Mental tasks discrimination by Neural networks with Wavelet transform

Choi Kyoung ho* and Minoru Sasaki**

* Department of Mechanical Engineering, Gifu University
1-1 Yanagido, Gifu City, Gifu 501-1193, JAPAN
e-mail: g3812206@guedu.cc.gifu-u.ac.kr

** Department of Mechanical Engineering, Gifu University
1-1 Yanagido, Gifu City, Gifu 501-1193, JAPAN
e-mail: sasaki@cc.gifu-u.ac.kr

Abstract

The study mainly focuses on the analysis of Electroencephalogram, to classify mental tasks by using features based on wavelet transform. We have used the daubechies family wavelets, level 6, to transform obtained signal from EEG signal. Local features can be described well with wavelets that have local extent in EEG. This offers improved features to the neural networks obtaining several classified mental tasks.

Through several processes, it led us more developed variety mental tasks classification results. We find that the neural networks perform over 75% success resulting with small number of electrodes better than a previous 70% resulting.

1. INTRODUCTION

For the EEG analysis, since the early days of automatic EEG processing, representations based on a Fourier transform have been most commonly applied. Numerous other techniques from the theory of signal analysis have been also used to obtain representations and extract the features of interest for classification purposes [1]. Finding a suitable representation of EEG signals is the key to learning a reliable discrimination and to understanding the extracted relationships [2,3].

We used Wavelet Transform to lead some features from the original EEG signal. The wavelet is the best since they allow a most distinctive decomposition in to frequency components while still keeping as much time information as possible. In combination with the spatial resolution available this makes wavelet analysis of EEG signals a powerful vehicle of analyzing the spatio-temporal architecture of the brain.

The present paper tries to give a core method to analyze some EEG to detect mental tasks. We introduce the wavelet transforms in order to find features. An experiment with neural networks may be found in next section. Examples of classified output are presented.

2. BRAIN WAVES MENTAL TASKS

For this paper, the data from four subjects performing five mental tasks was analyzed. Most subjects attended four such sessions recorded on separate weeks with the Cyberlink™ system. The subject was given written instructions at the beginning of each program. The program includes: relaxing, for which the subject was asked to relax as much as possible; counting numbers, for which the subject was imagined to count from 0 to 200 step by step; listening preferred music, for which the subject chose preferred music then listen the music without any physical movements; and seeing preferred photos, for which the subject chose preferred photos then was asked to see those with physical movements as small as possible. An example signals on sub-band 6 from the Cyberlink™ is shown in Fig.1. It represents 'Seeing photos', 'Listening music', 'Counting numbers', and 'Relaxing' from bottom graph.

4. EEG STATES CLASSIFICATION

![Fig.1. Different mental state's pattern in sub-band 6](image-url)
4.1 Wavelet expansions to EEG signal

The ability to capture a global behavior of a signal on low resolution expansion and to move progressively into more details as needed provides a flexible tool for an efficient decomposition. We here aimed at exploiting the characteristic time-frequency decomposition of wavelets to capture main features of various mental tasks by following several stimulations.

To find desired features based on the previous theory from EEG signal, we applied $\epsilon$-decimated discrete wavelet transforms with levels (from 1 to 6). We have used level 4 to 6 as features to neural networks with the EEG recordings obtained from human subjects at 3 electrodes. Fig.2 shows an example screen shot of the wavelet-transformed signal of a ‘Relax’ state, it contains original and transformed signals from level 1 to 6. A ‘daubechies 6’ wavelet filter has been chosen, since the shape of its mother wavelet show the ability to extract features from EEG signal to be classified.

![Wavelet transformed signal](image)

Fig.2. The wavelet transformed signal of a ‘Relax’ state

4.2 Neural networks as classifiers

Neural networks have the capability of finding a nonlinear transformation of the pattern in order to classify more accurately. The best network was found within 400 epochs. It was then applied to the test set for validation. The output of any of the classifiers should be the proper value by following each mental task if the input pattern belongs to the mental task it has to be recognized by the network. Training neural networks with a single hidden layer containing 40 hidden units took under 250 seconds. This was implemented on the base of Matlab and C++ language [6].

5. RESULTS

Table 1 shows the results of all classification experiments as the average percent of test patterns classified correctly. This table includes at least 75%-80% confidence intervals, based on several repetitions. Clearly the best classification accuracy is achieved with the relaxing and listening preferred music, like previous our result without wavelet transform, giving an average accuracy of about 80% for a network with 40 hidden units. It leads more confidence in counting numbers and Listening music compare to the previous 70% without wavelet transform.

<table>
<thead>
<tr>
<th>Mental task</th>
<th>Success rate</th>
</tr>
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<tbody>
<tr>
<td>Relaxing</td>
<td>90%</td>
</tr>
<tr>
<td>Counting numbers</td>
<td>75%</td>
</tr>
<tr>
<td>Listening music</td>
<td>80%</td>
</tr>
<tr>
<td>Seeing photos</td>
<td>85%-90%</td>
</tr>
</tbody>
</table>

6. CONCLUSIONS AND FUTURE WORKS

In this work, we developed classification system at least more 75% per each stimulated mental tasks than 70% compared with previous methods. Following this result, the trained neural networks based on the wavelet transformed feature extraction would therefore be able to discriminate a subject’s mental state while the subject’s train his/her own mental tasks.

Using the time-frequency localization property of the wavelet transform, and the high sampling feature of SWT in all frequency bands, the proposed technique has clearly shown its potential in classifying several mental tasks.

REFERENCES

Transactions, Proceedings or Journal Articles:

Book: