Chapter 41

Surface EMG and Upper-Limb Rehabilitation

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ABSTRACT

In rehabilitating hemiplegic patients, purposeful movements such as the opening and closing of hands are reported to be more effective than passive movement with an instrument. The authors of this chapter used surface electromyogram (surface EMG) signals as a way to convey the patient’s conscious ability to open and close their hands. The muscles in the forearm contract when the hand is closed or opened, which creates a simple signal that is comparatively easy to measure with surface EMG, a simple measuring device. The action potentials of the muscles involved in the opening-and-closing motions of hands were measured from several points in the forearm when those muscles contracted, and their distribution was analyzed. The purpose of this study is to develop a simple system to recognize the movement of a patient’s hand using measurements of EMG signals from only the most characteristic points on the forearm to replace similar, but more complex, research such as multi-channel measurement and wave analysis by FFT. The authors specified the optimum measuring points on the palm and dorsal sides of the forearm for the recognition of hand motion by the experimental system. This system successfully recognized hand motion through the analysis of the surface EMG signals measured from only two optimum points to allow arbitrary control of the rehabilitation device based on the recognition results.

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INTRODUCTION

There are various rehabilitation strategies involving an instrument for patients who suffer from paralysis in a part of their body as a result of disease or injury. For example, hemiplegic patients who cannot open and close their hands caused by a blockage of their nerve pathways due to neurofunctional disorders such as apoplexy can use rehabilitation instruments to assist them in opening and closing their hands. By using such an instrument, however, patients can perform only passive rehabilitation movements. Purposeful movement to open and close their hands has been reported to be more effective than passive movement with an instrument for the rehabilitation of hemiplegic patients (Lum, Burgar, Shor, Majmundar, & Loos, 2002; Lindberg, Schmitz, Forssberg, Engardt, & Borg, 2004; Hogan, Krebs, Rohrer, Palazzolo, & Dipietro, 2006). This active rehabilitation under strong consciousness is believed to greatly contribute to the rebuilding of patient’s nerve pathways. Under this form of rehabilitation, the conscious act of opening-and-closing their hands needs to be fed back into a rehabilitation instrument to maintain arbitrary control over the instrument.

The analysis of patient brain-waves is one method for conveying their consciousness to an instrument, but this type of analysis during the purposeful movements of opening-and-closing hands is a large, complex problem and also requires large-scale measuring devices. Instead of brain-waves, surface EMG can be used as a measurement of consciousness for the opening-and-closing of hands because the operation of muscles in the forearm generates a signal that is comparatively easy to measure with simple measuring devices. For example, patients can actively control a rehabilitation instrument by using the action potential of their muscles measured from their forearms on their normal side as a signal of consciousness for opening-and-closing hands (Figure 1). Because this method is a form of active rehabilitation, a high rehabilitation effect can be expected. This method requires measurement of surface EMG from the forearm on the normal side while opening-and-closing the hand and construction of a system that recognizes the motion of the hand from the action potential signal.

The purpose of this study is to develop a simple system to recognize the motion of the hand and support the movement of a patient’s hand.

Figure 1. Conceptual diagram of the rehabilitation efforts