Frequency Modulation Based Vibrotactile Device for Teleoperation

H. P. Pham and R. Chellali.

***Abstract*—We present here a portable haptic system for displaying various signals to achieve interception or path following tasks with a limited number of vibrotactors. This haptic interface conveys vibrotactile information to the operators using Handissima [1]. The vibrotactors are triggered individually or simultaneously to carry out information to guide user to reach a fixed or moving target.**

I. Introduction

PREVIOUS studies about spatial acuity have shown that human capacity to discriminate two simultaneous vibrotactile stimulations different in amplitude/frequency was aggraded when an adapting stimulus was used just before every trial. Further, subjects' performance was better if the stimuli were presented sequentially [2]. However, these techniques do not satisfy real-time constraints of various tasks in VR and teleoperation. This paper investigates a configuration of modulated vibration signals to overcome human limitations of vibrotactile spatial/frequency discrimination. We aim to using tactile channel to assist operator in interception or path following task. Thus let kinesthetic haptic and visual senses free to process other displayed information. Experimentation on ten subjects has been carried out for verifying this configuration

II. Experiments

Ten subjects participated in two experiments. During experiments, all were blindfold and let listen to pink-noise. In every experiment, they passed 3 series of 10 trials. In the first experiment, subjects found hard to indentify the stronger between two vibrotactors (50 mm apart) delivering stimuli at 170 Hz and 100 Hz to subjects hand dorsum (Fig. 1 (a)). In the second experiment, a low frequency modulation was applied: either both or each vibrotactor was repeatedly activated for a short period (from 0.2 to 1 s) then stopped for another period. This configuration aggraded subjects' spatial discrimination and also gave several possibilities for stimuli combining (Fig. 1 (b)). With these advantages, frequency modulation was chosen to guide operator towards targets. Experiments of moving a proxy following a straight line to a defined target with Handissima and Virtuose 6D 34-45 [3] have been done in 3 mode: visual, uninterrupted, and modulated vibrotactile.

P. H. Pham is with the Italian Institute of Technology, Genoa, Italy (Phone: +39 328 327 2265; e-mail: phong.pham-huynh@iit.it).

R. Chellali is with the Italian Institute of Technology, Genoa, Italy (ryad.chellali@iit.it).

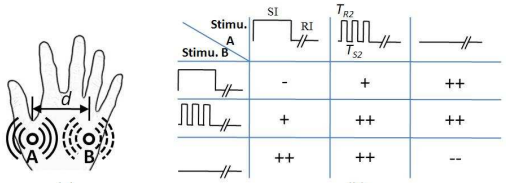

Fig. 1. Vibrotactile frequency modulation protocol. a) Two vibrotactors on Handissima [1] located 50 mm apart give stimuli on the hand dorsum. b) Discrimination possibilities for combining frequency modulation vibrotactile. ++ stands for high discrimination, + is for average discrimination, and – shows low spatial resolution.

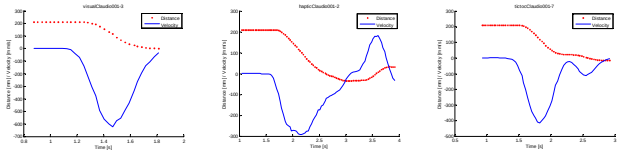

Fig. 2. Proxy's position (red dot) and velocity profile (blue line) in (a) visual, (b) long modulated, and (c) modulated vibrotactile experiments.

III. Results

Results from experiments of targeting above have shown that velocity profiles of the proxy are similar but in different time scale (Fig. 2). Modulated vibrotactile aggraded subjects' performance in position error and trajectory length. Thus, if the difference in time scale between visual and tactile satisfies task requirements, we can utilize vibrotactile to convey visual information.

IV. Discussion

This work is part of an IIT's project investigating new sensory feedback paradigm for teleoperation systems dedicated unfamiliar physics worlds. In addition, Handissima is portable, gravity free which is useful to supply vision/haptics in interception or path following tasks in space applications.

V. Future Work

The system will be developed to assist operator in targeting in 2-D and 3-D space.

References

[1] TERA Team (IIT), "Handissima, a wireless cyber-glove system," unpublished.

[2] Z. Zhang, V. Tannan, J. K. Holden, R. G. Dennis, and M. Tommerdahl, "A quantitative method for determining spatial discriminative capacity," BioMedical Engineering OnLine, Vol. 7 (10 March 2008), 12.