Virtual Reality Game Modeling for a Haptic Jacket

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Abstract *In this paper, we describe a haptic jacket and wheel as a haptic interface to enhance VR game realism. Building upon the VR game system using this devices, our haptic interface technique allows the user to intuitive interact on game contents, and then to sense the game event properties such as walking, attacking, driving and fire in a natural way. In addition, we extended the initial haptic model to support haptic decoration and dynamic interactions due to the added game event in a real time display. An application example presented here is a VR Dino-Attack game. This game supports interactions among dynamic and our intuitive haptic interface. Modeling physic interactions involves precise collision detection, real-time force computation, and high control-loop bandwidth.*

Keywords: *: virtual reality, haptic interface, force feedback, immersive*

1. INTRODUCTION

Haptic feedback is a crucial sensorial modality in Virtual Reality(VR) interactions. Haptics means both force feedback and tactile feedback[1][2]. Force feedback integrated in a VR interaction provides data on a virtual object hardness, weight, and inertia. Tactile feedback is used to give the user a feel of the virtual object surface contact geometry, smoothness, slippage, and temperature. Proving such sensorial data requires desk-top or portable special-purpose hardware called haptic interfaces.

In order to add haptic interface, a typical VR game needs several enhancements. First the system needs a customized haptic display device that transmits a feedback to some part of the user's body. Second, physical modeling mechanisms need to be developed, containing a library of functions to calculate and replicate contact forces, impulse forces, object weights, feeling of game character, etc.

Many conventional arcade games have typically used guns as their desplay devices. While guns were cost-effective but easy to natural, they failed to convey a feeling of immersion to their users. We believe that valid VR Game contents requires a different model of immersive environment, one that delivers a sense of presence among the game environments, incorporates immersive tactile-feedback capabilities, is available all the time, is easy to use game device command and helps encourage the entertainment. So, we are interested in is how to design and build a low cost device that satisfies these requirements and design how to display it to adaptive into the fully-immersive VR game environments. As well as, there are many growths in the user interface. These interfaces must have a high degree of clarity and allow the interaction in the form of human-like behavior through computer-aided tools.

The most popular haptic feedback interface at present is the PHANToM family of arms, manufactured by the SensAble Technologies. The PHANToM has six degrees of freedom, and three electrical actuators, each model has different dimensions. Depending on model, its work envelope progresses from wrist motion up to shoulder motion, the haptic rendering of it suited for point interaction mediated by a single virtual finger, or a stylus, or pencil Because PHANTOM is not compatible to PC and is expensive, and specialized in a certain part of hand such as a palm or a finger. Most of today's interfaces for VR game are joysticks, or small robotic arms. Many other commercially available devices have a force feedback bandwidth between the ranges of 10-50 Hz. It is not appropriate to apply to valid VR game

The HJ-I illustrated in figure 1, is a research prototype developed in our paper. This haptic jacket has a smaller weight and portable, due to the use of vibrator motors with high power/weight ratio. The low friction of the motors, and their placement in the body provide for high interface dynamic range. Since motors do not overheat, they can produce a maximum valid effects equal to the sustained one of 5N/motor. The goal of our interface, HJ-II haptic jacket, is to provide a user with more immersive VR game environment. With this interface, the users feel valid weights and sense of game event, and thus the users feel the game environment close to the real environment.

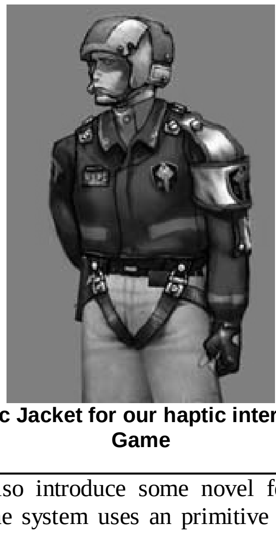

Figure1. Haptic Jacket for our haptic interface in Our VR Game

This paper also introduce some novel features in haptic display. First, the system uses an primitive effect to provide additional game event properties to display the body from interacting through game character without introducing any force discontinuity. Haptic decoration and event sensing can also be performed on valid game events using the primitive effect. Next, a primitive effect is used to force the tool tip to stick to the surface can simulate multiple objects by merging their implicit surfaces into a single implicit surface which represents combined multiple objects.

2. OUR VR GAME SYSTEM

Our VR game is the interactive VE(virtual environment) of driving simulation and on-line Role Playing Game supported by 2 users. In interactive VE(virtual environment), our game platform is carried out two PCs.

The one is the main game PC that renders the game environment and to process user's input. The other is the user interface PC that displays the user's game information and menu. The user interface PC track user's sensors and register the relevant game information and menu according to this sensors' positions. Also, it receives the user's input, sends this input to the main game PC, and displays this input appropriately to the user. Also, it receives the user's input, sends this data to the main PC, and displays this input appropriately to the user. In order to achieve this, a tight connection between these two PC is needed. We can achieve this by using point-to-point or TCP/IP network protocols.

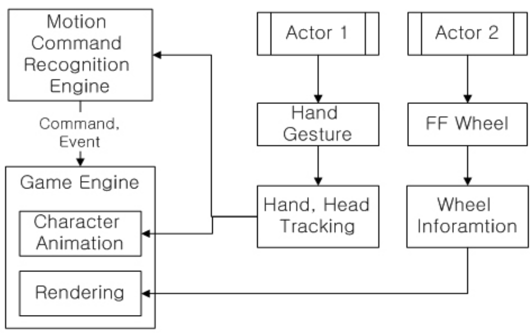

Figure 2: User interface for *Proposed Our System*

A user plays game with hand glove which trackers the hand positions and triggers the button event. The other user drives the safari off road with force feedback wheel handle. The hand gesture of player1 is captured by two CCD cameras. And then it is transmitted to Motion Command Recognition Engine. The extracted game command is transfered to Rendering and Animation Engine. And the motion of actor is generated with virtual actor by real-time onto screen. Player 1 wear see-through and polorized HMD and player 2 wear haptic suit with tactile feedback. So, the players entertain the safari hunter with stereo wide screen. Upon a game event, the players reports, player can increase "presence", a typical VR game using customized haptic interface that transmits a feedback to appropriate part of the user's body.

The tracking system reports the latest position and orientation of hand hand trackers. From the head data, and predefined offsets, the positions of the user's eyes are calculated. Input game command is a marker-free system that consists of two synchronized CCD cameras installed front-left and front-right of a user and two clients system connected to each camera. The commands are transferred to Rendering and Animation engine.

3. HAPTIC RENDERING TECHNIQUE FOR VR GAME

In this section we describe our haptic rendering model and some novel features such as offset surface for thin objects, magnetic surface, and multiple objects simulation.

3.1 Haptic Model for VR Game

We first briefly summarize our implicit-based haptic model; the detailed algorithm was described in [*].

Collision Detection

In the implicit representation, collision detection becomes trivial due to the inside/outside property of the implicit surface. If the potential value at the position of tool tip changes sign from positive to negative, a collision is detected(the iso-surface is, by convention, defined as zero).

Force Generation

The force direction is computed by interpolating the gradients of 8 cell points around the tool tip. The interpolation function makes the system avoid the force discontinuity. In order to determine the amount of force, we first find the virtual contact point(VCP) on a surface which is the intersection point between the surface and a ray along the computed force direction. The amount of force is proportional to the distance between the VCP and the tool tip. Once the VCP is determined, a spring-damper model is used to computer the final force vector that tries to keep the virtual contact point and the tool tip at the same position.

Adding friction to the model

Simulating friction is implemented by limiting the movement of the virtual contact point like in the constraint-based method. In addition to surface friction, the system takes into account the depth of penetration. It means that as the tool penetrates deeply inside the surface, the user feels higher friction.

Effect-based haptic texture

In previously introduced algorithms, haptic textures are implemented by modulating the surface friction and/or local surface normals. In our algorithm, haptic texturing is simulated by applying texture values directly to the potential value of each point in the 3D grid, without any need for preprocessing. No modification to the existing algorithm is necessary in order to accommodate the new texture features of the surface. Moreover, there is no additional computational cost imposed due to haptic texturing since direction and amount of the force are computed dynamically as the tool tip moves along the surface, where or not this one has been modified by additional textures.

3.2 New Primitive Effect Scheme for Game Event

In order to give valid game event sufficient internal characteristic without force discontinuity, we use an primitive effect which represents an base signal with a positive from the implicit event. An additional effect between the offset surface and the original surface allows the system to generate the appropriate constraint force for thin objects.

Note that the system uses the surface normal as the forces direction and surface properties at the closest point on the original surface from the tool tip to simulate the original surface as accurately as possible. The closest point is also used to represent the sisual contact point on the surface and to updata texture map and material map when the user performs haptic editing on the offset surface. The force magnitude is proportional to the distance between the physical tool tip and the VCP on the offset surface. The offset surface could smooth out small dent on the surface but the system provides reasonable haptic fidelity in high resolution of volumetric implicit surface representation.

We propose that the primitive effects can be modeled as one-dimensional sinusoidal grating with Amplitude A and Wavelength L., superimposed at a detection situation(see fig 3). Sinusoidal gratings can be used as basic building effects for textured event on game event perception and as a basis function set for modeling game effect such as fig 6.

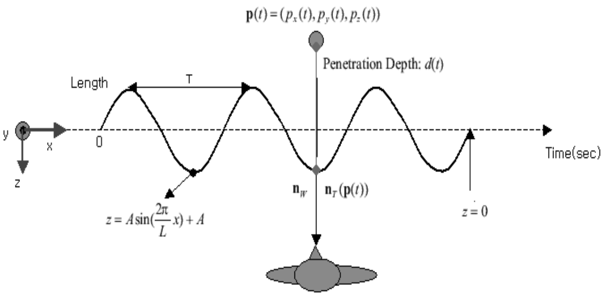

Figure 3. Illustration of parameters used in tactile rendering

Two tactile-like rendering methods, one based on impact-based method(denoted by $F_{mag}(t)$) and the other vibration-based method(denoted by $F_{vec}(t)$), were employed. The former renders a force with a constant direction normal to the underlying flat wall(n_w in Fig *). The latter renders a force in a direction that stays normal to the sinusoidal patterned vibration($n_T(p(t))$ in fig 3.).

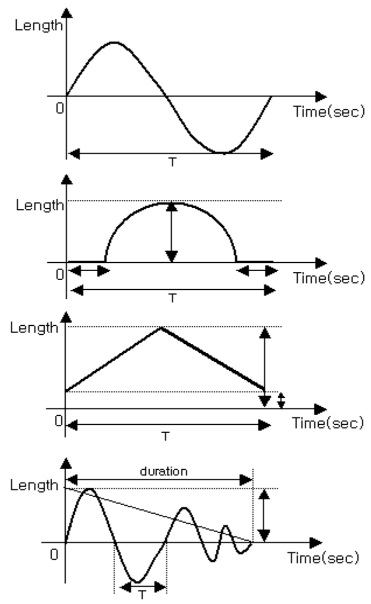

Figure4. Illustration of base signal used in tactile rendering

The important difference between the tactile patterns used in the first method and those in second method was the wavelength with which penetration condition were calculated. At the first method, collision detection was based on the z-coordinate of the collision position and the underlying flat wall. Penetration depth was calculated as

$$p_1(t)=\begin{cases}0 & if\ \ p_z(t)>0\\ A\sin(\frac{2\pi}{L}p_x(t))+A-p_z(t) & if\ \ p_z(t)\le 0\end{cases}$$

where $p(t)=(p_z(t),p_y(t),p_z(t))$ is the position of the collsion state. Therefore, in order to optimally calculate the mechnical force, an stiffness of force and velocity of object are considered. The following equation can be developed to expressthe total dynamcis reaction force $F_r(t)$:

$$F_r(t)=(p_c-p_t)\cdot k-v\cdot b$$

$$F_r(t)=\begin{cases}k_{wall}\Delta x+B\cdot x' & for\ x'<0\\ k_{wall}\Delta x & for\ x'\le 0\end{cases}$$

In the next method, collision detection was performed on the boundary defined by the sinusoidal textured surface. Penetration depth was calculated as

$$F_r(t)=\begin{cases}0 & if\ \ p_z(t)>h(p_x(t))\\ A\sin(\frac{2\pi}{L}p_x(t))+A-p_z(t) & if\ \ p_z(t)\le h(p_z(x))\end{cases}$$

Where $h(p_z(x)) = A\sin(\frac{2\pi}{L}p_x(t))+A$ is the height of texture model at $p_x(t)$ as shown in fig *.

The generated signals in two methods were uniquely defined by the amplitude(A) and wavelenth(L) of the sinusoidal texture model, the effect stiffness(K), and the effect pattern(F), and force shaping method.

3.3 Giving Interaction Feedback to the User

Typical haptic interfaces are designed to render the tactile-like feeling of contact with physical objects, but our platform is considered game effects which could be used effects of game contents and target situations with a game character. It is not yet clear what game effect of character are best suited for haptic interaction, how such models are related to tactile percept such as walking, attack, magic, and how model parameters are to be acquired for real events.

The goal of our haptic interface is to provide a user with more immersive VR game environment. With our interface, the users feel valid situations of game event, and thus the users feel a tactile (pressure, temperature, roughness, and vibration), kinestic information(gravitation and inertial force) so that the game environment close to the real environment.

Therefore, we concentrate that users can feel a sense of touch through, typically, vibrating nodules or expanding air bubbles inside a suit. Also, This provide acustic-tactile display for interaction with music signal.

The HJ-II is designed to make it possible to explore these insues. Broadly, game effects models suitable for synthesis can classified as real-time haptic rendering models and file-based rendering models. In this system we consider come of the constraints imposed by both types of haptic rendering models on the design of the HJ-I. The HJ-I is meant to be a multi-type rendering device, which could be used to support the construction of a variety of tactile models, as well as for general user interaction. Also, this paper proposes an interaction model between articulated bodies that accounts for an impulse of virtual objects' interaction. The proposed force mapping and object dynamics are based on a haptic interaction mesh model.

4. GAME EFFECT DISPLAY

Generally, we have only visual feedback, sometimes tactile and/or force feedback are added to visual, but other senses like tact and audition are not usually present and are rarely combined. We are convinced that auditive feedback can improve the realism of immersion in tactile interactions within virtual spaces. That because humans are extremely sensitive to changes in an acoustic signal over time. We believe that 3D sound can be used to effectively augmented information. It can produce alerts or orientation responses that can be detected by the user more quickly than visual signals.

Sounds with haptic response

Using force feedback and sounds with the devices it is possible to enhance the virtual reality of the user even further. As combining information from these different sensory streams has, our system present. As we want to give the user more "presence" of game event and virtual environmet, haptic interface is used to generate one kind of valid game situation such as engine sounds to express the speed to the user.

Tactile feedback interaction

In the force feedback could be used to inform the use about moving, collisions, obstacles, etc. Also the speed of moving object manipulation and other changes in the virtual world could affect the feel gotten from the devices. In general force feedback would be used to make the driving like experience more real to the user.

Figure 7 is shows a tactile signal for valid effects such as explosion, sword, and walking. And Figure 8 is show an screens of visual data with tactile feedback.

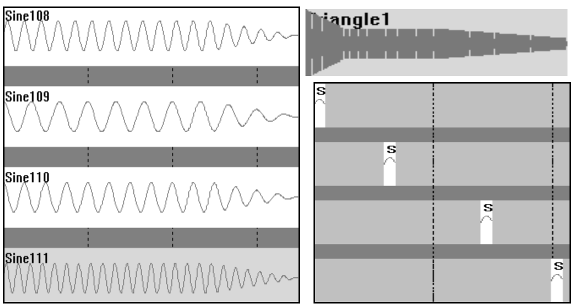

Figure 5. The Effects shown is along the valid game event

Figure 6. Visual rendering data of game event

5. CONCLUSIONS

We described the method of vibro-tactile feedback display with HJ-II haptic suits based impulse and vibration motors for force actuator in order to generate high-resolution effects at real time frame rates. Haptic display using HJ-II, which is used Sensory-626 board. And the PC is Pentium 4, 1.6GHz CPU with NVIDIA® Geforce3 Ti 4100 models. The control loop running at 1000Hz .

We present that vibro-tactile feedback provides another sense that can be used for multi-modal interaction in addition to hearing and sight. From our system, user can enable the sense of tactile in a game character and environment. Also, users can interact with the other game object as they do in real life. After this future work, we plan to evaluate how natural this tactile effects is to users.

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