SPIDAR G&G: A Two-Handed Haptic Interface for Bimanual VR Interaction

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Abstract. In this paper, we propose a new haptic interface for tasks requiring two-handed manipulation. The system, named "SPIDAR-G&G", consists of a pair of string-based 6DOF haptic device called "SPIDAR-G". By grasping a special grip provided by each device, user can interact with virtual objects using both hands and accomplish life-like bimanual tasks in an intuitive manner. furthermore, the interface imparts user with the ability to feel different kind of force feedback. The system was evaluated by measuring "completion time" of a 3D pointing task, and shown to enhance interactivity for bimanual works.

1 Introduction

Most of the tasks that we perform in our daily life, involve the use of both hands for a wide variety of purposes ranging from a simple pickup tasks to a more complex and fine manipulation such as surgery tasks. However, both hands work all the time in concert with each other and in a seamless and spontaneous manner to acomplish desired tasks. Keeping such skillful interaction within virtual environemnet will be of great interest to many applications that require the use of both hands such as mechanical assembling, medical surgery, free form modering ...etc.

Many studies on two-handed action have been proposed and tested. Andrea Leganchuk et al. [1] have pointed out that bimanual manipulation may bring two types of advantages: manual and cognitive. Manual benefits come from increased time motion efficiency, due to the twice as many degrees of freedom as simulteneously available to the user. Cognitive benefits are due to reduction of load of mentally composing and visualizing the task at an unnaturally low level, which is imposed by traditional uni-manual techniques. Guiard [2] two-handed interface. According to Guiard, most of the common activities involve a division of tasks between both hands. Hence in order to accomplish a complex task, different roles are assigned to each hand in form of different subtasks to be performed.

Furthermore, Boud et al. [4] have pointed out that an assembly task as "The Tower of Hanoi"problem may need haptic feedback to support visual feedback in 3D manipulation task.

The current paper present a new haptic interface that provides user with the ability to use both hands to interact with virtual objects in an intuitive manner.

The design and setting of the interface took in consideration human's bi-manual working behavior so as it can be fitted for many bimanual manipulation but also feeling various kind of force interaction generated between hands and virtual objects.

1.1 Relate works

Many prototypes for two-handed operation have been developed. Such as, the 3-Draw system [5] which was developed for a CAD application, the ToolGlass and Magic Lenses system developed by Bier et al. [6]. Hinckley et al. designed the neuro-surgical planning system [7] with props interface where user manipulates two props, a head prop and a cutting plane prop with both hands. Responsive Workbench system [8] allowed users to naturally manipulate virtual objects with both hands by using a pair of gloves and a stylus as they are displayed on their tabletop VR devices. However, these bi-manual prototypes did not provide haptic feedback.

Based on the original SPIDAR [12] device, Sato et al. already presented a couple of both-handed devices known as Both-Hands-SPIDAR and SPIDAR-8. Both-Hands-SPIDAR [13] is based on two 3DOF version of SPIDAR embedded within the same working frame. Although the device have been proven to increase the level of reality during virtual object manipulation, it has few backdrops relation mainly to its 3DOF constrain and to the limitation of working area where strings connected to each hand my interfere with each other during wide rotation. SPIDAR-8 [15] is a two-handed, multi-fingered(four fingers for each hand) and string-based haptic feedback interface device which allows users to perceive force feedback via their fingertip caps. The device is very intuitive to use but due the number of involved string(24 in total) and their possible interference with each other during manipulation, the quality of force feedback is satisfactory only in a limited working space.

1.2 Our approach

Ideally, an effective device for virtual object manipulation should satisfy the following requirements:

1. The device should allow natural translational and rotational manipulation of virtual objects.
2. The device should provide force and torque feedback.

Furthermore, it is well stated in many publications that two-handed manipulation leads to faster completion than one-handed manipulation within the context of the interface. Thus to take advantage of user's existing bi-manual skills, it is recommended that the device allows a highly intuitive two-handed interface with 6DOF motion and 6DOF force feedback.

To satisfy the above assumptions and consideration, SPIDAR-G&G system was designed and developed based on a new version of SPIDAR system known as SPIDAR-G [16]. A 6DOF force feedback device with 1DOF in plus for the spherical grip element. The grip will be used to track hand movement as well as to grasp or release a virtual object (1DOF). Taking advantage of such device, SPIDAR-G&G system uses two SPIDAR-Gs to provides suitable environment for virtual bimanual tasks. Each hand has its own working space and able to feel different haptic sensations such as contact, weight, inertia, ...etc. being independent from each other, both hands can cooperate together to acomplish task in a natural manner. We believe that SPIDAR-G&G system could be effectively used for a number of applications such as virtual prototyping, virtual scruptureing, free form modeling, medical simulation,molecular simulation and tele-operation.

2 6DOF both-handed manipulation system –SPIDAR-G&G system

2.1 System configuration

SPIDAR-G&G's hardware configuration is illustrated in Fig. 1. As stated earlier, the system is composed mainly of two 6DOF haptic devices, a PC, and an LCD display. The PC controls and communicates with the haptic devices through two controllers which are attached directly to its USB port.

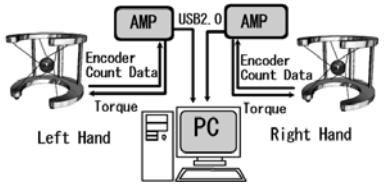

Fig. 1. System configuration for SPIDAR-G&G system

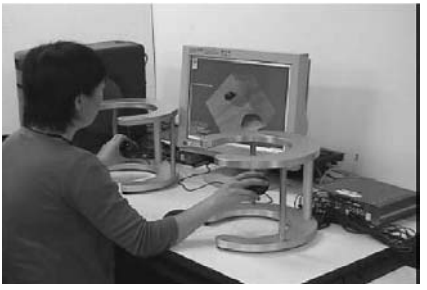

Fig. 2. Overview of SPIDAR-G&G system

The developed prototype of SPIDAR-G&G is shown in Fig. 2. Both devices are place about 40cm apart from each other and separated by a 17" LCD display where virtual objects are projected. To interact with the interface, user are required to grasp a special grip provided by each haptic device. The grip size is 3.25[cm] in radius and can be moved within the cubic frame of each haptic device (each frame side is 20cm length). It is important to note that the distance separating both devices was set in such way it provides comfortable working posture and do not interfere with bimanual manipulation.