Observation on ViT X EfficientNetB4 Hybrid Model :

First Training Test :

Learning rate : 0.00001

Epoche : 10

Rotation Range : 40

Width\_shift\_range : 0.4

Height\_shift\_range : 0.4

Shear\_range : 0.3

Zoom\_range : 0.4

Vertical\_flip = True

Result :

Epoch 1/30

179/179 [==============================] - 216s 816ms/step - loss: 1.2683 - accuracy: 0.4304 - val\_loss: 1.3655 - val\_accuracy: 0.3362

Epoch 2/30

179/179 [==============================] - 145s 807ms/step - loss: 0.9244 - accuracy: 0.6577 - val\_loss: 1.2519 - val\_accuracy: 0.3386

Epoch 3/30

179/179 [==============================] - 145s 804ms/step - loss: 0.6511 - accuracy: 0.7668 - val\_loss: 1.0321 - val\_accuracy: 0.5483

Epoch 4/30

179/179 [==============================] - 145s 808ms/step - loss: 0.5333 - accuracy: 0.7971 - val\_loss: 1.3233 - val\_accuracy: 0.3252

Second Training Test:

Learning Rate : 0.0001

Epoche : 30

Rotation\_Range : 20

Width\_shift\_range : 0.2

Height\_shift\_range : 0.2

Shear\_range : 0.2

Zoom\_range : 0.2

Vertical\_flip = False

Result:

Epoch 1/30

179/179 [==============================] - 216s 828ms/step - loss: 0.4330 - accuracy: 0.8381 - val\_loss: 1.5094 - val\_accuracy: 0.4030

Epoch 2/30

179/179 [==============================] - 144s 805ms/step - loss: 0.1641 - accuracy: 0.9425 - val\_loss: 1.8209 - val\_accuracy: 0.3197

Epoch 3/30

179/179 [==============================] - 146s 811ms/step - loss: 0.1064 - accuracy: 0.9637 - val\_loss: 2.3185 - val\_accuracy: 0.3370

Epoch 4/30

179/179 [==============================] - 144s 804ms/step - loss: 0.0690 - accuracy: 0.9772 - val\_loss: 3.5033 - val\_accuracy: 0.3181

Epoch 5/30

179/179 [==============================] - 145s 810ms/step - loss: 0.0593 - accuracy: 0.9814 - val\_loss: 0.6580 - val\_accuracy: 0.7439

Epoch 6/30

179/179 [==============================] - 149s 829ms/step - loss: 0.0528 - accuracy: 0.9820 - val\_loss: 1.2787 - val\_accuracy: 0.5734

Epoch 7/30

179/179 [==============================] - 145s 808ms/step - loss: 0.0346 - accuracy: 0.9895 - val\_loss: 3.1254 - val\_accuracy: 0.3409

Epoch 8/30

179/179 [==============================] - 145s 808ms/step - loss: 0.0346 - accuracy: 0.9884 - val\_loss: 0.3528 - val\_accuracy: 0.8775

Epoch 9/30

179/179 [==============================] - 144s 801ms/step - loss: 0.0316 - accuracy: 0.9904 - val\_loss: 2.1506 - val\_accuracy: 0.4580

Epoch 10/30

179/179 [==============================] - 145s 808ms/step - loss: 0.0295 - accuracy: 0.9895 - val\_loss: 1.6275 - val\_accuracy: 0.5020

Epoch 11/30

179/179 [==============================] - 145s 807ms/step - loss: 0.0159 - accuracy: 0.9946 - val\_loss: 2.1292 - val\_accuracy: 0.4996

Epoch 12/30

179/179 [==============================] - 145s 806ms/step - loss: 0.0257 - accuracy: 0.9916 - val\_loss: 6.0443 - val\_accuracy: 0.3559

Epoch 13/30

179/179 [==============================] - 145s 808ms/step - loss: 0.0198 - accuracy: 0.9940 - val\_loss: 0.4916 - val\_accuracy: 0.8523

Third Training Test:

Learning Rate : 0.00001

Epoche : 30

Rotation\_Range : 20

Width\_shift\_range : 0.2

Height\_shift\_range : 0.2

Shear\_range : 0.2

Zoom\_range : 0.2

Vertical\_flip = False  
  
Included Checkpoint

Result :  
Epoch 1/30

179/179 [==============================] - ETA: 0s - loss: 1.1431 - accuracy: 0.5464/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103: UserWarning: You are saving your model as an HDF5 file via model.save(). This file format is considered legacy. We recommend using instead the native Keras format, e.g. model.save('my\_model.keras').

saving\_api.save\_model(

179/179 [==============================] - 218s 837ms/step - loss: 1.1431 - accuracy: 0.5464 - val\_loss: 1.3923 - val\_accuracy: 0.3134

Epoch 2/30

179/179 [==============================] - 150s 835ms/step - loss: 0.6690 - accuracy: 0.7873 - val\_loss: 1.3529 - val\_accuracy: 0.3260

Epoch 3/30

179/179 [==============================] - 152s 847ms/step - loss: 0.4305 - accuracy: 0.8562 - val\_loss: 0.8985 - val\_accuracy: 0.5797

Epoch 4/30

179/179 [==============================] - 150s 839ms/step - loss: 0.3240 - accuracy: 0.8924 - val\_loss: 0.7187 - val\_accuracy: 0.7164

Epoch 5/30

179/179 [==============================] - 153s 855ms/step - loss: 0.2700 - accuracy: 0.9047 - val\_loss: 0.5782 - val\_accuracy: 0.7958

Epoch 6/30

179/179 [==============================] - 144s 803ms/step - loss: 0.2347 - accuracy: 0.9161 - val\_loss: 1.5516 - val\_accuracy: 0.3708

Epoch 7/30

179/179 [==============================] - 151s 841ms/step - loss: 0.1970 - accuracy: 0.9306 - val\_loss: 0.5100 - val\_accuracy: 0.8154

Epoch 8/30

179/179 [==============================] - 145s 806ms/step - loss: 0.1872 - accuracy: 0.9357 - val\_loss: 0.7193 - val\_accuracy: 0.7258

Epoch 9/30

179/179 [==============================] - 145s 811ms/step - loss: 0.1633 - accuracy: 0.9425 - val\_loss: 0.8410 - val\_accuracy: 0.6096

Epoch 10/30

179/179 [==============================] - 156s 870ms/step - loss: 0.1512 - accuracy: 0.9455 - val\_loss: 0.3125 - val\_accuracy: 0.8940

Epoch 11/30

179/179 [==============================] - 156s 869ms/step - loss: 0.1336 - accuracy: 0.9559 - val\_loss: 0.2679 - val\_accuracy: 0.9144

Epoch 12/30

179/179 [==============================] - 145s 806ms/step - loss: 0.1291 - accuracy: 0.9541 - val\_loss: 0.4792 - val\_accuracy: 0.8044

Epoch 13/30

179/179 [==============================] - 156s 871ms/step - loss: 0.1099 - accuracy: 0.9609 - val\_loss: 0.1809 - val\_accuracy: 0.9403

Epoch 14/30

179/179 [==============================] - 145s 806ms/step - loss: 0.1160 - accuracy: 0.9571 - val\_loss: 0.4956 - val\_accuracy: 0.7973

Epoch 15/30

179/179 [==============================] - 144s 805ms/step - loss: 0.0977 - accuracy: 0.9655 - val\_loss: 0.2211 - val\_accuracy: 0.9199

Epoch 16/30

179/179 [==============================] - 145s 806ms/step - loss: 0.0986 - accuracy: 0.9657 - val\_loss: 0.2903 - val\_accuracy: 0.8892

Epoch 17/30

179/179 [==============================] - 145s 807ms/step - loss: 0.0852 - accuracy: 0.9711 - val\_loss: 0.4203 - val\_accuracy: 0.8358

Epoch 18/30

179/179 [==============================] - 145s 809ms/step - loss: 0.0896 - accuracy: 0.9702 - val\_loss: 0.3545 - val\_accuracy: 0.8578

40/40 [==============================] - 10s 172ms/step - loss: 0.1809 - accuracy: 0.9403

Test Loss: 0.18085671961307526, Test Accuracy: 0.9402984976768494

Fourth Training Test:

Epoche: 30  
  
Learning Rate : 0.0001

Included Reduced Lr in the code .

reduce\_lr = ReduceLROnPlateau(monitor='val\_loss', factor=0.2, patience=3, min\_lr=1e-6)

Results :

Found 5708 images belonging to 4 classes.

Found 1273 images belonging to 4 classes.

Epoch 1/30

179/179 [==============================] - ETA: 0s - loss: 1.6980 - accuracy: 0.8367/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103: UserWarning: You are saving your model as an HDF5 file via model.save(). This file format is considered legacy. We recommend using instead the native Keras format, e.g. model.save('my\_model.keras').

saving\_api.save\_model(

179/179 [==============================] - 217s 844ms/step - loss: 1.6980 - accuracy: 0.8367 - val\_loss: 2.6975 - val\_accuracy: 0.3181 - lr: 1.0000e-04

Epoch 2/30

179/179 [==============================] - 146s 812ms/step - loss: 1.3018 - accuracy: 0.9445 - val\_loss: 2.4951 - val\_accuracy: 0.3181 - lr: 1.0000e-04

Epoch 3/30

179/179 [==============================] - 148s 823ms/step - loss: 1.1099 - accuracy: 0.9650 - val\_loss: 1.5460 - val\_accuracy: 0.7502 - lr: 1.0000e-04

Epoch 4/30

179/179 [==============================] - 146s 811ms/step - loss: 0.9592 - accuracy: 0.9769 - val\_loss: 2.6085 - val\_accuracy: 0.4619 - lr: 1.0000e-04

Epoch 5/30

179/179 [==============================] - 149s 830ms/step - loss: 0.8246 - accuracy: 0.9807 - val\_loss: 4.5175 - val\_accuracy: 0.3221 - lr: 1.0000e-04

Epoch 6/30

179/179 [==============================] - 151s 842ms/step - loss: 0.7133 - accuracy: 0.9811 - val\_loss: 0.8404 - val\_accuracy: 0.9293 - lr: 1.0000e-04

Epoch 7/30

179/179 [==============================] - 145s 810ms/step - loss: 0.5947 - accuracy: 0.9870 - val\_loss: 4.1597 - val\_accuracy: 0.3551 - lr: 1.0000e-04

Epoch 8/30

179/179 [==============================] - 145s 814ms/step - loss: 0.5039 - accuracy: 0.9900 - val\_loss: 2.6479 - val\_accuracy: 0.4297 - lr: 1.0000e-04

Epoch 9/30

179/179 [==============================] - 146s 810ms/step - loss: 0.4251 - accuracy: 0.9912 - val\_loss: 0.7380 - val\_accuracy: 0.8845 - lr: 1.0000e-04

Epoch 10/30

179/179 [==============================] - 145s 810ms/step - loss: 0.3613 - accuracy: 0.9888 - val\_loss: 3.6102 - val\_accuracy: 0.3480 - lr: 1.0000e-04

Epoch 11/30

179/179 [==============================] - 149s 828ms/step - loss: 0.2908 - accuracy: 0.9947 - val\_loss: 3.1961 - val\_accuracy: 0.4234 - lr: 1.0000e-04

Epoch 12/30

179/179 [==============================] - 146s 812ms/step - loss: 0.2390 - accuracy: 0.9958 - val\_loss: 1.1449 - val\_accuracy: 0.7298 - lr: 1.0000e-04

Epoch 13/30

179/179 [==============================] - 145s 811ms/step - loss: 0.2105 - accuracy: 0.9954 - val\_loss: 0.4991 - val\_accuracy: 0.9002 - lr: 2.0000e-05

Epoch 14/30

179/179 [==============================] - 148s 823ms/step - loss: 0.1983 - accuracy: 0.9965 - val\_loss: 0.2667 - val\_accuracy: 0.9709 - lr: 2.0000e-05

Epoch 15/30

179/179 [==============================] - 146s 810ms/step - loss: 0.1903 - accuracy: 0.9965 - val\_loss: 0.3599 - val\_accuracy: 0.9419 - lr: 2.0000e-05

Epoch 16/30

179/179 [==============================] - 145s 810ms/step - loss: 0.1806 - accuracy: 0.9970 - val\_loss: 0.3404 - val\_accuracy: 0.9411 - lr: 2.0000e-05

Epoch 17/30

179/179 [==============================] - 153s 853ms/step - loss: 0.1697 - accuracy: 0.9974 - val\_loss: 0.1882 - val\_accuracy: 0.9890 - lr: 2.0000e-05

Epoch 18/30

179/179 [==============================] - 145s 810ms/step - loss: 0.1592 - accuracy: 0.9977 - val\_loss: 0.2454 - val\_accuracy: 0.9670 - lr: 2.0000e-05

Epoch 19/30

179/179 [==============================] - 145s 809ms/step - loss: 0.1500 - accuracy: 0.9974 - val\_loss: 0.4338 - val\_accuracy: 0.9010 - lr: 2.0000e-05

Epoch 20/30

179/179 [==============================] - 145s 810ms/step - loss: 0.1422 - accuracy: 0.9975 - val\_loss: 1.1522 - val\_accuracy: 0.6826 - lr: 2.0000e-05

Epoch 21/30

179/179 [==============================] - 152s 850ms/step - loss: 0.1357 - accuracy: 0.9979 - val\_loss: 0.1469 - val\_accuracy: 0.9945 - lr: 4.0000e-06

Epoch 22/30

179/179 [==============================] - 145s 810ms/step - loss: 0.1342 - accuracy: 0.9984 - val\_loss: 0.1464 - val\_accuracy: 0.9937 - lr: 4.0000e-06

Epoch 23/30

179/179 [==============================] - 152s 846ms/step - loss: 0.1304 - accuracy: 0.9982 - val\_loss: 0.1362 - val\_accuracy: 0.9969 - lr: 4.0000e-06

Epoch 24/30

179/179 [==============================] - 145s 811ms/step - loss: 0.1277 - accuracy: 0.9989 - val\_loss: 0.1352 - val\_accuracy: 0.9961 - lr: 4.0000e-06

Epoch 25/30

179/179 [==============================] - 145s 810ms/step - loss: 0.1283 - accuracy: 0.9984 - val\_loss: 0.1822 - val\_accuracy: 0.9796 - lr: 4.0000e-06

Epoch 26/30

179/179 [==============================] - 152s 845ms/step - loss: 0.1261 - accuracy: 0.9981 - val\_loss: 0.1313 - val\_accuracy: 0.9976 - lr: 4.0000e-06

Epoch 27/30

179/179 [==============================] - 144s 802ms/step - loss: 0.1235 - accuracy: 0.9981 - val\_loss: 0.1306 - val\_accuracy: 0.9961 - lr: 4.0000e-06

Epoch 28/30

179/179 [==============================] - 144s 804ms/step - loss: 0.1198 - accuracy: 0.9988 - val\_loss: 0.1346 - val\_accuracy: 0.9945 - lr: 4.0000e-06

Epoch 29/30

179/179 [==============================] - 144s 803ms/step - loss: 0.1183 - accuracy: 0.9984 - val\_loss: 0.1306 - val\_accuracy: 0.9953 - lr: 4.0000e-06

Epoch 30/30

179/179 [==============================] - 144s 805ms/step - loss: 0.1162 - accuracy: 0.9981 - val\_loss: 0.1225 - val\_accuracy: 0.9969 - lr: 4.0000e-06

40/40 [==============================] - 9s 167ms/step - loss: 0.1313 - accuracy: 0.9976

Test Loss: 0.1313374936580658, Test Accuracy: 0.9976433515548706

Fifth Training Test:

Cross-Validation of Fourth Training Test including other metrics like Fscore, Recall, Precision, AUC

Results:

Found 5708 images belonging to 4 classes.

Found 1273 images belonging to 4 classes.

Epoch 1/30

179/179 [==============================] - ETA: 0s - loss: 1.7054 - accuracy: 0.8320/usr/local/lib/python3.10/dist-packages/keras/src/engine/training.py:3103: UserWarning: You are saving your model as an HDF5 file via model.save(). This file format is considered legacy. We recommend using instead the native Keras format, e.g. model.save('my\_model.keras').

saving\_api.save\_model(

179/179 [==============================] - 212s 823ms/step - loss: 1.7054 - accuracy: 0.8320 - val\_loss: 3.4837 - val\_accuracy: 0.3181 - lr: 1.0000e-04

Epoch 2/30

179/179 [==============================] - 144s 801ms/step - loss: 1.2887 - accuracy: 0.9441 - val\_loss: 4.0600 - val\_accuracy: 0.3181 - lr: 1.0000e-04

Epoch 3/30

179/179 [==============================] - 145s 811ms/step - loss: 1.1112 - accuracy: 0.9620 - val\_loss: 2.2104 - val\_accuracy: 0.4941 - lr: 1.0000e-04

Epoch 4/30

179/179 [==============================] - 147s 822ms/step - loss: 0.9447 - accuracy: 0.9762 - val\_loss: 2.3074 - val\_accuracy: 0.5609 - lr: 1.0000e-04

Epoch 5/30

179/179 [==============================] - 144s 801ms/step - loss: 0.8225 - accuracy: 0.9783 - val\_loss: 3.3032 - val\_accuracy: 0.3896 - lr: 1.0000e-04

Epoch 6/30

179/179 [==============================] - 144s 801ms/step - loss: 0.6981 - accuracy: 0.9832 - val\_loss: 3.3179 - val\_accuracy: 0.4375 - lr: 1.0000e-04

Epoch 7/30

179/179 [==============================] - 149s 832ms/step - loss: 0.6169 - accuracy: 0.9911 - val\_loss: 0.9634 - val\_accuracy: 0.8445 - lr: 2.0000e-05

Epoch 8/30

179/179 [==============================] - 146s 811ms/step - loss: 0.5903 - accuracy: 0.9933 - val\_loss: 0.9736 - val\_accuracy: 0.8460 - lr: 2.0000e-05

Epoch 9/30

179/179 [==============================] - 144s 803ms/step - loss: 0.5658 - accuracy: 0.9932 - val\_loss: 1.8827 - val\_accuracy: 0.6316 - lr: 2.0000e-05

Epoch 10/30

179/179 [==============================] - 151s 844ms/step - loss: 0.5388 - accuracy: 0.9947 - val\_loss: 0.5707 - val\_accuracy: 0.9811 - lr: 2.0000e-05

Epoch 11/30

179/179 [==============================] - 144s 803ms/step - loss: 0.5188 - accuracy: 0.9937 - val\_loss: 0.6859 - val\_accuracy: 0.9332 - lr: 2.0000e-05

Epoch 12/30

179/179 [==============================] - 144s 802ms/step - loss: 0.4969 - accuracy: 0.9942 - val\_loss: 1.7978 - val\_accuracy: 0.6402 - lr: 2.0000e-05

Epoch 13/30

179/179 [==============================] - 144s 801ms/step - loss: 0.4740 - accuracy: 0.9944 - val\_loss: 1.9290 - val\_accuracy: 0.6339 - lr: 2.0000e-05

Epoch 14/30

179/179 [==============================] - 144s 803ms/step - loss: 0.4568 - accuracy: 0.9953 - val\_loss: 0.6024 - val\_accuracy: 0.9466 - lr: 4.0000e-06

Epoch 15/30

179/179 [==============================] - 149s 833ms/step - loss: 0.4489 - accuracy: 0.9960 - val\_loss: 0.4563 - val\_accuracy: 0.9921 - lr: 4.0000e-06

Epoch 16/30

179/179 [==============================] - 151s 844ms/step - loss: 0.4456 - accuracy: 0.9960 - val\_loss: 0.4532 - val\_accuracy: 0.9929 - lr: 4.0000e-06

Epoch 17/30

179/179 [==============================] - 152s 845ms/step - loss: 0.4383 - accuracy: 0.9960 - val\_loss: 0.4448 - val\_accuracy: 0.9953 - lr: 4.0000e-06

Epoch 18/30

179/179 [==============================] - 144s 802ms/step - loss: 0.4344 - accuracy: 0.9953 - val\_loss: 0.4384 - val\_accuracy: 0.9953 - lr: 4.0000e-06

Epoch 19/30

179/179 [==============================] - 144s 802ms/step - loss: 0.4275 - accuracy: 0.9960 - val\_loss: 0.4509 - val\_accuracy: 0.9882 - lr: 4.0000e-06

Epoch 20/30

179/179 [==============================] - 144s 802ms/step - loss: 0.4221 - accuracy: 0.9961 - val\_loss: 0.5025 - val\_accuracy: 0.9654 - lr: 4.0000e-06

Epoch 21/30

179/179 [==============================] - 144s 805ms/step - loss: 0.4145 - accuracy: 0.9967 - val\_loss: 0.4322 - val\_accuracy: 0.9914 - lr: 4.0000e-06

Epoch 22/30

179/179 [==============================] - 148s 823ms/step - loss: 0.4123 - accuracy: 0.9958 - val\_loss: 0.4232 - val\_accuracy: 0.9906 - lr: 4.0000e-06

Epoch 23/30

179/179 [==============================] - 144s 801ms/step - loss: 0.4044 - accuracy: 0.9963 - val\_loss: 0.4977 - val\_accuracy: 0.9576 - lr: 4.0000e-06

Epoch 24/30

179/179 [==============================] - 144s 801ms/step - loss: 0.3961 - accuracy: 0.9965 - val\_loss: 0.4400 - val\_accuracy: 0.9835 - lr: 4.0000e-06

Epoch 25/30

179/179 [==============================] - 144s 802ms/step - loss: 0.3895 - accuracy: 0.9970 - val\_loss: 0.5116 - val\_accuracy: 0.9513 - lr: 4.0000e-06

Epoch 26/30

179/179 [==============================] - 151s 843ms/step - loss: 0.3872 - accuracy: 0.9968 - val\_loss: 0.3910 - val\_accuracy: 0.9969 - lr: 1.0000e-06

Epoch 27/30

179/179 [==============================] - 144s 802ms/step - loss: 0.3904 - accuracy: 0.9944 - val\_loss: 0.3915 - val\_accuracy: 0.9961 - lr: 1.0000e-06

Epoch 28/30

179/179 [==============================] - 144s 803ms/step - loss: 0.3811 - accuracy: 0.9972 - val\_loss: 0.3898 - val\_accuracy: 0.9969 - lr: 1.0000e-06

Epoch 29/30

179/179 [==============================] - 144s 804ms/step - loss: 0.3823 - accuracy: 0.9963 - val\_loss: 0.3871 - val\_accuracy: 0.9961 - lr: 1.0000e-06

Epoch 30/30

179/179 [==============================] - 144s 802ms/step - loss: 0.3809 - accuracy: 0.9963 - val\_loss: 0.3856 - val\_accuracy: 0.9953 - lr: 1.0000e-06

40/40 [==============================] - 9s 167ms/step - loss: 0.3910 - accuracy: 0.9969

Test Loss: 0.3910380005836487, Test Accuracy: 0.9968578219413757

40/40 [==============================] - 9s 163ms/step

Classification Report:

precision recall f1-score support

glioma 1.00 1.00 1.00 262

meningioma 0.99 0.99 0.99 306

notumor 1.00 1.00 1.00 405

pituitary 0.99 1.00 1.00 300

accuracy 1.00 1273

macro avg 1.00 1.00 1.00 1273

weighted avg 1.00 1.00 1.00 1273

AUC Scores per class: [0.9999886742020975, 0.9995809423390176, 1.0, 0.9996848235697157]

**Training Tests Summary**

| **Test #** | **Learning Rate** | **Epochs** | **Data Augmentation** | **Reduce LR on Plateau** | **Checkpoint** | **Best Loss (Train)** | **Best Accuracy (Train)** | **Best Loss (Val)** | **Best Accuracy (Val)** | **Test Loss** | **Test Accuracy** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 0.00001 | 10 | Rotation: 40, Width Shift: 0.4, Height Shift: 0.4, Shear: 0.3, Zoom: 0.4, Vertical Flip: True | No | No | 0.5333 | 79.71% | 1.3233 | 32.52% | N/A | N/A |
| 2 | 0.0001 | 30 | Rotation: 20, Width Shift: 0.2, Height Shift: 0.2, Shear: 0.2, Zoom: 0.2, Vertical Flip: False | No | No | 0.0346 | 98.84% | 0.3528 | 87.75% | 0.1809 | 94.03% |
| 3 | 0.00001 | 30 | Rotation: 20, Width Shift: 0.2, Height Shift: 0.2, Shear: 0.2, Zoom: 0.2, Vertical Flip: False | No | Yes | 0.1099 | 96.09% | 0.1809 | 94.03% | 0.1313 | 99.76% |
| 4 | 0.0001 | 30 | Rotation: 20, Width Shift: 0.2, Height Shift: 0.2, Shear: 0.2, Zoom: 0.2, Vertical Flip: False | Factor: 0.2, Patience: 3, Min LR: 1e-6 | Yes | 0.2390 | 99.58% | 1.1449 | 72.98% | 0.1313 | 99.76% |
| 5 | 0.0001 | 30 | Rotation: 20, Width Shift: 0.2, Height Shift: 0.2, Shear: 0.2, Zoom: 0.2, Vertical Flip: False | Factor: 0.2, Patience: 3, Min LR: 1e-6 | Yes | Not Provided | Not Provided | Not Provided | Not Provided | Not Provided | Not Provided |

**Best Results**

* **Test Accuracy:** 99.76% (Test 3 and Test 4)
* **Best Validation Accuracy:** 99.76%
* **Test Loss:** 0.1313 (Test 3 and Test 4)

**Notes**

* Performance improvements observed with increased epochs, adjusted learning rates, and included checkpoints.
* Moderate data augmentation settings yielded better accuracy and loss metrics.
* Cross-validation metrics like F-Score, Recall, Precision, and AUC were suggested for a comprehensive performance evaluation.