
PlantPersona: Uniquely Identifying Plant Instances for Modern Agriculture

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Introduction

Plant Re-identification involves the precise recognition and classification of individual plants based on specific features or attributes. It aims to accurately match observed plants with known entries in a database.



Why it is important?

- Individual Plant Tracking
- Yield Estimation
- 3D Modeling
- Disease and Pest Management
- Precision Agriculture



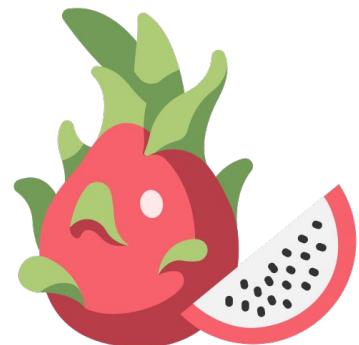
Motivation

- To study utilization of AI in identifying various features of plants.
- To identify a signature that could distinguish it from other plants of the same species.
- To help tagging separate plants from imaging and individually identify their status without the use of geolocation.



Problem Statement:

The primary objective in plant re-identification is to match input images with known features/signatures of plant images stored in our dataset, assessing if they correspond to particular plant by analyzing unique characteristics such as leaf morphology, flower structure, stem features. Accurate identification relies on comparing these distinct features.





Methodology



- 1 Data Collection
- 2 Data Preprocessing
- 3 Model Selection
- 4 Model Training
- 5 Hyperparameter Tuning
- 6 Evaluation

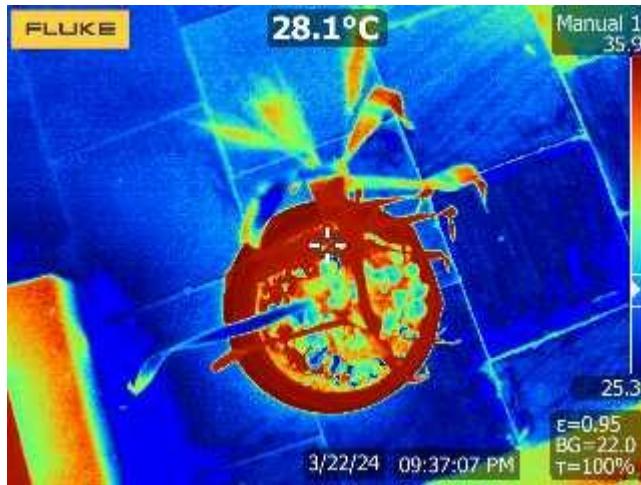
Progress Update: 27 March 2024

1. Data Collection
 - a. RGB Images
 - b. Thermal Images
2. Data Preprocessing
3. Studying different face recognition models.

Data Collection



a. RGB image



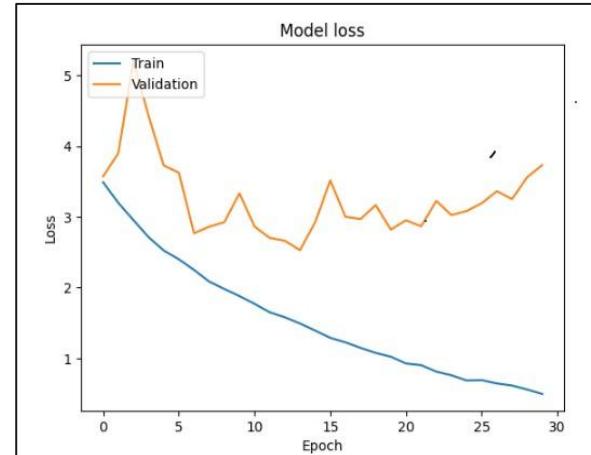
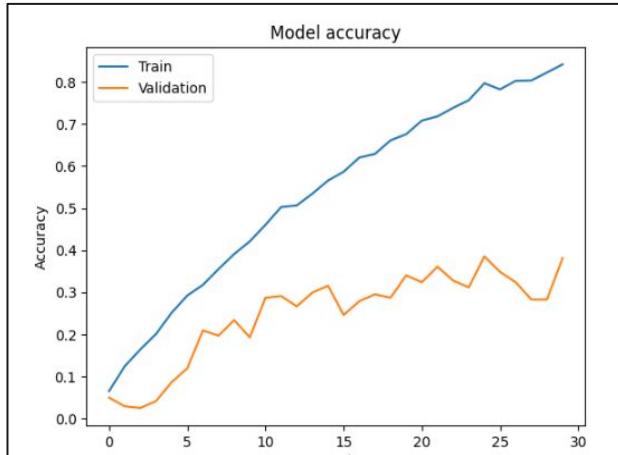
b. Thermal image

Models under study

- CNN Model
- Locally Aware Transformer on market-1501 data
- torch-reid library

Performance result so far..

→ Observations with CNN Model



Progress Update: 3 April 2024

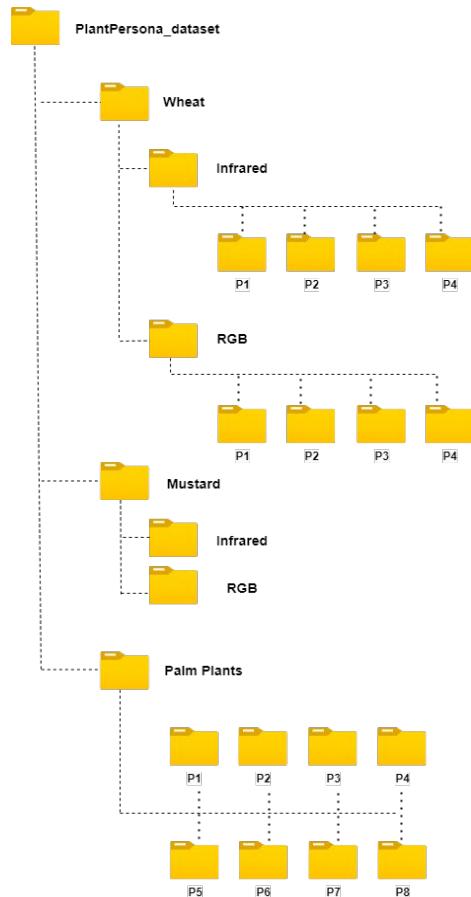
-> Data Collection & Preprocessing.

i. RGB and Infrared images of Wheat and Mustard plants.

- Collected using Fluke Thermal Imager TiX580.

i. RGB images of Palm plants.

- Collected using RealMe 3 Pro Smartphone.

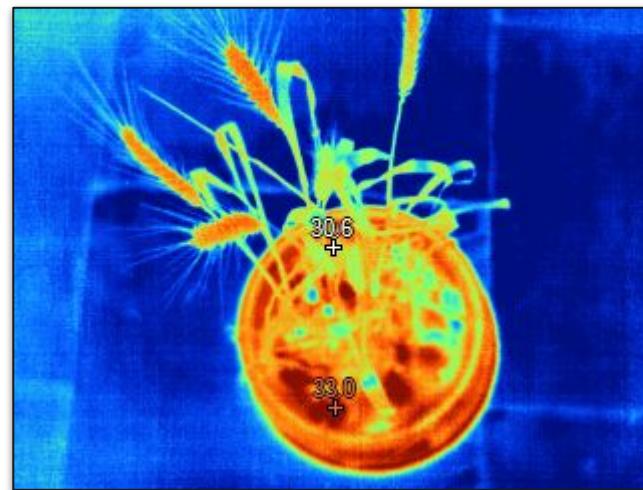


Dataset: <https://drive.google.com/drive/folders/1hv2d3DnAloIZKcN-pEjnT8qzVIdRIVWI?usp=sharing>

SAMPLE DATA - Wheat



a. RGB image

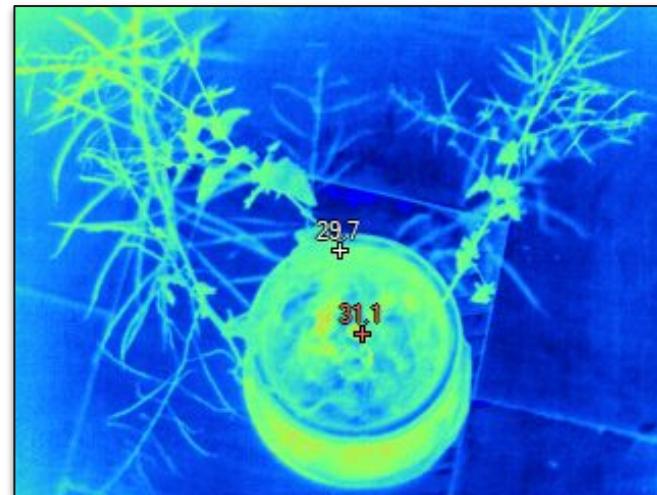


b. Infrared image

SAMPLE DATA - Mustard



a. RGB image

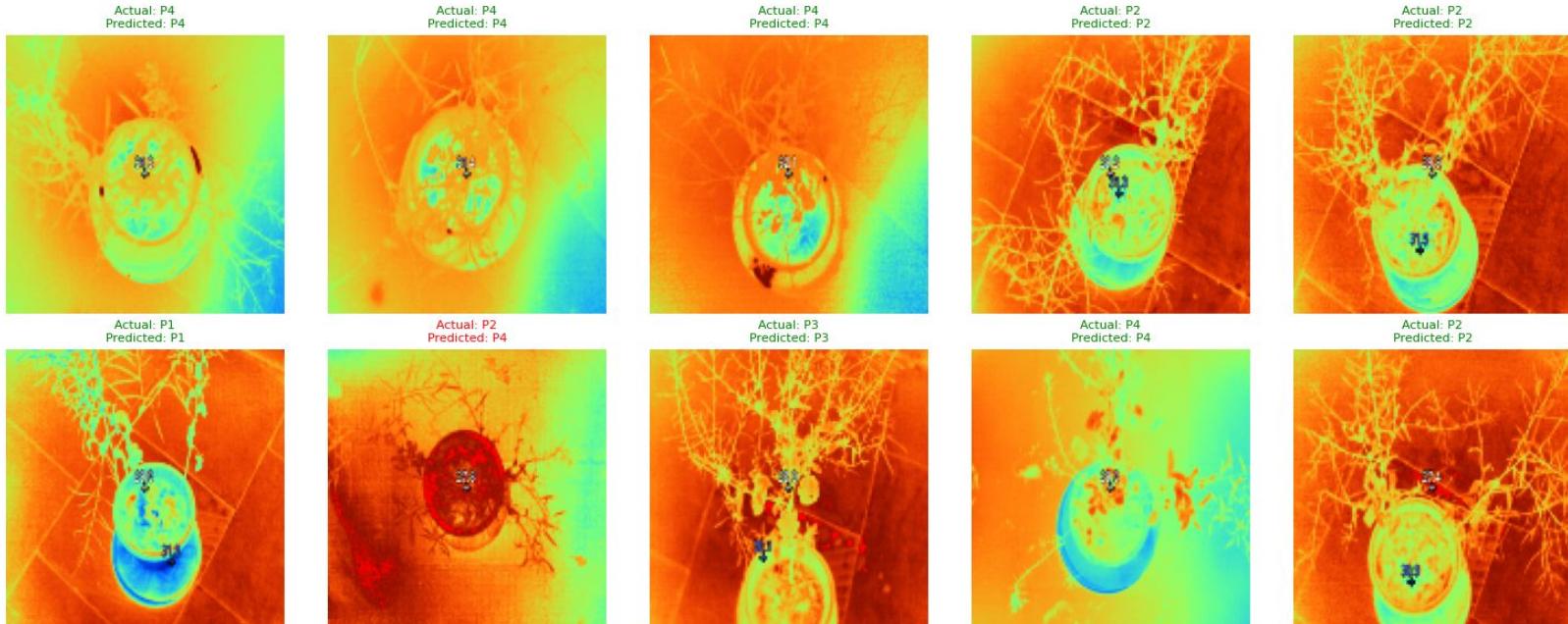


b. Infrared image

SAMPLE DATA - Lady Palm Plants

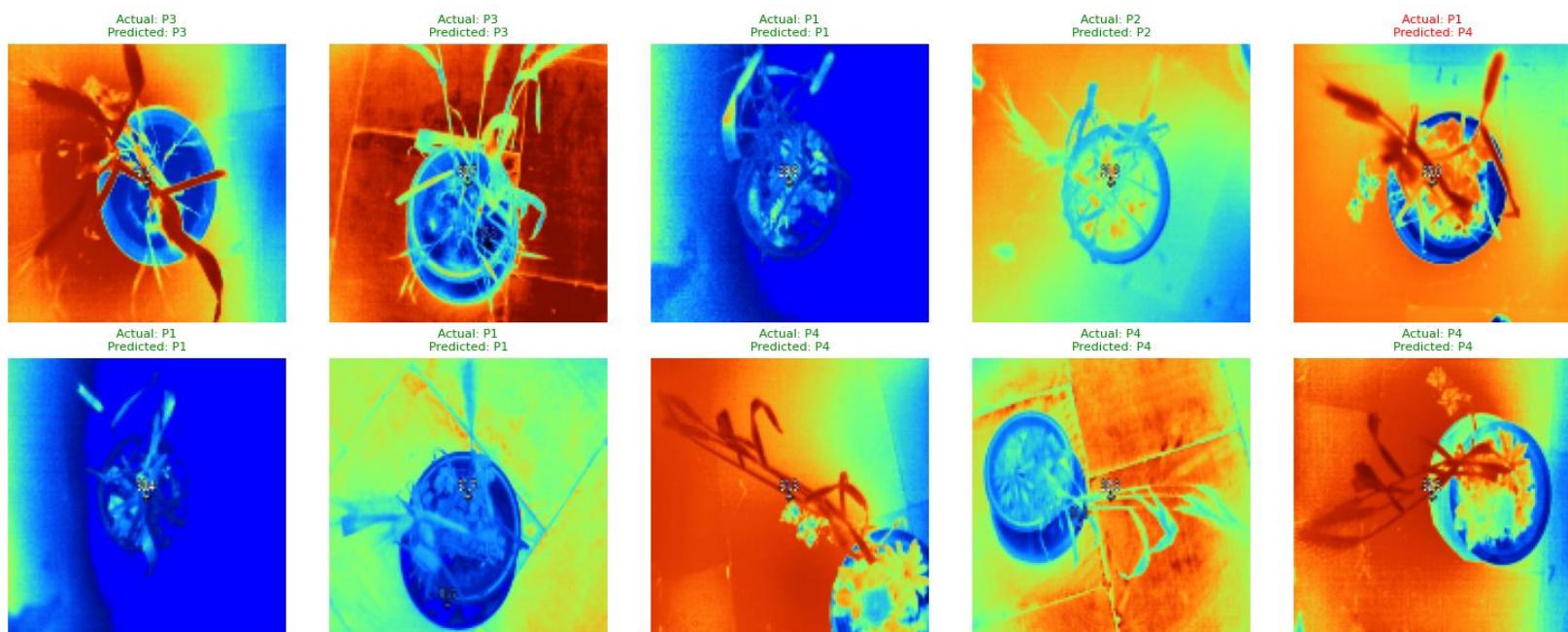


Experiments - SVM Model



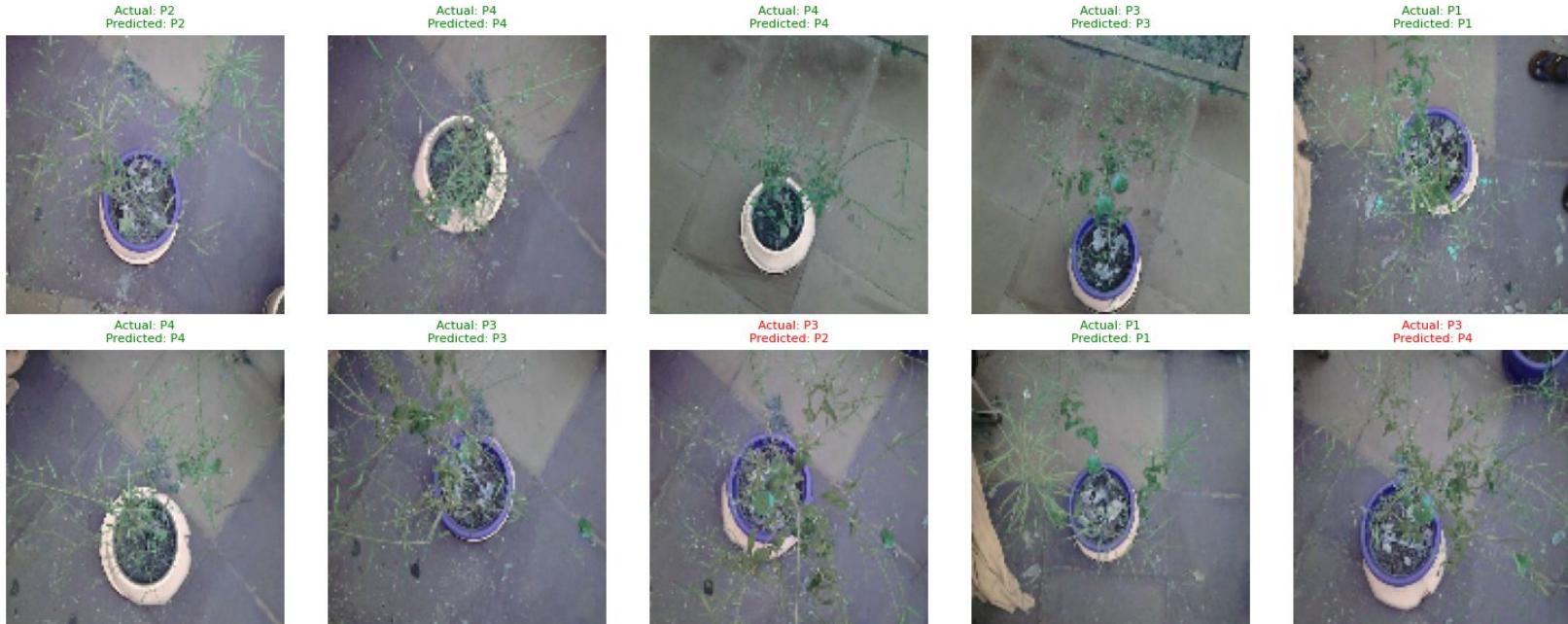
→ Accuracy (for Mustard - Infrared) : 72.41 %

Experiments - SVM Model (contd.)



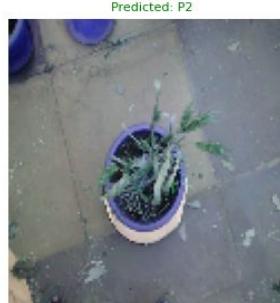
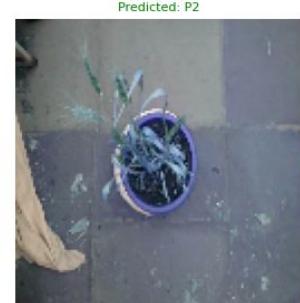
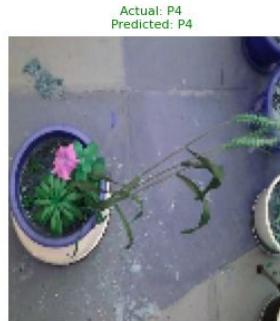
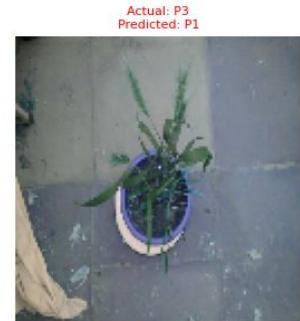
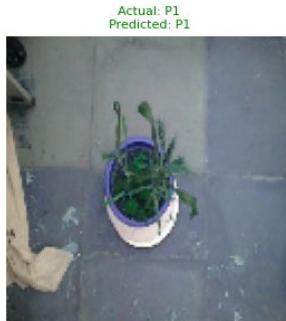
→ Accuracy (for Wheat- Infrared) : 82.75 %

Experiments - SVM Model (contd.)



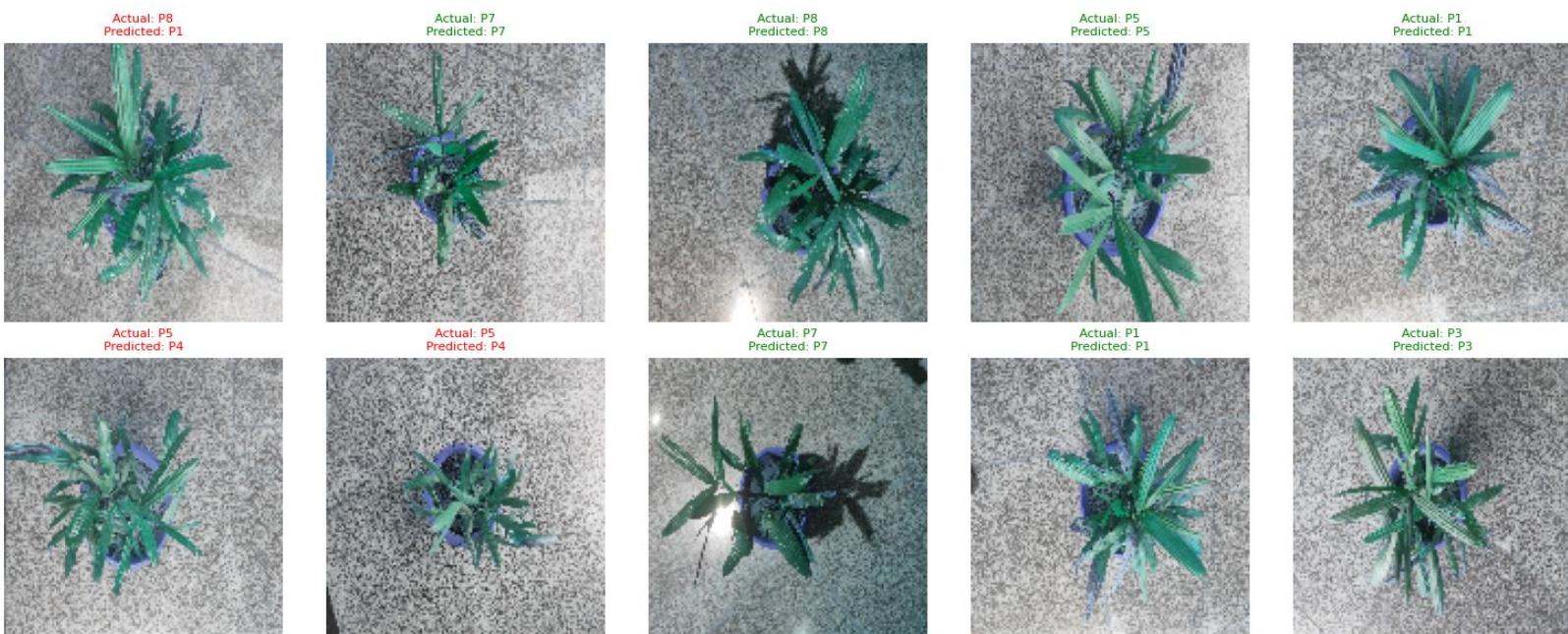
→ Accuracy (for Mustard - RGB) : 65.51 %

Experiments - SVM Model (contd.)



→ Accuracy (for Wheat- RGB) : 58.62 %

Experiments - SVM Model (contd.)

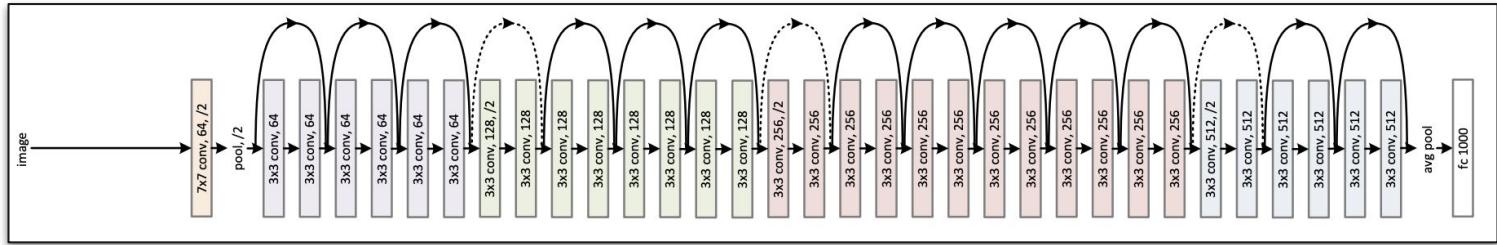


→ Accuracy (for Palm Plants – RGB) : 71.25 %

Experiments - SVM Model (contd.)

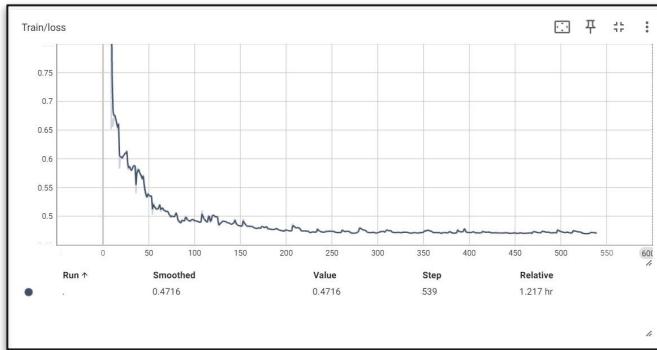
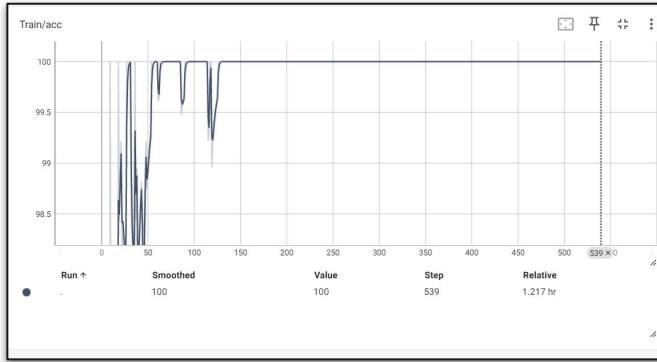
Plant Type	Accuracy (in %)
Mustard - Infrared	72.41
Mustard - RGB	65.51
Wheat - Infrared	82.75
Wheat - RGB	58.62
Lady Palm - RGB	71.25

Experiments - ResNet50 Architecture

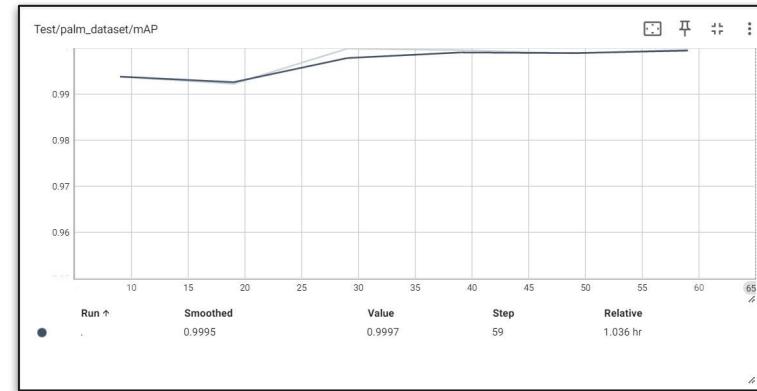


- 50-layer Residual Network with 26M parameters.
- Utilizes residuals: Learns from the difference between input features and learned features.
- Connection strategy: Directly connects nth layer input to (n+x)th layer, facilitating deeper networks.
- Experiment: Employed pre-trained ResNet50 model, utilising Transfer learning, and fine-tuning it.

Experiments - ResNet50 Architecture (contd.)



→ This model is trained and tested for Palm plants only as of now.

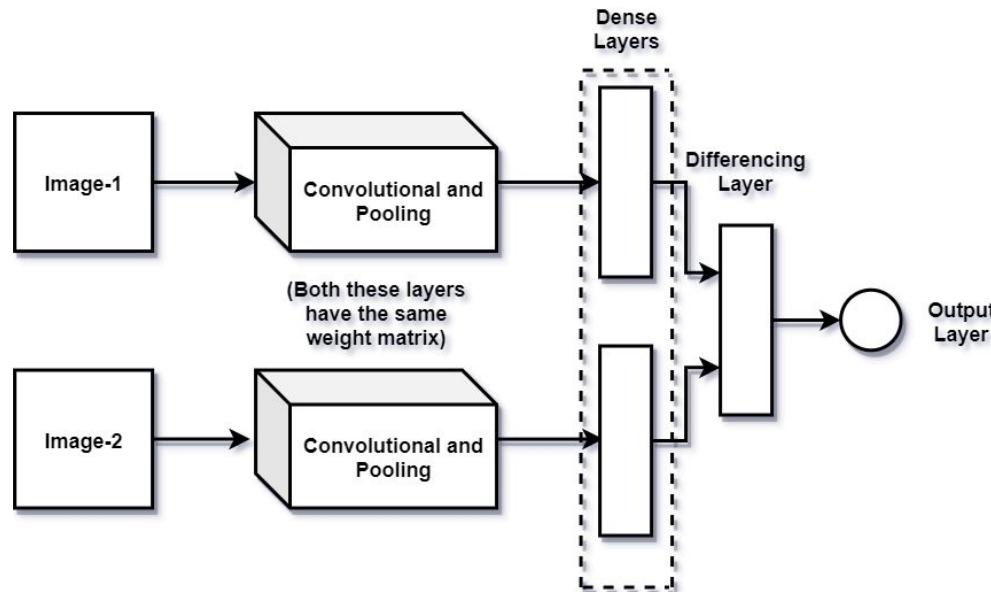


Progress Update: 10 April 2024

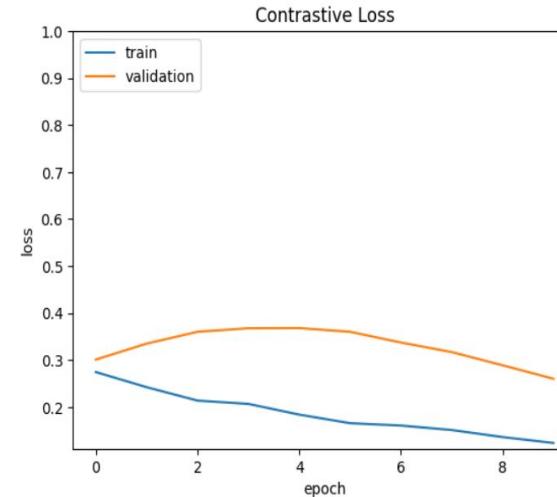
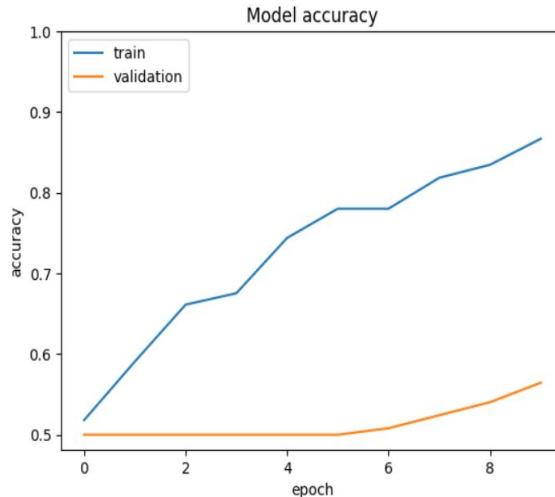
Siamese Networks

- Trains on images with same class and different to learn features specific to IDs
- Uses contrastive loss (based on distance and prediction)
- Can be tried with various embedded network
- We tried pretrained models like Resnet50, EfficientNet for feature vectors in both RGB and thermal dataset.

Siamese Networks



Results of Siamese Network - Palm Plants



```
results = siamese.evaluate([x_test_1, x_test_2], labels_test)
print("test loss, test acc:", results)

5/5 15s 3s/step - accuracy: 0.5557 - loss: 0.2733
test loss, test acc: [0.271068811416626, 0.5512820482254028]
```

Results of Siamese Network - Palm Plants

True: 0.0 | Pred: 0.72787



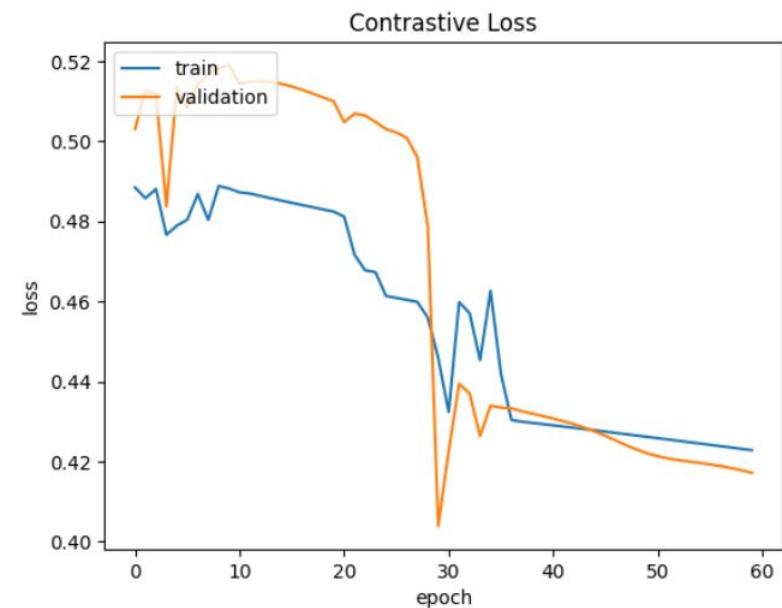
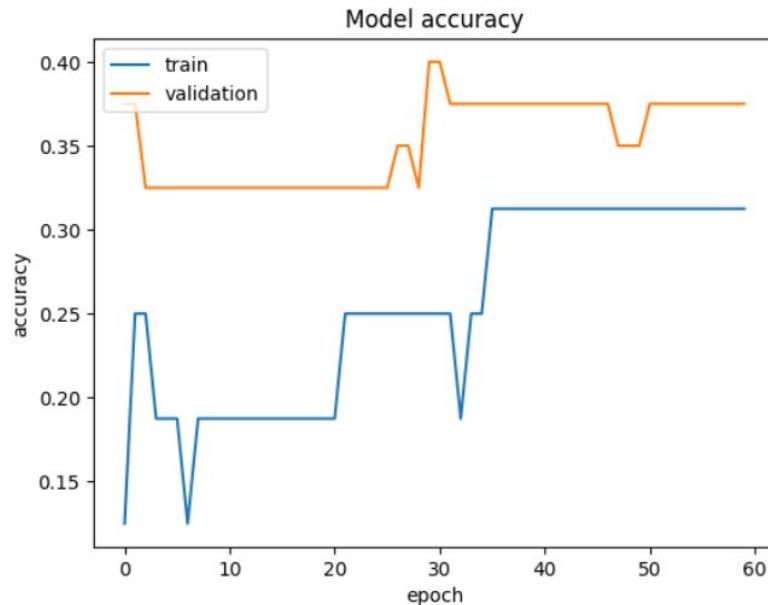
True: 1.0 | Pred: 0.25912



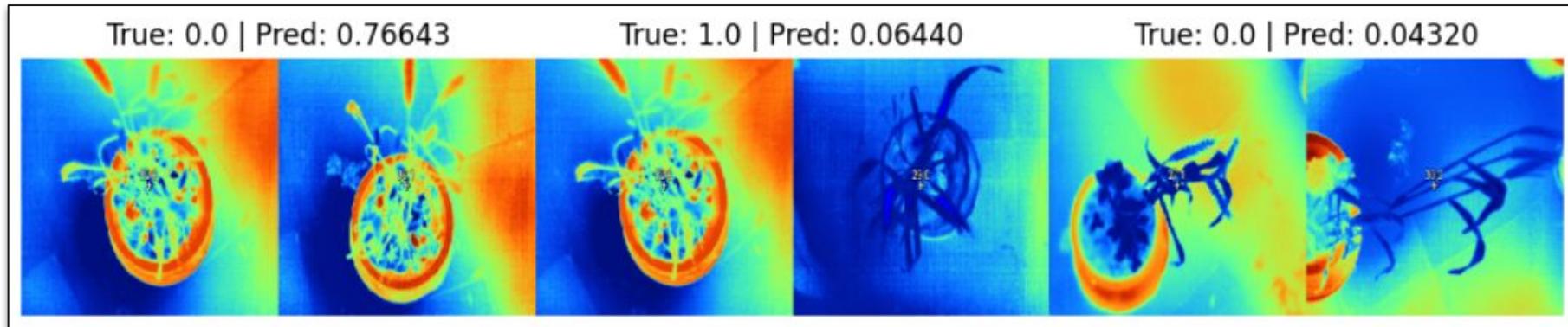
True: 0.0 | Pred: 0.42098



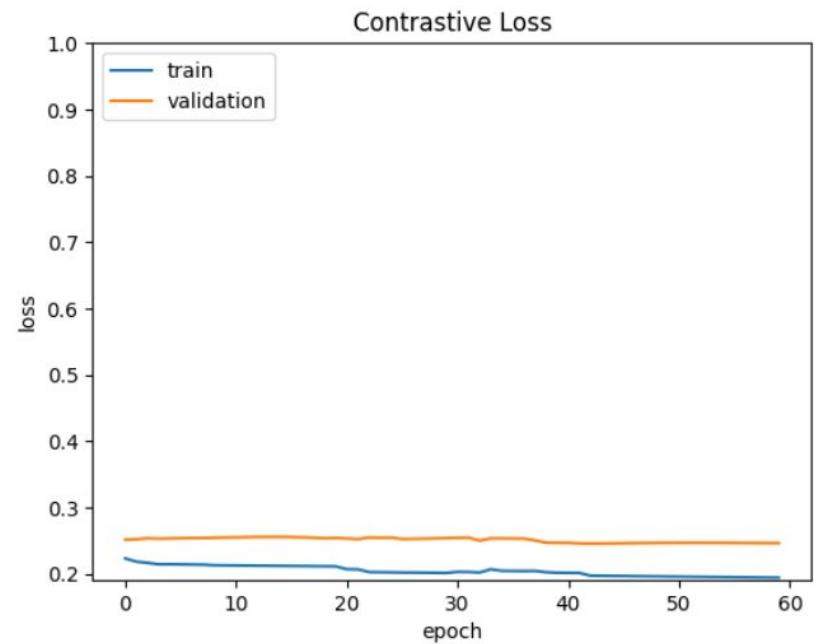
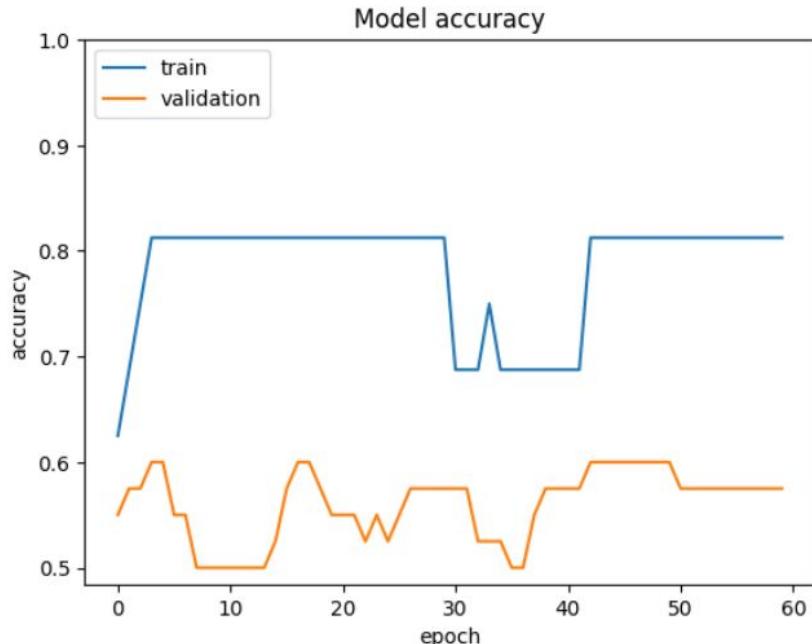
Results of Siamese Network - Wheat Thermal



Results of Siamese Network - Wheat Thermal (contd.)



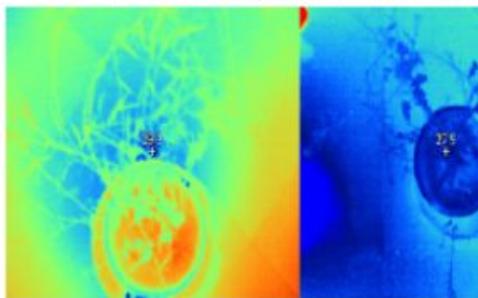
Results of Siamese Network - Mustard Thermal



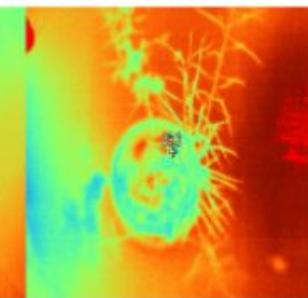
Results of Siamese Network - Mustard Thermal



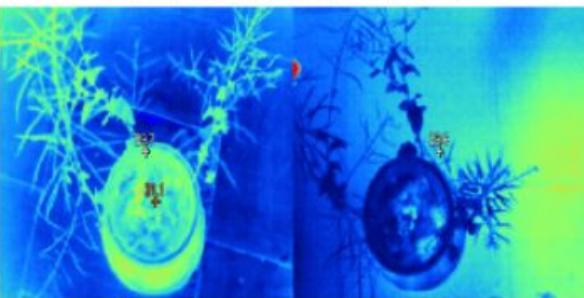
True: 0.0 | Pred: 0.63100



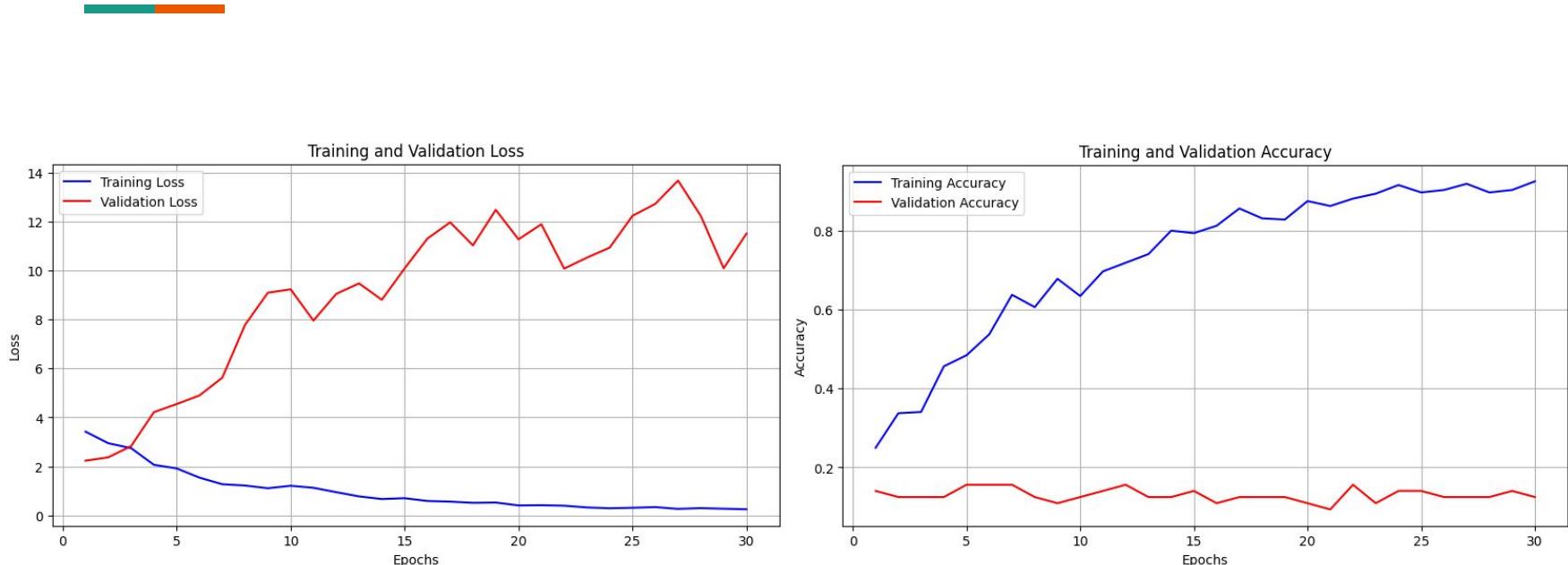
True: 1.0 | Pred: 0.55726



True: 0.0 | Pred: 0.63976



CNN Model result with palm plant



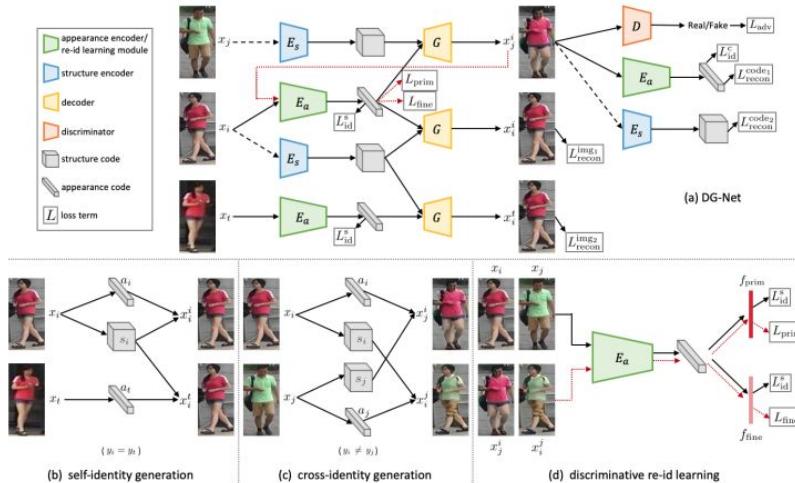


Progress Update:

17 April 2024

DG Net

Generates using GAN by combining same identity and cross identity, which is further used to discriminate between the classes.



src - <https://arxiv.org/abs/1904.07223>

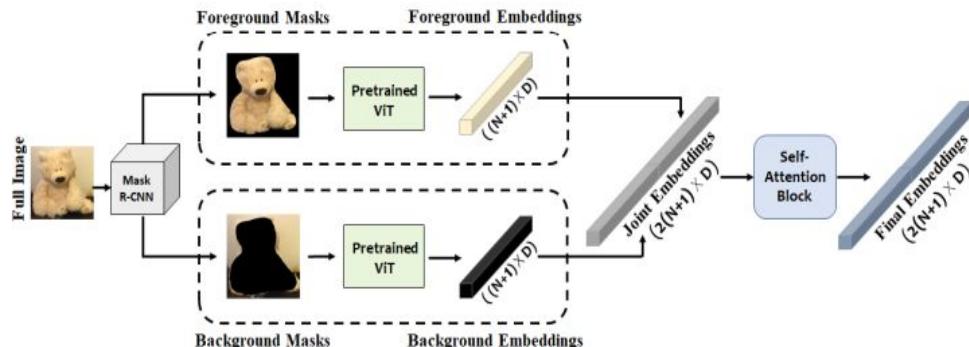
(Joint Discriminative and Generative Learning for Person Re-identification)

Object Instance Re-Identification with Attention

Uses mask RCNN to separate foreground and background of the image.

Using these separate images, it generates embeddings which is then used to create final embeddings.

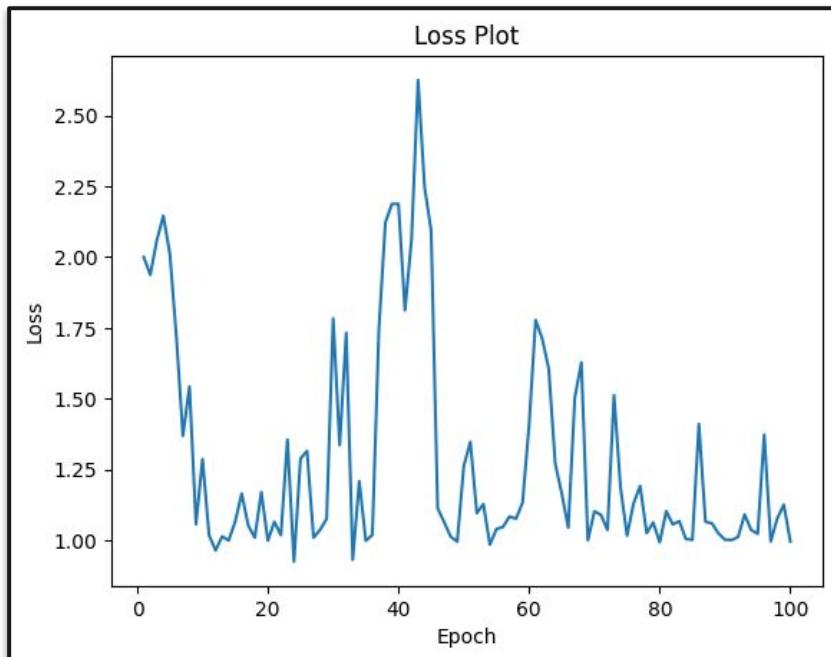
Final embeddings are passed to a triplet sampling layer, for triplet loss.



Further explored Siamese Network

- 1) Modified and tested with different internal CNN Models
- 2) Tried various dissimilarity metrics, such as,
 - a) Euclidean Distance
 - b) Manhattan Distance
 - c) KL-Divergence

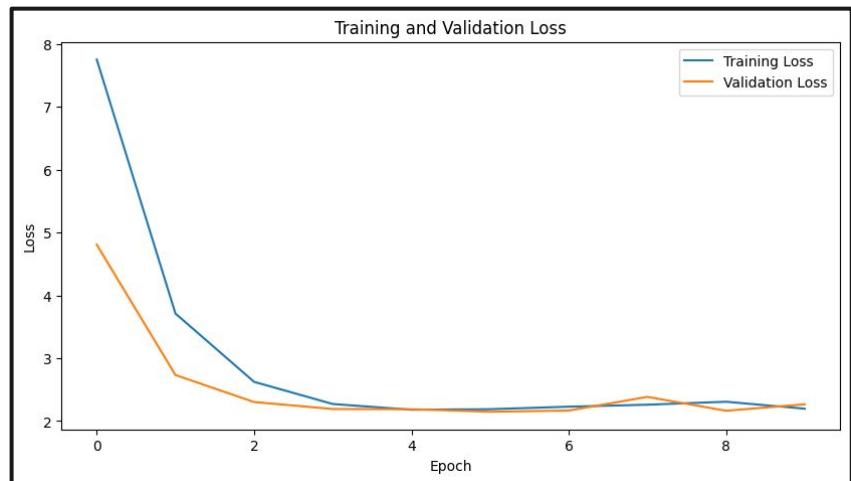
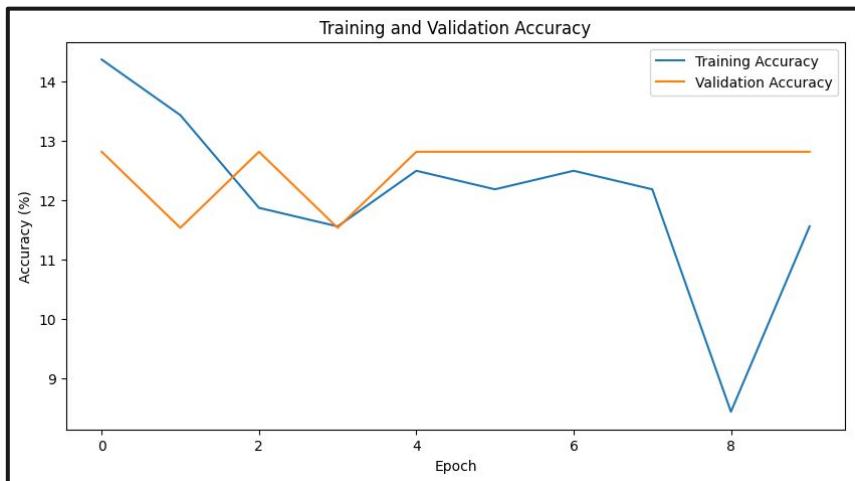
Results



Results (contd.)



Vision Transformer



Accuracy: ~14%

GhostFaceNet

The GhostFaceNet framework provides multiple object detector models, face recognition models and similarity metrics to work with. We utilised the followings:

1. Detector Models: VGG-Face, Facenet, OpenFace, ArcFace, SFace, GhostFaceNet
2. Recognition Models: opencv, ssd, dlib, fastmtcnn, retinaface, mediapipe, yolov8
3. Similarity metrics: cosine, euclidean

GhostFaceNet - Observations

		hash	target_x	target_y	target_w	target_h	source_x	source_y	source_w	source_h	threshold	distance
1	identity		0	0	640	481	0	0	640	481	1.13	0.12512709336716363
2	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04588.png	42a3141e854a801c711da55a1049172d70db905	0	0	640	481	0	0	640	481	1.13	0.13790637569018901
3	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04662.png	e1295ab2ba0dd446680ec22849f2d5b258155197	0	0	640	481	0	0	640	481	1.13	0.13790637569018901
4	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04661.png	21c178bed39f73bccc092d334b23aea7c2e713a	0	0	640	481	0	0	640	481	1.13	0.13880784152918524
5	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04439.png	e1fd40253f41a01bdc4921997413bcc19e30d97	0	0	640	481	0	0	640	481	1.13	0.1393392328804147
6	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04668.png	0b4d38288e892b4697ee99c30f50b35145999f27	0	0	640	481	0	0	640	481	1.13	0.13987782628152232
7	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04497.png	549b832dcaaf5c4f6fcbe462070fb4abb688d2e	0	0	640	481	0	0	640	481	1.13	0.1421846800065068
8	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04581.png	f9f558cad059a010e0ab87ae6a344325c5ed6ff	0	0	640	481	0	0	640	481	1.13	0.1435164502837301
9	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04504.png	1e012a111e5c7f7a4e431196ee579dc32ce951a	0	0	640	481	0	0	640	481	1.13	0.14436077717532475
10	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04584.png	88ec10f13870093fb67207b0e0e1a594f260	0	0	640	481	0	0	640	481	1.13	0.14436077717532475
11	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04440.png	e170fd508271870546c1d344a9e02871e4d184d1c	0	0	640	481	0	0	640	481	1.13	0.14716264774355728
12	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04582.png	a75e22cb91a5709cc0e0f346a511ff28c07372d	0	0	640	481	0	0	640	481	1.13	0.148748843879498
13	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04436.png	01e2a111e5c7f7a4e431196ee579dc32ce951a	0	0	640	481	0	0	640	481	1.13	0.15895724439816984
14	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04580.png	2fc477dc4a10afdf2c760998c0891c3b8912f80	0	0	640	481	0	0	640	481	1.13	0.1522933503185892
15	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04505.png	43c1f95bd0a2b019fc0e588bd3e1980a04854fd1	0	0	640	481	0	0	640	481	1.13	0.1524455624709055
16	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04660.png	e1c1464690a265330a02j605b659743a4f854680	0	0	640	481	0	0	640	481	1.13	0.1532388395287838
17	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04670.png	f44242d25198c946998b3b164219340b51b051	0	0	640	481	0	0	640	481	1.13	0.1575297313837711
18	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04583.png	d8059f39c7121e9247c39723f339fb5170b111	0	0	640	481	0	0	640	481	1.13	0.16066740175476431
19	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04437.png	328231bf2d8f748cf8de8375aa22075dfc53236	0	0	640	481	0	0	640	481	1.13	0.16562744895486034
20	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04579.png	4376740e0a7a1de5c4050b0bc9aaef9af6494eb	0	0	640	481	0	0	640	481	1.13	0.16618880799678592
21	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04498.png	a0db2a11397021a1bea4356bd05b0861264facc	0	0	640	481	0	0	640	481	1.13	0.1708911696455554
22	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04502.png	18cc0ecc0cd04e1bfeacd7c1a2132e8e70573	0	0	640	481	0	0	640	481	1.13	0.1704311191741907
23	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04585.png	f8031d5d1386e599c7a211ac98de5c3625ca	0	0	640	481	0	0	640	481	1.13	0.17045189399481486
24	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04586.png	6f8ad4c90a711ff903eaaef16937617744f8c1	0	0	640	481	0	0	640	481	1.13	0.174519152879487
25	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04665.png	7e79eccc79ad77c52bbfb1db1c808d8a5f990aca7	0	0	640	481	0	0	640	481	1.13	0.1763048796472395
26	drive/My Drive/Colab/ACPS/PlantPersona_data/Mustard/RGB/P1/IR_04499.png	df3c12269fbfd259b1b1225411370002f1c3898	0	0	640	481	0	0	640	481	1.13	0.17773759188743365

distance
0.12512709336716363
0.13790637569018901
0.13880784152918524
0.1393392320804147
0.13987782628152232
0.1421846800065068
0.1435164502837301
0.14436077717532475
0.14716264774355728
0.1487488443079498
0.15005724439816984
0.1522933503185892
0.15244556247097055
0.15323883952872838
0.1575297313037711
0.16066740175470431
0.16562744895486034
0.16618880799678592

Conclusion

1. We identified the plant instances with upto 70% and 80% accuracy for Mustard and Wheat plants respectively, using SVM classification.
2. For reidentification techniques, the similarity metric gives inconsistent values throughout the experimentation, resulting in indistinguishable from other plant instances.
3. We concur that the top view of plants could help when the crops have larger canopy such as lettuce and cauliflower, but for crops such as Wheat and Mustard, we may require side view to capture more details.



Thank You