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Classification for EEG Signals of Different Mental Tasks Based on PNN neural network

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Abstract. Electroencephalogram (EEG) signal is an important information source of underlying brain processes. The communication based on EEG between human brain and computer is a new modality of human—computer interaction. Through time-domain regression method for EEG Denoising pretreatment, AR model coefficient is extracted as feature vector, and classifies the mental tasks based on PNN network. According to the an analysis and experiment results, the method can get high correct rate of Classification.

Keywords: EEG signal; AR pretreatment feature extraction; PNN neural network

1.Introduction

When people different thinking activity, the left and the right hemispheres of EEG signals detected are not the same. In recent years, using different thinking homework EEG signals for realizing brain – computer interface (BCI) and brain function of a new technology, has received wide attention. As long as the brain is able to normal thinking, can pass brain-computer interface technology and external communications, so for those high brainstem injury or paraplegia completely artesian patients has very broad practical prospect .[1,2,3]

2.Experimental methods

2.1. Data Sources[4]

EEG data comes from the experimental data of Keim and Aunon who are from Purdue University .An Electro-Cap elastic electrode cap was used to record from positions C3, C4, P3, P4, O1, and O2, defined by the 10-20 system of electrode placement. The electrodes were connected through a bank of Grass amplifiers and band pass filtered from. Data was recorded at a sampling rate of 250 Hz with a Lab Master 12 bit A/D converter mounted in computer. Eye blinks were detected by means of a separate channel of data recorded from two electrodes placed above and below the subject's left eye. Data was recorded for 10 seconds during each task and each task was repeated five times per session. The subjects were asked to perform five mental tasks:

A baseline task: for any possible subjects relaxed and not thinking activity; The letter task: subjects imagine to writes a letter give a relative or friend;Math task: imagined complex multiplication: for example 49X78;Visual counting task: imagine will a 3d graphics around an axis rotation; Geometric figure rotation: subjects imagine written a digital on the blackboard. And Figure 1 shows one half-second window of EEG signals from the six channels for each of the five tasks.

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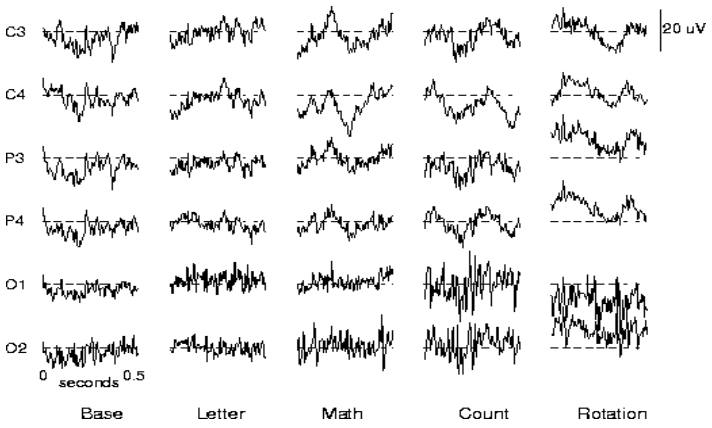

Figure1. the task before each half a second wave of mental tasks

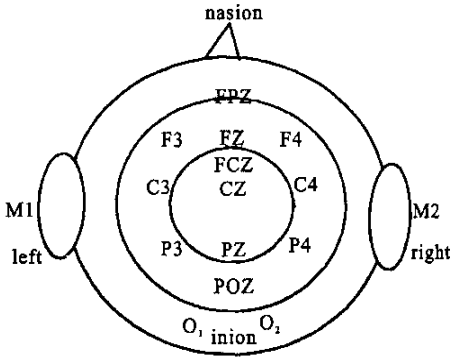

Figure 2 . electrode placement model

2.2. EEG Signal Preprocessing [5] And Feature Extraction

Use a time-domain regression method to remove the blink artifact noise contained in the original EEG signals. Aiming at different leads, eye signals multiplied by corresponding weighting factors to modify amplitude , and then the EEG signal subtract the modified eye signals to reach the purpose of removing the strong eye electricity. The reason of using AR Parameter model method is that the EEG signals are typically non-stationary random signals .Assuming that the sample sequence of x (t) is x [n], then the AR model of the sequence x [n] is :

$$x[n] = -\sum_{k=1}^{p} a_k x[n-k] + u[n]$$

Among them p is the model rank time, a_k is the AR model parameters, $u[n]$ is the excitation white noise.

Subject 2 is the study object of this test. Each mental task is repeated 5 times. Each time lasts 10 seconds. Each channel records 2500 sample data for each test.

Write a piece of Programming to draw out the graphs of five kinds of mental tasks that repeat once in MATLAB 7.0, in the graphs the abscissa stands for the2500 sample data of each test , and the vertical axis stands for the unit of EEG amplitude ,and the unit is μ v. One of the two graphs contains EOG, and the other does not.

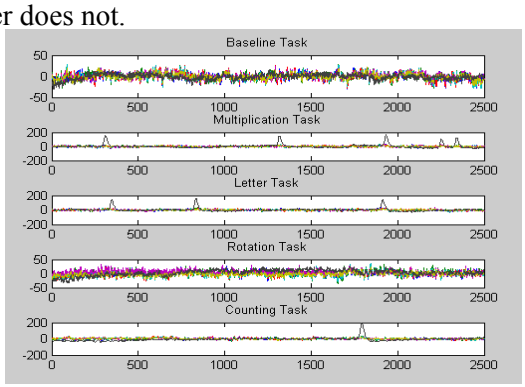

Figure 3. contain EO

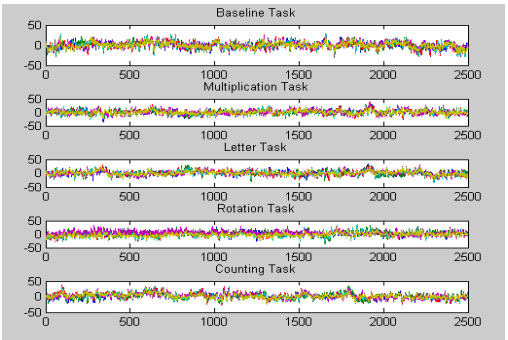

Figure 4. not contain EOG

EEG data are segmented by rectangular windows. The length of each window is 1s (250 sampling points).The previous section overlaps the under section with 0.5s, and the data length is 10s, so it can be divided into 19 segments. Build a AR model for each section of data. Model is as follows:

$$x_{ic}(t) = \sum_{i=1}^{p} a_{ic} x_{ic}(t-i)$$

a_{ic} is the i coefficient of AR in the C channel, C = {C3, C4, P3, P4, O1, O2}, P is the order of AR model.

A large number of experiments show that 6 is the appropriate model order for this article. Use AR parameter to estimate the 36 features of each EEG segment to get a coefficient sequence .And the length of the coefficient sequence is 36.Use the coefficient sequence to form a feature vector and treat it as a sample.

3. PNN classification algorithm

3.1. PNN Neural Network Algorithm

D.F.S pecht proposed probabilistic neural network (PNN) is the radial basis function (RBF) network is a kind of important deformation. The network composes by the input and output layer, radial grassroots layers. In the famous Parzen papers, he pointed out that classes of probability density function of estimation methods, this method can asymptotic approach that provide smooth and continuity of the original root density. Probabilistic neural network is starting from this method, it is the basic principle, use multiple centers in the training sample place of multidimensional Gaussian kernel function is weighted sum to approximate and approximation input data of probability density function (PDF). The weighted sum of coefficient by the neural network in training through iterative algorithm can achieve. Input with noise samples, through the network get it belongs to all kinds of model of a posteriori probability, finally by selecting the biggest output competition layer posteriori probability as the verdict, can see, probabilistic neural network realization is a Bays judgment.

Probabilistic neural network (PNN often used in pattern classification, the network structure as shown in figure 4, with a radial basis the network layer and a competition network layer. The first layer of various patterns with weight vector distance weighted representation and the training sample of similarity degree. Second neuron number equals classification model number, weights for objective vector T, no threshold vector, neurons transmission function for competition transmission function, it choose those distance weighted value the biggest networking as output, objective vector T represents various patterns and the training sample relationship, line number representation classified number, column number shows the training sample serial number (position).

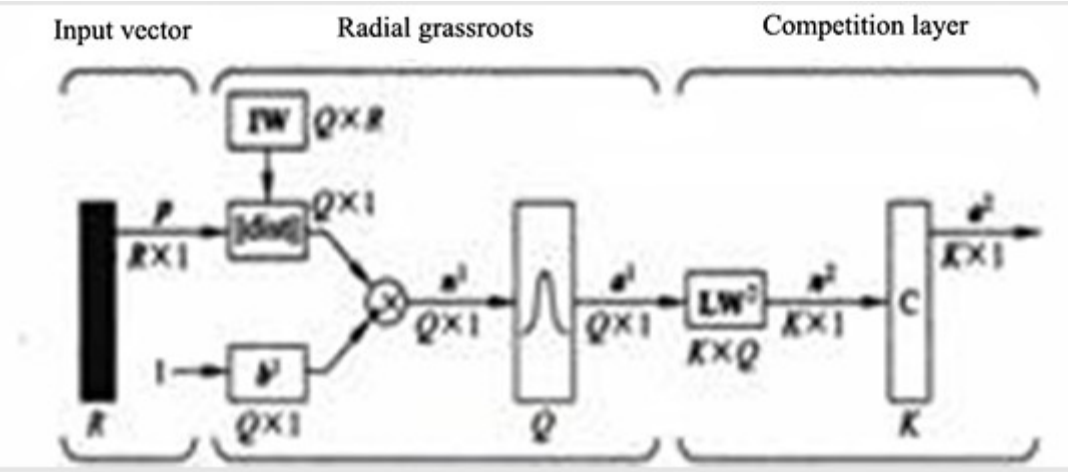

Figure 5. PNN network structure

4.Experimental Results And Analysis

Use PNN algorithm to classify five mental states of the first two, the first three, first four, and all of them .The classification results are as follows:

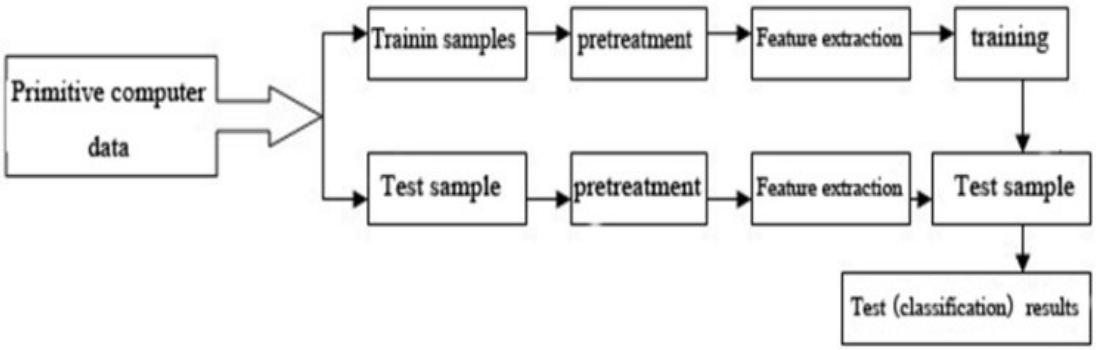

Figure 6. EEG classification process based on PNN neural network

Table 1. PNN algorithm classification accuracy compared

Thinking task	Not subsection	subsection
2	92.5%	90.2%
3	87.6%	84.7%
4	83.3%	83.7%
5	70%	67.4%

(1) On this article the 10s EEG data, it may not segmentation, Not segmentation signal classification accuracy is higher than segmentation.
(2) With homework increase classification accuracy reduced .
(3) Considering the conductive extremely information correlativity exists.

5.Acknowledgment

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