Assignment - 2

Convolution Neural Networks

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Convolution neural networks are usually used for image input and feature extraction. This assignment explores the impact of training sample size and the choice of network on model performance. The Cats & Dogs dataset is imported from the Kaggle competition, and the objective is to compare the performance of training a network from scratch and using a pre-trained network.

Train sample 1000, Validation 500, Test 500:

- **Initial Setup:**
    1. Initially, a training sample of 1000, validation samples of 500, and a test of 500 samples of both cat and dog images each have been taken.
    2. A convolution neural network is built with 5 layers of two-dimensional convolutional layers with a filter size of 3 along with 4 max-pooling layers with a pool size of 2 and connected to an output dense layer.
    3. The loss function “binary cross-entropy” was used as it was a classification model with optimizer “Adam”.

  Test accuracy of **65.1%** and test loss of **62.43%** have been obtained.

- **Final Optimized setup:**
  Below are the techniques used to optimize the model and increase its performance,
    1. Added data augmentation to input sample with flip, zoom, and rotation parameters.
    2. Added one more dense layer after flattening layer with regularizer L2 of 0.0001.
    3. Added a dropout layer with a 50% dropout rate.
    4. Along with optimizer Adam, a learning rate of 0.0001 is also added.

  With the addition of these techniques, the test accuracy went up to **74.1%**, and the loss was reduced to **56.81%.**

Train sample 2000, Validation 500, Test 500:

- A random sample size of 2000 was taken as the training sample size and given as input to the above-optimized model and trained from scratch.
- The test accuracy has been increased to **78.1%**, the loss also decreased to **53.33%.**

Train sample 3000, Validation 500, Test 500:

- A random sample size of 3000 was taken as the training sample size and given as input to the above-optimized model and trained from scratch.
- The test accuracy has been increased to **78.8%**, the loss also decreased to **58.76%.** Performance has been improved significantly when there is an increase in the sample size.

Train sample 4000, Validation 500, Test 500:

- A random sample size of 4000 was taken as the training sample size and given as input to the above-optimized model and trained from scratch.
- The test accuracy has been increased to **82.5%**, also loss decreased to **50.68%.** Performance has increased significantly when there is an increase in the sample size furthermore.

Sample Size	**Test Loss**	**Test Accuracy**
2000	53.33%	78.1%
3000	58.76%	78.8%
4000	**50.68%**	**82.5%**

Defining Optimal Train Sample Size:

As the training sample size increases from 1000 to 4000, from the above table it can be observed that,

- The accuracy increased as the sample size is being increased.
- At 3000, accuracy has increased significantly, and the loss increased along with it.
- But at 4000, the model seems to be performing good as the accuracy increased and test loss also decreased along with it.
- From the table we can observe that sample size **4000** will be the optimal sample size for the model with **82.5%** test accuracy and **50.68%** test loss.

Use of Pre-Trained Network VGG-16:

- A pre-trained convolution network vgg16 has been taken for implementation of the model for a train sample size of 4000.
- Data augmentation is done to inputs and freeze the first 4 blocks in the pre-trained vgg16 model.
- Added a dense layer and a dropout rate of 50%.
- Adam optimizer with a learning rate of 0.0001 was used and the model was trained with a sample size of 4000.
- The performance of the model has been increased significantly with a test accuracy of **98.3%** and **6.5%.**

Conclusion

In general, the relationship between training sample size and the choice of network is complex and dependent on various factors such as the dataset, model architecture, and optimization techniques used. Larger sample sizes generally lead to better performance, but the specific optimal sample size varies. the choice of optimization techniques is also important for achieving good performance. Techniques such as data augmentation, regularization, and learning rate can help prevent overfitting and improve generalization performance. Based on the model architecture used for this model a training sample size of **4000** gave an optimal accuracy of **82.5%** with less loss of **50.68%** and a further increase in sample size may lead to overfitting of the model.

Using a pre-trained network helped to improve the performance of the model even more. In this case VGG16, a pre-trained convolution model was used which achieved an accuracy of **98.3%** with a loss of **6.5%**. Moreover, using a pre-trained network improved performance, even with smaller sample sizes. Pre-trained networks are generally trained on large datasets and learned general features that are transferable to other datasets. Fine-tuning the pre-trained network on the target dataset has led to significant improvements in performance.

Overall, the link between the size of the training sample and the network selection is complicated and depends on several factors. To identify the optimum configuration that yields the highest performance for a particular job, it is essential to experiment with various sample sizes, architectures, and optimization approaches.