ASSIGNMENT 2

Enhancing Convolutional Neural Network Performance through Regularization Techniques: A Comprehensive Analysis

Abstract:

In this paper, we present a comprehensive analysis of convolutional neural network (CNN) optimization techniques for image classification tasks, with a focus on distinguishing between cats and dogs. We explore the efficacy of various regularization methods, including data augmentation and dropout, in mitigating overfitting and improving model generalization. Additionally, we investigate the impact of increasing the training sample size and leveraging pretrained networks for feature extraction and fine-tuning. Our experiments demonstrate the effectiveness of these strategies in enhancing CNN performance, yielding superior accuracy on the cats vs. dogs classification problem.

Introduction:

Convolutional neural networks (CNNs) have emerged as powerful tools for image classification, yet overfitting remains a significant challenge, particularly in scenarios with limited training data. The task of distinguishing between cats and dogs serves as a canonical example, necessitating robust models capable of generalizing well to unseen images. In this study, we delve into the optimization of CNN architectures through the implementation of regularization techniques and the exploration of pretrained models.

Methodology:

We begin by constructing CNN architectures from scratch and training them on a modest dataset comprising 1000 samples of cat and dog images. We partition the data into training, validation, and test sets to evaluate model performance. To address overfitting, we employ data augmentation and dropout regularization during training. Subsequently, we increase the training sample size to assess its impact on model accuracy. Additionally, we investigate the use of pre-trained CNNs, specifically VGG16, for feature extraction and fine-tuning.

Let's look at the summary of the results obtained by performing the above tasks on the data set and formulate the results for better understanding:

SUMMARY:

Question - 1.

Consider the Cats & Dogs example. Start initially with a training sample of 1000, a validation sample of 500, and a test sample of 500 (like in the text). Use any technique to reduce overfitting and improve performance in developing a network that you train from scratch. What performance did you achieve?

Starting initially with a training sample size of 1000, validation of 500, and test of 500, we build the model from scratch with and without any regularization techniques and note the differences in test accuracy.

Without any regularization technique, the test accuracy is 0.641 which is 64% accuracy.

Therefore, after applying regularization techniques such as

a) Data Augmentation, b) Dropout method, and c) Image augmentation and dropout method.

We can notice that the test accuracy is 74%, 64%, and 75% respectively from the above-mentioned techniques. We can conclude that there is a change in accuracy with use of the regularization technique.

As mentioned, we can use any technique to enhance the model's performance, I prefer **Image augmentation and dropout regularization** techniques to reduce overfitting and improve performance.

Let's Summarize the results,

MODEL	TEST ACCURACY	VALIDATION ACCURACY	TEST LOSS
Without regularization	64%	68%	0.63
With Data augmentation regularization	74%	75%	0.52
With dropout regularization	64%	68%	0.63
With Image augmentation and dropout regularization	75%	75%	0.51

According to the results, the performance of the model improves after regularizing the model using the Image augmentation and dropout technique. The accuracy increases from 70 to 75.

Let's now increase the sample size by 5000 and see the change in the performance of the model.

Question - 2.

Increase your training sample size. You may pick any amount. Keep the validation and test samples the same as above. Optimize your network (again training from scratch). What performance did you achieve?

Now, I have increased the sample size of training by 4000 keeping the validation and test size the same, the new size is 5000 and I used image augmentation and dropout technique for regularization.

MODEL	TEST ACCURACY	VALIDATION ACCURACY	TEST LOSS
With 1000 samples	75%	75%	0.51
With 5000 samples	92%	83%	0.19

We can see that the performance of the model has now greatly increased by increasing the training sample size and using Image augmentation as a regularization technique, the test accuracy has changed from 75% to 92% whereas the test loss has decreased to 0.51 from 0.19.

Question - 3.

Now change your training sample so that you achieve better performance than those from Steps 1 and 2. This sample size may be larger, or smaller than those in the previous steps. The objective is to find the ideal training sample size to get the best prediction results. ?

Now, I have increased the training sample size from 5000 to 10000 keeping the validation and test sample size the same. Let's summarize the results.

MODEL	TEST ACCURACY	VALIDATION ACCURACY	TEST LOSS
With 1000 samples	75%	75%	0.51
With 2000 samples	92%	83%	0.19
With 5000 samples	96%	92%	0.10

There is an increase in test accuracy of 96% from 92% with an increase in training samples from 5000 to 10000 whereas there is a decrease in test loss from 0.19 to 0.10 which means our model performance has been improving with an increase in the training sample data size.

Therefore, as the sample size increases the performance of the model increases resulting in better accuracy and we can say for the cat's vs dog's example, the regularized model with

10000 samples is best for getting the best predictions, it can be considered as the ideal training dataset size.

Question - 4.

Repeat Steps 1-3, but now using a pre-trained network. The sample sizes you use in Steps 2 and 3 for the pre-trained network may be the same or different from those using the network where you trained from scratch. Again, use any optimization techniques to get the best performance.

Going further as required, we will be using a pre-trained model and we will be using VGG16 convolutional base as a pre-trained model.

Let's summarize the results obtained by improving the models with different sample sizes of training data sets.

	TEST ACCURACY	VALIDATION ACCURACY	TEST LOSS
With VGG16 pretrained model	67%	57%	0.59
VGG16 and 1000 samples	95%	95%	0.14

From the above table, we can see that the testing and validation accuracy tend to improve, and the validation loss goes down as the sample size increases. They are even better when regularized and fine-tuned when compared to only regularized models. We can easily predict that with increasing sample size, like earlier, there will be an increase in all the parameters such as test accuracy and validation accuracy, and a decrease in loss.

Conclusion:

In conclusion, our study highlights the importance of regularization techniques in enhancing CNN performance for image classification tasks. By employing data augmentation, dropout, and increasing the training sample size, we effectively mitigate overfitting and improve model generalization. Furthermore, the utilization of pretrained networks for feature extraction and fine-tuning demonstrates the efficacy of transfer learning in accelerating model convergence and achieving superior accuracy. Overall, our findings underscore the significance of optimization strategies in developing robust CNN models for real-world applications.