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EPRO SP - 001	Internal Emotion Classification Using EEG Signal with Sparse Discriminative Ensemble

Among various physiological signal acquisition methods for the study of the human brain, EEG (Electroencephalography) is more effective. EEG provides a convenient, non-intrusive, and accurate way of capturing brain signals in multiple channels at fine temporal resolution. We propose an ensemble learning algorithm for automatically computing the most discriminative subset of EEG channels for internal emotion recognition. Our method describes an EEG channel using kernel-based representations computed from the training EEG recordings. For ensemble learning, we formulate a graph embedding linear discriminant objective function using the kernel representations. The objective function is efficiently solved via sparse non-negative principal component analysis and the final classifier is learned using the sparse projection coefficients. Our algorithm is useful in reducing the amount of data while improving computational efficiency and classification accuracy at the same time. The experiments on publicly available EEG dataset demonstrate the superiority of the proposed algorithm over the compared methods.

EPRO SP - 002	EEG Pathology Detection Based on Deep Learning

With the advancement of machine learning technologies, particularly deep learning, the automated systems to assist human life are flourishing. In this paper, we propose an automatic electroencephalogram (EEG) pathology detection system based on deep learning. Various types of pathologies can affect brain signals. Thus, the brain signals captured in the form of EEG signals can indicate whether a person suffers from pathology or not. In the proposed system, the raw EEG signals are processed in the form of a spatio-temporal representation. The spatio-temporal form of the EEG signals is the input to a convolutional neural network (CNN). Two different CNN models, namely, a shallow model and a deep model, are investigated using transfer learning. A fusion strategy based on a multilayer perceptron is also investigated. The experimental results on the Temple University Hospital EEG Abnormal Corpus v2.0.0 show that the proposed system with the deep CNN model and fusion achieves 87.96% accuracy, which is better than some reported accuracy rates on the same corpus.

EPRO SP - 003	Secure EEG Signal Transmission for Remote Health Monitoring Using Optical Chaos

For the very first time, we present the use of optical chaos for the secure transmission of electroencephalogram (EEG) signals through optical fiber medium in remote health monitoring systems. In our proposed scheme, a semiconductor laser source is used to generate optical chaos, which hides EEG signal before its transmission over the optical fiber medium. The EEG signals are acquired by using a 14-channel Emotiv headset device, which are then processed and rescaled to be compatible with the experimental environment (Optisystem). The mixing of EEG signals and chaos is performed using additive chaos masking scheme, which exhibits certain useful properties such as simplicity and easy recovery of the message. Chaotic data (a combination of EEG signals and chaos) is sent over the optical fiber medium to investigate propagation issues associated with secure EEG signal transmission. The scheme is implemented for long haul communication in which the linear impairments of optical fiber are controlled for successful transmission of the secure signal. The parameters at transmitting and receiving sides are selected to achieve synchronization, such that the transmitted signal could be subtracted from identical chaos to restore the original EEG signal at the receiving side. The scheme is tested for different lengths of the optical fiber cable in which the quality of the received signal is determined by obtaining Q-factors. This scheme could also be used with medical signals such as electrocardiography and electromyography.

EPRO SP - 004	Analysis and Feature Extraction of EEG Signals Induced by Anesthesia Monitoring Based on Wavelet Transform

Anesthesia signal monitoring is a very important indicator in surgery, and the effective monitoring of anesthesia depth has been the goal of anesthesiologists and biomedical engineering experts in recent decades. First, the wavelet transform method is used to analyze the anesthesia monitoring EEG signals, and the extracted features are clustered by wavelet classifier to estimate the depth of anesthesia. Second, the characteristics of eigenvectors are constructed by a singular value decomposition based on wavelet transform coefficients. The extraction method extracts the characteristics of the mid-latency auditory evoked EEG under anesthesia. Finally, this paper collected a large amount of clinical data and established a clinical database of anesthesia depth. The experimental results show the effectiveness of the method.

EPRO SP - 005	Spectrum Analysis of EEG Signals Using CNN to Model Patient's Consciousness Level Based on Anesthesiologists' Experience

One of the most challenging predictive data analysis efforts is an accurate prediction of depth of anesthesia (DOA) indicators which has attracted growing attention since it provides patients a safe surgical environment in case of secondary damage caused by intraoperative awareness or brain injury. However, many researchers put heavily handcraft feature extraction or carefully tailored feature engineering to each patient to achieve very high sensitivity and low false prediction rate for a particular dataset. This limits the benefit of the proposed approaches if a different dataset is used. Recently, representations learned using the deep convolutional neural network (CNN) for object recognition are becoming a widely used model of the processing hierarchy in the human visual system. The correspondence between models and brain signals that holds the acquired activity at high temporal resolution has been explored less exhaustively. In this paper, deep learning CNN with a range of different architectures is designed for identifying related activities from raw electroencephalography (EEG). Specifically, an improved short-time Fourier transform is used to stand for the time-frequency information after extracting the spectral images of the original EEG as input to CNN. Then CNN models are designed and trained to predict the DOA levels from EEG spectrum without handcrafted features, which presents an intuitive mapping process with high efficiency and reliability.

EPRO SP - 006	Improved Time-Frequency Features and Electrode Placement for EEG-Based Biometric Person Recognition

This paper introduces a novel feature extraction method for biometric recognition using EEG data and provides an analysis of the impact of electrode placements on performance. The feature extraction method is based on the wavelet transform of the raw EEG signal. Furthermore, the logarithms of wavelet coefficients are processed using the discrete cosine transform (DCT). The DCT coefficients from each wavelet band are used to form the feature vectors for classification. As an application in the biometrics scenario, the effectiveness of the electrode locations on person recognition is also investigated, and suggestions are made for electrode positioning to improve performance. The effectiveness of the proposed feature was investigated in both identification and verification scenarios. The identification results of 98.24% and 93.28% were obtained using the EEG Motor movement/imagery dataset (MM/I) and the UCI EEG database dataset, respectively, which compares favorably with other published reports while using a significantly smaller number of electrodes. The performance of the proposed system also showed substantial improvements in the verification scenario, when compared with some similar systems from the published literature. A multi-session analysis is simulated using with eyes open and eyes closed recordings from the MM/I database.

EPRO SP - 007	Multilevel Weighted Feature Fusion Using Convolutional Neural Networks for EEG Motor Imagery Classification

Deep learning methods, such as convolution neural networks (CNNs), have achieved remarkable success in computer vision tasks. Hence, an increasing trend in using deep learning for electroencephalograph (EEG) analysis is evident. Extracting relevant information from CNN features is one of the key reasons behind the success of the CNN-based deep learning models. Some CNN models use convolutional features from different CNN layers with good effect. However, extraction and fusion of multilevel convolutional features remain unexplored for EEG applications. Moreover, cognitive computing and artificial intelligence experience increasing applications in all fields. Cognitive process is based on understanding human brain cognition through signals, such as EEG. Hence, deep learning can aid in developing cognitive systems and related applications by improving EEG decoding. The classification and recognition of EEG have consistently been challenging due to its characteristics of dynamic time series data and low signal-to-noise ratio. However, the information hidden in different convolution layers can aid in improving feature discrimination capability. In this paper, we use the EEG motor imagery data to uncover the benefits of extracting and fusing multilevel convolutional features from different CNN layers, which are abstract representations of the input at various levels.

EPRO SP - 008	Robustness Analysis of Identification Using Resting-State EEG Signals

The brain activity pattern can be presented by Electroencephalogram (EEG), which is considered as an alternative to traditional biometrics. Researchers have done conducted studies on EEG-based identification, while few of them discussed the effect of time robustness which is very important for the identification system. In this study, we compared and analyzed the two runs EEG signals of resting-state of eye open/closed (REO/REC). The time intervals between two runs were at least two weeks. Here are 17 participants joined in this study. Each of them took two runs experiment. Each run contains four sessions, each session includes 150 seconds of REO/REC. Spectral and statistical analyses were used to extract feature. Three classifiers, Euclidean distance, SVM, and LDA, were used to get classification accuracies and to compare the performance between features of each run and two runs. The results of two runs PSD values of both REO and REC conditions show that there is a similarity within each subject and a difference between subjects. The classification accuracies of three methods of each run are almost 99%. The classification accuracies using two runs data as training set can also reach up to 97% while using each of two-run data as training set is nearly 80%. Thus, the features of most subjects have cross-time robustness and could be used as identification. This study will have an important role in EEG-based identification system.

EPRO SP - 009	Personal Identification Using a Robust Eigen ECG Network Based on Time-Frequency Representations of ECG Signals

This paper is concerned with personal identification using a robust EigenECG network (REECGNet) based on time-frequency representations of electrocardiogram (ECG) signals. For this purpose, we use a robust principal component analysis network (RPCANet) and wavelet analysis. In general, PCA performance and applicability in real case scenarios is limited by the lack of robustness to outliers and corrupted observations. However, in a real nonstationary ECG noise environment, RPCA shows good performance when the method is applied with variable dimensions of local signal subspaces. That is why RPCA-based ECG identification is extremely robust with nonlinear data. Also, a REECGNet performs well without back-propagation to obtain features from the visual content. We constructed a Chosun University ECG Database (CU-ECG DB) and compared with the Physikalisch-Technische Bundesanstalt ECG database (PTB-ECG DB), which is shared data. Finally, the experimental results show the advantages and effectiveness of the applied recognition scheme with 98.25% performance. In addition, to demonstrate the superiority of REECGNet, we experimented with adding noise and the experimental result showed 97.5% recognition rate.

EPRO SP - 010	Noise Reduction in ECG Signals Using Fully Convolutional Denoising Autoencoders

The electrocardiogram (ECG) is an efficient and noninvasive indicator for arrhythmia detection and prevention. In real-world scenarios, ECG signals are prone to be contaminated with various noises, which may lead to wrong interpretation. Therefore, significant attention has been paid on denoising of ECG for accurate diagnosis and analysis. A denoising autoencoder (DAE) can be applied to reconstruct the clean data from its noisy version. In this paper, a DAE using the fully convolutional network (FCN) is proposed for ECG signal denoising. Meanwhile, the proposed FCN-based DAE can perform compression with regard to the DAE architecture. The proposed approach is applied to ECG signals from the MIT-BIH Arrhythmia database and the added noise signals are obtained from the MIT-BIH Noise Stress Test database. The denoising performance is evaluated using the root-mean-square error (RMSE), percentage-root-mean-square difference (PRD), and improvement in signal-to-noise ratio (SNR_{imp}). The results of the experiments conducted on noisy ECG signals of different levels of input SNR show that the FCN acquires better performance as compared to the deep fully connected neural network- and convolutional neural network-based denoising models.

EPRO SP - 011	User Identification System Using 2D Resized Spectrogram Features of ECG

Studies have been actively conducted on biometrics technology applying electrocardiogram (ECG) signals, which are more robust against forgeries and alterations than fingerprint and face authentication. The ECG lead-I signals measured using ECG acquisition devices consist of 1D data. Therefore, it has limitations with regard to feature extraction and data analysis. This paper proposes a user-recognition system that extracts multi-dimensional features through 2D resizing based on bi-cubic interpolation, which improves the calculation speed and preserves the original data values after converting the measured ECG into a spectrogram. An ECG measuring device was developed, and the ECGs were measured using the developed device. The proposed system consists of an ECG acquisition step, an ECG signal processing step, a segmentation step, a feature extraction step, and a classification step. For ECG signals, the CU-ECG dataset was created by acquiring ECG lead I signal data from 100 subjects in a relaxed state for a period of 160 s. For three sets of shuffle classes that applied the CU-ECG dataset, the average recognition performance was 93% for the existing algorithm and 88.9% for the parameter adjustment method. The average recognition performance of the proposed user recognition system showed a 0.33% improvement compared to the existing algorithm and a 4.43% improvement compared to the parameter adjustment method.

EPRO SP – 012	ECG Authentication Method Based on Parallel Multi-Scale One-Dimensional Residual Network with Center and Margin Loss

To enhance the security level of digital information, the biometric authentication method based on Electrocardiographic (ECG) is gaining increasing attention in a wide range of applications. Compared with other biometric features, e.g., fingerprint and face, the ECG signals have several advantages, such as higher security, simpler acquisition, liveness detection, and health information. Therefore, various methods for ECG-based authentication have been proposed. However, the generalization ability of these methods is limited because the feature extraction for the ECG signals in conventional methods is data dependent. To improve the generalization ability and achieve more stable results on different datasets, a parallel multi-scale one-dimensional residual network is proposed in this paper. This network utilizes three convolutional kernels with different kernel sizes, achieving better classification accuracy than the conventional schemes. Moreover, two loss functions named center loss and margin loss are used during the training of the network. Compared with the conventional softmax loss, these two loss functions can further improve the generalization ability of the extracted embedding features. Furthermore, we evaluate the effectiveness of our proposed method thoroughly on the ECG-ID database, the PTB Diagnostic ECG database, and the MIT-BIH Arrhythmia database, achieving 2.00%, 0.59%, and 4.74% of equal error rate (EER), respectively. Compared with other works, our proposed method improves 1.61% and 4.89% classification accuracy on the ECG-ID database and the MIT-BIH Arrhythmia database, respectively.

EPRO SP - 013	ECG Baseline Wander Correction and Denoising Based on Sparsity

To reduce the influence of both the baseline wander (BW) and noise in the electrocardiogram (ECG) is much important for further analysis and diagnosis of heart disease. This paper presents a convex optimization method, which combines linear time-invariant filtering with sparsity for the BW correction and denoising of ECG signals. The BW signals are modeled as low-pass signals, while the ECG signals are modeled as a sequence of sparse signals and have sparse derivatives. To illustrate the positive of the ECG peaks, an asymmetric function and a symmetric function are used to punish the original ECG signals and their difference signals, respectively. The banded matrix is used to represent the optimization problem, in order to make the iterative optimization method more computationally efficient, take up the less memory, and apply to the longer data sequence. Moreover, an iterative majorization-minization algorithm is employed to guarantee the convergence of the proposed method regardless of its initialization. The proposed method is evaluated based on the ECG signals from the database of MIT-BIH Arrhythmia. The simulation results show the advantages of the proposed method compared with wavelet and median filter.

EPRO SP - 014	A Novel Technique to Diagnose Sleep Apnea in Suspected Patients Using Their ECG Data

Sleep Apnea is a breathing disorder that occurs while the patient is sleeping. Traditionally, Polysomnography is used to diagnose it. However, it is quite inconvenient and expensive. Because of the troublesome diagnosis, this ailment often remained undiagnosed. This paper aims at the development of such a method that provides an easy diagnostic solution to the doctors. Electrocardiogram (ECG) is one of the most common tests done at the hospitals. In this paper, we aim to develop a method which deploys ECG data to diagnose the sleep ailment, Apnea. A technique deploying wavelet packet transform on RR interval of ECG has been presented. Probability density functions of data, both when Apnea is present and when it is not, are obtained by constructing histograms of decision variable for each signal segment. From the overlapping PDFs of the normal and abnormal cases, a threshold is then derived. This helped in segregating the Apnea cases from normal cases. The stated method provided a 100% accuracy in diagnosing Sleep Apnea.

EPRO SP - 015	Centralized Wavelet Multiresolution for Exact Translation Invariant Processing of ECG Signals.

Dyadic wavelet transform is useful in analyzing electrocardiogram (ECG) signals due to its fast computation and its multiresolution ability. In order to improve the feature extraction performance of dyadic wavelet transform, a new construction example of centralized multiresolution (CMR) is proposed. The proposed CMR example consists of two elements, namely, a dyadic part and a non-dyadic part. The dyadic part, based on the maximal overlap second generation wavelet packet transform (SGWPT), generates dyadic wavelet packets. The non-dyadic part engenders ensemble wavelet packets by postprocessing on the dyadic part. The produced wavelet packets and ensemble wavelet packets are combined to realize continued spectral refinement around fixed central analysis frequencies. Numerical simulation and a case study of ECG signal decomposition are utilized to validate the enhancements of the proposed CMR example. The processing results of the CMR example are compared with those of the dual tree complex wavelet transform and the conventional SGWPT. It is validated this CMR example achieves better feature extraction performances due to the presence of the exact translation invariance property.

EPRO SP - 016	Internal Emotion Classification Using EEG Signal with Sparse Discriminative Ensemble

Among various physiological signal acquisition methods for the study of the human brain, EEG (Electroencephalography) is more effective. EEG provides a convenient, non-intrusive, and accurate way of capturing brain signals in multiple channels at fine temporal resolution. We propose an ensemble learning algorithm for automatically computing the most discriminative subset of EEG channels for internal emotion recognition. Our method describes an EEG channel using kernel-based representations computed from the training EEG recordings. For ensemble learning, we formulate a graph embedding linear discriminant objective function using the kernel representations. The objective function is efficiently solved via sparse non-negative principal component analysis and the final classifier is learned using the sparse projection coefficients. Our algorithm is useful in reducing the amount of data while improving computational efficiency and classification accuracy at the same time. The experiments on publicly available EEG dataset demonstrate the superiority of the proposed algorithm over the compared methods.

EPRO SP - 017	Denoising and Baseline Drift Removal Method of MEMS Hydrophone Signal Based on VMD and Wavelet Threshold Processing

Aiming at the problem that the signals received by MEMS vector hydrophones are mixed with a large amount of external environmental noise, and inevitably produce baseline drift and other distortion phenomenons which made it difficult for the further signal detection and recognition, a joint denoising method (VMD-NWT) based on variational mode decomposition (VMD) and nonlinear wavelet threshold (NWT) processing is proposed. The main frequency of the noisy signal is first obtained by Fourier transform. Then the noisy signal is decomposed by VMD to obtain the IMF components. The center frequency and correlation coefficient of each IMF component further determine that the IMF components belong to noise IMF components, noisy IMF components or pure IMF components. Then the pure IMF components are reserved, the noise IMF components are removed, and the noisy IMF components are denoised by NWT processing method with new threshold function as a whole. Finally, the denoised IMF components and the pure IMF components are reconstructed to obtain the denoised signal to realize the extraction of useful signals and baseline drift removal. Compared with complete ensemble empirical mode decomposition with adaptive noise combined with wavelet threshold processing method (CEEMDAN-WT), ensemble empirical mode decomposition combined with wavelet threshold processing method (EEMD-WT).

EPRO SP - 018	Cognitive Smart Healthcare for Pathology Detection and Monitoring

We propose a cognitive healthcare framework that adopts the Internet of Things (IoT)-cloud technologies. This framework uses smart sensors for communications and deep learning for intelligent decision-making within the smart city perspective. The cognitive and smart framework monitors patients' state in real time and provides accurate, timely, and high-quality healthcare services at low cost. To assess the feasibility of the proposed framework, we present the experimental results of an EEG pathology classification technique that uses deep learning. We employ a range of healthcare smart sensors, including an EEG smart sensor, to record and monitor multimodal healthcare data continuously. The EEG signals from patients are transmitted via smart IoT devices to the cloud, where they are processed and sent to a cognitive module. The system determines the state of the patient by monitoring sensor readings, such as facial expressions, speech, EEG, movements, and gestures. The real-time decision, based on which the future course of action is taken, is made by the cognitive module. When information is transmitted to the deep learning module, the EEG signals are classified as pathologic or normal. The patient state monitoring and the EEG processing results are shared with healthcare providers, who can then assess the patient's condition and provide emergency help if the patient is in a critical state.

EPRO SP - 019	Convolutional Neural Networks Using Dynamic Functional Connectivity for EEG-based Person Identification in Diverse Human States

Highly secure access control requires Swiss-cheesetype multi-layer security protocols. The use of Electroencephalogram (EEG) to provide cognitive indicators for human workload and fatigue has created environments where EEG data is wellintegrated into systems, making it readily available for more forms of innovative uses including biometrics. However, most of the existing studies on EEG biometrics rely on resting state signals or require specific and repetitive sensory stimulation, limiting their uses in naturalistic settings. Moreover, the limited discriminatory power of uni-variate measures denies an opportunity to use dependencies information inherent in brain regions to design more robust biometric identifiers. In this paper, we proposed a novel model for ongoing EEG biometric identification using EEG collected during a diverse set of tasks. The novelty lies in representing EEG signals as a graph based on within-frequency and cross-frequency functional connectivity estimates, and the use of graph convolutional neural network (GCNN) to automatically capture deep intrinsic structural representations from the EEG graphs for person identification. An extensive investigation was carried out to assess the robustness of the method against diverse human states, including resting states under eye-open and eye-closed conditions and active states drawn during the performance of four different tasks. We compared our method with the state-of-the-art EEG features, classifiers and models of EEG biometrics.

EPRO SP – 020	Multisource Transfer Learning for Cross-Subject EEG Emotion Recognition

Electroencephalogram (EEG) has been widely used in emotion recognition due to its high temporal resolution and reliability. Since the individual differences of EEG are large, the emotion recognition models could not be shared across persons, and we need to collect new labeled data to train personal models for new users. In some applications, we hope to acquire models for new persons as fast as possible, and reduce the demand for the labeled data amount. To achieve this goal, we propose a multisource transfer learning method, where existing persons are sources, and the new person is the target. The target data are divided into calibration sessions for training and subsequent sessions for test. The first stage of the method is source selection aimed at locating appropriate sources. The second is style transfer mapping, which reduces the EEG differences between the target and each source. We use few labeled data in the calibration sessions to conduct source selection and style transfer. Finally, we integrate the source models to recognize emotions in the subsequent sessions. The experimental results show that the three-category classification accuracy on benchmark SEED improves by 12.72% comparing with the nontransfer method. Our method facilitates the fast deployment of emotion recognition models by reducing the reliance on the labeled data amount, which has practical significance especially in fast-deployment scenarios.

EPRO SP - 021	A CNN Model for Semantic Person Part Segmentation with Capacity Optimization

In this paper, a deep learning model with an optimal capacity is proposed to improve the performance of person part segmentation. Previous efforts in optimizing the capacity of a convolutional neural network (CNN) model suffer from a lack of large datasets as well as the over-dependence on a single-modality CNN, which is not effective in learning. We make several efforts in addressing these problems. First, other datasets are utilized to train a CNN module for pre-processing image data and a segmentation performance improvement is achieved without a time-consuming annotation process. Second, we propose a novel way of integrating two complementary modules to enrich the feature representations for more reliable inferences. Third, the factors to determine the capacity of a CNN model are studied and two novel methods are proposed to adjust (optimize) the capacity of a CNN to match it to the complexity of a task. The over-fitting and under-fitting problems are eased by using our methods. Experimental results show that our model outperforms the state-of-the-art deep learning models with a better generalization ability and a lower computational complexity.

EPRO SP - 022	Path R-CNN for Prostate Cancer Diagnosis and Gleason Grading of Histological Images

Prostate cancer is the most common and second most deadly form of cancer in men in the United States. The classification of prostate cancers based on Gleason grading using histological images is important in risk assessment and treatment planning for patients. Here, we demonstrate a new region-based convolutional neural network framework for multi-task prediction using an epithelial network head and a grading network head. Compared with a single-task model, our multi-task model can provide complementary contextual information, which contributes to better performance. Our model is achieved a state-of-the-art performance in epithelial cells detection and Gleason grading tasks simultaneously. Using fivefold cross-validation, our model is achieved an epithelial cells detection accuracy of 99.07% with an average area under the curve of 0.998. As for Gleason grading, our model is obtained a mean intersection over union of 79.56% and an overall pixel accuracy of 89.40%.

THANK YOU!