Chapter VII

Myoelectric Teleoperation of a Dual-Arm Manipulator Using Neural Networks

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Abstract

In this chapter, an advanced intelligent dual-arm manipulator system teleoperated by EMG signals and hand positions is described. This myoelectric teleoperation system employs a probabilistic neural network, so called log-linearized Gaussian mixture network (LLGMN), to gauge the operator’s intended hand motion from EMG patterns measured during tasks. In addition, an event-driven task model using Petri net and a non-contact impedance control method are introduced to allow a human operator to maneuver a couple of robotic manipulators intuitively. A set of experimental results demonstrates the effectiveness of the developed prototype system.

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**Introduction**

Many researchers have actively studied teleoperation technology as an effective human interface for supporting an operator in various tasks. However, current technology is still far from realizing an autonomous robotic system that has high intelligence for auto-recognition and judgment in human task situations. If the operator can control a tele-exist slave-robot as his own arm with natural feeling, task performance will increase.

In this chapter, an advanced intelligent dual-arm manipulator system teleoperated by EMG signals and hand positions is described. The presented myoelectric teleoperation system employs a probabilistic neural network, so called log-linearized Gaussian mixture network (LLGMN), to gauge the operator’s intended hand motion from EMG patterns measured during tasks. In addition, an event-driven task model using Petri net and a non-contact impedance control method are introduced to allow a human operator to maneuver a couple of robotic manipulators intuitively. A set of experimental results demonstrates the effectiveness of the developed prototype system.

**Background**

In the late 1940s, Argonne National Laboratory developed the first teleoperation system that could handle radioactive materials in a nuclear reactor using a robotic manipulator from outside. The motion of the master-arm was transmitted to the slave-arm in the nuclear reactor via a mechanical link structure (Sheridan, 1992). Fundamental concept of current teleoperation systems using electric signals was proposed by Goertz (1954). Since then, many researchers have actively studied teleoperation technology as an effective human interface for supporting an operator in various tasks (Shimamoto, 1992; Yokokohji & Yoshikawa, 1994; Yoon et al., 2001; Mobasser et al., 2003; Ueda & Yoshikawa, 2004).

Some teleoperation tasks require dexterous manipulation of a robotic arm. If the operator can control a tele-exist slave-robot as his own arm with natural feeling, task performance will increase. However, controlling the robot manipulator by means of a conventional interface system, such as a joystick or a master-arm robot, is difficult because it requires highly skilled and experienced system operators. Experimental studies utilizing bioelectric signals, such as electroencephalogram (EEG) and electromyogram (EMG) as an input of the interface system have been undertaken (Farry et al., 1996; Kim et al., 2001; Englehart & Hudgins, 2003; Suryanarayanan & Reddy, 1997; Tsujiuchi et al., 2004; Wolpaw
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