Multiple Joint Controller Method for Motion Style Deformation

Ismahafezi Ismail, Mohd Shahrizal Sunar, Syadiah Nor Wan Shamsuddin, Norkhairani Abdul Rawi and Mohd Kufaisal Mohd Sidik

Corresponding Author: Ismahafezi Ismail, Center of Learning for Multimedia, Faculty of Informatics and Computing, Universiti Sultan Zainal Abidin, Besut Campus, 22200, Terengganu, Malaysia.

Abstract: Realistic movements of 3-Dimension (3D) human character play a very important role in virtual environment. Nonetheless, the main challenge in this field is to deform a new style of motions from original motion capture data input. The deformation of 3D human character movements contains complex parameters such as joints position and angle rotation in the generated motions. In this study, motion style deformation was controlled using multiple joint controller method. By using this method, the movements of 3D human character can be manipulated in real-time. Based on the results obtained, this system produced balance movements in the short sequences of 3D human character. This study can contribute in aiding the motion editing process to identify new style deformations by altering multiple joints in the real-time. This method is capable of producing realistic 3D human movements with a simple user interface.

Keywords: 3D Human Character Movement - Real time Motion Editing

INTRODUCTION

Realistic 3D human character motions have been often used in virtual environment especially in computer games and animation. However, the motion style deformation is still a major problem in this field [1]. The main challenge lies in the difficulty of reusing and editing the movement data according to the user’s final requirement [2]. In addition, the human 3-Dimension character has complex data dimensions as a result of human rotation, position and orientation of the human 3-Dimensional character. It is very important for the 3D human character to have a similar style motion to the real human movement style.

Nowadays, there is a very high demand for the development of motion style deformation in the virtual environment. This is due to the complexity in producing realistic movements for the 3D human character [3]. The editing process consumes much time due to the complex data structure. The main challenge is to manipulate the motion capture data into a new style deformation motion. The editing process will change the 3D human character posture, making the movements to be unbalance.

Related Work: Motion capture technology has become very well-known for its process of obtaining real human movement data. This is because the movement data could be directly mapped to the 3D human character. There are much software frequently used for mapping the motion capture data such as Autodesk MotionBuilder, Newtek Lightwave and Autodesk Maya. However, this data need to be processed prior the realistic 3D human motion development. This problem can be solved using real time motion editing techniques. Nowadays, there are various techniques produced by researchers. However, the scope of motion style deformation is vast with some disadvantages in the real-time motion editing method that are yet to be explored by researchers.

Based on the previous study, various frameworks have been introduced to find the method to solve the problem of 3D human character motion style deformation.
The commonly used framework is the trajectory control on the movement of 3D human character directly as a movement interpolation method [4]. However, there are various weaknesses formed by direct trajectory controls that need to be corrected by researchers. This occurs due to the motion deformation process required in balancing physical parameters. If any of 3D human character motions has unbalanced action in the early stage of style deformation, the real-time editing results will become unrealistic.

According to Xiao [5], the human character frame is represented by two types of joint; fixed joints and ball joints including 6 Degree of freedoms (DOFs) representing rotation and translation. Figure 1 displays 3D human character frame with the respective joint. 3D human character body uses a hierarchical concept to connect each joint with others. For example, in the human hand connection, the shoulders are the parent from the top of the elbow. In real-time animation environment, each bone depends on the orientation together with its parent. Figure 2 clearly demonstrates the parent-child concept in the anatomy of 3D human character.

To control the postures of the character frame, kinematic concepts were applied. Inverse kinematic and kinematic function were used to calculate bone position including joint and angular position [6]. Normally, the forward kinematic is used for 3D human movements involving the lower limbs of the body that include the joints from the toes to the hips. This is very complex since body position will move below the surface or ground. This transaction makes the movements of the 3D human character to be very unconvincing.

The realistic motion capture data editing for new styles of motion deformation is still being discussed among current researchers [1, 2, 7]. Generally, the movements of 3D human character can be recorded using motion capture data technology. However, this technology still needs to be edited and cleaned for making realistic movements according to user requirements. Typically, the animator will manually process the data on movements to achieve user’s style deformation. Difficulty occurs in obtaining the actual deformation of movements at a particular time frame [8]. In addition, creating new style deformation takes time to be manually done.

In depth study needs to be done to obtain the suitable style motion deformation for 3D human movements in computer games and animation. This is to enable the style motion deformation of 3D human character to be more natural and convincing. In addition, the time for editing 3D human character can be increased [9]. With this, the editing process can maintain the balance of the 3D human character movements with improvements in posture and motion style deformation. Thus, a new method was proposed by this study using multiple joint controllers for the purpose of editing 3D human character motion. This controller has a limitation value in the joint rotation to deform new style of motion. Additionally, a simple user interface to edit 3D human character motion in real-time was provided in this study.
Multiple Joint Controllers: The main purpose of 3D human character motion editing system is to allow the animator to reuse and control the motion capture data in virtual environment. Realistic movements can be categorised as the movements of 3D human characters in computer animation that resemble real human movements. With the use of real human movement data, the analysis of human 3-Dimensional character movements in computer animation can be carried out. Meanwhile, to produce realistic movements, human movement data must be generated using motion capture tools in dynamic environments involving physical laws.

One of the parameters studied is the structure of human hierarchy and the average weight of human acting character. Among the methods used is optimisation of data by determining the weight distribution. The physical characteristics of human character were taken from motion capture users based on study conducted by [5]. This data is important to ensure the development of 3D human character movements according to appropriate physics laws. According to Craig [10], the basic calculation of movement system for human character is written as follows:

\[ \tau = M(\dot{\theta}) \dot{\theta} + C(\theta, \dot{\theta}) + G(\theta) + F(\theta) \]

where;
- \( \tau \) = joint torque
- \( M(\dot{\theta}) \) = n x n inertia matrix for weight
- \( C(\theta, \dot{\theta}) \) = Centrifugal impression
- \( G(\theta) \) = Gravity power
- \( F(\theta) \) = External power

To produce a new movement, the specific joints in 3D human character were controlled. A new angle of rotation was generated by changing the original value of the joint. The sequences of motion input were manipulated on each posture key to deform a new style of motions. To produce a posture, a special model was formed so that the movements produced by the 3D human character look realistic. The process of modifying input movements was performed on every major posture. Through the analysis performed, the specific model [11] for deformation in each of the main postures, Pe was defined as:

\[ Pe(t) = Po - Pi(t) \]
Pe: Modified posture
Po: Posture output
Pi: Posture Input Posture
T: Recent Frame Index

Therefore, output motion deformation result is the addition of input motion posture in the recent frame index depending on the time frame of motion capture data. Figure 3 shows the complete flowchart of how multiple joint controller works and the movement limitation of this system. The process starts by selecting the joints to be modified. The four main body joints were chosen to be controlled such as the right hand, left hand, right foot and left foot joints. The joint selection was detected and accessed through the function of multiple joints. Meanwhile, joint rotation was performed on the selected joints with the angle of rotation reduced to a certain value on the x, y and z axes. Actions against the effector occurred in the 3D human character motion through the inverse kinematics calculation. The algorithm of multiple joint derived from the local euler angle rotation:

Step 1: If, Joint rotation = Joint rotation in local Euler Angles
Step 2: Joint rotation in (xX, xY, xZ) = Rotation position in recent frame index

On top of that, the new generated motion using multiple joints controller was observed for jumping motion. Motion style deformation for 3D human jumping motion was produced in four different postures from normal jumping to high jumping. After that, the results between original input motion, ground truth data and multiple joint controller output motion were compared as shown in Figure 4. From the observation, a realistic style motion deformation has been successfully generated in the real-time.
CONCLUSION

Multiple joint controller technique has been developed. This technique is very important for the motion deformation process of 3D human character. It was derived from observation and analysis of real human posture position and angle rotation limit. Specific models have been developed to determine the limit of joint movements of 3D human character in two different situations from original movement to the stronger movement.

The multiple joint control algorithms have been used to calculate the rotational control limit and position of the 3D human character by referring to the motion capture data. Subsequently, the developed simulator updates the entire process of movement with the dynamic movements of 3D human character. This technique can accelerate the process of generating dynamic new movements compared to the original movement of the 3D human character in computer animation. In the future, the complex deformation motion model needs to be done for editing 3D human character in real time especially for long sequence motion. The main challenges are:

- Producing dynamic response
- Editing superhuman motion
- Changing 3D Human Character Exaggeration Pose

3D Human Character motion deformation in computer games and animation involves high costs and takes time to be developed. Nevertheless, by using this method, animators can reduce their time to develop new style motion deformation.

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