**Assignment-3: Convolution**

**Database Description:**

This is a balanced dataset with equal number of images for each class, and these data is ready for training, validation, and testing in a binary image classification task where the goal is to distinguish between images of cats and dogs.

This dataset contains images of cats and dogs divided into three sets:

1. **Training Set**: 2,000 images (1,000 cats and 1,000 dogs)
2. **Validation Set**: 1,000 images (500 cats and 500 dogs)
3. **Test Set**: 1,000 images (500 cats and 500 dogs)

**Introduction to CNN:**

A Convolutional Neural Network (CNN) is a specialized type of artificial neural network designed to process and analyze visual data like images. CNNs are highly effective at automatically learning and identifying patterns within image data, such as edges, textures, and shapes. They use layers of convolutions (filters) to scan over the input, pooling layers to reduce dimensionality, and fully connected layers at the end for classification or regressio**n.**

**Usage of CNN in our Project:**

To use a CNN on the Cats vs. Dogs dataset, the process involves:

1. **Data Preparation**: The dataset is split into training, validation, and test sets. Data augmentation techniques are applied to the training images to improve generalization, such as random rotations, shifts, and flips. This makes the model more robust to variations in image appearances.

2. **CNN Model Architecture**: A Convolutional Neural Network is defined with a series of convolutional layers to capture features from the images. Each convolutional layer is followed by a max-pooling layer to reduce dimensionality while retaining key features. The model ends with fully connected layers for classification, where the final layer has a sigmoid activation for binary output (cat or dog).

3. **Training**: The model is trained on the augmented data using a binary cross-entropy loss, optimized by the Adam optimizer. Early stopping is used to prevent overfitting by monitoring validation loss, allowing training to stop automatically if performance stops improving.

4. **Evaluation**: After training, the model is evaluated on the test set to measure its accuracy and loss, ensuring the model generalizes well to new, unseen images.

This approach leverages CNN power to capture spatial hierarchies in images, making it well-suited for distinguishing between cats and dogs based on visual features.

**Model Performance on Cats vs Dogs Dataset**

To compare the accuracies of the trained vs. pre-trained models under different training sample sizes, you can structure a table as follows:

Table: Model Performance on Cats vs. Dogs Dataset

|  |  |  |  |
| --- | --- | --- | --- |
| Model Type | Train  Accuracy Loss | Validation  Accuracy Loss | Test Accuracy |
| T.F.Scratch T=1k | 0.58 0.67 | 0.59 0.66 | 0.56 |
| T.F.Scratch T=1504 | 0.66 0.61 | 0.66 0.59 | 0.65 |
| T.F.Scracth T=1600 | 0.72 0.57 | 0.72 0.52 | 0.71 |
| P.T. VGG16 T=1k | 0.89 0.70 | 0.92 0.66 | 0.91 |
| P.T.VGG16 T=1504 | 0.85 0.83 | 0.89 0.75 | 0.88 |
| P.T.VGG16 T= 1600 | 0.89 0.60 | 0.90 0.57 | 0.90 |

Each Model Type row includes:

1. **Trained from Scratch:** A model trained solely on the Cats vs. Dogs data without transfer learning. Shows performance with varying sample sizes (1,000, 1504 and 1600 sample determined from testing).

2. **Pre-trained (VGG16):** A model leveraging pre-trained weights from a larger dataset (ImageNet), then fine-tuned on Cats vs. Dogs. Shows performance with the same sample size variations.

This table will help identify the relationship between sample size, model choice, and resulting accuracy, clarifying whether pre-trained models or custom-trained models yield better outcomes under each condition.

**In Comparison of the Accuracies:**

For the Cats vs. Dogs dataset, using a pretrained model generally yields better performance than training a model from scratch. Pretrained models like VGG16 have been trained on large datasets like ImageNet and come equipped with robust, generalized feature detectors. When fine-tuned on a specific task like Cats\_vs\_Dogs, they quickly learn relevant features, achieving high accuracy even with smaller training datasets. This approach also reduces the risk of overfitting and saves substantial computational resources. In contrast, models trained from scratch often struggle with small datasets, requiring more data and time to achieve comparable accuracy, making pretrained models the preferred choice.

**Observation:**

From the above table we observed that,

1.) Increasing the training sample size improves model accuracy up to a certain point by providing better generalization, reducing overfitting, and allowing the model to learn features effectively. This trend can often be observed by evaluating validation and test accuracies as the training dataset size grows.

2.) In comparison to the Model, Pre-trained is the best model for Cats\_vs\_dogs dataset.

**Conclusion:**

In conclusion, the pre-trained model with the largest training sample size (T=1600) achieved the highest accuracy, minimized loss, and effectively reduced overfitting, demonstrating strong performance overall.