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Message from the Editor-in-Chief

As the world of science becomes ever more specialized, researchers may lose themselves in the deep forest of the ever increasing number of subfields being created. This open access journal Applied Sciences has been started to link these subfields, so researchers can cut through the forest and see the surrounding, or quite distant fields and subfields to help develop his/her own research even further with the aid of this multi-dimensional network.

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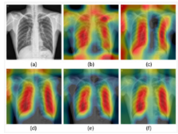
Section Biomedical Engineering

Featured Papers

DOI:10.3390/app12115500

IMNets: Deep Learning Using an Incremental Modular Network Synthesis Approach for Medical Imaging Applications

Authors: Redha Ali, Russell C. Hardie, Barath Narayanan Narayanan and Temesguen M. Kebede

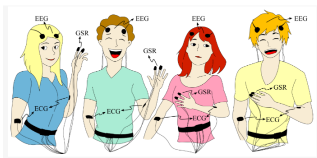


Abstract: Deep learning approaches play a crucial role in computer-aided diagnosis systems to support clinical decision-making. However, developing such automated solutions is challenging due to the limited availability of annotated medical data. In this study, we proposed a novel and computationally efficient deep learning approach to leverage small data for learning generalizable and domain invariant representations in different medical imaging applications such as malaria, diabetic retinopathy, and tuberculosis. We refer to our approach as Incremental Modular Network Synthesis (IMNS), and the resulting CNNs as Incremental Modular Networks (IMNets). Our IMNS approach is to use small network modules that we call SubNets which are capable of generating salient features for a particular problem. Then, we build up ever larger and more powerful networks by combining these SubNets in different configurations. Our proposed IMNS design leads to high average classification accuracies of 97.0%, 97.9%, and 88.6% for malaria, diabetic retinopathy, and tuberculosis, respectively. Our modular design for deep learning achieves the state-of-the-art performance in the scenarios tested. The IMNets produced here have a relatively low computational complexity compared to traditional deep learning architectures. The largest IMNet tested here has 0.95 M of the learnable parameters and 0.08 G of the floating-point multiply–add (MAdd) operations. The simpler IMNets train faster, have lower memory requirements, and process images faster than the benchmark methods tested.

DOI:10.3390/app11114945

Emotion Recognition from ECG Signals Using Wavelet Scattering and Machine Learning

Authors: Axel Sepúlveda, Francisco Castillo, Carlos Palma and Maria Rodriguez-Fernandez

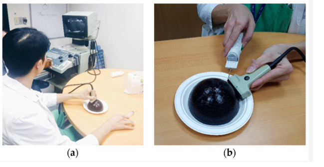


Abstract: Affect detection combined with a system that dynamically responds to a person’s emotional state allows an improved user experience with computers, systems, and environments and has a wide range of applications, including entertainment and health care. Previous studies on this topic have used a variety of machine learning algorithms and inputs such as audial, visual, or physiological signals. Recently, a lot of interest has been focused on the last, as speech or video recording is impractical for some applications. Therefore, there is a need to create Human–Computer Interface Systems capable of recognizing emotional states from noninvasive and nonintrusive physiological signals. This work improves the performance of emotion recognition from ECG signals using wavelet transform for signal analysis. Features of the ECG signal are extracted from the AMIGOS database using a wavelet scattering algorithm that allows obtaining features of the signal at different time scales, which are then used as inputs for different classifiers to evaluate their performance. The results show that the proposed algorithm for extracting features and classifying the signals obtains an accuracy of 88.8% in the valence dimension, 90.2% in arousal, and 95.3% in a two-dimensional classification, which is better than the performance reported in previous studies. This algorithm is expected to be useful for classifying emotions using wearable devices.

DOI:10.3390/app11167728

Low-Cost and Easily Fabricated Ultrasound-Guided Breast Phantom for Breast Biopsy Training

Authors: Si Yen Ng, Yao-Lung Kuo and Chi-Lun Lin

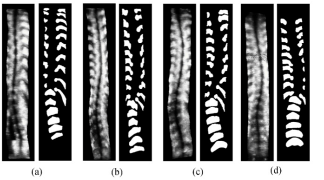


Abstract: We aimed to develop an inexpensive and easy-to-fabricate gelatin-based training phantom for improving the breast biopsy skill and confidence level of residents. Young's modulus and acoustic properties of the gelatin tissue phantom and simulated tumors were investigated. Six residents were requested to evaluate the effectiveness of the breast phantom. The results showed that 83% (n = 5) of the participants agreed that the ultrasound image quality produced by the breast phantom was excellent or good. Only 17% (n = 1) of the participants claimed that there was room for improvement for the haptic feedback they received during the placement of the core needle into the breast phantom. The mean pre-instructional score was 17% (SD 17%) for all participants. The mean post-instructional score was 83% (SD 17%), giving an overall improvement of 67%. In conclusion, the mean needle biopsy skill and confidence levels of the participants substantially increased through simulation training on our breast phantom. The participants' feedback showed the phantom is sufficiently realistic in terms of ultrasound imaging and haptic feedback during needle insertion; thus, the training outcome can be linked to the performance of residents when they perform a live biopsy.

DOI:10.3390/app112110180

Light-Convolution Dense Selection U-Net (LDS U-Net) for Ultrasound Lateral Bony Feature Segmentation

Authors: Sunetra Banerjee, Juan Lyu, Zixun Huang, Hung Fat Frank Leung, Timothy Tin-Yan Lee, De Yang, Steven Su, Yongping Zheng and Sai-Ho Ling



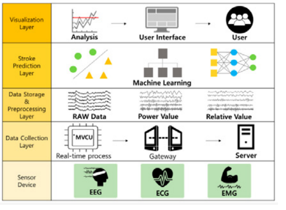
Abstract: Scoliosis is a widespread medical condition where the spine becomes severely deformed and bends over time. It mostly affects young adults and may have a permanent impact on them. A periodic assessment, using a suitable modality, is necessary for its early detection. Conventionally, the usually employed modalities include X-ray and MRI, which employ ionising radiation and are expensive. Hence, a non-radiating 3D ultrasound imaging technique has been developed as a safe and economic alternative. However, ultrasound produces low-contrast images that are full of speckle noise, and skilled intervention is necessary for their processing. Given the prevalent occurrence of scoliosis and the limitations of scalability of human expert interventions, an automatic, fast, and low-computation assessment technique is being developed for mass scoliosis diagnosis. In this paper, a novel hybridized light-weight convolutional neural network architecture is presented for automatic lateral bony feature identification, which can help to develop a fully-fledged automatic scoliosis detection system. The proposed architecture, Light-convolution Dense Selection U-Net (LDS U-Net), can accurately segment ultrasound spine lateral bony features, from noisy images, thanks to its capabilities of smartly selecting only the useful information and extracting rich deep layer features from the input image. The proposed model is tested using a dataset of 109 spine ultrasound images. The segmentation result of the proposed network is compared with basic U-Net, Attention U-Net, and MultiResUNet using various popular segmentation indices. The results show that LDS U-Net provides a better segmentation performance compared to the other models. Additionally, LDS U-Net requires a smaller number of parameters and less memory, making it suitable for a large-batch screening process of scoliosis without a high computational requirement.

DOI:10.3390/app11041761

Machine-Learning-Based Elderly Stroke Monitoring System Using Electroencephalography Vital Signals

Authors: Yoon-A Choi, Sejin Park, Jong-Arm Jun, Chee Meng Benjamin Ho, Cheol-Sig Pyo, Hansung Lee and Jaehak Yu

Abstract: Stroke is the third highest cause of death worldwide after cancer and heart disease, and the number of stroke diseases due to aging is set to at least triple by 2030. As the top three causes of death worldwide are all related to chronic disease, the importance of healthcare is increasing even more. Models that can predict real-time health conditions and diseases using various healthcare services are attracting increasing attention. Most diagnosis and prediction methods of stroke for the elderly involve imaging techniques such as magnetic resonance imaging (MRI). It is difficult to rapidly and accurately diagnose and predict stroke diseases due to the long testing times and high costs associated with MRI. Thus, in this paper, we design and implement a health monitoring system that can predict the precursors of stroke diseases in the elderly in real time during daily walking. First, raw electroencephalography (EEG) data from six channels were preprocessed via Fast Fourier Transform (FFT). The raw EEG power values were then extracted from the raw spectra: alpha (a), beta (β), gamma (y), delta (σ), and theta (ɵ) as well as the low β, high β, and ɵ to β ratio, respectively. The experiments in this paper confirm that the important features of EEG biometric signals alone during walking can accurately determine stroke precursors and occurrence in the elderly with more than 90% accuracy. Further, the Random Forest algorithm with quartiles and Z-score normalization validates the clinical significance and performance of the system proposed in this paper with a 92.51% stroke prediction accuracy. The proposed system can be implemented at a low cost, and it can be applied for early disease detection and prediction using the precursor symptoms of real-time stroke. Furthermore, it is expected that it will be able to detect other diseases such as cancer and heart disease in the future.



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