

Haptic Interaction Rendering Technique for HIRO: an Opposite Human Hand Haptic Interface

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Abstract. HIRO (Haptic Interface ROBot) is a new device that enables users to interact and feel the virtual object safely. Hand interaction with virtual object requires a more elaborated model than the Haptic Interaction Point (HIP) due to the complex shape of the virtual hand. This paper describes a general haptic rendering of 3D object for hand interaction that takes in consideration the real shape and the orientation of the hand as well as accounts for the shape of the interacting objects. A VR medical application system for breast palpation using HIRO was developed in which the proposed haptic interaction method was implemented and tested.

1. Introduction

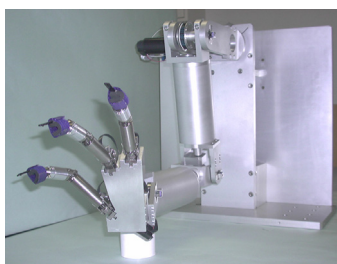
Haptic interfaces add the sense of touch to interactions with a virtual scene. Haptic rendering is the term for computing these interaction forces between models. Haptic rendering tools were usually designed for specific devices. Most papers are concerned with only the end effector point of contact known as the Haptic Interface Point (HIP) [1] [2] that suit the common haptic device PHANToM. The ray-based haptic rendering technique proposed by Basdogan et al. takes into account haptic instrument shape [3], which approximates the pen shape of haptic interface end effector with a line segment. A more complex category of haptic interfaces is haptic gloves. Several haptic gloves were designed for VR simulations, as for example the “Rutger Master” [4], the “LPR” Glove [5], the “CyberGrasp” [6], a force-reflecting exoskeleton that fits over a CyberGlove and adds resistive force feedback to each finger but does not provide grounded forces. CyberForce [7] is the only force feedback armature that only conveys grounded forces to the hand and arm.

Hand interaction with virtual object requires a more elaborated model, than the HIP, due to the complex shape of the virtual hand. This paper describes a general method for haptic rendering of 3D deformable object for hand interaction that takes

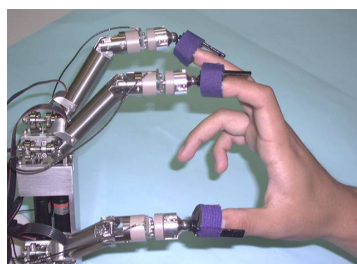
in consideration the real shape of the hand and accounts for the shape of the interacting objects.

2. HIRO Design

The HIRO consists of arm, multi-fingered haptic hand, human arm posture sensor, and controller. The HIRO is an anthropomorphic interface of the human arm from the shoulder to the fingertips. The interface can be divided into two main parts: the Interface Arm and the Interface Hand as can be seen from Fig. 1 (a). A detailed technical description of the interface design can be found in [8]. The haptic hand design is basically consists of the base which represents the palm and three haptic fingers representing the human fingers. The design of the haptic hand is based on the Gifu Hand II, a robot hand that previously developed in our Laboratory [9]. Fig. 1. (b) shows the haptic hand interface and how to attach the human hand to the haptic hand.



(a)



(b)

Fig. 1. (a) The HIRO (Haptic Interface RObot), (b) The haptic hand

3. Haptic Rendering Technique

The goal of haptic rendering is to display the shape surface of arbitrary 3D objects in real time through a haptic interface. Initial haptic rendering methods focused on displaying object primitives. Later Zilles and Salisbury [1] developed a more sophisticated constraint-based method to render generic polygonal meshes. Pervious methods are not sufficient to model the haptic interaction with more complex category of haptic interfaces like gloves and haptic hands. Popescu and his colleges [10] used a haptic interaction mesh (a set of points used for haptic rendering) that accounts for the hand interaction model. The method provided better representation of finger haptic interaction but still can only covers a certain patch of the fingertip. The proposed haptic interaction technique considers the exact point of the fingertip that touched the virtual object and the orientation relative to the virtual object. For the sake of simplicity, we restrict ourselves to static environment composed of

