

High performance automatic sleep stages classification using Multi-Layer Perceptron

Andrey Abramov

*Department of Biomedical Systems, Moscow State Institute of
Electronics Technology (Technical University)
e-mail: xrinder@mail.ru*

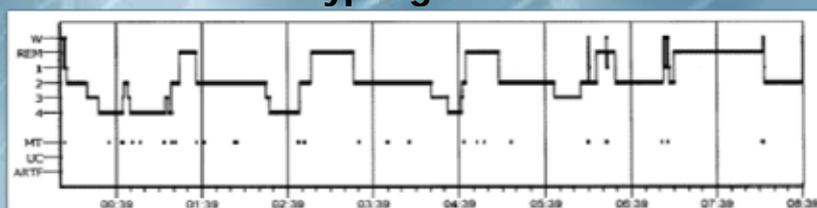
Sleep structure

Scientists divide sleep process into two phases : **slow sleep** and **fast sleep (Rapid Eye Movement)**.

The phase of slow sleep is divided into four stages:

- **Stage 1 - light sleep,**
- **Stage 2 - dream sleep,**
- **Stage 3 - deep sleep,**
- **Stage 4 - very deep sleep.**

Hypnogram



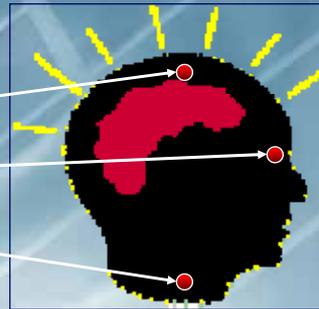
Rechtschaffen & Kales rules

Rechtschaffen & Kales 1968

- Channels EEG, EMG, EOG
- 20-30 seconds segments
- mean amplitude and spectrum parameters

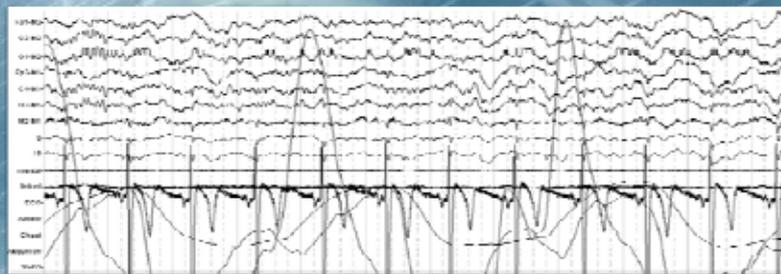
Polysomnography :

EEG
EOG
EMG



Sleep structure

Electroencephalogram



Hypnogram



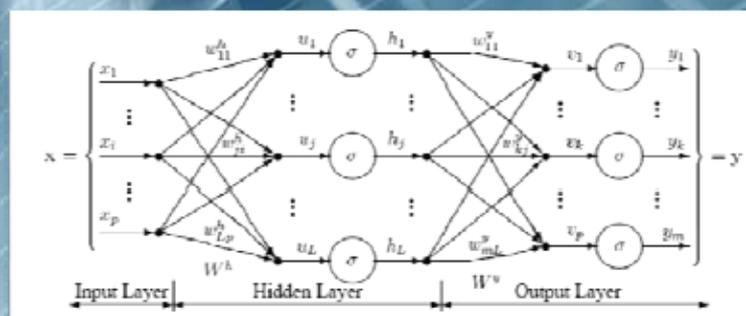
Automation of sleep staging

Manual method has several defects:

- it is very hard and time consuming to use that method
- the R&K rules leave much room for subjective interpretation
- we need recoding many signals from different channels

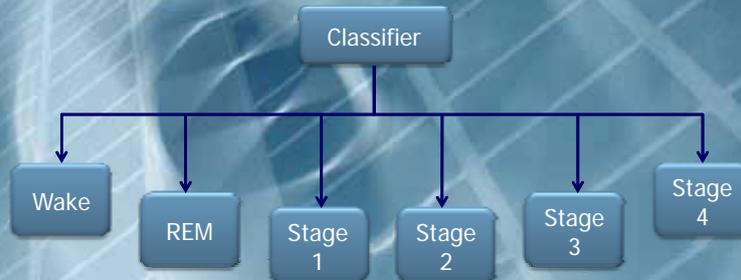
Multi-Layer Perceptron

Multi-Layer Perceptron (MLP) - Hierarchical network structure in which connected among themselves neurons (net nodes) are joins in some layers



Automatic method

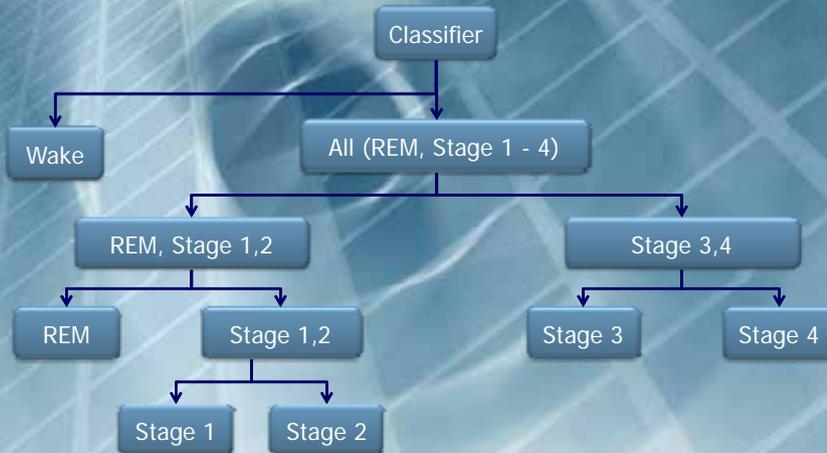
Division on 6 stages



Accuracy - 44 %

Automatic method

Division by the cascade of classifiers



Results

Classifiers	Number of neurons in the hidden layer	Accuracy, %
Wake - All (REM, Stage 1 - 4)	3	84,6
Wake - All (REM, Stage 1 - 4)	4	83,9
REM, Stage 1,2 - Stage 3,4	4	90,2
REM - Stage 1,2	4	78,3
REM - Stage 1,2	8	75,5
All - S2	7	76,6
All - S2	8	78,1
All - S4	8	86

Results

Expert

MLP



MLP

Expert

	Wake	S1	S2	S3	S4	REM
Wake	94,03	1,49	4,48	0	0	0
S1	28,95	50	15,79	0	0	5,26
S2	3,86	9,49	75,37	3,56	2,08	5,64
S3	0	0	29,41	58,82	11,76	0
S4	0	0	1,15	9,19	89,66	0
REM	7,57	8,33	4,54	0	0,7	78,79

Accuracy : 74,44 %

Records from international database Physionet (www.physionet.org)

Results



MLP

	Wake	S1	S2	S3	S4	REM
Wake	94,36	3,97	0,6	0	0	0
S1	21,13	65,53	10,01	0	0	3,34
S2	2,29	3,05	73,28	9,92	6,11	5,34
S3	0	3,57	28,57	42,86	17,86	7,14
S4	0	0	1,77	15,04	83,19	0
REM	1,24	10,56	7,45	0,6	0,6	79,5

Accuracy : 73,29 %

Records from international database Physionet (www.physionet.org)

Results

The main advantages of this approach:

- Automatic sleep analysis is much faster than manual scoring
- Automatic analysis is objective
- The signals are used only from the two EEG channels and the one EOG channel
- Using the cascade of classifiers allows to increase an accuracy

We can easily apply this method to different EEG records

