ISSN : 0974 - 7435 Volume 10 Issue 19

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(19), 2014 [11606-11610]

Study on the application of three-dimension reconstruction technology in human movement sciences

Jin Zhang

Changchun Financial College, Changchun, 130028, (CHINA)

ABSTRACT

The three-dimension reconstruction technology plays an important role in human movement sciences. It effectively analyzes human bones and the range of motion of joints, making articular range of motion during this exercise more scientific, and exerting positive impact on the adjustment of its athlete's gestures, as well as reflecting problems about their range of motion. Based on model design of three dimensions of human bones, the study focuses on common body construction by the means of three-dimension reconstruction technology, laying a solid foundation for the application of three-dimension reconstruction technology by the principle of rigid motions of the human bones. Also, it analyzes human skeleton model based on constraints, providing a theoretical background for the application of three-dimension reconstruction technology. It gives an improvement on the application of three-dimension reconstruction technology by the inertial sensors, initial calibration, real-time tracking of the human body posture andposture of human motion data acquisition and processing, making the process of the study more closely, and ensuring the study more scientific and rational, to lay a good foundation for future research on theory and practice.

KEYWORDS

Three-dimension reconstruction; Human movement science; Movement posture; Application and research.

INTRODUCTION

The technological value of three-dimension reconstruction technology is that it can make the study on human bones involving in movement and joint range of motion more scientific, and make the construction and application of basic model of human movement possible. This study focuses on three-dimension human skeleton model, hierarchical motion model of human bonesbased on constraints, inertial sensors, initial calibration, real-time tracking of the human body posture, and posture of human motion data acquisition and processing. This study aims to give positive impact on human movement science research and make athletes' movement more scientific.

THREE-DIMENSION HUMAN SKELETON MODEL

Common methods of human body model construction

The methods of human body model construction can be divided into two categories: the construction of human body model based on anatomical theory and the construction from a geometric perspective. The former focuses on human bones, muscle and tissues to form a scientific model of human body, while the latter mainly researches on the model in the grid way based on three-dimension drawing software to form a connection in the human body model construction. As for reconstruction of movements of the human body, the construction method can be divided into two parts based on human skeleton space model: one is human skeleton model and the other is a three-dimension human skeletal model[1].

Two-dimension human skeleton model

The essence of human skeleton model is the effective description of the spatial position of human motion in a two-dimension space to construct a two-dimension model, which consists of two-dimension stick-like model and two-dimension regional model.

Two-dimensional stick-like model aims to describe human body by lines and dots to makes human body a more realistic geometry. For example, limbs can be described by lines while instrument can be represented by points. However, the establishment of human motion tracking system aims at the effective research on monocular video sequences, so that the sequences of lines and points can be effectively arranged in the video capture process, making the formation of human skeletal geometry easier, and giving a detailed description of human body.

The two-dimensional regional model forms models primarily based on the analysis of human video sequences. This construction method mainly focuses on the two-dimension representation of each body part to build a two-dimension image. However, according to this method, the depth image information is lost, and the model image is less stereoscopic.

Three dimension human skeleton model

The threedimension human skeleton model is to describe human motion gestures by three-dimension space. The process is realized by two forms: one is the threedimension geometrical model and the other is the three dimensionfacet model.

The three dimensiongeometric model applies the basic geometry to form models to represent human body and joints in three dimension space. During the formation of the three dimensiongeometric model, the gesture reconstruction of human body model will be realized by monocular video sequence based on conditions mentioned above, which can reflect basic features of human movement.

The construction of facet model is more realistic. From the body surface structure as the fundamental starting point, the skeleton and joint model will be construction through the grid pattern, and the human body movement is processing based on monocular video sequences to form the express posture reconstruction, which make the model more authentic.

The essay uses the inertia sensors to capture human body movements, reconstruct the movements by computer, and completes the construction of human body model by three dimension construction technology, to relive the human movement gestures[2].

Principle of rigid motions of human bones

When movement is conducted, human skin and muscle does not influence the whole movement. To make it simple, by effective tracking and analysis of human motion, the human skeleton model can be constructed by relevanthuman kinetics theories. According to human kinetics, cylinder block is the actual physical model of the object, which does not have a change in shape by external force while its basic internal characteristics do not change as well. By contrast, rigid body is abstract physical model, whose movement is generally considered unchangeable. This dynamic thought is an important part of the kinetic theory and it studies the rule of rigid body under external force, which is widely adopted in the process of industrial production and scientific research. The study of the dynamics of a rigid body is correspondent with the study of the bones and joints of the human body motion capture and tracking. However, rigid body consists in particles and its movement is divided into two parts: translation and rotation around a fixed point.

During the displacement of rigid body, the basic process is a process of displacement plus a rotation process. The location and orientation of the displacement can be achieved by a fixed initial state and an upcoming displacement and rotation. As is shown in TABLE 1, the movement of rigid body is a process of translation from t1 to t2. The motion path of two internal particles is relatively parallel and the direction of these two particles is constant[3]. The translation movement of rigid movement is shown as Figure 1.

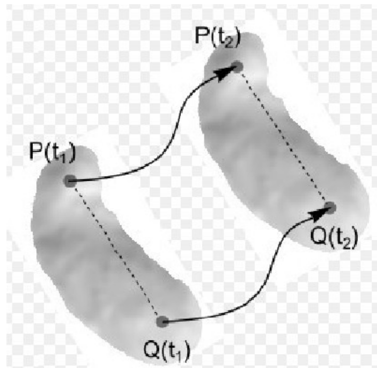

Figure 1 : Translation movement of rigid movement

HIERARCHICAL MOTION MODEL OF HUMAN BONESBASED ON CONSTRAINTS

According to human movement science, human body is comprised of 206 bones, which are connected by joints. Except six auditoryossicles, 200 bones can be classified into three categories: 23 skull bones, 51 trunk bones and 126 limbs bones. All these bones coexist and interact with one another. The movement properties of bones are constrained by joints. Based on this fact, the construction of human skeleton model requires large amounts of computation and an analysis on its complex movement connections. So this study does not take these less influential bones into account and reduces the constraints on the human bones movement to gradually simplify the model construction.

The study uses the skeletal tree model to complete the model construction. As human skeleton is seen as a tree, bone is considered the root node of the tree, while the nodesare seen as countless parent-child relationship leaves[4]. If a corresponding root node exists without a parent node and other parent nodes exist, it means there is a parent bone among these bones. In the human movement, it can be regarded as bones and joints movement represented by a parent node. Because the motion range of hip joint in the movement is minimal, it is usually seen as the root node of the human skeleton tree. According to these descriptions above, based on the rigid body dynamics principle, every node on hip joint can be defined as rigid body. Its location and direction can be obtained only by the comprehensive calculation and analysis on these nodes. (as is shown Figure 2).

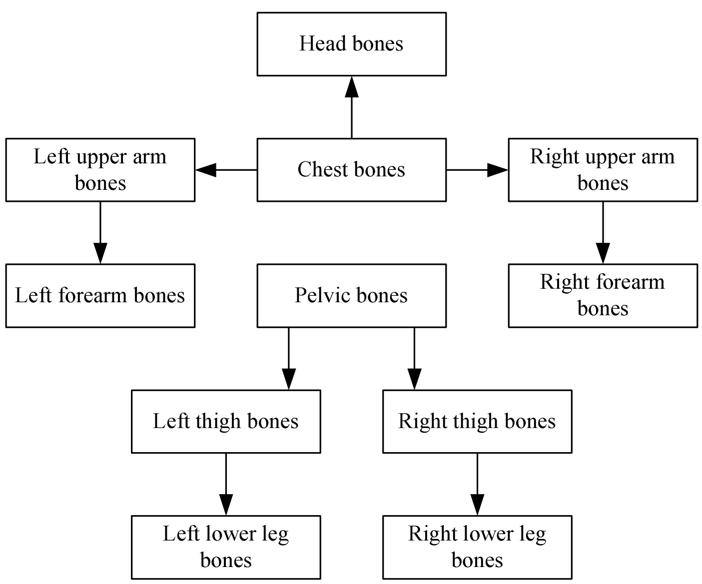

Figure 2 : Human skeleton tree hierarchy diagram

The importance of joints for bones is obvious because bones are connected by joints. As human body is a whole, there are numerous joints, which are divided into seven categories, such as hip joints, elbow joints, knee joints and neck joints. However, their motion is of great difference, which can be classified into six forms, including extension, abduction and adduction. In the anatomic perspective, human joints have six parts, such as sliding type joints and spherical joints. As for the different degrees of freedom and types, their motion ranges are limited in some extent. The degree of freedom can be seen in the TABLE 1.

TABLE 1 : Degree of freedom of joints in the human skeleton model

Name of joint	Category of parent bones	Type of joint	Degree of freedom
Neck joint	Chest bone	Universal joint	3
Left shoulder joint	Chest bone	Universal joint	3
Right shoulder joint	Chest bone	Universal joint	3
Left elbow joint	Left upper arm bone	Hinge	2
Right elbow joint	Right upper arm bone	Hinge	2
Left hip joint	Pelvic bone	Universal joint	3
Right hip joint	Pelvic bone	Universal joint	3
Left knee joint	Left thigh bone	Hinge	2
Right knee joint	Right thigh bone	Hinge	2

In the movement, due to different joints' features, there is difference in the motion range of each joint. Take every root node of pelvic joints and nodes of hip joints on thigh as an example. To complete the knee flexion movements, its magnitude and range remain between 0 and 125 degree, while if the knee is not flexed, the range is between 0 and 100 degree. The range keeps between 0 and 25 degree in the stretching movement. The joint range of motion is within 0 and 45 degree at the inward knee flexion, and it remains between 0 and 125 degree in the Venus phase stretching movement. The maximum amplitude of these joint movements is effectively limited, and the scope and range of its motion are reduced too. Then human motion gestures can be captured through these constraints. Later, in order to relive clearer image of human motion, whether self-tuning angles correspond to actual human movement should be checked[5].

In the TABLE 2, the motion range of human joints has been effectively limited, and the specific constraints are shown in TABLE 2.

TABLE 2 : Maximum motion range of human joints

Name of joint	Scope limit
Hip joint	0-125 degree
Knee joint	0-140 degree
Shoulder joint	0-180 degree
Elbow joint	0-145 degree
Neck joint	0-80 degree

INERTIAL SENSORS AND INITIAL CALIBRATION AND REAL-TIME TRACKING OF BODY POSTURE

As for the measurement of human motion data, these data are obtained by inertial sensors to establish the human motion gesture models. During this process, body movements and the sensor should be initialized to ensure the tracking process of movements. The sensor is fixed on each joint, which can be seen as a relatively constant process that the corresponding position with body motion remains the same. Meanwhile, the basic condition of structure is met. Therefore, this process can be seen as rigid body movement. Based on early initialization settings, the rotation matrix of this motion can be determined too. Then the corresponding conversion betweensensors coordinates and human body coordinates is generated. Therefore, in the process of tracking, the conversion among joints coordinates is continuously updated and the effectiveness of real-time tracking is strengthened.

ACQUISITION AND PROCESS OF HUMAN MOTION DATA

The multi-sensor data transmission is based on the body motion capture of inertial sensors, and human motion data can only be obtained through inertial sensors. Because the eleven inertial sensors are fixed on human bodies, if the sensors and the host computer program of the PC is connected by wired transmission, every body parts of movement should be fixed with transmission lines, which highly limit the body's range of motion and velocity[6]. The effect of cable data transmission is shown in Figure 3.

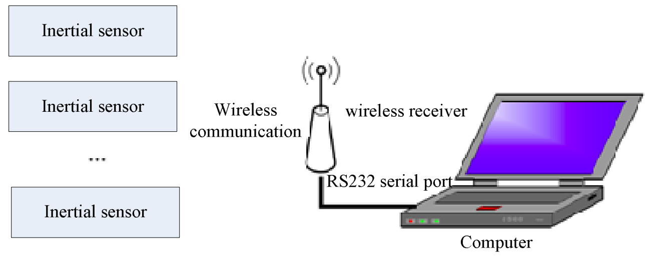

Figure 3 : Data transmission diagram

The function of the Being Motion Receiver (BMR) is to receive and analyze the angular data from the eleven sensors by the RS232 serial port. Then it conducts coordinate conversions and calculations. It sends the coordinate data after conversion to three dimension display program by the network protocols, and obtains the motion data gained from the conversion into a database. The software modules include user interaction modules, system configuration module, data computation moduleand data communication module. The design of software schema is shown in Figure 4.

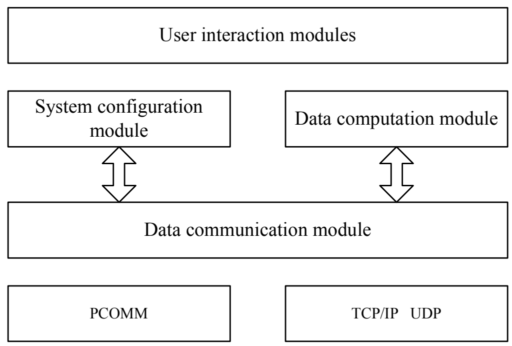

Figure 4 : BMR schema

On the BMR's main interface of data receiving and processing program, when the user clicks the "open" button, BMR sends an "open" commend to the wireless receiver. According to sensor's data sent by the wireless receiver, BMR can correspondingly display all these data on the human body model in the main interface. In the graph, the green mark represents the inertial sensor fixed on the joint has been connected and it is in the full power state. The yellow one means the connection is positive but it is in the low power state. The red one shows the inertial sensor fails to be connected. When the user clicks the "begin to collect data"button, BMR sends the angular data command to the wireless receiver and the sensors begin to collect data.

CONCLUSION

Above all, the study describes the application of three dimension construction technology in human body science. In order to make the study more comprehensive, the analysis combines human skeleton model with data acquisition and processing, laying a solid theoretical and practical support for further research.

REFERENCE

[1] Liu Tonghai, Teng Guanghui, Li Zhuo, Guo Peng; Reconstruction and application of 3D pig body model based on point cloud data, Journal of Agricultural Machinery, **45(6)**, 291-295 **(2014)**.

[2] Zheng Min; Dimensional reconstruction of lower limb bone based on reserve engineering, Manufacturing Automation, **36(2)**, 57-60 **(2014)**.

[3] Zhang Donghai; 3D reconstruction frame computer automatic diagnosis in movement technology analysis, Bulletin of Science and Technology, **29(6)**, 146-148 **(2013)**.

[4] Wang Jun, Wen Yaya, Yu Juan, CaiDuoduo; Three dimensional reconstruction method for moving target from ISAR sequences, Journal of System Simulation, **25(4)**, 809-816 **(2013)**.

[5] ZhengChunxiao, Zhang Juan; 3D reconstruction of multiple views based on trifocal tensor, Journal of Biomedical Engineering, **29(4)**, 769-774 **(2012)**.

[6] QuXuejun, Song Yuewen, Wang Yong, Han Zhiren, Zhang Lingyun; 3D shape measurement method based on new system mathematic model, Journal of Mechanical Engineering, **48(14)**, 17-24 **(2012)**.

[7] Yu Shuisheng, Cai Yong, RaoJinfeng; Study on the reconstruction technology of three-dimensional model having symmetrical characteristic, Machinery Design and Manufacture, **(9)**, 80-82 **(2012)**.