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Analysis of EEG Source Localization Problem in Epilepsy Patients Using MPSO Method

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Abstract: One of the most important things in diagnosis of epilepsy is to find the exact location of the epileptogenic point. EEG is a tool commonly used at epilepsy diagnosis centers for diagnosis purposes. . In this paper, the modified particle swarm optimization (MPSO) method used to solve the EEG source localization problem. The attempt has been done here to estimate the brain activity on the basis of spectrum analysis. EEG classification can be very useful in predicting the action or the intention of action performed on the basis of EEG which leads to more development in brain computer interface. The brain waves α, β, ϒ, δ, ϴ were extracted using frequency filtering and estimating the level of disease is done by the clinical experts based on the amplitudes of the brain waves. The EEG data has been referred from a MRI scanning center and the mathematical tool for EEG analysis called EEGLAB has been used results are shown in MATLAB to perform work in this paper.

Index Terms: Electroencephalogram (EEG), particle swarm optimization (PSO).

I. INTRODUCTION

Epilepsy is one of the most common brain diseases in the world. Epilepsy is brief re-current disorder of cerebralfunction that is usually associated with disturbances ofconsciousness and accompanied by a sudden, excessiveelectrical discharge of cerebral neurons. EEG is of highvoltage relative to the background and results from an un-physiological synchronous discharge of aggregation ofneurons. Clinically, epilepsy is defined as a conditioncharacterized by the recurrent two or more unprovoked seizures. The source localization of epileptic activity is a tool to delineate cortical areas/volumes with abnormalneuronal condition in which the things are happen of cellsand networks. However, correct and anatomically preciselocalization of the epileptic focus is compulsory to decideif resection of brain tissue is possible. Present daycomputer systems can be used for the time domainvisualization of multi-channel EEG data.

It is well known fact that the Electroencephalogram (EEG)signals are the measure of the vigilance state of brainwhich changes according to task performed by a person. Thesechanges are classified into few different frequency bandsnamed as delta, theta, alpha, beta [2].The accurateclassification of electrical activity for a particular state ofhuman brain helps in neurological diagnosis. Theprocedure of the EEG source localization deals with twoproblems: 1) a forward method to find the scalppossibilities for the given current source(s) inside thebrain, 2) an inverse problem to assess the place of originthat appropriate with the given latent qualities orpossibilities distribution at the scalp electrodes. In thispaper, the MPSO method is applied to EEG data.Resolving the EEG source localization problem in thedaily routine laboratory application. The EEG data that isused in the present study was recorded from evokedpotentials stimulation on a healthy subject. In this paper,EEG signal of visual attention task have been analyzed.For the EEG data set of 32 channels has been used .Firstly,the signal has been filtered to remove artifacts from thesignal.

II. EXISTING METHOD

In previous studies done by theauthors, [16], [17], a modified particle swarm optimization (MPSO) method was proposedfor solving the EEG source localization. It is shown inseveral examples that, where as the deterministic method DIvide RECTangle (DIRECT) failed to efficiently solve the sourcelocalization problems, the MPSO could found the optimal solution significantly faster than other improved versions of PSO, aswell as GA. In addition, the MPSO is less prone to be trapped inlocal minima. Comparing the convergence rate between MPSOand GA in [16] showed that the MPSO converged to the globalminima in all cases whereas the mean of the GA's convergencewas 79%. In [17], it is shown that the

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MPSO is feasible to solvethe EEG source localization in a real clinical setup.

III. PROPOSED METHOD

A clinical expert independentlyidentified the expected source location, further corroboratingthe source analysis methods. The MPSO converged to theglobal minima with significantly lower computational complexitycompared to the exhaustive search method that required almost3700 times more evaluations.

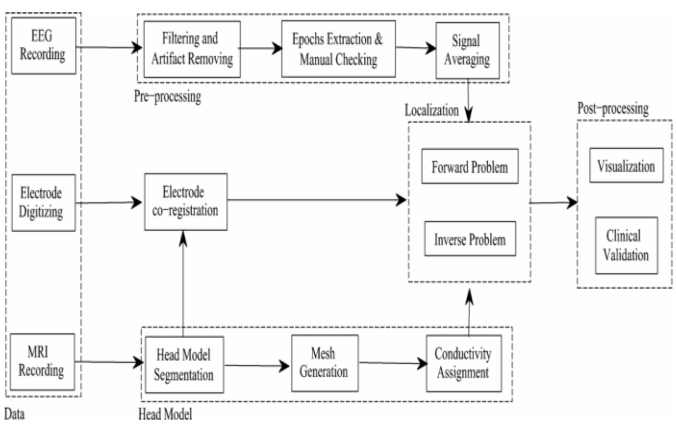

FIG 1: Different steps in the EEG source localization procedure

The EEG source localization has several different sub problems that each should be done carefully. Fig. 1 illustrates allnecessary steps performed in the EEG source localization procedure. In the following sections we go through each step and present our proposed method for solving the EEG source localization.

PARTICLESWARMOPTIMIZATION

A. Standard Particle Swarm Optimization

The Particle Swarm Optimization concept was first introduced by Kennedy and Eberhart in 1995 based on the social system behavior such as the movement off lock of birds or a school offish when searching for food. Each individual in the swarm is called a particle. The th particle of the swarm is represented by the vectors Xi for its position and Vi for its velocity. The particle has a memory to record the position of its previous best performance, personal best(pbest) , in the vector Pi and the position of the best particle in the swarm, global best (gbest), which is recorded in the vector Pg . The particle swarm optimization algorithm consists of, in each iteration, changing the velocity of each particle towards the position of its best performance, Pi , and the swarm best position, Pg, Thus in the original version particles move according to the following formula:

$$\begin{cases} \mathbf{V}_i^{t+1} = & \mathbf{V}_i^t + c_1 \text{Rand}()(\mathbf{P}_i - \mathbf{X}_i^t) \\ & \quad + c_2 \text{Rand}()(\mathbf{P}_g - \mathbf{X}_i^t) \\ \mathbf{X}_i^{t+1} = & \mathbf{X}_i^t + \mathbf{V}_i^{t+1}. \end{cases}$$

Parameters C1 and C2 are thecognitiveandsocial learning rates. These two rates control the relative influence of the memoryof the swarm best performance to the memory of the individualand are often selected to the same value to give each learningrate equal weight. In addition to the C1 and C2 parameters, implementation of the original algorithm also requires placing limitson the search area (Xmaxand Xmin), and the velocity (Vmax).

B. Modified Particle Swarm Optimization (MPSO):

The Modified Particle Swarm Optimization is used to source localization of epilepsy foci path. In this method M particles are selected among the swarm population by the q-competition selection method and then mutated by the EP method. By evaluating the aptness value of all the atoms, the global best position is resolute. For each particles, the nearest best particle is determined by the geometer distance. The velocity and the position of the particles are updated according to the global best position, the nearest best position, and the personal best position.

These are applied to the PSO with inertia weight as follows:

$V_i^{t+1} = \omega V_i^t + c_1\text{Rand}()(P_i - x_i^t) + c_2\text{Rand}()(P_g - x_i^t) + c_3\text{Rand}()(P_e - x_i^t)$ …

where c_3 denotes the constant of the nearest elite and P_e the nearest elite position.

In the MPSO, we introduced the concept of expert to maintain the exploration ability and increase the exploitation ability. In the concept of expert, as the swarm moves close to lowest the R closest atoms to gbest are extracted and they are allowed to fly freely based on their storage and knowledge. Thus, the velocity update is divided into two parts as

$$V_i^{t+1} = \omega V_i^t + c_1\text{Rand}()(P_i - x_i^t) + c_2\text{Rand}()(P_g - x_i^t) + c_3\text{Rand}()(P_e - x_i^t)$$

where i= 1,2,…,N-R and

$$V_r^{t+1} = \omega V_r^t + c_1\text{Rand}()(P_r - x_r^t)$$

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where Vr, Xr, and Pr are the velocity, position and personal best of the th particle, respectively, for r = N-R+1,…,N. The R nearest particles to gbest are reselected in each iteration to ensure that the particles which actuated away from the gbest mislay their authority and next repetitions update their velocity based on. It means that in some steps the mites which are closer to the global best can influence the performance and decision of the swarm more than others. The concept of experts allows the swarm to have more information around gbest before loads of particles come close to it and jammed with each other, thus it improves the exploitation ability. The concept of master mixed with EP helps to keep the balance of the investigation-exploitation trade-off as well as to avoid trapping in local minima. A natural choice for R is the number of neighborhoods for each particle in the swarm, which in our case is equal to 5. The concept of authority allows the swarm to have more information around gbest before lots of particles approach it and get stuck to each other, thus it improves the exploitation ability.

C. SOMATOSENSORY EVOKED POTENTIAL

Evoked potentials are the electrical signals generated by thenervous system in response to sensory stimuli. Auditory, visual, and somatosensory stimuli are commonly used for clinicalevoked potential studies. SEP consist of a series of waves thatreflect sequential activation of neural structures along the somatosensory pathways. Sensory nerves (cell bodies in the dorsalroot ganglia) transmit the signal rostrally and ipsilaterally (firstorderfibers), in the posterior column to a synapse in the dorsalcolumn nuclei at the cervicomedullary junction. Then thesignal is passed via the second order fibers that cross to the contralateral thalamus via the mediallemniscus. Finally, the signaltravels via the third-order fibers from the thalamus to the front parietal sensory cortex. While SEP can be elicited by mechanical stimulation, clinical studies use electrical stimulation of peripheral nerves, which gives larger and more robust responses. The stimulation sites typically used for clinical diagnostic SEPstudies are the median nerve at the wrist, the common peronealnerve at the knee, and/or the posterior tibial nerve at the ankle.

IV. RESULTS

The patient's data are stored in the disk under different conditions eyes open, eyes closed, epileptic patients, person awake, thinking, deep sleep. For each data file the Discrete Fourier Transform (DFT) is applied to calculate the magnitude of 8 channels. For better accuracy N=512 is used as a N point DFT, for example a data file containing some samples of 8 channels After applying DFT to each patients file, the data is processed through different filters of each band to calculate the rhythm in each band.

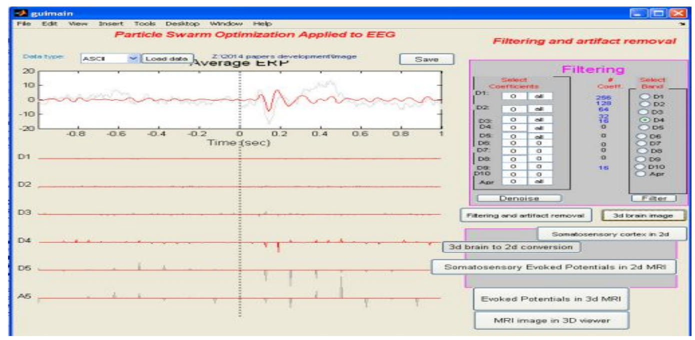

Fig 2: Filtered Noise activity

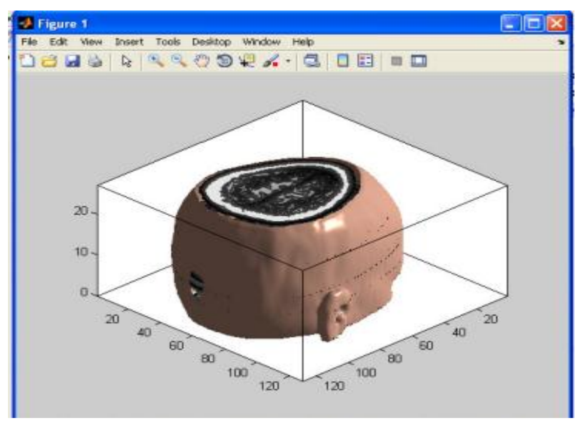

Fig 3: somatosensory cortex in 2D

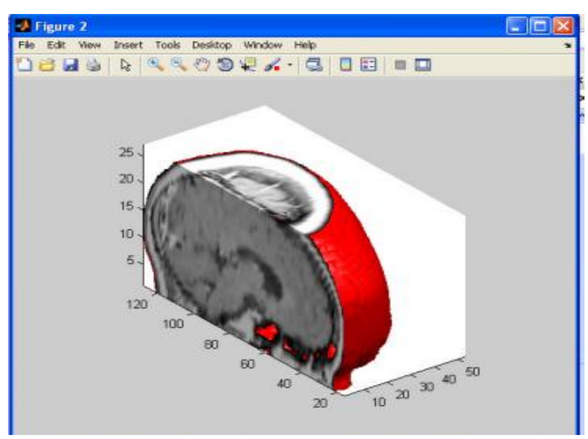

Fig 4: somatosensory Evoked potentials in 2D MRI

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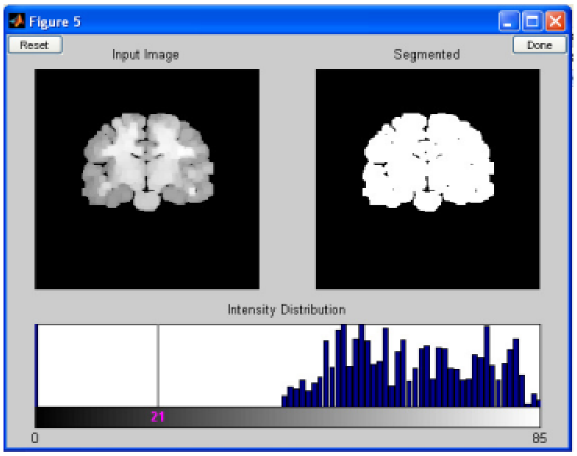

Fig 5: Evoked potentials in 3D MRI

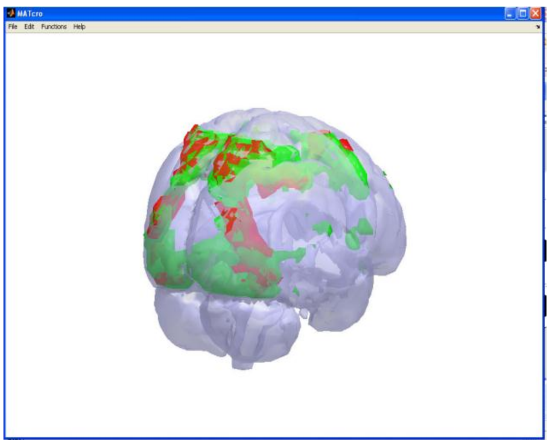

Fig 6: MRI image in 3D view

V. CONCLUSION

Electroencephalography (EEG) signals furnish useful know-how to be taught the mind perform and neurobiological problems. Digital signal processing gives the primary instruments for the analysis of EEG alerts. The EEG signal was once accrued from the ordinary data base. These EEG alerts were not distinguishable with human eyes. We used the sign processing tools to specified them and furnish the status of the man or woman. DWT and AR system are used for the feature extraction. Efficiency of proposed mixture of features is in comparison with the DWT points and AR aspects making use of ANN classifier. Experiment outcome indicates that the combo of facets classify the EEG alerts extra adequately. As a consequence, the two feature extraction schemes are in part complementary in nature whose blend helps to represent and characterize the sign more without problems than making use of any of them alone.

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