Experimental Research on Human Body Motion Simulation Based on the Motion Capture Technology

Dayong Dong, Lijing Wang, and Xiugan Yuan

School of Aeronautic Science and Technique,
Beijing University of Aeronautics and Astronautics, Beijing 100083, China
{Dayong Dong}dy_dong@163.com

Abstract. Moveable human body model can be built based on human motion data, which is recorded by the VICON optical motion capture system and imported to the MOTION BUILDER software. In this experiment, two simulation projects were designed successfully, and satisfying results were obtained. The first test was an arm swinging test which simulates the pilot's action of manipulating dashboard. The other test involved arm swinging, walking and turning in standing mode, focused on testing the stability of the system in multi-degree-of-freedom complex motion situation

Keywords: motion capture, VICON, motion simulation, human body model, human factors.

1 Introduction

Human body motion simulation, which has been developed since the end of the 20th century, is a practical new & high technology integrating sensor, simulation, HMI and high parallel real-time calculate. In recent years, the combination of human body motion tracing and motion simulation technology has become a very promising field of research with its great potential development and pragmatic application

Since the 1970s, computer human simulation has been used in collision simulation. It was mainly used for simulating the motion of the human body and the degree of his injury, when the vehicle is being collided, and then the safety could be enhanced through the improvement of protecting equipments. In the field of man-machine engineering, motion simulation can be used to evaluate man's maneuverability and efficiency when he is in a limited space. In virtual designing, it can be used to investigate the feasibility of design in its early stage in order to enhance the design. In robot controlling, it can be used in designing controllers in simulating human balancing such as humanoid robot's the ability of homeostasis. Human body motion simulation can also be employed to analyze the speed, acceleration, force and torque of different parts of body when athletes, disabled people, and actors are moving. Interestingly, it can also be applied in computer animation. Computer animation has vast space of development and application in the fields of motion description, movie production, and games. In recent years, the concept of animated virtual human has been raised based motion control algorithm. Nowadays, the research on virtual human is in the ascendant, and virtual actor and

V.G. Duffy (Ed.): Digital Human Modeling, HCII 2007, LNCS 4561, pp. 42–47, 2007.

digital agent have entered the stage of practicability research. With the introduction of artificial intelligence and multi-agent theory, virtual human is extending towards intellectualization and multitudinal.

2 Human Motion Tracing

There are many approaches on investigating human motion, and they can be summarized into two methods: the mathematics method and the experimental method. Both of these two methods aim to build modeling human body. The mathematical method is to establish mathematical models using the algorithm of Inverse Kinematics to drive different sections of the human body model to conduct simulation movements. The experimental method is to record the actual data of human body motion through employing human body motion tracing technology, then use these data to drive the human body model to conduct motion simulation. Comparing these two methods, the mathematical method is easier for mathematical models are easier to establish. But the human body motion is controlled totally by mathematical models which are different from natural human body movement; therefore, it can only be called "*animation simulation*". The experimental method can accurately simulate the actual movements of human body because it drives the human body model with real human motion data. But it requires a large quantity of experimental data, thus the job of data processing is fairly complicated. So we can choose a more suitable one from these two methods according to our needs. And this paper is mainly on the experimental method.

2.1 VICON Motion Capturing System

Vicon optical motion capturing system is developed by an English company, Vicon Motion Systems (VMS). It is used in human body motion capturing. The motion capturing system is composed of the following parts:

Sensor. It is the tracing equipment attached to certain positions of the moving object. It provides the Motion Capture system with information about the position of the moving object. In most cases, the number of sensors depends on the required particularity and the capturing equipment.

Signal Capturing Equipment. This kind of equipments varies according the types of Motion Capturing system. Their function is to capture signals of positions. In machinery system, it is a circuit board for capturing electronic signals; in optical system, it is a high-resolution IR camera.

Data Transfer Equipments. Motion Capture system, especially those that provide real-time data, need to transfer large quantities of data from signal capturing equipment to computer system accurately and rapidly. Data transfer system is designed to carry out this task.

Data Processing Equipment. Data captured by Motion Capture system need to be amended, processed and integrated into 3D model to fulfill the job of producing computer animation. This requires the use of data processing software or hardware.

The VICON system used in this test consists of 6 high-speed IR sensitive cameras. In the process of data collection, certain joints of the human body are attached with IR reflective markers. The high-speed IR sensitive cameras capture the motion trace of each marker, hence they can accurately capture the motion data of the joints. (See Fig. 1.)

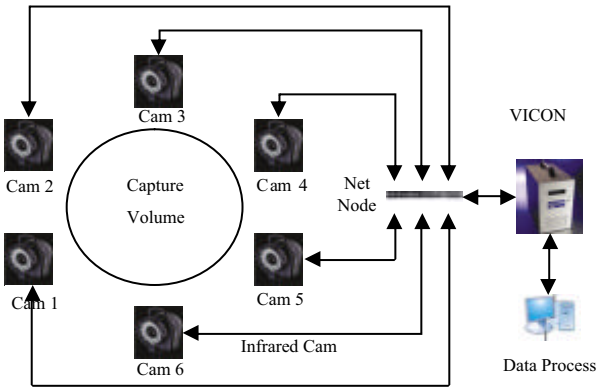

Fig. 1. The configuration of VICON motion tracing system

The tests firstly calibrate the system in static and dynamic mode to establish the 3D coordinate system. After that, test subject wearing markers enters the capture volume to conduct motion capturing.

2.2 Diagnosing and Mending the 3D Data

We can record human body motion through the system described above with sampling rate of 120Hz, and artificially validate the original data of the Marker points. Then we can conduct 3D reconstruction after finishing revision in VICON Workstation, and convert the captured motion trace in into 3D coordination data.

In the process of capturing, some useful data are missing or error data are recorded occasionally, because motions are sheltered or Marker points are lapped over. Accordingly, data amendment is to amend the mistakes in it, and to use some methods to revise the lost information in the process of data collecting.

When the data amendment has reached the anticipated value, we can use VICON Workstation system to export files in the following formats: *.eni, *.enf, *.tvd, *.mp, *sp, *.car, *.c3d. We can intercept the portion of frames exported to facilitate the following steps of the test. Then we choose several groups of well-recorded data from the data collected from the test and import them into Motion Builder to produce animation and save in *.c3d format.

3 Human Body Motion Simulation

We design two movements in this test. The first one is the motion of arm swinging in sitting posture to simulate the pilots' operating instruments. The second one is the motion of arm swinging in standing mode, of walking and of turning to test the

performance and stability of the system in multi-dimensional complicated movements. To satisfy the need of capturing these two movements, we distribute the markers on the human body as shown in Fig. 2.

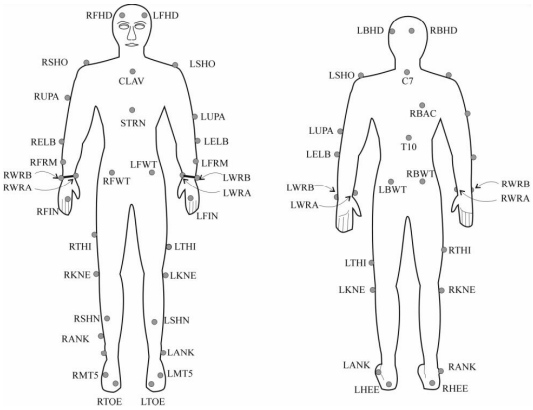

Fig. 2. Distribution of markers on human body

3.1 Motion Builder Platform

Motion Builder (MB for short), a product of Alias Company, is a human motion simulation software, which is widely used in field such as movie, animation and virtual compere. It is real-time and flexible to operate. What's more, MB provides a variety of data interfaces including *.c3d, which can seamlessly connect with the data obtained in motion capturing. In this test, we choose this software as our human body motion simulation platform.

3.2 Human Motion Simulation

We choose *c3d* files produced from VICON Workstation system, and import them into MB.A special attention should be paid to adjusting parameter, or disturbing markers will appear and severely affect the animation simulation. Before selecting "*import*", we shouldn't tick the "*Create Optical Segments*" option, or numerous unidentified disturbing makers will be caused. As soon as we import the data, the 3D data captured by motion tracing system are in the system immediately.

Create Actor. Actor is part of the human body model, and we select Actor from the asset browser and import it to the scene.

Bind 3D Data with Corresponding Section of the Actor. By doing this, the Actor can then move according to the captured 3D data, and be driven by the 3D data. (See Fig. 3.)

Amendments to Motion Simulation. After the binding, the human model can move according to the captured data, but there still exist some singularity points or crossover points, which will cause disorder in the motion. For this reason, it is required to examine the motion data frame by frame in MB to ensure the smoothly of the motion.

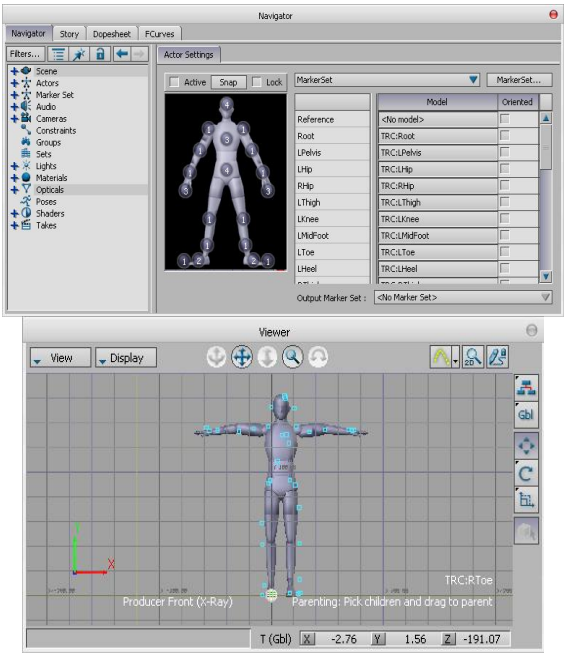

Fig. 3. Binding Actor and the 3D data

Fig. 4. Models of arm swinging movement

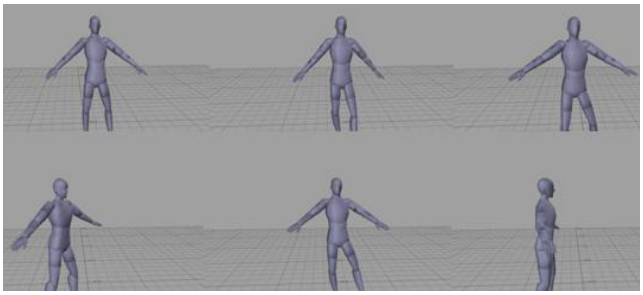

Fig. 5. Models in walking and turning status

Export to Video File. After the process of data binding and combination, we can then verify the human body motion in real-time. (See Fig. 4. and Fig.5.) The system can also export video files, and cooperate with other rendering software including MAYA, 3DS MAX or Lightwave etc. to produce videos of reality.

4 Conclusion

In this test, MB is chosen as the software platform for human body motion simulation. Through using this software, the author of this thesis find that the software itself can implement kinematics simulation fairly well, but it lacks support for kinetics. It will be insufficient as for more complicated tasks on ergonomics analysis. The whole simulation environment will more practical if we develop our own human body motion simulation platform in our future research, and add a variety of ergonomics evaluation tools about force, torque and operation gesture etc.

This investigation has actualized the technique of human motion capturing and motion simulation, which can be fairly useful in many fields such as ergonomics, human-machine engineering, sim-training, and biodynamics etc.

References

1. Wilhelms, J.: Using Dynamic Analysis for Animation of Articulated Bodies [J]. IEEE Computer Graphics & Applications 7(6), 12–27 (1987)
2. Ko, H., Badler, N.I.: Straight-line Walking Animation based on Kinematics Generalization that Preserves the Original Characteristics [A]. In: Proceedings of Graphics Interface'93 [C]. Los Angeles California, pp. 9–16 (1993)
3. Bingxiao, L., Heqin, Z., lei, W.: A Physical based human motion simulation combined with motion capture data (in Chinese). Computer Simulation 23(3), 187–189 (2006)
4. Rui, C., Guoyu, L., Guoying, Z., Hua, L.: 3D Human Motion Tracking Based on Sequential Monte Carlo Method [J]. Journal of computer-aided design & computer graphics 1, 85–92 (2005)
5. Yi, T., Yunjian, G., Jianju, J. et al.: Computer Simulation of Human Motion and Its Tendency [J]. Journal of System Simulation 16(5), 863–867 (2004)
6. Shanlin, S.: Research summarize on virtual human body model in ergonomics field [J] (in Chinese). Chinese Journal of Ergonomics 4(1), 52–57 (1998)
7. Changshui, Y., Zhaoji, W., wen, G., Yiqiang, C.: Skeleton Building of Individual Virtual Human Model [J] (in Chinese). Journal of computer-aided design & computer graphics 1, 67–72 (2004)
8. Software of Vicon Motion Systems. Vicon Motion Systems Ltd. United Kingdom (2002)