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Pattern Recognition of Human Hands-and-Knees Crawling Movements Based on Surface Electromyography Signals

Chengxiang Li, Xiang Chen, Member, *IEEE*

***Abstract*— This study conducted a pattern recognition study on human crawling movements. 10 healthy adults participated in the crawling data collection experiments. The surface electromyography (sEMG) signals were recorded from 16 limbs and trunk muscles related to crawling movement and the pressure signal was recorded from left palm. A pattern recognition model based on sEMG signals and linear discriminant analysis (LDA) method was proposed and implemented for the 8 defined inter-limb coordination modes. High accuracies were obtained for participant-dependent, multi-participant, and participant-independent schemes.**

***Clinical Relevance*— This work provides a new analytical approach for human crawling through pattern recognition.**

I. INTRODUCTION

Crawling is a primitive instinct to human beings. There are several crawling postures mainly adopted by human beings, such as hands-and-knees, hands-and-feet and step-scoot mix. Among them, hands-and-knees crawling is the most common posture [1]. What's more, human crawling is a kind of typical quadruped locomotion, several inter-limb coordination modes may appear. It will be meaningful to conduct a pattern recognition study on different inter-limb coordination modes.

This study defined 8 crawling modes and achieved high accuracies pattern recognition based on LDA method.

II. METHODS

The definitions of all the 8 crawling modes can be seen in table I. All crawling modes started with left hand touching land. Ten healthy adults (7 males, 3 females, 23.90 ± 0.88 years) were recruited to complete the crawling data acquisition. They crawled at low, medium and fast speed at 3.5s/cycle, 2.33s/cycle and 1.75s/cycle, separately. 16-channel sEMG signals and one-channel pressure signal were collected synchronously. The pressure signal was used to distinguish crawling cycles. The target muscles included trapezius (TR), anterior deltoid (AD), latissimus dorsi (LD), biceps brachii (BB), triceps brachii (TB), rectus femoris (RF), adductor longus (AL), biceps femoris (BF) of both two sides of body.

TABLE I
8 INTER-LIMB COORDINATION MODES DURING HANDS-AND-KNEES CRAWLING

Modes	Order of limbs touching land
M1	left hand, left knee-> right hand, right knee
M2	left hand, right knee-> right hand, left knee
M3	left hand-> right hand-> left knee-> right knee
M4	left hand-> right hand-> right knee-> left knee
M5	left hand-> left knee-> right hand-> right knee
M6	left hand-> left knee-> right knee-> right hand
M7	left hand-> right knee-> right hand-> left knee
M8	left hand-> right knee-> left knee-> right hand

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Chengxiang, Li, is with Department of Electronic Science and Technology at University of Science and Technology of China, Hefei, Anhui Province, China. (E-mail: cxlee023@mail.ustc.edu.cn)

Xiang Chen, is with Department of Electronic Science and Technology at University of Science and Technology of China, Hefei, Anhui Province, China. (E-mail: xch@ustc.edu.cn)

Four sEMG features would be calculated, including: Mean Absolute Value, Zero Crossing, Waveform length and Slope Sign Changes [2]. Feature extraction task was completed on Matlab 2019a, and the pattern recognition task based on LDA was completed on TensorFlow platform in python language.

III. RESULTS

From Fig. 1, it can be seen that, at low speed, medium speed, and fast speed, the classification accuracies were respectively 98.7 ± 0.95%, 98.8 ± 0.42%, 96.5 ± 0.97% in multi-participant scheme, 86.6 ± 19.13%, 90.8 ± 5.55%, 85.1 ± 11.53% in participant-independent scheme, 98.8 ± 2.3%, 96.6 ± 3.81%, 98.1 ± 2.28% in participant-dependent scheme.

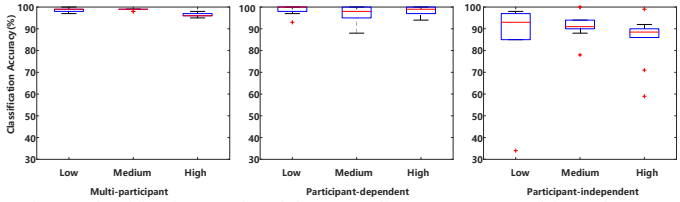

Fig. 1. Classification results of three crawling pattern recognition schemes.

IV. DISCUSSION & CONCLUSION

This work provides a new analytical approach for pattern recognition of human crawling modes.

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