Effect of Tactile Feedback and Viewpoint on Task Performance in a Collaborative Virtual Environmment

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Abstract

In this paper, we present cooperative virtual environments that allows two users to control different degrees of freedom of a virtual robot from two distant machines connected through LAN. In this context, we investigate the effect of tactile feedback and viewpoint on performance, awarness and user coordination. Ten volunteer subjects were instructed to cooperatively pick-and-place virtual objects using the Nintendo Wiimote^{TM}. Results show that both viewpoint and tactile feedback significantly enhance task performance, awarness and users coordination.

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

1. Introduction

A lot of work has already been done in the field of CVEs. Most of this work is pertinent to the general software sketch, the underlying network architecture and framework [ACF*07]. Other important works are related to cooperative manipulation of objects in the EVs. In this context haptic cues may play a crucial role and have a profound effect on task performance, users coordination and mutual awareness . Basdogan et al. have investigated the role of force feedback [BHSS01]. They reported that force feedback increase the user performance in task accomplishment. Similarly Salnas et al. observed a significant effect of force feedback over presence, awarenesse and task performance [SRGS00]. Some other researchers used vibro-tactile cues to provide useful guidance information in the context of navigation [Bos03].

In this paper, we present a simple cooperative replicated VE that allows two users to control a virtual robot form two VR stations connected through LAN and investigate the effect of vibro-tactile cues and viewpoint on task performance, awareness and user coordination.

2. CVE architecture

Our system architecture uses a complete replicated approach. Each VR station has module which acquires the input from the local user. This input is not only applied to local VE, but is also sent to the remote station where it is applied in the same manner.

3. Experiment

The experimental VE, illustrated in Fig 1 is a robotic workcell that contains two tables. Three cylinders of different size and color are placed on the left table. A string-based robotic platform with 3 degrees of freedom is used to pickup, move and place the cylinders on the other table. The *Wiimote*^{TM} (accelerometers) was used to control the movement of the robot. Participants (an expert and twelve novices all males) were instructed to cooperatively perform the task from two different VR stations using a Nintendo *Wiimote*^{TM}. The novice operators controlled the forward/backward and vertical movements of the robot. The expert controlled the lateral movement of the robot. In addition he was responsible for the picking and release of the cylinders. The expert operate the robot from a human-scale VR station Fig 2 while the novices' station is based on a desk-top configuration with a large screen (107cm diagonal). Participants had normal or corrected to normal sight and were aged from 22 to 30. They were given a short briefing about the experiment and a pretrial in which they experienced all conditions in different order.

All novice participants performed the experiment in each

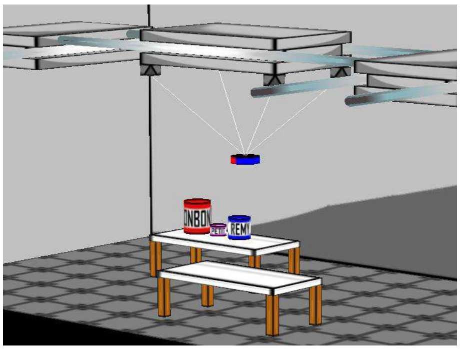

Figure 1: *shifted (right) view of the robotic workcell*

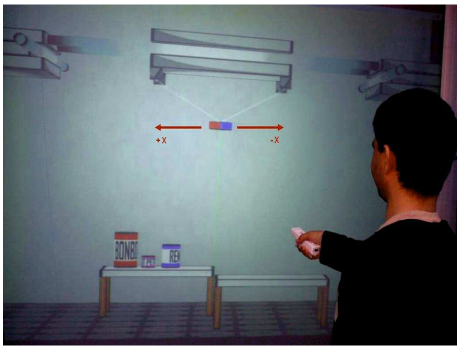

Figure 2: *The expert user operating the robot in immersive configuration*

of the following conditions: C1= same viewpoint as the expert (front view), no tactile cues. C2= perpendicular viewpoint, no tactile cues and C3= perpendicular viewpoint and tactile cues. Thus, in C2 and C3 the viewpoint of the novices was right side view of the workcell. In C3, selection of a virtual object by the expert triggered vibration both on his own *Wiimote*^{TM} and on the novice's *Wiimote*^{TM}. In all conditions the expert's viewpoint was the same (front view of the workcell).

3.1. Results

Not surprisingly, results revealed a significant effect of viewpoint configuration on task completion time (F(2,11)=111.38, $p < 0.05$). Perpendicular viewpoints allowed the participants to achieve the cooperative task faster and in a more synchronous way (Fig 3). As illustrated in Fig. 4, in C1 condition the task was performed asynchronously resulting in longer completion times. Thus, in condition C1, C2 and C3 task completion times were 164.9 sec (std 19.7), 93.7 sec (std 5.8) and 93.6 sec (std 8.9) respectively. We observed that tactile cues had non significant effect on task completion time. However all novices participants reported that they preferred the C3 condition in terms of comfort. In addition, eleven novices (over 12) reported that C3 condition increased their awareness of the expert's actions.

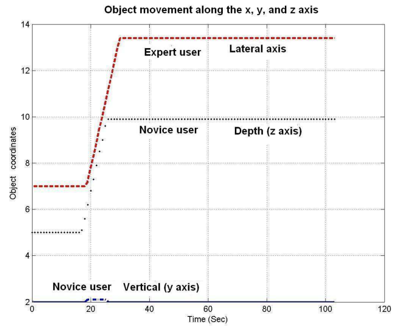

Figure 3: *Illustration of the object's movements in condition C3*

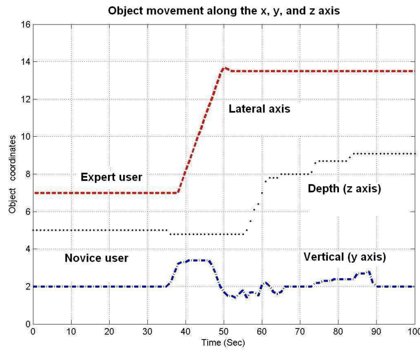

Figure 4: *Illustration of the object's movements in condition C1*

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