A study on character animation with human reactions in pain

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ABSTRACT

Computer graphics is developing day by day, and computer animation with 3D virtual character becomes usual. As this character animation is especially focused on humanoid and has fascinating factor, it is used in the variety of fields.
In general, there are 2 kinds of methods in character animation. One is the key frame animation by artists and the second is motion control based on motion capture data. These methods just apply the pre-made animation data to virtual character. Virtual character doesn't have any human factor like response, reaction, emotion and so on. It makes artists take high cost and efforts for natural and realistic animation.
In this paper, we suggest a behaviour method in character animation to deal with a human reaction, pain. It makes character animation realistic in a certain cases with less effort.

KEY WORDS
Computer graphics, virtual reality, character animation, simulation, human reaction, behaviour

1. Introduction

Nowadays, character animation faces new stage. After motion capture technology is introduced, there are many changes in character animation.
Although motion capture could supports natural and realistic animation of human, it has some shortcomings. As motion data is from real human's movements, it takes long time to make useful motion, and it is hard to modify. Therefore, some artists who have to modify many parts of motion prefer key frame method for character animation.
Key frame method is easier to modify the motion than motion capture, but it entirely depends on artist's creative and skill. The problems in modifying motions are whether the modified results are appropriate.
It is essential to develop the method to modify the motion appropriately, because every motion could not be captured, neither made by artists. Behaviour seems to fit case of the modification, and there were some previous works.
Reynolds was the first man to introduce the behaviour in animation [1]. Tu and Terzopoulos created the artificial fish using behavioural animation [2]. Musse and Thalmann suggested a case of behavior to handle virtual human crowd in realtime [3]. Norser and Thalmann used L-system to deal with character behavior [4].
Ken Perlin and Athomas Goldberg showed the script system to manage the scene and character animation [5].
Funge introduced cognitive concept to character animation [6] and it had many common things to be able to use in behavioural animation. Badler showed an example for cognitive behaviour model [7].
Park and Shin presented the methods of example motions, and it had the merits to keep the quality to modify the motion in various situations [8]. Kim and Shin showed the motion synthesis using movement transition graph [9].
Norman Badler, Jan Allbeck, Liwei Zhao, and Meeran Byun tried to parameterize the agent's behaviour [10].
Zordan and Hodgins combined the dynamic simulation and motion capture data to simulate hitting and reacting [11]. Their work could treat the unpredictable events in order to maintain realism. Neff and Fiume thought that tension and relaxation in muscle could give rise to nuanced motion and researched the control of tension and relaxation in character animation [12].

Behaviour is very useful and is said the keyword of the next generation of character animation. However, there seems to be no established theory to explain behaviour because terms of behaviour are used in variety of fields and contain complex concepts.
In this paper, we simulate the human reactions. However, as there are enormous reactions in human actions, we will focus our attention on reactions relative to pain. A continuous examination of our research would strengthen the other reactions.

2. Character with human reactions

In this chapter, we describe our system for character animation with human reactions and explain how to simulate the animation with pain.

2.1. Structure

To simulate the human reaction, we design our system structure, which is shown in figure 1.

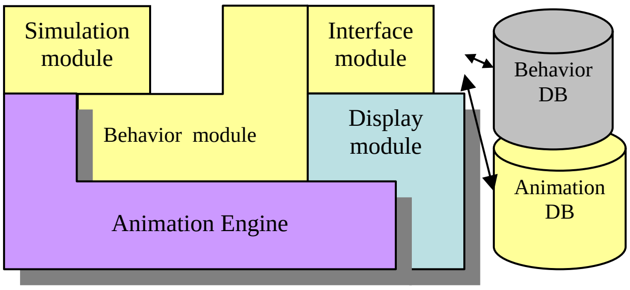

Figure 1. Configuration of our system

Our system consists of animation engine, behaviour module, simulation module, interface module and display module.
Animation engine is the base of character animation in our system. It could control the character, handle the motion capture and key frame data, and play the motion [13]. Display module supports the rendering results to user. Interface module carries out data communication with behaviour database and animation database. Behaviour module takes charge of brain of our system, it decide the conditions and modify the motions.
Simulation module receives the request from behaviour module, perform the simulation, and send the results of simulation to behaviour module or animation engine.
Animation database stores primitive motions for character animation and send the proper motions according to request from interface module. Behaviour database has the tendency of animation or meta-data from various cases.

2.2. Pre-processing

Our system uses the motion data from animation database. To construct animation database, we classify the motion data and set the primitive motions. Then primitive motion are saved and treated as example motions in animation database

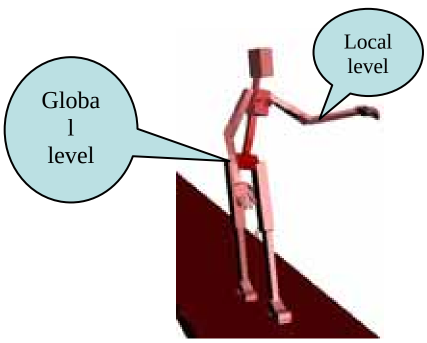

Figure 2. Global and local level.

For efficiency, behaviour module deals with motions in global and local level. Global means something by whole body, and local by only one or two segments of body, like arm, head, leg, and so on. Figure 2 shows the global and local level. Of course in animation database, motion data is divided into both levels and stored
And each primitive motion has 3 types of motions: normal motion, stiff/tense motion, and relax motion. The difference between these types could helps to extract the parameter and understand tendency. These parameters are stored in behavior database.

2.3. Behaviour for pain

To describe human reactions, we classify the human actions into 4 groups, which is drawn in figure 3. The first group is conscious action by own will. In this group, actions got power from human inside and there's no interaction. The second is interactive action. It happens when one interacts with the others, and contains conscious and unconscious actions. The third is human reaction. It happens by internal and external force, and could cause conscious and unconscious actions. We are concerned about this action. The last is unconscious movement by only external force. In this action, movements depend on entirely external forces, not internal forces. That is, it is similar to physical simulation of multi-joint objects that could not move.

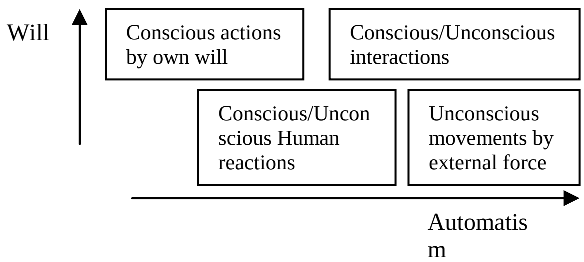

Figure 3. 4 kinds of action groups

As we consider that pain belongs to human reaction, pain has same attributes from human reaction. It has conscious and unconscious actions. To treat pain, we adopt 2 kinds of method: automatic insertion of painful motion and influence in original motion. This is relative with intensity of pain.
If strong pain happens during man's an action, man could not help stopping the action and new painful motion is started. For example, jumping, covering and wave the painful spot.
In weak pain, man's original motion is continuously carried out but the motion is slightly changed. It means that pain influences original motion.
In this paper, we could not use the real forces to measure the intensity of pain. Therefore, it is necessary to determine intensity value which method to apply. We use virtual intensity values by users interactively.

2.4. Insertion of painful motion

Insertion of painful motion means that the intensity of pain is enough strong to stop the original motion. We choose 6 painful motions to insert. There are 3 global

level motions and 3 local level motions. Global painful motions are *jump*, *plump down*, and *fall down*. Local motions are *shake/wave*, *cover and press*, and *rub*.
In case of global level, new animation is inserted to whole body. But in local level, inserted animation could not cover whole body. So, it is necessary to maintain original motions except inserted local motions. To handle intuitively, we divide character's body into 4 parts: head, body, arm, and leg in Figure 4.

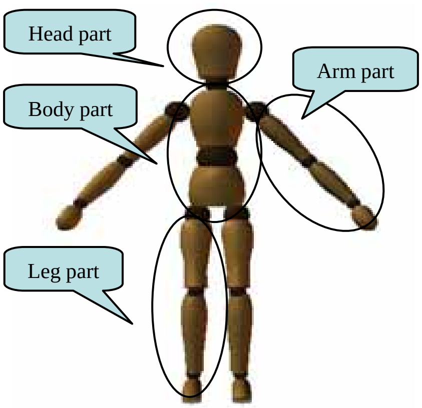

Figure 4. 4 parts of body for local level

Figure 5 explain the mechanism of pain reactions. If any pain is not happened, the original motion would be played to end (left section of figure 5). If strong pain occurs, original motion should be stopped, and new motion corresponding to intensity of pain should be inserted and played. For seamless insertion, posture and motion blending is performed (middle section of figure 5). And for local painful motions, IK is employed.
After new motion is played to end, the rest parts of original motion which is influenced is played.

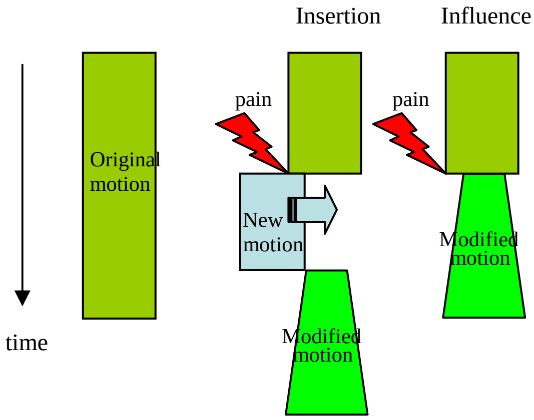

Figure 5. Comparison between insertion and influence

2.5. Influence in motion

Influence in motion means that the intensity of pain is not strong to stop the original motion. After pain occurs, original motion keeps going to play, but motion is influenced by pain. This is illustrated in figure 5.
This influence is carried out using parameters from behaviour database. The magnitudes of influence are determined by intensity of pain, and it is implemented by motion interpolation.

3. Experiments and results

In experiments, we set the situations. When a character animation is performed, several pain events could be happened to the character.
At the first event, pain is occurred in the character's upper body from outside of character. In this case, we could get 2 kinds of *Insertion*, and one *Influence*. For upper body, Insertion of painful motion could be global and local level both. The weak impact could be processed as a local level, and the strong as a global level. Figure 6 shows the painful motion *Insertion* in local. The character shows the shaking arms to simulate the reducing pain. The painful motions for Head part, Body part, and Arm part are inserted. The original motion or modified motion is used for Leg part. When modified motion is used, *Influence* could be applied.

Figure 6. An example of local painful motion Insertion

The second, pain event is occurred in the character's lower body from outside of character. Only global *Insertion* could be happen. When the impact is occurred in leg, the motion for whole parts of body should be changed. Figure 7 shows the painful motion *Insertion* in global level. The character shows the wrapping legs and rubbing the event's spots. After painful motion inserted, *Influence* is performed to finish the rest of original motion.

Figure 7. An example of global painful motion insertion

The last event is simulating internal pain. In this case, both *Insertion* and *Influence* is applicable. Pain from the specific internal part, *Insertion* is right and mainly used. In opposite case, we prefer *Influence*. Figure 8 shows the comparison between the original motion and modified motion which receives *Influence* from internal pain event.

(a) Original motion (b) Modified motion

Figure 8. Comparison between original and modified motion

During the experiments, we felt that it was not easy to present human reactions only by character's body animation. There are many ambiguities in human reactions, and are difficulties in presenting the human reactions in character animation. Therefore, to make accurate expression of human reaction and animation, the facial animation should be added.

4. Conclusion

In this paper, we suggested a method to present human reactions and explain our system. Though we adopted a simple idea to present human reactions, but it was very intuitive and convenient.

As there were many human reactions and our methods could be applicable to those reactions, especially we tried to implement and test the reactions relative to pain.

This method helps the animator's task, reduces the production time, and makes character animations more realistic.

In the future, to make character's reactions real, we will consider the face animations to express the human reactions, and develop more sophisticated methods.

We will research other human reactions, to make a character system which is able to have the similarities to human reactions.

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