Deep Learning - Assignment 3

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1 Introduction

The data-set consists of several documents with magnetoencephalography data. The goal is to classify the task that the subject was performing during the recording: resting, math and story task, working memory, and motor task. To do so, we implemented a CNN model and trained it with the available training data. We also compared the accuracy of intra-subject and cross-subject classification. Furthermore, we analyzed the influence of some hyper-parameters on the result and the difference between the training and testing accuracy.

2 Implementation Details

We implement a Convolutional Neural Network model with Residual Blocks. The number of residual blocks is configurable but during the training, we are using 3 blocks that contain 3 1D convolution layers and applies batch normalization. The activation function for these blocks is ReLU. The CNN model is also holding 1D convolutional layers and a linear one. Since we are dealing with a classification problem, the activation function for the output layer is softmax. We have the measurements of 248 sensors with a sampling rate is 2034 Hz. We resample the signal to 500 Hz: in this way we have a smaller dataset which fit in memory and we can also filter out some higher frequency noise. Then, we take windows of 1 second as training examples. Between one window and the next one there are 5 time steps.

3 Training the models

We training the data for ten epochs. We train the model with the train data of cross and intra data, the train and validation loss is shown in Figure 1. To measure the performance of the classification model we are using the loss function Cross-Entropy for all the experiments and the optimizer is Adam.

Looking into the Intra case, shown in the image 1 on the left, we can see how the training loss decreased in the first epoch and then remains falling until almost the end of the graph, epoch 8, when suddenly appears a significant increment, caused by over-fitting. The accuracy, precision, and recall obtained

in testing Intra classification are 99% and the confusion matrix shows a good performance in the classification.

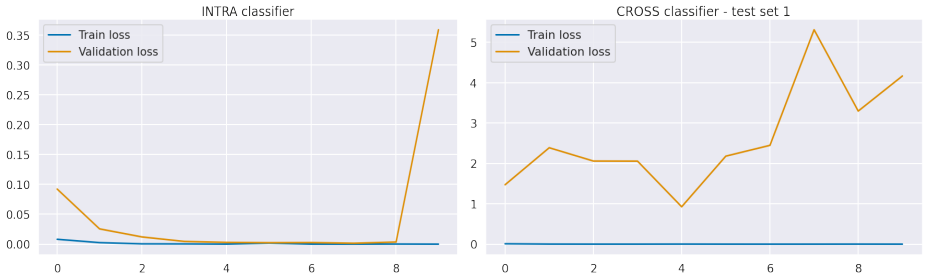

Figure 1: Train and validation loss for Intra (left) and Cross (right) classification

Analyzing the Cross loss plot, the right image in Figure 1, we can see an unstable loss that is getting higher in the latest epochs. The accuracy with this classifier is worse than with Intra, having a 47% in the first and second set and a 25% in the third. The confusion matrix shows an unsatisfactory performance.

4 Explain the choices of hyper-parameters

We train the models, as described in section 3, then we performed a random search on the number and the size of the residual blocks of the network. We perform this experiment on the model train and tested on the intra-subject data and the model trained and tested on the cross-subject data. The learning rate is always constant and equal to 0.00002 and the down-sample rate is 0.5. Then, we report the best model's accuracy as well as the hyper-parameters that resulted in the best model. In Table 1 you see the parameters and accuracy of the best models for Intra and Cross data.

Data	res. blocks	res. block size	training loss	testing loss	accuracy
Intra	5	2	0.00064	0.0080	99.96 %
Cross	5	3	0.00035	1.390	75.77 %

Table 1: Parameter values, loss values and accuracy of the best models. The learning rate is 2e-5. The input channels depend on the data, in this case is 248.

The random search is able to find hyper-parameters that gives a better accuracy on the Cross data case. For the Intra data case, we still have an high accuracy (Table 2). So, as we can see the number of residual blocks and the learning rate plays significant role in predicting the labels for the Cross data. For the Intra data these parameters don't play significant role.

Data	res. blocks	res. block size	training loss	testing loss	accuracy
Intra	3	2	0.00002	0.0023	99.96 %
Cross	3	2	0.00008	5.9360	55.10 %

Table 2: Original parameter values, loss values and accuracy of the best models before performing the random search.

5 Difference between cross-subject and intra-subject classifiers

You can see all the accuracy values in Table 3, 4, 5, 6. But in Table 4, 6 we notice that the accuracy from training and testing the Cross data are significantly different. The reason for this is because Cross data have information for different subjects, so the prediction is more challenging in comparison to Intra data that contain only one subject. As we already discussed in section 4, to increase the accuracy of the prediction for the Cross data we changed the number of residual blocks for our architecture and increased the learning rate. This way the model learns to predict with higher accuracy.

	Accuracy	**Precision**	**Recall**
Intra Classifier	0.999785836664763	0.9997857958251795	0.9997859181692926

		Predicted			
		rest	math	memory	motor
True	rest	3498	0	0	0
	math	1	3503	0	0
	memory	1	1	3501	0
	motor	0	0	0	3503

Table 3: Intra Classifier tested on the intra-subject test set

	Accuracy	**Precision**	**Recall**
Cross Classifier test1	0.47458595088520844	0.5873462657444807	0.47451891282029235
Cross Classifier test2	0.4634494574528841	0.37507179598025275	0.46331960430438224
Cross Classifier test3	0.24757281553398058	0.30834797222467675	0.24746681889539032

		Predicted			
		rest	math	memory	motor
True	rest	1906/5989/3394	1/693/1906	0/0/0	5090/324/1707
	math	7/2/1	3739/60/0	3261/6936/1885	0/0/5109
	memory	1/6978/0	1108/1/1	733/27/110	5164/0/6986
	motor	0/0/1	1/1/2314	87/97/1260	6981/6908/3432

Table 4: Cross Classifier tested on the three cross-subject test sets. As we can see, the results varies a lot between the set. Also, some task are easier to distinguish that others (e.g., motor is rarely classified as rest).

	Accuracy	Precision	Recall
Intra Classifier test	0.9937178754997145	0.9938675199798368	0.9937206261234662

		Predicted			
		rest	math	memory	motor
True	rest	3498	0	0	0
	math	0	3457	47	0
	memory	0	1	3502	0
	motor	0	0	40	3463

Table 5: Cross Classifier tested on the intra test set. Surprisingly, the model has an accuracy similar to the Intra Classifier

	Accuracy	Precision	Recall
Cross Classifier test1	0.3999143346659052	0.41695500276041	0.3997835950032526
Cross Classifier test2	0.7884066247858367	0.7881226823312776	0.788342038429152
Cross Classifier test3	0.37896202170188464	0.5805638158424381	0.3788066268460427

		Predicted			
		rest	math	memory	motor
True	rest	1/7005/3503	0/0/0	6066/1/3504	930/100/0
	math	1/0/0	3264/3934/112	3742/3064/300	0/0/6583
	memory	1/19/1	816/2841/2	936/4145/0	5253/1/7004
	motor	1/1/0	2/0/0	0/1/5	7003/7004/7002

Table 6: Intra Classifier tested on the three cross test sets. Again we can see that some classes are easier to classify. Also, the performance changes a lot between the different test sets.

6 Conclusion

Training big data is challenging, but using techniques like down sampling, and splitting the data into batches we manage to reduce the training time and are able to train the data with different models and increase the prediction accuracy. So, this was very significant as the architecture we implemented has good results. For the Intra case, we have an extremely high accuracy. The Cross case is more difficult, so we have lower accuracy. The random search is able to find a better architecture for the model and effectively increase the accuracy on the cross-subject data. It is using the largest values we allowed for those parameters, so it also suggests that a deeper model might further improve the results.