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# Wavelet Based Classification of Epileptic Seizures in EEG Signals

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## Abstract

Epilepsy is a chronic neurological disorder characterized by recurrent, sudden discharges of cerebral neurons, called seizures. Seizures are not always clearly defined and have extremely varied morphologies. Epilepsy is constantly under the microscope and systems for automated detection of seizures are thoroughly examined.

In this paper, a method for automated detection of epileptic activity is presented. The Discrete Wavelet Transform (DWT) is used to decompose the EEG recordings in several subbands and five features are extracted from the wavelet coefficients creating a set of features. The extracted feature vector is used to train a Support Vector Machine (SVM) classifier. Five classification problems are addressed, reaching high levels of overall accuracy.

## Background

- Almost 1% of the world's population suffers from epileptic seizures while up to 5% of any population will experience a seizure at some point in their life.
- About 1/3 of the epileptic patients do not respond to anti-epileptic medication.
- Visual analysis may be prone to significant mistakes, owing to the complexity of the seizures, which are not always clearly defined and have extremely varied morphologies, misleading the physicians' assessment.
- Since the early 1970's scientists have developed a variety of methodologies and signal processing techniques for detecting epileptic activity.

TABLE I. RESULTS FOR THE FIVE CLASSIFICATION PROBLEMS IN TERMS OF ACCURACY, SENSITIVITY, SPECIFICITY AND KAPPA STATISTIC. ALL WAVELET COEFFICIENTS ARE INCLUDED IN THE CLASSIFICATION.

| Classification problem | *Accuracy* (%) | *Sensitivity* (%) | *Specificity* (%) | *Kappa statistic* |
|---|---|---|---|---|
| ZONF-S | 99.20 | 99.50 | 97.00 | 0.969 |
| Z-S | 99.50 | 99.00 | 100 | 0.990 |
| ZO-NF-S | 98.00 | 98.77 | 98.33 | 0.969 |
| Z-F-S | 98.33 | 98.33 | 99.17 | 0.975 |
| Z-O-N-F-S | 87.00 | 87.00 | 96.44 | 0.837 |

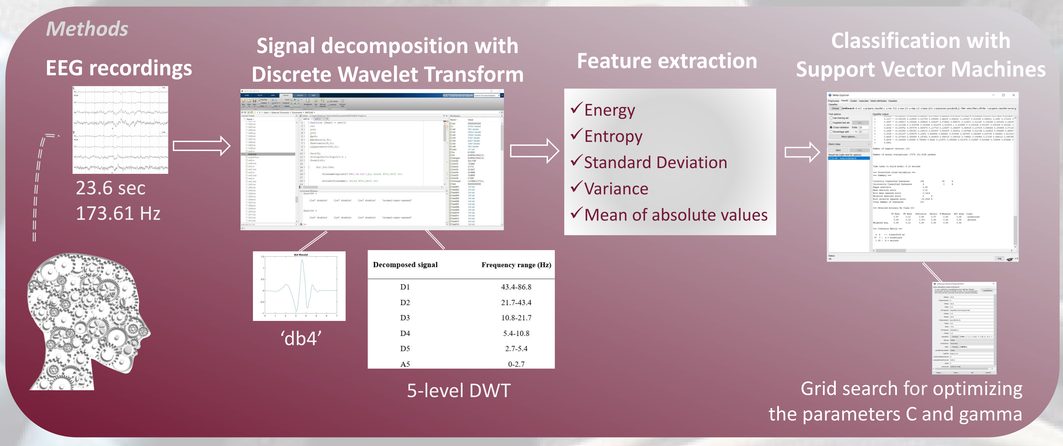
## Aim

Development of a method for automated seizure detection based on Wavelet Analysis and Support Vector Machines.

A three step method for automated seizure detection is presented:

1. Signal processing based on Discrete Wavelet Transform
2. Feature extraction
3. Classification based on Support Vector Machines

## Methods




## The Database

The dataset of the University of Bonn consists of the sets A, B, C, D and E, each containing 100 single-channel EEG segments specified as Z, O, N, F and S respectively.

- *Z: normal EEG while relaxed and awake with eyes opened*
- *O: normal EEG while relaxed and awake with eyes closed*
- *N: interictal EEG obtained from the opposite hemisphere of the epileptogenic zone*
- *F: interictal EEG obtained from the epileptogenic zone during seizure-free intervals*
- *S: ictal EEG during seizure*

## Results

Five different classification problems were created, including the classification in two, three and five classes, to comprise the most common discriminations in the medical field related to epilepsy:

1. *ZONF-S*
2. *Z-S*
3. *ZO-NF-S*
4. *Z-F-S*
5. *Z-O-N-F-S*

TABLE II. RESULTS FOR THE FIVE CLASSIFICATION PROBLEMS IN TERMS OF ACCURACY, SENSITIVITY, SPECIFICITY AND KAPPA STATISTIC. ONLY D3,D4,D5 AND A5 COEFFICIENTS ARE USED.

| Classification problem | *Accuracy* | *Sensitivity* | *Specificity* | *Kappa statistic* |
|---|---|---|---|---|
| ZONF-S | 98.40% | 99.00% | 96.00% | 0.95 |
| Z-S | 100% | 100% | 100% | 1 |
| ZO-NF-S | 97.40% | 94.30% | 98.65% | 0.959 |
| Z-F-S | 97.33% | 96.72% | 98.66% | 0.960 |
| Z-O-N-F-S | 82.80% | 54.85% | 95.37% | 0.785 |

Two classification cases:

1. Including the entire spectrum.
2. Including only the features that correspond to the frequency range of interest (0-21.7 Hz)

## Future work

In the future, the method can be tested in long-term EEG datasets, which are closer to clinical EEG recordings. Alternative approaches, including different classifiers and feature combinations, must be examined to improve the method's statistical results.

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