



EEG Microsleep Characterization based on Self-Organizing Feature Maps

Introduction

Analysis of EEG - Segments accompanied by Slow Eye Movement (SEM) for Microsleep Research based on the Extraction of 47-dimensional Feature Vectors using Discrete Fourier Transform.

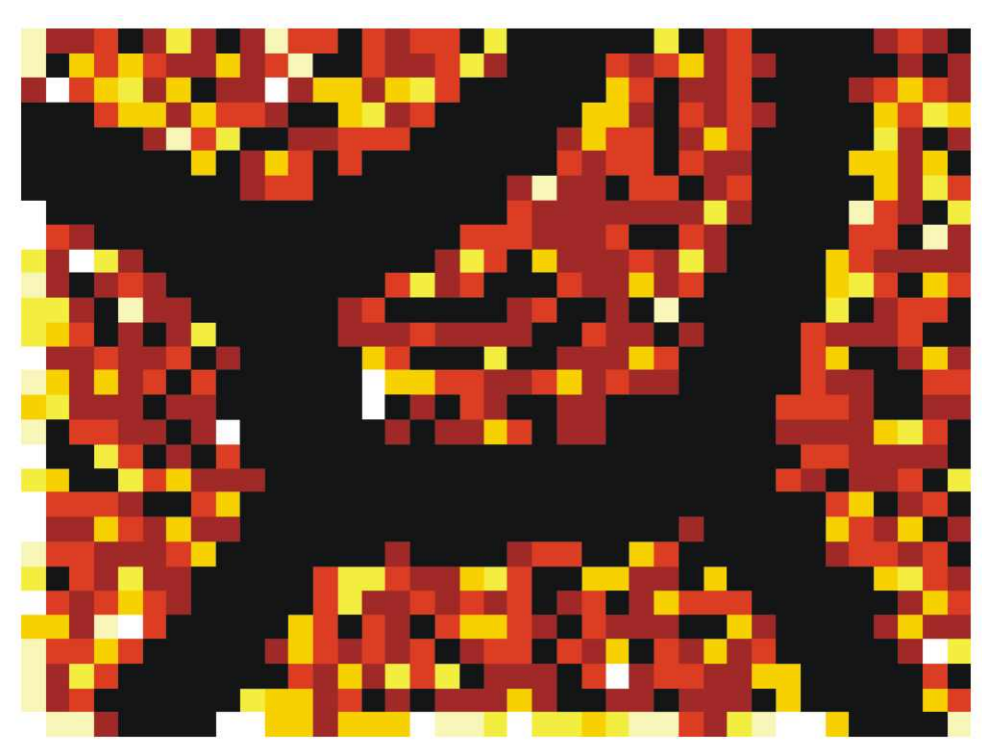
Aim 1: Comprehensive Characterization of Microsleep Events based on 2 Seconds EEG-Segments.

Aim 2: Performance of Self-Organizing Feature Maps (SOM) for Clustering of Data with high Noise.

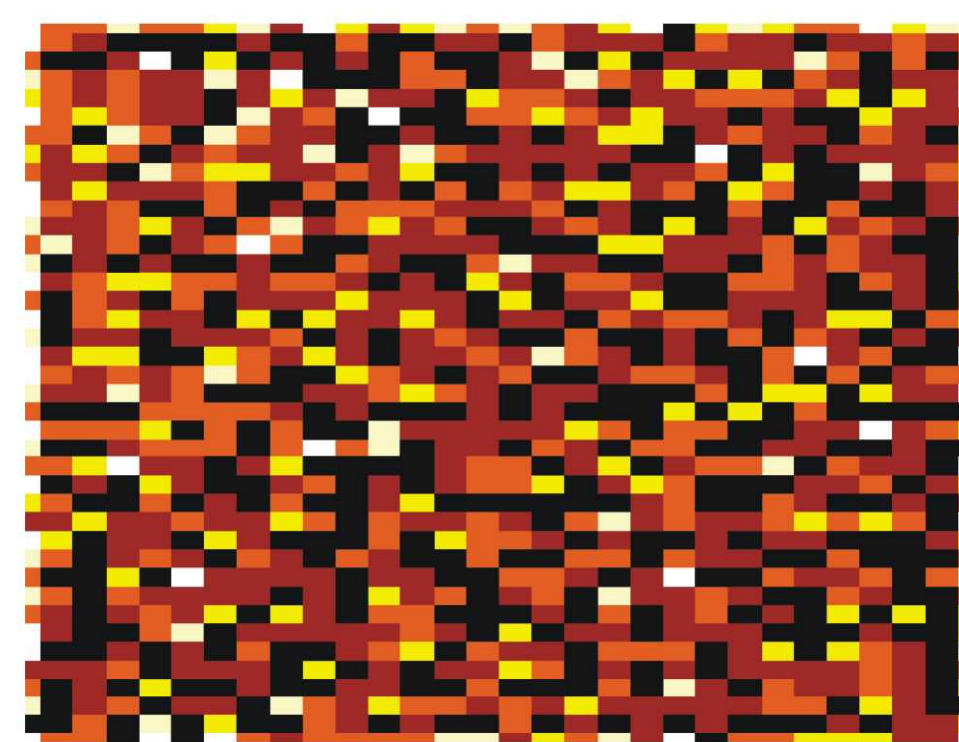
Aim 3: Estimation of the Number of Clusters and the Cluster-Prototypes with an automatic Method.

Simple Evaluation

Winner Frequency for a Self-Organizing Feature Map with 30x40 Neurons



Artificial Gauss-Mixture Data
1652 Feature Vectors
5 Clusters
47 dim. Feature Vectors



Recorded SEM-EEG Data
1652 Feature Vectors
unknown Number of Clusters
47 dim. Feature Vectors

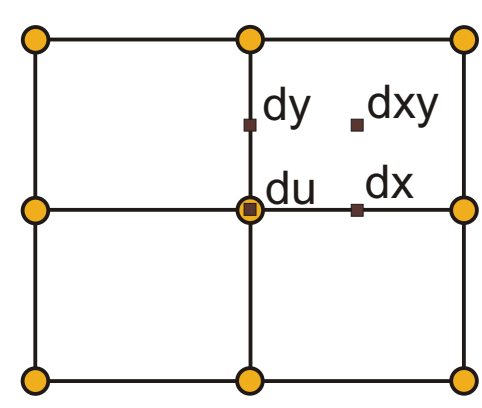
Enhanced Evaluation

Unified Distance Matrix (U-Matrix) [Ultsch et al., 89]

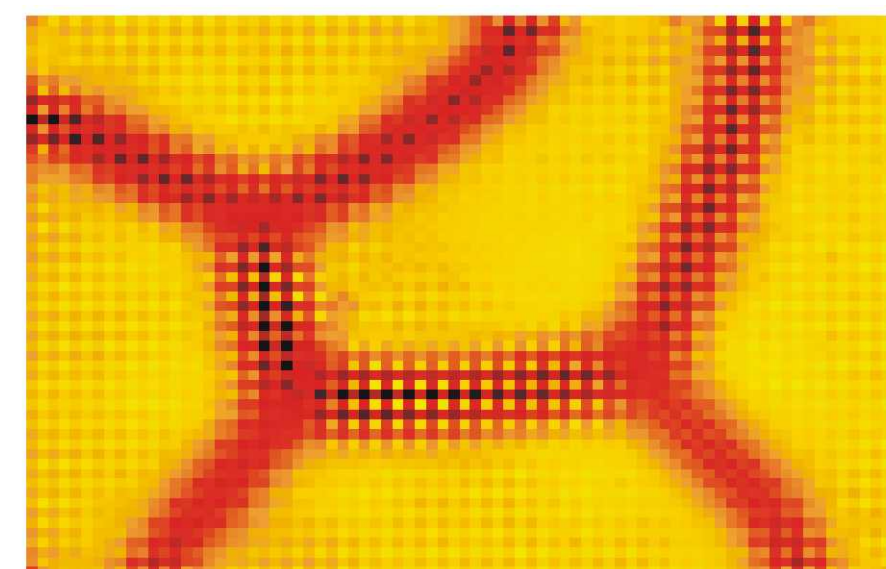
Method for the Visualization of Distances between topological adjacent Prototype Vectors

$$dy(x,y) = \|w_{x,y} - w_{x,y+1}\| \quad dx(x,y) = \|w_{x,y} - w_{x+1,y}\|$$

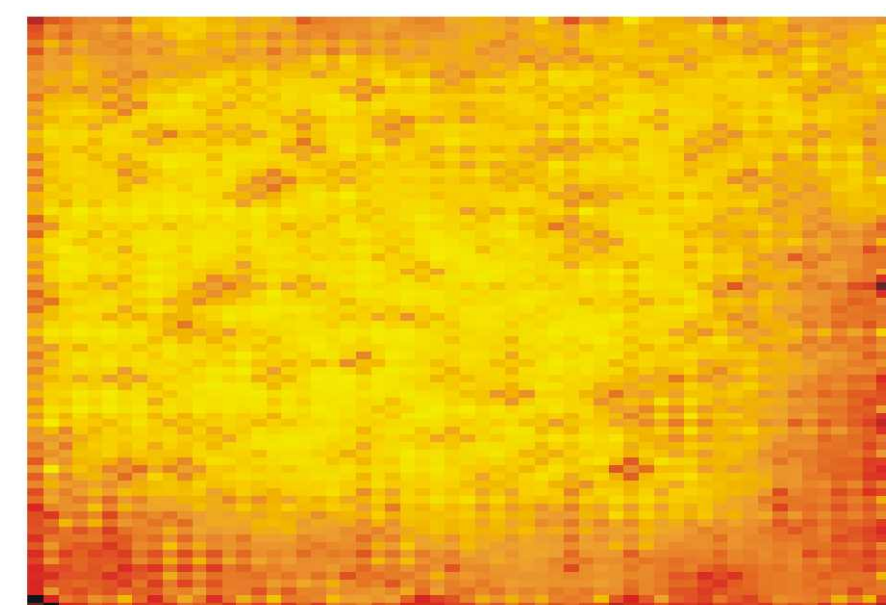
$$dxy(x,y) = \frac{1}{2} \left(\frac{\|w_{x,y} - w_{x+1,y+1}\|}{\sqrt{2}} + \frac{\|w_{x,y+1} - w_{x+1,y}\|}{\sqrt{2}} \right)$$



$$U = \begin{bmatrix} du(1,1) & dx(1,1) & du(2,1) & \dots & du(n_x,1) \\ dy(1,1) & dxy(1,1) & dy(2,1) & \dots & dy(n_x,1) \\ du(1,2) & dx(1,2) & du(2,2) & \dots & du(n_x,2) \\ dy(1,2) & dxy(1,2) & dy(2,2) & \dots & dy(n_x,2) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ du(1,n_y) & dx(1,n_y) & du(2,n_y) & \dots & du(n_x,n_y) \end{bmatrix}$$



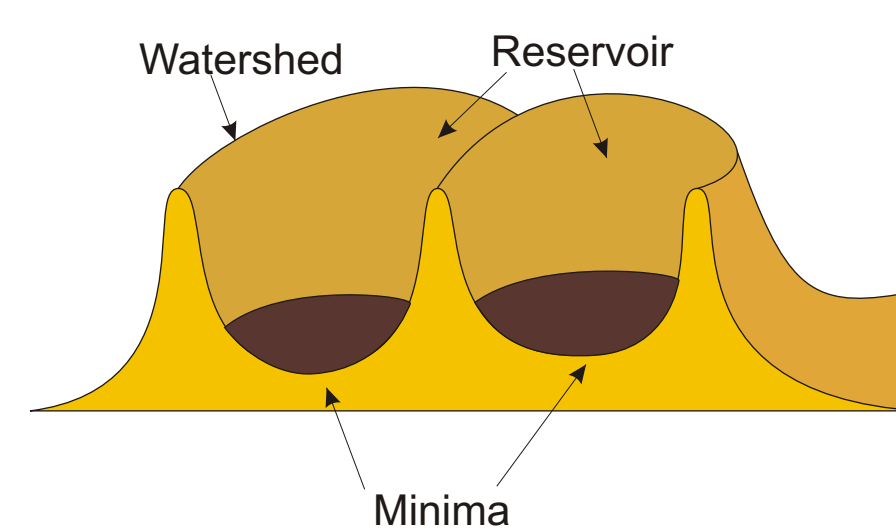
U-Matrix for Gauss-Mixture Data



U-Matrix for SEM-EEG Data

Segmentation

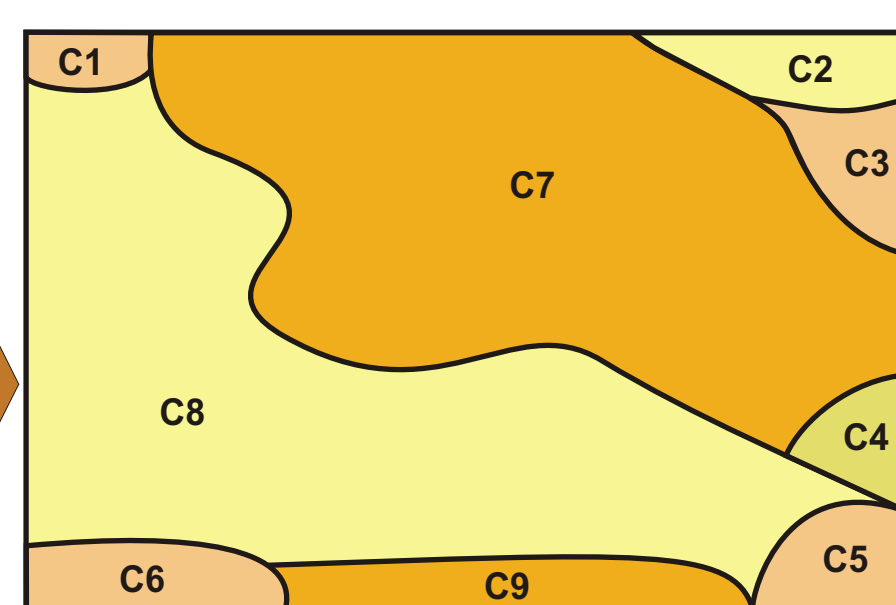
Segmentation with the Watershed Algorithm [Beucher et al., 79]



Method for Image Segmentation

Steps:

- 1) Smooth the Function $U(x,y)$
- 2) Set initial Ground Level h_{min}
- 3) Mark all Minima Regions
- 4) Flood the Minima Regions
- 5) Install water-dividing Barriers



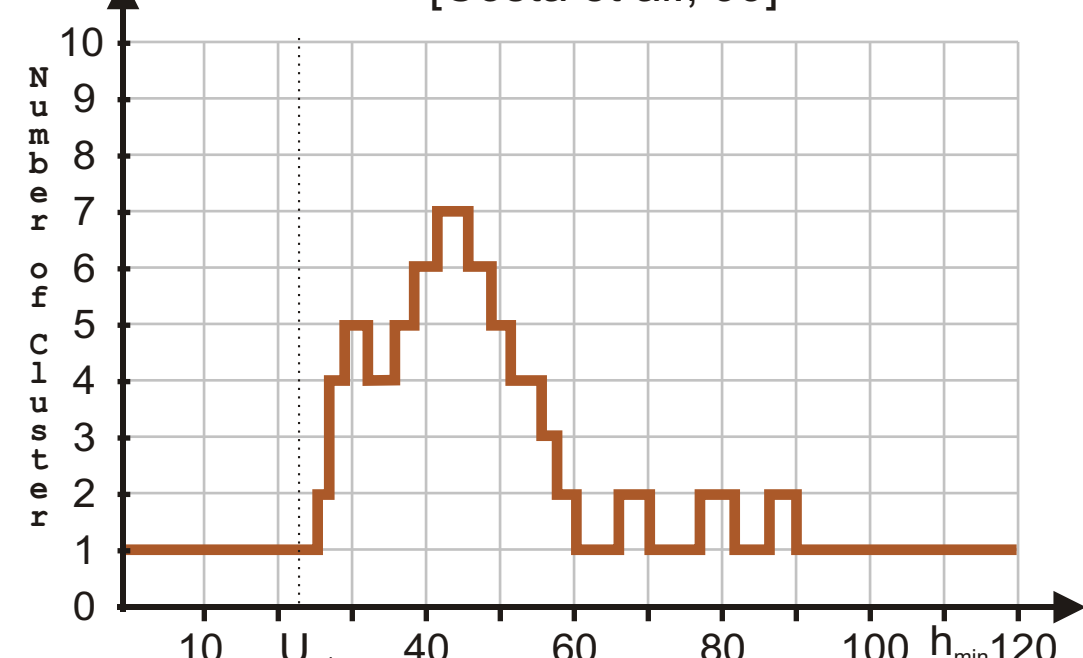
Segmented SOM of SEM-EEG Data Cluster C1 to C9

Results

The "Segmented U-Matrix Method" is applied to the SEM-EEG Data Set in order to evaluate the Number of Clusters as a Function of the Ground Level (h_{min}).

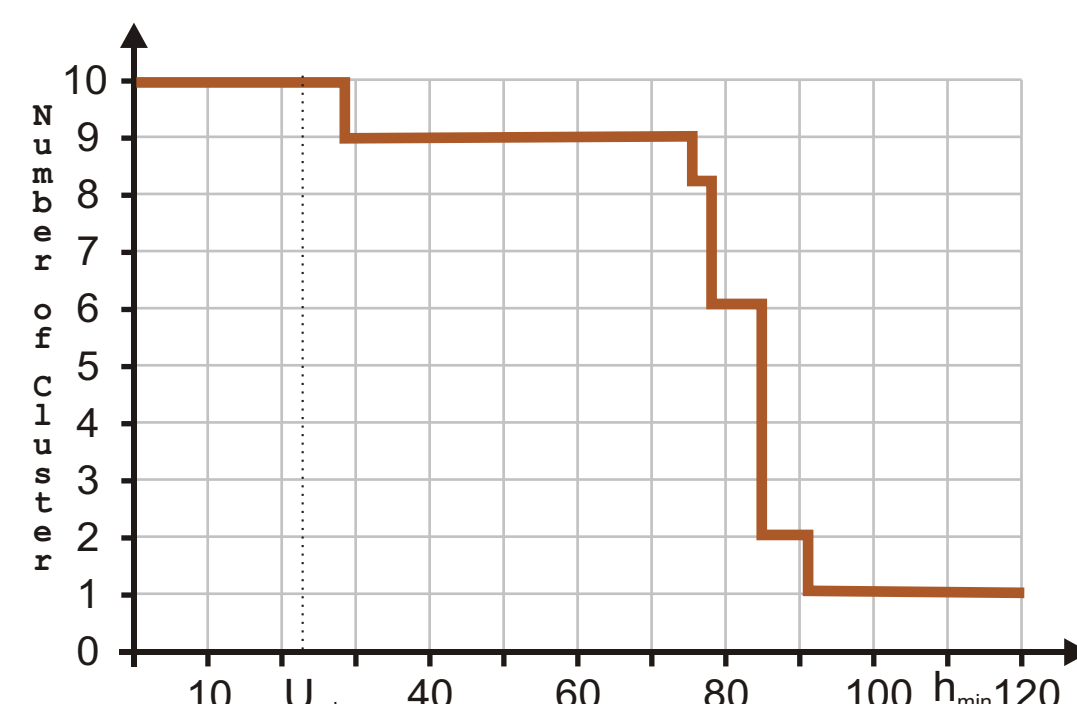
Alpha-Burst Microsleeps are only one type among the Diversity of EEG-Microsleep Events. Therefore, the depicted Result represents an Extension of the current scientific Knowledge

a: without Generation of new Minima Regions [Costa et al., 99]

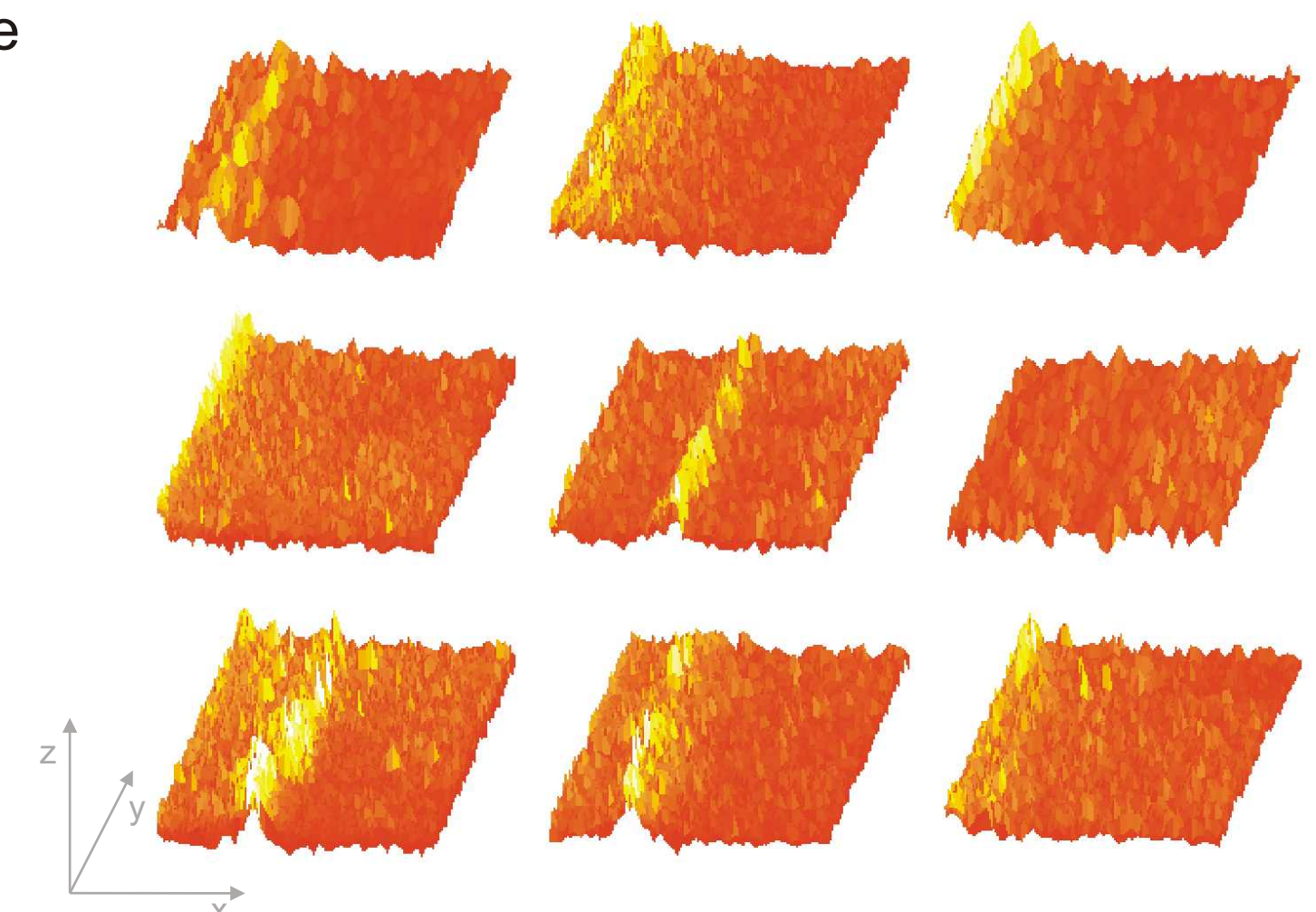


a: Selection for the Number of Clusters is difficult.

b: with Generation of new Minima Regions



b: Selection for the Number of Clusters is straight forward.



Representation of 9 Microsleep Clusters using Waterfall Plots (x: Frequency, y: Item, z: EEG Spectral Power)