Sketching Haptic System Based on Point-Based Approach for Assisting People with Down Syndrome

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Abstract. This paper describes the 2D sketching haptic system (2DSHS) designed for the assessment and training of sketching control movements. The system has been developed for people with Down syndrome, who can use the system for drawing simple and complex sketches. These users are able to feel virtual objects by using a haptic device, which acts as a virtual guide taking advantages of its force feedback capabilities; in fact, the haptic device is driven under the user's movements and assisted through the Magnetic Geometry Effect (MGE). The 2DSHS has been used as an input device for tracking the sketching movements made by a user according to the visual feedback received from a physical template without haptic assistance. Then, the 2DSHS has been used as an output device that provides force feedback capabilities through a point-based approach. Preliminary evaluation has been performed in order to validate the system. Two different tasks have been performed -sketching a template and hatching a surface- with the aim to obtain more information related to the accuracy of the device. The performance has been evaluated by comparing the analysis of the tracking results.

Keywords: Haptic technology, assisted sketching, unskilled people.

1 Introduction

A sketch is a rapidly executed freehand drawing that is not intended as a finished work. Sketching is one of the most complex human activities in which the hand movements are controlled by the central nervous system, which regulates the activity of the hand and arm muscles to act in synergy. The central nervous system receives dynamic feedback information from visual sensors and from other body sensors located on the skin, muscles and joints while regulating the motor output. In case of developmental disorders, such as Down Syndrome, motor control may be greatly affected [1]. People with Down Syndrome may demonstrate reduced sensory acuity, lengthened reaction time, hypotonia and altered postural responses to perturbation. One of the hypotheses suggests that the source of motor difficulties originates in deficit of the central representation of actions. As suggested by the literature [1, 2]

C. Stephanidis (Ed.): Posters, Part I, HCII 2011, CCIS 173, pp. 378–382, 2011.
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practice can have positive influence on the motor skill. Haptic guidance has a significant value in many applications, such as medical training [3], hand writing learning [4], and in applications requiring precise manipulations [5]. The guiding force can be either generated by a force-feedback device, such as a Phantom haptic device [6]. There are, however, only very few assisted applications for unskilled people in order to promoting them in a specific employment role. The aim of our study was to assess how the sketching control movements under haptic feedback are affected in people with Down Syndrome. We have designed the sketching haptic device for providing assistance movements while sketching through the haptic point-based approach.

2 The Concept

The sketching device concept has been developed through a series of virtual and physical prototypes to enable the evaluation of its potential for improving 2D operations (sketching and hatching). In order to enable the 2D operations by the user, several configurations have been analyzed. Figure 1 shows both, the CAD concept and the physical prototype.

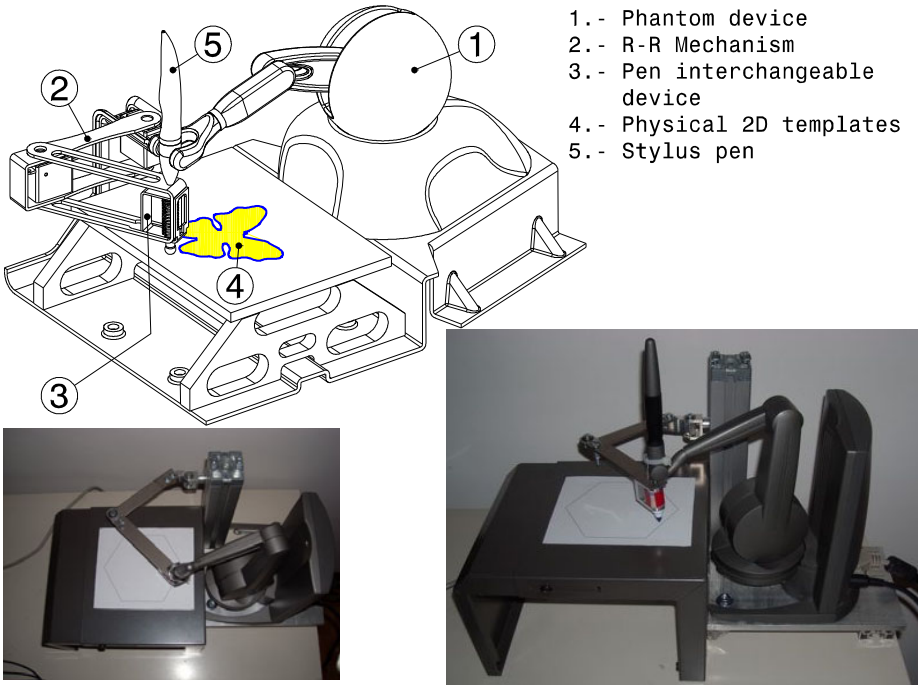

Fig. 1. CAD assembly concept and physical prototype of the sketching device

The Phantom device (1) is linked through the R-R mechanism (2) in order to provide 2 degrees of freedom. The pen interchangeable device (3) is used as a quick mechanism to change different pen's color; it is also possible to interchange the physical templates (4). 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 the virtual geometry that is used as a virtual guide. In fact, this effect is used in order to assist the user's hand.

3 Preliminary Test

We have carried out several preliminary tests in order to validate the sketching device while performing sketching and hatching tasks. The 2D operations accuracy has been measured using the Phantom device as input. The operations have been performed by tracking the stylus of the Phantom device through the DeviceLog command provided by the H3D API platform. The tracked sample rate is 25 Hz.

3.1 Sketching Operations

In this task, a 2D printed sketch has been provided with the same coordinate system of the 2D haptic sketch. First, we ask for a free sketching by using the device without the haptic support, and then the same sketch has been designed by enabling the 2D haptic sketch as a guide path.

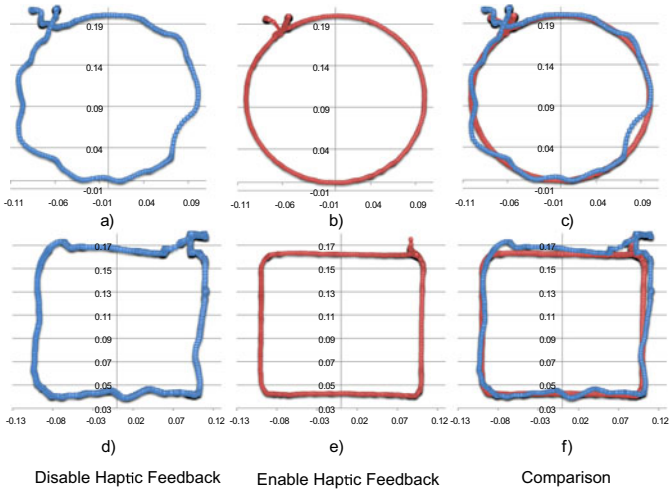

Fig. 2. Sketching geometry

Figure 2-a shows the resulting path tracked by the user's sketching operation in which the haptic feedback is off. Figure 2-b shows the same sketch operation with the haptic feedback enabled; we can observe a strong difference (Figure 2-c) in the

accuracy of the operation. Similar task has been requested using a rectangle as can be seen from Figures 2-d, 2-e and 2-f. The most evident advantage provided by the 2D haptic sketches is the accuracy.

3.2 Hatching Operations

In the hatching task we request to fill the internal surface of the butterfly sketch as can be seen in Figure 3-a. Figure 3-b shows the hatching operation performed by the user without the haptic feedback, in fact, the 2D haptic sketch has been disable. Figure 3-c shows the hatching operation with the haptic feedback enable.

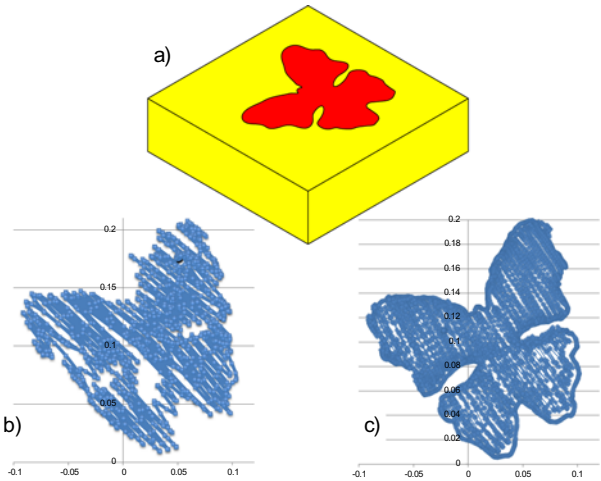

Fig. 3. Hatching an internal surface

Also in this operation, it is evident the advantage of using the 2D haptic sketches as a virtual guide for assisting the user's hand movement while hatching a region.

4 Conclusions and Future Work

The paper proposes a sketching system based on the point-based haptic approach. The main application of the haptic device is related to assisting people with Down Syndrome in the assessment and training of hand movements like sketching and hatching tasks. We explored user performance while using the haptic point-based approach. Results show that the effects of using the 2D haptic sketches increase the accuracy in the tasks operations. We are currently performing an evaluation with Down people in order to measure their improvements in 2D operations skills. In fact, this evaluation considers several parameters, which involve time, velocity, distance, and learning while the user is performing 2D operations with the sketching haptic device.

Acknowledgments. The authors would like to thank Emanuele Fedeli for his support in the preliminary evaluation of the sketching haptic device. Emanuele Fedeli provides specialized manual training for Down people at Laboratorio Artimedia (Calolziocorte, Italy).

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