Journal of Dynamic Systems, Measurement, and Control

Editorial

Special Issue on Biomedical Sensing, Dynamics, and Control for Diagnostics, Treatment, and Rehabilitation

Medical devices and sensors are routinely used to record various physiological signals for simple monitoring of the human health, and sensing is an integral part of health monitoring. However, more advanced devices, signal measurement, modeling, and closed-loop control may be critical for surgical procedures, earlier diagnosis of diseases and disorders, drug administration, and clinical rehabilitation. The goal of this special issue is to provide a forum for latest research in biomedical signal measurement and processing, dynamic modeling and analysis, and control for clinical diagnosis, patient health monitoring, drug administration, and biosignal-assisted rehabilitation. There has been a significant increase in research activities in these areas within diverse specialties including mechanical, electrical, and biomedical engineering. Developing sensors to produce appropriate biosignals, developing dynamic models of biosystems and biosignals for diagnostics, and using biosignals as feedback in controlled processes such as drug delivery and rehabilitation are some of the biggest challenges encountered in these engineering fields.

This special issue presents some of the latest innovative approaches to medical diagnostics and procedures as well as clinical rehabilitation from a point of view of dynamic modeling, system analysis, and control. There are 14 regular research papers in this special issue. The papers roughly fall within three groups: (1) application of feedback control in medical therapeutic and rehabilitation devices and procedures; (2) clinical rehabilitation devices and data analysis; and (3) data processing and analysis for diagnostic and classification of various medical conditions.

There are five papers presenting closed-loop control methods for various applications in the medical field. The paper by Bighamian et al. introduces a closed-loop fluid resuscitation system that uses estimated blood volume to overcome hypovolemia via a controlled variable linearly correlated with changes in blood volume and verify its performance through in silico simulations. Another paper by Nguyen and Leonessa presents an adaptive output feedback control using human arm muscle excitation as input where they are able to deal with musculoskeletal nonlinearities and uncertainties unlike previous open-loop and feedforward approaches. The paper by Sovizie et al. efficiently solves the flexible needle tracking problem in biopsies and other medical procedures using a Markov chain approach to optimal control and demonstrate improved performance in the presence of uncertainties for both deterministic and stochastic models. The paper by Sharifi et al. employs a nonlinear bilateral adaptive approach to control the impedance of telesurgical and rehabilitation devices, where human–robot interactions play an important role. The last paper in this group by Mohammed introduces a tracking system for capsule endoscopes to navigate through the intestine using an actuation system based on magnetic levitation and linear control techniques.

Moving on to the next topic, there are five papers presenting devices and data analyses crucial to clinical rehabilitation. The paper by Borboni et al. introduces a compliant transmission-based hand rehabilitation device with pneumatic actuators for stroke patients. The device has been successfully tested in a series of clinical studies. The paper by Lu et al. introduces the design of a six degrees-of-freedom passive upper limb exoskeleton controlled by brain–machine interface and verifies its performance by a pilot animal test with a macaque monkey. Another paper by Zhang et al. introduces a wireless human motion monitoring system equipped with inertial sensors and smart shoes for gait analysis and visual feedback to detect abnormal walking behavior. Continuing with rehabilitation training, Schmitz and Norberg explored the sensitivity of lower extremity joint torques to force plate measurement inaccuracies in order to provide better guidance to clinicians for designing rehabilitation programs. The last paper in the group by Roldan et al. presents a multidimensional scaling map of hand motion trajectories that can quantitatively identify various phases of recovery for stroke-impacted hemiparetic patients.

The last group of four papers introduces procedures and algorithms that can be employed for classification of abnormalities and aid with clinical diagnosis. The paper by Shin et al. presents a dynamic motion-based myoelectric classification for controlling prosthetic devices in human–computer interface and verifying their approach through a series of human subject experiments. The paper by Marri and Swaminathan uses multifractal analysis of surface electromyography signals from a clinical study to estimate muscle fatigue conditions which can be employed in clinical rehabilitation, sports medicine, and prosthetics design. The paper by Jalali et al. uses a mathematical model of mechanical ventilation along with data from anesthesia machine to automatically detect endotracheal intubation in children under general anesthesia during surgery, which can consequently be employed in clinical decision support systems and closed-loop control of mechanical ventilation. The last paper in this group by Jaleel et al. introduces an expert system based on electrocardiogram signals and mapping of clinical definitions of myocardial infarctions and their differential diagnosis to facilitate early detection of cardiac abnormalities.

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