Tele-Kinesthetic Interaction: Using Hand Muscles to Interact with A Tangible 3D Object

Y. Koike*
Tokyo Institute of Technology

K. Nakakoji†
SRA Key Technology Laboratory Inc.,
University of Tokyo

Y. Yamamoto‡
University of Tokyo

Abstract

Our tele-kinesthetic interaction environment, consisting of MyKinSynthesizer and SPIDARmotion, allows a user to remotely interact with a physical object by moving and straining his/her hand. MyKinSynthesizer approximates the user's hand's motion with force by synthesizing EMG signals. SPIDARmotion displays the 3D motion of a hanging ball within a cubic frame.

Keywords: EMG, SPIDAR, interaction

1 Overview

The goal of this project is to demonstrate a tele-kinethetic interaction environment, where a user can remotely interact with a 3D physical object hanging in a cubic space by moving and straining his/her hand.

The core technical innovations demonstrated in this work consist of three components (Figure 1): (1) MyKinSynthesizer (MyoKinetic

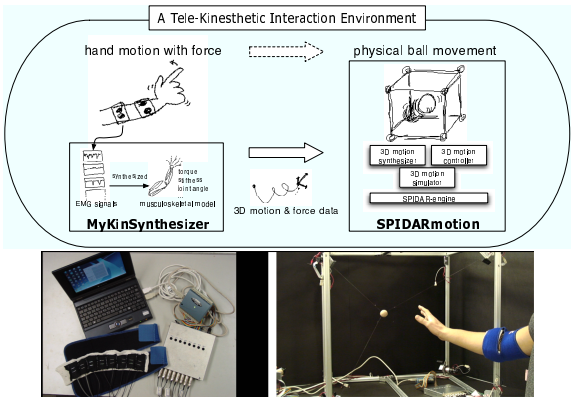

Figure 1: A Tele-Kinesthetic Interaction Environment

Synthesizer), a technology that approximates a user's hand motion and force through a musculo-skeletal model synthesized from EMG signals [Koike and Kawato 1995], (2) SPIDARmotion, a physical tangible display device displaying the 3D motion of a hanging ball within a cubic frame based on the SPIDAR technology [Ishii and Sato 1994], and (3) the integration of the two technologies to realize a tele-kinesthetic interaction environment.

*e-mail: koike@pi.titech.ac.jp
†e-mail: kumiyo@kid.rcast.u-tokyo.ac.jp
‡e-mail: yxy@kid.rcast.u-tokyo.ac.jp

2 Mechanisms

MyKinSynthesizer is a technique we have developed to synthesize EMG signals over multiple EMG electrodes placed on a person's forearm to develop a musculo-skeletal model of the human body. The musculo-skeletal model represents rich sources of temporal motion information, including time-varying data on torque, stiffness, joint angles, and postures. We use this model to approximate the person's intended 3D motion and force.

SPIDARmotion is an extended version of SPIDAR, which has been developed over the years by Sato et al. as a haptic display device and used as a 3D input device. SPIDAR has a small ball as an effector, positioned at the center of a cubic frame. The ball is held by four (or eight, depending on different versions) strings, each of which goes to a separate corner of the cubic frame. Each string is wound around a pulley attached to a DC motor placed in each of the corners. The position of the ball within the 3D space of the cubic frame is controlled by adjusting the tension and the length of each string via the motor. We have developed SPIDARmotion by extending SPIDAR so that the position and the movement of the ball can be programmed by controlling the behavior of the DC motors. The 3D motion simulator and the 3D motion controller components of SPIDARmotion generate the motion of the ball based on preprogrammed behavior, such as an oscillating pendulum obeying the gravity. The 3D motion synthesizer component of SPIDARmotion takes 3D motion and force data as an input as external force added to the current 3D motion of the ball.

We integrate MyKinSynthesizer and SPIDARmotion by dynamically feeding the 3D motion and force data of the user's hand calculated by MyKinSynthesizer into SPIDARmotion. When the user moves and strains the hand, the motion of the ball of SPIDARmotion is updated by taking into account the user's hand's motion and force data. Thus the user would feel as if he/she is engaged in a tele-kinesthetic interaction with the ball of SPIDARmotion.

Our premise is that people can tele control 3D objects more properly using their body movement and force, and that the use of EMG gives people a natural way to interact with a 3D object; even if it happens remotely. This work gives a starting point for the space of tele-kinesthetic interaction, where people naturally use their kinesthetic skill to remotely interact with a 3D object. We hope that the technical framework is going to help develop a platform for the important areas of HCI research, such as media art, entertainment, education, and scientific simulation, which explore the relationships between kinesthetic skills and interactions with physical objects.

References

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