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Systolic Blood Pressure Estimation from PPG Signal Using ANN

Authors: Benedetta C. Casadei, Alessandro Gumiero, Giorgio Tantillo, Luigi Della Torre andGabriella Olmo

Abstract: High blood pressure is one of the most important precursors for Cardiovascular Diseases (CVDs), the most common cause of death in 2020, as reported by the World Health Organization (WHO). Moreover, many patients affected by neurodegenerative diseases (e.g., Parkinson's Disease) exhibit impaired autonomic control, with inversion of the normal circadian arterial pressure cycle, and consequent augmented cardiovascular and fall risk. For all these reasons, a continuous pressure monitoring of these patients could represent a significant prognostic factor, and help adjusting their therapy. However, the existing cuff-based methods cannot provide continuous blood pressure readings. Our work is inspired by the newest approaches based on the photoplethysmographic (PPG) signal only, which has been used to continuously estimate systolic blood pressure (SP), using artificial neural networks (ANN), in order to create more compact and wearable devices. Our first database was derived from the PhysioNet resource; we extracted PPG and arterial blood pressure (ABP) signals, collected at a sampling frequency of 125 Hz, in a hospital environment. It consists of 249,672 PPG periods and the relative SP values. The second database was collected at STMicroelectronics s.r.l., in Agrate Brianza, using the MORFEA3 wearable device and a digital cuff-based sphygmomanometer, as reference. The pre-processing phase, in order to remove noise and motion artifacts and to segment the signal into periods, was carried out on Matlab R2019b. The noise removal was one of the challenging parts of the study because of the inaccuracy of the PPG signal during everyday-life activity, and this is the reason why the MORFEA3 dataset was acquired in a controlled environment in a static position. Different solutions were implemented to choose the input features that best represent the period morphology. The first database was used to train the multilayer feed-forward neural network with a back-propagation model, whereas the second one was used to test it. The results obtained in this project are promising and match the Association for the Advancement of Medical Instruments (AAMI) and the British Hypertension Society (BHS) standards. They show a Mean Absolute Error of 3.85 mmHg with a Standard Deviation of 4.29 mmHg, under the AAMI standard, and reach the grade A under the BHS standard.

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Section Bioelectronics

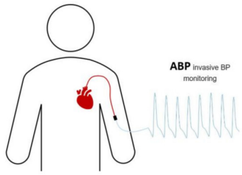
Selected Papers

DOI:10.3390/electronics11091442

Improving Cuff-Less Continuous Blood Pressure Estimation with Linear Regression Analysis

Authors: Valeria Figini, Sofia Galici, D niele Russo, Ilenia Centonze, Monica Visintin and Guido Pagana

Abstract: In this work, the authors investigate the cuff-less estimation of continuous BP through pulse transit time (PTT) and heart rate (HR) using regression techniques, which is intended as a first step towards continuous BP estimation with a low error, according to AAMI guidelines. Hypertension (the 'silent killer') is one of the main risk factors for cardiovascular diseases (CVDs), which are the main cause of death worldwide. Its continuous monitoring can offer a valid tool for patient care, as blood pressure (BP) is a significant indicator of health and, using it together with other parameters, such as heart and breath rates, could strongly improve prevention of CVDs. The novelties introduced in this work are represented by the implementation of pre-processing and by the innovative method for features research and features processing to continuously monitor blood pressure in a non-invasive way. Currently, invasive methods are the only reliable methods for continuous monitoring, while non-invasive techniques measure the values every few minutes. The proposed approach can be considered the first step for the integration of these types of algorithms on wearable devices, in particular on those developed for the SINTEC project.

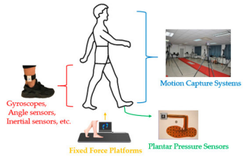


DOI:10.3390/electronics11101633

Measurement, Evaluation, and Control of Active Intelligent Gait Training Systems—Analysis of the Current State of the Art

Authors: Yi Han, Chenhao Liu, Bin Zhang, Ning Zhang, Shuoyu Wang, Meimei Han, João P. Ferreira, Tao Liu andXiufeng Zhang

Abstract: Gait recognition and rehabilitation has been a research hotspot in recent years due to its importance to medical care and elderly care. Active intelligent rehabilitation and assistance systems for lower limbs integrates mechanical design, sensing technology, intelligent control, and robotics technology, and is one of the effective ways to resolve the above problems. In this review, crucial technologies and typical prototypes of active intelligent rehabilitation and assistance systems for gait training are introduced. The limitations, challenges, and future directions in terms of gait measurement and intention recognition, gait rehabilitation evaluation, and gait training control strategies are discussed. To address the core problems of the sensing, evaluation and control technology of the active intelligent gait training systems, the possible future research directions are proposed. Firstly, different sensing methods need to be proposed for the decoding of human movement intention. Secondly, the human walking ability evaluation models will be developed by integrating the clinical knowledge and lower limb movement data. Lastly, the personalized gait training strategy for collaborative control of human–machine systems needs to be implemented in the clinical applications.



DOI:10.3390/electronics11142160

Telemedicine System Applicability Using Drones in Pandemic Emergency Medical Situations

Authors: Paul Lucian Nedelea, Tudor Ovidiu Popa, Emilian Manolescu, Catalin Bouros, Gabriela Grigorasi, Doru Andritoi, Catalin Pascale, Avramescu Andrei and Diana Carmen Cimpoesu

Abstract: Drones have evolved significantly in recent years, acquiring greater autonomy and carrier capacity. Therefore, drones can play a substantial role in civil medicine, especially in emergency situations or for the detection and monitoring of disease spread, such as during the COVID-19 pandemic. The aim of this paper is to present the real possibilities of using drones in field rescue operations, as well as in nonsegregated airspace, in order to obtain solutions for monitoring activities and aerial work in support of the public health system in crisis situations. The particularity of our conceptual system is the use of a "swarm" of fast drones for aerial reconnaissance that operate in conjunction, thus optimizing both the search and identification time while also increasing the information area and the operability of the system. We also included a drone with an RF relay, which was connected to a hub drone. If needed, a carrier drone with medical supplies or portable devices can be integrated, which can also offer two-way audio and video communication capabilities. All of these are controlled from a mobile command center, in real time, connected also to the national dispatch center to shorten the travel time to the patient, provide support with basic but life-saving equipment, and offer the opportunity to access remote or difficult-to-reach places. In conclusion, the use of drones for medical purposes brings many advantages, such as quick help, shortened travel time to the patient, support with basic but life-saving equipment, and the opportunity to access remote or difficult-to-reach places.

DOI:10.3390/electronics11152410

FPGA-Based Hardware Accelerator on Portable Equipment for EEG Signal Patterns Recognition

Authors: Yu Xie, Tamás Majoros andStefan Oniga

Abstract: Electroencephalogram (EEG) is a recording of comprehensive reflection of physiological brain activities. Because of many reasons, however, including noises of heartbeat artifacts and muscular movements, there are complex challenges for efficient EEG signal classification. The Convolutional Neural Networks (CNN) is considered a promising tool for extracting data features. A deep neural network can detect the deeper-level features with a multilayer through nonlinear mapping. However, there are few viable deep learning algorithms applied to BCI systems. This study proposes a more effective acquisition and processing HW-SW method for EEG biosignal. First, we use a consumer-grade EEG acquisition device to record EEG signals. Short-time Fourier transform (STFT) and Continuous Wavelet Transform (CWT) methods will be used for data preprocessing. Compared with other algorithms, the CWT-CNN algorithm shows a better classification accuracy. The research result shows that the best classification accuracy of the CWT-CNN algorithm is 91.65%. On the other side, CNN inference requires many convolution operations. We further propose a lightweight CNN inference hardware accelerator framework to speed up inference calculation, and we verify and evaluate its performance. The proposed framework performs network tasks quickly and precisely while using less logical resources on the PYNQ-Z2 FPGA development board.