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Evaluation of a Haptic Macro-Micro Tele-Manipulation System

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Abstract

In this paper the evaluation of a novel haptic macro-micro tele-manipulation system is presented. The system includes an interface between a haptic mechanism and a mobile microrobotic platform driven by two centripetal force actuators. The unique characteristics and challenges that arise during the haptic micromanipulation using the specific microrobotic platform are described. The tele-manipulation control environment is also presented. The entire system is evaluated through the execution of simulations and manipulation experiments. The results demonstrate that despite the complicated interaction between the haptic mechanism and the mobile microrobotic platform, the successfully accomplished micromanipulation task appears to the operator as a simple and intuitive manipulation operation.

Keywords: Haptics, Force feedback devices, Micromanipulation

1 Introduction

Recently, several mechatronic systems have been proposed that aim at the tele-manipulation of objects in the micro and nano scale. The examples in (Kwon, et al, 1999) employ haptic devices as master manipulators. The main fields of application of such haptic micromechatronic systems are microsurgery, biomedical operations (such as cell injection), micro-fabrication, and microassembly, (Menciassi, et al, 2003). The main contribution of this paper is that for the first time a centripetal force actuated microrobotic platform is considered as the slave driven by a conventional master haptic mechanism.

2 Description of the Haptic Tele-manipulation System

The proposed haptic tele-manipulation environment employs an existing 5-dof haptic mechanism as the master and a 2-dof microrobotic platform driven by two centripetal force actuators as the slave, (see Fig 1). The devices are described in detail in (Vlachos, et al, 2003) respectively. Several limitations and challenges that arise due to the physics of the microrrobotic platform's actuation mechanism define the requirements of the master haptic device and provide design guidelines.

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(a) (b)

Fig 1. (a) The haptic master device. (b) The slave microrobotic platform.

3 Description of the Haptic Tele-manipulation Environment

There is a bilateral communication between the main elements of the haptic tele-manipulation system, e.g. the master haptic device and the slave microrobotic platform. In order to realize the first communication channel from the haptic mechanism to the microplatform, three input modes are defined. These are the *Macroscopic*, the *Macroscopic Rotation*, and the *Microscopic* modes. In order to realize the second communication channel from the microrobot to the haptic mechanism, we define two control phases, the *Macroscopic* and the *Microscopic* control phases. The input modes and the control phases are described in detail.

4 Experimentation and Evaluation

First, the experimental setup is presented. It consists of three blocks. The first is the *Macro block*, where the operator translates the haptic device end-effector in the X axis and rotates it about the Y axis. Then is the *Micro block*, which consists of the microrobot, a needle-type cantilever manipulator (see Fig. 1b) with an on-board 1-dof strain gauge force sensor, and the driving PWM circuits. The last block is the *Data Acquisition block*. The scenario of the conducted experiments involves three tasks. The first task is the driving of the slave platform towards a micro target, the second task is the micromanipulation of the target (pushing operation), and the last task is the return of the micro platform to its initial position. Finally, the experimental results are presented and evaluated.

5 Conclusions

In this paper the evaluation of a novel haptic macro-micro tele-manipulation system is presented. The system includes an interface between a haptic mechanism and a microrobotic platform driven by two centripetal force actuators. It is shown, that while the interaction between the haptic mechanism and the vibration driven device is complicated, the execution of the micromanipulation tasks is successful and appears to the operator as a simple and intuitive operation.

6 References

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