ABSTRACT

The paper deals with the application of haptic technology when improving manual skills of people with specific disorders, such as Down syndrome, mental retardation, etc. The development of a cutting haptic system is the base of this paper to show specificity of the development and verification of hardware for the given group of handicapped users. The cutting operation is performed using a hot wire tool, which is linked through an R-R mechanism to a PHANTOM device. The haptic cutting device is able to cut soft materials as expanded and extruded polystyrene foam from 5 to 20 mm thickness. The device is driven under the user’s hand movement and assisted through the Magnetic Geometry Effect (MGE). The haptic cutting device has been used as an input system for tracking the sketching movements made by the user according to the visual feedback received from a physical template without haptic assistance. Then the cutting device has been used as an output system that provides force feedback capabilities. Finally, the system performance has been evaluated by comparing the analysis of the tracking results with the final polystyrene components.

1. INTRODUCTION

Haptic technology can play a role of important supporting and compensational means for group of users with specific motor and visuo-spatial impairments. For example people with Down syndrome, forms of mental retardation and other development defects, which cause problems related to precision of movement, coordination of force, speed and reduced efficiency in performance as compared with healthy people. Lot of studies in literature suggest that the source of motor difficulties in those particular population originates from deficit of the central representation of actions. As suggested by the literature [Blank et al., 1999, Kurillo et al., 2005] practice can have positive influence on the motor skill even reducing the motor impairments. Haptic guidance has a significant value in many applications, such as medical training [Liu et al., 2003], hand writing learning [Teo et al., 2002], and in applications requiring precise manipulations [Ahlström, D., 2005]. Starting from those evidences we have designed the cutting haptic device for providing assistance movements while cutting through the haptic point-based approach, wondering that such device could be a useful tool also to train patient’s motor skills.

2. THE CONCEPT

Figure 1 provides the isometric view of both, the CAD concept and the real prototype of the cutting system by using the RR mechanism (2). The stylus (5) of the Phantom desktop is driven under the operator’s movement and assisted by the Magnetic Geometry Effect (MGE). When this option is activated, a spring force tries to pull the sphere of the stylus (5) of the haptic device towards the surface of geometry. In fact, this effect is used in order to assist the user’s hand. In order to find link lengths (subassembly 2), we have performed some analyses that display the kinematic properties. While user follow the 2D template by using the haptic guidance, the wire tool (6) cuts the polystyrene foam (3). The polystyrene foam is an interchangeable element.

Figure 1. Haptic Cutting System.
3. PRELIMINARY TEST

We have performed a preliminary test with 6 users. Participants were down people; right-handed volunteers (5 females, 1 male) aged 8 to 28 years. Verbal instructions and familiarization period were issued.

All participants were asked to perform a task that involved using a combination of visual and haptic functions in order to design a circle with 100 mm of radius. The majority of participants were able to complete the specified tasks; the time taken to complete the task varied considerably between participants. Figure 2 shows the tracked motion with (right) and without (left) haptic guidance while sketching the circle. In order to systematically assess the contribution of the haptic guidance we computed the error as the means of the differences between the radii of a perfect circle and the radii of the drawn circle for each point sampled. Wilcoxon rank sum test with continuity correction has been applied to the subject’s errors with and without haptic guidance. Results showed that the error significantly decrease (p = 0.004) when subjects were guided. In summary, participants were generally pleased with the ease with which they were able to draw an almost “perfect” circle. The overall response to the experience was positive.

4. DISCUSSION AND CONCLUSIONS

The results of our study showed that the cutting haptic device help people during cutting operations by means of using haptic technology. The opportunity to create a haptic system that would make real difference in Down people’s life appeared to be a highly motivating factor. We are currently performing an evaluation with unskilled people in order to measure their learning improvements in 2D operations skills. Results show that the effect of using the haptic cutting system increases the accuracy in the tasks operations. We can resume that the system leads to the satisfaction of the following objectives:

1. The coherence and collocation between the haptic and the physical 2D template is assured;
2. The force feedback enhances the interaction between user and computer and can be used as a tool for enhancing human skills. We also wonder that it can be useful as a rehabilitation tool for disable people;

Further research, however, is still needed to improve the performance of the cutting haptic device by increasing the working volume.

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