The Implementation OF Prosthetic Index Finger Based On EMG Signals

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Abstract

The main goal of this paper is to provide an integrated design of the artificial index finger and to present the result of human like behavior. The big advantages of the prosthetic index finger are their incredible small size, volume and weight, their low cost .This paper describes our implementation of one finger of a future biomechatronic hand and remote control .This index finger captures the muscle activity like human index finger. The purpose of this paper is to illustrate the methodology for EMG signal analysis to provide efficient and effective ways of understanding the signal and its nature.

Keybords: Index Terms-EMG, Hilbert Transform, Neural Network.

1. Introduction

Small electrical currents are generated by muscle fibres prior to the production of muscle force. These currents are generated by the exchange of ions across muscle fibre membranes, a part of the signaling process for the muscle fibres to contract. The signal called the Electromyogram (EMG) can be measured by applying conductive elements or electrodes to the skin surface, or invasively within the muscle. Surface EMG is the more common method of measurement, since it is non-invasive and can be conducted by personnel other than Medical Doctors, with minimal risk to the subject. Measurement of surface EMG is dependent on a number of factors and the amplitude of the surface EMG signal (sEMG) varies from the uV to the low mV range.

There are many applications for the use of EMG. EMG is used clinically for the diagnosis of neurological and neuromuscular problems. It is used diagnostically by gait laboratories and by clinicians trained in the use of biofeedback or ergonomic assessment. EMG is also used in many types of research laboratories, including those involved in biomechanics, motor control, neuromuscular physiology, movement disorders, postural control, and physical therapy.

In this paper, we propose and develop a new prosthetic index finger based on the EMG signals. The proposed system uses EMG signals to realize a control of the prosthetic index finger.

Fig.1. Prosthetic index finger

2. The prosthetic index finger

This prosthetic index finger used in **the bionic man** machine control system and remote control is shown in fig. 1.The prosthetic index finger is almost same size as an adult's index finger .This prosthetic index finger is driven by the stepper motor .This prosthetic index finger adapts the same shape when the human finger open and close. In the base joint of index finger, we use one electrode .

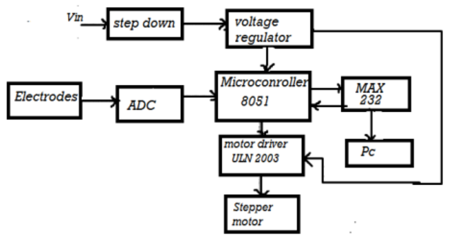


fig.2 The system of the control circuit

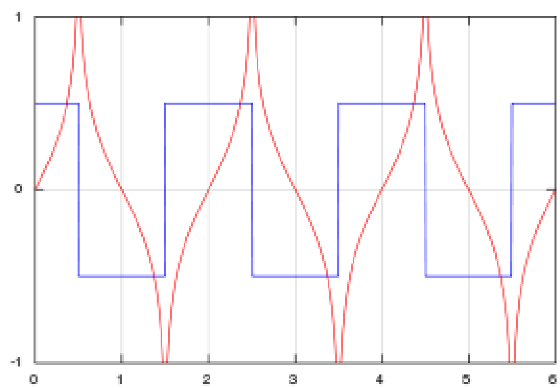
3. Control circuit system

The control circuit system of the prosthetic index finger is presented in fig.2.Microcontroller 8051 is used, which will drive the prosthetic index finger using the stepper motor. The communication with PC is realized by max232.Emg signals from electrode communicate with motor controller through 8051microcontroller.The complete control circuit board implement on the PCB .EMG signals are used as the control signals to control the prosthetic index finger. These signals are measured from the operator's forearm muscles when the operators contract their muscles to control their finger motion.

4. Methodology

In mathematics and in signal processing, the Hilbert transform is a linear operator which takes a function, $u(t)$, and produces a function, $H(u)(t)$, with the same domain. The Hilbert transform is named after David Hilbert, who first introduced the operator in order to solve a special case of the Riemann–Hilbert problem for holomorphic functions. It is a basic tool in Fourier analysis, and provides a concrete means for realizing the harmonic conjugate of a given function or Fourier series. Furthermore, in harmonic analysis, it is an example of a singular integral operator, and of a Fourier multiplier. The Hilbert transform is also important in the field of signal processing where it is used to derive the analytic representation of a signal $u(t)$.

The Hilbert transform was originally defined for periodic functions, or equivalently for functions on the circle, in which case it is given by convolution with the Hilbert kernel. More commonly, however, the Hilbert transform refers to a convolution with the Cauchy kernel, for functions defined on the real line R (the boundary of the upper half-plane). The Hilbert transform is closely related to the Paley–Wiener theorem, another result relating holomorphic functions in the upper half-plane and Fourier transforms of functions on the real line.



In this fig. The Hilbert transform, in red, of a square wave, in blue.

The Hilbert transform of u can be thought of as the convolution of $u(t)$ with the function $h(t) = 1/(\pi t)$. Because $h(t)$ is not integrable the integrals defining the convolution do not converge. Instead, the Hilbert transform is defined using the Cauchy principal value (denoted here by p.v.) Explicitly, the Hilbert transform of a function (or signal) $u(t)$

is given b $$H(u)(t) = \text{p.v.} \int_{-\infty}^{\infty} u(\tau)h(t-\tau)\,d\tau = \frac{1}{\pi}\ \text{p.v.} \int_{-\infty}^{\infty} \frac{u(\tau)}{t-\tau}\,d\tau,$$

provided this integral exists as a principal value. This is precisely the convolution of *u* with the tempered distribution p.v. $1/\pi t$ (due to Schwartz (1950); see Pandey (1996, Chapter 3)). Alternatively, by changing variables, the principal value integral can be written explicitly (Zygmund 1968, §XVI.1) as

$$H(u)(t) = -\frac{1}{\pi} \lim_{\varepsilon \downarrow 0} \int_{\varepsilon}^{\infty} \frac{u(t+\tau) - u(t-\tau)}{\tau}\,d\tau.$$

When the Hilbert transform is applied twice in succession to a function *u*, the result is negative *u*:

$$H(H(u))(t) = -u(t),$$

provided the integrals defining both iterations converge in a suitable sense. In particular, the inverse transform is $-H$. This fact can most easily be seen by considering the effect of the Hilbert transform on the Fourier transform of $u(t)$(see Relationship with the Fourier transform, below).

For an analytic function in upper half-plane the Hilbert transform describes the relationship between the real part and the imaginary part of the boundary values. That is, if $f(z)$ is analytic in the plane Im $z > 0$ and $u(t) = \text{Re}\, f(t + 0\cdot i)$ then $\text{Im}\, f(t + 0\cdot i) = H(u)(t)$ up to an additive constant, provided this Hilbert transform exists.

5. Conclusions

EMG signal carries valuable information regarding the nerve system. So the aim of this paper was to give brief information about EMG and reveal the methodology to analyze the signal. This study clearly points up the various types of EMG signal analysis techniques so that right methods can be applied during any clinical diagnosis, biomedical research, hardware implementations and end user applications. A prosthetic finger system based on the EMG signals is proposed and developed in this paper. In order to achieve simplicity, lightweight, dexterity underactuated self adaptive theory is adopted to decrease the weight. The feature of the control system is that it uses a VLR based Hilbert transform two EMG patterns. We use this prosthetic finger for remote control and for those people who has no index finger. The experimental results showed that using Hilbert transform has high recognition ability even for several samples of each motion.

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