Neural Network Interest Group

Título/*Title*:
EEG Processing

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Relatório Técnico/*Technical Report* No. 2 /2008

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Publicado por/*Published by*: NNIG. http://paginas.fe.up.pt/~nnig/

EEG processing

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NNIG, July 18, 2008

n-back memory test

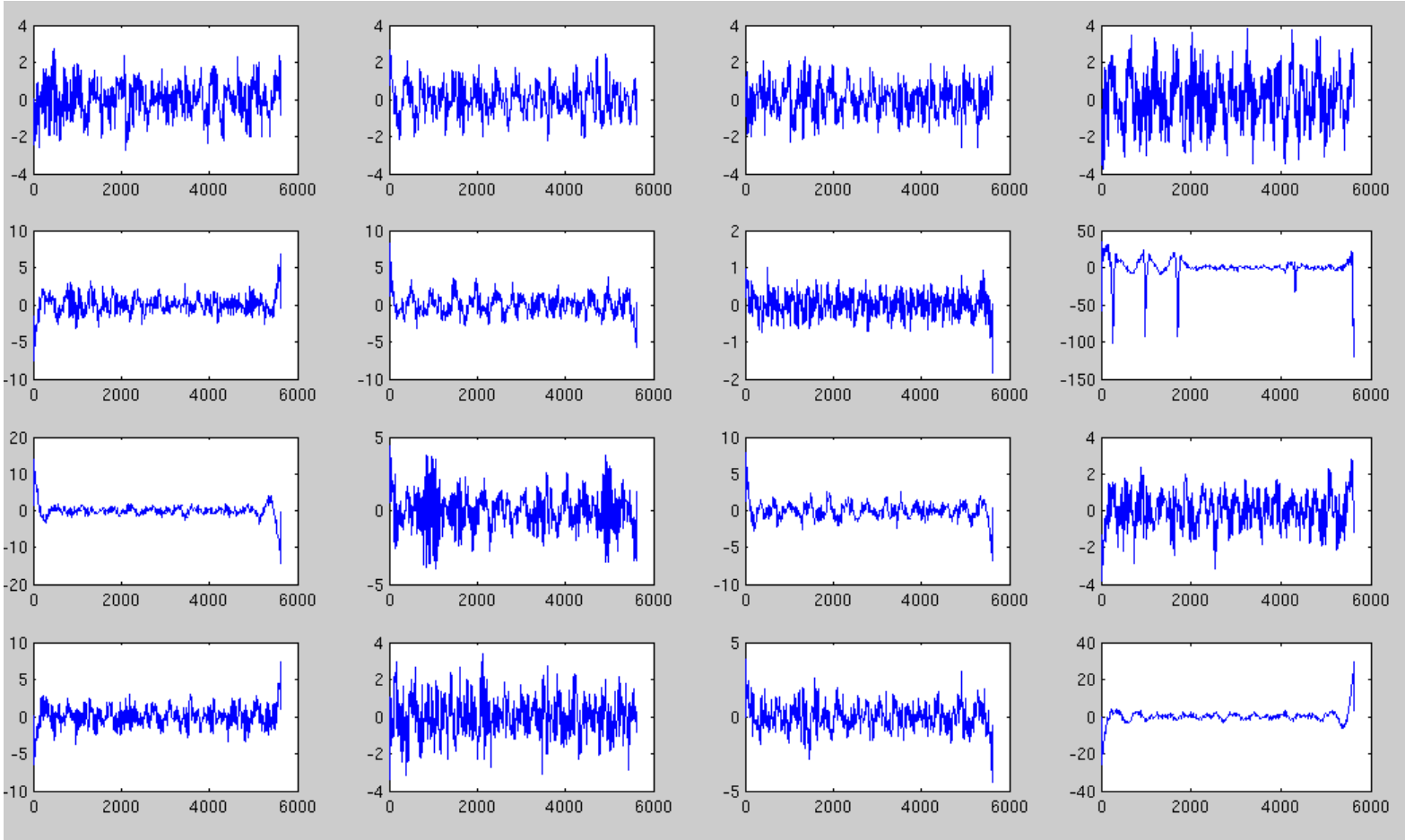
- The subject must press a button if the current stimulus is identical to the one presented n trails ago.
- The stimulus was a single light being on, on a circular pattern similar to a watch dial where the place where each hour would be has a light that can be on or off.

The data

- 64 electrodes (2 are discarded leaving 62)
- 5 subjects (there were in fact 6 but the data of one of them was too noisy)
- 4 tasks (0-back to 3-back)
- each task has 102 trials (the first 6 and the last 6 are discarded yielding 90 trials)
- each trial takes 2.2 seconds
- sample rate of 512Hz
- signals passed through a 0.01-100Hz bandpass filter
- data was filtered with a surface Laplacian
- 3 bands: A (1-20Hz), B (1-50Hz), C (1-80Hz) (used only band A)
- size for one band only:
  $62 * 5 * 4 * 90 * 2.2 * 512 = 125706240$ (since each double is usually represented with 8 bytes this gives 960Mbytes on disk)

The data

First 16 channels of subject 1, task 1 and segment 1 (5 trials).



Three possible problems

- Problem 1: use data from only one person and try to predict the task being done: 4 class problem, easy.
- Problem 2: use data from five persons and try to predict the task being done by which person: $5 \times 4 = 20$ class problem, medium.
- Problem 3: use data from five persons and try to predict the task being done independently of the person that is doing it: 4 class problem, hard.

The approach

- Since the amount of data is large, the basic approach is to try to reduce it while preserving the discriminative information that it contains.
- Previous work used entropy of the signals and mutual information from pairs of electrodes.

The approach

- I tried to reach similar results using:
  - PS: Welch's approach to finding the power spectrum
  - PS2: power spectrum
  - entropia: entropy according to [1]
  - entropia2: naif entropy (histogram based)
  - waveletF1: detail coeficients at a given decomposition level
  - waveletF2: approximation coeficients at a given decomposition level
  - ent2wF1: entropy 2 after waveletF1
  - ent2wF2: entropy 2 after waveletF2
  - ent2PS: entropy 2 after PS
  - ent2PS2: entropy 2 after PS2
  - SOM1:
  - mediaSinais: average of the wavelet (qual ??)

Power spectrum

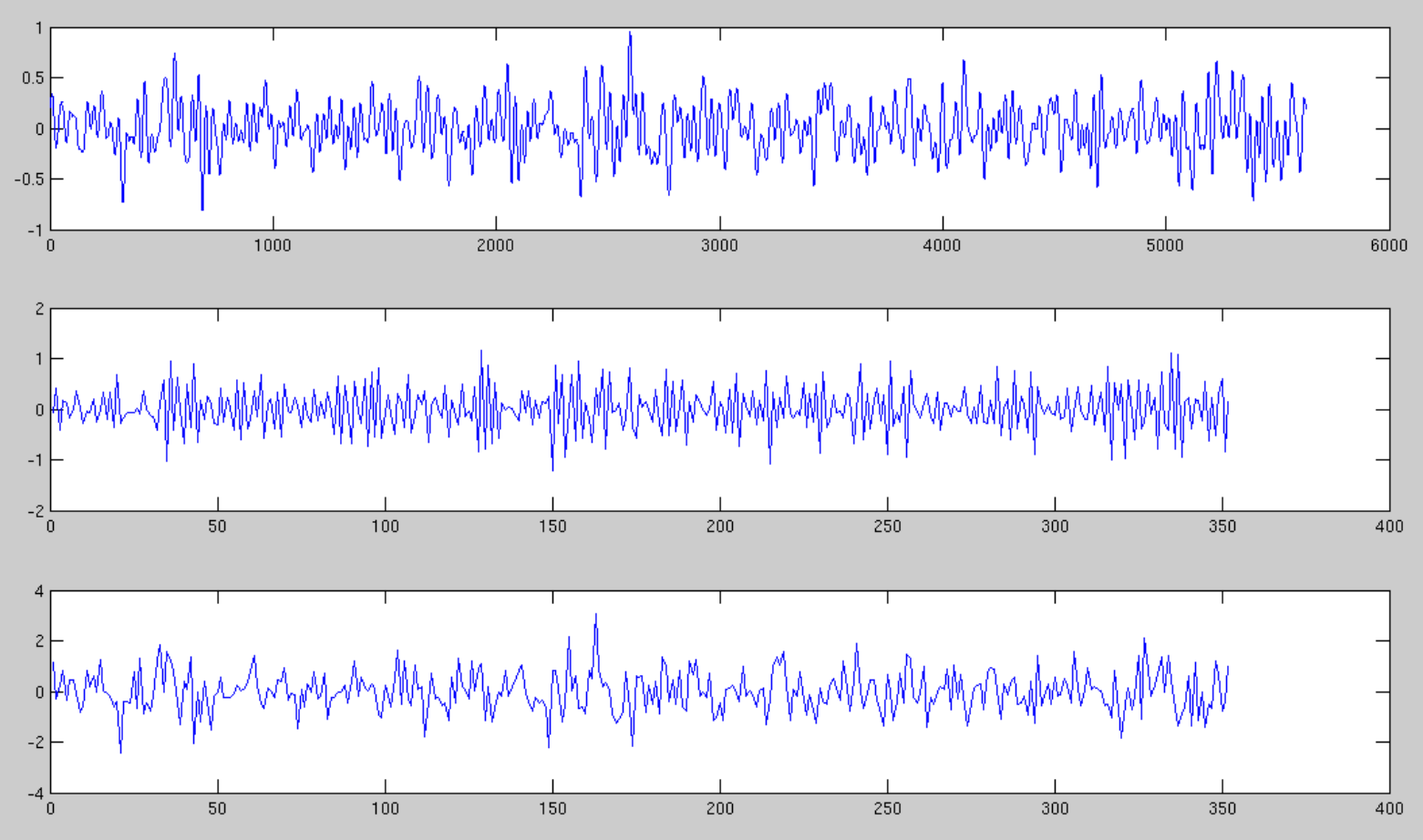
- PS parameters: by default, the signal is divided into eight sections with 50% overlap, each section is windowed with a Hamming window and eight modified periodograms are computed and averaged.
- PS2 parameters: number of points to retain after finding the power spectrum calculation (typically 128)

entropia

- entropia parameters: $\beta = 0$, number of bins on the histogram
- entropia2 parameters: number of bins on the histogram

Wavelets

- Parameters:
  - decomposition level
  - mother wavelet



ent2wFX

- Parameters: all of the parameters of the wavelets plus the paramenters of entropia2.

SOM1

- A 1-D SOM tryies to approximate the signals after wavelet decomposition.
- Both wF1 and wF2 were tested. wF1 gave better results.
- Parameters: number of neurons (tested 1 and 10, 1 was better) plus wavelet parameters

mediaSinais

- Average of the 62 signals after a wavelet decomposition. Implemented to check the SOM1 results
- Both wF1 and wF2 were teste. wF1 gave better results.
- Parameters: wavelet parameters

Classifiers

- Used two classifiers: 1-NN and SVM-RBF
- SVM parameters: C and kernel width

Results

- Accuracy in percentage on a leave-one-out CV experiment for problem 2 (20 class problem).

Features	1-NN	SVM-RBF
PS	33.4	-
PS2	28.4	-
entropia2	39.7	47.4
waveletF1	11.6	-
waveletF2	12.6	-
ent2wF1	43.9	55.0
ent2wF2	40.3	48.2
ent2PS	56.6	73.2
ent2PS2	30.5	46.6
SOM1 $*$	10.0	10.8
mediaSinais $*$	9.7	-

$*$=leave 76 out.

Cleaning the signals

- Use the information on the eye channels to remove eye artifacts from the other signals
- Try to choose the channels that give more information (different people might use different parts of the brain for the same task so this might not work)
- Study carefully the noise reduction procedures that can be applied to the signals

Using RNNs

- How can RNNs be used in this problem ?
- Idea 1: train a RNN to learn the signal from each channel, task and subject.
  - This gives $62 * 4 * 5 = 1240$ RNNs.
  - In test mode, give the error while trying to approximate the input signals as input to another classifier.
  - This can be used for problem 2.
  - For problem 1 a subset of this can also be used (only one subject)
- Idea 2: Use RNNs to filter the signals somehow ...

L. Wu, P. Neskovic, E. Reyes, E. Festa, and W. Heindel. Classifying n-back EEG data using entropy and mutual information features.
In *ESANN*, pages 61–66, 2007.