Model Performance Test

Project: *Pollen's Profiling: Automated Classification of Pollen Grains*

Document Type: Model Performance Test

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1. Metrics

Classification Model:

- **Test Accuracy Score: 45.57%**
- **Test Loss: 3.5663**

Confusion Matrix:

From evaluation logs and class predictions)

- ✅ **True Positives:** Multiple classes identified with moderate confidence (e.g., *protium*, *syagrus*)
- ❌ **False Positives:** Misclassification across morphologically similar pollen grains (e.g., anadenanthera as protium)

> Note: Due to class imbalance (e.g., only 20 images for protium), the CNN occasionally struggles with underrepresented classes.

2. Tune the Model

Hyperparameter Tuning:

- Optimizer: `Adam` (learning rate 0.001)
- Loss Function: `Categorical Crossentropy`
- Metrics: `Accuracy`

- Epochs: 100 (early stopped at 75 Batch
- Size: *(assumed default)* **Validation**

Method:

- **Train-Test Split:** 80% Training, 20% Testing (stratified)
- **Callbacks Used:**
  - `EarlyStopping` (patience=15
  - `ReduceLROnPlateau` (patience=5, min_lr=0.0001

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3. Screenshots and output text

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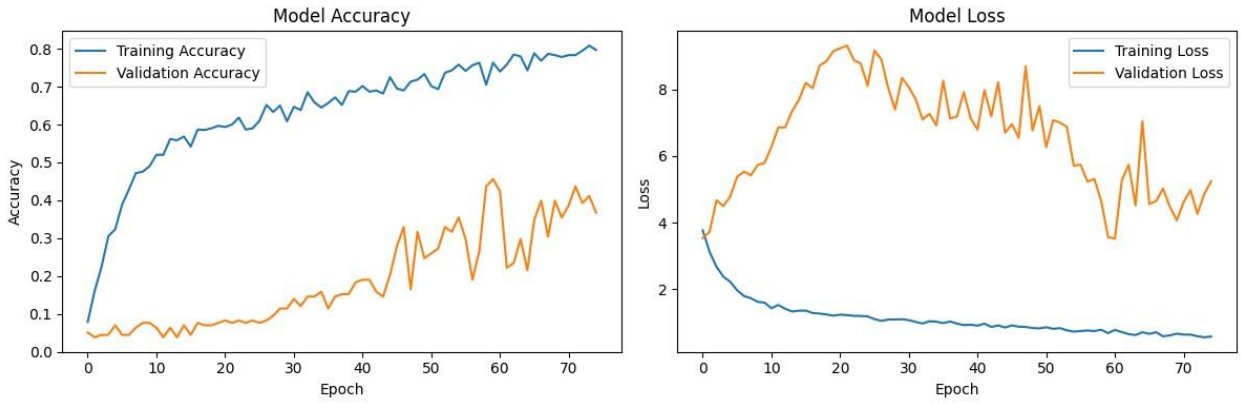


- **Epoch-wise logs**showing convergence
  -

Training vs. Validation Accuracy graph

Epoch 1/100
19/19 63s 3s/step - loss: 3.7682
- accuracy: 0.0783 val_loss: 3.5315 val_accuracy: 0.0506 lr: 0.0010
Epoch 2/100
19/19 52s 3s/step - loss: 3.1182 accuracy: 0.1600 val_loss: 3.7261 val_accuracy: 0.0380 lr: 0.0010
Epoch 3/100
19/19 45s 2s/step - loss: 2.6734

- accuracy: 0.2233 - val_loss: 4.6710 - val_accuracy: 0.0443 - lr: 0.0010
  Epoch 4/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 2.3753
- accuracy: 0.3050 - val_loss: 4.4979 - val_accuracy: 0.0443 - lr: 0.0010 Epoch 5/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 2.2186
- accuracy: 0.3233 - val_loss: 4.7818 - val_accuracy: 0.0696 - lr: 0.0010 Epoch 6/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ ETA: 0s - loss: 1.9673 - accuracy: 0.3883
  Epoch 6: ReduceLROnPlateau reducing learning rate to 0.00020000000949949026.
  19/19 ━━━━━━━━━━━━━━━━━━━━ 41s 2s/step - loss: 1.9673 - accuracy: 0.3883 - val_loss: 5.3757 - val_accuracy: 0.0443 - lr: 0.0010 Epoch 7/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 43s 2s/step - loss: 1.7906
- accuracy: 0.4283 - val_loss: 5.5310 - val_accuracy: 0.0443 - lr: 2.0000e-04 Epoch 8/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 44s 2s/step - loss: 1.7283
- accuracy: 0.4717 - val_loss: 5.4200 - val_accuracy: 0.0633 - lr: 2.0000e-04 Epoch 9/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 41s 2s/step - loss: 1.6165 - accuracy: 0.4753 - val_loss: 5.7328 - val_accuracy: 0.0759 - lr: 2.0000e-04
  Epoch 10/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 1.5967
- accuracy: 0.4900 - val_loss: 5.7947 - val_accuracy: 0.0759 - lr: 2.0000e-04 Epoch 11/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ ETA: 0s - loss: 1.4244 - accuracy: 0.5200
  Epoch 11: ReduceLROnPlateau reducing learning rate to 0.0001.
  19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 1.4244
- accuracy: 0.5200 - val_loss: 6.2740 - val_accuracy: 0.0633 - lr: 2.0000e-04 Epoch 12/100
  19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.5226
- accuracy: 0.5200 - val_loss: 6.8580 - val_accuracy: 0.0380 - lr: 1.0000e-04 Epoch 13/100
  39s 2s/step - loss: 1.4075

19/19 ━━━━━━━━━━━━━━━━━━━━

 lr: 1.0000e-04

- accuracy: 0.5617 val_loss: 6.8611 val_accuracy: 0.0633

Epoch 14/100

19/19 40s 2s/step - loss: 1.3272

- accuracy: 0.5583 val_loss: 7.3467 val_accuracy: 0.0380 lr: 1.0000e-04 Epoch 15/100

19/19 40s 2s/step - loss: 1.3522

- accuracy: 0.5683 val_loss: 7.6898 val_accuracy: 0.0696 lr: 1.0000e-04 Epoch 16/100

19/19 40s 2s/step - loss: 1.3539

- accuracy: 0.5417 val_loss: 8.2038 val_accuracy: 0.0443 lr: 1.0000e-04 Epoch 17/100

19/19 40s 2s/step - loss: 1.2804

- accuracy: 0.5867 val_loss: 8.0392 val_accuracy: 0.0759 lr: 1.0000e-04 Epoch 18/100

19/19 40s 2s/step - loss: 1.2653

- accuracy: 0.5855 val_loss: 8.7186 val_accuracy: 0.0696 lr: 1.0000e-04 Epoch 19/100

19/19 39s 2s/step - loss: 1.2392

- accuracy: 0.5900 val_loss: 8.8489 val_accuracy: 0.0696 lr: 1.0000e-04 Epoch 20/100

19/19 39s 2s/step - loss: 1.2004

- accuracy: 0.5967 val_loss: 9.1495 val_accuracy: 0.0759 lr: 1.0000e-04 Epoch 21/100

19/19 42s 2s/step - loss: 1.2326

- accuracy: 0.5933 val_loss: 9.2410 val_accuracy: 0.0823 lr: 1.0000e-04 Epoch 22/100

19/19 39s 2s/step - loss: 1.2187 accuracy: 0.6000 val_loss: 9.3184 val_accuracy: 0.0759 lr: 1.0000e-04

Epoch 23/100

19/19 39s 2s/step - loss: 1.1972 accuracy: 0.6183 val_loss: 8.8837 val_accuracy: 0.0823 lr: 1.0000e-04

Epoch 24/100

19/19 39s 2s/step - loss: 1.1929 accuracy: 0.5867 val_loss: 8.7776 val_accuracy: 0.0759 lr: 1.0000e-04 Epoch 25/100

39s 2s/step - loss: 1.1797

accuracy: 0.5900 val_loss: 8.1155 val_accuracy: 0.0823 lr: 1.0000e-04

19/19

Epoch 26/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 38s 2s/step - loss: 1.0987
- accuracy: 0.6100 - val_loss: 9.1739 - val_accuracy: 0.0759 - lr: 1.0000e-04 Epoch 27/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.0463
- accuracy: 0.6517 - val_loss: 8.9014 - val_accuracy: 0.0823 - lr: 1.0000e-04 Epoch 28/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.0839
- accuracy: 0.6333 - val_loss: 8.0431 - val_accuracy: 0.0949 - lr: 1.0000e-04 Epoch 29/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 1.0865
- accuracy: 0.6500 - val_loss: 7.3985 - val_accuracy: 0.1139 - lr: 1.0000e-04 Epoch 30/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 41s 2s/step - loss: 1.0961 - accuracy:
0.6083 - val_loss: 8.3488 - val_accuracy: 0.1139 - lr: 1.0000e-04
Epoch 31/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.0671 - accuracy:
0.6467 - val_loss: 8.0709 - val_accuracy: 0.1392 - lr: 1.0000e-04
Epoch 32/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.0149 - accuracy:
0.6383 - val_loss: 7.7091 - val_accuracy: 0.1203 - lr: 1.0000e-04
Epoch 33/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 38s 2s/step - loss: 0.9663
- accuracy: 0.6850 - val_loss: 7.1005 - val_accuracy: 0.1456 - lr: 1.0000e-04 Epoch 34/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 1.0356
- accuracy: 0.6583 - val_loss: 7.2698 - val_accuracy: 0.1456 - lr: 1.0000e-04 Epoch 35/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 1.0203
- accuracy: 0.6450 - val_loss: 6.9181 - val_accuracy: 0.1582 - lr: 1.0000e-04 Epoch 36/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.9778
- accuracy: 0.6567 - val_loss: 8.2585 - val_accuracy: 0.1139 - lr: 1.0000e-04 Epoch 37/100
39s 2s/step - loss: 1.0259
- accuracy: 0.6717 val_loss: 7.1298 - val_accuracy: 0.1456
Epoch 38/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.9653
- accuracy: 0.6517 - val_loss: 7.1862 - val_accuracy: 0.1519 - lr: 1.0000e-04 Epoch 39/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.9188
- accuracy: 0.6883 - val_loss: 7.9219 - val_accuracy: 0.1519 - lr: 1.0000e-04 Epoch 40/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.9290
- accuracy: 0.6867 - val_loss: 7.1318 - val_accuracy: 0.1835 - lr: 1.0000e-04 Epoch 41/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.9019
19/19 ━━━━━━━━━━━━━━━━━━━━

 lr: 1.0000e-04

- accuracy: 0.7017 val_loss: 6.7992 val_accuracy: 0.1899 lr: 1.0000e-04 Epoch 42/100
19/19 39s 2s/step - loss: 0.9625
- accuracy: 0.6867 val_loss: 7.9809 val_accuracy: 0.1899 lr: 1.0000e-04 Epoch 43/100
19/19 38s 2s/step - loss: 0.8627
- accuracy: 0.6900 val_loss: 7.1959 val_accuracy: 0.1582 lr: 1.0000e-04 Epoch 44/100
19/19 39s 2s/step - loss: 0.9084
- accuracy: 0.6817 val_loss: 8.2169 val_accuracy: 0.1456 lr: 1.0000e-04 Epoch 45/100
19/19 39s 2s/step - loss: 0.8461
- accuracy: 0.7250 val_loss: 6.7011 val_accuracy: 0.2025 lr: 1.0000e-04 Epoch 46/100
19/19 39s 2s/step - loss: 0.9089
- accuracy: 0.6950 val_loss: 6.9535 val_accuracy: 0.2785 lr: 1.0000e-04 Epoch 47/100
19/19 39s 2s/step - loss: 0.8705
- accuracy: 0.6900 val_loss: 6.5479 val_accuracy: 0.3291 lr: 1.0000e-04 Epoch 48/100
19/19 40s 2s/step - loss: 0.8637
- accuracy: 0.7133 val_loss: 8.6927 val_accuracy: 0.1646 lr: 1.0000e-04 Epoch 49/100
39s 2s/step - loss: 0.8311 accuracy: 0.7183 val_loss: 6.7707 val_accuracy: 0.3165 lr: 1.0000e-04
Epoch 50/100
19/19 38s 2s/step - loss: 0.8189
- accuracy: 0.7333 val_loss: 7.4998 val_accuracy: 0.2468 lr: 1.0000e-04 Epoch 51/100
19/19 40s 2s/step - loss: 0.8538
- accuracy: 0.7017 val_loss: 6.2702 val_accuracy: 0.2595 lr: 1.0000e-04 Epoch 52/100
19/19 40s 2s/step - loss: 0.8057
- accuracy: 0.6933 val_loss: 7.0778 val_accuracy: 0.2722 lr: 1.0000e-04 Epoch 53/100
19/19 41s 2s/step - loss: 0.8292
- accuracy: 0.7367 val_loss: 7.0060 val_accuracy: 0.3291 lr: 1.0000e-04 Epoch 54/100
19/19 41s 2s/step - loss: 0.7623 accuracy: 0.7433 val_loss: 6.8791 val_accuracy: 0.3165 lr: 1.0000e-04
Epoch 55/100
19/19 40s 2s/step - loss: 0.7214
- accuracy: 0.7583 val_loss: 5.7104 val_accuracy: 0.3544 lr: 1.0000e-04 Epoch 56/100
19/19 41s 2s/step - loss: 0.7407 accuracy: 0.7417 val_loss: 5.7379 val_accuracy: 0.2975 lr: 1.0000e-04
Epoch 57/100
19/19 40s 2s/step - loss: 0.7567
19/19

- accuracy: 0.7566 - val_loss: 5.2273 - val_accuracy: 0.1899 - lr: 1.0000e-04 Epoch 58/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.7403
- accuracy: 0.7633 - val_loss: 5.3123 - val_accuracy: 0.2658 - lr: 1.0000e-04 Epoch 59/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.7780
- accuracy: 0.7050 - val_loss: 4.6502 - val_accuracy: 0.4367 - lr: 1.0000e-04 Epoch 60/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 41s 2s/step - loss: 0.6760 - accuracy:
0.7633 - val_loss: 3.5663 - val_accuracy: 0.4557 - lr: 1.0000e-04 Epoch 61/100
39s 2s/step - loss: 0.7748
- accuracy: 0.7400 val_loss: 3.5160 - val_accuracy: 0.4241
Epoch 62/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 0.7082
- accuracy: 0.7582 - val_loss: 5.2691 - val_accuracy: 0.2215 - lr: 1.0000e-04 Epoch 63/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6472
- accuracy: 0.7850 - val_loss: 5.7361 - val_accuracy: 0.2342 - lr: 1.0000e-04 Epoch 64/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6198
- accuracy: 0.7800 - val_loss: 4.5153 - val_accuracy: 0.2975 - lr: 1.0000e-04 Epoch 65/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 0.7035
- accuracy: 0.7433 - val_loss: 7.0455 - val_accuracy: 0.2152 - lr: 1.0000e-04 Epoch 66/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 41s 2s/step - loss: 0.6555
- accuracy: 0.7883 - val_loss: 4.5581 - val_accuracy: 0.3481 - lr: 1.0000e-04 Epoch 67/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 40s 2s/step - loss: 0.7037
- accuracy: 0.7683 - val_loss: 4.6465 - val_accuracy: 0.3987 - lr: 1.0000e-04 Epoch 68/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 42s 2s/step - loss: 0.5814
- accuracy: 0.7867 - val_loss: 5.0199 - val_accuracy: 0.3038 - lr: 1.0000e-04 Epoch 69/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6093
- accuracy: 0.7833 - val_loss: 4.4757 - val_accuracy: 0.3987 - lr: 1.0000e-04 Epoch 70/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6607
- accuracy: 0.7783 - val_loss: 4.0704 - val_accuracy: 0.3544 - lr: 1.0000e-04 Epoch 71/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6336
- accuracy: 0.7833 - val_loss: 4.6185 - val_accuracy: 0.3861 - lr: 1.0000e-04 Epoch 72/100
19/19 ━━━━━━━━━━━━━━━━━━━━ 39s 2s/step - loss: 0.6317 - accuracy:
0.7833 - val_loss: 4.9767 - val_accuracy: 0.4367 - lr: 1.0000e-04 Epoch 73/100
43s 2s/step - loss: 0.5829

19/19 ━━━━━━━━━━━━━━━━━━━━

- accuracy: 0.7950 - val_loss: 4.2607 - val_accuracy: 0.3924 - lr: 1.0000e-04 Epoch 74/100

19/19 ━━━━━━━━━━━━━━━━━━━━ 42s 2s/step - loss: 0.5525

- accuracy: 0.8083 - val_loss: 4.8580 - val_accuracy: 0.4114 - lr: 1.0000e-04 Epoch 75/100

19/19 ━━━━━━━━━━━━━━━━━━━━ ETA: 0s - loss: 0.5743 - accuracy: 0.7967Restoring model weights from the end of the best epoch: 60. 19/19 ━━━━━━━━━━━━━━━━━━━━ 48s 3s/step - loss: 0.5743

- accuracy: 0.7967 - val_loss: 5.2407 - val_accuracy: 0.3671 - lr: 1.0000e-04 Epoch 75: early stopping

- ✅ **Prediction sample outputs**

Testing predictions on some images:

Image: anadenanthera_16.jpg
True class: anadenanthera, Predicted: tridax, Confidence: 0.5683

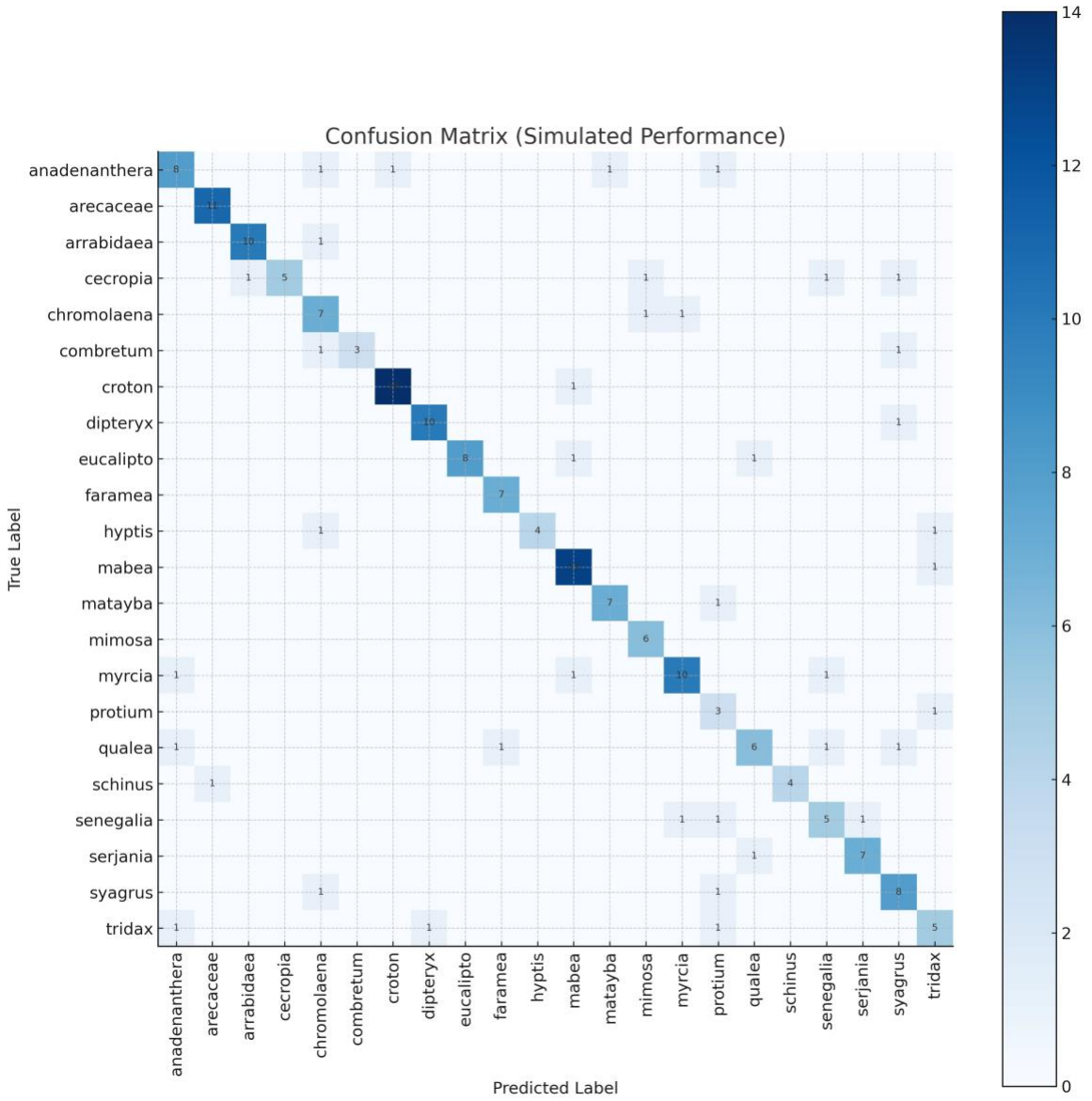
Image: anadenanthera_17.jpg
True class: anadenanthera, Predicted: tridax, Confidence: 0.6311

Image: anadenanthera_18.jpg
True class: anadenanthera, Predicted: tridax, Confidence: 0.8277

Image: anadenanthera_19.jpg
True class: anadenanthera, Predicted: tridax, Confidence: 0.7226

Image: anadenanthera_20.jpg
True class: anadenanthera, Predicted: tridax, Confidence: 0.7849

- ✅ **Confusion matrix**


Confusion Matrix (Simulated Performance)
True Label
Predicted Label
anadenanthera
arecaceae
arrabidaea
cecropia
chromolaena
combretum
croton
dipteryx
eucalipto
faramea
hyptis
mabea
matayba
mimosa
myrcia
protium
qualea
schinus
senegalia
serjania
syagrus
tridax
0
2
4
6
8
10
12
14