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Research on Running of Virtual Human Based on CCD Algorithm

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Abstract

With the development of virtual reality technology, virtual human technology gradually highlights the significance, and gradually become an important branch of virtual reality technology and research hotspots. The motion generation and control of virtual human is an important aspect of virtual human technology research. With the development of computer graphics, virtual reality, distributed computing, distributed simulation and grid 3D games, the modeling method has been put forward higher requirements. The model not only requires the model to be highly realistic and real-time response on the graph, but also requires the model to have physical attributes and behavioral capabilities. The virtual human has the ability of autonomous behavior, that is, the virtual human action is generated automatically by the computer according to the laws of human anatomy, kinematics and biomechanics. This paper studies the running of virtual human based on CCD algorithm. This paper mainly introduces the modeling method of virtual human, analyzes the running movement, and runs the kinematics solution based on the CCD algorithm.

Keywords: CCD algorithm, Virtual human, Running movement, Model building.

1. INTRODUCTION

The representation of geometric characteristics and behavior characteristics of virtual human or human in the computer generated space virtual environment is the research content of multifunctional perception and affective computing. It can be widely used in human-computer interaction, motion representation, man-machine function, video compression, game entertainment, military training, digital library and other fields. Therefore, the study of virtual human beings is of great significance (Zhang and Chen, 2017).

Virtual human as the main body of virtual environment, its verisimilitude directly determines the user's immersion in the virtual world (Behrad and Roodsarabi, 2012). From the concept of virtual human, we can see that virtual human not only has geometric characteristics, but also has behavioral characteristics. To establish the model of virtual people, not only to establish the geometric model, but also to establish the movement model (Bouziane et al., 2012).

The establishment of motion model is the research content of virtual human motion control technology, and it is also an extremely important field of virtual human research (Yanget al., 2015). Running is one of the basic behavioral characteristics that virtual human beings should possess. In this paper, the application of computer graphics, virtual reality, kinematics and sports biomechanics and other related disciplines, virtual human running movement technology research.

2. RESEARCH ON MODELING OF VIRTUAL HUMAN

2.1 Modeling and rendering based on image

The use of photos / images in graphics has long been a typical example of texture mapping techniques. In order to obtain realistic and detail levels that are hard to achieve in traditional rendering techniques, real photos are used as templates to map to models and structures created by geometric modeling techniques (Doebele et al., 2012). Another widely used technique is the environmental mapping, which refers to the process of mapping the surrounding environment to a shiny object (Yuet al., 2015).

The original use of environmental mapping is a cheap alternative to ray tracing. The idea is that the surface of a shiny object maps the environment around it, so it can be pre calculated and stored. When rendering the object, the texture mapping method is used to produce the mapping effect of the environment, thus avoiding the complex process of ray tracing. The typical environment shapes used in environmental mapping include planes, cubes and spheres. Environment mapping technology will also play an important role in image based rendering (Jianget al., 2015).

IBMR - image based modeling and rendering, as the name suggests, refers to the shape and appearance of a scene in a predetermined set of images (synthetic or real). The synthesis of new images is achieved by properly combining the original images. Compared with geometry based modeling and rendering, IBMR has the following outstanding advantages:

(1)Modeling is easy: it doesn't require a lot of energy and skill, because it's easier to take pictures. In addition, this kind of light camera capture device not only can directly reflect the real scene and the appearance of the details, but from the photo also can extract motion features and geometric features of objects, scenes of the object's reflection characteristics. The data of photographs taken from different lines of sight and positions are organized in some form to represent scenes, such as panoramic images and light fields, which is the so-called modeling in the sense of IBMR.

(2)Fast rendering: without complex computation, a new view is directly synthesized from the existing view, for example, the corresponding parts of the panoramic image can be mapped according to the different line of sight direction. The whole drawing process is carried out in two-dimensional space (Liand Li, 2010). The rendering time does not depend on the complexity of the scene, but only with the resolution of the display.

(3)Strong sense of reality: image based method can truly reflect the shape of the scene and the rich light and shade, material and texture details, without additional lighting simulation.

(4)Interactive good: because of the speed and realism of the guarantee, coupled with advanced interactive devices and feedback technology, image based VR has better interactivity.

In addition, most of the geometric based rendering methods need to establish a complete and accurate expression of the scene, and the whole scene should be calculated and stored during rendering. On the contrary, the IBMR method only needs discrete photo sampling, and only the image adjacent to the current view is processed when rendering. Therefore, the latter only has a small computational overhead.

2.2 Geometric modeling

In order to establish a virtual human with physiological characteristics, it must be modeled according to the skeleton structure of the real human body, but it does not need to copy the real human body completely. However, the specific values of the shape information, joint type and joint limit must be set according to the actual physiological data (Ma et al., 2012).

In this paper, we simplify the body structure of a virtual human into 52 bones, as shown in figure 1. The 52 bones are divided into 4 parts: the first part is the head (skull and neck, 2); the second part is the upper part of the body (spine, 3); the third part is the hand (including the left scapula and the left hand arm, small arm, hand and fingers, 38); the fourth part is the body (including hip, left and right leg thigh, calf and foot and toes, a total of 9 pieces). Here, when modeling, wear shoes for the virtual person, so the front foot part only creates one toe for each foot. In order to establish a more realistic motion model, the hand will build a complete hand skeleton.

In this paper, we set up a virtual male, whose height is set to 1.78m, and the proportion of each part of the body length is measured according to Grosso and other physical characteristics of the human body. The total length of the thigh is 0.211, so the length is 38cm; the proportion of shank to human body length is 0.237, so the length is 42cm, and the rest of the length is slightly.

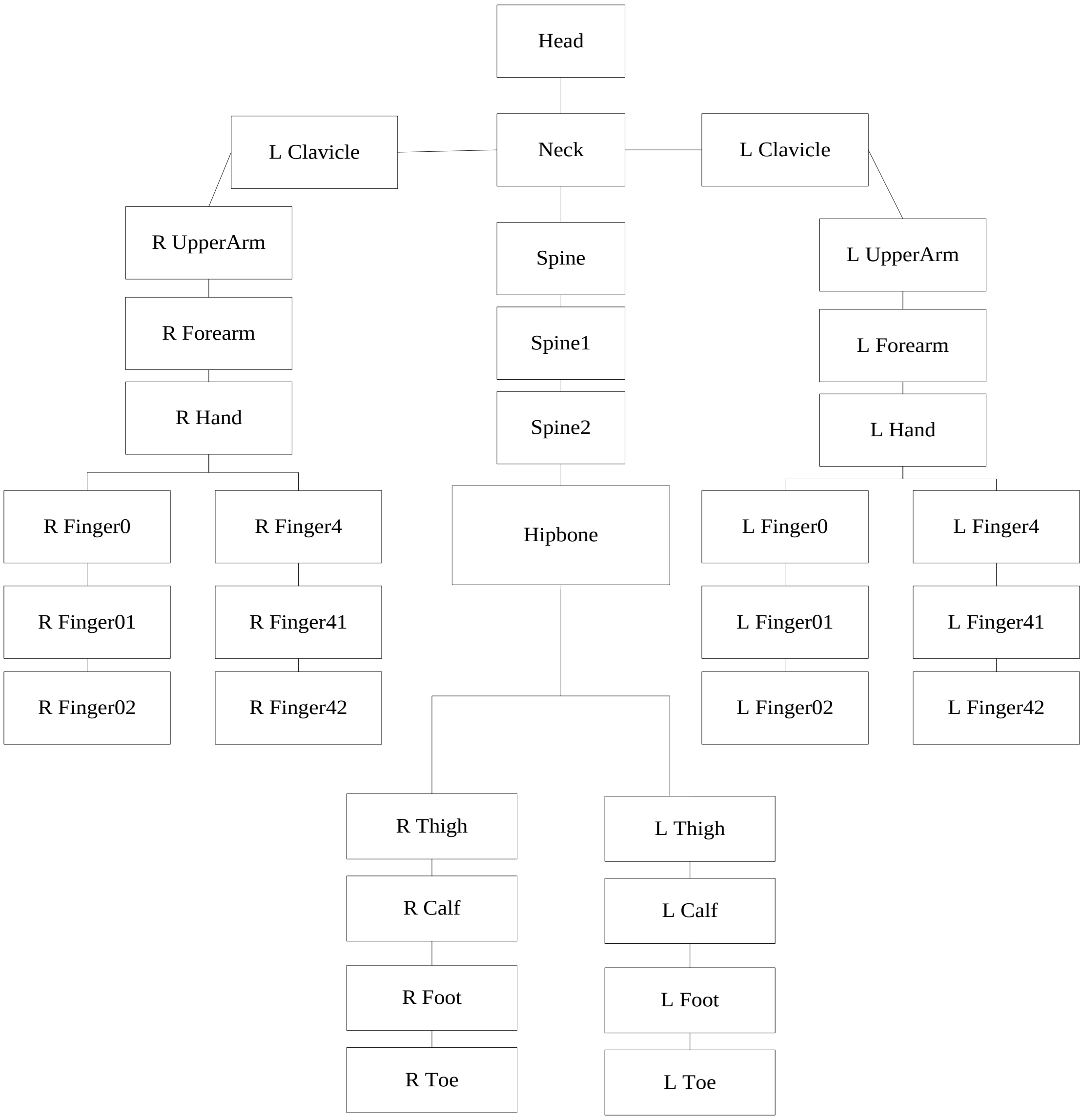

Figure 1. Skeleton structure

3. ANALYSIS OF RUNNING

Running is one of the most basic exercises of the human body. Next, refer to the research results of kinematics, sports mechanics, sports biomechanics, anatomy and other disciplines, do a simple analysis of the running process. The full cycle of the run (see figure 2) is a complex step, which consists of two single steps, alternately supporting and swinging the legs. A single step consists of two stages of support and flight. In the supporting stage, the body rotates with the support of the foot as the fulcrum, and it can be divided into two stages: buffering and pedaling. The buffer begins from the foot of the supporting leg to the maximum bending of the knee joint. The kick starts from the movement of the knee joint until it is pushed off the ground (Traumet al., 2015). From the angle of one leg, the leg is in the state of support and swing in a running cycle.

(1) Support stage

In the supporting stage, the interaction between the lower limb and the ground enables the human body to obtain the displacement force, thus the human body produces the fast displacement. The analysis of the three-dimensional space of the running shows that the action line of the force does not pass through the center of gravity of the human body. This is due to the structural characteristics of the human body, in the support process of the total body center of gravity and the relative position of the fulcrum changes. In the support process, the movement of the human body is essentially caused by the rotation of the fulcrum.

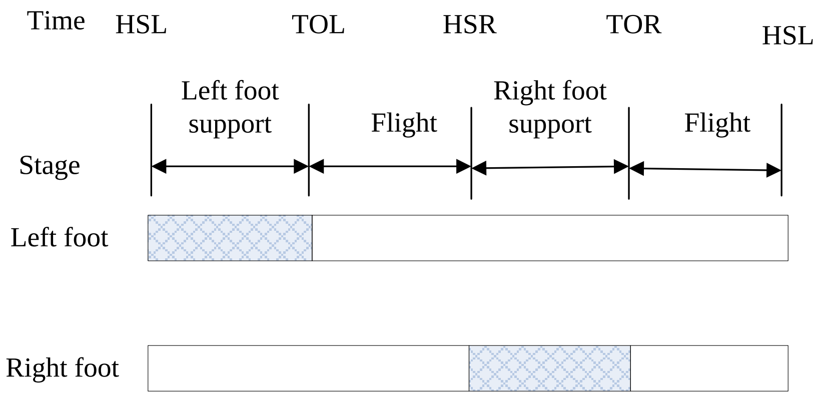

Figure 2. Running cycle sequence diagram

In the sagittal plane, the human body is subjected to three forces, the horizontal component force and the vertical component force, which are supported by gravity and support reaction force. In the forward pedaling stage, the projection point of the human body's center of gravity is behind the fulcrum, and the horizontal component is the resistance to advance. The vertical component resists the downward movement of the body and keeps the body at a certain height. At the same time, the horizontal component brings about the moment of rotation of the total gravity center of the body. The moment of backward turning of the vertical is component to the total gravity center of the human body (Kevinet al., 2015). The transition of the human body from the forward supporting stage to the backward pedal stage is actually the rotation of the human body around the fulcrum. The mechanical condition of the forward overturning is provided by the moment of the horizontal component force. Therefore, in this stage, the moment of forward overturning is greater than the moment of backward overturning, so that the body can keep dynamic balance and move forward quickly.

In the backward pedaling stage, the projection point of the total gravity center of the human body is in front of the fulcrum. At this time, the horizontal component is the driving force of the movement, which makes the total gravity center of the body produce horizontal acceleration motion. At the same time, in this condition, the horizontal component causes the human body to produce the backward overturning moment, and the vertical component produces the torque that causes the body to turn forward. That is to say, the horizontal component, in addition to the power before it, maintains the balance force of the forward position of the body when it is backward, because it can overcome the force of forward turnover.

(2) Flight phase

During the flight phase, the legs relative to the hip opposite movement, human based inertial forward movement. Gravity makes the human body produce vertical and downward acceleration motion, so the gravity orbit of the human body in the flight phase is parabolic. At the beginning of the flight speed and flight angle determines the size and shape of parabola, as shown in figure 3.

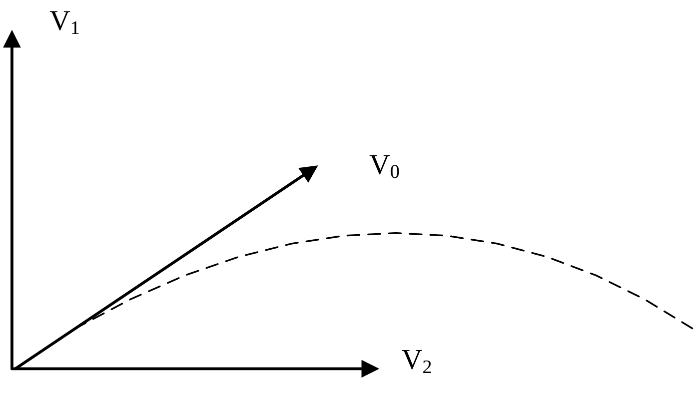

Figure 3. The initial velocity and flight phase center trajectory

The horizontal component V2 of the initial velocity V0 and the flight time determine the displacement of the total gravity center of the body during the flight phase, and its vertical component V1 determines the height of the flight. Therefore, the horizontal component of the initial velocity is the key factor to determine the running speed, and the vertical component of the initial velocity plays a role in providing the appropriate flight time.

4. KINEMATICS SOLVING OF RUNNING BASED ON CCD ALGORITHM

4.1 CCD algorithm

CCD algorithm was first proposed by Li-Chun Tommy Wang and Chin Cheng, which was introduced into the computer animation field by Chris Welman. CCD algorithm is a heuristic iterative search algorithm, and it reduces the position error by changing the parameters of one joint at one time. Each iteration is from the end of the kinematic chain to the fixed end of the traversal. By minimizing the objective function, each rotatable joint q_i can be changed. For each joint, the minimization problem is fairly simple. Therefore, you can complete an iteration very quickly.

The position and orientation of the terminal effector are updated in time to respond to changes in the joint. In the current iteration, the farther away from the fixed end, the greater the change in the joint. The Jacobi matrix method changes all the joints in each iteration.

Let's say the current end effector position is as follows:

$$P_e = \left(x_e, y_e, z_e\right) \quad (1)$$

And the current end effector is oriented to the rotation matrix O_e, which is composed of three orthogonal vectors

$$O_e = \left(u_{1e}, u_{2e}, u_{3e}\right)^T \quad (2)$$

By finding a joint vector q, the terminal effector is as close as possible to the target position Pd and toward the Od.

$$E(q) = E_p(q) + E_o(q) \quad (3)$$

Among them, the position error is:

$$E_p(q) = \left\|(P_d - P_e)\right\|^2 \quad (4)$$

Towards misunderstanding is:

$$E_o(q) = \sum_{j=1}^{3} ((u_{jd} \cdot u_{je}) - 1)^2 \quad (5)$$

This method takes only one joint at a time from the end to the fixed end. Before changing the next joint qi of the joint qi-1, modify the qi to minimize the equation. At each joint, the minimization equation becomes a simple one dimensional optimization problem. When the joint qi changes, the other joints are fixed. Since the joints can be rotated or translational, these two types of joints should be considered.

4.2 Exercise in the upper body

In running, the movement of the upper limb is very important. Swinging arms can keep your body balanced. For example, the right arm is placed along with the left leg, while the shoulder and foot belt also turns left, accompanied by the torsion of the spine. Thus, the imbalance between the front swing of the left leg and the pelvis torsion is overcome, which is the opposite movement of the upper and lower limbs with the longitudinal axis and the rotation axis of the spine. At the same time, with the acceleration of the swing of both arms, it can drive the leg swing, so as to make up for the lack of movement frequency of legs.

The movement of the upper limb and the leg is simultaneous, and the angle of the front and back of the shoulder joint is:

$$\phi = k\alpha + \theta \tag{6}$$

In the formula, ϕ is the front and back swing angle of the shoulder joint; k is the scale factor; α is the back and forth swing angle of the body reverse leg femoral joint; θ is the offset.

In addition, in the process of running, the body is slightly tilted forward to maintain the balance of body.

4.3 Comparison of two algorithms

The Jacobi matrix transpose method, like the CCD algorithm, belongs to the iterative method, which is used to solve the inverse kinematics problem of interactive operations. They all try to minimize the cost of each iteration. The numerical stability can be guaranteed when the kinematic singularity is approached.

The square in figure 4 represents the Jacobi matrix transpose method, and the circle represents the CCD algorithm. From the graph, we can see that the CCD algorithm is more efficient when the precision is the same. When the precision requirement is very high, the speed of the two methods approach the target is not fast, and the performance of the two algorithms will decline, but the speed of the Jacobi matrix is decreased faster.

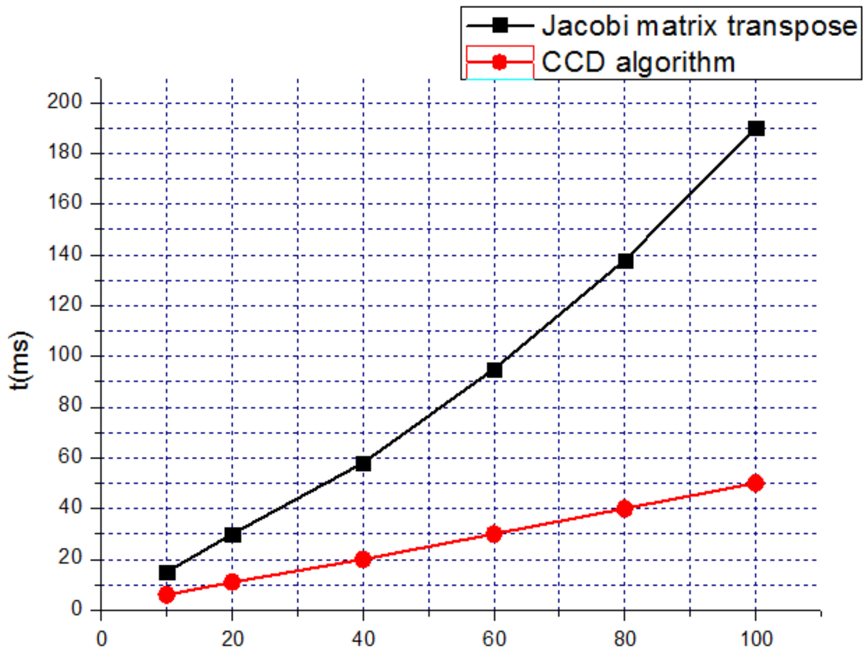

Figure 4. Comparison of convergence of Jacobi matrix transpose method and CCD algorithm

The Jacobi matrix method is like an elastic stick, and the CCD algorithm is like a loose chain. When the singular point problem occurs, the efficiency of the CCD algorithm close to the target is higher than that of the Jacobi matrix. Especially when the accuracy requirements become high, the advantage is more obvious. Because the idea of Jacobi matrix algorithm is that the joint does not affect the other joints when it moves in one direction, especially when approaching the target, it is more affected by this idea. Therefore, the CCD algorithm should be used when the specified location is accurate and close to the singular point.

5. CONCLUSIONS

Virtual human as a new discipline, involves computer animation, computer graphics, physiology, psychology, biomechanics, mechanics, robotics and artificial intelligence and other research areas. The research of virtual human is a basic subject with theoretical significance and practical value. Virtual human in the virtual environment reflects not only enhances the natural interaction between human and virtual environment, but also improve the fidelity of the virtual environment and immersion, lays a solid theoretical foundation for the creation of virtual space person. The virtual human running motion control technology first simplifies the running movement into the periodic repetitive movement, and then divides the movement in a cycle into a key movement by using the idea of Fractional Motion superposition. In the study of the running of the virtual human, the parameters are used to make the running posture personalized, and the algorithm is simplified to solve the inverse kinematics problem in running.

REFERENCES

BehradA., Roodsarabi, N. (2012). 3d human motion tracking and reconstruction using dct matrix descriptor. Isrn Machine Vision, 2012(7),1-12.

Bouziane A., Chahir Y., MolinaM.,JouenF. (2012). Unified framework for human behaviour recognition: an approach using 3d zernike moments. Neurocomputing, 100(2), 107-116.

DoebeleS., SiebenlistS., VesterH., WolfP., HagnU., SchreiberU.(2012). New method for detection of complex 3d fracture motion - verification of an optical motion analysis system for biomechanical studies. Bmc Musculoskeletal Disorders, 13(1), 33.

Jiang H.K., Tian X.L., Xu A.A. (2015). A new segmentation algorithm for lunar surface terrain based on CCD images, Research in Astronomy and Astrophysics, 15(9), 1604-1612.

Kevin M.N., Richard C., Alex H., George, L. (2015). Reprint of PopGen: A virtual human population generator, Toxicology, 332(1), 77-93.

Li L., Li D.Y. (2010). Research on Genetic Algorithm and Ant Colony Optimization Algorithm and Its Application on Multi-CCD Sensor Planing, Second Wri Global Congress on Intelligent Systems, IEEE Computer Society, 47-50.

Ma C., Zhang W., Meng F. (2012) Application of data fusion algorithm at CCD colorimetric temperature measurement, IEEE Fifth International Conference on Advanced Computational Intelligence, 284-286.

Traum D., Roque A., Leuski A., Georgiou P., Gerten J., Vaswani A. (2015). Hassan: A virtual human for tactical questioning, Proceedings of Sigdial Workshop on Discourse & Dialogue, 32, 71-74.

Yang R., Li D., Hu Y., Liu J., Hu D. (2015). Rapid Skin Deformation Algorithm of the Three-Dimensional Human Body, International Conference on Intelligent Human-Machine Systems and Cybernetics, 16(9), 244-247.

Yu B., Yan Z.H., Wang L.T., Li X.D., Wang D.Y. (2017). The application research on improvement of genetic algorithm in linear CCD detection, 12, 191-195.

Zhang Y., Chen T. (2017). A Q-leaming algorithm applied to the behavioural decision-making of affective virtual human, International Conference on Advanced Communication Technology, 12(4), 403-407.