role, it will case feet penetrate the ground, sliding, skin stretching or distortions due to bone size inconsistencies. Base on bone length scale factor of virtual role and Capture body, this thesis proposes a movement redirect method of end constraint effectors. First determine the end constraint of the first frame, and get the three-dimensional coordinate information of the end constraint; secondly, based on the length of the human skeleton invariance redirect the three-dimensional coordinates of the other joints. Third, determine the end constraint of the next frame and get its three-dimensional coordinates; finally, calculate other joints three-dimensional coordinates of other frames. The experimental results show that the algorithm can solve the problem of distortion animation, and get standard capture motion data, which will conducive to data analysis.

Keywords: badminton, auxiliary training, Kinect motion capture

1 Introduction

Motion capture records the information of motion can be processed by computer with motion sensors, optical devices tracker etc. Processing the original motion data restore the three-dimensional information of the tracking. The Kinect via OpenNI_ racking human skeleton, and obtain information about each joint and rotation with inexpensive, simple data processing, real-time advantages [1].

Motion capture is used to measure, track and record real human motion information by sensors, which can be translated into abstract movement data. In recent years, a lot of techniques on motion captures are researched both at home and abroad, many methods of motion capture increasingly improve, and the corresponding motion capture systems are more and more widely applied. At the same time, the traditional motion capture data are mainly used to drive virtual character animation, and recreate real human body movement. Now the motion data capture is widely applied in increasingly diverse fields, such as sports, entertainment, intelligent control and etc. This article discusses some modes and researches the corresponding applications based on the optical and the mechanical motion capture [2].

In terms of optical motion capture, we use the Kinect motion-sensing cameras to obtain 3D depth information in the observation range, then translate into human body skeleton information, and carry on the human body skeleton tracking. The presented system can analyze and recognize the human body posture and gestures, and transform into control signal. It can apply to the systems for virtual campus roaming and smart home controlling. By building virtual campus roaming system, the Kinect motion capture data can drive the virtual human to roam in the virtual campus. By constructing the smart home system, the Kinect motion capture data can be translated to control signals for smart home controlling.

In the aspect of mechanical motion capture, we mainly analyze two kinds of inertial measurement units of MTI and Razor IMU [3]. In the information retrieval system based on MTI, the motion analysis of freestyle skiing aerial skill can be applied, and furthermore can be used to reproduce the 3D animation to aid sports training. The Razor IMU with 9 degrees of freedom sensor can be analyzed, and combined with Unity3d to build the simulation system of human motion. It can preliminary be applied to explore the human motion analysis.

2 Motion features

Motion Capture is to record the motion track in three dimensions by sensor devices, to transform it to motion data, and then to drive the virtual human to move based on these data.

In recent years, there are a lot of works done on the Motion Capture outside nation and many systems on Motion Capture have been provided to use. But all of the systems are so expensive that few institutes or companies in our country can afford. A few institutes in our country have been engaging in the business for several yeas, however, the images collected by the system made by them are often planar and have no three-dimensional motion parameter because the images are captured by cameras and have to be disposed on sensibility experience. As a result, it is very necessary to design a 3D Motion Capture system by ourselves to fulfil the internal demand [4].

Based on "TRI-EYE" which is a device collecting spatial information made by CFR, this dissertation aims at real-time and reality, reaches a new precision level in

foundation of guaranteeing it's real-time, and uses the device to assist training, and create an applied training system based on motion capture.

There is a badminton competition scene as shown in Figure 1. We can see that the motion is complex.

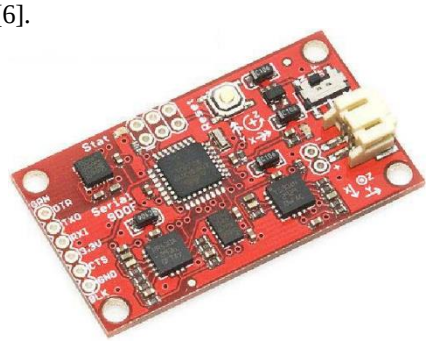
FIGURE 1 Badminton competition scene

Computer vision in the modern information technology industry has been rapid development, technical analysis based on the image content analysis has been successfully used in transportation vehicles, the detection of industrial products, agricultural pest control, interactive advertising machine, visual intercom and medical disease detection and other fields occasions. In the field of medical rehabilitation robot-assisted rehabilitation and human support rehabilitation there are two ways. Robot-assisted rehabilitation system because of its expensive maintenance and the high cost of a single intelligence in the actual popularization and application of market bleak; assisted rehabilitation is the best choice for the rehabilitation of patients, but in reality to be rehabilitation patients need rehabilitation coach lofty on the supply side. Provide a rehabilitation effect at the same time meet the rehabilitation of patients with the ability to buy and easy to use system is an important topic in the field of rehabilitation.

FIGURE 2 Microsoft Kinect

In this paper, the above problem, computer vision, the core of the problem-solving and equipment acquisition through Kinect the spatial depth map of the patients, the reconstruction of patient rehabilitation action flow [5]. The system set the two sports role: a rehabilitation coach and rehabilitation patients, doctor patient rehabilitation progress report feedback to the assessment of the stream through its demonstration and training actions. Client developed another system and WEB version management end to the rehabilitation process, role the Kinect depth acquisition-based rehabilitation model and processes.

The method of rehabilitation based on the depth of vision technology. Collecting device and coordinate system (a) and sensors (b) are shown in Figure 2. The method through the analysis of the depth of image motion in computer vision, collected from the flow of human movement rehabilitation action. To establish rehabilitation of positive and negative sample collected by the movement of the two roles of rehabilitation coaches and rehabilitation patients [6].



(a)

(b)

FIGURE 2 Collecting device and coordinate system (a) and sensors (b)

Rehabilitation of office flow, three roles interact rehabilitation office business model. The office business model to the integration of the three roles in the rehabilitation process: doctors, patients, rehabilitation coach to the training process. And role-based permissions management system designed for business functions.

Flow similarity assessment study rehabilitation collecting positive and negative action, action fusion DWT algorithm and hidden Markov model flow similarity assessment algorithm, an effective solution to the problem of assessment of the effects of patient training, to provide confidence to the doctor the high output of results.

3D modeling and scene study rehabilitation training system to build a system for visual rehabilitation action flow through animated characters in a 3D scene to reproduce the rehabilitation of the same scene, the realization of innovative multi-terminal offsite training effect.

3 The three dimensional model

$$L=\sqrt{(x_a-x_b)^2+(y_a-y_b)^2+(z_a-z_b)^2}\,, \tag{1}$$

$$\begin{cases} V_{bx,k}=\dfrac{x_{b,k}-x_{b,k-1}}{t} \\ V_{by,k}=\dfrac{y_{b,k}-y_{b,k-1}}{t} \\ V_{bz,k}=\dfrac{z_{b,k}-z_{b,k-1}}{t} \end{cases} \tag{2}$$

$$\varphi(i)=\varphi(i-1)+\frac{1}{2F_s}[y(i-1)+y(i)]\,. \tag{3}$$

Three dimensional motions are Equations (1), (2) and (3). Equation (2) is the three directional velocities. Human-computer interaction identify human action, such as

gestures, body potential, facial expressions, to achieve interaction between human and machine, even combined with voice recognition to achieve mufti-channel integration of human and computer interaction techniques. Human posture recognition is a key technology for the development of Human- computer interaction. People by making a variety of posture to pass information to the computer and the computer achieve an accurate understanding of the meaning of human posture by identifying the human body's movements. Thus, for this natural harmony of human-computer interaction needs, human posture recognition technology has become a hot topic.

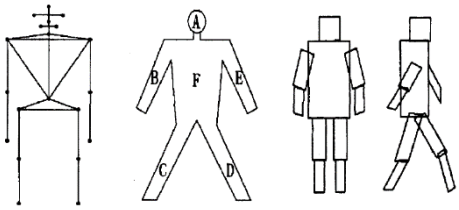


FIGURE 3 A two-dimensional model of the human body

A two-dimensional model of the human body is shown in Figure 3, while the three-dimensional entity model is shown in Figure 4. We research on the algorithm of human body detection and tracking, use the depth image which obtained by Kinect to track the human body. In order to improve the accuracy of posture recognition, this paper presents a method of measuring human joints angles to identify human posture based on Kinect. This method is to use Kinect to get the space coordinates of body joints, to realize posture recognition by matching the angle of posture recognition; it can accurately recognize human posture in real time.

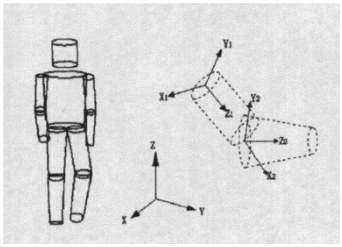


FIGURE 4 The three-dimensional entity model

We investigate the repair algorithm of human body joints for the human body parts are obscured by objects and the confusion between body parts when tracking. This repair algorithm combines with the invariance of the human skeleton length, the continuity of human movement and the rotation angle limit of joints to assess the trustworthiness of joints, and then use the assessed value to repair the joints. The joint which has been identified, we test its reliability, combined with behavior, reliability, and track the status of the kinematics and assign weights to them to determine the reliability of this joint. Combined joints repair algorithm and key points of posture correction method for the synthesis and optimization of human posture. After, we study the posture correction method based on joints, and synthesis and optimization the human posture.

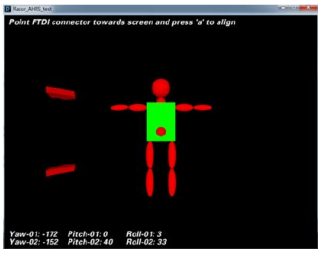


FIGURE 5 Real time human motion models

Real time human motion model is shown in Figure 5. We design a system of human pest recognition and assessment based on Kinect. This system utilize depth image obtained by Kinect to get the skeleton joints, the function of angle measure achieved the method of measuring the angle between the joints, and achieve the posture recognition the information of these angle. In the process of assessment, if the user's posture does not meet posture set condition, posture error message are prompted the user to be re-started. System eventually realizes the real-time recognition and assessment of human posture.

Gesture recognition is a key technology for natural human-computer interaction, compared with the traditional mouse, keyboard and other mechanical equipment, gesture has the advantages of natural, intuitive and easy to understand, and is more close to human's daily communication habit. Kinect is equipment released by Microsoft which can capture RGB color image and depth image simultaneously. It can predict twenty human skeleton joints' three-dimensional coordinate from a single depth image, and it's the ideal equipment for gesture recognition research based on computer vision. According to the recognized object, gesture recognition can be divided into static and dynamic gesture recognition. In this paper, static and dynamic gesture recognition is studied respectively, using Kinect as an input device.

Static gesture recognition classifies hand shape in single image, generally consists of three steps: gesture segmentation, feature extraction and classification. The paper combines hand joint's position and skin detection method with adaptive threshold to segment gesture, extracts He invariant moments and the number of fingers as the feature, finally uses SVM to classify. Dynamic gesture recognition classifies hand's trajectory in continuous multi-frame images, generally consists of four steps: hand segmentation, hand tracking, feature extraction and classification. The paper gets skeleton joints' position, uses skeleton joints' trajectory as dynamic gesture's feature, then uses distance-weighted dynamic time warping algorithm to calculate the distance between training sample and testing sample, finally uses K-NN to classify.

The popular sports teaching system should have the function of motion capture, reconstruction and analysis. At present, there are many studies on the motion capture, while the equipment is expensive and more motion constraints. In addition, very few about human motion reconstruction and comparison analysis, and yet there is no a good solution. Tracking the human body codes is shown in Figure 6.

Firstly, in the three-dimensional human motion capture aspect, this topic use the latest Microsoft Kinect depth information detection device to measure the key node data

of human skeleton and convert it to motion data that match with the hierarchical structure of human skeleton. Kinect uses the advanced technology of optical encoding technology in the process of information acquisition. The technique does not require the special light-sensitive chip, only an ordinary CMOS sensor chip can put it into action, which makes the cost of depth information acquisition is decreased greatly. In the motion data generation, Kinect uses the motion data which match with the hierarchical structure of human skeleton. One hand, the amount of data to be logged is decreased greatly; on the other hand, it provides convenience to the subsequent motion construction and analysis.

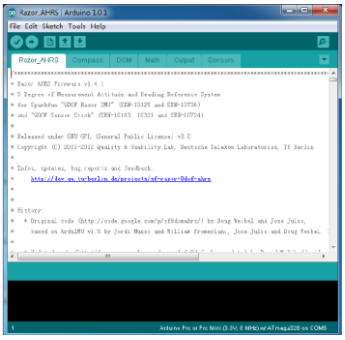


FIGURE 6 Tracking the human body codes

Secondly, in the reconstruction of three-dimensional human motion reconstructs the three-dimensional motion of the human body vividly this topic with the technology of skinned mesh animation and individuality manikin models. According to the different application, two human motion reconstruction methods are designed in this paper, namely the motion reconstruction method which based on the standard human models and the individuality manikin models. Two reconstruction methods can observe action sequence or a fixed posture from an arbitrary viewing point in the OpenGL environment. Finally, in the aspect of three-dimensional motion analysis, in this paper, aiming at the practical problems existing in the motion data, we designed a variety of comparison analysis methods and conducted the confirmatory test. This part is mainly to reduce the error of the manually contrast, thus gives more intelligent quantitative evaluation result.

4 Conclusion

In this paper, we propose badminton swing analysis system with auxiliary training based on Kinect motion capture. It gets motion data from the Kinect via OpenNI. Repair blocked joints, redirect motion data, and then the data is assigned to the virtual role and reproduction swing animation. The supplementary training analysis is divided into four areas: swing single plane judgment, trajectory analysis, speed analysis, joint angles analysis. Swing single plane judgment is based on the trajectory of the shoulder and wrist, and fitting the shoulder and wrist articulation plane, according to the positional relationship of the two planes to adjust the training. Comparison of the key joint movement parameters, full swing divided into seven posture, and calculate three-dimensional coordinates, velocity database, or angular velocity database of critical joint of high level players in each swing posture; then real-time capture the motion data of trainer; Provide specific value and intuitive curve comparison, adjust the training, and raise the level of the trainer. The tests showed that the auxiliary system can give the swing posture between the trainer and the high-level badminton, the trainer corrects the common swing errors.

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