Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 23
ISSUE 2
August
2007

Finger curvature movement recognition interface technique using SEMG signals

Y. Itoh [a,*], H. Uematsu [b], F. Nogata [c], T. Nemoto [a], A. Inamori [a], K. Koide [a], H. Matsuura [a]
[a] Department of Gerontechnology, National Institute for Longevity Sciences, NCGG, 36-3 Gengo, Morioka, Obu, 474-8522 Aichi, Japan
[b] Graduate School of Engineering, Gifu University, 1-1 Yanagido, 501-1193Gifu, Japan
[c] Department of Human & Information Systems, Gifu University, 1-1 Yanagido, 501-1193 Gifu, Japan
* Corresponding author: E-mail address: yito@nils.go.jp

Received 11.04.2007; published in revised form 01.08.2007

Properties

ABSTRACT

Purpose: Until recently, keyboard has been used as the primary input method for machinery operation system. But in recent years, numerous methods related to direct input interface have been developed. One of them is to measure the surface electric potential that generates on the skin surface during muscle contraction. Based on this fact, hand finger operation can also be recognized with the help of the surface muscle electric potential. The purpose of this study is to identify the hand finger operation using surface electromyogram (SEMG) during crookedness state of the finger.

Design/methodology/approach: Two electrodes (Ag-AgCl electrode) were sticked randomly on the forearm muscles and the intensity of EMG signals at different muscles were measured for each crooked finger. Then depending on the intensity of the obtained electric potentials, a position was located and considered to have participated most actively during the crookedness state of that finger. Thus five locations on the forearm muscles were identified for five different fingers. Moreover, four different types of crookedness states were considered for each finger.

Findings: In this experimental study, the electric current that generates on the skin during muscle activity was measured for different hand finger operations. As a result, it is found that there is a specified position related to the maximum intensity of EMG signals for each finger.

Practical implications: This paper cleared that the amount of crookedness of each finger can also be recognized with the help of surface EMG. It could be used as a machine interface technology in the field of welfare equipments, robot hand operation, virtual reality, etc.

Originality/value: The objective of this research project was to develop the method of recognizing the hand finger operation and their crookedness states from surface electromyogram (SEMG).

Keywords: Non-destructive testing; Biomaterials; EMG signal; Finger flexure movement; Muscle activity

1. Introduction

Until recently, keyboard has been used as the primary input method for machinery operation system. But in recent years, numerous methods related to direct input interface have been developed. One of them is to measure the surface electric current on the skin overlying the muscle [1-7]. When muscles are active, they produce an electric current that is usually proportional to the level of muscle activity [8-14]. Based on this fact, it is considered that hand finger operation can also be recognized with the help of the surface muscle electric current. This report mainly explains the method of recognizing the hand finger operation and their crookedness states from surface electromyogram (SEMG). It is expected that this study will be in use as a new machine interface technology in the field of welfare equipments, robot hand operation, virtual reality, etc [15].

2. Surface EMG

With the free movement of the hand, either the thumb faces the other fingers, or all the fingers move independently. Thus, the muscles that operate the fingers have complicated structure. The muscles operating the joints of different fingers are normally generated from the arm or hand. Three kinds of muscles that generated from the arm participate in flexure of fingers. They are flexure digitorum superficialis muscle, flexure digitorum profundus muscle and flexure pollicis longus muscle. The flexure pollicis longus muscle participates in flexure of the thumb, where as flexure digitorum superficialis muscle and flexure digitorum profundus muscle participate in flexure of the index finger, middle finger, ring finger and small finger. It is known that the muscle belly of these above mentioned muscles are located on the forearm portion. This experimental study was conducted considering that by measuring the surface EMG from the forearm portion, it is possible to recognize the flexure operation of the finger.

3. Experimental method

3.1. Electrode sticking position

Fig.1 illustrates different measurement points where electrodes to be placed for interfacing hand finger operation.

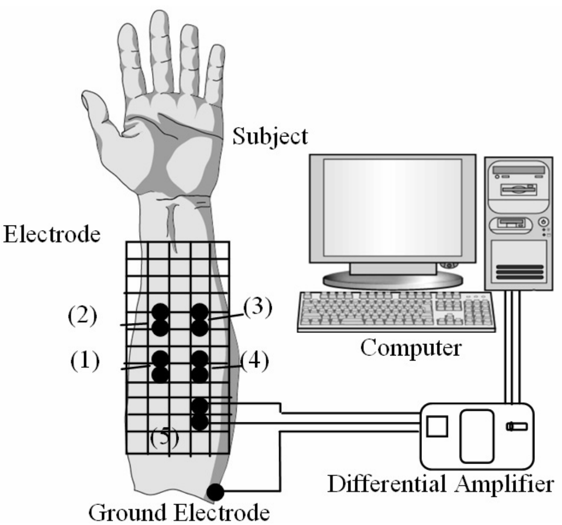

Fig. 1. Different measurement points where electrodes to be placed for interfacing hand finger operation

To examine strong voltage area, two exploring electrodes (Ag-AgCl electrode) along with a reference electrode were sticked in a reticular pattern on the forearm muscles for in sum total 78-points (7×13) and the intensity of surface EMG at different muscles was measured for each crooked finger. The reference electrode was sticked near to the elbow where the muscle electric potential at the time of finger flexure is known to be the minimum. Obtained surface EMG was passed through an amplifier and was digitized by an A/D converter before storing into a computer hard disk. Depending on the intensity of the surface EMG, a position was identified and considered to have participated most actively during the crookedness state of a particular finger. Thus five locations on the forearm muscles were identified for five different fingers (Fig. 2). In Fig.2, position (1) indicates the sticking position of electrodes where the muscle surface EMG for the crooked thumb appears remarkably intense compared to other fingers. Similarly points (2), (3), (4) and (5) indicate the sticking positions of electrodes for the crooked index finger, middle finger, ring finger and small finger, respectively.

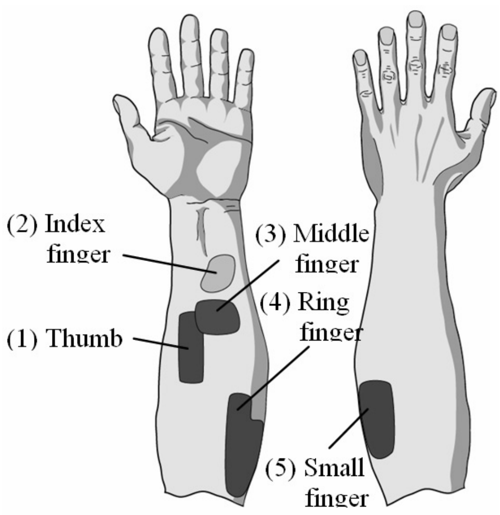

Fig. 2. Specified positions related to the maximum intensity of EMG signals

3.2. Recognition of crookedness state

In order to recognize the crookedness states of 5 different fingers, 4 different types of steps were considered for each finger and the surface EMG for each step was measured to recognize the crookedness state. The surface EMG was measured by repeatedly crookening the finger (step 1-3) for 5 seconds and then straightening (step 0) for another 5 seconds. During measuring surface EMG, sampling was done with a frequency of 120 Hz and a resolution of 8 bit. Later, frequency analysis was conducted within the average frequency region of 20-40 Hz. As the thumb has a different structure than the other 4 fingers, the crookening method for the thumb was decided separately.

3.3. Crookening method of thumb

Fig.3 illustrates the movement of the thumb at each step.
Step 0: Straightening the thumb

Step 1: Crookening only Interphalangeal (IP) joint as permissible
Step 2: Crookening IP joint and Metacarpo-phalangeal (MP) joint as permissible
Step 3: Crookening IP joint and MP joint as permissible after crookening Carpometacarpal (CMP) joint

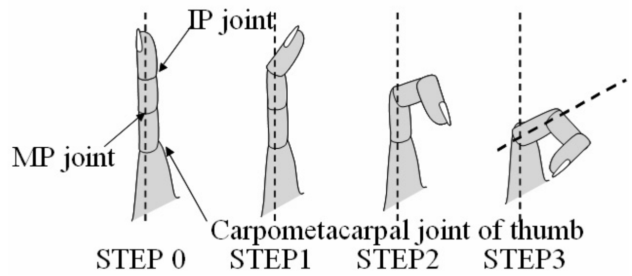

Fig. 3. Movement of thumb

3.4. Crookening method of other 4 fingers

Fig.4 illustrates the movement of the index finger, middle finger, ring finger and small finger at each step.
Step 0: Straightening the finger
Step 1: Crookening Proximal Interphalangeal (PIP) joint to about 90 degree
Step 2: Crookening MP joint to about 45 degree and PIP joint to about 90 degree
Step 3 : Crookening finger tip till it touches to the palm
In case of step 1-3, it is difficult to achieve a desired flexure of the Distal Interphalangeal (DIP) joint. So the DIP joint was allowed to move independently.

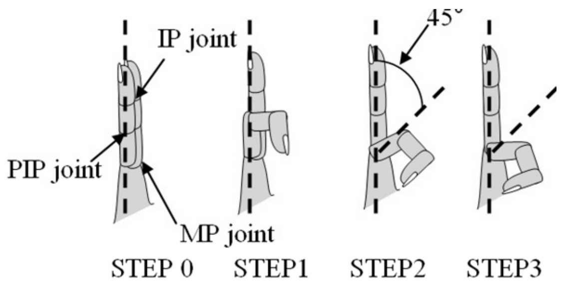

Fig. 4. Movement of four fingers except a thumb

4. Experimental results

Fig. 5-9 illustrate the change in intensity of the surface EMG at each electrode sticking position (measurement point) for each crooked finger at different crookedness states. According to Fig.5 (measurement point 1), measured surface EMG is considerably larger for a crooked thumb, compared to other crooked fingers, and it increases further with the increase of the crookedness state of the thumb. In case of other four fingers, the surface EMG at point 1 seems to be unaffected with the crookening of fingers, or change in their crookedness states. So it can be said that by measuring the surface EMG at measurement point 1, the crookening and the crookedness states of a thumb can be recognized.

Similarly, Fig.6-9 illustrate relationships between the intensity of surface EMG and a crooked index finger, middle finger, ring finger and small finger, as well as the amount of their crookedness, respectively. So, by measuring the surface EMG at measurement points 2, 3, 4 and 5, the crookening and the crookedness states of a index finger, middle finger, ring finger and small finger, respectively, can be recognized.

Thus, with the help of the surface EMG, it is possible to specify which finger is being crooked. Furthermore, by observing the change in surface EMG at each measurement point, it is possible to recognize the crookedness state of a particular finger.

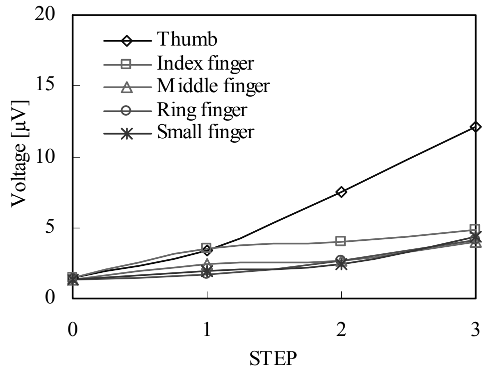

Fig. 5. Measured EMG signals at measurement point (1)

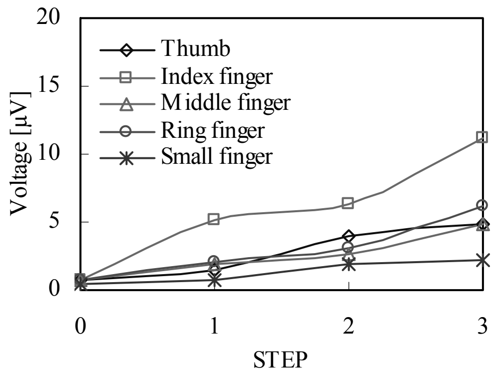

Fig. 6. Measured EMG signals at measurement point (2)

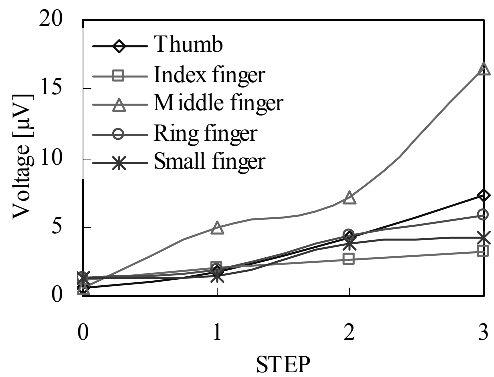

Fig. 7. Measured EMG signals at measurement point (3)

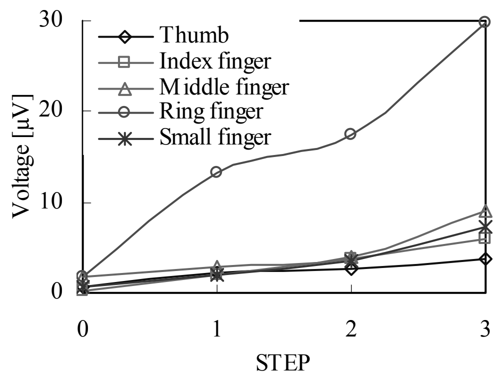

Fig. 8. Measured EMG signals at measurement point (4)

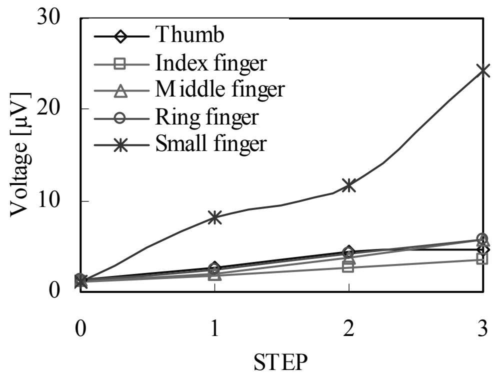

Fig. 9. Measured EMG signals at measurement point (5)

5. Conclusions

In this experimental study, the electric current that generates on the skin during muscle activity was measured for different hand finger operations and the following conclusions were obtained.

1. It is found that there is a specified position related to the maximum intensity of EMG signals for each finger.
2. Hand finger operation can be recognized with the help of surface EMG sticked in the specialized placement.
3. The amount of crookedness of each finger can also be recognized with the help of surface EMG, which could be used as a machine interface technology in the field of welfare equipments, robot hand operation, virtual reality, etc.

References

[1] R.H. Jebsen, N. Taylor, R.B. Trieschman, M.J. Trotter, L.A. Howard, An objective and standardized test of hand function, Archives of Physical Medicine and Rehabilitation 50 (1969) 313-319.

[2] M.A. Maier, M.C Hepp-Reymond, EMG Activation Patterns during force production in precision grip. I. Contributions of 15 Finger Muscles to Isometric Force, Experimental Brain Research 103 (1995) 108-122.

[3] W.J. Weiss, M. Flanders, Muscular and postural synergies of the human sand, Journal of Neurophysiology 92 (2004) 523-535.

[4] M.W. Jiang, R.C. Wang, J.Z. Wang, D.W. Jin, A Method of recognizing finger motion using wavelet transform of Surface EMG Signal, Proceedings of the 27th Annual International Conference of IEEE Engineering in Medicine and Biology Society 27/3, 2005, 2672-2674.

[5] K. Choi, Y. Koike, H. Hirose, T. Iijima, Prediction of four degrees of freedom arm movement using EMG signal, Proceedings of the 27th Annual International Conference of IEEE Engineering in Medicine and Biology Society 27/6 (2005) 5820-5823.

[6] H. Choi, J.H Jeong, S.H. Hwang, W.H. Cho, Feature evaluation and pattern recognition of lower limb muscle EMG during postural balance control, Key Engineering Materials 326-328 (2006) 867-870.

[7] J.U. Chu, I. Moon, M.S. Mun, A Real-Time EMG pattern recognition system based on linear-nonlinear feature projection for a multifunction myoelectric hand, IEEE Transaction on Biomedical Engineering 53/11 (2006) 2232-2239.

[8] M.C. Hammond, S.S. Fitts, G.H. Kraft, P.B. Nutter, M.J. Trotter, L.M. Robinson, Co-contraction in the Hemiparetic Forearm: Quantitative EMG Evaluation, Archives of Physical Medicine and Rehabilitation 69 (1988) 348-351.

[9] S.L. Kilbreath, S.C. Gandevia, Limited independent flexion of the hhumb and fingers in human subjects, The Journal of Physiology 479 (1994) 487-497.

[10] M.H. Schieber, Muscular production of individuated finger movements, The roles of extrinsic finger muscles, The Journal of Neuroscience 15 (1995) 284-297.

[11] C.G. Burgar, F.J. Valero-Cuevas V.R. Hentz, Fine-wire electromyographic recording during force generation: application to index finger, American Journal of Physical Medicine and Rehabilitation 76 (1997) 732-740.

[12] C.R. Rose, D.A. Keen, G.F. Koshland, A.J. Fuglevand, Coordination of multiple muscles in the elaboration of individual finger movements, Society for Neuroscience Abstract 25 (1999) 1149.

[13] C.K. Hager-Ross, M.H. Schieber, Quantifying the independence of human finger movements: Comparisons of digits, hands, and movement frequencies, The Journal of Neuroscience 20 (2000) 8542-8550.

[14] K.T. Reilly, M.H. Schieber, Incomplete functional subdivisions of the human multitendoned finger muscle flexor digitorum profundus: An electromyographic study, Journal of Neurophysiology 90 (2003) 2560-2570.

[15] B.H. Kim, B.J. Yi, I.H. Suh, S.R. Oh, Y.S. Hong, Biomimetic compliance control of robot hand by considering structures of human finger, Proceedings of International Conference on Robotics and Automation (2000) 3879-3886.