COURSE INSTRUCTOR
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DEEP LEARNING

Assignment 03

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Report on Convolutional Neural Network (CNN) for CIFAR-10 Classification

1. Introduction: In this project, a Convolutional Neural Network (CNN) was implemented to classify images from the CIFAR-10 dataset. The objective was to achieve high accuracy in image classification across ten different classes.

2. Dataset and Preprocessing: The CIFAR-10 dataset consists of 60,000 32x32 color images in 10 different classes, with 6,000 images per class. The data was loaded and preprocessed by normalizing pixel values to the range [0, 1] and one-hot encoding the class labels.

3. Model Architecture: The CNN architecture employed a series of convolutional and pooling layers, followed by fully connected layers. Noteworthy design choices include the use of MaxNorm kernel constraints and dropout layers to enhance model generalization and prevent overfitting.

CMS ID 3122832
Model: "sequential"

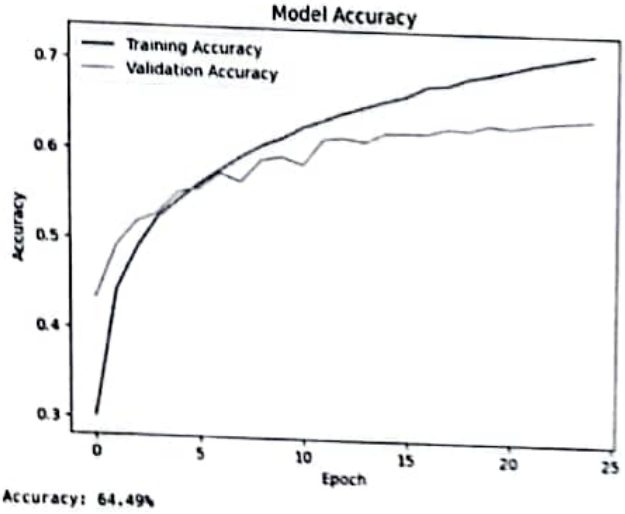
Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 32, 32, 32)	896
dropout (Dropout)	(None, 32, 32, 32)	0
max_pooling2d (MaxPooling2D)	(None, 16, 16, 32)	0
conv2d_1 (Conv2D)	(None, 16, 16, 12)	396
conv2d_2 (Conv2D)	(None, 16, 16, 12)	1308
conv2d_3 (Conv2D)	(None, 16, 16, 12)	1308
conv2d_4 (Conv2D)	(None, 16, 16, 12)	11676
conv2d_5 (Conv2D)	(None, 16, 16, 12)	1308
conv2d_6 (Conv2D)	(None, 16, 16, 12)	1308
max_pooling2d_1 (MaxPooling2D)	(None, 8, 8, 12)	0
flatten (Flatten)	(None, 768)	0
dense (Dense)	(None, 512)	393728
dropout_1 (Dropout)	(None, 512)	0
dense_1 (Dense)	(None, 10)	5130

Total params: 417058 (1.59 MB)
Trainable params: 417058 (1.59 MB)
Non-trainable params: 0 (0.00 Byte)

None

4. Training and Results: The model was trained for 25 epochs using Stochastic Gradient Descent (SGD) as the optimizer. The learning rate was set at 0.01 with a decay rate, and momentum was incorporated to expedite convergence. The training and validation accuracies, as well as losses, were monitored over the epochs.

Epoch	Training Accuracy	Validation Accuracy	Training Loss	Validation Loss
1	30.14%	43.33%	1.8958	1.5456
10	61.67%	59.63%	1.0654	1.1330
25	71.66%	64.49%	0.7882	1.0221



5. Analysis:

- The model demonstrated an improvement in accuracy from 30.14% to 71.66% on the training set and from 43.33% to 64.49% on the validation set over 25 epochs.
- The training and validation curves indicate that the model is learning and generalizing well, with a modest increase in accuracy even after 25 epochs.
- The inclusion of MaxNorm constraints and dropout layers likely contributed to the model's ability to generalize and prevent overfitting.

6. Conclusion: The implemented CNN architecture shows promise in classifying CIFAR-10 images. Further fine-tuning of hyperparameters, exploration of different architectures, or the use of advanced techniques like data augmentation could potentially lead to even higher accuracies. The final accuracy of 64.49% on the validation set is a commendable outcome, considering the complexity of the CIFAR-10 dataset.

QUESTION #02

Part (A)

Memory Cost:-

Input	$227 \times 227 \times 3$	$= 154587$
CONV1	$55 \times 55 \times 96$	$= 290400$
MAX POOL 1	$27 \times 27 \times 96$	$= 69984$
CONV 2	$27 \times 27 \times 256$	$= 186624$
MAX POOL 2	$13 \times 13 \times 256$	$= 43264$
CONV 3	$13 \times 13 \times 384$	$= 64896$
CONV 4	$13 \times 13 \times 384$	$= 64896$
CONV 5	$13 \times 13 \times 256$	$= 43264$
MAX POOL 3	$6 \times 6 \times 256$	$= 9216$
FC 1	1×4096	$= 4096$
FC 2	1×4096	$= 4096$
OUTPUT	1×1000	$= 1000$

Total $= 936323$

Size $= 936323 \times 4$ bytes

$= 3.745292$

$= 3.745$ MB

Part B :-

Parameters :-

CONV 1 $(11 \times 11 \times 3 \times 96) + 96 = 34944$

CONV 2 $(5 \times 5 \times 96 \times 256) + 256 = 614656$

CONV 3 $(3 \times 3 \times 256 \times 384) + 384 = 885120$

CONV 4 $(3 \times 3 \times 384 \times 384) + 384 = 1327488$

CONV 5 $(3 \times 3 \times 384 \times 256) + 256 = 884992$

FC 1 $(9216 \times 4096) + 4096 = 37752832$

FC 2 $(4096 \times 4096) + 4096 = 16781312$

FC 3 $(4096 \times 1000) + 1000 = 4097000$

Total = 62 378344

$= 62.378M.$

ESTION #03:-

No. of Instructions:-

Calculating all multiplications involved;

CONV1 $55 \times 55 \times 11 \times 11 \times 3 \times 96 = 105415200$

CONV2 $27 \times 27 \times 5 \times 5 \times 96 \times 256 = 447897600$

CONV3 $13 \times 13 \times 3 \times 3 \times 256 \times 384 = 149520384$

CONV4 $13 \times 13 \times 3 \times 3 \times 384 \times 384 = 224280576$

CONV5 $13 \times 13 \times 3 \times 3 \times 384 \times 256 = 149520384$

FC1 $6 \times 6 \times 256 \times 4096 = 37748736$

FC2 $4096 \times 4096 = 16777216$

FC3 $4096 \times 1000 = 4096000$

Total = 1135256096

→ clk speed at i3 1st Gen;

$\approx$ 3GHz = 3×10^9 Hz

$$\text{Time} = \frac{\text{No. of Instructions}}{\text{clk speed}}$$

$$= \frac{1135256096}{3 \times 10^9}$$

= 0.378 (for 1 fwd pass)