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Editorial

Special Issue on Robotic-Based Technologies for Rehabilitation and Assistance

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Robotic technology designed to assist rehabilitation can potentially increase the efficiency of and accessibility to therapy by assisting therapists in providing consistent training for extended periods of time and collecting data to assess progress. Recently, wearable-type robots have been used directly on patients to overcome the physical limitations of the body, resulting in the temporary or permanent augmentation of a person's abilities and features. This Special Issue is designed to provide an opportunity to introduce and share state-of-the-art research in the field of robotic-based technology for rehabilitation and assistance. The scope covers the derivation of a new concept of robots, mechanical design, and controller development for rehabilitation and assistance robots, and the evaluation of robot assistance in biomechanical and physiological aspects.

In this Special Issue, seven excellent papers are published on robotic-based technologies for rehabilitation and assistance. The papers are categorized into three groups as follows:

A. Mechanical Design and Analysis
B. Control algorithm and Human testing
C. Deep Learning and Signal processing

The detailed contents can be summarized as follows.

1. Mechanical Design and Analysis

1.1. Robotic Device for Out-of-Clinic Post-Stroke Hand Rehabilitation

This paper describes the design of a robotic device for post-stroke wrist and finger rehabilitation and evaluates the movement it can perform. Deviations from the baseline trajectory between measurement protocols and the root-mean-square deviation (RMSD) values indicate that the motion of the hand, imposed by the developed device, is comparable to the unconstrained motion of the healthy subjects, especially when moving into the extension, opening the hand [1].

1.2. Incorporation of Torsion Springs in a Knee Exoskeleton for Stance Phase Correction of Crouch Gait

Torsion springs have been used in cycling to store energy in the knee flexion to reduce fatigue in the quadriceps during knee extension. All crouch gait moments were significantly reduced, and the correction of peak crouch moments was achieved, corresponding to the normal gait cycle during the stance phase. These results offer significant potential for nonsurgical and less invasive options for wearable exoskeletons in crouch gait correction [2].

2. Control Algorithm and Human Testing

2.1. Computer Vision-Based Adaptive Semi-Autonomous Control of an Upper Limb Exoskeleton for Individuals with Tetraplegia

A tongue-based interface was used together with the semi-autonomous control such that individuals with complete tetraplegia were able to use it despite being paralyzed from the neck down. The semi-autonomous control uses computer vision to detect nearby objects and estimate how to grasp them to assist the user in controlling the exoskeleton. The studies showed a clear and significant improvement in both performance and user ratings when using either of the semi-autonomous control schemes [3].

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2.2. A Self-Adaptive-Coefficient-Double-Power Sliding Mode Control Method for Lower Limb Rehabilitation Exoskeleton Robot

In this article, a self-adaptive-coefficient double-power sliding mode control method is proposed to overcome the difficulty of tracking the robot trajectory. The method combines an estimated dynamic model with sliding mode control. Compared with the traditional computed torque method, the proposed method decreases the tracking error by more than 71.77% [4].

2.3. Making Best Use of Home-Based Rehabilitation Robots

This study investigated whether a low-cost rehabilitation robot could be deployed in a home setting for the rehabilitation of people recovering from stroke and whether clinical outcome measures correlated well with kinematic measures gathered by the robot. The results support the feasibility of patients independently using the robot with improvement in both clinical measures and kinematic data [5].

3. Deep Learning and Signal Processing

3.1. Feature Optimization for Gait Phase Estimation with a Genetic Algorithm and Bayesian Optimization

The optimal parameter values, which determine a feature set and its values, can vary across subjects. To address this problem, this paper proposes a new feature extraction approach. Specifically, the components of the feature set are selected using a binary genetic algorithm, and the length of the time window is determined through Bayesian optimization. In this approach, the two optimization techniques are integrated to conduct a dual optimization task [6].

3.2. Flexible Covariance Matrix Decomposition Method for Data Augmentation and Its Application to Brainwave Signals

Covariance matrix decomposition (CMD), a widely used data synthesis approach, generates artificial data using the correlation between features and random noise. This study has improved the performance of CMD by releasing such constraints. Specifically, a generalized normal distribution (GND) was used as it can alter the kurtosis and skewness of the random noise, affecting the distribution of the artificial data. For the validation of GND performance, a motor imagery brainwave classification was conducted on the artificial dataset generated by GND [7].

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