SOFTWARE
IMPLEMENTATION
CHAPTER 8
SOFTWARE IMPLEMENTATION

8.1 INTRODUCTION

In order to fulfil the requirement of research work related to analysis, detection of K-complex and identification of power spectra in EEG signal, program was designed that can be used:

- To analyze the EEG signal with different parameters.
- To classify the bands of EEG signals.
- To detect k-complex waveform of EEG signal.
- To measure power of EEG signal.
- To identify EEG power spectra.
- To diagnose the disease after complete analysis of signal.

As a key feature, the software is implemented in hospital to diagnose the patient related to brain disease in detail; following points are to be covered:

- Processing of digital time series. Recorded at sampling rate of 256Hz with a 12-bit resolution.
- Masking of artifacts, blanking of disturbed segments with appropriate corrections in the spectral domain.
- Data management for large volume comprising several giga bytes of information of EEG data.
- Computerized and manual segmentation of time series.
- ANN is used to analyze EEG signal parameters, such as amplitude, frequency and energy per frequency band.
- Detection of K-complex wave by ANN.
- Spectral analysis of time series, computation of long term spectra and construction of EEG spectral patterns by ANN.
- Identification of EEG power spectra using ANN.

All programs are controlled by main program, which has been specially designed for interactive use, although it works just as well in batch mode with only a slight compromise on efficiency. This main program consists of different major components, which communicate with each other and with application programs through standard interfaces. The implementation of new applications can be accomplished by simply registering the corresponding names and defaults in the central directory.

Since typical applications include several interdependent steps of analysis, the monitor program allows combining single steps, which are processed as entities. Results derived from preceding steps enabling routine applications, which are processed as batch jobs. The parameter values assigned to an application are always passed to the immediately following application, so that successive calls of the same program with systematic changes of a few parameters are considerably facilitated.

EEG data files are received from EEG machines in the form of 64 channels, 256 samples per channel. Data files are analysed to diagnose the waveform where EEG data has been built around a databank specifically developed to meet the demands of research. This databank supports the storage and retrieval of data at the different stages of analysis, in particular, scalar parameters of the time and frequency domain, as well as feature vectors and spectral patterns.

Although the main purpose of our integrated databank system is to provide means for efficient data analyses within the scope of EEG research, the system design also allows one to extract data from empirical
studies and to establish a basis of structured background knowledge. Accordingly, we have collected reference patterns of some healthy persons and some of the patients in order to determine the distribution of EEG variants in the general population and to gain insight into the nature of inter-individual EEG differences. Moreover, the data derived from repeated assessments of the same healthy individuals serve us as reference values with respect to magnitude of natural EEG fluctuations over time, thus enabling the detection of significant intra-individual changes at high resolution.

8.2 USER FRIENDLY SOFTWARE

Software can prove itself a milestone in processing biomedical signals. The graphical information of different parameters has been given for investigation.

- Program provides new patient entry with details and particular code, case paper number, which helps in further diagnosis.
- Display list of patients with information with particular code or case paper number.
- Provides results in graphical form with respect to numerical values.
- Program provides option for saving results of analysis with date, time and prescription given by doctor.

8.3 NEURAL NETWORK BASED EEG LAB SOFTWARE

NNTOOL in MATLAB is used to create a network to input patients EEG data. Create New network having input layer, hidden layer and output layer. Input layer contains 256 neurons. Data file and Data type is set to inputs. The Network/Data Manager window comes up and
shows as an input. Next, create a network target on new data, to test data under data type.

The network receives the 256 values as a input to input layer. The basic network is given in Fig.8.1 used for training data.

This is the perceptron network that creates to generate the network. Training result outputs and errors graph gives the sensitivity of training network. This makes easy to identify while training parameters. It shows parameters such as the epochs and error goal.

Perception detection sensitivity that sets the minimum perception, lower values will increase sensitivity. The minimum duration for seizure events, Spike burst, Rhythmic burst detections, lower values will increase sensitivity. Perceptron network, training result is shown in fig.8.2.
Fig. 8.2 Training data for 4-epochs gives performance

Thus, the network was trained to zero error in six epochs. Check the trained network does indeed give zero error by using the input and simulating the network.

8.4 PROGRAM FOR TRAINING EEG DATA

Samples are captured at the rate of 256 samples per second to display graph of those pixels in the MATLAB. EEG data files are imported in a format required in MATLAB, NNTOOL and data of 25 normal patients are given as a training sets. EEG data for different age group under different conditions are used as a test sets. Training started for pre defined number of iterations and after completion of iterations the
result is available which presents to the doctor for diagnosis to find the accuracy of training ANN. Listing of the program is given in appendix-1.

ANN is designed for detection of K-complexes in EEG waveforms, obtained from Ruby Hospital, Pune and PH Medical center for various 200 patients. Out of all these files, only 20 to 27 data files are selected in which some of the data files are includes k-complexes. These data files are given as training set and unknown data files are given as test sets. Training starts for 2000 iterations and detected a K-complex at 252 samples, ends at 268 samples. (Fig.8.3)

![Figure No. 1](image)

Fig.8.3 K-complex wave detected between 252 and 268 samples.
The Error graph shows after backpropagation training network where error becomes zero at 63 epochs after 2000 iterations (fig.8.4).

Fig.8.4 Sum-Squared Error at 63 Epochs for 2000 iterations

Total numbers of electrode are 20, located at different locations on a skull. EEG data file is imported for analysis and detection, all the channels are shown in Fig 8.5 out of which one channel is selected for detection of K-complex as a test set to train the ANN.
Fig. 8.5 Imported data file of EEG signal for 20 channels.

8.5 ANN BASED EEG LAB

ANN is designed by considering architecture, topology, algorithms and parameters for a neural network. These settings are all accomplished in the Neural Network tool in MATLAB.

The steps for designing Neural Network are:

- Selected architecture to determine types of learning rules.
- Select the number of hidden layers.
• For the output layer and each hidden layer, select a learning rule. Within a given network, different learning rules are implemented.

• All other parameters are independent and depend on the selection of learning rule.

ANN is designed for identification of power spectra for different bands of EEG. Neural Network having a 50 hidden layer or 1 output layer and number of 256 input nodes specifies the number of processing elements. The input layer, the number of nodes specifies the number of the inputs. The input layer does not possess processing elements, used to formalize the input data and it's preprocessing. Whenever the number of nodes is set to a value greater than Max Nodes, Max Nodes is brought up to the same setting.

The learning rule sets for each hidden layer and the output layer. Selection of a learning rule affects the input functions; transfer functions and parameters are available for use.

8.6 PLOTTING CHANNEL POWER SPECTRA

To begin processing the data, there power spectra to be sure that the loaded data are suitable for further analysis. Matlab signal processing toolbox is required to use these functions. To plot the channel spectra and associated topographical maps, select Plot > Channel spectra and maps. This will pop up the pop_spectopo() window.

The function should return a spectopo() plot, that sampled 15% of the data trials, results slightly changes for each call as shown in fig.8.6..
Fig. 8.6 Power spectra for channels at frequencies from 0.5 to 30 Hz.

Each colored trace represents the spectrum of one electrode or data channel. The leftmost scalp map shows the scalp distribution of power at 6 Hz, which is concentrated above the frontal midline. The other scalp maps indicate the power scalp map at 10 Hz and 22 Hz. The pop_spectopo() window menu allows the user to compute and plot spectra in specific time windows in the data.
To plot the average of all dataset epochs, with selected scalp maps, select Plot > Channel > with scalp maps. We keep the default settings in the resulting pop_timtopo () window. Fig.8.7.
8.7 Plotting Epochs

To plot the average of an epoched dataset as single-channel traces in topographic order, select Plot > Average > In scalp array, gives average of an epoched database, shown in fig 8.8.

Fig.8.8 Average of an epoched database for ee114 continuous epochs
Visualize a specific channel time producing a pop-up sub-axis view as below, fig. 8.9. Test data set is applied to the network, trained with training data sets and peaks are detected.

Fig.8.9 Detection of peaks for test set after training.
8.8 FINDING PEAK LATENCIES

EEG peak amplitudes and latencies can use the Matlab toolbox to determine the latency of a peak, as shown in fig 8.10.

Fig. 8.10 Peak latency detection for test set 4
Three different single-trial epochs would be coded as three different colored lines indicates the average power, as shown in fig. 8.11.

Fig. 8.11 Average Power for three-test sets
Fig. 8.12 Power spectra of EEG data in term of colour dot
8.9 PLOTTING ERP IMAGES WITH SPECTRAL OPTIONS

EEG phase value in a specified time/frequency window, Sort trials by phase section, enter 10 (Hz) under Frequency and 0 (ms) under Center time and enter time limits (ms), to obtain the ERP-image, fig. 8.13.

Fig.8.13 Spectral image for test EEG data set 3.
To plot ERP image fig. 8.14, choose to enter the following parameters in the pop_erpimage () window:

![ERP Image](image.png)

Fig.8.14 Spectral image for test EEG data set 3.
Fig. 8.15 Phase sorted noise for EEG data

Plotting spectral amplitude in single trials and additional options:

Fig. 8.16 spectral amplitude in single trial data sets
8.10 PLOTTING COMPONENT HEADPLOTS

Plot a 3-D head plot of a component topography by selecting Plot > Component maps > In 3-D. This calls pop_headplot(). Select one or more components below:

The headplot() window below appears. Matlab rotate 3-D option is used to rotate these headplots with the mouse else, enter a different view angle in the window above.

Fig.8.17 Component map for electrodes on scalp
8.11 IDENTIFICATION OF EEG FREQUENCY COMPONENTS

To identify EEG power spectra, frequency component properties for rejection and to identify components to subtract from the data, select Tools > Reject using ICA > Reject components by map. The difference between the resulting figure(s) and the previous 2-D scalp map plots is that one can here plot the properties of each component by clicking on the rectangular button above each component scalp map shown in fig. 18.18

Fig. 8.18 component scalp map for 32 single ended channels
Fig. 8.19 Power spectrum for EEG component activity
These components are spatially localized and show high power at high frequencies in the range of EEG signal frequencies. Fig. 8.20.

Fig. 8.20 Power spectra for 31-components topography activity
Fig. 8.21 Power spectra for 23-topography activity
8.12 PLOTTING COMPONENT SPECTRA

To plot EEG component spectra, it is to find out which components contribute most strongly to which frequencies in the data. Since our EEG dataset is fairly small, we choose to change this data set then visualize which components contribute the most at specific frequency by entering range or frequency in the scalp signal frequency.

Fig. 8.22 Component spectra for all test channels
After observing which components contribute to frequency bands of interest, it is interesting to look at which components contribute the most to the ERP.

Fig. 8.23 detection of component ERPs of test data
Select component to fit the sample dataset to plot component scalp signals. The channel location for this subject scanned using electrode locations, which are not exactly symmetrical. fig. 8.24.

Fig. 8.24 channel locations for scanned electrodes

In this chapter, Neural Network is trained and tested, get the results as shown in fig. 8.6 to 8.23. Backpropagation Network with different learning rules is used to train the test EEG data. Software is written in MATLAB NNTOOL and results related to analysis of EEG, detection of K-complex and identification of power spectra of depressed patients are considered to discuss the results in chapter 9.