TERM PAPER

Mid Evaluation Report - Term Paper

Deception Detection of familiar/unfamiliar faces using EEG signals

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PAPER - 1

Better than random? A closer look on BCI results

By : Gernot R. Müller-Putz, Reinhold Scherer, Clemens Brunner, Robert Leeb, Gert Pfurtscheller

Published In: International Journal of Bioelectromagnetism

Summary:

Brain-computer interface (BCI) is a collaboration between a brain and a device that enables signals from the brain to direct some external activity, such as control of a cursor or a prosthetic limb.

This paper is a basic comparison between Theoretical approach and Simulation(Practical) approach of BCI for the case of 2-class paradigm.

The theoretical approach states that the probability of correctly classified trial in a 2-class paradigm of N trails follows a binomial distribution with p = 0.5, i.e, both classes are equally likely to occur. In this context a BCI experiment consisting of trials (50 per class), the expected chance level would be at exactly 50 correctly classified trials (with equally probable classes). If the reported accuracy of a classifier is 59 correctly classified trials (or alternatively, 59%), it is straightforward to see that this probability does not lie within the theoretical limits of 40.39% and 59.61% (for a confidence of). Thus, it can be assumed that the given classifier does not significantly differ from a random one.

The theoretical results for BCI of a 2-,3-,4- and 8-class are 50%, 33.3% 25% and 12.5% respectively. However, the Simulation results vary from the theoretical for N = 80, the results of 2-,3-,4-,8-class BCI are 57.5%, 39.6%, 29.7% 15.2% for a significance level α=5%.

Concluding, we want to take into account the proposed considerations and to check their results also in relation to the real level of chance and not only to the theoretical one.

PAPER - 2

Classification of EEG Signals by using Support Vector Machines

By : K. Sercan Bayram, M. Ayyüce Kızrak, Bülent Bolat

Published In: ResearchGate

Summary:

In this work, EEG signals were classified by support vector machines to detect whether a subject's planning to perform a task or not. Various different kernels were utilized to find the best kernel function and after that, a feature selection process was realized.

EEG recordings of four different mental states was classified by using five classifiers. In this work, the best result was obtained by using a resilient back propagation method as 95%. With the help of multilayer perceptron(MLP) it was recognised whether a person was sleeping or was awake by using EEG signals.

The five different metal activities were also classified with Support Vector Machine with maximum accuracy of 72%. The accuracy for using a quantum neural networks was 81.33%. Another classifier used was neural networks had an accuracy of 80%. The ID3 classifier had an accuracy of 71%. The final classifier used was fuzz rough ID which correctly classified 76.2% of the data.

In the first step of the work, the dataset classified by linear and nonlinear SVMs, and the best kernel function was determined. Based on the results, the best choice is radial basis function (RBF) kernel for σ=1.2 with 71.43% accuracy. By applying the SFS on data, the result had the accuracy of 72.53%. The SBE gave the best result as 74.73%. At last t-scores and p-values were calculated. The accuracy range of t-score varied from 67 to 71.43% and that of p-value varied from 70.33 to 71.43%.

PAPER - 3

Analysis of EEG Signals for Deception Detection

By : Roshani J. Khandelwal, Juilee D. Mahajan, Ujjwala P. Bombatkar, Snehal G. Badhe

Published In: International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Summary:

Prominent deception detection approaches include the standard polygraph which monitors the signature changes in autonomic responses and the cognitively more central EEG. .Deception detection is the practice of attempting to determine whether someone is lying. The common signs of deceptive behavior are body language, emotional gestures and contradiction, interactions and reactions, verbal context and content,facial micro-expressions, change of topic etc. These deception techniques are used by police, forensic psychologists, security experts and other investigators to help prevent them from being a victim of fraud or scams and other deceptions.

Throughout history, it has often been assumed that lying is accompanied by a change in the body's physiological activity. The polygraph is a set of equipment that accurately measures various sorts of bodily activity such as heart rate, blood pressure, respiration, and palm sweating. Lying causes a conflict between lie and the truth within the brain. The increased activity can be detected by F- MRI which records brain activity by identifying changes in brain blood flow and the metabolic rate. The radar based procedure which could perform remote, unobtrusive, non-invasive and stealthy lie detection is when an UWB radar pulse passes through the human thorax it gets echoed back by the cardiac structure i.e. the heart wall. Heart rate variability is the physiological phenomenon of variation in the time interval between heartbeats i.e. the variation in the beat-to-beat interval. HRV is also an indicator of the emotional arousal.

Several morphological features were extracted to know the various parameters and distinguish truth from lie telling. Classification is done by Euclidean distance method, which will calculate the minimum value between the vectors to display the output. The output is generally displayed with a message as "lie EEG signal" or "true EEG signal".

The conceptual study indicates that it is feasible to identify the basic lie detection.EEG signals will be used for the lie detection because this is non invasive, cheap, and are the direct results of the electric activity inside the brain.

PAPER - 7

Deception Detection of EEG-P300 Component Classified by SVM Method

By : K. Sercan Bayram, M. Ayyüce Kızrak

Published In: IEEE

Summary:

By interfacing the brains signals directly, it is possible to design brain computer interfaces to control devices without mechanical interfaces. Especially direct controlling the prosthetic organs is very important for disabled people. The most common brain activity monitoring device is electroencephalogram (EEG). The ability to measure noninvasively the related brain activity of lying within an individual subject could offer a significant improvement over currently available tools to detect deception

A vast variety of approaches to the classification of quantitative features from an EEG signals. SVM have become extremely successful discriminative approaches to pattern classification and regression problems. In other words, SVM is a technique used to obtain the most probable hyperplane to separate two classes. It is done by measuring the hyperplane's margin and determines its maximum point. Margin is defined as distance between the corresponding hyperplane and the nearest pattern from each class.

To enhance signal noise ratio of P300 components, the independent component analysis (ICA) method was adopted to separate non-P300 (i.e. artifacts) and P300 components from

every single trial. Then the P300 waveforms with high SNR were reconstructed. And then group of features based on time, frequency, and amplitude were extracted from the reconstructed

P300 waveforms. Finally, two different class of feature samples were used to train a support vector machine classifier because it has higher performance compared with several other classifiers.

PAPER - 9

Classification of EEG Signals by using Support Vector Machines

By : K. Sercan Bayram, M. Ayyüce Kızrak

Published In: IEEE

Publishing Date: 2013

Summary:

By interfacing the brains signals directly, it is possible to design brain computer interfaces to control devices without mechanical interfaces. Especially direct controlling the prosthetic organs is very important for disabled people. The most common brain activity monitoring device is electroencephalogram (EEG).

Support vector machine (SVM) is a statistical learning theory based classification method. For a given two-class linearly separable classification problem, SVM tries to find a hyperplane which separates the input space with a maximum margin. The first group which called as filters deals each features independently form theothers. Due to their nature, filters are fast and computationally cheap. On the other hand, filter methods can’t interpret therelations between

features, and this disability limits the filters' performance. Wrappers consist of a searching algorithm and a classifier. The search algorithm searches new solutions through the feature space while the classifier produces a fitness function to the search algorithm. The most common

algorithms are genetic algorithms, particle swarm optimization,

The algorithm starts with the entire dataset. In every step, existing features are removed from the dataset one by one. The feature that gives the least decrease on the accuracy is

excluded from the dataset. The algorithm continues until the stopping criterion is reached To raise the accuracy and to find the most relevant features, four different feature selection algorithms applied to the dataset. To find the most suitable kernel, different SVMs were

trained with original data. The data divided into two equal parts as training and test data.

All of the experiments realized ten times, and averaged to find the accuracies. In the first step of the work, the dataset classified by linear and nonlinear SVMs, and the best kernel function was determined.

PAPER - 11

Deception Detection of EEG-P300 Component Classified by SVM Method

By : Arjon Turnip, M Faizal Amri, Hanif Fakrurroja, Artha Ivonita Simbolon, M. Agung Suhendra, and Dwi Esti Kusumandari

Published In: Technical Implementation Unit for Instrumentation Development

Publishing Date: 2013

Summary: Electroencephalography (EEG), being one of the major brain signal using in Brain-Computer Interface (BCI) applications and in many others also. Comparing to other brain signals, it is very easy to acquire and very cheap. Also, there will be no risk for the user while acquiring the EEG signals and also it is a non-invasive technique. EEG signals are used for clinical as well as research purposes.Analyzing the Event Related Potentials (ERPs) triggered while the subject is exposed to different faces , N170 and P2 waves gave the degree of familiarity effects with small amplitude signals after 170ms and 250ms respectively. Independent Component Analysis (ICA) as the signal processing tool. Due to the low Signal-to-Noise ratio (SNR) value of EEG components, using of ICA enhance the conditioning thus by reducing the noise component. By finding the suitable linear combinations of mixed variables helps for the calculation of independent components. ICA is not a commonly used one, comparing to Principal Component Analysis (PCA). But it is better for signals having multiple recordings at the same time. Based on the property of non-linear feature extraction technique of autoencoders, we designed a classifier for classifying the familiarity and unfamiliarity of the images.

A subject brain wave activities based EEG-P300 component will be monitored while they first respond truthfully and then falsely to questions in regards to a mock theft scenario. Eleven males whose age are around 24 ± 3 years old were subject to the experiment. For extraction and classification, an independent component analysis and support vector machine methods were adopted.In this paper we will discuss about the new method of deception detection using EEG-P300 analysis of guilty and truthful suspect. There are three types of P300 stimuli; probe

stimuli, target stimuli, and irrelevant stimuli. Probe (P) stimuli are related to hidden information known only to lying subjects and observers. Unlike probe stimuli, target (T) stimuli are known by anyone, and the subjects are told to do some tasks while being presented.Support vector machines (SVM) which have become extremely successful discriminative approaches to pattern classification and regression problems is used. The SVM method is able to separate lying subjects from the innocent one based on signal P300 with an accuracy of 70.83% and computation time of 0.0283 s. The results show that a larger spike in the P300 component when the subject was instructed to conceal which watch they had chosen. The findings of these experiments have been promising in testing the validity of using an EEG in deception detection.

PAPER - 12

An Improved Approach for EEG Signal Classification using Autoencoder

By : Abhijith V Nair, Kodidasu Murali Kumar, Jimson Mathew

Published In: IEEE

Publishing Date: 2018

Summary:

The network consists of the dense neural network in encoding layer and decoding layer. and finally, we gave the output of the decoder to a single neuron forgetting the classified output - familiar or unfamiliar. The autoencoder tries to learn significant features from the input data and these features were helped us in the final classification in a very better way. We used Rectified Linear Unit (relu) as the activation function for getting better results. In the classification stage, the system is trained with the EEG signals of familiar and unfamiliar trials and tested the model using the test phase signal. A better deep learning method-autoencoders-has been used in this

over the conventional machine learning methods for the classification of the EEG signals. Autoencoder gave a better result by using the RMSLE loss function and Adam as an optimizer. Before the classification, the signal has been undergone for independent component analysis, which whitens the signals and gave independent components by reducing the correlation, for getting a promising result in classification. Also for getting an idea of how the signal is varying for familiar and unfamiliar, we represented the signal in terms of some time-frequency feature sets, where we saw the effects of N170 by high amplitude for the familiar faces. Classifier gave an almost steady response to all the subjects. It gave accuracy in the range of 80% - 84%. We got a mean accuracy of 82.21%, where the reference model only got an accuracy of 70.71% using machine learning methods.Due to the low Signal-to-Noise ratio (SNR) value of EEG components, using of ICA enhance the conditioning thus by reducing the noise component. By finding the suitable linear combinations of mixed variables helps for the calculation of independent components. ICA is not a commonly used one, comparing to Principal Component Analysis (PCA).

PAPER - 13

Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals

By : U. Rajendra Acharya [a,b,c,*], Shu Lih Oh [a], Yuki Hagiwara [a], Jen Hong Tan [a], Hojjat Adeli [d]

Published In: Computers in Biology and Medicine

Publishing Date: 2017

Summary:

Deep learning is a machine learning technique based on representation learning where the system automatically learns and discovers the features needed for classification from the processing of multiple layers of input data. In this study, a deep learning method is employed to automatically identify the three classes of EEG signals. To the best the authors' knowledge, this is the first EEG

study to employ deep learning algorithm for the automated classification of three EEG classes. A 13-layer deep convolutional neural network (CNN) is developed to categorize the normal, preictal, and seizure class. Deep learning has already proven its capability and has outperformed humans in audio and image recognition tasks To the best the authors' knowledge, this is the first EEG study to employ deep learning algorithm for the automated classification of three EEG classes. A 13-layer deep convolutional neural network (CNN) is developed to categorize the normal, preictal, and seizure class.

EEG signals obtained from 5 healthy subjects, each containing 100 cases. Similarly, the preictal class contains 100 data from 5 epileptic patients, when they did not undergo seizure during the time of acquisition. The seizure class consists of 100 cases with the same subjects when they were having epilepsy during the time of signals acquisition.An improved and recently-developed neural network, known as Convolutional Neural Network (CNN) is employed in this research. The improved ANN is both shift and translational invariance. The convolution operation in.

PAPER - 14

Decoding EEG and LFP Signals using Deep Learning:

By : Ewan Nurse,Benjamin S. Mashford and Antonio Jimeno Yepes

Published In: ACM

Publishing Date: 2016

Summary:

Deep learning technology is uniquely suited to analyse neurophysiological signals such as the electroencephalogram (EEG) and local field potentials (LFP) and promises to outperform traditional machine-learning based classification and feature extraction algorithms. The EEG/LFP decoding problem can be cast into similar problems faced in computer vision that avoid the need for hand-coded features by learning representations of features directly from data. Importantly, the quality of the features that are learnt improve with larger datasets. Learning from data also provides a systematic approach for finding features, as opposed to a trial and error

hand-coded approach.Interestingly, the learnt rules can be studied to understand what signal properties are important for decoding, which can advance our knowledge about the processes that take place in the brain.EEG data was acquired from a participant who performed a self-paced hand squeeze task. The onset of movement were time-locked to the EEG by simultaneously collecting electromyography (EMG) using the same acquisition system. EEG data was taken from patients squeezing their hands with the two data labels being left hand and right hand squeeze patterns. After achieving state of the art classification accuracy of 81% we re-built the neural network into a configuration that is designed to operate within the TrueNorth neuromorphic architecture. We then trained this constrained network using the same EEG dataset and achieved 76% classification accuracy, demonstrating that the neural network can be run on one single TrueNorth chip at a maximum peak power consumption of only 70 mW.

PAPER - 15

EEG-Based Emotion Recognition Using Deep Learning Network with Principal Component Based Covariate Shift Adaptation

By : Suwicha Jirayucharoensak,[1,2] Setha Pan-Ngum,[1] and Pasin Israsena[2]

Published In: The Scientific World Journal

Publishing Date: 2014

Summary:

Automatic emotion recognition is one of the most challenging tasks. To detect emotion from non stationary EEG signals, a sophisticated learning algorithm that can represent high-level abstraction is required. This study proposes the utilization of a deep learning network (DLN) to discover unknown feature correlation between input signals that is crucial for the learning task.The DLN is implemented with a stacked autoencoder (SAE) using hierarchical feature learning approach. Input features of the network are power spectral densities of 32-channel EEG

signals from 32 subjects. To alleviate overfitting problem, principal component analysis (PCA) is applied to extract the most important components of initial input features. Furthermore, covariate shift adaptation of the principal components is implemented to minimize the nonstationary effect of EEG signals. Experimental results show that the DLN is capable of classifying three different levels of valence and arousal with accuracy of 49.52% and 46.03%, respectively. Principal component based covariate shift adaptation enhances the respective classification accuracy by 5.55% and 6.53%. Moreover, DLN provides better performance compared to SVM and naive Bayes classifiers.

PAPER - 16

Deep Learning With Convolutional Neural Networks for EEG Decoding and Visualization

By : Robin Tibor Schirrmeister ,1,2* Jost Tobias Springenberg,2,3 Lukas Dominique Josef Fiederer ,1,2,4 Martin Glasstetter

Published In:Human Brain Mapping

Publishing Date: 2017

Summary:

Deep learning with convolutional neural networks (deep ConvNets) has revolutionized computer vision through end-to-end learning, that is, learning from the raw data. There is increasing interest in using deep ConvNets for end-to-end EEG analysis, but a better understanding of how to design and train ConvNets for end-to-end EEG decoding and how to visualize the informative EEG features the ConvNets learn is still needed. Here, we studied deep ConvNets with a range of

different architectures, designed for decoding imagined or executed tasks from raw EEG. Our results show that recent advances from the machine learning field, including batch normalization and exponential linear units, together with a cropped training strategy, boosted the deep ConvNets decoding performance, reaching at least as good performance as the widely used filter bank common spatial patterns (FBCSP) algorithm (mean decoding accuracies 82.1% FBCSP, 84.0% deep ConvNets).Machine-learning techniques allow extracting information from electroencephalographic (EEG) recordings of brain activity, and therefore play a crucial role in several important EEG-based research and application areas. For example, machine-learning techniques are a central component of many EEG-based brain-computer interface (BCI) systems for clinical applications.ConvNets have both advantages and disadvantages compared to other machine learning models. Advantages of ConvNets include that they are well suited for end-to end learning, that is, learning from the raw data without any a priori feature selection, that they scale well to large datasets, and that they can exploit hierarchical structure in natural signals.

PAPER - 17

EEG-BASED EMOTION CLASSIFICATION USING DEEP BELIEF NETWORKS

By : Wei-Long Zheng, Jia-Yi Zhu, Yong Peng, and Bao-Liang Lu*

Published In:National Natural Science Foundation of China

Publishing Date: 2017

Summary:

In recent years, there are many great successes in using deep architectures for unsupervised feature learning from data, especially for images and speech. In this paper, we introduce recent advanced deep learning models to classify two emotional categories (positive and negative) from EEG data.It has been proven that, for a fixed length EEG segment, differential entropy is equivalent to the logarithm energy spectrum in a certain frequency band.This study measures brain activity based on EEG and uses machine learning methods to accurately read emotions in individuals. This paper applied deep learning (DL) to the construction of reliable models of emotion recognition from EEG data. The algorithm was tested on 62 channels EEG signals for predicting the positive and negative emotional states while watching emotionally laden movie

clips. The dataset was derived from 6 subjects, each for two trails at intervals of one week or longer. We also compared the performance with KNN, SVM and GELM in this study.

PAPER - 18

Statistical Signal Processing of EEG Signals for Lie Detection

By : International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering

Published In:National Natural Science Foundation of China

Publishing Date: 2015

Summary:

he need for lie detection is to resolve disputes that arise over inheritance, forgery, impersonation as well as in forensic science which deals with application of science to law aiding to deliver justice by eliciting truth, scientific evaluation of physical evidence usually encountered in many civil, criminal regulatory and statutory cases. All the methods for lie detection including the most popular polygraph test depend on the measurement of variation of physiological conditions like heart beat rate, respiratory rate (breath rate), etc. by establishing physical contact of some medical device with the person‘s body and thus are invasive and obtrusive. But this leads to an ambiguous and/or inaccurate decision about the person telling lies. Recently newer methods of recording electromagnetic signals from the brain show promise in permitting the detection of deception of truth telling. Forensic electroencephalogram (EEG) based lie detection has recently begun using the guilty knowledge test (GKT) as a potentially more robust alternative to the classical comparative question test. For the evaluation of this method, we have used P300 wave of EEG. This method of using EEG to differentiate lying from truth telling will create an expectation of a break in search of objective methods of lie detection. The method proposed in this paper improves the efficiency of lie detection as compared to the previous reported methods.

PAPER - 19

Sleep Stage Classification Using EEG Signal Analysis

By : Khald Ali I. Aboalayon [1], Miad Faezipour [1,*], Wafaa S. Almuhammadi [2] and Saeid Moslehpour [3]

Published In:MDPI

Publishing Date: 2017

Summary:

Sleep specialists often conduct manual sleep stage scoring by visually inspecting the patient's neurophysiological signals collected at sleep labs. This is, generally, a very difficult, tedious and time-consuming task. The limitations of manual sleep stage scoring have escalated the demand for developing Automatic Sleep Stage Classification (ASSC) systems. Sleep stage classification refers to identifying the various stages of sleep and is a critical step in an effort to assist physicians in the diagnosis and treatment of related sleep disorders. The aim of this paper is to survey the progress and challenges in various existing Electroencephalogram (EEG) signal-based methods used for sleep stage identification at each phase; including pre-processing, feature extraction and classification; in an attempt to find the research gaps and possibly introduce a reasonable solution. Many of the prior and current related studies use multiple EEG channels, and are based on 30 s or 20 s epoch lengths which affect the feasibility and speed of ASSC for real-time applications. Thus, in this paper, we also present a novel and efficient technique that can be implemented in an embedded hardware device to identify sleep stages using new statistical features applied to 10 s epochs of single-channel EEG signals. In this study, the PhysioNet Sleep European Data Format (EDF) Database was used. The proposed methodology achieves an average classification sensitivity, specificity and accuracy of 89.06%, 98.61% and 93.13%, respectively, when the decision tree classifier is applied. Finally, our new method is compared with those in recently published studies, which reiterates the high classification accuracy performance.

PAPER - 20

Emotion Recognition using EEG Signals with Relative Power Values and Bayesian Network

By : Kwang-Eun Ko, Hyun-Chang Yang, and Kwee-Bo Sim*

Published In:International Journal of Control, Automation, and Systems

Publishing Date: 2009

Summary:

Many researchers use electroencephalograms (EEGs) to study brain activity in the context of seizures, epilepsy, and lie detection. It is desirable to eliminate EEG artifacts to improve signal

collection. In this paper, we propose an emotion recognition system for human brain signals using EEG signals. We measure EEG signals relating to emotion, divide them into five frequency ranges on the basis of power spectrum density, and eliminate low frequencies from 0 to 4 Hz to eliminate EEG artifacts. The resulting calculations of the frequency ranges are based on the percentage of the selected range relative to the total range. The calculated values are then compared to standard values from a Bayesian network, calculated from databases. Finally, we show the emotion results as a human face avatar.

PAPER - 25

Evaluation of P300 based Lie Detection Algorithm

By : Syed Kamran Haider, Malik Imran Daud, Aimin Jiang, Zubair Khan

Published In: IEEE

Summary:

Lie detection is used to verify people's value. Earlier methods were unable to accurately determine mental behaviour.A researchable analysis gives us an idea that, with the help of EEG signals we can easily monitor the psychological variations, brain activities and deception detection related features But lately, we can get an idea of psychological behaviour using Electroencephalogram(EEG). We use an EEG to detect brain signals.

We extract the desired features from the brain signals acquired through sixteen electrodes using various extraction techniques. Then, they have implemented linear discriminant analysis (LDA) classification technique to differentiate the positive and negative samples from the signals obtained from sensors in order to achieve a decision for either guilty subject or innocent subject accordingly.

Twenty subjects (15 males and 5 females, ages between 20-25 years) that were generally universities students and all had good health with stable psychological behaviour participated in the study.

They recorded data of over 15 to 20 subjects. In one scenario, some precious items (e.g., jewellery, cash, smart phones, etc.) were placed in front of some subjects. Those subjects were not informed about the scenario and the subject can be any random person. Another person called as Subject-2 intended to perform this test come and stole that item that was placed in front of person called as Subject-1. It can be any person but suggestively that can be his/her close friend. As this test was performed in university, university authorities would handle the case of that stolen item. This was done only to put our subject under pressure for lie and truth response.

First some obvious questions were asked that everybody would answer the obvious answers, i.e., the true answer. The brain signals were recorded with the sample rate of 128 samples per second. The recorded signals which were digitized and amplified can be monitored offline with the help of MATLAB software. Pass band filter were used with the range of 0.3-30 Hz prior to data analysis. For P300-based study about Guilty Knowledge Test (GKT) the previous mentioned pass band filter range were used [9]. The EEG signals from EPOC headset are itself digitized because headset contains the built-in analog to digital converter (ADC).

After applying pass band filter on EEG signals, each continuous subject record is divided into single sweep as per the times known by stimulus presentation [10]. The total length of each single sweep is 1000ms, and contains 128 samples. Then the signal pattern recognition technique includes special features extraction and features selection. After that apply classification method on the signals to assess the detection rate. It should be noticed that, in all cases related to P300 ERP the Pz is the prime location where P300 can be monitored maximal and therefore visual related experiments were performed only on Pz data.

The EEG signal is in time domain and the energy is distributed. The optimal features are suppressed with the noise. In order to dig out the features, EEG signal is observed under the signal energy in the form of time domain or frequency domain. The frequency domain analysis is the best for those features utilized in the mental task related to EEG signals.

LDA is a dimensionality reduction technique which is commonly used for the supervised classification problems. It is used for modeling differences in groups i.e. separating two or more classes. It is used to project the features in higher dimension space into a lower dimension space.

For example, we have two classes and we need to separate them efficiently. Classes can have multiple features. Using only a single feature to classify them may result in some overlapping as shown in the below figure. So, we will keep on increasing the number of features for proper classification. Achieved 85% accuracy in detecting lie and truth subjects.

PAPER - 26

Lie Detection Based EEG-P300 Signal Classified by ANFIS Method

By : Arjon Turnip, M. Faizal Amri, M. Agung Suhendra, and Dwi Esti Kusumandari

Published In: Springer

Summary:

The lie detector is an instrument that is often discussed or researched by scientists and experts. Because of a number of problems posed by lies and frauds, which be able to lead to criminal activities, lie detector needs to be improved. Many subjects or suspects of criminal activities to lie when questioned by authorities. This shows the importance of tools that can differentiate between a subject who is lie or not.

Once the signals recording was complete, the continuous EEG data from each subject were inspected and filtered for artifacts using band-pass filter and Independent Component Analysis (ICA), respectively. Parts of the signals that contained noises by task-irrelevant movement or

artifact be cut by band-pass filtered using 0.1 Hz and 30 Hz cut-offs [17] and then the noises were removed by ICA.

In this research, discrete wavelet transform (DWT) is used as an extraction method. The reason why the wavelet transform has been selected because the component of ERP signal-to-noise ratio (SNR) is low and not stationary

The DWT uses multi filter banks and special wavelet filters for the analysis and reconstruction of signals. The DWT provides a compact representation of a signal in time and frequency that can be computed efficiently. The method calculates the wavelet coefficients at discrete intervals of time and scale instead of at all scales.

An Adaptive Network Fuzzy Interference System (ANFIS) is used as a classifier after signals extraction.The results of signal from three stimuli responses which are produced through signal processing, response from P stimuli has the most important information in determining whether subjects are lying or not. Before we got the signal features that affected by P stimuli, preprocessing signals and feature extraction had been through.

The ANFIS method applied at the features classification step has the advantage of much less training time is achieved. The results indicated that the existing method in this article had great result for lie detection. The ANFIS method is able to separate lying subjects from honest subjects based on EEG-P300 signals with an accuracy of 64.27%.

PAPER - 27

Wavelet analysis for EEG feature extraction in deception detection

By : Anna Caterina Merzagora, Scott Bunce, Meltem Izzetoglu and Banu Onaral

Published In: 28th IEEE

EMBS Annual International Conference

New York City, USA

Summary:

By interfacing the brains signals directly, it is possible to design brain computer interfaces to control devices without mechanical interfaces. Especially direct controlling the prosthetic organs is very important for disabled people. The most common brain activity monitoring device is electroencephalogram (EEG).

A primary emphasis in this study was to examine the capacity for physiological measures to differentiate among the cognitive elements of truth and deception, i.e. the knowledge that one is lying. The task was designed to elicit high motivation to escape detection, but to minimize participants' anxiety about being deceptive. To accomplish this end, the task was framed as a form of poker-like card game in which it is socially acceptable to "bluff," or to lie, minimizing feelings of anxiety about lying.

Participants were given a total of 5 cards, four of which (one from each suit) were face-up on the computer screen (the 'hand'). Participants were informed that the identities of these four face-up cards, as in some forms of poker, were known by the participants, as well as the researchers. Participants were then asked to choose a fifth card from among three sealed envelopes, each of which contained a playing card which they kept in their hand ('target' card) and $50. Participants were informed that only they knew the identity of this card, and the experimenter would be attempting to learn the identity of this card by alternately presenting a series of cards, asking the question

"Do you have this card?", and examining their brain responses. They were told that if they were successful in concealing the identity of the card, that would be able to keep the $50, in addition to their participation remuneration ($25).

Quadratic B-spline wavelets were used in the wavelet analysis due to their near optimal time frequency localization properties. Moreover, their waveform is similar to the waveforms to be detected in the EEG signal; hence extraction of EEG components is more likely to be successful.

The aim of this preliminary study was to investigate the ability of wavelet domain features obtained from the EEG differentiate truth from deception during a low anxiety task. The results revealed that wavelet coefficients corresponding to beta waves were found to differentiate when subjects were telling the truth versus when they were lying.

PAPER - 28

An Overview of Sleep Apnea and EEG Recording

By-Shaguftah, Mohd Maroof Siddiqui

Published In-International Journal of Advanced Research in Computer Science and Software Engineering

October-2015

Summary:

This paper is an overview of sleep apnea and recording of EEG signals. It can be used in medical practice guidelines. Sleep apnea is breaks in breathing or they are instances of deep or limited breathing during night sleep. This paper also includes the symptoms, treatment and causes of sleep apnea and types of sleep apnea. EEG recording technique can be used in sleep research.EEG recording includes computer digitization along with EEG filtering and fast Fourier transform.

Electroencephalography is used to monitor the electrical activity of brain by placing the electrodes along the scalp. It measures and records the voltage fluctuations which results from ionic current within the neurons of the brain. It can be used to diagnose tumours, sleep disorders and strokes. Usually 20–40 minutes of brain activity is recorded from multiple electrodes by placing it on the scalp of the person. Generally diagnostic applications focus on the spectral collection of EEG which is observed in EEG signals and is the type of neural oscillations. In neurology, the diagnostic application of EEG is epilepsy. On a standard EEG study it can create clear abnormality. A major use of EEG is in the diagnosis of brain deaths, encephalopathy, and coma. A third use of EEG is for the studies of sleep disorders and sleep where recordings are done for one whole night, sometimes it may increase but this use is decreasing with the beginning of anatomical imaging techniques such as MRI and CT with high spatial resolution. In spite of limited spatial resolution, EEG still continues to be a important tool for diagnosis and research.

PAPER - 29

The utility of routine EEG in the diagnosis of sleep disordered breathing.

By-Karakis I, Chiappa KH, San Luciano M, Sassower KC, Stakes JW, Cole AJ

Date- 2012 Aug

Summary:

Sleep disordered breathing (SDB) is a common medical condition. Its manifestations of snoring, nocturnal choking, arousals, and sleep fragmentation can lead to excessive daytime sleepiness, neuropsychological slowing, lapses of consciousness, and accidents that can be misinterpreted as epileptic phenomena. They retrospectively evaluated the reporting of sleep apnea symptomatology in routine inpatient and outpatient adult EEG studies performed in our institution over the past 12 years. Comparisons were performed with the medical records to ascertain the coexistence of objectively diagnosed SDB with polysomnography before or after the EEG study and the importance of reporting variations in assisting with the diagnosis.

reporting showed a statistically significant association with the completion of a sleep study. Routine EEG offers a unique opportunity of direct clinical observation along with electrophysiologic and cardiorespiratory monitoring. When sleep is recorded, it can help identify clinical and electrographic features of sleep apnea and prompt confirmation with a polysomnogram in the appropriate clinical context. It can therefore serve as a valuable, adjunctive tool for the diagnosis of SDB.

PAPER – 30

The Application of EEG related

By-Shuli Huanga ,Huabo Xiaob

Published In-2011 3rd International Conference on Environmental Science and Information Application Technology (ESIAT 2011)

Summary:

Many studies indicate that different EEG frequency bands, representing the corresponding activities of the brain, this stage are divided into the following EEG frequency bands:

σ Band (1-4 Hz) reflects sleep, relaxation and fatigue.

θ Band (4-8 Hz) reflects the excitement and shock.

α Band (8-14 Hz) reflects the calm of the brain work.

β Band (14-30 Hz) reflects the concentrated work of a busy brain. α

In the analysis of EEG frequency bands, applications are generally divided into two types, one is the direct use of the different EEG frequency bands, in the research, such as the AR model using wavelet analysis and other methods will be able to extract the signals of different frequency bands of EEG.

For EEG feature extraction and classification methods, in order to improve the accuracy of the algorithm used in many algorithms used are not generally divided into two stages, first feature extraction stage, the main algorithm in the following areas:

(1) the characteristics of time-domain signal extraction: including Fourier transform, wavelet transform, autoregressive model, a specific band filtering, Kalman filtering;

(2) the spatial domain feature extraction include: Laplace transform, principal component analysis, independent component analysis;

(3), - spatial domain feature extraction: including time - spatial domain component analysis, multivariate autoregressive models;

(4) feature extraction transformation model: including EEG into brain ECoG, EEG dipole source such conversion.

PAPER - 31

EEG Signal Processing for BCI Applications

By-A. Roman-Gonzalez

Published In-IEEE 2012

Summary:

In this article they offer a communication system to people who undergo a severe loss of motor function as a result of various accidents and/or diseases so that they can control and interact better with the environment, for which a braincomputer interface has been implemented through the acquisition of EEG signals by electrodes and implementation of algorithms to extract characteristics and execute a method of classification that would interpret these signals and execute corresponding actions The first objective is to design and construct a system of communication and control based on the thought, able to catch and measure EEG signals. The second objective is to implement the system of data acquisition including a digital filter in real time that allows us to eliminate the noise. The third objective is to analyze the variation of the EEG signals in front of the different tasks under study and of implementing an algorithm of extraction of characteristics. The fourth objective is to work on the basis of the characteristics of the EEG signals, to implement a classification system that can discriminate between the two tasks under study on the basis of the corresponding battles.

PAPER - 32

Emotion Recognition using EEG Signals with Relative Power Values and Bayesian Network

By-Kwang-Eun Ko, Hyun-Chang Yang, and Kwee-Bo Sim

Published In- International Journal of Control, Automation, and Systems (2009)

Summary:

Emotion recognition in humans is an increasingly important research subject in this area. EEG signals are well known in the measurement of brain activity, and have been studied for various purposes.

To assess the mental condition of a human, researchers often use a dimension model and a foundation emotion model. Wundt classified three dimensions: pleasant/ unpleasant feeling, excitement/calmness, and tension/ relaxation. Russell combined existing research and considered two dimensions: pleasant/unpleasant feeling and awakening/sleeping.

They measured EEG signals from 0 Hz to 50 Hz; these were transformed into power spectra using FFTs. They measured delta (0~4 Hz), theta (4~8 Hz), alpha (8~13 Hz), beta (13~30 Hz), and gamma (30~50 Hz). The calculated relative power values were compared with the database for emotion recognition. The resulting values clearly differed by individual. They estimated emotions using probability inference in order to account for the differences. When they compared the results with

the database, the mean values of the database were the standards of the value judgements. If a measured value was higher than the mean, the value was allocated a positive binary number. The binary values were used to calculate probability inference using a Bayesian network.

PAPER - 33

Classification of EEG Signals Based on Autoregressive Model and Wavelet Packet Decomposition

By-Yong Zhang, Bo Liu, Xiaomin Ji & Dan Huang

Published In- Springer 13 June 2016

Summary:

Classification of electroencephalogram (EEG) signals is an important task in the brain computer interface system. This paper presents two combination strategies of feature extraction on EEG signals. In the first strategy, Autoregressive coefficients and approximate entropy are calculated respectively, and the features are obtained by assembling them. In the second strategy, the EEG signals are first decomposed into sub-bands by wavelet packet decomposition. Wavelet packet coefficients are then sent to the autoregressive model to calculate autoregressive coefficients, which are used as features extracted from the original EEG signals. These features are fed to support vector machine for classifying the EEG signals. The classification accuracy has been used for evaluating the classification performance. Experimental results in five mental tasks show that the combination strategies can effectively improve the classification performance when the order of autoregressive model is greater than 5, and the second strategy is superior to the first one in terms of the classification accuracy.

PAPER - 34

1D-local binary pattern based feature extraction for classification of epileptic EEG signals

By-Murat Uyar, Ramazan Tekin

Published In- Sciencedirect (15 September 2014)

Summary:

In this paper, an effective approach for the feature extraction of raw Electroencephalogram (EEG) signals by means of one-dimensional local binary pattern (1D-LBP) was presented. For the importance of making the right decision, the proposed method was performed to be able to get better features of the EEG signals. The proposed method was consisted of two stages: feature extraction by 1D-LBP and classification by classifier algorithms with features extracted. On the classification stage, the several machine learning methods were employed to uniform and non-uniform 1D-LBP features. The proposed method was also compared with other existing techniques in the literature to find out benchmark for an epileptic data set. The implementation results showed that the proposed technique could acquire high accuracy in classification of epileptic EEG signals. Also, the present paper is an attempt to develop a general-purpose feature extraction scheme, which can be utilized to extract features from different categories of EEG signals.

PAPER – 35

Classification of EEG Signals Based on Pattern Recognition Approach

By-Hafeez Ullah Amin, Wajid Mumtaz, Ahmad Rauf Subhani, Mohamad Naufal

Published In-Frontiers in computational neuroscience (21 November 2017)

Summary:

Feature extraction is an important step in the process of electroencephalogram (EEG) signal classification. The authors propose a “pattern recognition” approach that discriminates EEG signals recorded during different cognitive conditions. Wavelet based feature extraction such as, multi-resolution decompositions into detailed and approximate coefficients as well as relative wavelet energy were computed. Extracted relative wavelet energy features were normalized to zero mean and unit variance and then optimized using Fisher's discriminant ratio (FDR) and principal component analysis (PCA).

Classifiers such as, K-nearest neighbors (KNN), Support Vector Machine (SVM), Multi-layer Perceptron (MLP), and Naïve Bayes (NB) were then employed. Outcomes yielded 99.11% accuracy via SVM classifier for coefficient approximations (A5) of low frequencies ranging from 0 to 3.90 Hz. Accuracy rates for detailed coefficients were 98.57 and 98.39% for SVM and KNN, respectively; and for detailed coefficients (D5) deriving from the sub-band range (3.90–7.81 Hz). Accuracy rates for MLP and NB classifiers were comparable at 97.11–89.63% and 91.60–81.07% for A5 and D5 coefficients, respectively. the proposed approach was also applied on public dataset for classification of two cognitive tasks and achieved comparable classification results, i.e., 93.33% accuracy with KNN. The proposed scheme yielded significantly higher classification performances using machine learning classifiers compared to extant quantitative feature extraction. These results suggest the proposed feature extraction method reliably classifies EEG signals recorded during cognitive tasks with a higher degree of accuracy.

PAPER - 36

Adaptive feature extraction for EEG signal classification

By-Shiliang Sun & Changshui Zhang

Published In-Springer (12 September 2006)

Summary:

One challenge in the current research of brain–computer interfaces (BCIs) is how to classify time-varying electroencephalographic (EEG) signals as accurately as possible. In this paper, we

address this problem from the aspect of updating feature extractors and propose an adaptive feature extractor, namely adaptive common spatial patterns (ACSP). Through the weighed update of signal covariances, the most discriminative features related to the current brain states are extracted by the method of multi-class common spatial patterns (CSP). Pseudo-online simulations of EEG signal classification with a support vector machine (SVM) classifier for multi-class mental imagery tasks show the effectiveness of the proposed adaptive feature extractor.