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ISME: Integrated Style Motion Editor for 3D Humanoid Character

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***Abstract*—**The motion of a realistic 3D humanoid character is very important especially for the industries developing computer animations and games. However, this type of motion is seen with a very complex dimensional data as well as body position, orientation, and joint rotation. Integrated Style Motion Editor (ISME), on the other hand, is a method used to alter the 3D humanoid motion capture data utilised in computer animation and games development. Therefore, this study was carried out with the purpose of demonstrating a method that is able to manipulate and deform different motion styles by integrating Key Pose Deformation Technique and Trajectory Control Technique. This motion editing method allows the user to generate new motions from the original motion capture data using a simple interface control. Unlike the previous method, our method produces a realistic humanoid motion style in real time.

***Keywords*—**Computer animation, humanoid motion, motion capture, motion editing.

I. Introduction

TODAY, the need for a 3D character motion editing method in the field of computer animation and games development has been largely increased. This is due to the fact that producing realistic movement for a 3D humanoid character is really challenging in this field [1]. Time taken for the data movement to be edited is also very high due to the complex data structure. Nevertheless, the main challenges lie in the recycling and editing of data movement especially from motion capture sources according to the needs of end users since the change in pose and movement can cause physical changes in a real human style action. In addition, the 3D character has a very high dimensional data resulted from the rotation of joint and the position and orientation of 3D character. It is very important for a 3D character to have its own style of movements according to a real human movement style.

To date, the problems regarding motion capture data are still being discussed among researchers. Generally, the motion capture data record real human movements with position and rotation of each joint in every frame. However, these data still need to be edited and cleaned to get a final and realistic result according to a user's needs. Normally, animators will manually perform the movement data editing process to get the realistic output motion. Difficulties present when the animators attempt to get actual deformation behaviour in a particular time frame. Furthermore, manually changing the original motion style into the edited version of it would require a long period to be achieved using key frame technique.

Alternatively, ISME has been proposed integrating the Key Pose Deformation Technique and Trajectory Control Technique. Basically, the purpose of developing Key Pose Deformation Technique is to actualise specific styles of pose deformation by controlling the joint rotation and position parameter. This is very important as the motion style represents a variety of realistic values of a 3D human character as shown in Fig. 1. On the other hand, Trajectory Control Technique is used to calculate additional forces needed for motion deformation process, which leads to the production of Trajectory control algorithm for controlling the motion data. Hence, the rest of this paper is organised as follows: Section II discusses the literatures related to the present study; Section III describes motion editing method and the final chapter, which is Section IV, addresses and concludes the research findings, limitations and future work.

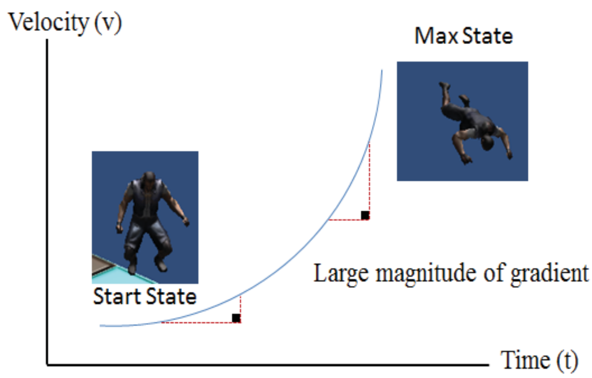

Fig. 1 Large magnitude of gradient shows dynamic motion manipulate in the motion editor system

II. Related Motion Editing Research

The focus of this study is on the fundamental approaches and techniques in motion editing. Motion editing is considered a longstanding problem in the field of computer games and animation. Integrated framework is of essential to easily alter the original motion data with physical quantities. There are several methods that can be applied to motion deformation model including joints rotation, inverse kinematic, and position adjustment of center of the mass. In recent years, researchers have been studying methods of modification and coordination of movements involving the synthesis of a

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physical reaction. This reaction sequence produces better natural movement. However, the complexity in the character structure had caused the reaction to be very sensitive towards the starting point of optimisation. As a result, this process was not able to resolve problems in a realistic character. The physical restriction [7] has adapted the character on the linear momentum to sustain the reaction between the forces and moments involved.

Editing 3D humanoid movement in real time is very necessary for a realistic motion. Currently, a method for obtaining human movement data was developed by using the motion capture technology in which the obtained data can actually be applied to the animated characters in real time. However, the human movement was found to be complex and unstructured. Thus, it is difficult to identify the movement of people who are different from the physical aspect. Besides, the production of character mapping scale was also discovered to be difficult due to the movement of animated characters in real time that seems flawed and inconclusive. Current research in the field of computer animation is aimed to produce a technique with the ability to utilise the existing data on the movement in various scenarios. Movement modification based on physical effects is the basis of the work to produce a dynamic response to the character movement. However, the main challenge in producing a dynamic response is the fact that non-linear reaction is very sensitive to any movement of data. This is because the reaction momentum involves the synthesis of dynamic movement in the whole process.

From the study based on [1], motion synthesis algorithms together with moments are calculated from a single input data to produce realistic motion. Meanwhile, Liu et al. [10] had used a physical model in his study in the character-centered techniques for motion synthesis. Additionally, there are many approaches available for controlling the dynamic alteration of character movement. Some of the examples are the use of a muscle strength model [9], the method of inverse kinematics, and the modification of path and speed of movement on muscle strength of the joints. Other techniques include creating a motion using inverse kinematics and the result of human walking motion using inverse dynamics [8].

Additionally, Shapiro et al. [2] have focused on the "DANCE" platform for developing physical based controllers for the articulated figures. This platform was made to train inexperienced users in developing dynamic controllers. Later on, the system [3] was improved in 2007 by the creation of a toolkit for dynamic articulated humanoid character controllers under physical simulation. These dynamic character controllers were developed by using key-framed based control, reduced dimensionality physics, scripting controllers via a controller language, and an interactive control over dynamic characters. Furthermore, Zordan et al. [4] introduced a new method that allows game characters to react accordingly to unexpected changes in environment based on specific dynamic effects. This system generates a physics-based response and takes advantage of the realistic movement achieved by an actuated dynamic model of motion capturing process. The dynamic 3D humanoid character simulation responds to contact forces and determines the best plausible re-entry into motion library playback following the impact. A physically valid response will be created to produce the result, and the blending process will be generated into the desired transition-to motion. The dynamic motion controller will further act in accordance with the upcoming motion.

"Dynamo" is a technique that allows a humanoid character to set and maintain its poses to dynamic interactions introduced by [5]. The system physically produces plausible transitions between motions without directly use a blending process. The main idea is to apply torques for matching the desired world-space pose and maintain the root orientation. Moreover, Sok et al. [6] has introduced the momentum and technique of force editing. There are two main parts in this implementation; parameter control for trajectory optimisation and a whole body synthesis for motion generation. They presented that the user of this technique can be able to manipulate the momentum and external forces as this system allows the controlling of momentum and forces for dynamic motions.

III. Motion Editing Method

We developed the ISME by integrating Key Pose Deformation Technique and Trajectory Control Technique.

A. Key Pose Deformation Technique

The main purpose of this technique is to create a new style of motion from the input data and the original motion captured data. Thus, we created a slider for user to change the level of pose deformation by controlling multiple joint rotations and translations at the same time as displayed in Fig. 2. To achieve such functionalities, each pose frame was specified with four short key poses. These key poses are preparation pose, minimum pose, maximum pose, and finishing pose.

3D character poses were represented by their joints rotation and pelvis position and orientation [7]. The joints rotation in our system was calculated by using rotation matrices. Fig. 3 demonstrates a parent's body concept in 3D character structure that requires translation to the child's body [8]. After transforming the child's body into the global space, we managed to calculate the new position of the body. The parent's body rotation matrix and body position are defined as R_0 and $\vec{p}_0$, respectively. By moving the parent's body, the child's body was automatically transformed from local space into global space. The parent's body position transformation was then stated as below:

$$\vec{p}'_o = R_0\vec{l} + \vec{p}_o \quad (1)$$

Meanwhile, the child's body is defined as R_1 and $\vec{p}_1$. The joint J_0 and J_1 changed to the same coordinate place as the parent's body moves to transform child's body from local space into global space:

$$\vec{j}'_n = R_n\vec{j}_n + \vec{p}_n \quad (2)$$

Fig. 2 Screen shots of the pose deformation control

To get the vector $\vec{d}$, we subtract $\vec{j}_o$ and $\vec{j}_1$. The new body position, $\vec{p}'_1$:

$$\vec{p}'_1 = \vec{p}_o + R_o\vec{j}_o - \vec{R}_1 j_1 \quad (3)$$

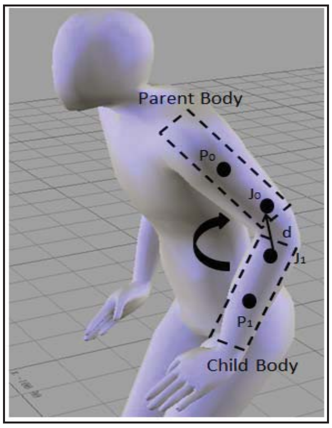

Fig. 3 Parent-child concept

Each of the key pose will be edited by a series of postures from input motions. To calculate the pose editing, Pe, the following expression can be adapted:

$$Pe(t) = Po - Pi(t) \quad (4)$$

where Po is the original posture, Pi is the input motion posture and t is the index of current frame.

B. Trajectory Control Technique

Based on the analysis of motion capture data, the new technique should be developed to produce natural and realistic 3D humanoid motion. Trajectory control technique development is based on extending the findings from [6] and [11]. Control parameter is very important to calculate and produce a 3D character movement optimisation.

This research has changed the trajectory of the center of mass using a dynamic normalising factor. The trajectory of the center of mass was obtained using dynamic normalisation by taking into account the constraints on the momentum and position of the object. There are two main parts to be considered on the basis of translational movement and rotation based movements. The algorithm trajectory control derived from the trajectory calculation was demonstrated in Fig. 4.

Using ISME, user can manipulate added forces to get new dynamic motion. Fig. 5 shows the different dynamic levels of jump motion referring to the original motion profile based on different speed in vertical axis. Dynamic motion refers to the physical properties of 3D object including mass or inertia, and specifies how the external and internal forces interact with the object [2]. With the dynamic of character data, the control of character's specific motion such as walking, running, kicking, falling, and jumping will appear more realistic.

Algorithm Trajectory Control
Step 1. Movement Vector = different joint rotation
Step 2. If Mag. >1, Normalize
Step 3. If additional force is true, New Magnitude = Speed Movement
Step 4. If V is true, add force control

Fig. 4 Trajectory Control Algorithm

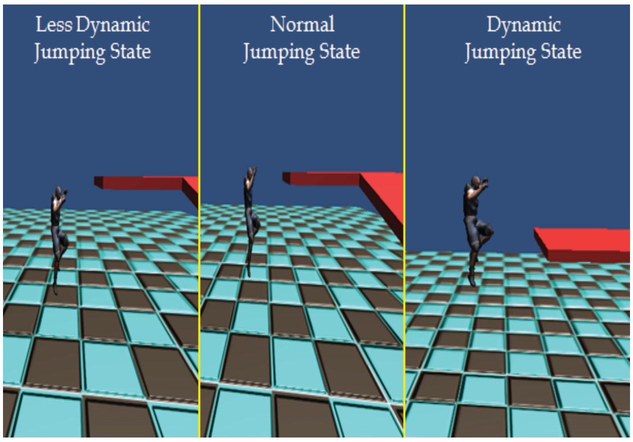

Fig. 5 Dynamic movement

C. Integration Result

Dynamic motion needs to be realistic and natural in computer animation. Fig. 6 presents the ISME user interface. It can be observed that the system has integration between key pose deformation technique and trajectory control technique. The system is able to manipulate 3D humanoid character dynamic actions such as jumping, front flip, running and walking with different deformation pose styles. The original virtual human motion can be manipulated to change into a more dynamic motion including superhuman motion or less dynamic like a movement weaker than the natural movement. Apart from the result obtained by this paper, there are additional results of motion deformation shown in the supplementary video.

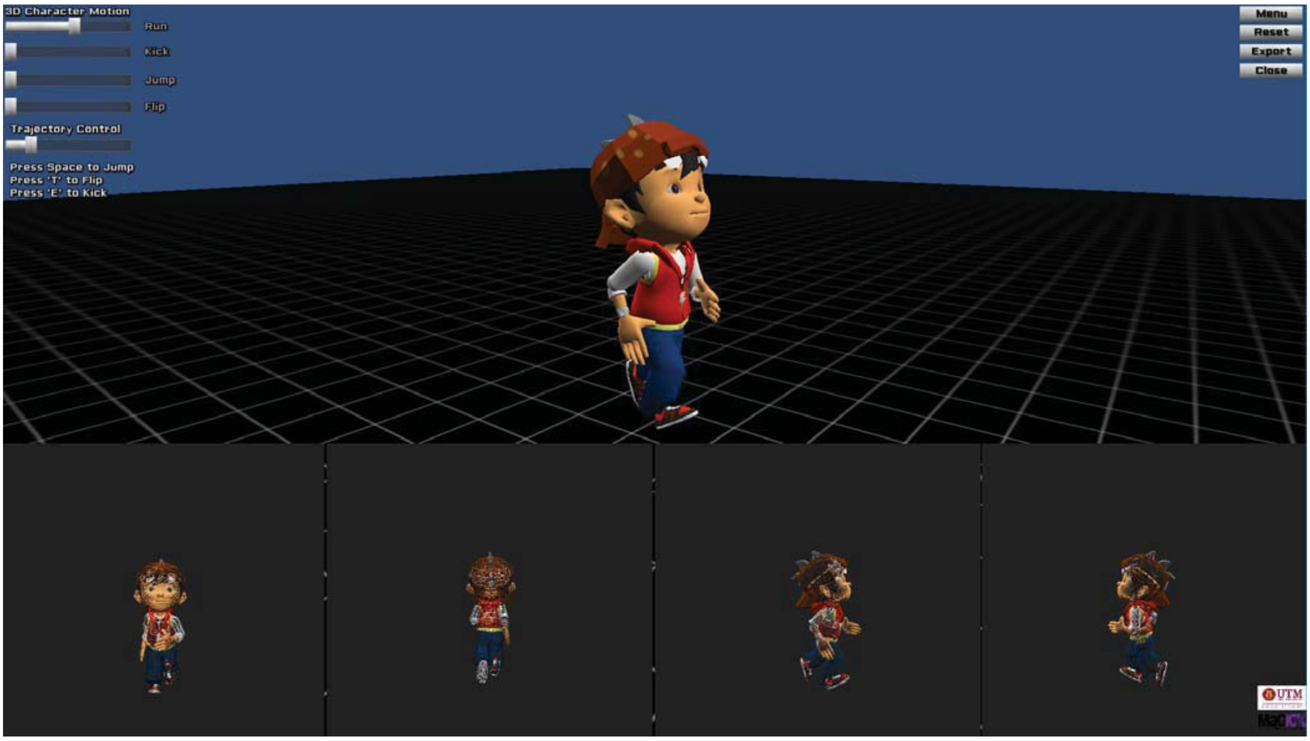

Fig. 6 ISME user system interface

IV. Conclusion

ISME has been presented by integrating key pose deformation and trajectory control techniques. The Key Pose Deformation technique has presented 3D humanoid pose deformation process by controlling each humanoid joint rotation and position parameter. Meanwhile, the Trajectory Control technique has demonstrated 3D humanoid motion deformation process used to calculate additional forces. Most of the target users of ISME are beginners and students working within the field of computer animation.

Our system is able to manipulate dynamic actions, but not a long sequence character movement. Thus, the exploration of the perfect balance between motion editor for 3D character and object interaction is yet to be achieved. The main challenge for character motion in real time animation comes when trying to automatically move the character and instruct it like a real human. Multiple models and different control methods need to be explored for getting a natural and balanced dynamic character motion while maintaining the character's physical properties. Furthermore, editing and modifying techniques for motion capture animation data need to be maximised to the highest level in order to achieve realistic and convincing motions for 3D humanoid characters.

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