Computational Intelligence project : Classifying EEG data recorded from an end-user with functional disability

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Some mental activities induce changes in spontaneous electroencephalogram (EEG) rhythms in a very specific and predictive way. This means that an individual can generate distinct EEG patterns at will and independently from sensory stimulation. Brain-computer interfaces (BCIs) detect such EEG patterns and translate them into action.

This project indicates that Individual selection of mental task pairs significantly boosts binary classification accuracy of induced EEG patterns in end-users with functional disability.

Results

After extracting the best features we conclude that we should consider the features with numbers [30 195 188 169 90 516 24 25 85 84 506 456 88 507 512 511 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59]. These features are related to varying properties of trials.(Note that the order of features is as follows: 1:30 for max amounts, 31:60 for index of max amounts, 61:90for variances, 91:120 for means, 121:526 for cross-correlations and the rest for mean power spectral density for each frequency band(7 bands))

After creating accuracy matrix for different MLP networks we conclude that the network with 1 hidden layer and 23 neurons in hidden layer is the best MLP network. The accuracy matrix is as below:

1	2	3	4	5	6	7	8
0.6818	0.6909	0.6636	0.6182	0.6545	0.6455	0.7182	0.6818

Fig. 1. Accuracy matrix for MLP networks with number of idx*3+2 neurons in only HL

Then I trained a MLP network with above characteristics and made label for each test data and saved the labels in MLP1.mat file.

After creating accuracy matrix for different RBF networks we conclude that the network with spread and 7 maximum neuron numbers 4 is the best RBF network.(Fig 2)

After training MLP network by trials and features which are extracted by PSO algorithm, We have the following accuracy matrix. Note that the features number [5 61 84 118 163 184 238 283 341 343 425 435 442 454 495 503 575 596 607 616 636 637 668 678] are selected.

As you can see in Fig 3 the network with 1 hidden layer and 14 neurons in the layer is the best MLP network.

As you can see in Fig 4 the network with spread 14 and maximum neurons 2 is the best RBF network.

	1	2	3	4	5	6	7	8	9
1	0.6000	0.6364	0.6091	0.6364	0.6364	0.6182	0.6182	0.6364	0.6273
2	0.6909	0.6818	0.7000	0.7091	0.7364	0.7273	0.7455	0.7455	0.7364
3	0.6727	0.7182	0.7091	0.7364	0.7182	0.7091	0.7000	0.7273	0.7273
4	0.7273	0.6909	0.7455	0.7455	0.7273	0.6909	0.7091	0.6545	0.6364
5	0.6909	0.7182	0.7182	0.7000	0.6909	0.6818	0.6636	0.6455	0.6364
6	0.6818	0.7273	0.7273	0.6909	0.7000	0.6545	0.6909	0.6727	0.6364
7	0.6909	0.7091	0.7000	0.7545	0.6909	0.6455	0.6364	0.6364	0.6455
8	0.7273	0.7182	0.7091	0.6818	0.6818	0.6545	0.6091	0.6273	0.6091
9	0.6909	0.7182	0.6909	0.6909	0.6818	0.6455	0.6273	0.6545	0.6273
10	0.6909	0.7182	0.7182	0.7000	0.6636	0.6455	0.6455	0.6455	0.6727
11	0.7000	0.7455	0.7000	0.6818	0.6909	0.6636	0.6455	0.6273	0.6364
12	0.7455	0.7364	0.7091	0.6818	0.6364	0.6636	0.6818	0.6545	0.6818
13	0.7455	0.7182	0.7182	0.7273	0.7000	0.6909	0.6273	0.6273	0.6455
14	0.7545	0.7273	0.7091	0.6818	0.7000	0.6273	0.6364	0.6364	0.6727

Fig. 2. Accuracy matrix for RBF networks; Row = spread, Column = maximum neuron number

	1	2	3	4	5	6	7	8
1	0.6000	0.6091	0.6455	0.7091	0.6545	0.7000	0.5727	0.6182

Fig. 3. Accuracy matrix for MLP networks with number of idx*3+2 neurons in only HL; best features are extracted with PSO algorithm

	1	2	3	4	5	6	7	8	9
1	0.4727	0.4727	0.4727	0.4727	0.4727	0.4727	0.4727	0.4727	0.4727
2	0.5000	0.5000	0.4909	0.4909	0.5000	0.5000	0.4909	0.4909	0.4818
3	0.5000	0.5000	0.4909	0.4909	0.4909	0.4909	0.4909	0.4909	0.4909
4	0.5000	0.5000	0.5000	0.5091	0.5091	0.5000	0.4909	0.4909	0.4909
5	0.4909	0.4909	0.4818	0.4909	0.5182	0.5273	0.5273	0.5273	0.5273
6	0.5182	0.5091	0.5000	0.5091	0.5091	0.5182	0.5455	0.5636	0.5636
7	0.5545	0.5091	0.5273	0.5273	0.5182	0.5364	0.5727	0.5636	0.5636
8	0.5273	0.5364	0.5545	0.5364	0.5364	0.5727	0.5727	0.6000	0.5909
9	0.5182	0.5818	0.5818	0.6000	0.5636	0.5455	0.5364	0.5545	0.5545
10	0.5273	0.5909	0.5818	0.6000	0.5909	0.5636	0.5909	0.5818	0.5909
11	0.5545	0.6182	0.6091	0.6273	0.6000	0.5909	0.6000	0.5727	0.5636
12	0.5455	0.6273	0.6182	0.6091	0.6000	0.5727	0.5818	0.5909	0.5545
13	0.5545	0.6273	0.6364	0.6182	0.6091	0.5636	0.5818	0.5727	0.5909
14	0.5727	0.6545	0.6364	0.6455	0.6091	0.5727	0.5818	0.5727	0.6000

Fig. 4. Accuracy matrix for RBF networks; Row = spread, Column = maximum neuron number, best features are extracted with PSO algorithm

Then I created MLP and RBF networks with above characteristics and save the results of testing test data in .mat files.

Materials and Methods

Assigning features to trials: In the first step I created features vector by assigning maximum amount of each trial for all channels, the index of maximum amount of each trial for all channels, variance of each trial for each all, mean of each trial for all channels, cross-correlation of all pairs of channels and mean of power spectral density of each band of each trial for all channels. These are totally 736 features and we could

increase this number by considering other features such as peak frequency of each band of each trial for all channels, etc. after creating the features matrix, I normalized it to get intervals varying from -1 to 1 .

Selecting best features: After creating features vector we need to extract best features which are main and distinguished properties of class 1 and class 2. We do this by calculating Fisher's criterion for each feature and sorting it in increasing order and considering 30 top features as best ones.

Training MLP Network and distinguishing best one: In this step I trained different MLP networks per number of hidden layers and number of neurons in each hidden layer. Then all accuracies are saved in ACCMat1. Note that indexes of best features are saved in matrix l. After this process best MLP network got distinguished by ACCMat1.

Training RBF Network and distinguishing best one: In this step I trained different RBF networks per different amounts of spread and different maximum neuron numbers per each spread. Then all accuracies are saved in ACCMat2. Note that Indexes of best features are saved in matrix l. After this process best RBF network got distinguished by ACCMat1.

Extracting best features by PSO: We can find best features by PSO algorithm as well. Here we set 25% of data as validation set and after applying PSO algorithm we get 6 features as best features to classify the EEG data.

Train Network: Then we can find best MLP and RBF networks as same as phase 1.

Conclusion

By extracting best features by PSO algorithm we could classify the EEG data with same accuracy but we used less features. By checking accuracy tables we can conclude that MLP networks are more Efficient than RBF networks in classifying this kind of EEG data.

References

1. Individually Adapted Imagery Improves Brain-Computer Interface Performance in End-Users with Disability Reinhold Scherer, Josef Faller, Elisabeth V. C. Friedrich, Eloy Opisso5 , Ursula Costa , Andrea Kübler , Gernot R. Müller-Putz