Optimizing passive presentation strategies for improved interpretation of haptic replay experiences

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***Abstract*— Haptic replay, in which a passive hand experiences tactile sensations that would normally be acquired through active interaction, can facilitate training of touch-dependent tasks and sharing of haptic experiences. These applications are limited by demonstrably worse interpretation of haptic data under passive conditions. In this work, we explore a variety of passive presentation conditions, in the hopes of optimizing passive perceptual performance for haptic replay. Using a custom 2D linear stage to move shapes against a passive hand, we evaluated shape identification accuracy for three different passive presentation strategies, informed by active exploration, and compared participant performance to that during active exploration. Highest perceptual accuracy for passive presentation occurred when relative motion followed the trajectory of active movement paths at a constant velocity.**

I. Introduction

The performance of passive presentation shown by Gibson et al. presents significant limitations for possible haptic scenarios wherein the user is not in control of the motion. Passive touch resulted in worse discrimination of cookie cutter shapes presented to participants, but Gibson noted improved perception when switching from pressing shapes into participants' palms to twisting them, which suggests that not all passive presentations are equal [1]. The objective of this paper is to explore a range of passive presentations for possible improvement of passive touch performance.

II. Experimental Setup

In this paper, the tactile stimulation was provided by 3D printed shapes inspired by previous papers [1]. The shapes were on a similar scale to a finger pad (d < 1.5 cm). To present these shapes passively, an X-Y stage was used to move the shapes against the participant's fingers. The shapes and setup are shown in Figure 1.

III. Procedure

First, five participants were recorded actively exploring the shapes without visual feedback; see representative finger motion in Figure 2. Our analysis of finger movement identified strategies later incorporated into the passive methods. Second, twelve participants performed blind shape identification under two passive methods: a constant speed method in which the movement path mimicked active exploration paths but at constant speed, and a variable speed method that more closely mimicked the movements and speeds seen in active exploration. Order of method was varied across participants and three shapes of the six were presented in a randomized order. The constant speed was kept at 1.25 cm/s, while the variable speed method had two speeds, a high speed (3.1 cm/s) for straight lines, and a low speed (0.63 cm/s) for corners, inspired by active strategies. Five participants performed shape identification using pressing (having the examiner push the shape guided by rails into the participants index finger) and active methods.

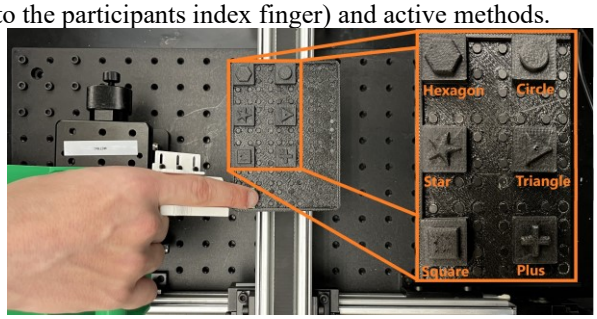

Figure 1. Experimetnal Setup

IV. Preliminary Results

Participant responses are shown in confusion matrices in Figure 2. The active method had 100% accuracy. The constant speed, variable speed, and pressing methods were 83%, 69%, and 40% accurate, respectively.

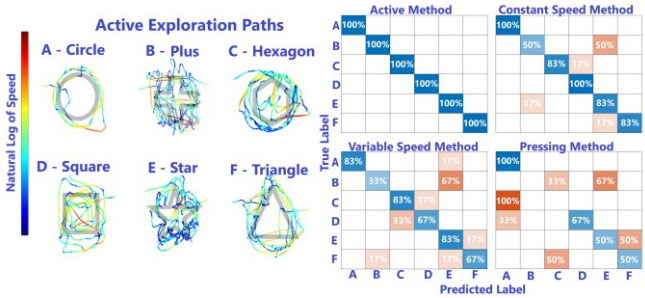

Figure 2. Preliminary Results

V. Preliminary Conclusions

As predicted, the active method had the highest accuracy, serving as the gold standard for perceptual performance. Contradicting our hypothesis, performance using the variable speed method was below that of the constant speed method, although both outperformed passive pressing. Constant speed may have better enabled participants to estimate their relative hand location under passive conditions. The pressing method may perform worst as it does not provide sufficient tactile data. Upcoming studies will explore the interplay of passively presented haptic data with concurrent visual feedback of active hand position, which may supplement or otherwise affect hand localization.

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