Quantitative Estimation of Muscle Fatigue for Human Workers

Muscle fatigue is commonly associated with the musculoskeletal disorder problem, especially for those who perform monotonous or repetitive works such as assembly workers. This phenomenon has introduced the needs of monitoring the degree of muscle fatigue in the field of ergonomics and physiological research. Previously, various techniques have been proposed to index the muscle fatigue, however, quantitative measurement is still difficult to achieve. Muscle fatigue is a continuous process, which evolves over time depending on the effort exerted. The development of muscle fatigue will decrease the maximal muscle capacity to generate force. In this study, a fatigue model is constructed by assuming that the amount of muscle capacity lost is equivalent to the degree of muscle fatigue. A series of static contraction experiments (at 50% MVC) is conducted using a handgrip dynamometer to investigate the relationship between the handgrip work and the total force lost. This relationship is then modeled using an exponential fit as shown in Fig. 2. After that, the degree of muscle fatigue is estimated by calculating the handgrip work (which is the independent variable of the proposed fatigue model) from surface electromyography (SEMG) using the frequency-band technique [1]. The error of the estimated muscle fatigue from 10 subjects is shown in Fig. 3. The results show no significant difference ($p > 0.05$) between the estimated value from the SEMG signal and the one measured using a dynamometer. The fatigue model is only valid to the contraction level where it was calibrated. Similar procedures are required to reconstruct another model before it can be applied to different force levels.

Keywords: Surface electromyography (SEMG), muscle fatigue.

Reference

1) Y. Soo, M. Sugi, M. Nishino, H. Yokoi, T. Arai, R. Kato, T. Nakamura, and J. Ota, “Quantitative estimation of muscle fatigue using surface electromyography during static muscle contraction,” *31st Annual International Conference of the IEEE EMBS*, pp. 2975-2978, 2009.

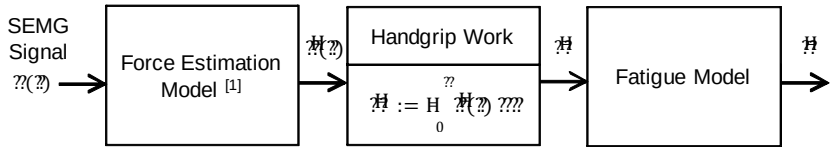

Fig. 1. Process for estimating the degree of muscle fatigue from the SEMG signal. The model has to be calibrated for each subject.

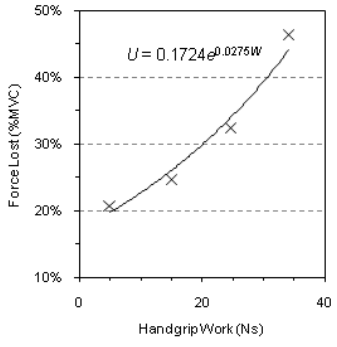

Fig. 2. An example of a fatigue model for one subject, which represents the relationship between the force exerted and the handgrip work.

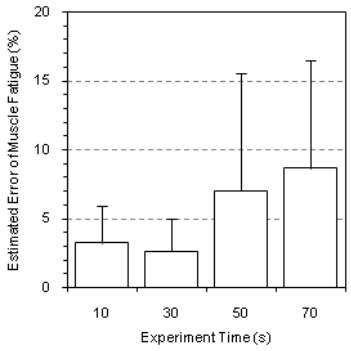

Fig. 3. Mean and standard deviation from 10 subjects, compared between the degrees of muscle fatigue estimated from the SEMG signal and the actual value measured using a dynamometer.