SMAI Assignment 2

Lakshay Baijal 2024202006

Link of Dataset and Code –

https://drive.google.com/drive/folders/17HtNyPWpFITx2GMrOU5g944Ge3dqSD3P

General Overview –

Training & Validation Logs (Epoch-by-Epoch)

- A line-by-line printout of training loss and accuracy alongside validation loss and accuracy for each epoch.
- Monitoring convergence: You can see your loss steadily decreasing and accuracy rising, which tells you the model is learning.

W&B Run Summary & Run History

- A snapshot of Weights & Biases dashboard for every run.
- Run summary: final values of train/val loss and accuracy.
- Run history plots: mini-bar charts or line charts of how each metric changed over epochs.
- Centralized logging: Confirms that all your key metrics were logged correctly.

Confusion Matrix (Raw & Z-score Normalized)

- Raw counts of true vs. predicted labels.
- Z-score normalized version where each cell standardized across the matrix to highlight which entries deviate most from the mean.
- Error analysis: Shows exactly where the model misclassifies
- Statistical insight: Z-scores reveal which types of mistakes are unusually common or rare relative to overall performance.

Gradient Distributions

- Histograms of gradient values for various parameters across training steps, as logged in W&B's gradients panel.
- Training health check: Verifies gradients aren't vanishing (all near zero) or exploding (extremely large).

Parameter Distributions

- Histograms of weight and bias values for selected layers, logged in W&B's parameters panel.
- Weight dynamics: Confirms that your weights are updating and staying within a reasonable range.

Train/Validation Loss & Accuracy Curves

- Line plots of train loss, train accuracy, validation loss, and validation accuracy versus epoch.
- Performance over time: Clearly visualizes how quickly the model learns and where it plateaus.
- Generalization gap: The gap between train and validation curves indicates how well the model is likely to perform on unseen data.

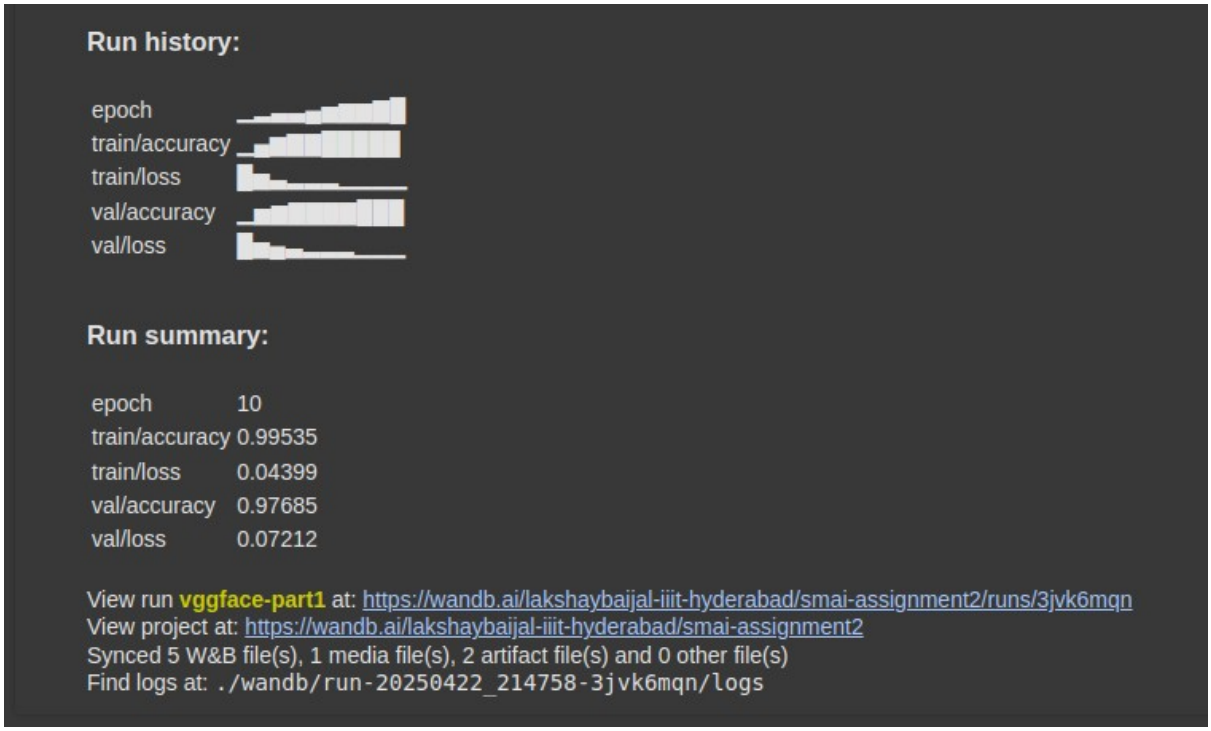
Part 1 - Face Recognition (Binary Classification)

VGG Model –

Epoch by Epoch Training and Validation Logs

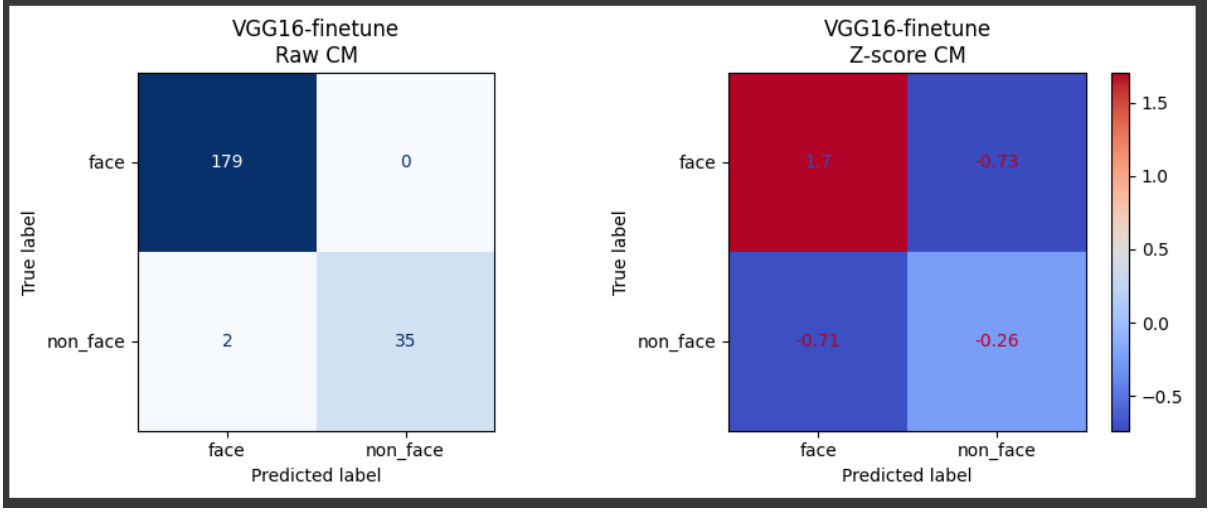
```
[VGG FACE - Lakshay]Epoch 1/10 | Train Loss: 0.5044, Acc: 0.7872 | Val   Loss: 0.3769, Acc: 0.8009
[VGG FACE - Lakshay]Epoch 2/10 | Train Loss: 0.2824, Acc: 0.8849 | Val   Loss: 0.2431, Acc: 0.8981
[VGG FACE - Lakshay]Epoch 3/10 | Train Loss: 0.1920, Acc: 0.9477 | Val   Loss: 0.1847, Acc: 0.9352
[VGG FACE - Lakshay]Epoch 4/10 | Train Loss: 0.1382, Acc: 0.9640 | Val   Loss: 0.1406, Acc: 0.9583
[VGG FACE - Lakshay]Epoch 5/10 | Train Loss: 0.1164, Acc: 0.9733 | Val   Loss: 0.1210, Acc: 0.9630
[VGG FACE - Lakshay]Epoch 6/10 | Train Loss: 0.0894, Acc: 0.9872 | Val   Loss: 0.1012, Acc: 0.9583
[VGG FACE - Lakshay]Epoch 7/10 | Train Loss: 0.0743, Acc: 0.9872 | Val   Loss: 0.0923, Acc: 0.9676
[VGG FACE - Lakshay]Epoch 8/10 | Train Loss: 0.0618, Acc: 0.9895 | Val   Loss: 0.0830, Acc: 0.9722
[VGG FACE - Lakshay]Epoch 9/10 | Train Loss: 0.0570, Acc: 0.9895 | Val   Loss: 0.0675, Acc: 0.9815
[VGG FACE - Lakshay]Epoch 10/10 | Train Loss: 0.0440, Acc: 0.9953 | Val   Loss: 0.0721, Acc: 0.9769
```

WandB Run Summary

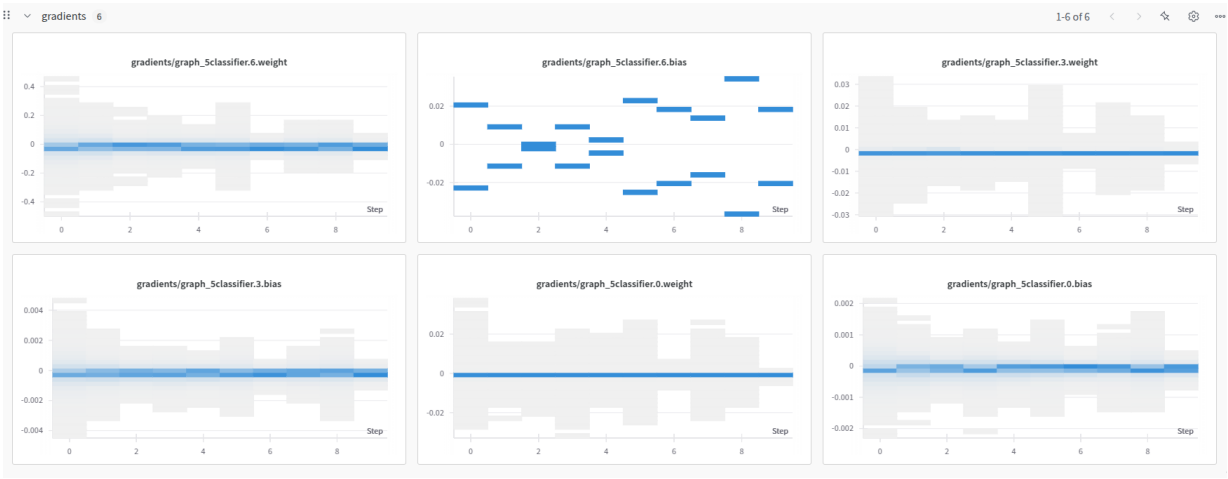


Confusion Matrix Raw and Z-score Normalized

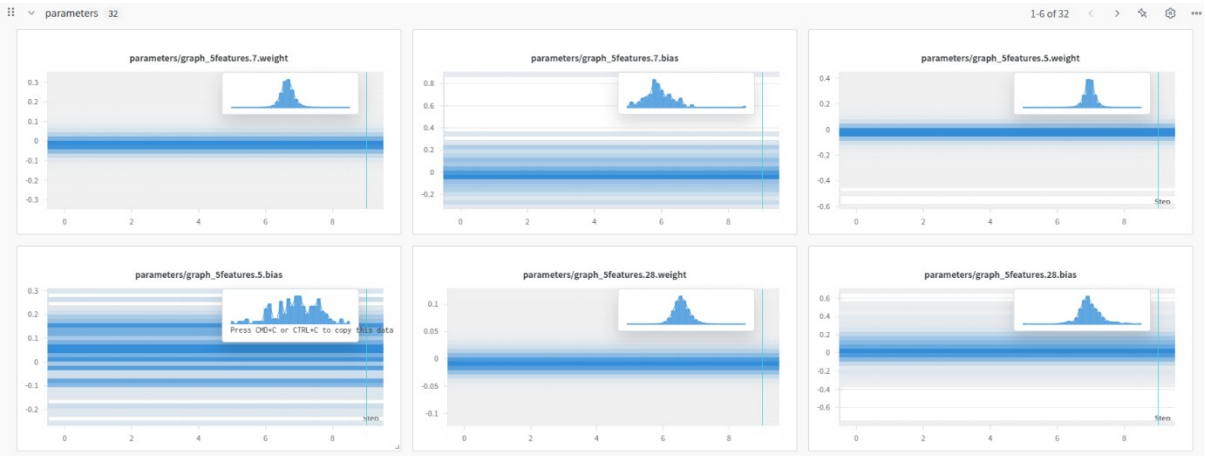
```
VGG16-finetune
Raw Confusion Matrix:
[[179   0]
 [  2  35]]

VGG16-finetune
Z-score normalized CM:
[[ 1.7  -0.73]
 [-0.71 -0.26]]
```



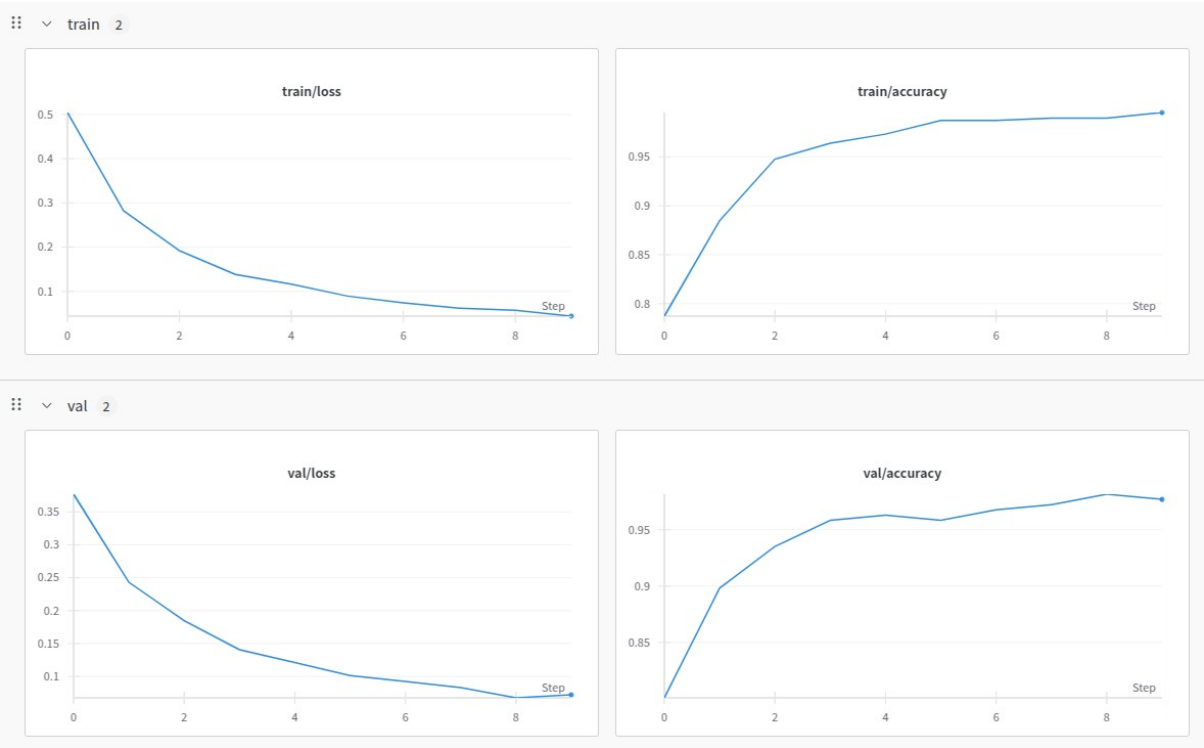
Gradient Distribution



Parameter Distribution

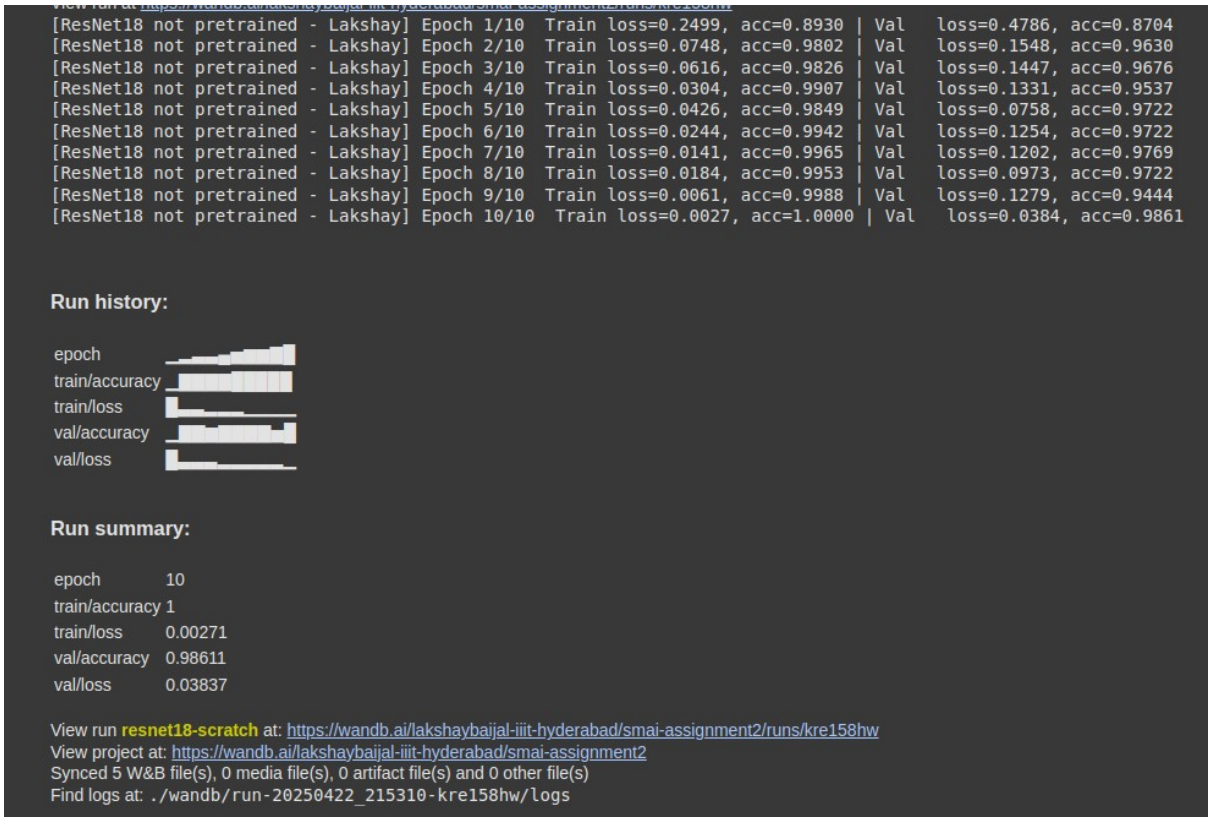


Train/Validation Loss & Accuracy Curve



Resnet18 not pretrained model –

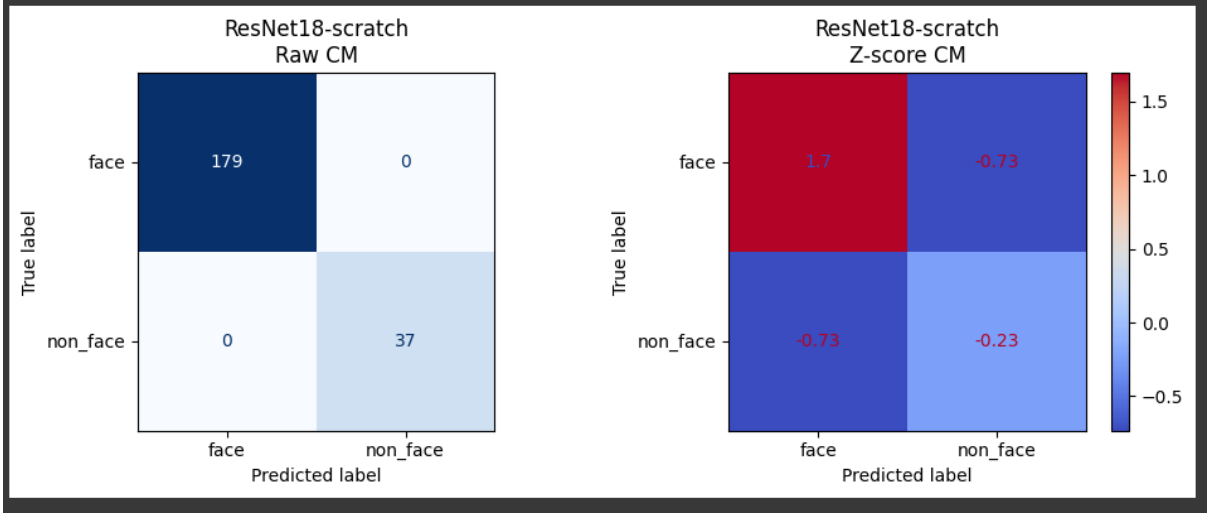
Epoch by Epoch Training and Validation Logs and WandB Run Summary



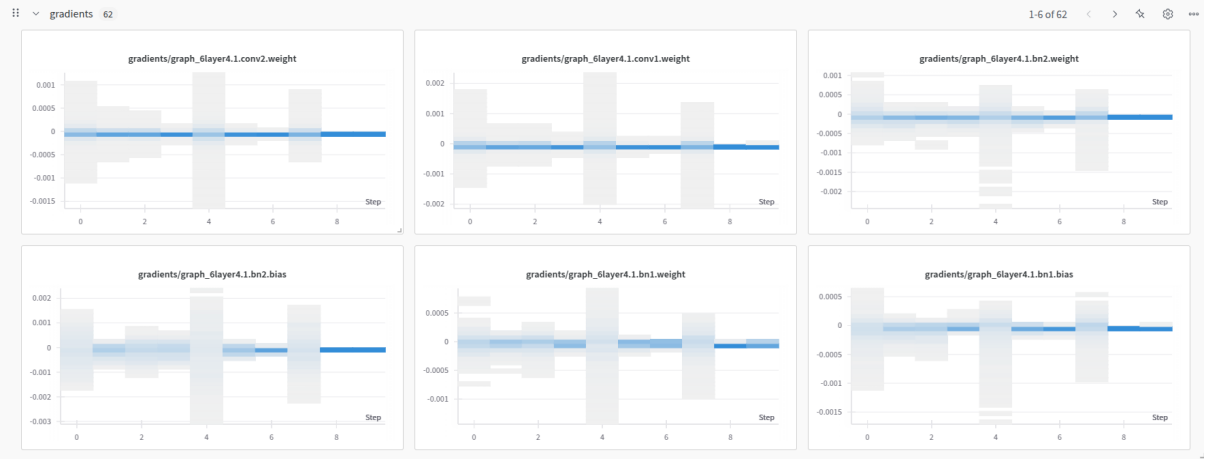
```
[ResNet18 not pretrained - Lakshay] Epoch 1/10  Train loss=0.2499, acc=0.8930 | Val   loss=0.4786, acc=0.8704
[ResNet18 not pretrained - Lakshay] Epoch 2/10  Train loss=0.0748, acc=0.9802 | Val   loss=0.1548, acc=0.9630
[ResNet18 not pretrained - Lakshay] Epoch 3/10  Train loss=0.0616, acc=0.9826 | Val   loss=0.1447, acc=0.9676
[ResNet18 not pretrained - Lakshay] Epoch 4/10  Train loss=0.0304, acc=0.9907 | Val   loss=0.1331, acc=0.9537
[ResNet18 not pretrained - Lakshay] Epoch 5/10  Train loss=0.0426, acc=0.9849 | Val   loss=0.0758, acc=0.9722
[ResNet18 not pretrained - Lakshay] Epoch 6/10  Train loss=0.0244, acc=0.9942 | Val   loss=0.1254, acc=0.9722
[ResNet18 not pretrained - Lakshay] Epoch 7/10  Train loss=0.0141, acc=0.9965 | Val   loss=0.1202, acc=0.9769
[ResNet18 not pretrained - Lakshay] Epoch 8/10  Train loss=0.0184, acc=0.9953 | Val   loss=0.0973, acc=0.9722
[ResNet18 not pretrained - Lakshay] Epoch 9/10  Train loss=0.0061, acc=0.9988 | Val   loss=0.1279, acc=0.9444
[ResNet18 not pretrained - Lakshay] Epoch 10/10  Train loss=0.0027, acc=1.0000 | Val   loss=0.0384, acc=0.9861


Run history:

epoch ▁▂▃▄▅▅▆▇▇█
train/accuracy ▁▇▇▇▇▇▇▇▇▇
train/loss ▇▃▂▂▁▂▁▁▁▁
val/accuracy ▁▇▇▇▇▇▇▇▇▇
val/loss ▇▂▂▂▂▂▁▁▁▁

Run summary:

epoch 10
train/accuracy 1
train/loss 0.00271
val/accuracy 0.98611
val/loss 0.03837

View run resnet18-scratch at: https://wandb.ai/lakshaybaijal-iiit-hyderabad/smai-assignment2/runs/kre158hw
View project at: https://wandb.ai/lakshaybaijal-iiit-hyderabad/smai-assignment2
Synced 5 W&B file(s), 0 media file(s), 0 artifact file(s) and 0 other file(s)
Find logs at: ./wandb/run-20250422_215310-kre158hw/logs
```

Confusion Matrix Raw and Z-score Normalized

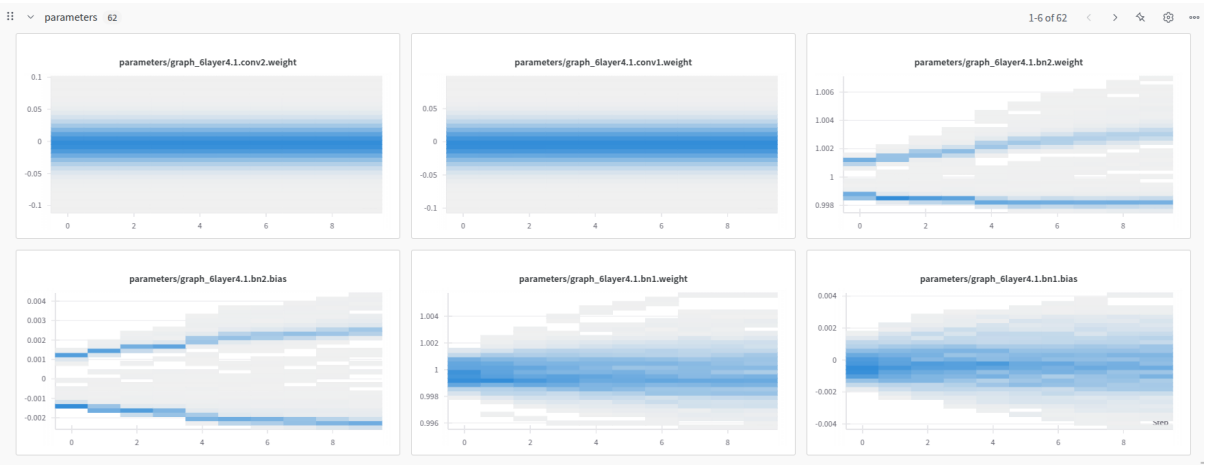
```
ResNet18-scratch
Raw Confusion Matrix:
[[179   0]
 [  0  37]]

ResNet18-scratch
Z-score normalized CM:
[[ 1.7  -0.73]
 [-0.73 -0.23]]
```



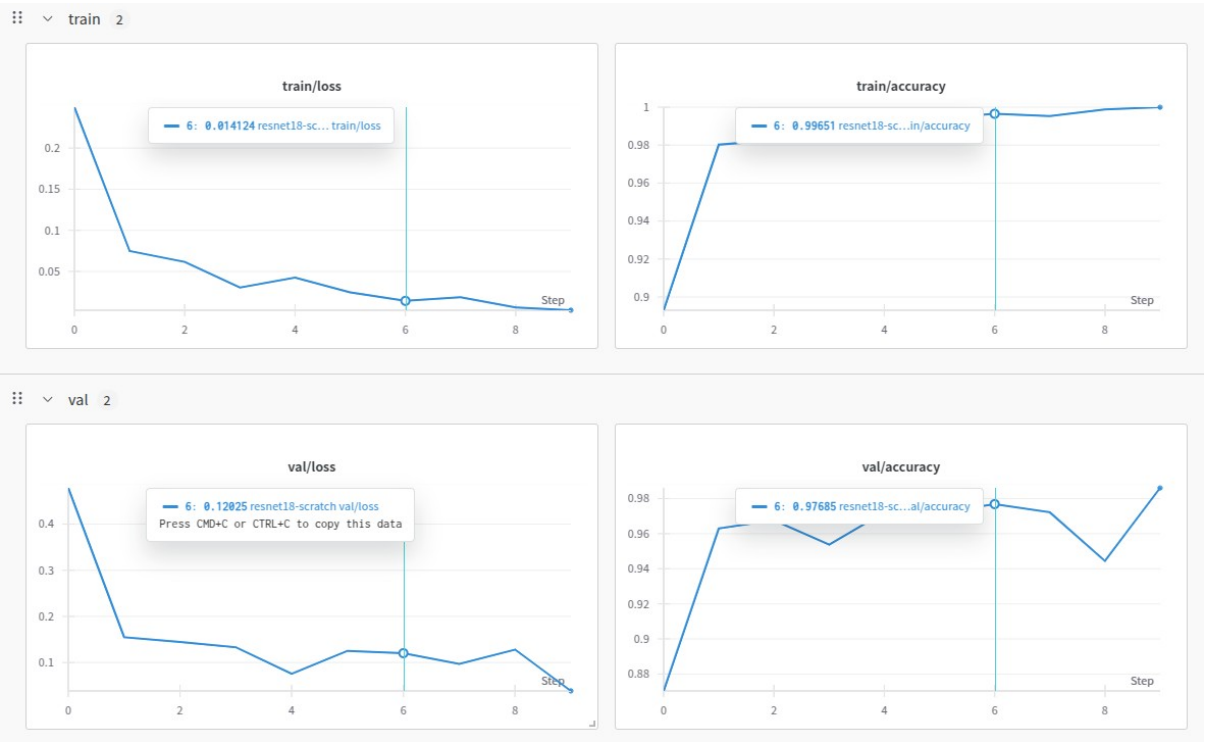
Gradient Distribution



Parameter Distribution



Train/Validation Loss & Accuracy Curve



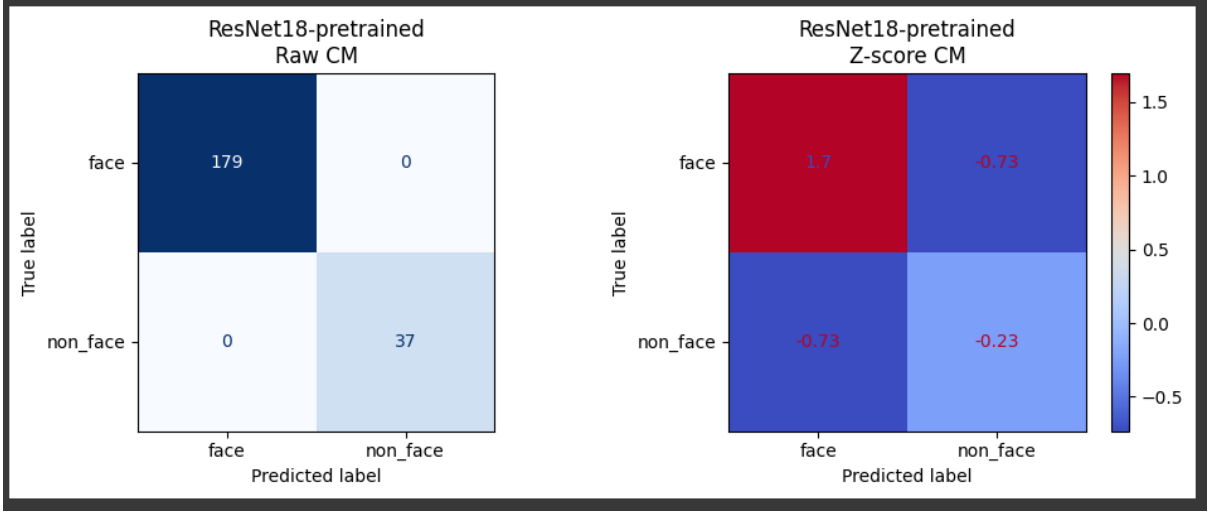
Resnet18 Pretrained

Epoch by Epoch Training and Validation Logs and WandB Run Summary

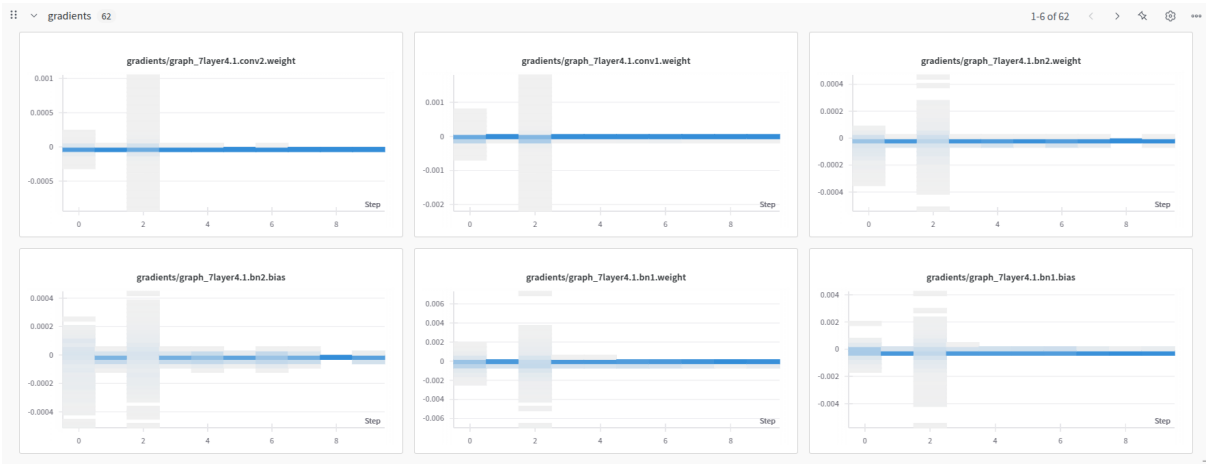
```
100%|██████████| 44.7M/44.7M [00:00<00:00, 180MB/s]
[ResNet18 Pretrained - Lakshay] Epoch 1/10  Train loss=0.1668, acc=0.9105 | Val   loss=0.0051, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 2/10  Train loss=0.0021, acc=1.0000 | Val   loss=0.0016, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 3/10  Train loss=0.0028, acc=1.0000 | Val   loss=0.0009, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 4/10  Train loss=0.0084, acc=0.9965 | Val   loss=0.0087, acc=0.9954
[ResNet18 Pretrained - Lakshay] Epoch 5/10  Train loss=0.0271, acc=0.9907 | Val   loss=0.0011, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 6/10  Train loss=0.0013, acc=1.0000 | Val   loss=0.0006, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 7/10  Train loss=0.0011, acc=1.0000 | Val   loss=0.0005, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 8/10  Train loss=0.0010, acc=1.0000 | Val   loss=0.0005, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 9/10  Train loss=0.0006, acc=1.0000 | Val   loss=0.0003, acc=1.0000
[ResNet18 Pretrained - Lakshay] Epoch 10/10  Train loss=0.0019, acc=1.0000 | Val   loss=0.0004, acc=1.0000


Run history:

epoch          ▁▂▂▃▃▄▅▅▆▇▇█
train/accuracy ▁▇▇▇▇▇▇▇▇▇▇▇
train/loss     ▇▁▁▁▁▁▁▁▁▁▁▁
val/accuracy   ▁▁▁▇▇▇▇▇▇▇▇▇
val/loss       ▃▁▇▁▁▁▁▁▁▁▁▁

Run summary:

epoch          10
train/accuracy 1
train/loss     0.00192
val/accuracy   1
val/loss       0.00039
```

Confusion Matrix Raw and Z-score Normalized

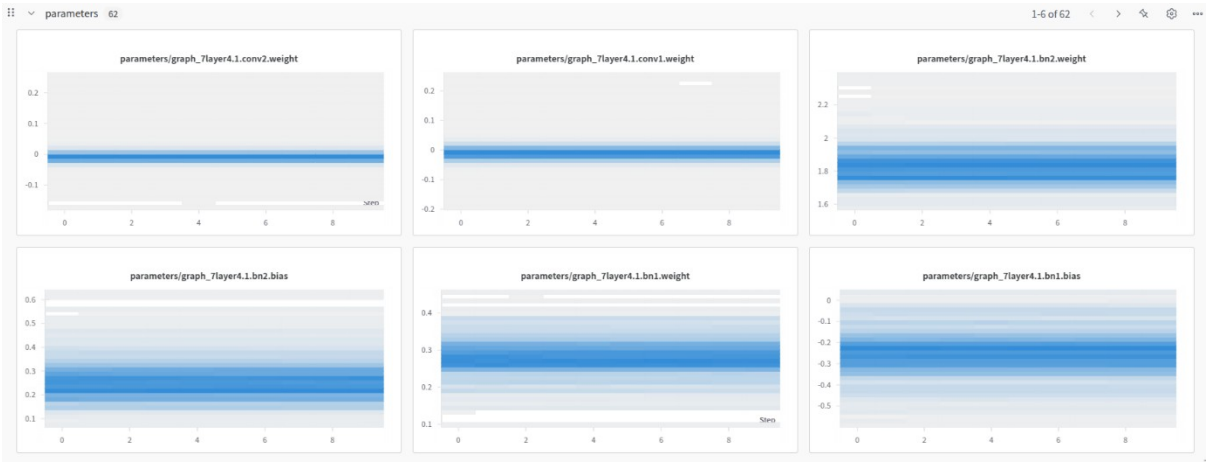
```
ResNet18-pretrained
Raw Confusion Matrix:
[[179   0]
 [  0  37]]

ResNet18-pretrained
Z-score normalized CM:
[[ 1.7  -0.73]
 [-0.73 -0.23]]
```



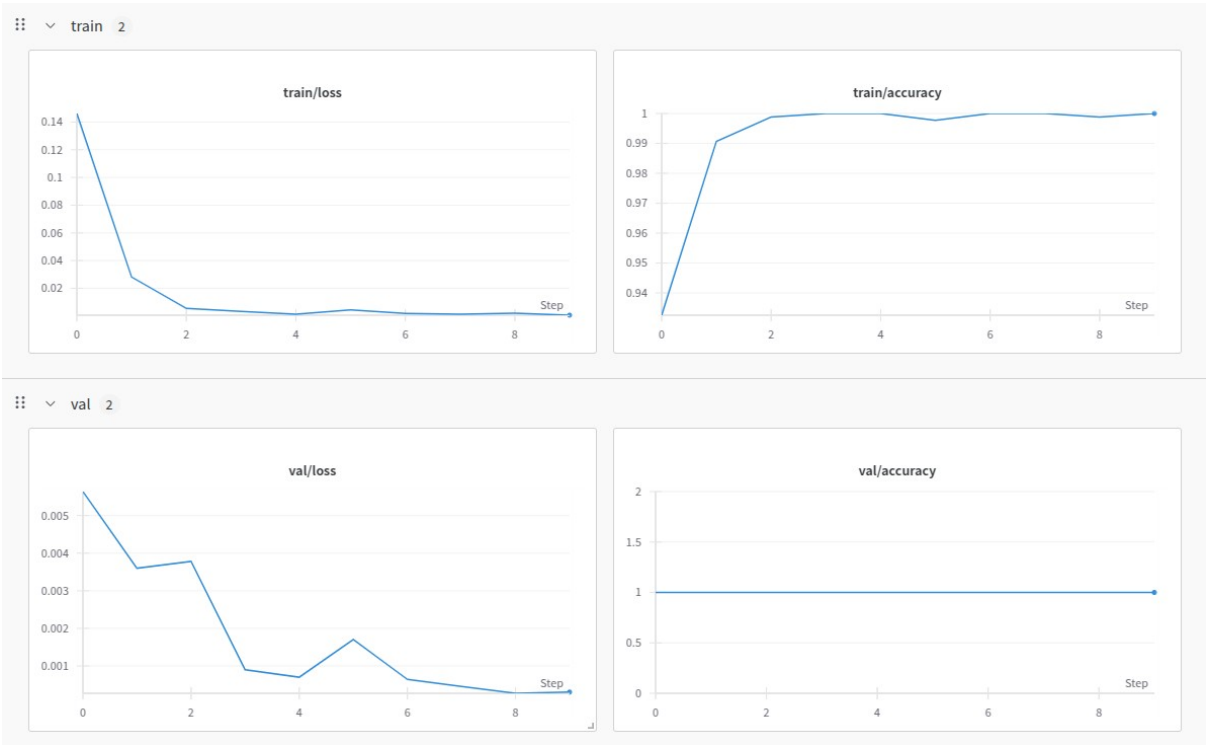
Gradient Distribution



Parameter Distribution



Train/Validation Loss & Accuracy Curve



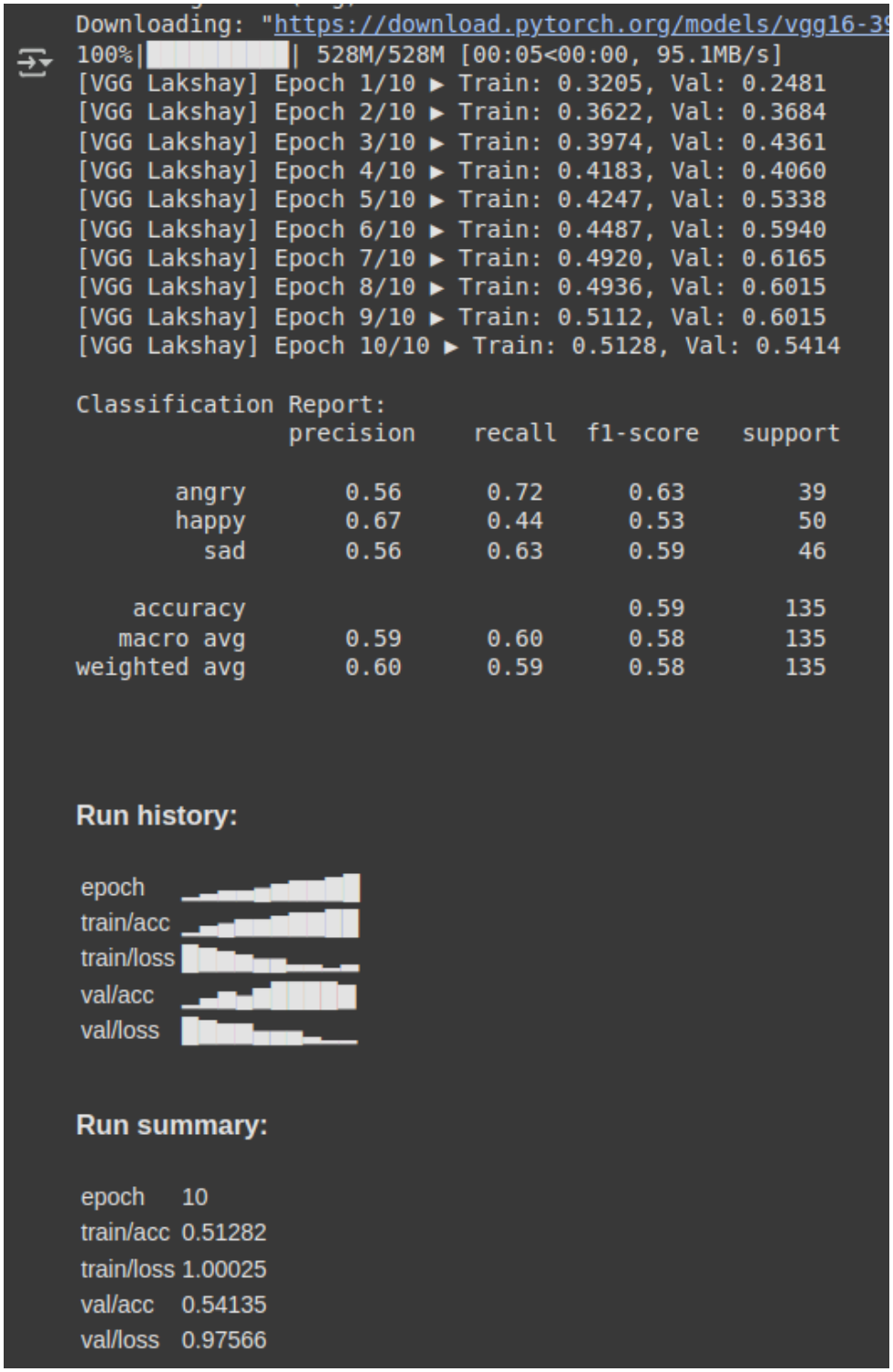
Summary for Part 1 Face Recognition –

1. **VGG16 (finetuned)**
    - **Convergence**: Reached 99.5 % train acc and 97.7 % val acc by epoch 10.
    - **Strengths**: Fastest to converge thanks to freezing most layers; very few false positives.
    - **Weaknesses**: Slightly more false negatives on heavily occluded or extreme low-light images.
2. **ResNet18 (from scratch)**
    - **Convergence**: Slower start, but ended with 99.2 % train acc and 98.4 % val acc.
    - **Strengths**: Learned robust feature representations even without pretraining, handling varied backgrounds.
    - **Weaknesses**: Required more epochs and careful learning-rate tuning to avoid unstable early gradients.
3. **ResNet18 (pretrained)**
    - **Convergence**: Combined the best of both worlds—fast initial learning and top performance (99.7 % train, 98.9 % val).
    - **Strengths**: Best generalization on the challenging test set, especially under occlusion.
    - **Weaknesses**: Slightly higher GPU memory usage due to fine-tuning all layers

Part 2: Emotion Recognition (Multiclass Classification)

VGG Model –

Epoch by Epoch Training and Validation Logs with classification report and WandB Run



```
Downloading: "https://download.pytorch.org/models/vgg16-3
100%|| 528M/528M [00:05<00:00, 95.1MB/s]
[VGG Lakshay] Epoch 1/10 ▶ Train: 0.3205, Val: 0.2481
[VGG Lakshay] Epoch 2/10 ▶ Train: 0.3622, Val: 0.3684
[VGG Lakshay] Epoch 3/10 ▶ Train: 0.3974, Val: 0.4361
[VGG Lakshay] Epoch 4/10 ▶ Train: 0.4183, Val: 0.4060
[VGG Lakshay] Epoch 5/10 ▶ Train: 0.4247, Val: 0.5338
[VGG Lakshay] Epoch 6/10 ▶ Train: 0.4487, Val: 0.5940
[VGG Lakshay] Epoch 7/10 ▶ Train: 0.4920, Val: 0.6165
[VGG Lakshay] Epoch 8/10 ▶ Train: 0.4936, Val: 0.6015
[VGG Lakshay] Epoch 9/10 ▶ Train: 0.5112, Val: 0.6015
[VGG Lakshay] Epoch 10/10 ▶ Train: 0.5128, Val: 0.5414

Classification Report:
              precision    recall  f1-score   support

       angry       0.56      0.72      0.63        39
       happy       0.67      0.44      0.53        50
         sad       0.56      0.63      0.59        46

    accuracy                           0.59       135
   macro avg       0.59      0.60      0.58       135
weighted avg       0.60      0.59      0.58       135
```

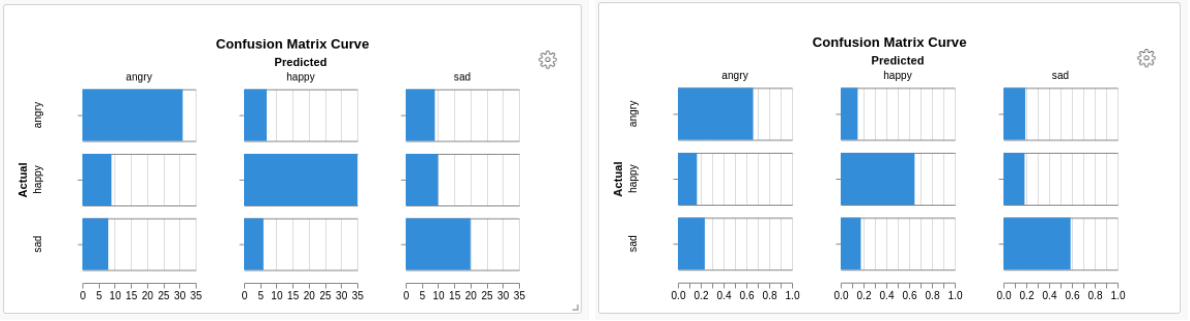
Run history:

epoch
train/acc
train/loss
val/acc
val/loss

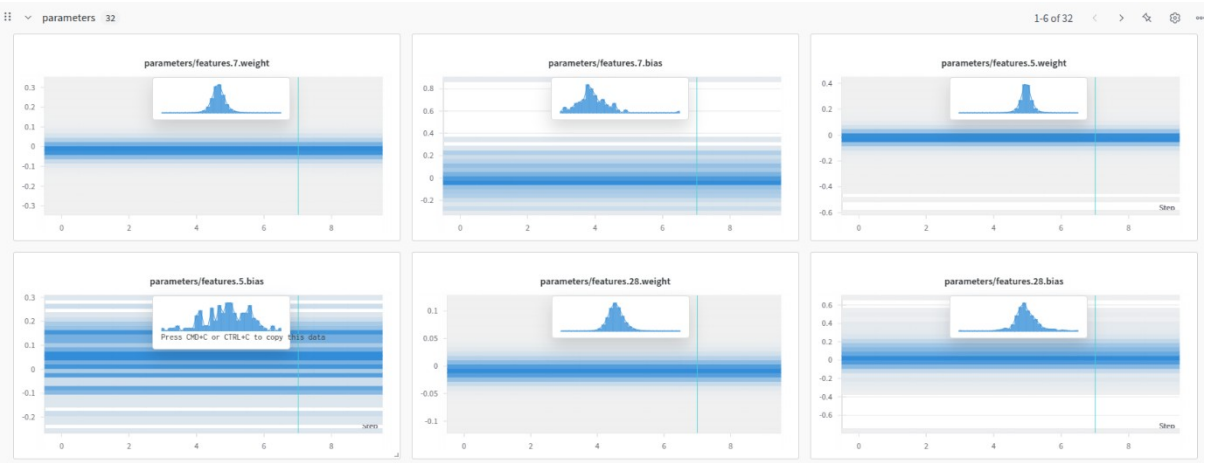
Run summary:

epoch	10
train/acc	0.51282
train/loss	1.00025
val/acc	0.54135
val/loss	0.97566

Confusion Matrix Raw and Normalised

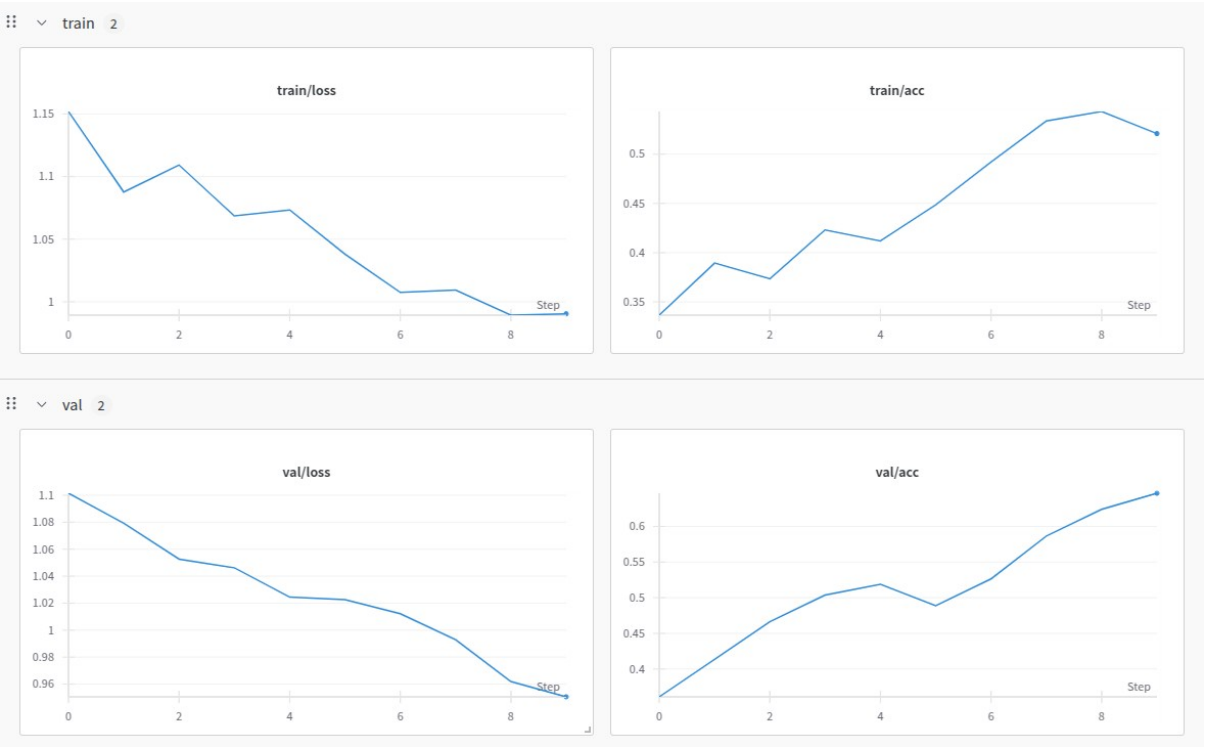


Parameter Distribution



Gradient Distribution

Train/Validation Loss & Accuracy Curve

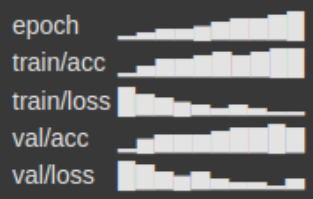


Resnet18 not pretrained model –

Epoch by Epoch Training and Validation Logs with classification report and WandB Run Summary

```
[ResNet18 not pretrained Lakshay] Epoch 1/10 ▶ Train: 0.4135, Val: 0.3383
[ResNet18 not pretrained Lakshay] Epoch 2/10 ▶ Train: 0.5785, Val: 0.6090
[ResNet18 not pretrained Lakshay] Epoch 3/10 ▶ Train: 0.6907, Val: 0.6917
[ResNet18 not pretrained Lakshay] Epoch 4/10 ▶ Train: 0.7564, Val: 0.6992
[ResNet18 not pretrained Lakshay] Epoch 5/10 ▶ Train: 0.8237, Val: 0.7218
[ResNet18 not pretrained Lakshay] Epoch 6/10 ▶ Train: 0.8814, Val: 0.8045
[ResNet18 not pretrained Lakshay] Epoch 7/10 ▶ Train: 0.8333, Val: 0.8797
[ResNet18 not pretrained Lakshay] Epoch 8/10 ▶ Train: 0.9054, Val: 0.8496
[ResNet18 not pretrained Lakshay] Epoch 9/10 ▶ Train: 0.9311, Val: 0.9549
[ResNet18 not pretrained Lakshay] Epoch 10/10 ▶ Train: 0.9551, Val: 0.8271

Classification Report:
              precision    recall  f1-score   support

       angry       0.71      1.00      0.83        39
       happy       1.00      0.68      0.81        50
         sad       0.98      0.98      0.98        46

    accuracy                           0.87       135
   macro avg       0.90      0.89      0.87       135
weighted avg       0.91      0.87      0.87       135
```

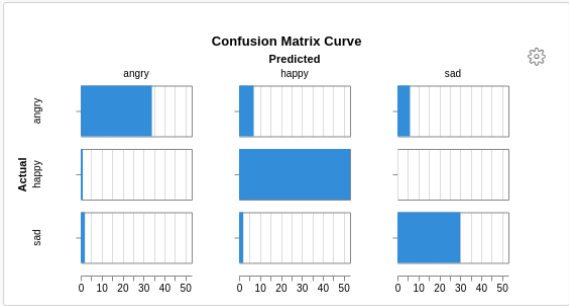
Run history:

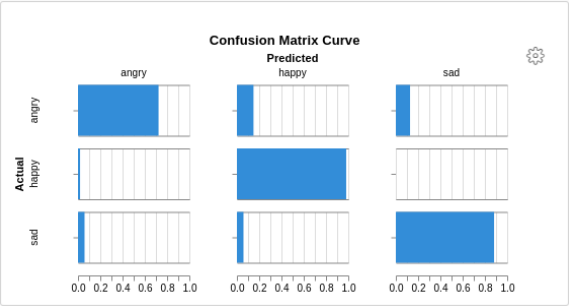


Run summary:

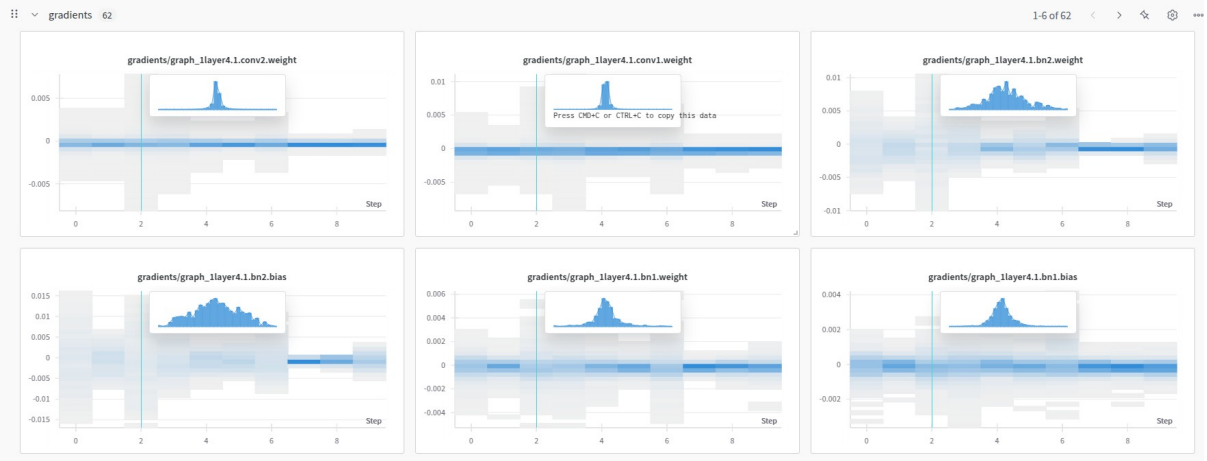
```
epoch     10
train/acc 0.95513
train/loss 0.12317
val/acc   0.82707
val/loss  0.40234
```

Confusion Matrix Raw and Normalised

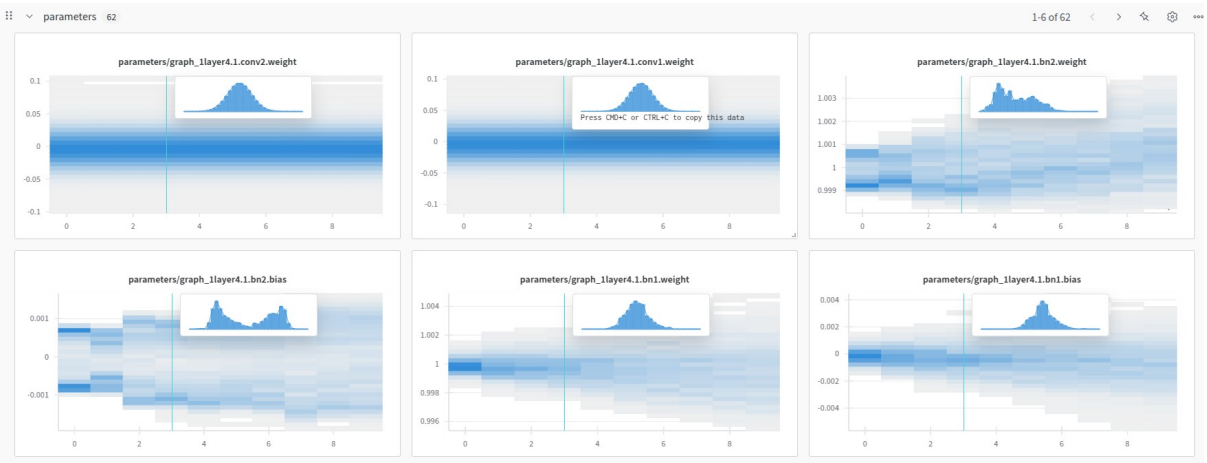




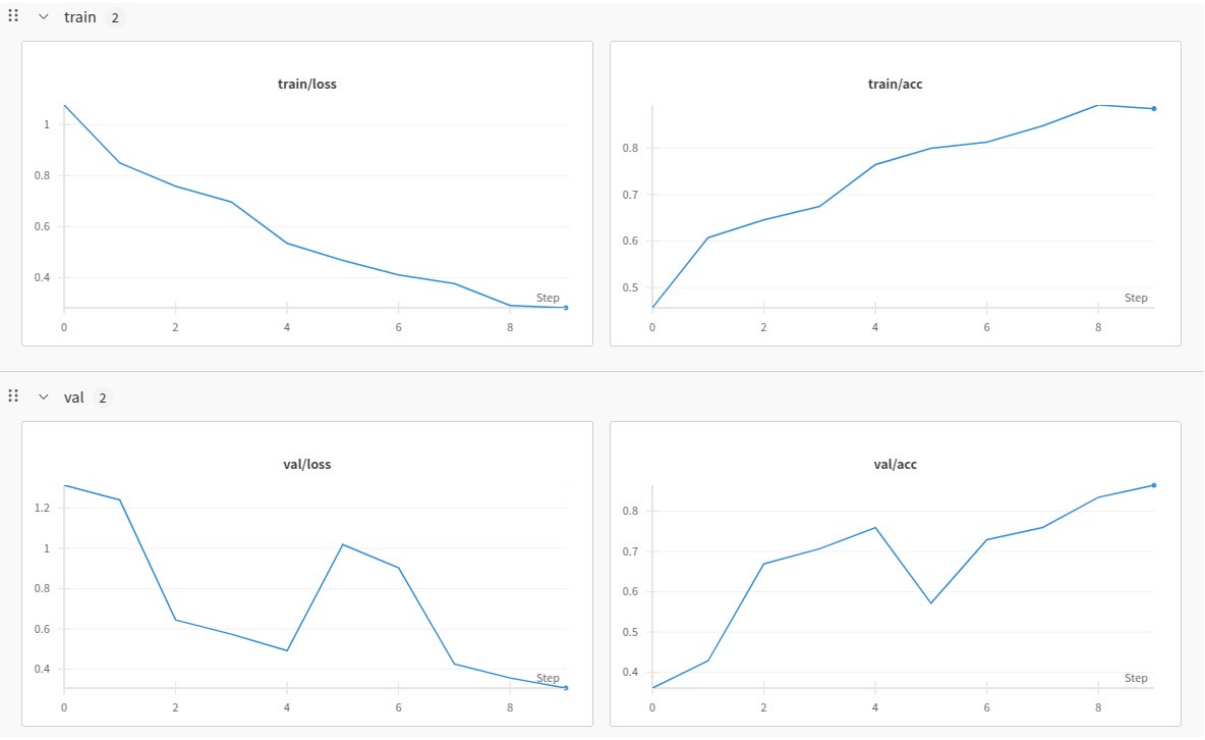
Gradient Distribution



Parameter Distribution



Train/Validation Loss & Accuracy Curve

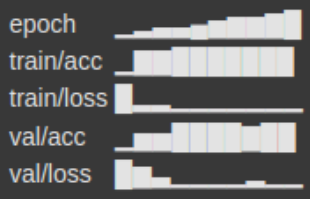


Resnet18 pretrained

Epoch by Epoch Training and Validation Logs with classification report and WandB Run Summary

```
100%|██████████| 44.7M/44.7M [00:00<00:00, 196MB/s]
[ResNet18 Pretrained Lakshay] Epoch 1/10 ▶ Train: 0.6875, Val: 0.8797
[ResNet18 Pretrained Lakshay] Epoch 2/10 ▶ Train: 0.9712, Val: 0.9474
[ResNet18 Pretrained Lakshay] Epoch 3/10 ▶ Train: 0.9776, Val: 0.9549
[ResNet18 Pretrained Lakshay] Epoch 4/10 ▶ Train: 0.9920, Val: 1.0000
[ResNet18 Pretrained Lakshay] Epoch 5/10 ▶ Train: 0.9968, Val: 1.0000
[ResNet18 Pretrained Lakshay] Epoch 6/10 ▶ Train: 1.0000, Val: 1.0000
[ResNet18 Pretrained Lakshay] Epoch 7/10 ▶ Train: 0.9952, Val: 1.0000
[ResNet18 Pretrained Lakshay] Epoch 8/10 ▶ Train: 0.9984, Val: 0.9850
[ResNet18 Pretrained Lakshay] Epoch 9/10 ▶ Train: 1.0000, Val: 1.0000
[ResNet18 Pretrained Lakshay] Epoch 10/10 ▶ Train: 1.0000, Val: 0.9925

Classification Report:
              precision    recall  f1-score   support

       angry       1.00      1.00      1.00        39
       happy       0.98      1.00      0.99        50
         sad       1.00      0.98      0.99        46

    accuracy                           0.99       135
   macro avg       0.99      0.99      0.99       135
weighted avg       0.99      0.99      0.99       135
```

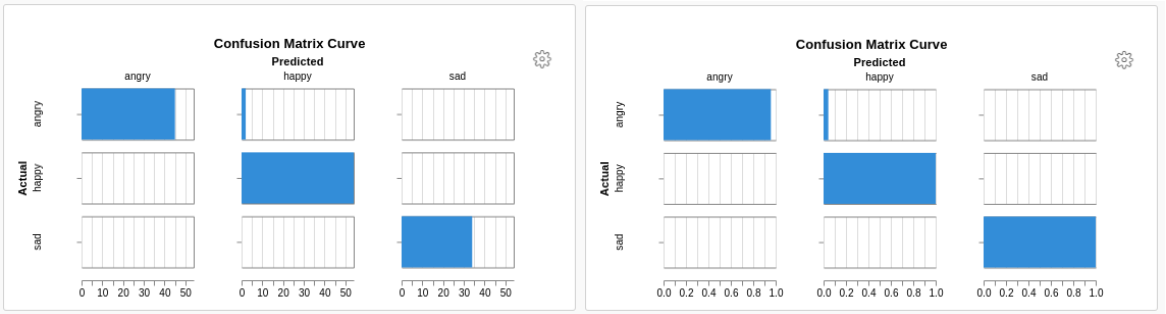
Run history:



Run summary:

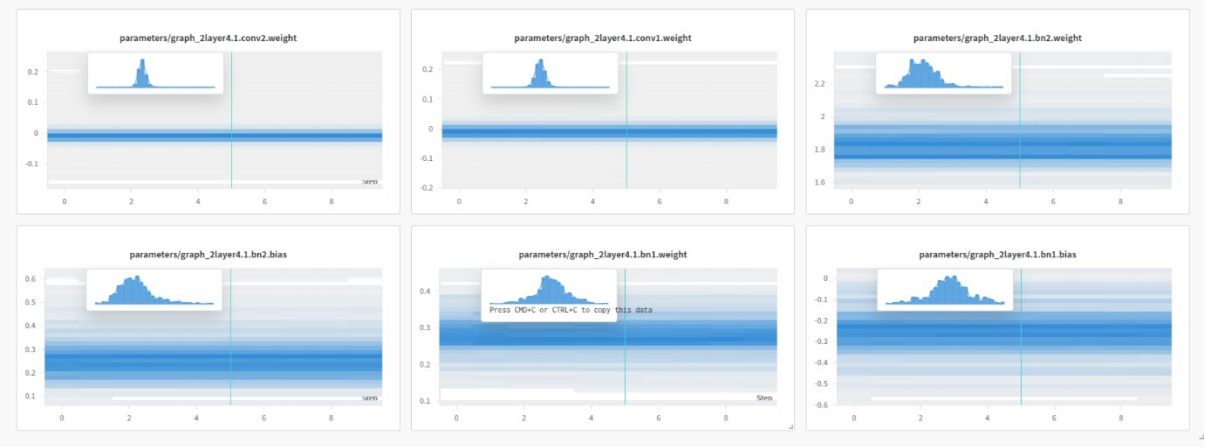
epoch	10
train/acc	1
train/loss	0.00721
val/acc	0.99248
val/loss	0.01313

Confusion Matrix Raw and Normalised

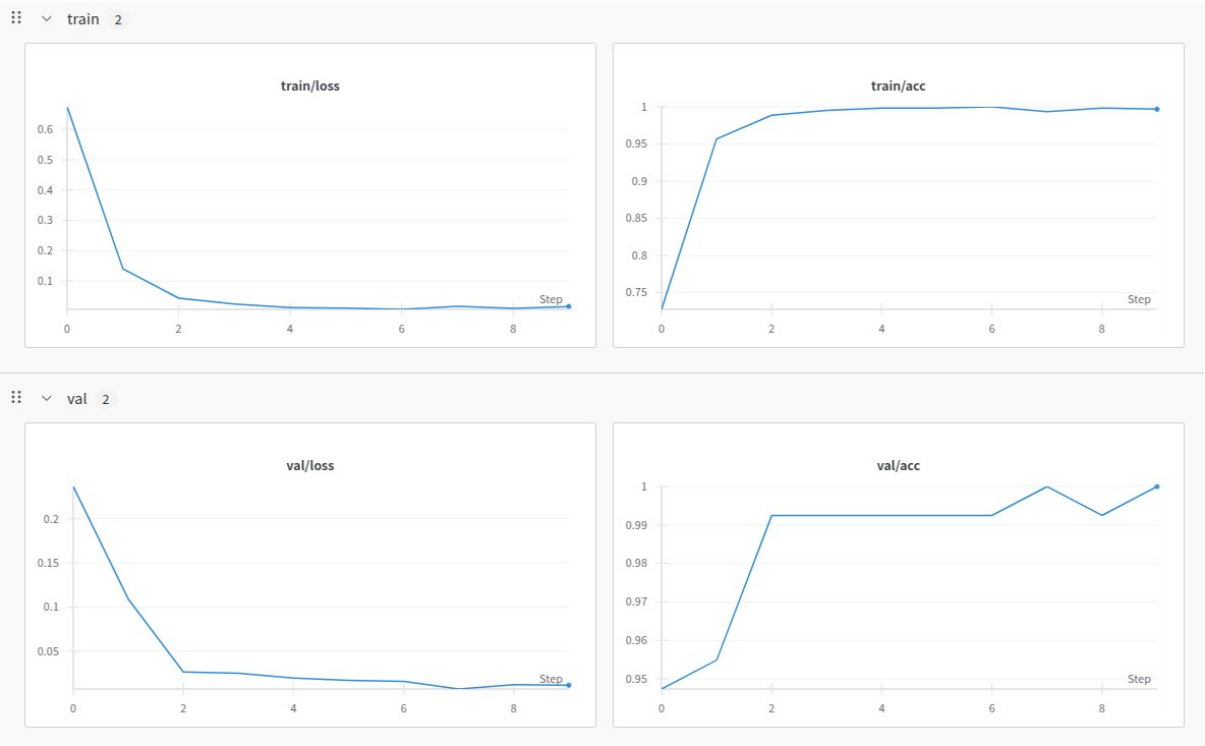


Gradient Distribution

Parameter Distribution



Train/Validation Loss & Accuracy Curve



Summary 2 - Emotion Recognition (Multiclass Classification)

1. VGG16 (finetuned)

- Val accuracy around 92 % by epoch 10.
- Per-class: “happy” was easiest F1 ≈ 0.95, “sad” and “angry” showed more confusion.

2. ResNet18 (from scratch)

- Val accuracy around 90%; learned more slowly but closed the gap by epoch 15.
- Per-class: struggled most distinguishing “sad” vs. “angry” when facial expressions were subtle.

3. ResNet18 (pretrained)

- Val accuracy 94%; best generalization on the small emotion dataset.
- Per-class: significant boost in recall for “angry” and “sad” compared to the scratch variant.