**Convolution Neural Networks**

Convolution Neural Network (CNN) is an artificial neural network that is mainly used in Image recognition and computer vision tasks. It consists of a convolution layer that applies filters to the input image. Convolution is a way of sliding the filters over the image that produces a set of feature maps that show different aspects of an image.

**Analysis:**

Cats and Dogs dataset consists of 25,000 images of cats and dogs. Images are trained using the convolution network to predict the test images.

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| Model | Training from scratch | | | Pretrained Model | | |
| Performance Metric | Accuracy | Validation Loss | No. of epochs | Accuracy | Validation Loss | No. of epochs |
| Initial Model (Training=1000, Validation=500, Test=1000) | 71.6% | 1.86 | 30 | 98.3% | 0.01 | 20 |
| Data Augmentation  (Training=2000, Validation=500, Test=1000) | 78.3% | 0.95 | 100 | 98.7% | 1.45 | 50 |
| Increased Training Data (Training=2000, Validation=500, Test=1000) | 71.7% | 2.19 | 30 | 99.4% | 0.04 | 20 |
| Optimal Training Data (Training=4000, Validation=500, Test=1000) | 73.5% | 2.49 | 30 | 99.6% | 0.07 | 20 |

In Training from scratch Network, random weights are assigned to the model and gradually update during the training process. Hence good quality and large size of labelled data is required to achieve good performance. Initial model built on this dataset using Training from Scratch resulted in an accuracy of 71.6% and validation loss of 1.86.

Pretrained Neural network model has been trained with the large dataset already. Weights of the model are downloaded and used for the similar and smaller dataset as a starting point. This improves the performance of the model and reduces overfitting because model has already learned the useful features that are used for smaller dataset. This also saves time and decreases computational resources. Initial model built on this dataset using Pretrained Neural Network resulted in an accuracy of 98.3% and validation loss of 0.01.

**Data Augmentation**

In training from scratch network test accuracy has increased to 78.3% and validation loss decreased to 0.95. Also, in pretrained network test accuracy has increased to 98.7% and validation loss increased to 1.45. This is because during training, the transformations such as rotating, flipping, zooming to each image are performed which creates a new form of image. In this way model is trained with various variations in the original data and helps to learn more robust features which improves performance and reduce overfitting. However Validation loss seemed to increase in pretrained network because sometimes Data Augmentation introduces noise that can lead to overfitting of the model.

**Training sample Increment**

Increase of training sample size in a CNN improves the performance of the model because the model learns more data and captures more underlying patterns in it. Hence it is visible that Test accuracy has increased to 71.7% in training from scratch network and 99.4% in pretrained network. Additionally, with more samples model memorizes less training data and can decrease overfitting. However, sometimes overfitting increases with low quality data. In this case validation loss has increased to 2.19 in training from scratch network and 0.04 in pretrained network.

**Optimal training Sample**

Increase of training sample increases the performance of the model. Model is tested with different training samples and observed that after a certain point increasing the training sample in the network does not affect the performance. This is because model learned all the robust features and addition of samples will not provide much information to the model. Hence the performance becomes stable.

The best sample size for both networks is 4000 having accuracy of 73.5% and validation loss of 2.49 for training from scratch network. Whereas, test accuracy of 99.6% and validation loss of 0.07 for pretrained network.

**Conclusion**

Pretrained network turns out to be the best network compared to training from scratch network. Though increasing of training sample may increase the Test accuracy but also increases Validation loss. Data Augmentation seems to work better for training from scratch network but not well for Pretrained network. I would consider Pretrained network with increase training data is the best model with 99.4% test accuracy and less validation loss of 0.04 with lesser number of epochs.



