SKILLS
Multimodal Interfaces for Capturing and Transfer of Skill

PERCRO Perceptual Robotics Laboratory

Control Strategies and Perception Effects in Co-located and Large Workspace Dynamical Encountered Haptics

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1. Abstract

The present work focuses on perceptual control of haptic manipulation during high frequency interaction with mobile objects, in particular on the analysis of the control and the erceptual issues of throwing and catching in juggling. A training multimodal system that exploits the concepts of co-located visuo-haptic feedback and encountered interfaces has been implemented. Using such a system the user juggles with a number of virtual balls that are in contact with him from catch to throw. The control design of the system has been supported by a psychometric validation of the catch contact.

2. Setup of the System

The overall system (figure 1) is composed by five computer, one dedicated to haptic control, one for the tracking system and three for the stereo projection and graphical rasterization. The master computer generates the graphical packets and the slaves PCs display the correct images trough four projectors. The system was composed by two GRAB robotic arms (reaching a workspace 1200 mm wide) that where placed inside an L-shaped projection environment composed of two large projection screens: one frontal, the other as a walkable floor. The environments was also equipped with a VICON Mx (OMG,UK) infrared camera system, working at 300hz, used as head tracking system to grant correct stereo projection to the user immersed in the virtual reality simulation.

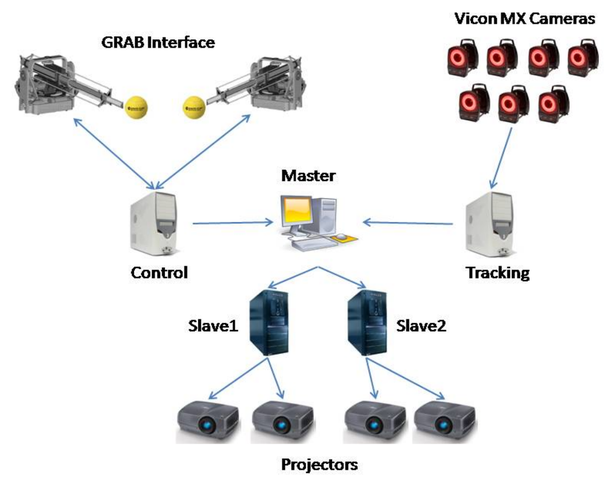
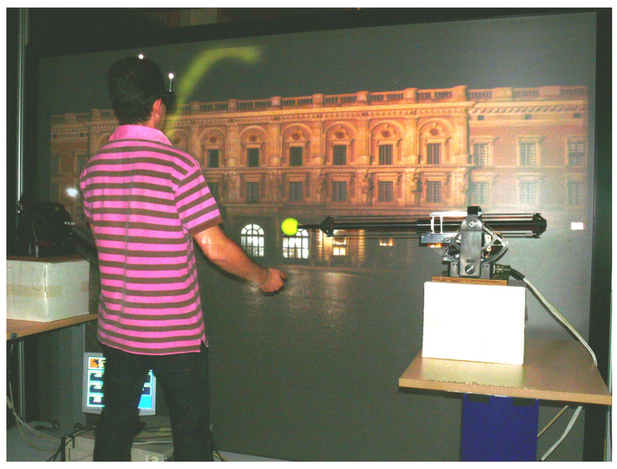
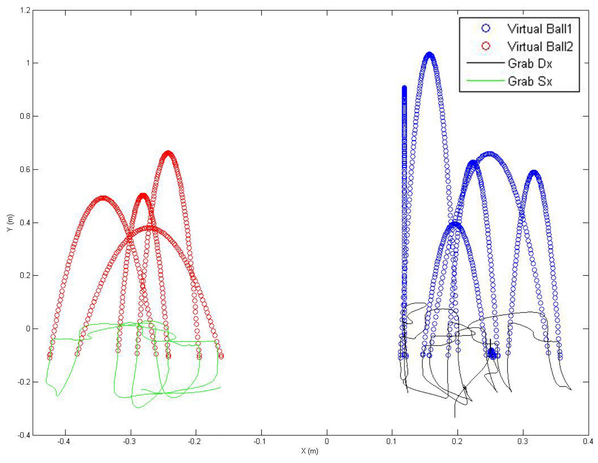
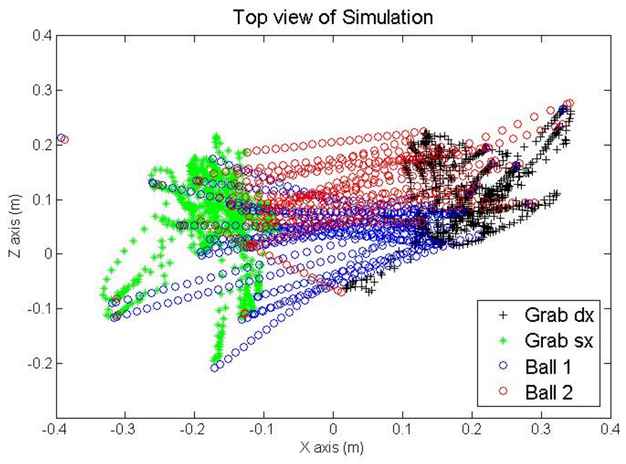


Figure 1. The Juggling Training System







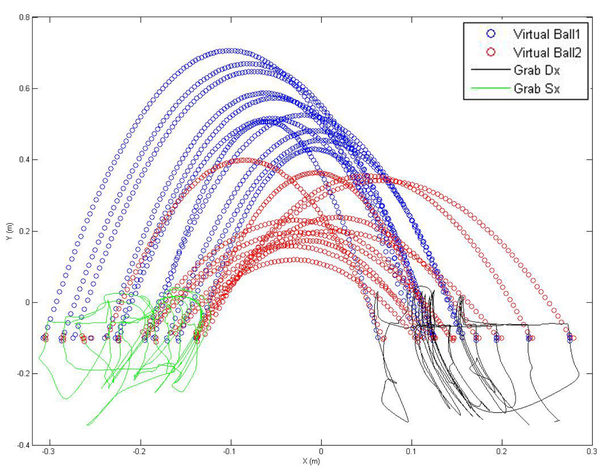


Figure 2. A trial session with trajectory plots

3. Dynamic encountering

The interaction with mobile objects requires additional issues to the haptic devices adopted. The correct representation of Mass/Inertia properties is fundamental to improve transparency condition of the environment during manipulation phases. The control of reflected inertia is possible by means of a closed loop feedback on the motor torque which can partially compensate for or enhance the real inertia of the haptic device. On the other side tracking of velocities of both haptic device and objects are of high importance for a clean rendering in the instant of contact of the user hand with the virtual objects. A particular attention should be given to energy transfer during impact when the high frequency of the velocity change may affect the real perception of masses. The Mechanical bandwidth of these systems is well below the typical frequencies expressed during impact. It is then required that compensation of the impact energy should be performed by an explicit pre-warping of the haptic velocity to maintain the consistence of the perception.

4. Perceptual evaluation

The tests performed were intended to investigate perception thresholds of users with both real tennis balls and haptic simulated tennis balls. We adopted a 2 alternative forced choice(2-AFC) design choosing the reference stimulus to be a ball falling down from an height of 15 cm to the palm of observer's hand. The algorithm used to perform the psychometric analysis is the QUEST proposed by Watson and Pelli. In particular we proposed a two interleaved QUEST to prevent the creation of a strategy by the experimenter. The experiment results confirmed the hypothesis that during control there's the need of a factor to compensate for the mechanical inertia of linkages at impact.

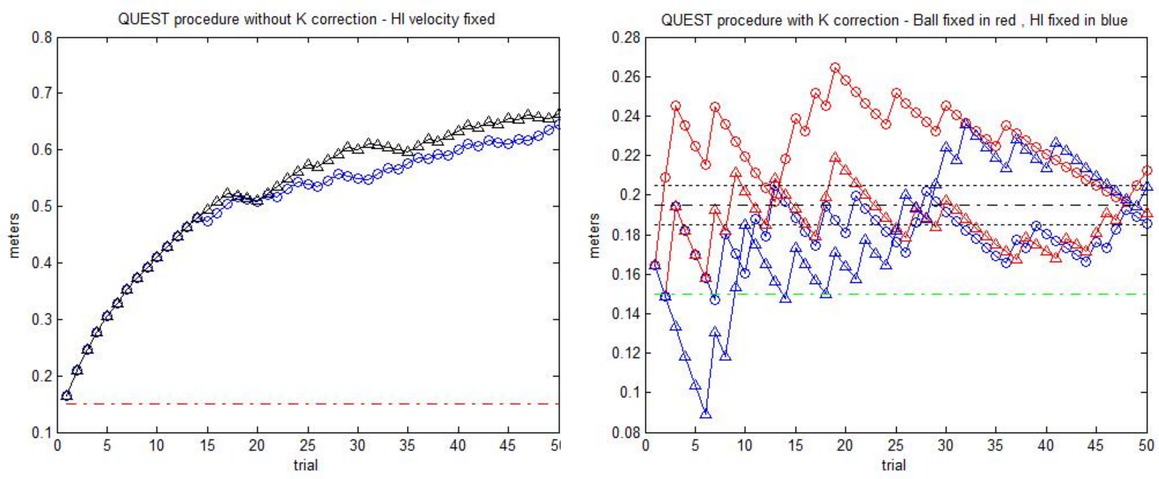


Figure 3. Results of the psychometric analysis

Acknowledgments

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