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Research Paper

Joint Controller Method: Application in 3D Humanoid Style Deformation

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Abstract

Realistic 3D humanoid style deformation is an attractive topic especially for the industries developing computer animations and games. Calculating the correct position style is a challenging task due to 3D humanoid complex dimensional data. Axis of interest and angle of rotation are two parameters measured in this real-time application. The main contribution of this article is through the development of joint controller method for controlling body position, orientation and joint rotation to produce style deformation. This method allows the deformation of new 3D humanoid styles by users using a simple interface control. This style joint controller method can help researchers to setup their motion editor and synthesis system.

Keywords: *3D Humanoid, Computer Animation and Games, Pose Deformation.*

1. Introduction

Nowadays, animation industry is rapidly growing due to the presence of animated companies that produce very realistic end-of-life animations primarily involving 3D humanoid movements. The realistic result of 3D humanoid movement is generated in the virtual environment using high quality motion capture technology[1]. However, this technology is very expensive[10-12] that not all parties can afford it. Therefore, researchers in the field of computer animation have to produce realistic and high quality output motion using motion editing and synthesis method through low cost motion capture technology.

3D Animation involves high costs and takes time to be developed. For example, Managing Director of Animonsta Studio Sdn Bhd stated that 100 minutes animation of BoBoiBoy The Movie had cost a total of RM5 million[2] and was made in two years' time. Furthermore, 50 workers[2] have been used to produce this movie. This is due to the many processes involved in producing animations such as creating scripts, drawing a storyboard, generating 3D models, animations, editing and special effects. Overall, there are three main phases in producing animation namely pre-production, production and post-production as shown in Figure 1. Realistic 3D humanoid movement is created in the production phase of animation process.

One of the main challenges in producing animation is in the editing 3D humanoid movement process. In this study, the main problems in this process are:

i. The increase in time when editing motion especially from motion capture data sources due to complex and unstructured data hierarchy.

ii. Challenge in producing a dynamic response and reusing normal motion approach to create new realistic motion.

iii. Edited motion is able to break physical plausibility and make the motion look unrealistic.

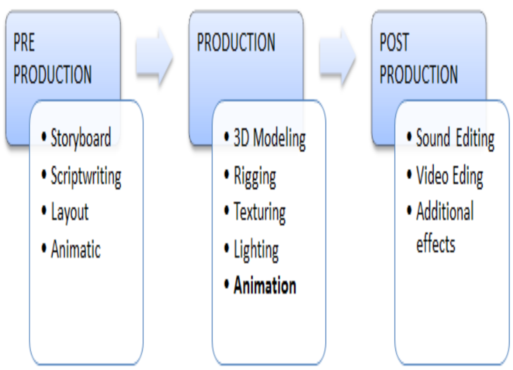

Fig. 1: 3 Dimensional animation development phase

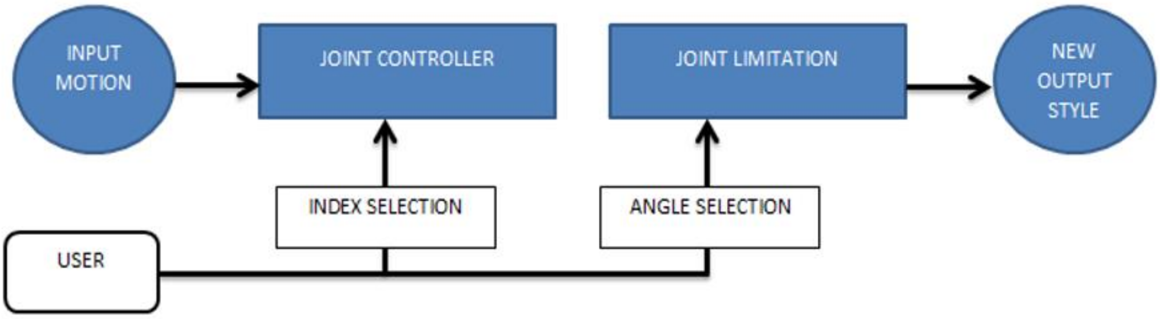

Fig. 2: Application overview

Many researchers are trying to find the best solution for generating realistic 3D humanoid motion in the virtual environment with various methods produced for motion editing and synthesis process[3, 8]. The proposed method in this study focused on the 3D humanoid joint to deform new styles of realistic motion by controlling body position, orientation and joint rotation. This method allows the users to create new 3D humanoid styles using a simple interface control.

2. Related research

Han Du et al. [4] have conducted a study on joint angle data representation for 3D humanoid motion editing in virtual environment. They used four phases of data reprocessing known as input frame sequence motion, keyframes of 3D humanoid motion, extraction process from each motion keyframes and motion decomposition process. Their experiment was set up by analysing the reconstruction error joint data representation in selected motion capture data such as walking, carrying, picking and placing. Finding from their study demonstrated that quaternion way is the best representation of joint angle data compared to exponential map and Euler representation method.

Byungkuk Choi[5] created SketchiMo by applying sketch-based approach to edit 3D character motion in computer animation. Two types of sketch target were extracted from 3D character motion namely body line in the skeleton structure and joint path. They tested their method with different 3D character joint and degree of freedoms. The selected actions in their experiment include martial arts, parkour, taekwondo, golf, dunk and ballet. They used high specification desktop computer including i7 3770 (3.4 GHz) processor and NVidida GT640 (8 GB RAM) graphic card. The experimental results showed that their prototype has succeeded in interactive motion editing[5] for 3D character.

Other studies in editing 3D humanoid motion data for computer animation are that carried out by Jehee Lee and Sung Yong Shi[6]. They proposed inverse kinematic approach to adapt in hierarchy curve fitting technique to optimise the orientation of degree of freedom from 3D humanoid joint. They tested several different movement conditions and selected motion transitions ranging from walking to sneaking and from sneaking motion to walking. Although smooth transition output result has been obtained, they faced problem in multiple frames constraint.

Ran Dong et al.[7] focused on blending and editing 3D humanoid dance motion capture data using Hilbert-Huang transform methods. The main objective of their study is to create new dance output motion by combining different dance motions[7]. Normally, dance motion capture data has a lot of noise that needs to be manually cleared by animator. Thus, they analysed the joint rotation and root position of 3D humanoid movement as well as introducing empirical mode decomposition algorithms[7] apart from using Euler angles to represent joint angle data. Three types of dance have been tracked and recorded namely perfume, waltzy and salsa[7] for experimental purpose. The drawback of this method is 3D humanoid motion has some foot slide effect, body penetration and collisions visible from user output observation.

From previous studies, a lot of hybrid methodologies have been proposed. Besides, different joint angle representations for 3D humanoid movement have been chosen. Euler angles and quaternion have been considered the standard setup for representing joint angle of control parameters in axis of interest and angle rotation.

3. Joint controller application

The proposed method of this study has two main phases. The first phase is joint controller and the second phase is joint limitation. An overview on the proposed application was shown in Figure 2.

An application was proposed for controlling the 3D humanoid joint using Euler angles representation. Using this method, users of joint controller can be updated in the selected position at each frame as shown below:

Joint Controller for x-axis rotation
JointRotation = Joints[Index].localEulerAngles
JointRotation.x = value

Joint Controller for y-axis rotation
JointRotation = Joints[Index].localEulerAngles
JointRotation.y = value

Joint Controller for z-axis rotation
JointRotation = Joints[Index].localEulerAngles
JointRotation.z = value

Using joint controller method, users are able to create a new different style by rotating 3D humanoid joint. There are 23 3D humanoid joints used in this approach as shown in Figure 3. A group of 3D humanoid joint can be controlled at the same time because of parenting concept. For example, 3D humanoid hand joint is child of elbow joint. If the elbow is moved, hand will automatically move. Users can choose any joint and axis of interest to be edited. According to Craig9, the basic calculation of 3D humanoid motion can be represented as follows:

$$\tau = M(\ddot{\Theta})\, \theta + C(\theta, \theta)\theta + G(\theta)+F(\theta) \quad (1)$$

Where;

T = joint torque
$M(\ddot{\theta})$ = n x n inertia matrix for weight
$C(\theta, \theta)$ = Centrifugal impression
$G(\theta)$ = Gravity power
$F(\theta)$ = External power

For joint limitation, angle selection can be selected using real human limitation angle of rotation. Meanwhile, input and constraint from motion capture data are calculated in joint limit processes such as reference joint angles constraint and body part constraints.

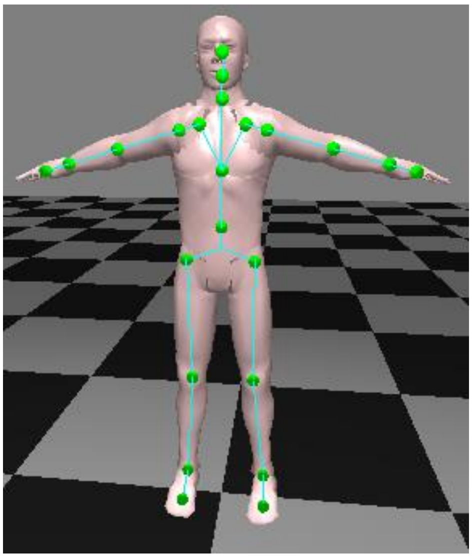

Fig. 3: 3 Dimensional humanoid joint

The proposed approach was tested using different angle controller and limitation as shown in Figure 4. Based on the result, the edited motion displayed different styles of motion. From the observation, the new styles of motion appeared more exaggerated than the original motion

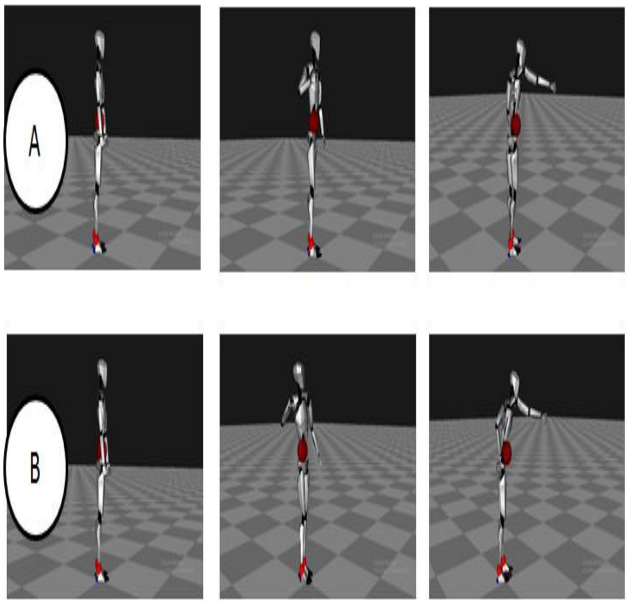

Fig. 4: Comparison between (A) Original motion and (B) Edit motion

4. Conclusion

Recently, most studies focused on controlling large data sets and motion capture data mapping. To maintain 3D humanoid realistic movement in virtual environment, different control method and motion synthesis approaches need to be explored. Therefore, the main challenge for developing realistic 3D humanoid realistic motion from motion capture data is in ensuring that the output movement result looks like real human movement.
This paper has presented the proposed method for motion editing process by controlling joint controller in 3D humanoid character. Motion editing application development is the combination of joint controller and joint limitation method. The benefits from the proposed control method are:

i. Users can choose which joint they want to manipulate.
ii. Users can select the axis of interest to create pose.

The proposed application had used Euler angle representation to control joint rotation in each character pose. The application created proved that it is possible to control 3D humanoid character movement style. To make the application more interactive, complex motion control needs to develop a controller for long sequence 3D humanoid motion style.

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