Reactive motion generation using motion database and haptic information in real time

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1 Introduction

Most people feel their important experiences through interactions with other people. The communication channels themselves are multi-modal and reponsive mutually. In special, interaction with involving touch and force feedback produce more vivid and vigorous effects. It is also possible to keep up our attention for hours in the interaction. However, in the existing studies about interacting with virtual character, only speech, facial expression and gesture have been the key factors [1]. Although these factors are effective communication channels in knowledge-based interaction, they are not enough to make us fully engaged in a vivid and natural interaction. Because they don't transmit feedback to the body, the virtual human's presence cannot be felt to any large extent, and so the user loses interest in the interaction as time passes.

Therefore, we will focus on force and touch sensations with intuitive feelings and strong feedback as well as visual sensation. With constructing a human-scale virtual environment with haptic elements, we realize a novel interaction with virtual human which is capable of a visual and haptic representation. In this study, we call it a *Reactive Virtual Human system*. It enables vitrual human to generates his reaction according to physical input originated by user's force and the feedback force can transmit to user's body.

2 Reactive Virtual Human System

To realize the proposed system, it should allow user to move freely and easily, and enable the user to feel and manipulate virtual objects with his body so as to create an intuitive interface. It is also important that user feels realistic presence when stepping into the virtual world. This can be achieved through a highly immersive virtual environment which provides multi-sense. Therefore, we employed a novel interface system which combine wire driven force feedback, SPIDAR-H system with a multi-projection display system [3]. In first, the display system covers the field of vision area completely and enables stereoscopic image projection. With a large screen the environment($4 \times 6.3 \times 1.5$ m^3 field) was able to provide a high degree of immersion to the users leading to an overwhelming feeling of presence. Secondly, the SPIDAR-H [2] generated an sppropriate tension in four wires connected to a ring to put on the user's finger. Because it is a wire-based system, it provides a working space where the user can move around and it has a transparent property so as to easily see the virtual world in shown Figure 1.

When a user manipulates virtual objects through this system, haptic- and physical information conveyed from the real world to the virtual one. At that time, the information originating from the user become key elements in generating appropriate reactions of the virtual human. The reactive virtual human ask for the high reality expression of movement, when his motions are embodied in a human-scale virtual environment. In place of creating computational model, the virtual human's movements are generated from motion-capture system in order to acquire realistic and natural human's motion. The virtual human's reactive motion is animated correspondence to user's actions from this pre-stored motion database.

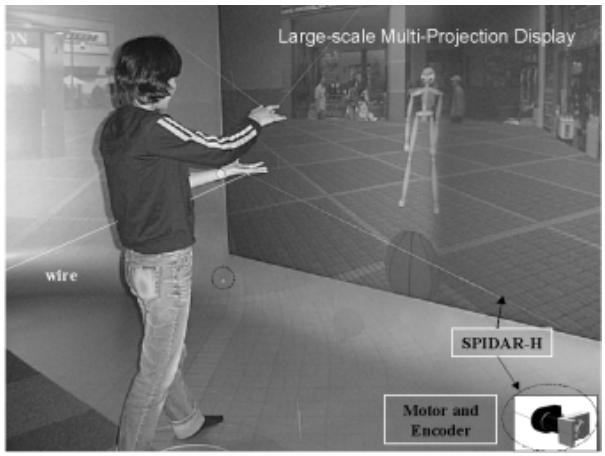

Figure 1: The reactive virtual human system; the circles indicate the installation point of motors on the behind of screen.

3 Implementation

3.1 *Virtual Catch Ball*

The Reactive Virtual Human system is an ongoing research. As a first work of our system, we implemented a *Virtual Catch Ball*. Even if the principal of catch ball is very simple, it requires elaborate observations of the partner's actions, and the user instinctually judges speed and ball trajectory with referring to his body. The user will notice that it can

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perform naturally reactive movements of catching a ball according to the partner's thrown position and direction. Using spidar-h device of our proposed system, user can hold and throw the virtual ball like real one. And because the instant when the ball reaches the hands of the virtual human can also be determined, virtual human is able to decide his behavior in response to user's physical information. Virtual human's real and responsive motion can be animated by the pre-stored database in turn.

3.2 Reactive motion generation

In first, we capture two actor's catch and throw motions under the various environment and situation such as throwing point and speed. Then we classify the motions with some category of primitive action and record the action data to our designed motion database. To look up a key-frame motion in motion database, we compute the virtual human's catching time using physical information such as the ball direction and speed. By predicated on the catch time, we determine a most approximate value from ball's falling position and retrieve a catchable virtual human's motion. After, the best-fit motion map and apply to the data structure of a skeleton model of ball-joint. At last, reactive motions are generated through motion synthesis process. Figure 2 shows a more detailed retrieve process.

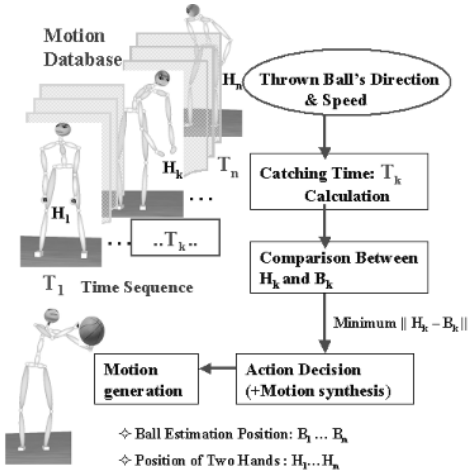

Figure 2: Reactive Motion Retrieve Process

Figure 3 shows how the user catches the ball using haptic- and visual information in the proposed system. When the ball exceeded the speed limit, we judged that a user threw the ball. After release, ball's trajectory moves in the virtual space in accordance with physics law. In the scenes at the top of figure 3, user takes hold of and throws the ball using his hands interacting with haptic interface. The virtual human's catch- and throw motions are depicted from the 3rd to the last frame of figure 3.

4 Conclusion

In this study, we proposed a novel reactive virtual human system that combines a force feedback device and a human-scale virtual environment. We realized a *Virtual Catch Ball* with force interaction successfully in our proposed system. Although the case study performed a interaction through ball as an intermediate mechanism, we could confirm that many people join in this demonstration with absorbed interest.

However, our system we have described still requires that it should build a believable multi-modal interaction system to involve various senses such as the user's head and eye movements for an alive virtual human. And we try for interacting with a touchable virtual human in near future.

Figure 3: A demonstration of "Virtual Catch Ball" ; (1) user picks up a ball, (2) user starts to throw a ball, (3) and (4) virtual human catches the ball, (5) returns the ball to user, (6) user starts to catch the ball

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