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Human Motion System Model Based on Real-Time Image Acquisition and Data Simulation

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The rapid development of video technology has gone hand-in-hand with communication technology, the development of which is a major force driving video technology advancement and expanding its range of applications. Simultaneously, issues such as security (among others) have been addressed and continue to attract research attention. However, the development of video technology has encountered many obstacles, one of which concerns the capturing of motion. Hence, the purpose of this study is to conduct an in-depth investigation of motion capture technology and to discuss how video technology and motion capture can be combined with the human body motion posture for a more accurate video recording of human movements. Related motion nodes can further capture the human motion process, and record and analyze the human motion data. This research can be used not only for the human motion research model, but can also be applied to various domains such as medicine, sports, and animation. The research focus of this study is on the analysis of human body posture and images of the human body that can be collected during movement. This is the key to the development of video technology. When collecting data on images of human movement, this article is based on the data It further simulates the motion posture of the human body, and after many experiments, the authenticity of the data is improved.

Keywords: image acquisition; data simulation; human movement; system model

1. INTRODUCTION

The advancement of video technology and image capture technology has led to the development and application of motion capture technology that is now being applied in domains other than medicine such as animation, robotics and film, to name just a few. For many people, motion capture technology has become a part of daily life, adding convenience to everyday activities as well as tasks in the workplace. Hence, it is a key technology that is drawing greater attention from the research community keen to extend its application, and overcome obstacles to achieve more accurate results [1]. Many scientists and scholars have begun to use motion capture technology to study the movement posture of the human body. Compared with the previous human movement posture recording, the motion capture technology is more convenient, and the human movement posture is captured more clearly, and more high-definition movements can be obtained. Posture picture, the human body motion posture data obtained through this technology is used as a basis to dynamically simulate the human body's motion posture and establish a three-dimensional model. It can also establish a human skeleton structure, which can visualize the human body's motion posture and skeleton structure during exercise. Moreover, with controlled simulation, the collected data can be applied to the creation of computer-aided animation, making the animated characters more realistic with a virtually unlimited range of actions [2]. At the same time, the human body movement posture data obtained by the motion capture technology can be used for educational purposes to determine students' physical health status so that steps can be taken to

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maintain good health or to address existing problems In the field of medicine and allied health domains, the data obtained by motion capture technology can help determine people's physical health and the correctness of their movements. The degree of recovery of the patient's body captured by this technology can indicate the patient's physical condition, assisting the doctor to make a diagnosis.

The motion capture technology obtains data on the human body motion posture. Based on this data, the human body motion posture can be simulated. There are three most important elements in the simulation process. The first is the virtual human skeleton model which must have a certain degree of accuracy [3]. If the accuracy of this model is poor, it will affect the further analysis of the human body motion posture and the establishment of other models. The second element is the data analysis of the human body motion posture, and again requires accuracy. Only the guaranteed accuracy and precision can ensure that there will be no deviation in the subsequent human motion posture simulation. The third and most important element is the free editing study of human motion posture [4]. These three factors affect the establishment of the human body motion posture model for two reasons. First, when capturing the human body motion posture, if the skeletal parameters during the movement cannot be accurately captured, it will be very easy for the human skin to be pulled in the subsequent motion model, which will then lead to an unrealistic human bone model, and to deviations in its parameter settings [5]. The second reason is that the main data used for analysis is the movement range and movement angle of each joint point of the human body during movement. These data are scattered data. Therefore, if we want to create a realistic human body movement posture model, we should use the least square method to calculate the fitting curve, and then analyze the curve, combine the changes of each joint point when the human body moves, analyze the human body movement posture model, and obtain the law of posture change when the human body moves.

2. RELATED THEORETICAL BASIS

2.1 Image Recognition Algorithm Based on LBP

In order to facilitate the description of the LBP operator, the function E is used to represent the distribution of the central pixel and the adjacent points:

$$E = e(g_r, g_0, g_1 \dots g_{k-1}) \tag{1}$$

The diameter and state of each center point and adjacent points can be different. The coordinates of other points g_k around a center point are (x_k, y_k), which can be expressed as follows:

$$(x_k, y_k) = \left(x_r + R\cos\left(2\pi\frac{k}{r}\right), y_r + R\sin\left(2\pi\frac{k}{r}\right)\right) \tag{2}$$

Assuming that each point does not interfere with any another point, the mutual independence of the center pixels will cause the loss of some data, but it has little effect on the result:

$$E = e(g_r, g_0 - g_r, g_1 - g_r \dots g_{k-1} - g_r) \tag{3}$$

Since the main purpose is to obtain binary features, only the difference result sign needs to be known, so that the result is not affected by the exposure intensity:

$$E = e(s(g_0 - g_r), s(g_1 - g_r) \dots s(g_{k-1} - g_r)) \tag{4}$$

In the formula:

$$s(x) = \begin{cases} 1, x \geq 0 \\ 0, \leq 0 \end{cases} \tag{5}$$

calculating the obtained binary value, s requires a weight value, and then performing a summation operation to obtain the local texture feature value of this pixel. The equation is:

$$LBP_{K,P} = \sum_{k=0}^{k-1} s(g_k - g_r)2^k \tag{6}$$

2.2 The Human Body's Movements, Movement Patterns and Movement Characteristics

2.2.1 Human Movement and Classification

In human movement, changing the position of the limbs will, generally, change the position of the body. However, apart from the limbs, human movement also involves the human nervous system, bones and muscles [6]. Hence, human movement is not just a simple muscle activity, but a coordinated process. The human body's action behavior is divided into three main categories. The first category is conscious action behavior, which occurs when people consciously perform a controlled movement. Here, the brain plans, controls and responds to the movement. The second category involves a sexual response made unconsciously by the brain, rather than deliberately as is the first category of movement. Because it is an action made by the brain unconsciously, the brain is required to do little or no thinking [7]. Influenced or stimulated by the external environment, the human body reacts with unconscious muscle activities through muscle memory. Muscle memory and reactive movements can be strengthened through training. The third category is reflex action, which is mainly carried out by the most basic neuromuscular system of the human body.

2.2.2 The Basic Movement Patterns and Characteristics of the Human Body

The action model of the human body is the basic framework of human movement formed by the bones and joints during movement. Through this framework, it is possible to explore the form of human movement and its mechanical transmission. The action model is not a single system. It is a three-dimensional motion axis [8] where the positions of bones and joints in the human body are combined and sorted according to the force generation method and force transmission process of the human body. During human movement, due to gravity, the movement of the center of gravity of the human body leads to the movement of the human body. This is the most

Table 1 Basic human body movement patterns.

Basic action mode	Daily life example	Examples of fitness exercises
Squat up	Sit and stand	Weight-bearing squat exercise
Lunge	Go up the stairs	Lunge walking practice
Gait	Walking or running	Rhythm running
Body flexion	Bent over to pick up things	Back lifting exercises
Body turn	Turn around to take something	Upper body diagonal exercise
Push support	Push the door or prop up	Push-up exercises
Stretch	Lift things	Head lift exercise
Lift	Lift the package	Kettlebell chest pull exercises
Roll	Turn over in bed	Chest rotation exercises
Crawl	Climbing stairs or walls	Animal crawling exercises

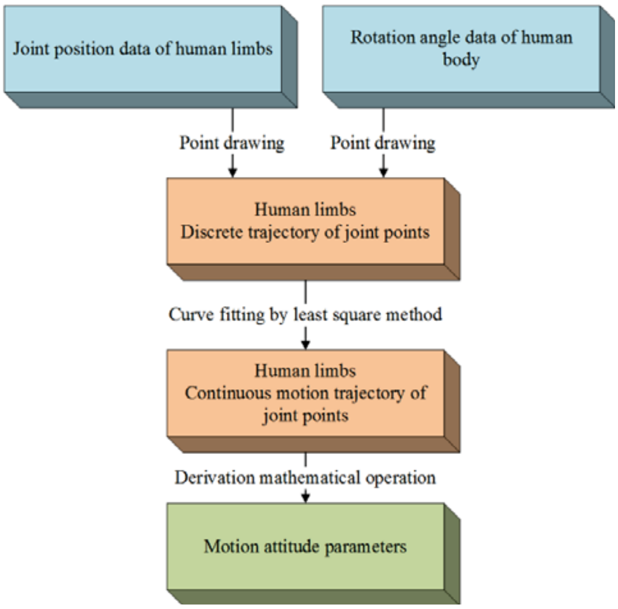

Figure 1 Flow chart of human body motion posture parameter extraction.

basic movement mode of the human body. No research has been able to determine how many basic movement modes the human body has. But it is certain that the number of the most basic movement patterns is certain [9]. This paper combines a large amount of research data and the research opinions of numerous scholars to classify the most basic movement patterns of the human body. The categories are shown below in Table 1.

The most basic action modes listed in the table above are an integral part of people's daily lives and affect how they perform other actions in the home, at work, when playing sport etc. [10]. These are the most basic movement patterns that will be repeated throughout life, and continue to be developed and perfected. Only by continuously strengthening these most basic movement patterns can we explore various professional sports skills. The most basic action mode includes many actions; for example, people can perform asymmetric actions at the same time [11]. That is to say, through the coordination of the body and the brain, people can perform asymmetrical movements of the body up and down and left and right. A popular sport in China is badminton. When performing the most basic action modes, the body's coordination and control capabilities are constantly being tested and improved. Only by continuously strengthening these capabilities can the action modes become professional sports skills that can be added to [12]. The perfection of the most basic mode of action requires not only the strengthening of the coordination and organization of the body, but also the combination of the physical and mental functions, the continuous improvement of the brain's ability to control and coordinate movement, and the strengthening of muscle memory. This coordination of functions can produce a unique sports style.

3. HUMAN MOTION SYSTEM MODEL BASED ON REAL-TIME IMAGE ACQUISITION AND DATA SIMULATION

3.1 The Extraction Process of Human Motion Posture Parameters

By deriving the continuous motion trajectory of the polynomial, the coefficients of the human polynomial are calculated to obtain the posture function of the human body. The flow chart of human body motion posture parameter extraction is as follows:

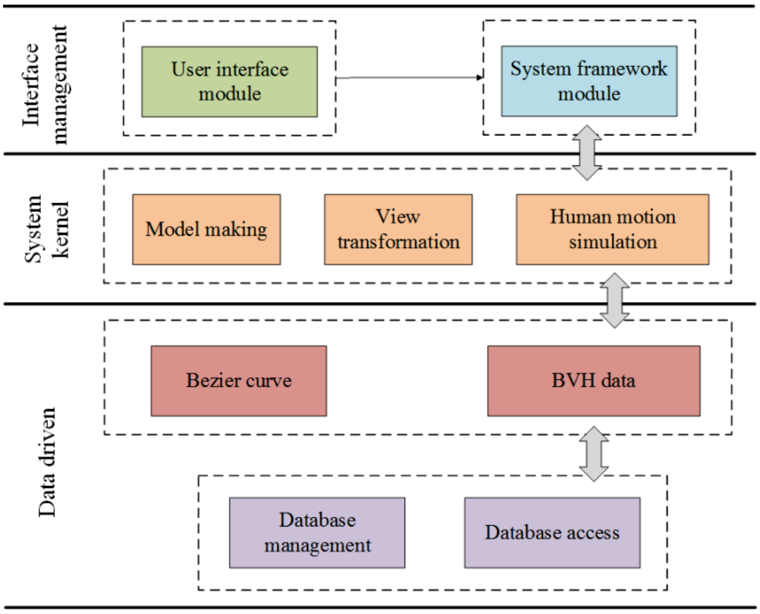

Figure 2 Human body motion posture simulation system architecture diagram.

3.2 Design and Construction of Human Motion System Model

3.2.1 Virtual Human Model

The physiological structure of the human body is very complex. The firmware virtual human model should first build the human bones and joint models. By acquiring a large amount of human motion posture data, the virtual human model can be constructed, which requires a sound understanding of human body motion [13]. Laws, master a large amount of human motion data, and construct geometric model data for human motion through a large number of calculations. The more comprehensive the human motion model of the firmware, the more realistic it is.

3.2.2 System Framework

The overall frame diagram of the human body motion posture simulation system is shown in Figure 2 below.

As shown in Figure 2, a hierarchical research framework was used when analyzing the human body movement posture. This research framework is divided into three levels from top to bottom. The first level is the presentation layer. The main function of the presentation layer is to receive various information from users. It can summarize and classify this information and submit it to the next level. In other words, this hierarchical system, it is equivalent to a huge container holding a summary of user information [14]. The second level is the logic layer. Its function is to process the information conveyed by the presentation layer. The main function of the logic layer is to convey the information conveyed by the expression layer to the next level which is the function layer. It can interact and transform the two levels of information, it can classify and transform the general information conveyed by users in the expression layer, and transform user information into a personalized user interface [15]. The user interface is for each user. Features are developed in a personalized way, with distinct personality characteristics, very powerful functions and good interactivity. The third and final level is the data layer, which can analyze and simulate the data provided by the logic model and the user's personalized information, and can calculate and analyze the acquired data through 3D capture technology to establish the posture model of human motion, which is the most important and critical level in the human motion posture simulation system, determines whether the human motion posture model can be successfully established [16]. The human body motion posture system comprises these three levels. All human body motion posture models are achieved by means of the functions of these three levels. At the same time, the material properties in the finite element model can be further analyzed with the help of Bezier curves, such as shown in Table 2. In this way, the construction of the human body motion posture model can be achieved.

3.3 Data Import

Combining the normal range of human motion in Table 3, the data obtained during the simulation of human motion posture is imported [17]. The imported data should correspond to the motion posture data of each joint point in the simulation process, combined with the normal range of human motion data. The movement posture of the human body can be evaluated, the movement posture of the human body can be simulated, and the movement posture model can be established.

3.4 Analysis of Experimental Results

From the analysis results, we find that the main parameters that affect the human body motion posture when the human body motion posture is studied include, mainly, the joints

Table 2 Material properties used in the finite element model.

Material	Young's modulus (E, MPa)	Poisson's ratio	Material	Young's modulus (E, MPa)	Poisson's ratio
Cortical bone	12000	0.3	Sacrum	5000	0.2
Cancellous bone	106	0.2	Nucleus pulposus	1	0.499
Rear structure	3101	0.25	Annulus	295	0.35
Rib cage	5000	0.1	Endplate	24	0.4
Costal cartilage	480	0.1	Ligament	-	Non-linear
Sternum	10000	0.2	Costo-transverse joint	480	0.1
Pelvis	5000	0.2	Sacral Exposure	5000	0.2

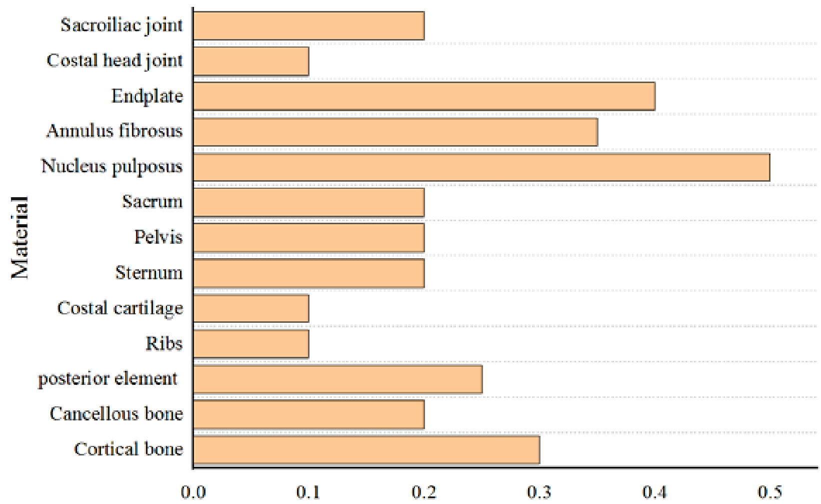

Figure 3 Material Poisson's ratio used in the finite element model.

Table 3 Normal range of motion of the human body.

Joint name	Normal range of joint motion/°		
	Left and right, lateral flexion	Forward flexion, extension	Internal rotation, external rotation
Skeletal joint	50, −50	145, −40	45, −30
Knee joint	0,0	10, −145	10, −20
Step on the joint	30, −35	30, −50	0,0
Shoulder joint	90, −90	180, −45	80, −30
Elbow joint	0,0	140, −10	90, −90

Table 4 Elbow joint human body motion posture coefficient table.

	10–5	4	3	2	1	0
xp	0.0000	0.0000	−0.0002	−0.0012	0.1104	−17.7243
yp	0.0000	−0.0000	0.0008	−0.0229	0.2789	91.2824
zp	0.0000	0.000	−0.0033	0.0883	−0.9649	0.0216
zr	0.0000	−0.0000	0.000h	−0.0099	0.062	−113.1970
xr	0.0000	−0.0002	0.0120	−0.3548	4.2922	−47.4114
yr	0.0000	0.0003	−0.0143	0.4738	−7.6024	−147.9464

during motion, displacement and acceleration, joint angles, etc. Table 4 lists the change parameters of the human body motion posture. These parameters can be further calculated, and the results can be analyzed to obtain the change in joint trajectory during human motion [18]. The equation is

$$f(x) = a_1 x + a_2 x^2 + .. + a_n x^n + b \quad (7)$$

4. CONCLUSION

Motion capture technology has a wide range of applications. Human body motion posture capture is now a most important research field, given its potentially wide range of applications and the many avenues open for further development. It can be fully integrated with sports, medicine, virtual reality, etc. In sports, the human body movement posture can be

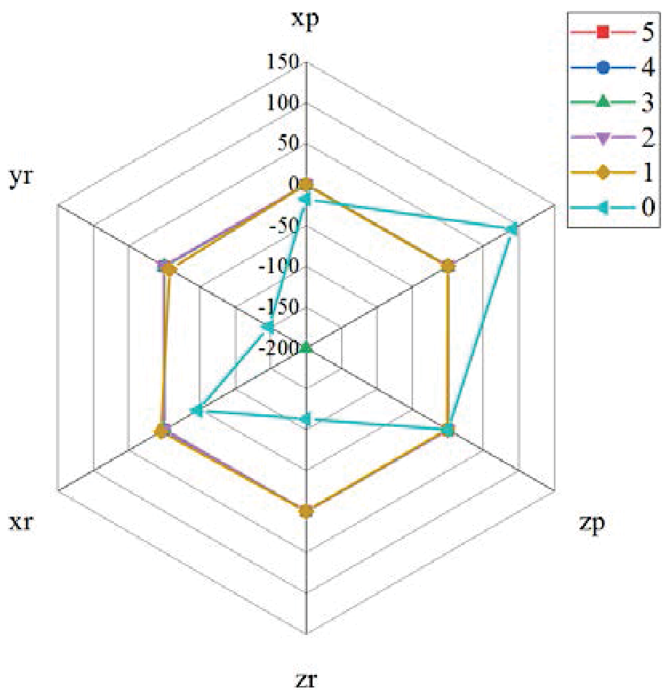

Figure 4 Elbow joint human body motion posture coefficient.

obtained through motion capture, and the athletes' posture and the strength of each joint and muscle during exercise can be further analyzed to help athletes have a better understanding of their own physical condition. Athletes and coaches can use the movement posture data obtained by motion capture to understand the incorrect force application method and movement posture in time, which will help the athletes to further improve their sports level. In medical research, doctors can use motion capture to obtain the patient's motion posture, analyze the patient's condition and degree of recovery, and help doctors make a more accurate diagnosis and give appropriate treatment. In terms of virtual reality, motion capture technology can be combined to obtain a large amount of data about human motion posture, and build models to simulate the motion postures of people in virtual reality situations. Models can be built in advance, which can improve the experience. The sense of immediacy can enhance the overall experience of the user. Another important research field is motion capture technology based on inertia. When studying motion capture technology, inertia can be combined with the discussion of human motion posture. The research results have the potential to change people's lives and to make tasks more convenient and easier to accomplish.

REFERENCES

1. M.A. Takalkar, H. Zhang, M. Xu. Improving micro-expression recognition accuracy using twofold feature extraction. In: International Conference on Multimedia Modeling (2019), 652–664.
2. S.J. Wang, W.J. Yan, X. Li, et al. Micro-expression recognition using dynamic textures on tensor independent color space. In: 2014 22nd International Conference on Pattern Recognition (2014), 4678–4683.
3. S.J. Wang, W.J. Yan, X. Li, et al. Micro-expression recognition using color spaces. IEEE Trans. Image Process. 24(12) (2015), 6034–6047.
4. Y. Wang, J. See, Y.H. Oh, et al. Effective recognition of facial micro-expressions with video motion magnification. Multimed. Tools Appl. 76(20) (2017), 21665–21690.
5. Y. Wang, J. See, R.C.W. Phan, Y.H. Oh Lbp with six intersection points: Reducing redundant information in lbp-top for micro-expression recognition. In: Asian Conference on Computer Vision (2014), 525–537.
6. G. Warren, E. Schertler, P. Bull Detecting deception from emotional and unemotional cues. J. Nonverbal Behav. 33(1) (2009), 59–69.
7. S. Weinberger, Airport security: intent to deceive? Nat. News 465(7297) (2010), 412–415.
8. S.C. Widen, J.A. Russell, A. Brooks. Anger and disgust: discrete or overlapping categories. In: 2004 APS Annual Convention, Boston College, Chicago, IL (2004), 529–534.
9. L. Wolf, T. Hassner, I. Maoz, Face recognition in unconstrained videos with matched background similarity. In: IEEE (2011), 734–751.
10. Q. Wu, X. Shen, X. Fu. The machine knows what you are hiding: an automatic micro-expression recognition system. In: International Conference on Affective Computing and Intelligent Interaction (2011), 152–162.
11. W.J. Yan, X. Li, S.J. Wang, et al. Casme ii: an improved spontaneous micro-expression database and the baseline evaluation. PLoS One 9(1) (2014), 860–881.
12. W.J. Yan, Q. Wu, J. Liang, et al. How fast are the leaked facial expressions: the duration of micro-expressions. J. Nonverbal Behav. 37(4) (2013), 217–230.
13. Y. Cai, M. Landis, D.T. Laidley, et al. Multi-modal vertebrae recognition using transformed deep convolution network. Comput. Med. Imaging Graph. 51 (2016), 11–19.
14. P. De Chazal, J. Tapson A. van Schaik. A comparison of extreme learning machines and back-propagation trained feed-forward networks processing the MINST database. In: IEEE conference

on (ICASSP) (2015), 2165–2168.
15. Y.L. Cun, B. Boser, J.S. Denker, et al. Handwritten digit recognition with a back-propagation network. In: Advances in Neural Information Processing Systems (1990), 396–404.
16. L. Deng. The MNIST database of handwritten digit images for machine learning research. IEEE Signal Process. Mag. 29(6) (2012), 141–142.
17. G. Ferroni, R. Bonfigli, E. Principi, et al. A deep neural network approach for voice activity detection in multi-room domestic scenarios. In: Proceedings of the International Joint Conference on Neural networks (2015), 1–8.
18. A. Fischer, C. Igel. An introduction to restricted Boltzmann machines. In: Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications (2012), 14–36.