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Recognition of walking environments and gait period by surface electromyography

Key words: Walking environment; Gait period; Surface electromyography (sEMG); Exoskeleton

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Motivation

1. Recognizing and predicting the movement and intention of the wearer in control of an exoskeleton robot is very challenging.

2. An electromyographic (EMG) signal, which is a biological signal, is detected by the activation of the muscles before the actual movement of a person.

3. Using EMG signal, the motion intention can be identified before actual movement, and the delay time in controlling the exoskeletal robot can be shortened to reduce the resistance felt by the user.

4. The surface electromyographic (sEMG) signal is used together with a mechanical sensor to identify the walking environment and gait period.

Main idea

1. Classify five different walking environments, level-ground walking, stair ascent/descent, and ramp ascent/descent, in different time periods with combination of sensors, sEMG sensor locations, and sEMG sensor features.

2. Classify the gait time period in the same gait environment on the same conditions.

3. Predict the walking intentions in the walking environment and the gait time period before the gait starts.

Method

1. The lower limb sensing suit system consists of a body frame with the following mechanical and bio sensors: position sensors, GRF sensors, interaction force sensors, and sEMG sensors.

2. sEMG features were mean absolute value (MAV), zero crossings (ZC), slope sign changes (SSC), and waveform length (WL).

3. Signal processing of the sEMG and mechanical sensors was based on Bayesian linear discriminant analysis (BLDA) as the pattern classification algorithm.

Major results

1. Walking environment classification performance increased when classified with the sEMG sensor.

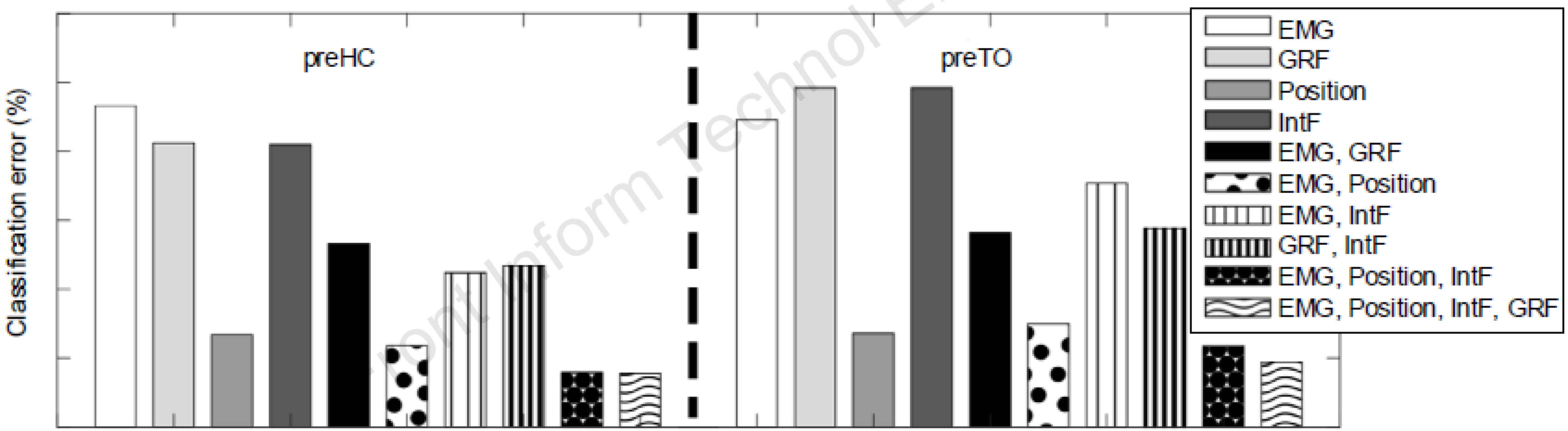

Fig. 4 Walking environment classification errors after combining the sensor data for the sEMG, GRF, position, and interaction forces for different gait periods

Major results (Cont'd)

2. The gait period classification result was 92.6% in the seven gait periods, and 99.2% in the six gait periods.

3. The combination of "MAV, ZC" or "MAV, WL" was the effective combination of the two sEMG features.

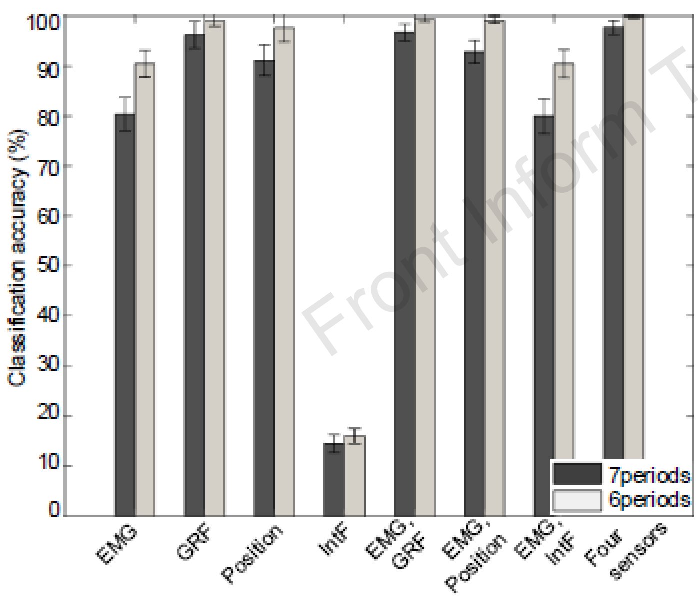

Fig. 6 Gait period classification results in seven and six periods according to sensor combinations

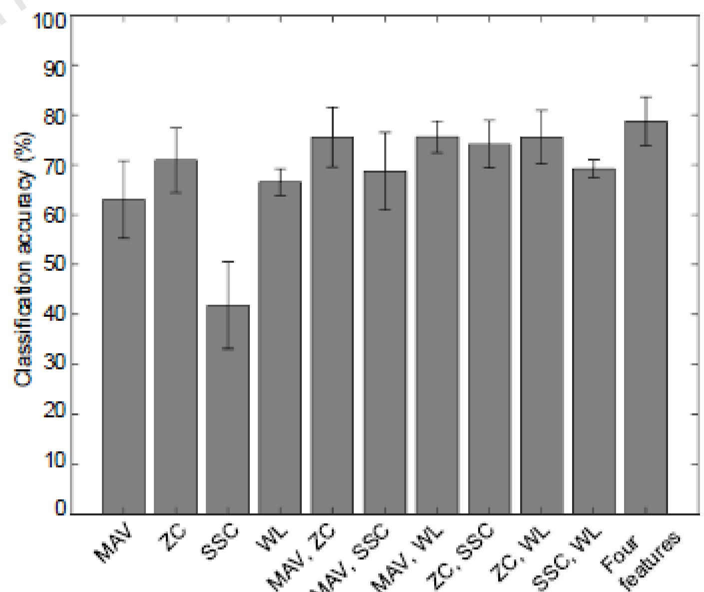

Fig. 7 Gait period classification results according to the sEMG feature combinations without other sensors

Conclusions

1. The purpose of this study is to show progress with the use of sEMG when recognizing a walking environment and gait period with other sensors.

2. When the sEMG is used, the VM and GAS muscle combination is recommended for the position of the sEMG sensor, and “MAV, ZC” or “MAV, WL” combination is recommended for the sEMG features.