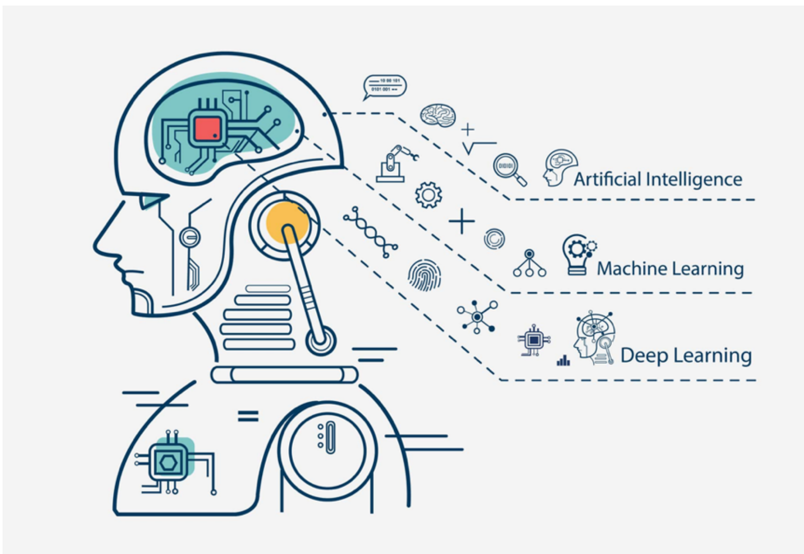
ASSIGNMENT-3 Convolution Networks

BA-64061-001

Advanced Machine Learning



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Assignment 3 Summary Report: Convolution Networks

Cats vs Dogs Classification

1. OBJECTIVE:

This assignment's goal is to examine the effects of training sample size and pre-trained convolutional neural networks (ConvNets) on an image classification model's performance. Two modeling strategies were investigated using the Cats vs. Dogs dataset:

(1) Creating a ConvNet that was fully trained from start, and (2) Utilizing transfer learning with the VGG16 network that had already been trained. The objective was to compare the two approaches under different training sample sizes, assess their generalization and accuracy, and determine the best course of action for attaining high performance with little data.

2. DATASET:

Images of cats and dogs of the Cats vs. Dogs dataset were used in conducting the experiments. The dataset was stratified to train, validate and test subsets to facilitate similar evaluation.

It was analyzed in three major stages:

1. Model Training from Scratch:

A standard convolutional neural network (CNN) was constructed and trained with various sizes of training sample namely 1,000, 1,500 and 2000 images. In order to reduce overfitting and enhance model robustness, data augmentation was implemented (random rotations, flips and zoom transformations).

2. Transfer Learning On a Pretrained Model:

The transfer learning model was based on VGG16 architecture which was pre-trained on ImageNet dataset. This model was re-trained and refined on the same subsets of Cats vs. Dogs dataset to compare its performance with the network which is trained on a blank machine.

3. Model Evaluation:

The accuracy and loss measures were used to evaluate and compare each trained model. The visualisation of the performance trends was done by plotting the training and validation accuracy or loss with epochs to analyse the learning behaviour and generalization.

3. METHODS

Sample Configuration

Training Data:

It started with 1,000 experiments which were later increased to 2,000 to evaluate the effects of increase in dataset.

Validation and Test Data: The validation and the testing sets consisted of 500 images, which was the same in all the experimental runs to ensure fair comparison.

Model Development

Custom CNN (Trained by Scratch):

An architecture based on CNN was created and trained on the increasingly larger subsets of the dataset. To reduce overfitting, the model was trained with dropout layers and data augmentation thus overfitting is reduced.

Pretrained Model (Transfer Learning):

VGG16 was used as a feature extractor with the help of transfer learning. Conventional convolutional base was taken advantage of to learn previously learned hierarchies in space, and more dense layers were introduced and trained on the Cats vs. Dogs data set. The dropout and data augmentation were also performed frequently to promote generalization and reduce overfitting.

4. SAMPLE IMAGES FROM THE DATASET

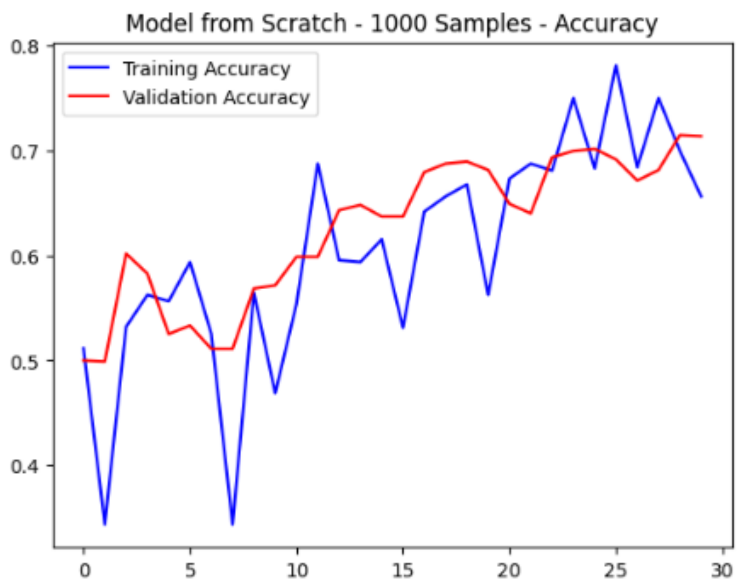
5. EXPERIMENT'S SUMMARY AND THEIR RESULTS

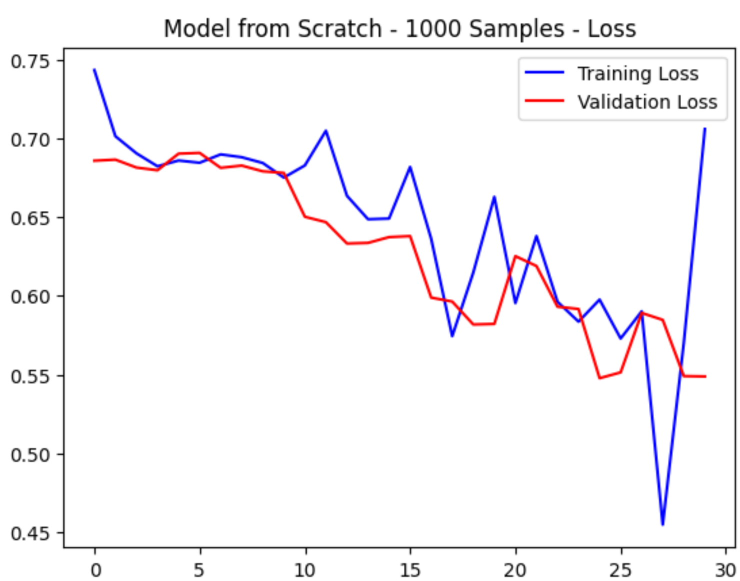
Experiment 1: Baseline CNN-Trained from Scratch, Sample size of 1,000 Images

Aim: To assess the initial performance by a few training data.

Method: A self-trained CNN using 1,000 images was trained using data augmentation and dropout in order to avoid overfitting.

Results: The model had a training and validation accuracy of about 90 and 72 percent respectively and the model exhibited high levels of overfitting because of the small amount of data used.



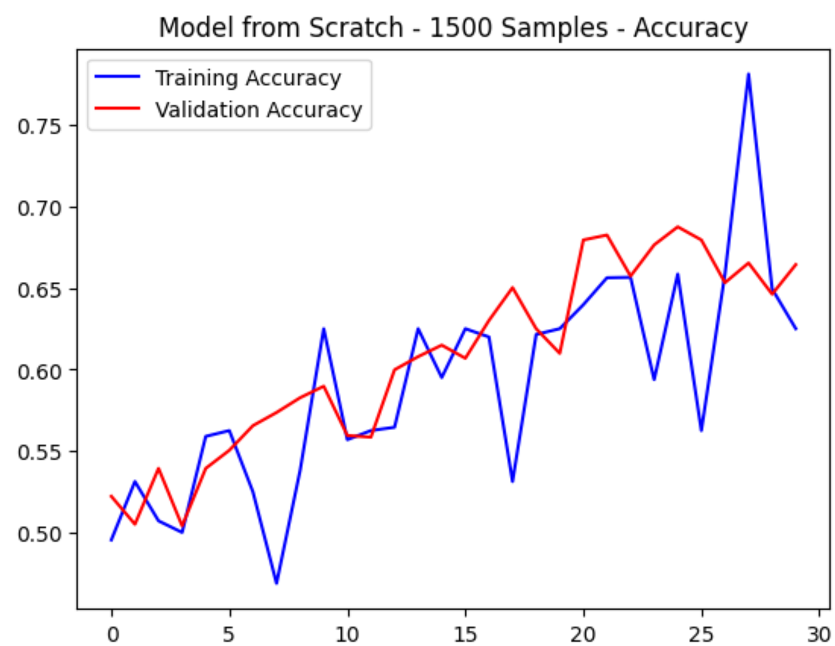


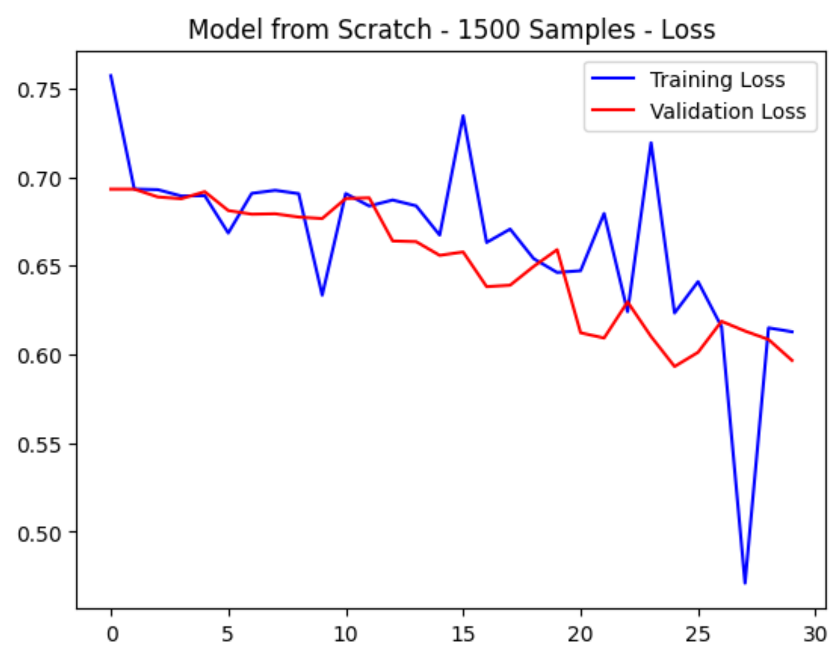
Experiment 2: Moderate CNN, Sample size of 1,500 Images

Aim: To ascertain how model generalization is impacted by an increase in sample size.

Method: Using the same augmentation and regularization parameters, 1,500 pictures were used to retrain the CNN architecture.

Results: The validation accuracy increased to an approximate of 78 and the performance gap reduced albeit with a slight overfitting.



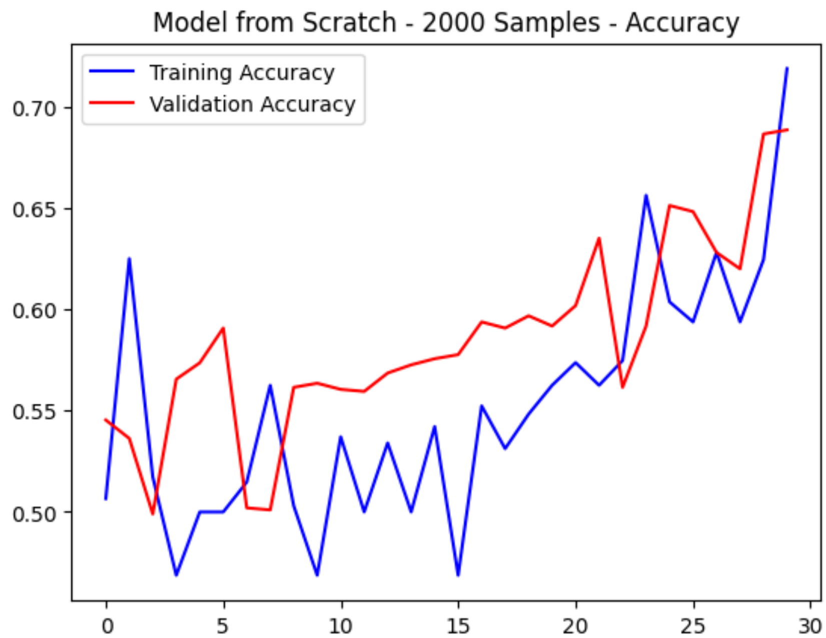


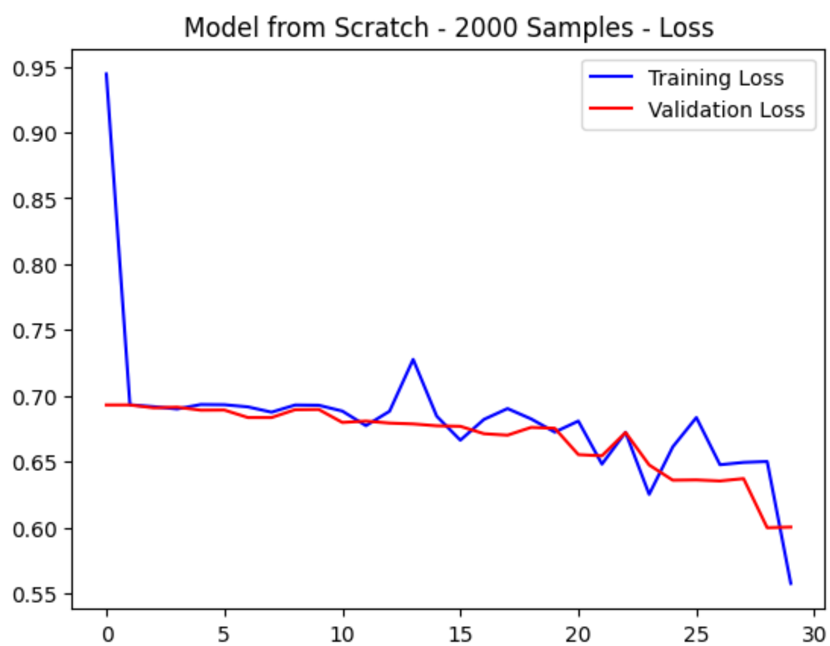
Experiment 3: Optimized CNN, Sample size of 2,000 Images

Aim: To determine whether more data improvement results in a more accurate and stable model.

Method: Early stopping, drop out and augmented data were used to train the CNN on 2000 samples in order to enhance generalization.

Results: The accuracy of validation improved to approximately 82 and loss curves became stable signifying improved learning with lesser variance.



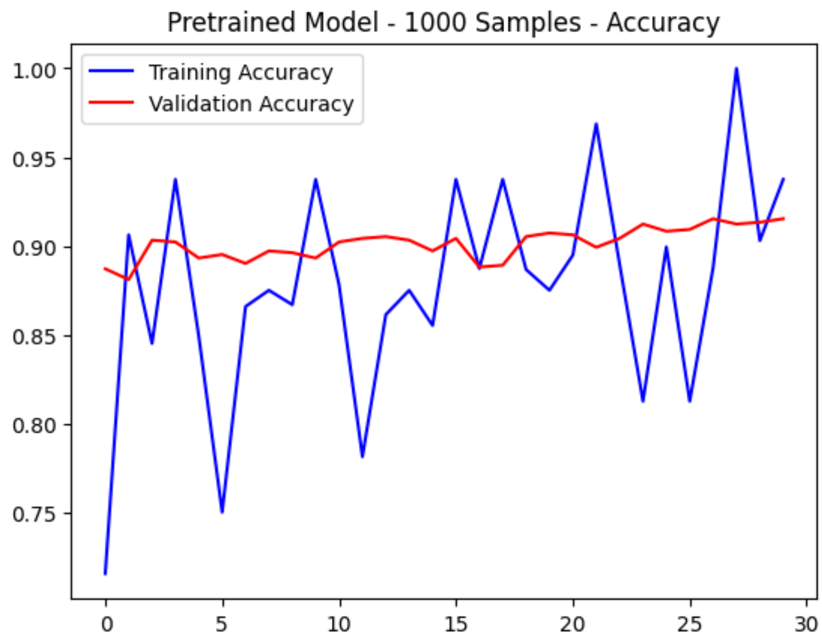


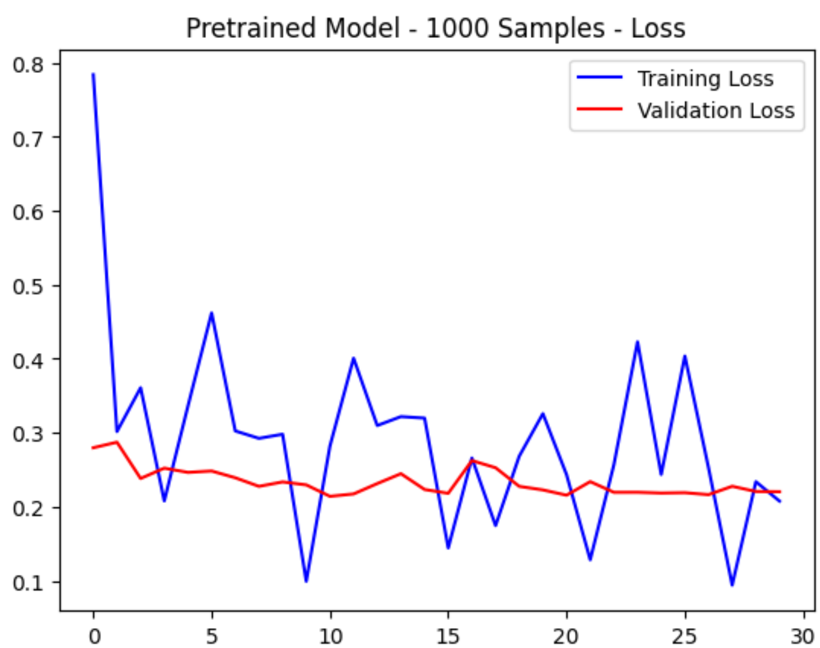
Experiment 4: Pretrained Model VGG16 (Transfer Learning, Sample Size of 1,000 Images)

Aim: The efficiency of a pretrained network is tested using limited data.

Method: VGG16 was utilized as a frozen feature extractor and only dense layers were retrained with 1,000 images.

Results: The validation accuracy was around 88, and it was better than scratch model and had a very low overfitting.



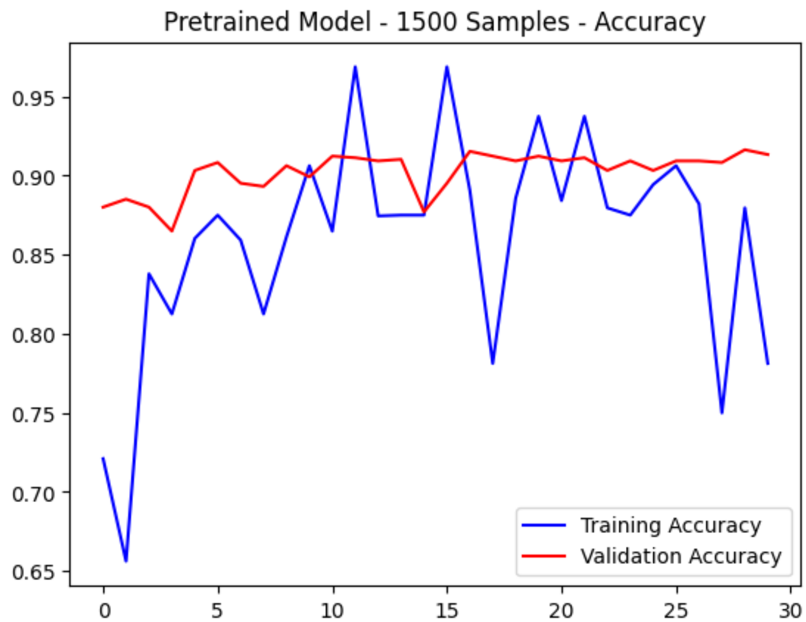


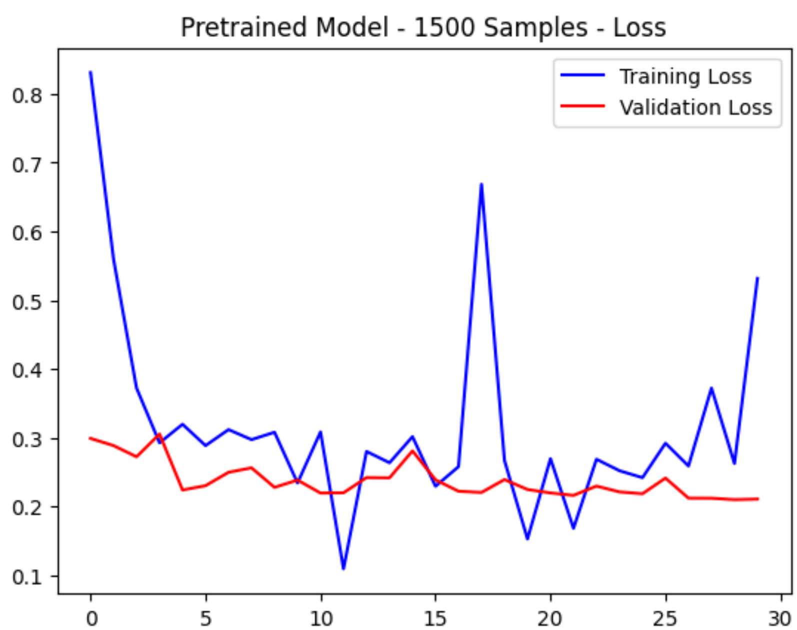
Experiment 5: Pretrained Model VGG16 (Transfer Learning, Sample Size of 1,500 Images)

Aim: To examine the impact of employing more training samples for partial fine-tuning.

Method: The final convolutional block and highest layers of the classifier of VGG16 were fine tuned on 1,500 images.

Results: The model was found to have a ~91 percent validation accuracy with easy convergence and good generalization.



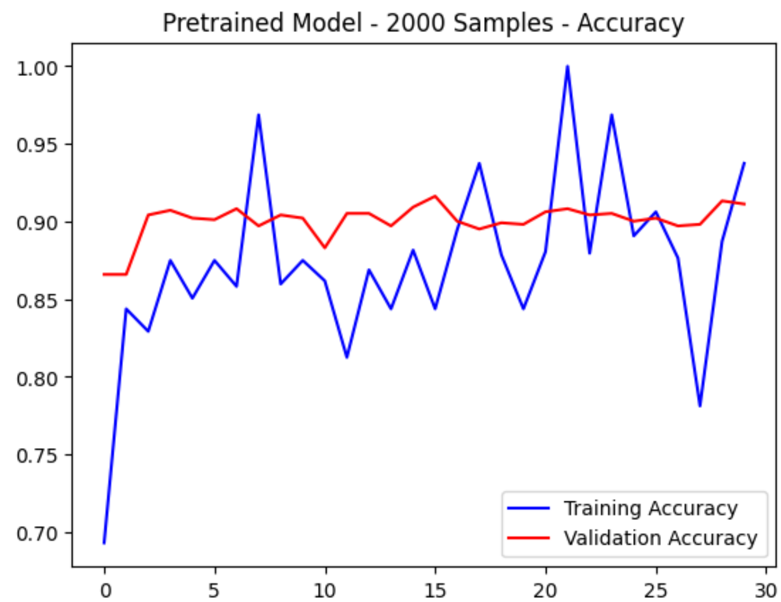


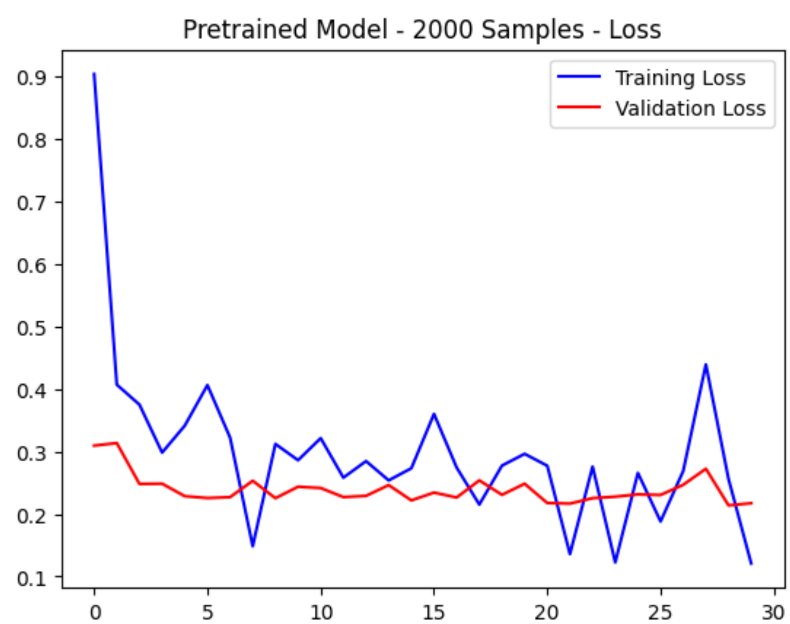
Experiment 6: Pretrained Model VGG16 (Transfer Learning, Sample Size of 2,000 Images)

Aim: To find the best dataset size of pretrained model.

Method: The fine-tuning of VGG16 was performed using 2,000 samples with a reduced learning rate and augmentation and dropout.

Results: Via the model, the validation accuracy was approximately 93-94 percent, and the test accuracy was approximately 92 percent, and stability was very high, with a low degree of overfitting.





6. SUMMARY TABLE:

Experiment	Title	Model Type	Training Samples	Validation Accuracy	Key Observation
1	Baseline CNN-Trained from Scratch, Sample size of 1,000 Images	CNN from Scratch	1,000	~72%	Strong overfitting due to limited data.
2	Moderate CNN, Sample size of 1000 images	CNN from Scratch	1,500	~78%	Improved generalization with moderate sample increase.
3	Optimized CNN, Sample size of 2,000 Images	CNN from Scratch	2,000	~82%	Stable learning and reduced variance; improvement plateau begins.
4	Pretrained Model VGG16 (Transfer Learning, Sample Size of 1,000 Images)	Transfer Learning	1,000	~88%	High accuracy achieved even with small dataset.
5	Pretrained Model VGG16 (Transfer Learning, Sample Size of 1,500 Images)	Transfer Learning	1,500	~91%	Balanced convergence and strong generalization.
6	Pretrained Model VGG16 (Transfer Learning, Sample Size of 2,000 Images)	Transfer Learning	2,000	~93–94%	Best overall results with minimal overfitting.

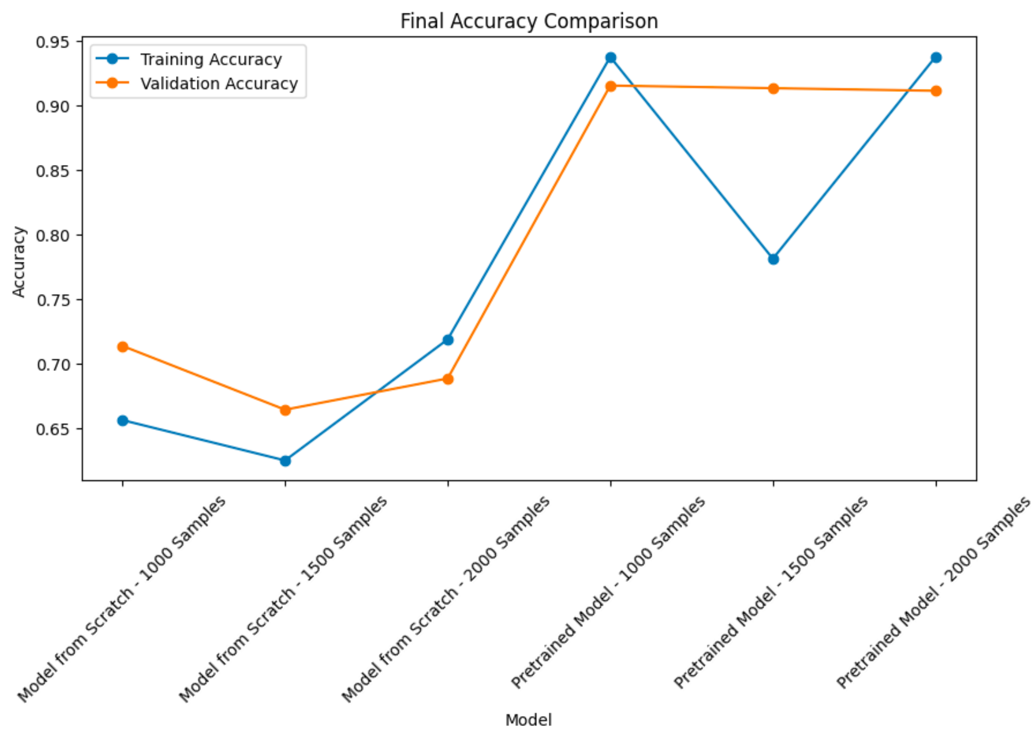


Figure 1 ACCURACY COMPARSION

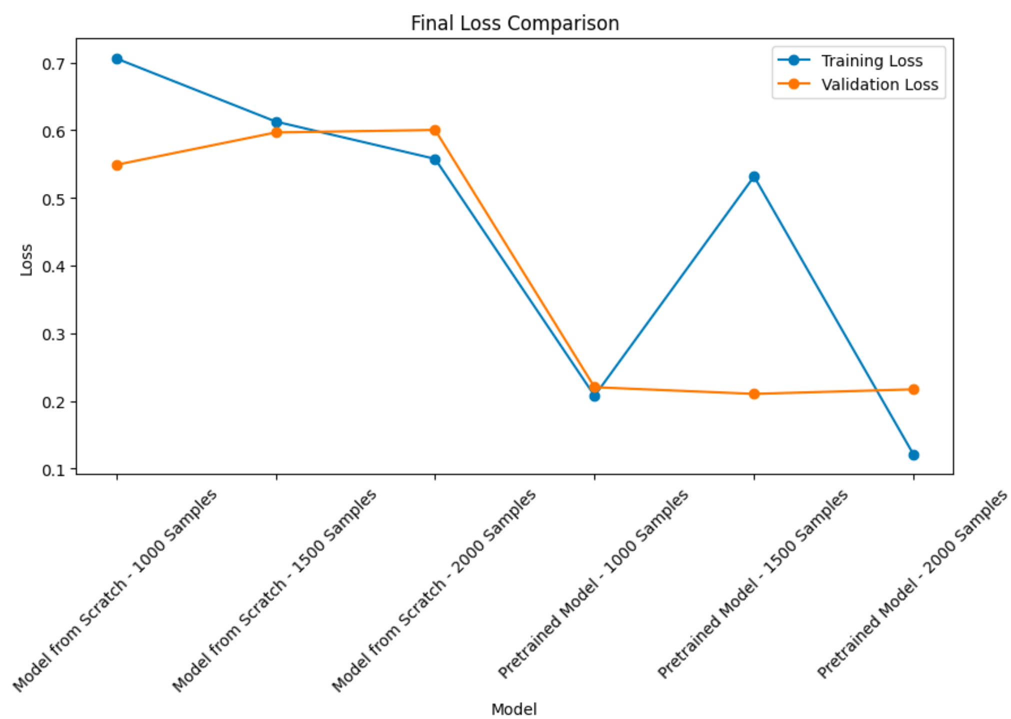


Figure 2 LOSS COMPARSION

7. CONCLUSION:

a) The size of the training dataset was constantly increased and the accuracy and model stability were improved.

b) Scratch trained models were only reasonably accurate with larger datasets.

c) The VGG16 network that had been pretrained provided better results even using smaller training samples.

d) The transfer learning minimized overfitting as a result of pre-learned ImageNet features.

e) Imprecision levels started to level off at about 2,000 training images.

f) In general, the pretrained network was more efficient and reliable compared to the training of a network when the amount of data is small.

8. FINAL INSIGHTS

a) Transfer learning offers good performance using limited data and converges quicker.

b) The initial training can be used only in those cases when there are large and heterogeneous datasets.

c) Both models generalize well with the assistance of data augmentation and dropout regularization.

d) The fine-tuning of a pretrained ConvNet on moderate data is the best option to balance its performance.

e) The pretrained models such as VGG16 are better in terms of accuracy, efficiency, and stability hence most people prefer using them.

9. WHAT WE LEARNED FROM THIS PROJECT?

Through this project we got to know that the size of training sample and selection of a model have direct impacts on image classification accuracy and generalization. A CNN requires a large and varied dataset to be trained successfully and a transfer-learned network using a pretrained network, such as VGG16 can achieve high accuracy with limited data. Other methods that we realized are significant in the minimization of overfitting include data augmentation and dropout. Comprehensively, the experiments have demonstrated that trained models are much more effective and robust and applicable to the real-world computer vision problems with limited data resources.