Assignment 3
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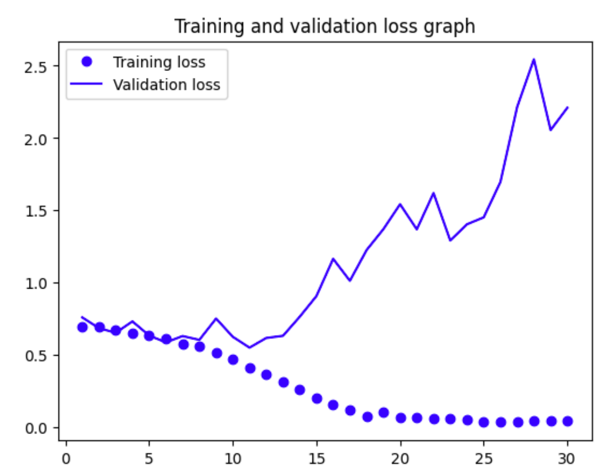
Introduction:

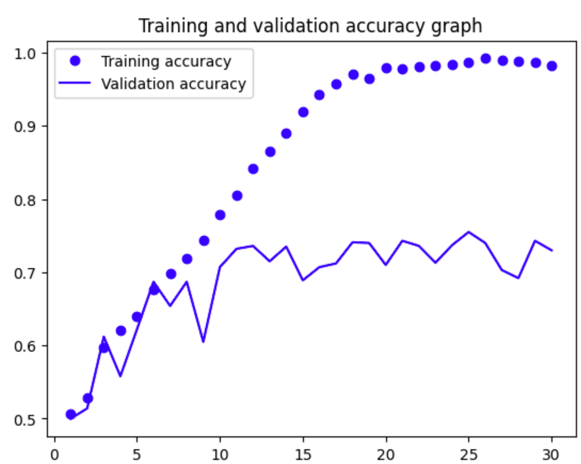
Convolutional Neural Network (CNN) is a specialized type of deep learning model designed for processing structured grid data, such as images. A Convolutional Neural Network (CNN) typically consists of convolutional layers for feature extraction, pooling layers for dimensionality reduction, fully connected layers for classification, and a final output layer to produce predictions.

Techniques like dropout, data augmentation, regularization (L2), and early stopping help prevent overfitting by reducing the model's reliance on specific data points and promoting better generalization.

Pretrained models are deep learning models that have been trained on large datasets, allowing them to leverage learned features for new tasks, often resulting in faster convergence and higher performance when fine-tuned for specific applications.

ANSWER 1:





Observations:

- The plotted graphs indicate that the model is overfitting. The training accuracy shows a nearly linear increase over time, eventually approaching 100%, while the validation accuracy remains stagnant at around 70-72%.
- This overfitting issue arises due to the limited number of training samples, causing the model to perform well on the training data but struggle with validation data.

To enhance the model's performance, I implemented three techniques and assessed their effectiveness over 100 epochs using a test dataset:

a) Dropout Method: This technique randomly drops certain neurons during training to prevent the model from relying too heavily on specific features, helping reduce overfitting.

b) Data Augmentation: By artificially increasing the size of the dataset through transformations like rotation and scaling, this method helps improve the model's ability to generalize by exposing it to more varied data.

c) A combination of Data Augmentation and the Dropout Method

These methods were evaluated to determine their impact on improving the model's ability to generalize and perform better on unseen data.

Model	Accuracy	Validation accuracy
Unregularised model	0.754	0.7818
Model with data augmentation	0.815	0.8191
Model with dropout	0.760	0.7802
Model with data augmentation and dropout	0.834	0.8563

After evaluating the performance metrics of the three techniques applied to the unregularized model, it was found that the combination of data augmentation and dropout produced the best results.

To regularize the model for the remaining training samples, the most effective technique was found to be data augmentation with dropout.

ANSWER 2:

Model	Test loss	Test Accuracy	Valid Accuracy
Regularized model with 5000 training samples	0.3510	0.834	0.8460

Observations:

- For the regularized model, the observed loss is 0.35, and the accuracy is 0.83.
- The regularized model exhibits slightly higher accuracy compared to the unregularized model.
- This model shows improved accuracy over the previous model, with a marginally lower loss.

ANSWER 3:

The sample size has been increased to 10,000.

Model	Test loss	Test Accuracy	Valid Accuracy
Regularized model with 10000 training samples	0.2028	0.917	0.9209

Important observations:

- The regularized model demonstrates a loss of 0.20 and an accuracy of 0.91.
- This model performs better than the unregularized model when compared.

Summary table of the three above findings:

Model	Test Loss	Test Accuracy	Valid Accuracy
Regularised Model with 1000 training samples	0.3914	0.834	0.8563
Regularised Model with 5000 training samples	0.3510	0.834	0.8460
Regularised Model with 10000 training samples	0.2028	0.917	0.9209

Observations:

- A noticeable trend is observed where the test loss decreases as the training sample size increases, while the test accuracy improves from 85% to 92%, showing significant progress.
- Therefore, it can be concluded that the model's performance improves proportionally with the increase in the training sample size.

ANSWER 4:

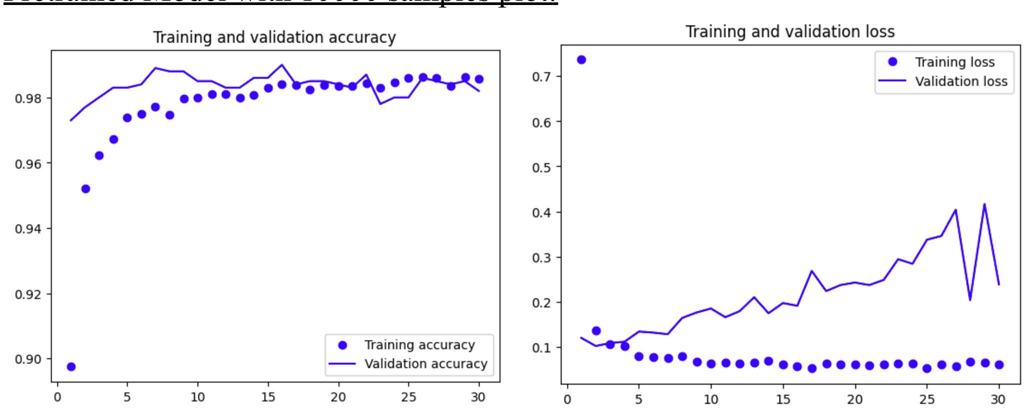
The tabular column represents the following values using pretrained value:

Model	Test Loss	Test Accuracy	Validation Accuracy
Pretrained Model with 1000 samples	0.1035	0.982	0.9848
Pretrained Model with 5000 samples	0.0928	0.980	0.9775
Pretrained Model with 10000 samples	0.0790	0.982	0.9868

Observations:

The values in the table clearly show that both testing and validation accuracy improve as the training sample size increases. Furthermore, the test loss demonstrates even greater improvement with a larger sample size. It is interesting to note the Pretrained Model with 10000 samples plot with respect to accuracy of training and validation and training and validation loss respectively.

<u>Pretrained Model with 10000 samples plot:</u>



Recommendations and Conclusion:

- Convolutional neural networks are among the most powerful algorithms for computer vision tasks in machine learning.
- Even with smaller datasets, training a model from scratch can still yield satisfactory results.
- The main challenge with smaller datasets is overfitting, but employing data augmentation techniques with image data can help reduce this issue.
- As the size of the training dataset increases, the model's performance generally improves.
- Further fine-tuning can lead to even better performance from the model.

References:

1. LeCun, Y., Bengio, Y., & Hinton, G. (2015). *Deep learning*. Nature, 521(7553), 436-444. https://doi.org/10.1038/nature14539
2. Brownlee, J. (2019). *A gentle introduction to the convolutional neural network*. Machine Learning Mastery. Retrieved from https://machinelearningmastery.com/a-gentle-introduction-to-the-convolutional-neural-network/