50.021 Artificial Intelligence

Project Report

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1 Introduction

With advancement in the field of artificial intelligence, it has become increasingly easy to create deepfake content. We are now able to manipulate or replace parts of images and videos with minimal effort by using tools that are often made available to the public for free [1]. These tools do not require users to have prior knowledge of how technology works or any prior experience in video and photo editing, making them extremely accessible and convenient. While there is great interest and potential to use this technology for new artistic possibilities such as movie making, and paintings, it has also increased the ease of generating digitally altered realistic content by bad actors.

Historically, deepfake have always been used for malicious purposes. Initially, it was mainly created to spread pornographic content. However, in recent years, they have been used to create fake news, fake evidence during court trials and privacy violations. These malicious content tend to spread fast, posing a grave threat to society. A survey found that 71% of the people do not know what a deepfake is [2]. This can lead to serious and dangerous consequences, such as becoming a victim of a scam, when they believe and act upon the false information given to them in the video. Hence, it is important to detect whether a content has been digitally altered [3].

Although detecting deepfakes can be an effective way to tackle the threat of malicious content spreading, it is not a simple task. Our goal is to detect videos that have been manipulated using methods such as Deepfakes, Face2Face, FaceSwap and NeuralTextures. We explored various Convolutional Neural Network (CNN) models such as Residual Network (ResNet) and EfficientNet. Our best performing model, using EfficientNetB2 architecture with Adam optimiser, was able to obtain an accuracy of 0.8512.

2 Dataset

2.1 Overview of Dataset

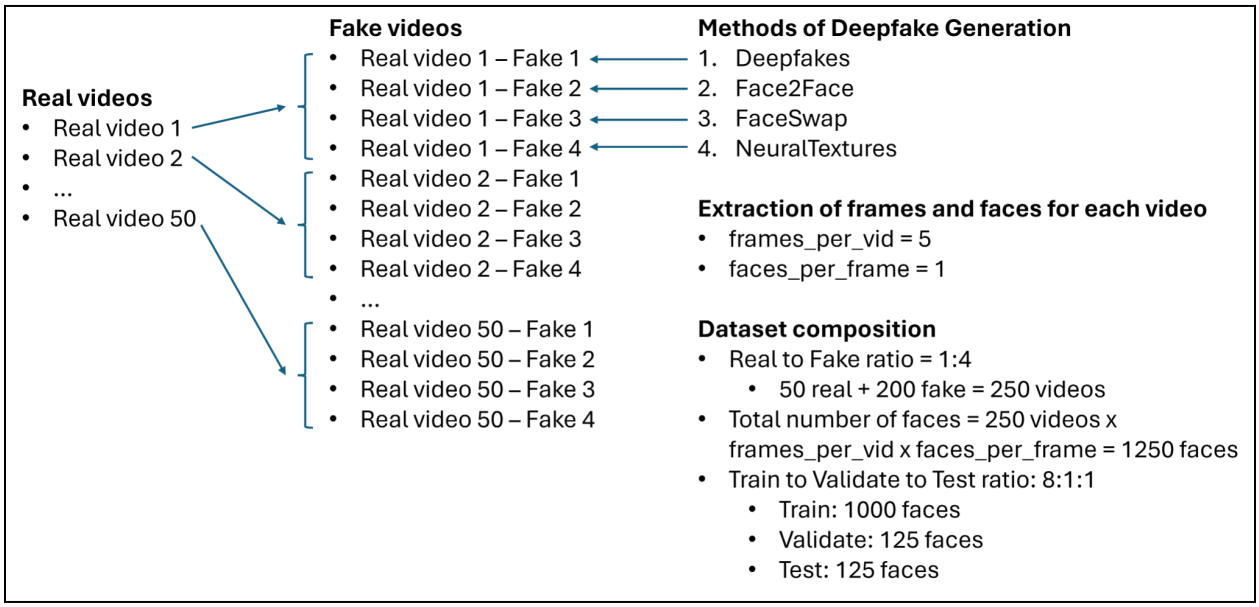


Figure 1. Overview of dataset

With the goal of detecting videos that have been manipulated using modern techniques, the team decided to train our model using FaceForensics++. It is a forensics dataset that is generated using state-of-the-art face manipulation methods such as facial reconstructions and facial reenactment [4]. The facial constructions method, include two different methods to perform facial reconstructions - FaceSwap and Deepfakes while facial reenactment houses another set of methods such as Face2Face and NeuralTextures. These four methods are then applied to 1000 video sequences sourced from youtube.

Due to resource constraints, we were only able to use a total of 250 videos, 50 real videos and 200 videos of their manipulated counterparts. The data was preprocessed to obtain a total of 1250 faces from all 250 videos and randomly split it into 1000 (80%) for training, 125 (10%) for validation and 125 (10%) for testing.

2.2 Preprocessing

The team preprocessed the training data to obtain the image data needed to train the model. First, we segmented the videos into frames and extracted 5 frames from each video. Next, the faces in these frames were extracted. During this process, the team realised that some images were not recognized correctly and were not helpful in the training process. Hence we decided to remove the wrong faces and only kept the images that are larger than 75x75 pixels. Following this, in order to prepare the image for training, we transformed all the images into 224x224 pixels. Using larger image sizes would require too much computational power, while small

image sizes would capture insufficient information required for training a model. Hence, we chose to use 224x224 image size as it strikes a balance between model accuracy and complexity. We were also using pre-trained ResNet models which required us to have input images of at least 224x224 [5].

Data preprocessing steps:

1. Extract 5 frames from each video
2. Use **face_recognition** to extract the faces
3. After generating the faces, we realised some images are not correctly recognized, these images are not helpful in the training process
4. Remove the wrong faces by only keeping faces >75x75 pixels
5. After getting all the images, transform them into pixels 224 x 224

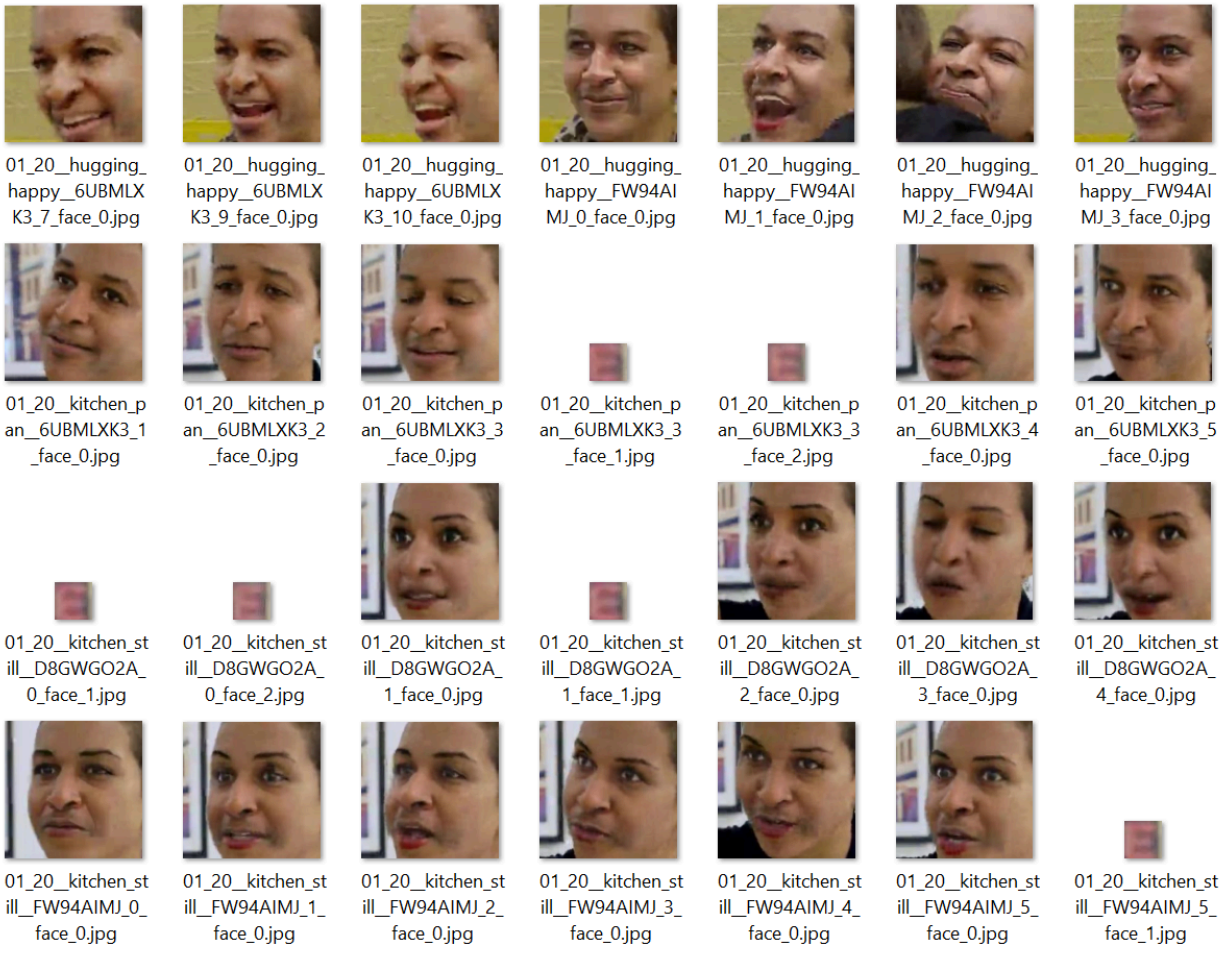


Figure 2. Images contained wrong faces and image of various sizes

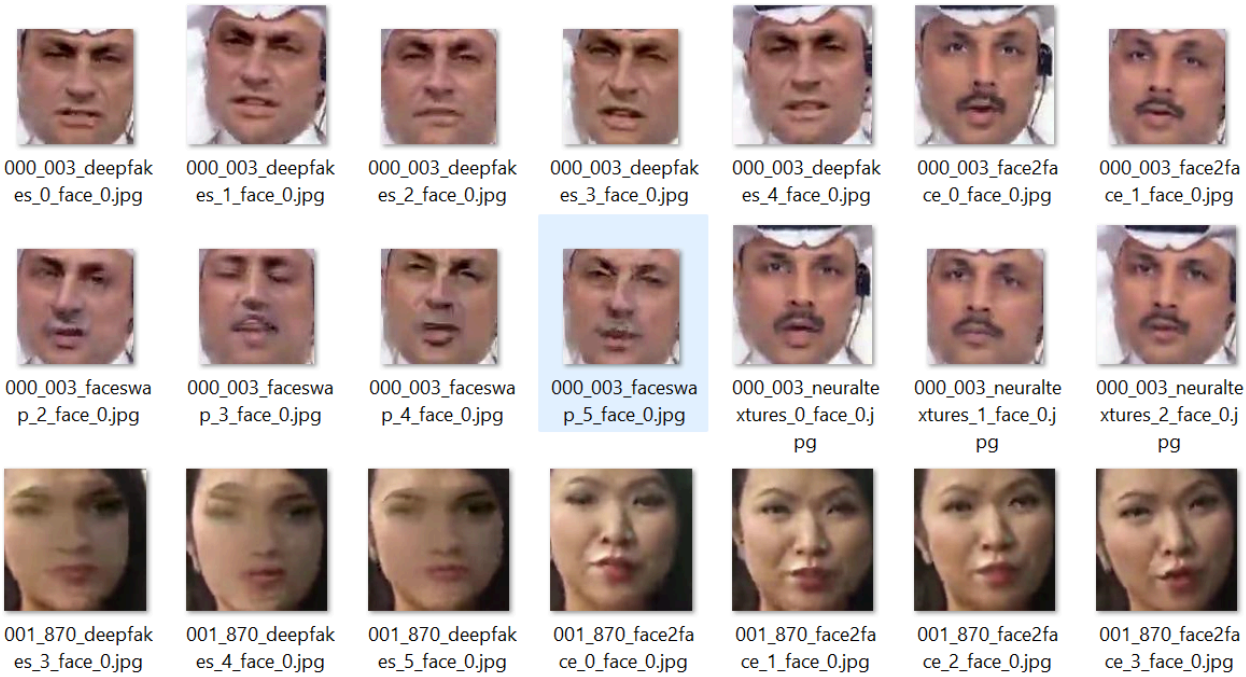


Figure 3. Filtered images after removal

3 Model

For our project, we decided to look into various CNN models, specifically, pre-trained models trained on ImageNet using ResNet and EfficientNet architectures. We have also decided to use the cross-entropy loss function as the default loss function across all models.

3.1 Residual Network (ResNet)

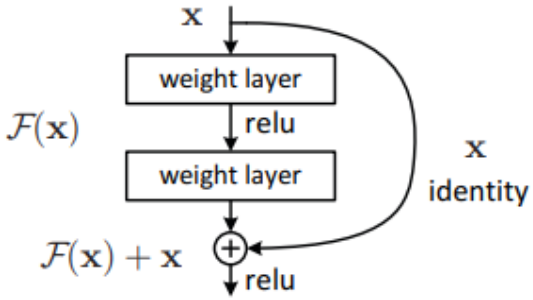


Figure 4. Residual learning

ResNet architecture was initially proposed in the “Deep Residual Learning for Image Recognition” paper to address the degradation problem encountered when training very deep neural networks [5]. The model learns residual functions with reference to the layer inputs instead of learning the desired underlying mapping directly. Each residual block consists of two or move convolution layers followed by a shortcut connection that skips one or more layers.

These shortcut connections perform identity mapping and add their output to the outputs of the stacked layers. The entire network can be trained by using stochastic gradient descent (SGD) with backpropagation.

3.2 EfficientNet

EfficientNet was first proposed in the paper “EfficientNet: Rethinking Model Scaling for Convolutional Neural Networks” to use a method called compound scaling to scale up models in a simple but effective manner [6]. It scales network width, depth and resolution uniformly with a set of fixed scaling coefficients, unlike traditional methods where these dimensions are scaled independently. The EfficientNet family includes different variants from EfficientNet-B0 to EfficientNet-B7, each representing a different scale of the EfficientNet architecture. EfficientNet-B0 is the baseline model in the EfficientNet series, while the other models are scaled from the baseline using different compound coefficients.

4 Training

4.1 Overview of Model Exploration

We conducted experiments using various ResNet and EfficientNet pre-trained models on ImageNet, while keeping the number of epochs and batch size the same across all experiments at 15 and 32 respectively. Cross-entropy loss function was used as the default loss function. We modified following hyper-parameters and configurations to find the best performing model to tackle the identification of deepfakes:

- Optimizer
- Learning rate
- L2 regularisation via weight decay
- Dropout rate

4.2 Methodology

The first exploration we did was architecture exploration, with the aim of finding the best model for each of the model architecture. The five ResNet models vary in the numbers of layers in the network, while the six EfficientNet models are of various different scales. We were able to narrow down all the ResNet options to ResNet50 and EfficientNet options to EfficientNetB2.

Further explorations were then conducted, focusing on ResNet50 and EfficientNetB2. The two models were trained with different hyper-parameters to find the best performing model among them.

We evaluated the models using accuracy, precision, recall and F1 score. These matrices score from 0 to 1 where a value close to 1 would mean that the model is performing very well on its given task, such as being able to identify deepfakes correctly in our project context.

The subsections will detail the settings used for each training and the results obtained. Full results obtained during training can be found in the appendix.

Constants	
Purpose	Transfer learning to improve the speed
Loss function	CrossEntropyLoss
Number of epochs	15
Batch size	32

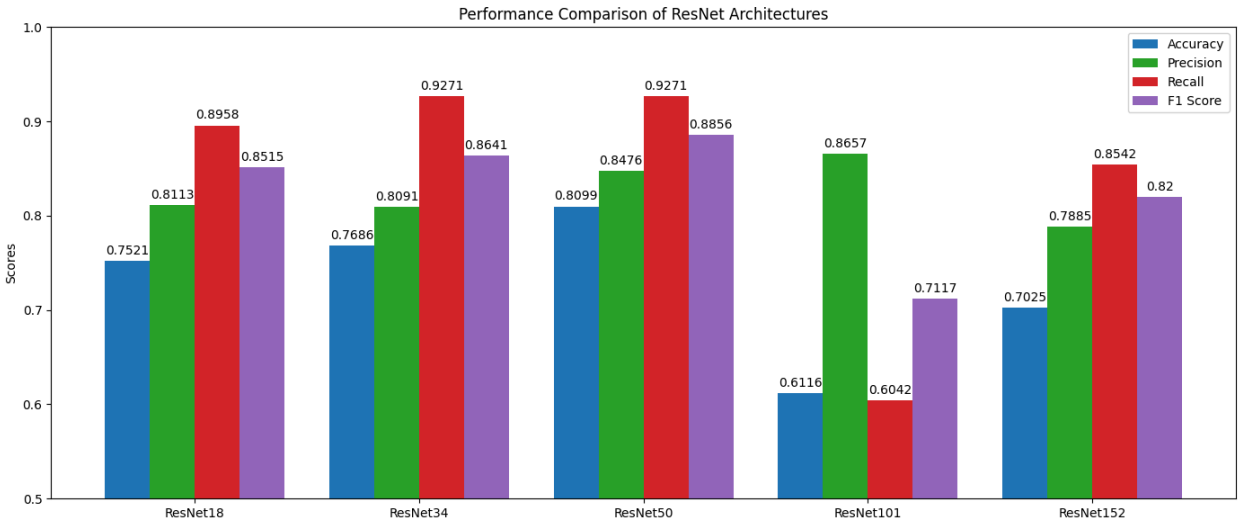
Variables		
Model	ResNet	ResNet18, ResNet34, ResNet50, ResNet101, ResNet152
	EfficientNet	EfficientNetB0, EfficientNetB1, EfficientNetB2, EfficientNetB3, EfficientNetB4, EfficientNetB5
Optimizer		Adam, SGD, Adadelta, RMSprop
Learning rate		5e-3, 1e-3, 5e-4
L2 regularisation via weight decay		0, 1e-3, 1e-4, 1e-5, 1e-6, 1e-7
Dropout		0, 0.1, 0.2, 0.3, 0.4, 0.5

4.2 ResNet Architecture Exploration

Try different ResNet architectures while keeping the parameters the same

- Optimiser: Adam, Learning rate: 1e-3, Weight decay: 0, Dropout probability: 0, Epochs: 15
- Best ResNet architecture from exploration: ResNet50

Comparison of ResNet test scores for the ResNet architecture exploration:



ResNet Architecture	Test Accuracy	Test Precision	Test Recall	Test F1 Score
ResNet18	0.7521	0.8113	0.8958	0.8515
ResNet34	0.7686	0.8091	0.9271	0.8641
ResNet50	0.8099	0.8476	0.9271	0.8856
ResNet101	0.6116	0.8657	0.6042	0.7117
ResNet152	0.7025	0.7885	0.8542	0.8200

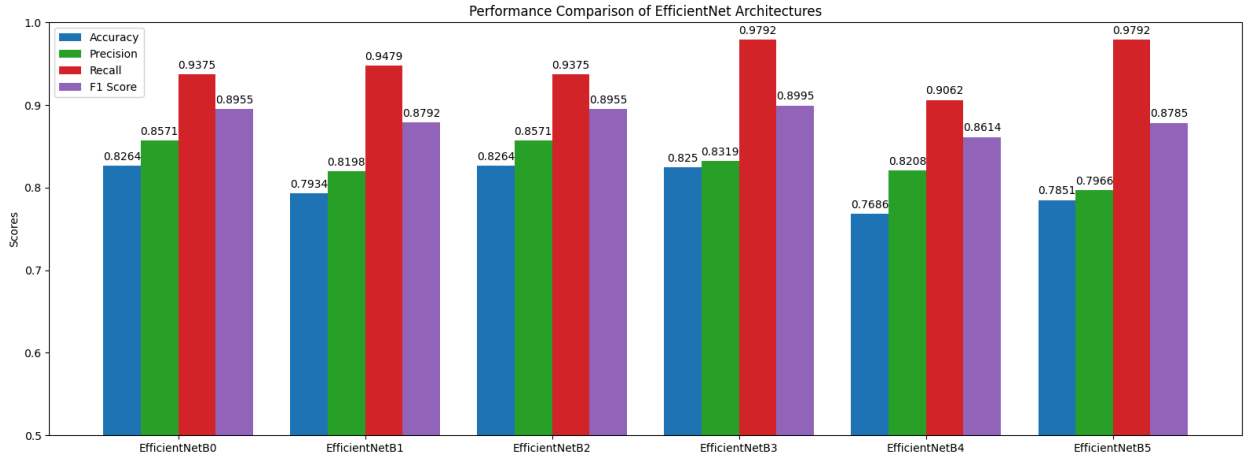
For ResNet, ResNet50 was chosen as the best ResNet architecture for our use case. Even though ResNet101 had a higher precision score, ResNet50 resulted in a much higher accuracy, recall and F1 score. This means that ResNet50 will predict much fewer false negatives.

4.3 EfficientNet Architecture Exploration

Try different EfficientNet architectures while keeping the parameters the same

- Optimiser: Adam, Learning rate: 1e-3, Weight decay: 0, Dropout probability: 0, Epochs: 15
- Best EfficientNet architecture from exploration: EfficientNetB2

Comparison of EfficientNet test scores for the EfficientNet architecture exploration:



EfficientNet Architecture	**Test Accuracy**	**Test Precision**	**Test Recall**	**Test F1 Score**
EfficientNetB0	0.8264	0.8571	0.9375	0.8955
EfficientNetB1	0.7934	0.8198	0.9479	0.8792
EfficientNetB2	0.8264	0.8571	0.9375	0.8955
EfficientNetB3	0.8250	0.8319	0.9792	0.8995
EfficientNetB4	0.7686	0.8208	0.9062	0.8614
EfficientNetB5	0.7851	0.7966	0.9792	0.8785

For EfficientNet, EfficientNetB2 was chosen as the best EfficientNet architecture for our use case. Even though EfficientNetB3 had a higher F1 score, EfficientNetB2 resulted in a higher accuracy and precision. A higher precision is preferable when the two architectures achieve a similar accuracy, in the context of a dataset with 4:1 fake to real composition, as this means that EfficientNetB2 will predict fewer false positives.

4.4 Optimiser Exploration

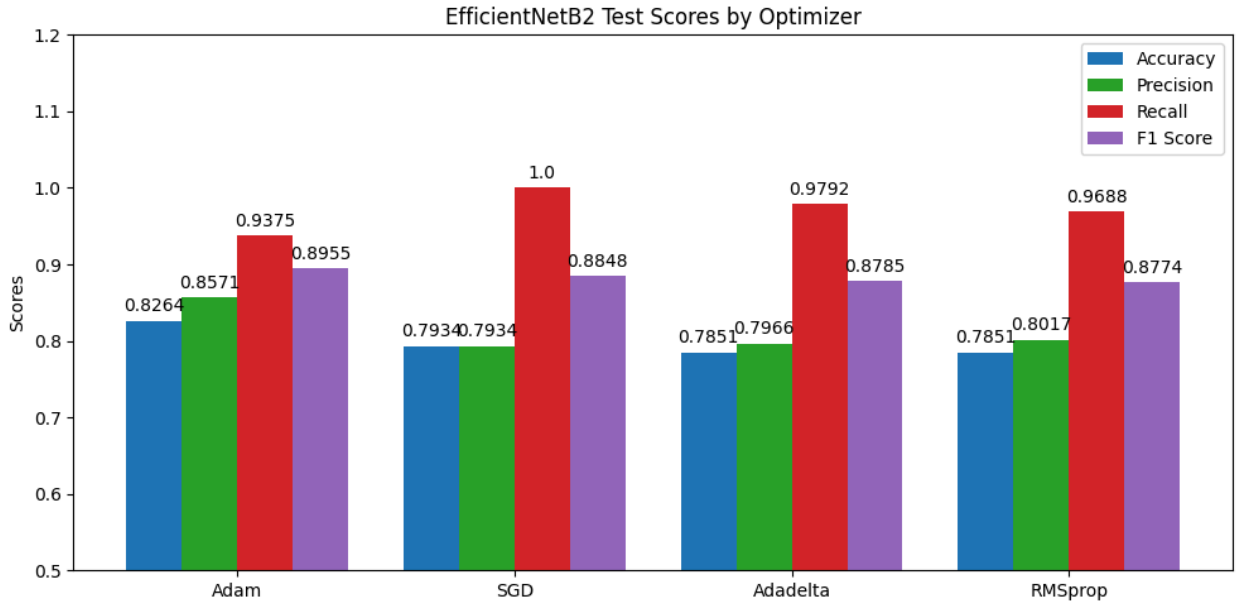
Using the best ResNet and EfficientNet architectures so far, try different optimisers while keeping the architecture and other parameters the same

- Model: ResNet50 and EfficientNetB2, Learning rate: 1e-3, Weight decay: 0, Dropout probability: 0, Epochs: 15
- Best optimiser from exploration: Adam

Comparison of ResNet50 test scores for the optimiser exploration:

Optimiser	Test Accuracy	Test Precision	Test Recall	Test F1 Score
Adam	0.8099	0.8476	0.9271	0.8856
SGD	0.7934	0.7934	1.0000	0.8848
Adadelta	0.7934	0.7934	1.0000	0.8848
RMSprop	0.7934	0.7934	1.0000	0.8848

Comparison of EfficientNetB2 test scores for the optimizer exploration



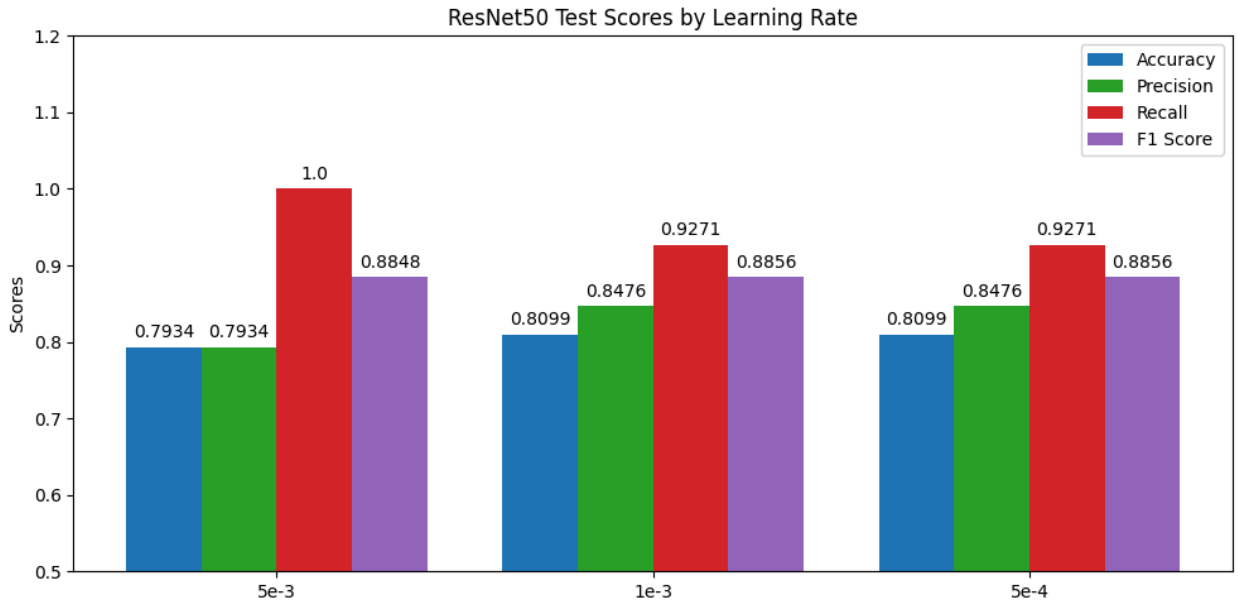
Optimiser	Test Accuracy	Test Precision	Test Recall	Test F1 Score
Adam	0.8264	0.8571	0.9375	0.8955
SGD	0.7934	0.7934	1.0000	0.8848
Adadelta	0.7851	0.7966	0.9792	0.8785
RMSprop	0.7851	0.8017	0.9688	0.8774

4.5 Learning Rate Exploration

Using the best ResNet architecture, EfficientNet architecture, and optimiser so far, try different learning rates while keeping the architecture and other parameters the same

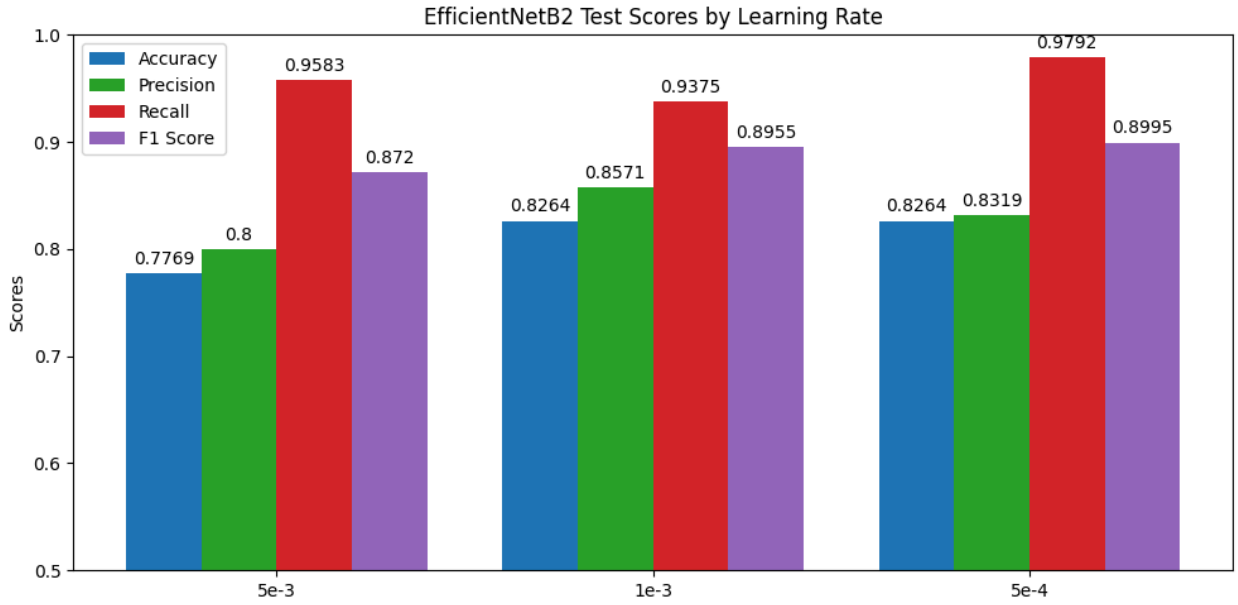
- Model: ResNet50 and EfficientNetB2, Optimiser: Adam, Weight decay: 0, Dropout probability: 0, Epochs: 15 (Dropout: 0)
- Best learning rate from exploration: 1e-3

Comparison of ResNet50 test scores for the learning rate exploration:



Learning Rate	Test Accuracy	Test Precision	Test Recall	Test F1 Score
5e-3	0.7934	0.7934	1.0000	0.8848
1e-3	0.8099	0.8476	0.9271	0.8856
5e-4	0.8099	0.8476	0.9271	0.8856

Comparison of EfficientNetB2 test scores for the learning rate exploration



Learning Rate	Test Accuracy	Test Precision	Test Recall	Test F1 Score
5e-3	0.7769	0.8000	0.9583	0.8720
1e-3	0.8264	0.8571	0.9375	0.8955
5e-4	0.8264	0.8319	0.9792	0.8995

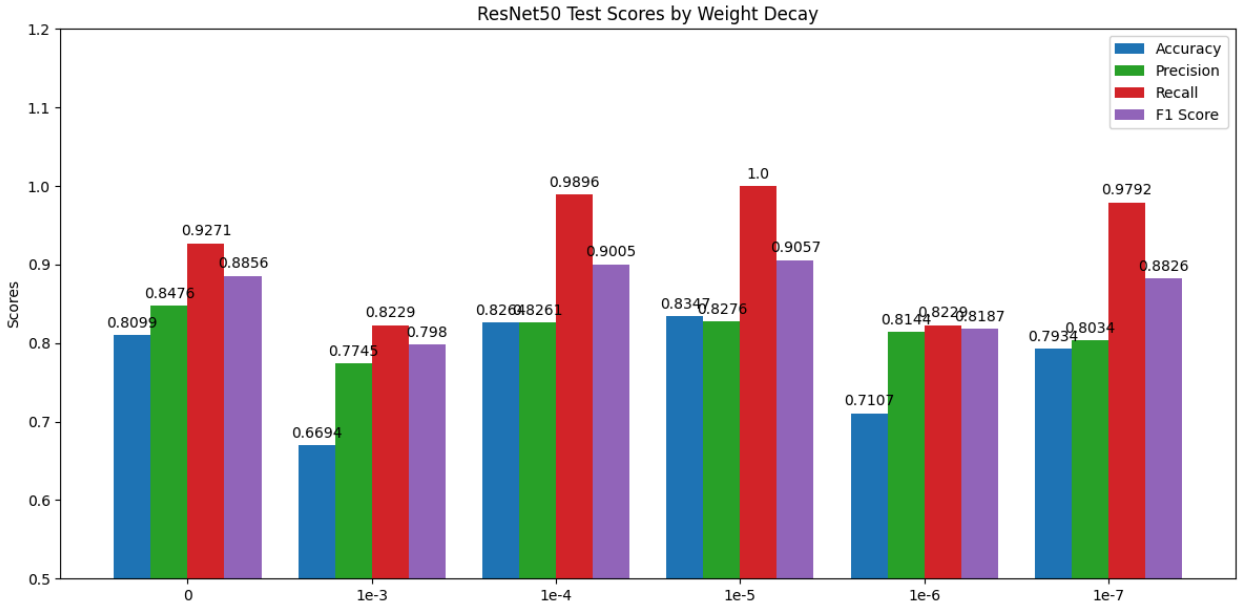
For EfficientNetB2, 1e-3 was chosen as the best learning rate, since 1e-3 and 5e-4 resulted in the same accuracy, but 1e-3 resulted in a higher precision. A higher precision is preferable when the two learning rates achieve a similar accuracy, in the context of a dataset with 4:1 fake to real composition, as this means that the model will predict fewer false positives.

4.6 Weight Decay Exploration

Using the best ResNet architecture, EfficientNet architecture, optimiser and learning rate so far, try different values for weight decay while keeping the architecture and other parameters the same

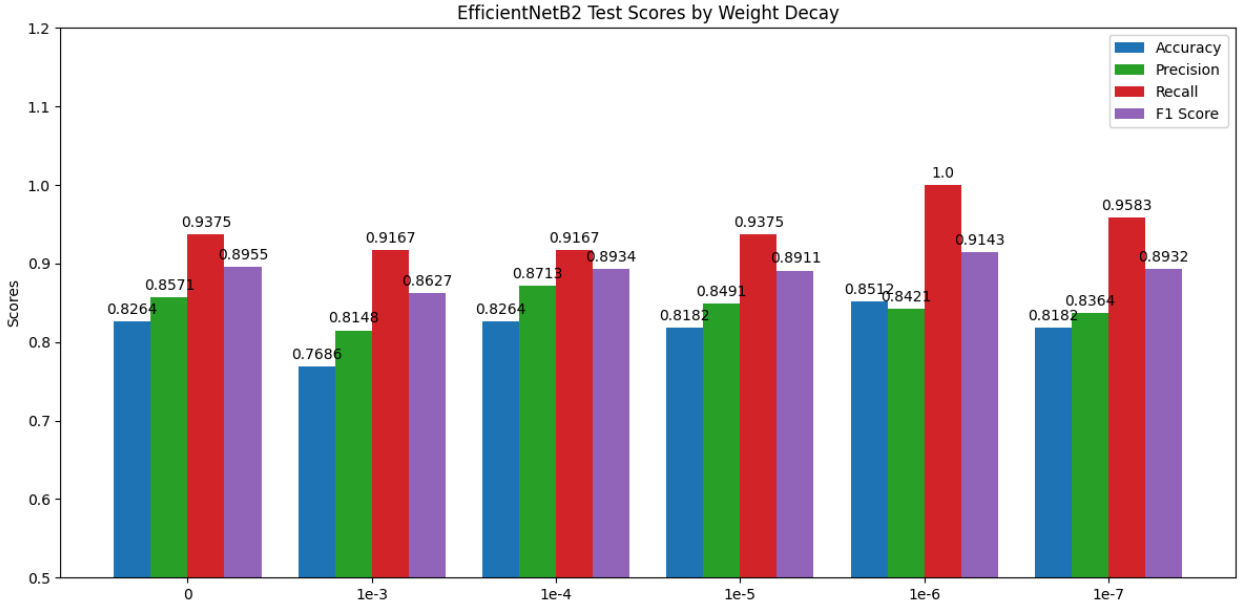
- Model: ResNet50 and EfficientNetB2, Optimiser: Adam, Learning rate: 0.001, Dropout probability: 0, Epochs: 15
- Best weight decay from exploration:
    - ResNet50: 1e-5
    - EfficientNetB2: 1e-6

Comparison of ResNet50 test scores for the weight decay exploration:



Weight Decay	Test Accuracy	Test Precision	Test Recall	Test F1 Score
0	0.8099	0.8476	0.9271	0.8856
1e-3	0.6694	0.7745	0.8229	0.7980
1e-4	0.8264	0.8261	0.9896	0.9005
1e-5	0.8347	0.8276	1.0000	0.9057
1e-6	0.7107	0.8144	0.8229	0.8187
1e-7	0.7934	0.8034	0.9792	0.8826

Comparison of EfficientNetB2 test scores for the weight decay exploration



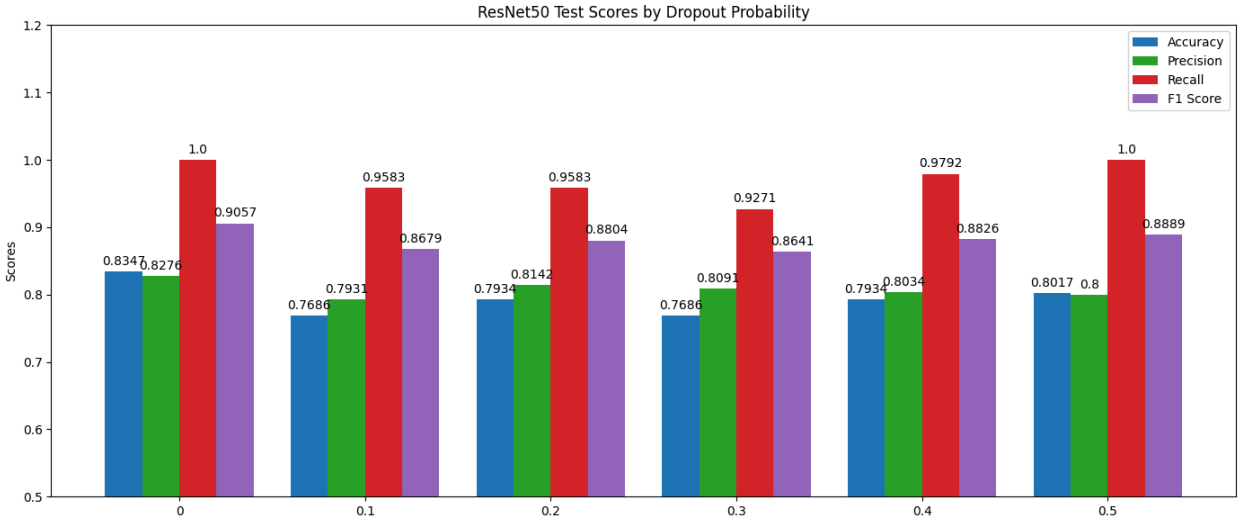
Weight Decay	Test Accuracy	Test Precision	Test Recall	Test F1 Score
0	0.8264	0.8571	0.9375	0.8955
1e-3	0.7686	0.8148	0.9167	0.8627
1e-4	0.8264	0.8713	0.9167	0.8934
1e-5	0.8182	0.8491	0.9375	0.8911
1e-6	0.8512	0.8421	1.0000	0.9143
1e-7	0.8182	0.8364	0.9583	0.8932

4.7 Dropout Probability Exploration

Using the best ResNet architecture, EfficientNet architecture, optimiser, learning rate and weight decay so far, try different values for dropout probability while keeping the architecture and other parameters the same

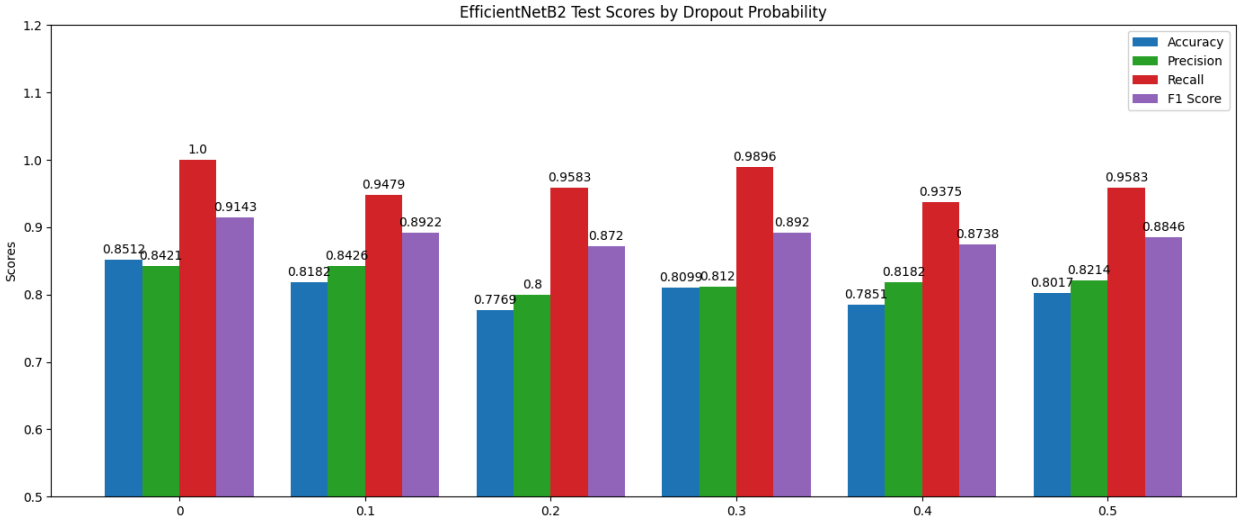
- Model: ResNet50 and EfficientNetB2, Optimiser: Adam, Learning rate: 0.001, Weight decay: 1e-5 (ResNet50) and 1e-6 (EfficientNetB2), Epochs: 15
- Best dropout probability from exploration: 0

Comparison of ResNet50 test scores for the dropout probability exploration:



Dropout Probability	Test Accuracy	Test Precision	Test Recall	Test F1 Score
0	0.8347	0.8276	1.0000	0.9057
0.1	0.7686	0.7931	0.9583	0.8679
0.2	0.7934	0.8142	0.9583	0.8804
0.3	0.7686	0.8091	0.9271	0.8641
0.4	0.7934	0.8034	0.9792	0.8826
0.5	0.8017	0.8000	1.0000	0.8889

Comparison of EfficientNetB2 test scores for the dropout probability exploration



Dropout Probability	Test Accuracy	Test Precision	Test Recall	Test F1 Score
0	0.8512	0.8421	1.0000	0.9143
0.1	0.8182	0.8426	0.9479	0.8922
0.2	0.7769	0.8000	0.9583	0.8720
0.3	0.8099	0.8120	0.9896	0.8920
0.4	0.7851	0.8182	0.9375	0.8738
0.5	0.8017	0.8214	0.9583	0.8846

5 Result

In conclusion, the best configuration we found was EfficientNetB2 architecture, with Adam optimiser with learning rate of 1e-3 and weight decay of 1e-6, with no dropout. We were able to achieve test scores with accuracy of 0.8512, precision of 0.8421, recall of 1 and F1 score of 0.9143.

The configuration of ResNet50 architecture, with Adam optimiser with learning rate of 1e-3 and weight decay of 1e-5, with no dropout, was able to reach a close level of performance. We were able to achieve test scores with accuracy of 0.8347, precision of 0.8276, recall of 1 and F1 score of 0.9057.

6 GUI

We have created a basic front-end GUI using Python's Tkinter library. When the user selects a video, the path of the video and four images extracted from the video will be displayed. If the selected file format is not a video, the GUI will remain empty. At the bottom, the GUI will display the prediction result indicating whether the video is classified as fake or real.

To access the GUI, please run the script named **GUI.py**.

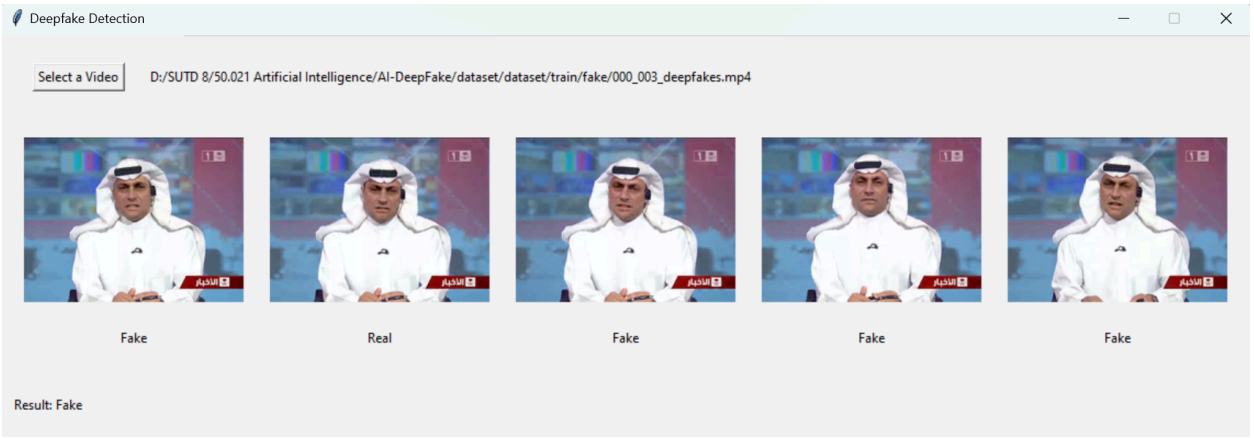


Figure 5. GUI of a video being classified as fake

7 Future Improvements

Moving forward, there are numerous enhancements that can be made to improve the effectiveness and generalizability of our deepfake detection system.

Better configurations of EfficientNet and ResNet models may be found with different exploration methods, such as a different order of exploring the parameters, as well as repeated searches iterating through the parameters multiple times, to achieve a more extensive search through the space of possible configurations.

We can also try to explore other architectures such as DenseNet, as well as transformers such as MaxViT and ViT-B. This would also include fine-tuning the models with a more extensive and diverse dataset.

To further improve on generalizability, we can apply different methods of distractions to the dataset during the pre-processing stage, as well as consider more methods of deepfake generation in obtaining the fake videos.

References

[1] “Deepfakes github,” https://github.com/deepfakes/faceswap.
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[3] S. Agarwal, H. Farid, Y. Gu, M. He, K. Nagano, and H. Li, “Protecting world leaders against deep fakes,” in IEEE Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), 2019.
[4] A. Rossler, D. Cozzolino, L. Verdoliva, C. Riess, J. Thies, and M. Nießner, “FaceForensics++: Learning to detect manipulated facial images,” in International Conference on Computer Vision (ICCV), 2019.
[5] He, Kaiming, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. "Deep residual learning for image recognition." In Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 770-778. 2016.
[6] M. Tan and Q. V. Le, “Efficientnet: Rethinking model scaling for convolutional neural networks,” in International Conference on Machine Learning, (ICML) 2019, ser. Proceedings of Machine Learning Research, vol. 97. PMLR, 2019, pp. 6105–6114

Appendix

ResNet Architecture Exploration

ResNet18_Adam_LR1e-3_WD0_DP0_EP15

- Training:
  - Epoch 1/15, Loss: 0.6518, Acc: 0.7622
  - Epoch 2/15, Loss: 0.5053, Acc: 0.7944
  - Epoch 3/15, Loss: 0.5162, Acc: 0.8079
  - Epoch 4/15, Loss: 0.4606, Acc: 0.8079
  - Epoch 5/15, Loss: 0.4201, Acc: 0.8245
  - Epoch 6/15, Loss: 0.3964, Acc: 0.8411
  - Epoch 7/15, Loss: 0.3611, Acc: 0.8588
  - Epoch 8/15, Loss: 0.4258, Acc: 0.8349
  - Epoch 9/15, Loss: 0.4691, Acc: 0.8120
  - Epoch 10/15, Loss: 0.3901, Acc: 0.8318
  - Epoch 11/15, Loss: 0.3660, Acc: 0.8515
  - Epoch 12/15, Loss: 0.2864, Acc: 0.8775
  - Epoch 13/15, Loss: 0.3298, Acc: 0.8671
  - Epoch 14/15, Loss: 0.2025, Acc: 0.9211
  - Epoch 15/15, Loss: 0.1876, Acc: 0.9367
- Validation Scores:
  - Accuracy: 0.8167
  - Precision: 0.8246
  - Recall: 0.9792
  - F1 Score: 0.8952
- Test Scores:
  - Accuracy: 0.7521
  - Precision: 0.8113
  - Recall: 0.8958
  - F1 Score: 0.8515

ResNet34_Adam_LR1e-3_WD0_DP0_EP15

- Training:
  - Epoch 1/15, Loss: 0.6564, Acc: 0.7705
  - Epoch 2/15, Loss: 0.4989, Acc: 0.8017
  - Epoch 3/15, Loss: 0.4897, Acc: 0.8027
  - Epoch 4/15, Loss: 0.4854, Acc: 0.7975
  - Epoch 5/15, Loss: 0.4956, Acc: 0.8006
  - Epoch 6/15, Loss: 0.5168, Acc: 0.8017
  - Epoch 7/15, Loss: 0.4842, Acc: 0.8037
  - Epoch 8/15, Loss: 0.4958, Acc: 0.7944

    - Epoch 9/15, Loss: 0.4626, Acc: 0.8152
    - Epoch 10/15, Loss: 0.4691, Acc: 0.8152
    - Epoch 11/15, Loss: 0.4474, Acc: 0.8183
    - Epoch 12/15, Loss: 0.4786, Acc: 0.8120
    - Epoch 13/15, Loss: 0.4450, Acc: 0.8235
    - Epoch 14/15, Loss: 0.4215, Acc: 0.8266
    - Epoch 15/15, Loss: 0.4085, Acc: 0.8318
- Validation Scores:
    - Accuracy: 0.7833
    - Precision: 0.8070
    - Recall: 0.9583
    - F1 Score: 0.8762
- Test Scores:
    - Accuracy: 0.7686
    - Precision: 0.8091
    - Recall: 0.9271
    - F1 Score: 0.8641

ResNet50_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5659, Acc: 0.7809
    - Epoch 2/15, Loss: 0.5120, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4492, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4397, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4411, Acc: 0.8017
    - Epoch 6/15, Loss: 0.4079, Acc: 0.8110
    - Epoch 7/15, Loss: 0.3784, Acc: 0.8172
    - Epoch 8/15, Loss: 0.3572, Acc: 0.8349
    - Epoch 9/15, Loss: 0.3216, Acc: 0.8484
    - Epoch 10/15, Loss: 0.2285, Acc: 0.9065
    - Epoch 11/15, Loss: 0.2850, Acc: 0.8837
    - Epoch 12/15, Loss: 0.2321, Acc: 0.9117
    - Epoch 13/15, Loss: 0.1949, Acc: 0.9232
    - Epoch 14/15, Loss: 0.1405, Acc: 0.9460
    - Epoch 15/15, Loss: 0.1105, Acc: 0.9657
- Validation Scores:
    - Accuracy: 0.7750
    - Precision: 0.8350
    - Recall: 0.8958
    - F1 Score: 0.8643
- Test Scores:
    - Accuracy: 0.8099
    - Precision: 0.8476
    - Recall: 0.9271

    - F1 Score: 0.8856

ResNet101_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5392, Acc: 0.7954
    - Epoch 2/15, Loss: 0.5245, Acc: 0.7902
    - Epoch 3/15, Loss: 0.4682, Acc: 0.7996
    - Epoch 4/15, Loss: 0.4406, Acc: 0.8089
    - Epoch 5/15, Loss: 0.4308, Acc: 0.8172
    - Epoch 6/15, Loss: 0.3692, Acc: 0.8515
    - Epoch 7/15, Loss: 0.4215, Acc: 0.8183
    - Epoch 8/15, Loss: 0.4153, Acc: 0.8193
    - Epoch 9/15, Loss: 0.3002, Acc: 0.8754
    - Epoch 10/15, Loss: 0.2076, Acc: 0.9242
    - Epoch 11/15, Loss: 0.3571, Acc: 0.8432
    - Epoch 12/15, Loss: 0.3564, Acc: 0.8671
    - Epoch 13/15, Loss: 0.2721, Acc: 0.8899
    - Epoch 14/15, Loss: 0.1599, Acc: 0.9387
    - Epoch 15/15, Loss: 0.1365, Acc: 0.9543
- Validation Scores:
    - Accuracy: 0.5833
    - Precision: 0.8286
    - Recall: 0.6042
    - F1 Score: 0.6988
- Test Scores:
    - Accuracy: 0.6116
    - Precision: 0.8657
    - Recall: 0.6042
    - F1 Score: 0.711

ResNet152_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5456, Acc: 0.7996
    - Epoch 2/15, Loss: 0.5078, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4975, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4777, Acc: 0.8100
    - Epoch 5/15, Loss: 0.4665, Acc: 0.8079
    - Epoch 6/15, Loss: 0.4428, Acc: 0.8089
    - Epoch 7/15, Loss: 0.3927, Acc: 0.8422
    - Epoch 8/15, Loss: 0.3194, Acc: 0.8744

    - Epoch 9/15, Loss: 0.3216, Acc: 0.8660
    - Epoch 10/15, Loss: 0.3249, Acc: 0.8795
    - Epoch 11/15, Loss: 0.3420, Acc: 0.8609
    - Epoch 12/15, Loss: 0.2068, Acc: 0.9159
    - Epoch 13/15, Loss: 0.2560, Acc: 0.8899
    - Epoch 14/15, Loss: 0.2382, Acc: 0.9003
    - Epoch 15/15, Loss: 0.1851, Acc: 0.9356
- Validation Scores:
    - Accuracy: 0.7417
    - Precision: 0.8218
    - Recall: 0.8646
    - F1 Score: 0.8426
- Test Scores:
    - Accuracy: 0.7025
    - Precision: 0.7885
    - Recall: 0.8542
    - F1 Score: 0.8200

EfficientNet Architecture Exploration

EfficientNetB0_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5451, Acc: 0.7622
    - Epoch 2/15, Loss: 0.4324, Acc: 0.8162
    - Epoch 3/15, Loss: 0.3787, Acc: 0.8442
    - Epoch 4/15, Loss: 0.2884, Acc: 0.8723
    - Epoch 5/15, Loss: 0.2309, Acc: 0.9107
    - Epoch 6/15, Loss: 0.1657, Acc: 0.9418
    - Epoch 7/15, Loss: 0.1127, Acc: 0.9668
    - Epoch 8/15, Loss: 0.1337, Acc: 0.9512
    - Epoch 9/15, Loss: 0.0990, Acc: 0.9605
    - Epoch 10/15, Loss: 0.2470, Acc: 0.9086
    - Epoch 11/15, Loss: 0.1996, Acc: 0.9273
    - Epoch 12/15, Loss: 0.0844, Acc: 0.9657
    - Epoch 13/15, Loss: 0.0506, Acc: 0.9834
    - Epoch 14/15, Loss: 0.0407, Acc: 0.9844
    - Epoch 15/15, Loss: 0.0474, Acc: 0.9834
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8544
    - Recall: 0.9167
    - F1 Score: 0.8844

- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8571
    - Recall: 0.9375
    - F1 Score: 0.8955

EfficientNetB1_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5311, Acc: 0.7747
    - Epoch 2/15, Loss: 0.4032, Acc: 0.8224
    - Epoch 3/15, Loss: 0.3067, Acc: 0.8692
    - Epoch 4/15, Loss: 0.3376, Acc: 0.8671
    - Epoch 5/15, Loss: 0.1526, Acc: 0.9377
    - Epoch 6/15, Loss: 0.1873, Acc: 0.9211
    - Epoch 7/15, Loss: 0.1218, Acc: 0.9626
    - Epoch 8/15, Loss: 0.0675, Acc: 0.9699
    - Epoch 9/15, Loss: 0.0672, Acc: 0.9782
    - Epoch 10/15, Loss: 0.1719, Acc: 0.9377
    - Epoch 11/15, Loss: 0.1087, Acc: 0.9543
    - Epoch 12/15, Loss: 0.0507, Acc: 0.9782
    - Epoch 13/15, Loss: 0.0173, Acc: 0.9938
    - Epoch 14/15, Loss: 0.0151, Acc: 0.9958
    - Epoch 15/15, Loss: 0.2486, Acc: 0.9200
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8158
    - Recall: 0.9688
    - F1 Score: 0.8857
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.8198
    - Recall: 0.9479
    - F1 Score: 0.8792

EfficientNetB2_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4416, Acc: 0.8079
    - Epoch 3/15, Loss: 0.3197, Acc: 0.8484
    - Epoch 4/15, Loss: 0.3537, Acc: 0.8453
    - Epoch 5/15, Loss: 0.2455, Acc: 0.8962

    - Epoch 6/15, Loss: 0.1704, Acc: 0.9335
    - Epoch 7/15, Loss: 0.1402, Acc: 0.9460
    - Epoch 8/15, Loss: 0.1529, Acc: 0.9491
    - Epoch 9/15, Loss: 0.1298, Acc: 0.9502
    - Epoch 10/15, Loss: 0.0703, Acc: 0.9761
    - Epoch 11/15, Loss: 0.1414, Acc: 0.9512
    - Epoch 12/15, Loss: 0.2478, Acc: 0.9097
    - Epoch 13/15, Loss: 0.0890, Acc: 0.9699
    - Epoch 14/15, Loss: 0.1319, Acc: 0.9470
    - Epoch 15/15, Loss: 0.0477, Acc: 0.9865
- Validation Scores:
    - Accuracy: 0.8333
    - Precision: 0.8585
    - Recall: 0.9479
    - F1 Score: 0.9010
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8571
    - Recall: 0.9375
    - F1 Score: 0.8955

EfficientNetB3_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5252, Acc: 0.7736
    - Epoch 2/15, Loss: 0.4069, Acc: 0.8100
    - Epoch 3/15, Loss: 0.2982, Acc: 0.8837
    - Epoch 4/15, Loss: 0.1846, Acc: 0.9377
    - Epoch 5/15, Loss: 0.2111, Acc: 0.9180
    - Epoch 6/15, Loss: 0.1257, Acc: 0.9574
    - Epoch 7/15, Loss: 0.1288, Acc: 0.9512
    - Epoch 8/15, Loss: 0.1015, Acc: 0.9720
    - Epoch 9/15, Loss: 0.0823, Acc: 0.9720
    - Epoch 10/15, Loss: 0.0693, Acc: 0.9772
    - Epoch 11/15, Loss: 0.1346, Acc: 0.9574
    - Epoch 12/15, Loss: 0.1492, Acc: 0.9522
    - Epoch 13/15, Loss: 0.0588, Acc: 0.9823
    - Epoch 14/15, Loss: 0.0534, Acc: 0.9813
    - Epoch 15/15, Loss: 0.1482, Acc: 0.9585
- Validation Scores:
    - Accuracy: 0.8250
    - Precision: 0.8319
    - Recall: 0.9792
    - F1 Score: 0.8995

- Test Scores:
    - Accuracy: 0.8182
    - Precision: 0.8304
    - Recall: 0.9688
    - F1 Score: 0.8942

EfficientNetB4_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5366, Acc: 0.7913
    - Epoch 2/15, Loss: 0.4134, Acc: 0.8079
    - Epoch 3/15, Loss: 0.2135, Acc: 0.9304
    - Epoch 4/15, Loss: 0.1790, Acc: 0.9283
    - Epoch 5/15, Loss: 0.1116, Acc: 0.9595
    - Epoch 6/15, Loss: 0.0546, Acc: 0.9813
    - Epoch 7/15, Loss: 0.1556, Acc: 0.9429
    - Epoch 8/15, Loss: 0.0837, Acc: 0.9720
    - Epoch 9/15, Loss: 0.0508, Acc: 0.9813
    - Epoch 10/15, Loss: 0.0735, Acc: 0.9720
    - Epoch 11/15, Loss: 0.0469, Acc: 0.9792
    - Epoch 12/15, Loss: 0.0414, Acc: 0.9844
    - Epoch 13/15, Loss: 0.0948, Acc: 0.9720
    - Epoch 14/15, Loss: 0.0828, Acc: 0.9740
    - Epoch 15/15, Loss: 0.1129, Acc: 0.9647
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8349
    - Recall: 0.9479
    - F1 Score: 0.8878
- Test Scores:
    - Accuracy: 0.7686
    - Precision: 0.8208
    - Recall: 0.9062
    - F1 Score: 0.8614

EfficientNetB5_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5772, Acc: 0.7383
    - Epoch 2/15, Loss: 0.3927, Acc: 0.8152
    - Epoch 3/15, Loss: 0.2627, Acc: 0.8920
    - Epoch 4/15, Loss: 0.1991, Acc: 0.9273
    - Epoch 5/15, Loss: 0.1558, Acc: 0.9470

    - Epoch 6/15, Loss: 0.1433, Acc: 0.9450
    - Epoch 7/15, Loss: 0.1112, Acc: 0.9595
    - Epoch 8/15, Loss: 0.0965, Acc: 0.9709
    - Epoch 9/15, Loss: 0.1362, Acc: 0.9522
    - Epoch 10/15, Loss: 0.0601, Acc: 0.9751
    - Epoch 11/15, Loss: 0.0851, Acc: 0.9688
    - Epoch 12/15, Loss: 0.0855, Acc: 0.9699
    - Epoch 13/15, Loss: 0.0680, Acc: 0.9772
    - Epoch 14/15, Loss: 0.1313, Acc: 0.9481
    - Epoch 15/15, Loss: 0.2746, Acc: 0.8858
- Validation Scores:
    - Accuracy: 0.8250
    - Precision: 0.8205
    - Recall: 1.0000
    - F1 Score: 0.9014
- Test Scores:
    - Accuracy: 0.7851
    - Precision: 0.7966
    - Recall: 0.9792
    - F1 Score: 0.8785

Optimiser Exploration

Adam

(from initial exploration)

ResNet50_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5659, Acc: 0.7809
    - Epoch 2/15, Loss: 0.5120, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4492, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4397, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4411, Acc: 0.8017
    - Epoch 6/15, Loss: 0.4079, Acc: 0.8110
    - Epoch 7/15, Loss: 0.3784, Acc: 0.8172
    - Epoch 8/15, Loss: 0.3572, Acc: 0.8349
    - Epoch 9/15, Loss: 0.3216, Acc: 0.8484
    - Epoch 10/15, Loss: 0.2285, Acc: 0.9065
    - Epoch 11/15, Loss: 0.2850, Acc: 0.8837
    - Epoch 12/15, Loss: 0.2321, Acc: 0.9117
    - Epoch 13/15, Loss: 0.1949, Acc: 0.9232
    - Epoch 14/15, Loss: 0.1405, Acc: 0.9460

        - Epoch 15/15, Loss: 0.1105, Acc: 0.9657
- Validation Scores:
    - Accuracy: 0.7750
    - Precision: 0.8350
    - Recall: 0.8958
    - F1 Score: 0.8643
- Test Scores:
    - Accuracy: 0.8099
    - Precision: 0.8476
    - Recall: 0.9271
    - F1 Score: 0.8856

EfficientNetB2_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4416, Acc: 0.8079
    - Epoch 3/15, Loss: 0.3197, Acc: 0.8484
    - Epoch 4/15, Loss: 0.3537, Acc: 0.8453
    - Epoch 5/15, Loss: 0.2455, Acc: 0.8962
    - Epoch 6/15, Loss: 0.1704, Acc: 0.9335
    - Epoch 7/15, Loss: 0.1402, Acc: 0.9460
    - Epoch 8/15, Loss: 0.1529, Acc: 0.9491
    - Epoch 9/15, Loss: 0.1298, Acc: 0.9502
    - Epoch 10/15, Loss: 0.0703, Acc: 0.9761
    - Epoch 11/15, Loss: 0.1414, Acc: 0.9512
    - Epoch 12/15, Loss: 0.2478, Acc: 0.9097
    - Epoch 13/15, Loss: 0.0890, Acc: 0.9699
    - Epoch 14/15, Loss: 0.1319, Acc: 0.9470
    - Epoch 15/15, Loss: 0.0477, Acc: 0.9865
- Validation Scores:
    - Accuracy: 0.8333
    - Precision: 0.8585
    - Recall: 0.9479
    - F1 Score: 0.9010
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8571
    - Recall: 0.9375
    - F1 Score: 0.8955

SGD

ResNet50_SGD_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6247, Acc: 0.7487
    - Epoch 2/15, Loss: 0.5431, Acc: 0.8017
    - Epoch 3/15, Loss: 0.5115, Acc: 0.8017
    - Epoch 4/15, Loss: 0.4998, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4941, Acc: 0.8017
    - Epoch 6/15, Loss: 0.4903, Acc: 0.8017
    - Epoch 7/15, Loss: 0.4873, Acc: 0.8017
    - Epoch 8/15, Loss: 0.4828, Acc: 0.8017
    - Epoch 9/15, Loss: 0.4757, Acc: 0.8017
    - Epoch 10/15, Loss: 0.4788, Acc: 0.8017
    - Epoch 11/15, Loss: 0.4708, Acc: 0.8017
    - Epoch 12/15, Loss: 0.4701, Acc: 0.8017
    - Epoch 13/15, Loss: 0.4729, Acc: 0.8017
    - Epoch 14/15, Loss: 0.4624, Acc: 0.8017
    - Epoch 15/15, Loss: 0.4624, Acc: 0.8017
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.7934
    - Recall: 1.0000
    - F1 Score: 0.8848

EfficientNetB2_SGD_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6248, Acc: 0.7227
    - Epoch 2/15, Loss: 0.5567, Acc: 0.7913
    - Epoch 3/15, Loss: 0.5383, Acc: 0.7944
    - Epoch 4/15, Loss: 0.5210, Acc: 0.7954
    - Epoch 5/15, Loss: 0.5165, Acc: 0.8017
    - Epoch 6/15, Loss: 0.5089, Acc: 0.8006
    - Epoch 7/15, Loss: 0.5091, Acc: 0.8006
    - Epoch 8/15, Loss: 0.5060, Acc: 0.8006
    - Epoch 9/15, Loss: 0.5016, Acc: 0.8017
    - Epoch 10/15, Loss: 0.4965, Acc: 0.8027
    - Epoch 11/15, Loss: 0.5081, Acc: 0.8017
    - Epoch 12/15, Loss: 0.4874, Acc: 0.8017
    - Epoch 13/15, Loss: 0.4967, Acc: 0.8017
    - Epoch 14/15, Loss: 0.4900, Acc: 0.8017
    - Epoch 15/15, Loss: 0.4848, Acc: 0.8037

- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.7934
    - Recall: 1.0000
    - F1 Score: 0.8848

Adadelta

ResNet50_Adadelta_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6918, Acc: 0.5192
    - Epoch 2/15, Loss: 0.6732, Acc: 0.6137
    - Epoch 3/15, Loss: 0.6570, Acc: 0.6874
    - Epoch 4/15, Loss: 0.6419, Acc: 0.7529
    - Epoch 5/15, Loss: 0.6257, Acc: 0.7778
    - Epoch 6/15, Loss: 0.6119, Acc: 0.7861
    - Epoch 7/15, Loss: 0.5999, Acc: 0.7975
    - Epoch 8/15, Loss: 0.5857, Acc: 0.7975
    - Epoch 9/15, Loss: 0.5743, Acc: 0.7996
    - Epoch 10/15, Loss: 0.5644, Acc: 0.7975
    - Epoch 11/15, Loss: 0.5510, Acc: 0.8027
    - Epoch 12/15, Loss: 0.5436, Acc: 0.8017
    - Epoch 13/15, Loss: 0.5380, Acc: 0.8017
    - Epoch 14/15, Loss: 0.5291, Acc: 0.8017
    - Epoch 15/15, Loss: 0.5236, Acc: 0.8017
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.7934
    - Recall: 1.0000
    - F1 Score: 0.8848

EfficientNetB2_Adadelta_LR1e-3_WD0_DP0_EP15

- Training:

    - Epoch 1/15, Loss: 0.6708, Acc: 0.5867
    - Epoch 2/15, Loss: 0.6556, Acc: 0.6376
    - Epoch 3/15, Loss: 0.6487, Acc: 0.6469
    - Epoch 4/15, Loss: 0.6350, Acc: 0.6874
    - Epoch 5/15, Loss: 0.6298, Acc: 0.7072
    - Epoch 6/15, Loss: 0.6232, Acc: 0.7165
    - Epoch 7/15, Loss: 0.6164, Acc: 0.7165
    - Epoch 8/15, Loss: 0.6077, Acc: 0.7445
    - Epoch 9/15, Loss: 0.5995, Acc: 0.7591
    - Epoch 10/15, Loss: 0.5937, Acc: 0.7674
    - Epoch 11/15, Loss: 0.5941, Acc: 0.7767
    - Epoch 12/15, Loss: 0.5802, Acc: 0.7799
    - Epoch 13/15, Loss: 0.5825, Acc: 0.7861
    - Epoch 14/15, Loss: 0.5714, Acc: 0.7747
    - Epoch 15/15, Loss: 0.5677, Acc: 0.7861
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889
- Test Scores:
    - Accuracy: 0.7851
    - Precision: 0.7966
    - Recall: 0.9792
    - F1 Score: 0.8785

RMSprop

ResNet50_RMSprop_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6401, Acc: 0.7632
    - Epoch 2/15, Loss: 0.5321, Acc: 0.8017
    - Epoch 3/15, Loss: 0.5128, Acc: 0.8017
    - Epoch 4/15, Loss: 0.5077, Acc: 0.8017
    - Epoch 5/15, Loss: 0.5003, Acc: 0.8017
    - Epoch 6/15, Loss: 0.5034, Acc: 0.8017
    - Epoch 7/15, Loss: 0.4964, Acc: 0.8017
    - Epoch 8/15, Loss: 0.4817, Acc: 0.8006
    - Epoch 9/15, Loss: 0.4876, Acc: 0.8006
    - Epoch 10/15, Loss: 0.4733, Acc: 0.8017
    - Epoch 11/15, Loss: 0.4678, Acc: 0.8037
    - Epoch 12/15, Loss: 0.4588, Acc: 0.7934
    - Epoch 13/15, Loss: 0.4613, Acc: 0.7996

        - Epoch 14/15, Loss: 0.4724, Acc: 0.7985
        - Epoch 15/15, Loss: 0.4602, Acc: 0.8037
    - Validation Scores:
        - Accuracy: 0.8000
        - Precision: 0.8000
        - Recall: 1.0000
        - F1 Score: 0.8889
    - Test Scores:
        - Accuracy: 0.7934
        - Precision: 0.7934
        - Recall: 1.0000
        - F1 Score: 0.8848

EfficientNetB2_RMSprop_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5962, Acc: 0.7830
    - Epoch 2/15, Loss: 0.5187, Acc: 0.7985
    - Epoch 3/15, Loss: 0.5075, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4833, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4984, Acc: 0.8006
    - Epoch 6/15, Loss: 0.4825, Acc: 0.8017
    - Epoch 7/15, Loss: 0.4658, Acc: 0.7996
    - Epoch 8/15, Loss: 0.4572, Acc: 0.7985
    - Epoch 9/15, Loss: 0.4196, Acc: 0.8027
    - Epoch 10/15, Loss: 0.3521, Acc: 0.8370
    - Epoch 11/15, Loss: 0.3410, Acc: 0.8474
    - Epoch 12/15, Loss: 0.2656, Acc: 0.8785
    - Epoch 13/15, Loss: 0.1648, Acc: 0.9283
    - Epoch 14/15, Loss: 0.1972, Acc: 0.9180
    - Epoch 15/15, Loss: 0.1150, Acc: 0.9543
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8158
    - Recall: 0.9688
    - F1 Score: 0.8857
- Test Scores:
    - Accuracy: 0.7851
    - Precision: 0.8017
    - Recall: 0.9688
    - F1 Score: 0.8774

Learning Rate Exploration

Learning Rate = 5e-3

ResNet50_Adam_LR5e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6147, Acc: 0.7767
    - Epoch 2/15, Loss: 0.5343, Acc: 0.8017
    - Epoch 3/15, Loss: 0.5136, Acc: 0.8017
    - Epoch 4/15, Loss: 0.5173, Acc: 0.8017
    - Epoch 5/15, Loss: 0.5162, Acc: 0.8017
    - Epoch 6/15, Loss: 0.5024, Acc: 0.8017
    - Epoch 7/15, Loss: 0.5040, Acc: 0.8017
    - Epoch 8/15, Loss: 0.4940, Acc: 0.8017
    - Epoch 9/15, Loss: 0.4966, Acc: 0.7985
    - Epoch 10/15, Loss: 0.5015, Acc: 0.8017
    - Epoch 11/15, Loss: 0.4831, Acc: 0.8027
    - Epoch 12/15, Loss: 0.4946, Acc: 0.8017
    - Epoch 13/15, Loss: 0.4840, Acc: 0.7944
    - Epoch 14/15, Loss: 0.4874, Acc: 0.7934
    - Epoch 15/15, Loss: 0.4744, Acc: 0.8037
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.7934
    - Recall: 1.0000
    - F1 Score: 0.8848

EfficientNetB2_Adam_LR5e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.6341, Acc: 0.7736
    - Epoch 2/15, Loss: 0.5218, Acc: 0.7965
    - Epoch 3/15, Loss: 0.5371, Acc: 0.7934
    - Epoch 4/15, Loss: 0.5202, Acc: 0.7892
    - Epoch 5/15, Loss: 0.5026, Acc: 0.7975
    - Epoch 6/15, Loss: 0.5030, Acc: 0.7923
    - Epoch 7/15, Loss: 0.4836, Acc: 0.7996
    - Epoch 8/15, Loss: 0.4638, Acc: 0.8027
    - Epoch 9/15, Loss: 0.4601, Acc: 0.7965

    - Epoch 10/15, Loss: 0.4569, Acc: 0.7954
    - Epoch 11/15, Loss: 0.4260, Acc: 0.8204
    - Epoch 12/15, Loss: 0.4631, Acc: 0.8027
    - Epoch 13/15, Loss: 0.3932, Acc: 0.8328
    - Epoch 14/15, Loss: 0.3997, Acc: 0.8287
    - Epoch 15/15, Loss: 0.4539, Acc: 0.8131
- Validation Scores:
    - Accuracy: 0.7583
    - Precision: 0.8131
    - Recall: 0.9062
    - F1 Score: 0.8571
- Test Scores:
    - Accuracy: 0.7769
    - Precision: 0.8000
    - Recall: 0.9583
    - F1 Score: 0.8720

Learning Rate = 1e-3

(from initial exploration)

ResNet50_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5659, Acc: 0.7809
    - Epoch 2/15, Loss: 0.5120, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4492, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4397, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4411, Acc: 0.8017
    - Epoch 6/15, Loss: 0.4079, Acc: 0.8110
    - Epoch 7/15, Loss: 0.3784, Acc: 0.8172
    - Epoch 8/15, Loss: 0.3572, Acc: 0.8349
    - Epoch 9/15, Loss: 0.3216, Acc: 0.8484
    - Epoch 10/15, Loss: 0.2285, Acc: 0.9065
    - Epoch 11/15, Loss: 0.2850, Acc: 0.8837
    - Epoch 12/15, Loss: 0.2321, Acc: 0.9117
    - Epoch 13/15, Loss: 0.1949, Acc: 0.9232
    - Epoch 14/15, Loss: 0.1405, Acc: 0.9460
    - Epoch 15/15, Loss: 0.1105, Acc: 0.9657
- Validation Scores:
    - Accuracy: 0.7750
    - Precision: 0.8350
    - Recall: 0.8958
    - F1 Score: 0.8643
- Test Scores:

    - Accuracy: 0.8099
    - Precision: 0.8476
    - Recall: 0.9271
    - F1 Score: 0.8856

EfficientNetB2_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4416, Acc: 0.8079
    - Epoch 3/15, Loss: 0.3197, Acc: 0.8484
    - Epoch 4/15, Loss: 0.3537, Acc: 0.8453
    - Epoch 5/15, Loss: 0.2455, Acc: 0.8962
    - Epoch 6/15, Loss: 0.1704, Acc: 0.9335
    - Epoch 7/15, Loss: 0.1402, Acc: 0.9460
    - Epoch 8/15, Loss: 0.1529, Acc: 0.9491
    - Epoch 9/15, Loss: 0.1298, Acc: 0.9502
    - Epoch 10/15, Loss: 0.0703, Acc: 0.9761
    - Epoch 11/15, Loss: 0.1414, Acc: 0.9512
    - Epoch 12/15, Loss: 0.2478, Acc: 0.9097
    - Epoch 13/15, Loss: 0.0890, Acc: 0.9699
    - Epoch 14/15, Loss: 0.1319, Acc: 0.9470
    - Epoch 15/15, Loss: 0.0477, Acc: 0.9865
- Validation Scores:
    - Accuracy: 0.8333
    - Precision: 0.8585
    - Recall: 0.9479
    - F1 Score: 0.9010
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8571
    - Recall: 0.9375
    - F1 Score: 0.8955

Learning Rate = 5e-4

ResNet50_Adam_LR5e-4_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5439, Acc: 0.7799
    - Epoch 2/15, Loss: 0.4187, Acc: 0.8017
    - Epoch 3/15, Loss: 0.3369, Acc: 0.8525
    - Epoch 4/15, Loss: 0.3025, Acc: 0.8775
    - Epoch 5/15, Loss: 0.3039, Acc: 0.8744
    - Epoch 6/15, Loss: 0.1856, Acc: 0.9200

    - Epoch 7/15, Loss: 0.2395, Acc: 0.8982
    - Epoch 8/15, Loss: 0.1451, Acc: 0.9564
    - Epoch 9/15, Loss: 0.0692, Acc: 0.9803
    - Epoch 10/15, Loss: 0.1025, Acc: 0.9709
    - Epoch 11/15, Loss: 0.1427, Acc: 0.9491
    - Epoch 12/15, Loss: 0.0896, Acc: 0.9637
    - Epoch 13/15, Loss: 0.1727, Acc: 0.9335
    - Epoch 14/15, Loss: 0.0978, Acc: 0.9616
    - Epoch 15/15, Loss: 0.0481, Acc: 0.9844
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8349
    - Recall: 0.9479
    - F1 Score: 0.8878
- Test Scores:
    - Accuracy: 0.8099
    - Precision: 0.8476
    - Recall: 0.9271
    - F1 Score: 0.8856

EfficientNetB2_Adam_LR5e-4_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5278, Acc: 0.7892
    - Epoch 2/15, Loss: 0.3408, Acc: 0.8681
    - Epoch 3/15, Loss: 0.2164, Acc: 0.9159
    - Epoch 4/15, Loss: 0.1968, Acc: 0.9200
    - Epoch 5/15, Loss: 0.1046, Acc: 0.9678
    - Epoch 6/15, Loss: 0.0643, Acc: 0.9803
    - Epoch 7/15, Loss: 0.0723, Acc: 0.9720
    - Epoch 8/15, Loss: 0.0678, Acc: 0.9761
    - Epoch 9/15, Loss: 0.0599, Acc: 0.9803
    - Epoch 10/15, Loss: 0.0265, Acc: 0.9927
    - Epoch 11/15, Loss: 0.1858, Acc: 0.9294
    - Epoch 12/15, Loss: 0.1900, Acc: 0.9211
    - Epoch 13/15, Loss: 0.0882, Acc: 0.9730
    - Epoch 14/15, Loss: 0.1276, Acc: 0.9512
    - Epoch 15/15, Loss: 0.0783, Acc: 0.9772
- Validation Scores:
    - Accuracy: 0.8250
    - Precision: 0.8378
    - Recall: 0.9688
    - F1 Score: 0.8986
- Test Scores:
    - Accuracy: 0.8264

    - Precision: 0.8319
    - Recall: 0.9792
    - F1 Score: 0.8995

Weight Decay Exploration

Weight Decay = 0

(from initial exploration)

ResNet50_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5659, Acc: 0.7809
    - Epoch 2/15, Loss: 0.5120, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4492, Acc: 0.8006
    - Epoch 4/15, Loss: 0.4397, Acc: 0.8017
    - Epoch 5/15, Loss: 0.4411, Acc: 0.8017
    - Epoch 6/15, Loss: 0.4079, Acc: 0.8110
    - Epoch 7/15, Loss: 0.3784, Acc: 0.8172
    - Epoch 8/15, Loss: 0.3572, Acc: 0.8349
    - Epoch 9/15, Loss: 0.3216, Acc: 0.8484
    - Epoch 10/15, Loss: 0.2285, Acc: 0.9065
    - Epoch 11/15, Loss: 0.2850, Acc: 0.8837
    - Epoch 12/15, Loss: 0.2321, Acc: 0.9117
    - Epoch 13/15, Loss: 0.1949, Acc: 0.9232
    - Epoch 14/15, Loss: 0.1405, Acc: 0.9460
    - Epoch 15/15, Loss: 0.1105, Acc: 0.9657
- Validation Scores:
    - Accuracy: 0.7750
    - Precision: 0.8350
    - Recall: 0.8958
    - F1 Score: 0.8643
- Test Scores:
    - Accuracy: 0.8099
    - Precision: 0.8476
    - Recall: 0.9271
    - F1 Score: 0.8856

EfficientNetB2_Adam_LR1e-3_WD0_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4416, Acc: 0.8079
    - Epoch 3/15, Loss: 0.3197, Acc: 0.8484

    - Epoch 4/15, Loss: 0.3537, Acc: 0.8453
    - Epoch 5/15, Loss: 0.2455, Acc: 0.8962
    - Epoch 6/15, Loss: 0.1704, Acc: 0.9335
    - Epoch 7/15, Loss: 0.1402, Acc: 0.9460
    - Epoch 8/15, Loss: 0.1529, Acc: 0.9491
    - Epoch 9/15, Loss: 0.1298, Acc: 0.9502
    - Epoch 10/15, Loss: 0.0703, Acc: 0.9761
    - Epoch 11/15, Loss: 0.1414, Acc: 0.9512
    - Epoch 12/15, Loss: 0.2478, Acc: 0.9097
    - Epoch 13/15, Loss: 0.0890, Acc: 0.9699
    - Epoch 14/15, Loss: 0.1319, Acc: 0.9470
    - Epoch 15/15, Loss: 0.0477, Acc: 0.9865
- Validation Scores:
    - Accuracy: 0.8333
    - Precision: 0.8585
    - Recall: 0.9479
    - F1 Score: 0.9010
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8571
    - Recall: 0.9375
    - F1 Score: 0.8955

Weight Decay = 1e-3

ResNet50_Adam_LR1e-3_WD1e-3_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5721, Acc: 0.7799
    - Epoch 2/15, Loss: 0.5065, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4826, Acc: 0.8120
    - Epoch 4/15, Loss: 0.4616, Acc: 0.8214
    - Epoch 5/15, Loss: 0.5062, Acc: 0.7902
    - Epoch 6/15, Loss: 0.4451, Acc: 0.8297
    - Epoch 7/15, Loss: 0.4399, Acc: 0.8204
    - Epoch 8/15, Loss: 0.4328, Acc: 0.8255
    - Epoch 9/15, Loss: 0.4293, Acc: 0.8297
    - Epoch 10/15, Loss: 0.3847, Acc: 0.8557
    - Epoch 11/15, Loss: 0.3508, Acc: 0.8702
    - Epoch 12/15, Loss: 0.4117, Acc: 0.8328
    - Epoch 13/15, Loss: 0.3709, Acc: 0.8567
    - Epoch 14/15, Loss: 0.3780, Acc: 0.8567
    - Epoch 15/15, Loss: 0.3804, Acc: 0.8567
- Validation Scores:

    - Accuracy: 0.7667
    - Precision: 0.8208
    - Recall: 0.9062
    - F1 Score: 0.8614
- Test Scores:
    - Accuracy: 0.6694
    - Precision: 0.7745
    - Recall: 0.8229
    - F1 Score: 0.7980

EfficientNetB2_Adam_LR1e-3_WD1e-3_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5582, Acc: 0.7747
    - Epoch 2/15, Loss: 0.4472, Acc: 0.8069
    - Epoch 3/15, Loss: 0.3420, Acc: 0.8411
    - Epoch 4/15, Loss: 0.3569, Acc: 0.8525
    - Epoch 5/15, Loss: 0.2377, Acc: 0.9117
    - Epoch 6/15, Loss: 0.1852, Acc: 0.9335
    - Epoch 7/15, Loss: 0.2066, Acc: 0.9211
    - Epoch 8/15, Loss: 0.1851, Acc: 0.9398
    - Epoch 9/15, Loss: 0.1278, Acc: 0.9522
    - Epoch 10/15, Loss: 0.1496, Acc: 0.9387
    - Epoch 11/15, Loss: 0.0725, Acc: 0.9772
    - Epoch 12/15, Loss: 0.0858, Acc: 0.9761
    - Epoch 13/15, Loss: 0.0538, Acc: 0.9782
    - Epoch 14/15, Loss: 0.1796, Acc: 0.9273
    - Epoch 15/15, Loss: 0.1600, Acc: 0.9398
- Validation Scores:
    - Accuracy: 0.7500
    - Precision: 0.8113
    - Recall: 0.8958
    - F1 Score: 0.8515
- Test Scores:
    - Accuracy: 0.7686
    - Precision: 0.8148
    - Recall: 0.9167
    - F1 Score: 0.8627

Weight Decay = 1e-4

ResNet50_Adam_LR1e-3_WD1e-4_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5659, Acc: 0.7799

    - Epoch 2/15, Loss: 0.5052, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4288, Acc: 0.8204
    - Epoch 4/15, Loss: 0.4284, Acc: 0.8276
    - Epoch 5/15, Loss: 0.4127, Acc: 0.8359
    - Epoch 6/15, Loss: 0.3764, Acc: 0.8380
    - Epoch 7/15, Loss: 0.3238, Acc: 0.8640
    - Epoch 8/15, Loss: 0.2723, Acc: 0.8899
    - Epoch 9/15, Loss: 0.2593, Acc: 0.8993
    - Epoch 10/15, Loss: 0.2518, Acc: 0.8972
    - Epoch 11/15, Loss: 0.1475, Acc: 0.9387
    - Epoch 12/15, Loss: 0.4360, Acc: 0.8245
    - Epoch 13/15, Loss: 0.2445, Acc: 0.9034
    - Epoch 14/15, Loss: 0.3861, Acc: 0.8380
    - Epoch 15/15, Loss: 0.2643, Acc: 0.9003
- Validation Scores:
    - Accuracy: 0.7667
    - Precision: 0.7931
    - Recall: 0.9583
    - F1 Score: 0.8679
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8261
    - Recall: 0.9896
    - F1 Score: 0.9005

EfficientNetB2_Adam_LR1e-3_WD1e-4_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4433, Acc: 0.8027
    - Epoch 3/15, Loss: 0.3120, Acc: 0.8588
    - Epoch 4/15, Loss: 0.3491, Acc: 0.8380
    - Epoch 5/15, Loss: 0.2390, Acc: 0.9034
    - Epoch 6/15, Loss: 0.1478, Acc: 0.9418
    - Epoch 7/15, Loss: 0.1768, Acc: 0.9367
    - Epoch 8/15, Loss: 0.1087, Acc: 0.9616
    - Epoch 9/15, Loss: 0.1155, Acc: 0.9533
    - Epoch 10/15, Loss: 0.0604, Acc: 0.9803
    - Epoch 11/15, Loss: 0.0940, Acc: 0.9616
    - Epoch 12/15, Loss: 0.2592, Acc: 0.8993
    - Epoch 13/15, Loss: 0.1788, Acc: 0.9356
    - Epoch 14/15, Loss: 0.1259, Acc: 0.9512
    - Epoch 15/15, Loss: 0.0762, Acc: 0.9720
- Validation Scores:
    - Accuracy: 0.7750

    - Precision: 0.8557
    - Recall: 0.8646
    - F1 Score: 0.8601
- Test Scores:
    - Accuracy: 0.8264
    - Precision: 0.8713
    - Recall: 0.9167
    - F1 Score: 0.8934

Weight Decay = 1e-5

ResNet50_Adam_LR1e-3_WD1e-5_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5670, Acc: 0.7799
    - Epoch 2/15, Loss: 0.5169, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4523, Acc: 0.8058
    - Epoch 4/15, Loss: 0.4388, Acc: 0.8193
    - Epoch 5/15, Loss: 0.4346, Acc: 0.8183
    - Epoch 6/15, Loss: 0.3776, Acc: 0.8339
    - Epoch 7/15, Loss: 0.3876, Acc: 0.8515
    - Epoch 8/15, Loss: 0.3165, Acc: 0.8681
    - Epoch 9/15, Loss: 0.3563, Acc: 0.8463
    - Epoch 10/15, Loss: 0.2551, Acc: 0.8941
    - Epoch 11/15, Loss: 0.2326, Acc: 0.9013
    - Epoch 12/15, Loss: 0.1819, Acc: 0.9273
    - Epoch 13/15, Loss: 0.2399, Acc: 0.9159
    - Epoch 14/15, Loss: 0.3871, Acc: 0.8494
    - Epoch 15/15, Loss: 0.1997, Acc: 0.9273
- Validation Scores:
    - Accuracy: 0.7917
    - Precision: 0.7983
    - Recall: 0.9896
    - F1 Score: 0.8837
- Test Scores:
    - Accuracy: 0.8347
    - Precision: 0.8276
    - Recall: 1.0000
    - F1 Score: 0.9057

EfficientNetB2_Adam_LR1e-3_WD1e-5_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5573, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4415, Acc: 0.8069

    - Epoch 3/15, Loss: 0.3207, Acc: 0.8525
    - Epoch 4/15, Loss: 0.3554, Acc: 0.8432
    - Epoch 5/15, Loss: 0.2445, Acc: 0.9055
    - Epoch 6/15, Loss: 0.1701, Acc: 0.9408
    - Epoch 7/15, Loss: 0.1470, Acc: 0.9491
    - Epoch 8/15, Loss: 0.2664, Acc: 0.8951
    - Epoch 9/15, Loss: 0.1405, Acc: 0.9512
    - Epoch 10/15, Loss: 0.0674, Acc: 0.9740
    - Epoch 11/15, Loss: 0.0835, Acc: 0.9668
    - Epoch 12/15, Loss: 0.1141, Acc: 0.9616
    - Epoch 13/15, Loss: 0.0514, Acc: 0.9813
    - Epoch 14/15, Loss: 0.2191, Acc: 0.9148
    - Epoch 15/15, Loss: 0.0897, Acc: 0.9688
- Validation Scores:
    - Accuracy: 0.7417
    - Precision: 0.8283
    - Recall: 0.8542
    - F1 Score: 0.8410
- Test Scores:
    - Accuracy: 0.8182
    - Precision: 0.8491
    - Recall: 0.9375
    - F1 Score: 0.8911

Weight Decay = 1e-6

ResNet50_Adam_LR1e-3_WD1e-6_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5566, Acc: 0.7809
    - Epoch 2/15, Loss: 0.4939, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4264, Acc: 0.8100
    - Epoch 4/15, Loss: 0.4242, Acc: 0.8120
    - Epoch 5/15, Loss: 0.3754, Acc: 0.8432
    - Epoch 6/15, Loss: 0.4012, Acc: 0.8359
    - Epoch 7/15, Loss: 0.3420, Acc: 0.8681
    - Epoch 8/15, Loss: 0.2372, Acc: 0.8993
    - Epoch 9/15, Loss: 0.3413, Acc: 0.8588
    - Epoch 10/15, Loss: 0.2291, Acc: 0.9065
    - Epoch 11/15, Loss: 0.2026, Acc: 0.9200
    - Epoch 12/15, Loss: 0.1596, Acc: 0.9304
    - Epoch 13/15, Loss: 0.3001, Acc: 0.8754
    - Epoch 14/15, Loss: 0.2227, Acc: 0.9138
    - Epoch 15/15, Loss: 0.1303, Acc: 0.9553

- Validation Scores:
    - Accuracy: 0.6917
    - Precision: 0.8105
    - Recall: 0.8021
    - F1 Score: 0.8063
- Test Scores:
    - Accuracy: 0.7107
    - Precision: 0.8144
    - Recall: 0.8229
    - F1 Score: 0.8187

EfficientNetB2_Adam_LR1e-3_WD1e-6_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5574, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4420, Acc: 0.8058
    - Epoch 3/15, Loss: 0.3196, Acc: 0.8536
    - Epoch 4/15, Loss: 0.3545, Acc: 0.8411
    - Epoch 5/15, Loss: 0.2482, Acc: 0.9013
    - Epoch 6/15, Loss: 0.1567, Acc: 0.9470
    - Epoch 7/15, Loss: 0.1122, Acc: 0.9616
    - Epoch 8/15, Loss: 0.1684, Acc: 0.9367
    - Epoch 9/15, Loss: 0.0853, Acc: 0.9709
    - Epoch 10/15, Loss: 0.1087, Acc: 0.9637
    - Epoch 11/15, Loss: 0.1808, Acc: 0.9367
    - Epoch 12/15, Loss: 0.0856, Acc: 0.9699
    - Epoch 13/15, Loss: 0.0647, Acc: 0.9761
    - Epoch 14/15, Loss: 0.1193, Acc: 0.9595
    - Epoch 15/15, Loss: 0.0907, Acc: 0.9720
- Validation Scores:
    - Accuracy: 0.8250
    - Precision: 0.8319
    - Recall: 0.9792
    - F1 Score: 0.8995
- Test Scores:
    - Accuracy: 0.8512
    - Precision: 0.8421
    - Recall: 1.0000
    - F1 Score: 0.9143

Weight Decay = 1e-7

ResNet50_Adam_LR1e-3_WD1e-7_DP0_EP15

- Training:

    - Epoch 1/15, Loss: 0.5726, Acc: 0.7788
    - Epoch 2/15, Loss: 0.5095, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4550, Acc: 0.8058
    - Epoch 4/15, Loss: 0.4647, Acc: 0.8069
    - Epoch 5/15, Loss: 0.4486, Acc: 0.7975
    - Epoch 6/15, Loss: 0.3700, Acc: 0.8411
    - Epoch 7/15, Loss: 0.4043, Acc: 0.8349
    - Epoch 8/15, Loss: 0.2896, Acc: 0.8764
    - Epoch 9/15, Loss: 0.3921, Acc: 0.8307
    - Epoch 10/15, Loss: 0.3071, Acc: 0.8557
    - Epoch 11/15, Loss: 0.2155, Acc: 0.9013
    - Epoch 12/15, Loss: 0.3394, Acc: 0.8557
    - Epoch 13/15, Loss: 0.3012, Acc: 0.8868
    - Epoch 14/15, Loss: 0.2054, Acc: 0.9097
    - Epoch 15/15, Loss: 0.1755, Acc: 0.9356
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8067
    - Recall: 1.0000
    - F1 Score: 0.8930
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.8034
    - Recall: 0.9792
    - F1 Score: 0.8826

EfficientNetB2_Adam_LR1e-3_WD1e-7_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5574, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4423, Acc: 0.8048
    - Epoch 3/15, Loss: 0.3190, Acc: 0.8546
    - Epoch 4/15, Loss: 0.3554, Acc: 0.8390
    - Epoch 5/15, Loss: 0.2318, Acc: 0.9200
    - Epoch 6/15, Loss: 0.1858, Acc: 0.9200
    - Epoch 7/15, Loss: 0.1851, Acc: 0.9398
    - Epoch 8/15, Loss: 0.1237, Acc: 0.9626
    - Epoch 9/15, Loss: 0.1314, Acc: 0.9574
    - Epoch 10/15, Loss: 0.0630, Acc: 0.9803
    - Epoch 11/15, Loss: 0.1488, Acc: 0.9491
    - Epoch 12/15, Loss: 0.2354, Acc: 0.9107
    - Epoch 13/15, Loss: 0.1070, Acc: 0.9637
    - Epoch 14/15, Loss: 0.1269, Acc: 0.9491
    - Epoch 15/15, Loss: 0.0793, Acc: 0.9709
- Validation Scores:

    - Accuracy: 0.7500
    - Precision: 0.8000
    - Recall: 0.9167
    - F1 Score: 0.8544
- Test Scores:
    - Accuracy: 0.8182
    - Precision: 0.8364
    - Recall: 0.9583
    - F1 Score: 0.8932

Dropout Probability Exploration

Dropout probability = 0

(from weight decay exploration)

ResNet50_Adam_LR1e-3_WD1e-5_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5670, Acc: 0.7799
    - Epoch 2/15, Loss: 0.5169, Acc: 0.8006
    - Epoch 3/15, Loss: 0.4523, Acc: 0.8058
    - Epoch 4/15, Loss: 0.4388, Acc: 0.8193
    - Epoch 5/15, Loss: 0.4346, Acc: 0.8183
    - Epoch 6/15, Loss: 0.3776, Acc: 0.8339
    - Epoch 7/15, Loss: 0.3876, Acc: 0.8515
    - Epoch 8/15, Loss: 0.3165, Acc: 0.8681
    - Epoch 9/15, Loss: 0.3563, Acc: 0.8463
    - Epoch 10/15, Loss: 0.2551, Acc: 0.8941
    - Epoch 11/15, Loss: 0.2326, Acc: 0.9013
    - Epoch 12/15, Loss: 0.1819, Acc: 0.9273
    - Epoch 13/15, Loss: 0.2399, Acc: 0.9159
    - Epoch 14/15, Loss: 0.3871, Acc: 0.8494
    - Epoch 15/15, Loss: 0.1997, Acc: 0.9273
- Validation Scores:
    - Accuracy: 0.7917
    - Precision: 0.7983
    - Recall: 0.9896
    - F1 Score: 0.8837
- Test Scores:
    - Accuracy: 0.8347
    - Precision: 0.8276
    - Recall: 1.0000
    - F1 Score: 0.9057

EfficientNetB2_Adam_LR1e-3_WD1e-6_DP0_EP15

- Training:
    - Epoch 1/15, Loss: 0.5574, Acc: 0.7767
    - Epoch 2/15, Loss: 0.4420, Acc: 0.8058
    - Epoch 3/15, Loss: 0.3196, Acc: 0.8536
    - Epoch 4/15, Loss: 0.3545, Acc: 0.8411
    - Epoch 5/15, Loss: 0.2482, Acc: 0.9013
    - Epoch 6/15, Loss: 0.1567, Acc: 0.9470
    - Epoch 7/15, Loss: 0.1122, Acc: 0.9616
    - Epoch 8/15, Loss: 0.1684, Acc: 0.9367
    - Epoch 9/15, Loss: 0.0853, Acc: 0.9709
    - Epoch 10/15, Loss: 0.1087, Acc: 0.9637
    - Epoch 11/15, Loss: 0.1808, Acc: 0.9367
    - Epoch 12/15, Loss: 0.0856, Acc: 0.9699
    - Epoch 13/15, Loss: 0.0647, Acc: 0.9761
    - Epoch 14/15, Loss: 0.1193, Acc: 0.9595
    - Epoch 15/15, Loss: 0.0907, Acc: 0.9720
- Validation Scores:
    - Accuracy: 0.8250
    - Precision: 0.8319
    - Recall: 0.9792
    - F1 Score: 0.8995
- Test Scores:
    - Accuracy: 0.8512
    - Precision: 0.8421
    - Recall: 1.0000
    - F1 Score: 0.9143

Dropout probability = 0.1

ResNet50_Adam_LR1e-3_WD1e-5_DP1e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5552, Acc: 0.7892
    - Epoch 2/15, Loss: 0.4901, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4982, Acc: 0.8017
    - Epoch 4/15, Loss: 0.4748, Acc: 0.8048
    - Epoch 5/15, Loss: 0.4376, Acc: 0.7944
    - Epoch 6/15, Loss: 0.3984, Acc: 0.8037
    - Epoch 7/15, Loss: 0.3665, Acc: 0.8536
    - Epoch 8/15, Loss: 0.2863, Acc: 0.8889
    - Epoch 9/15, Loss: 0.4403, Acc: 0.8079
    - Epoch 10/15, Loss: 0.3204, Acc: 0.8588

    - Epoch 11/15, Loss: 0.2919, Acc: 0.8723
    - Epoch 12/15, Loss: 0.2903, Acc: 0.8837
    - Epoch 13/15, Loss: 0.2118, Acc: 0.9159
    - Epoch 14/15, Loss: 0.2848, Acc: 0.8920
    - Epoch 15/15, Loss: 0.1456, Acc: 0.9460
- Validation Scores:
    - Accuracy: 0.7833
    - Precision: 0.8125
    - Recall: 0.9479
    - F1 Score: 0.8750
- Test Scores:
    - Accuracy: 0.7686
    - Precision: 0.7931
    - Recall: 0.9583
    - F1 Score: 0.8679

EfficientNetB2_Adam_LR1e-3_WD5e-6_DP1e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5553, Acc: 0.7830
    - Epoch 2/15, Loss: 0.4485, Acc: 0.8120
    - Epoch 3/15, Loss: 0.3400, Acc: 0.8712
    - Epoch 4/15, Loss: 0.2727, Acc: 0.8827
    - Epoch 5/15, Loss: 0.2738, Acc: 0.9024
    - Epoch 6/15, Loss: 0.2207, Acc: 0.9148
    - Epoch 7/15, Loss: 0.1596, Acc: 0.9418
    - Epoch 8/15, Loss: 0.2649, Acc: 0.8930
    - Epoch 9/15, Loss: 0.1564, Acc: 0.9481
    - Epoch 10/15, Loss: 0.1434, Acc: 0.9439
    - Epoch 11/15, Loss: 0.1202, Acc: 0.9616
    - Epoch 12/15, Loss: 0.1179, Acc: 0.9626
    - Epoch 13/15, Loss: 0.1192, Acc: 0.9595
    - Epoch 14/15, Loss: 0.1198, Acc: 0.9564
    - Epoch 15/15, Loss: 0.0751, Acc: 0.9834
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8349
    - Recall: 0.9479
    - F1 Score: 0.8878
- Test Scores:
    - Accuracy: 0.8182
    - Precision: 0.8426
    - Recall: 0.9479
    - F1 Score: 0.8922

Dropout probability = 0.2

ResNet50_Adam_LR1e-3_WD1e-5_DP2e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5684, Acc: 0.7850
    - Epoch 2/15, Loss: 0.4964, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4570, Acc: 0.7965
    - Epoch 4/15, Loss: 0.4253, Acc: 0.8255
    - Epoch 5/15, Loss: 0.3946, Acc: 0.8297
    - Epoch 6/15, Loss: 0.3239, Acc: 0.8515
    - Epoch 7/15, Loss: 0.3444, Acc: 0.8567
    - Epoch 8/15, Loss: 0.2628, Acc: 0.8899
    - Epoch 9/15, Loss: 0.2779, Acc: 0.8982
    - Epoch 10/15, Loss: 0.2159, Acc: 0.9304
    - Epoch 11/15, Loss: 0.1854, Acc: 0.9356
    - Epoch 12/15, Loss: 0.1994, Acc: 0.9263
    - Epoch 13/15, Loss: 0.1730, Acc: 0.9335
    - Epoch 14/15, Loss: 0.1075, Acc: 0.9585
    - Epoch 15/15, Loss: 0.0948, Acc: 0.9668
- Validation Scores:
    - Accuracy: 0.8167
    - Precision: 0.8246
    - Recall: 0.9792
    - F1 Score: 0.8952
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.8142
    - Recall: 0.9583
    - F1 Score: 0.8804

EfficientNetB2_Adam_LR1e-3_WD5e-6_DP2e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5564, Acc: 0.7819
    - Epoch 2/15, Loss: 0.4248, Acc: 0.8214
    - Epoch 3/15, Loss: 0.3465, Acc: 0.8474
    - Epoch 4/15, Loss: 0.2904, Acc: 0.8930
    - Epoch 5/15, Loss: 0.2523, Acc: 0.8982
    - Epoch 6/15, Loss: 0.1886, Acc: 0.9325
    - Epoch 7/15, Loss: 0.1611, Acc: 0.9325
    - Epoch 8/15, Loss: 0.1340, Acc: 0.9481
    - Epoch 9/15, Loss: 0.0973, Acc: 0.9688
    - Epoch 10/15, Loss: 0.2996, Acc: 0.8619
    - Epoch 11/15, Loss: 0.1823, Acc: 0.9356
    - Epoch 12/15, Loss: 0.1363, Acc: 0.9564

    - Epoch 13/15, Loss: 0.1184, Acc: 0.9616
    - Epoch 14/15, Loss: 0.0726, Acc: 0.9782
    - Epoch 15/15, Loss: 0.1082, Acc: 0.9668
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8067
    - Recall: 1.0000
    - F1 Score: 0.8930
- Test Scores:
    - Accuracy: 0.7769
    - Precision: 0.8000
    - Recall: 0.9583
    - F1 Score: 0.8720

Dropout probability = 0.3

ResNet50_Adam_LR1e-3_WD1e-5_DP3e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5682, Acc: 0.7871
    - Epoch 2/15, Loss: 0.5084, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4815, Acc: 0.7985
    - Epoch 4/15, Loss: 0.4680, Acc: 0.8027
    - Epoch 5/15, Loss: 0.4425, Acc: 0.8027
    - Epoch 6/15, Loss: 0.4303, Acc: 0.8120
    - Epoch 7/15, Loss: 0.3983, Acc: 0.8339
    - Epoch 8/15, Loss: 0.3571, Acc: 0.8505
    - Epoch 9/15, Loss: 0.3256, Acc: 0.8629
    - Epoch 10/15, Loss: 0.2399, Acc: 0.9013
    - Epoch 11/15, Loss: 0.3134, Acc: 0.8754
    - Epoch 12/15, Loss: 0.3158, Acc: 0.8712
    - Epoch 13/15, Loss: 0.1687, Acc: 0.9335
    - Epoch 14/15, Loss: 0.1875, Acc: 0.9294
    - Epoch 15/15, Loss: 0.1787, Acc: 0.9304
- Validation Scores:
    - Accuracy: 0.7917
    - Precision: 0.8142
    - Recall: 0.9583
    - F1 Score: 0.8804
- Test Scores:
    - Accuracy: 0.7686
    - Precision: 0.8091
    - Recall: 0.9271
    - F1 Score: 0.8641

EfficientNetB2_Adam_LR1e-3_WD5e-6_DP3e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5586, Acc: 0.7819
    - Epoch 2/15, Loss: 0.4056, Acc: 0.8235
    - Epoch 3/15, Loss: 0.3435, Acc: 0.8525
    - Epoch 4/15, Loss: 0.2664, Acc: 0.8941
    - Epoch 5/15, Loss: 0.2591, Acc: 0.8962
    - Epoch 6/15, Loss: 0.1722, Acc: 0.9377
    - Epoch 7/15, Loss: 0.1508, Acc: 0.9460
    - Epoch 8/15, Loss: 0.3668, Acc: 0.8567
    - Epoch 9/15, Loss: 0.1663, Acc: 0.9346
    - Epoch 10/15, Loss: 0.1646, Acc: 0.9335
    - Epoch 11/15, Loss: 0.1147, Acc: 0.9512
    - Epoch 12/15, Loss: 0.1009, Acc: 0.9688
    - Epoch 13/15, Loss: 0.1557, Acc: 0.9439
    - Epoch 14/15, Loss: 0.0858, Acc: 0.9730
    - Epoch 15/15, Loss: 0.0420, Acc: 0.9855
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8120
    - Recall: 0.9896
    - F1 Score: 0.8920
- Test Scores:
    - Accuracy: 0.8099
    - Precision: 0.8120
    - Recall: 0.9896
    - F1 Score: 0.8920

Dropout probability = 0.4

ResNet50_Adam_LR1e-3_WD1e-5_DP4e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5698, Acc: 0.7913
    - Epoch 2/15, Loss: 0.4990, Acc: 0.8017
    - Epoch 3/15, Loss: 0.5129, Acc: 0.8017
    - Epoch 4/15, Loss: 0.4769, Acc: 0.8079
    - Epoch 5/15, Loss: 0.4394, Acc: 0.8079
    - Epoch 6/15, Loss: 0.4109, Acc: 0.8162
    - Epoch 7/15, Loss: 0.3709, Acc: 0.8453
    - Epoch 8/15, Loss: 0.3003, Acc: 0.8702
    - Epoch 9/15, Loss: 0.2969, Acc: 0.8702
    - Epoch 10/15, Loss: 0.2431, Acc: 0.9055

    - Epoch 11/15, Loss: 0.2252, Acc: 0.9076
    - Epoch 12/15, Loss: 0.3668, Acc: 0.8484
    - Epoch 13/15, Loss: 0.1851, Acc: 0.9283
    - Epoch 14/15, Loss: 0.1971, Acc: 0.9315
    - Epoch 15/15, Loss: 0.1904, Acc: 0.9263
- Validation Scores:
    - Accuracy: 0.8083
    - Precision: 0.8174
    - Recall: 0.9792
    - F1 Score: 0.8910
- Test Scores:
    - Accuracy: 0.7934
    - Precision: 0.8034
    - Recall: 0.9792
    - F1 Score: 0.8826

EfficientNetB2_Adam_LR1e-3_WD5e-6_DP4e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5580, Acc: 0.7819
    - Epoch 2/15, Loss: 0.4174, Acc: 0.8224
    - Epoch 3/15, Loss: 0.3401, Acc: 0.8577
    - Epoch 4/15, Loss: 0.2244, Acc: 0.9200
    - Epoch 5/15, Loss: 0.2462, Acc: 0.8962
    - Epoch 6/15, Loss: 0.1880, Acc: 0.9221
    - Epoch 7/15, Loss: 0.1413, Acc: 0.9346
    - Epoch 8/15, Loss: 0.1584, Acc: 0.9408
    - Epoch 9/15, Loss: 0.1134, Acc: 0.9616
    - Epoch 10/15, Loss: 0.1776, Acc: 0.9356
    - Epoch 11/15, Loss: 0.0905, Acc: 0.9657
    - Epoch 12/15, Loss: 0.2505, Acc: 0.9200
    - Epoch 13/15, Loss: 0.1058, Acc: 0.9647
    - Epoch 14/15, Loss: 0.0649, Acc: 0.9782
    - Epoch 15/15, Loss: 0.0564, Acc: 0.9834
- Validation Scores:
    - Accuracy: 0.7917
    - Precision: 0.8142
    - Recall: 0.9583
    - F1 Score: 0.8804
- Test Scores:
    - Accuracy: 0.7851
    - Precision: 0.8182
    - Recall: 0.9375
    - F1 Score: 0.8738

Dropout probability = 0.5

ResNet50_Adam_LR1e-3_WD1e-5_DP5e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5598, Acc: 0.7913
    - Epoch 2/15, Loss: 0.5019, Acc: 0.8017
    - Epoch 3/15, Loss: 0.4845, Acc: 0.8017
    - Epoch 4/15, Loss: 0.4577, Acc: 0.8120
    - Epoch 5/15, Loss: 0.4074, Acc: 0.8162
    - Epoch 6/15, Loss: 0.3954, Acc: 0.8204
    - Epoch 7/15, Loss: 0.3560, Acc: 0.8567
    - Epoch 8/15, Loss: 0.4059, Acc: 0.8255
    - Epoch 9/15, Loss: 0.3051, Acc: 0.8754
    - Epoch 10/15, Loss: 0.2513, Acc: 0.9034
    - Epoch 11/15, Loss: 0.2362, Acc: 0.9034
    - Epoch 12/15, Loss: 0.3228, Acc: 0.8837
    - Epoch 13/15, Loss: 0.2061, Acc: 0.9148
    - Epoch 14/15, Loss: 0.1574, Acc: 0.9408
    - Epoch 15/15, Loss: 0.2113, Acc: 0.9148
- Validation Scores:
    - Accuracy: 0.7833
    - Precision: 0.7966
    - Recall: 0.9792
    - F1 Score: 0.8785
- Test Scores:
    - Accuracy: 0.8017
    - Precision: 0.8000
    - Recall: 1.0000
    - F1 Score: 0.8889

EfficientNetB2_Adam_LR1e-3_WD5e-6_DP5e-1_EP15

- Training:
    - Epoch 1/15, Loss: 0.5540, Acc: 0.7882
    - Epoch 2/15, Loss: 0.4487, Acc: 0.8172
    - Epoch 3/15, Loss: 0.3491, Acc: 0.8640
    - Epoch 4/15, Loss: 0.2751, Acc: 0.8868
    - Epoch 5/15, Loss: 0.2239, Acc: 0.9200
    - Epoch 6/15, Loss: 0.1739, Acc: 0.9460
    - Epoch 7/15, Loss: 0.1646, Acc: 0.9439
    - Epoch 8/15, Loss: 0.1553, Acc: 0.9377
    - Epoch 9/15, Loss: 0.0794, Acc: 0.9688

    - Epoch 10/15, Loss: 0.3029, Acc: 0.8972
    - Epoch 11/15, Loss: 0.1358, Acc: 0.9564
    - Epoch 12/15, Loss: 0.0937, Acc: 0.9678
    - Epoch 13/15, Loss: 0.1214, Acc: 0.9668
    - Epoch 14/15, Loss: 0.0965, Acc: 0.9637
    - Epoch 15/15, Loss: 0.0629, Acc: 0.9772
- Validation Scores:
    - Accuracy: 0.8000
    - Precision: 0.8273
    - Recall: 0.9479
    - F1 Score: 0.8835
- Test Scores:
    - Accuracy: 0.8017
    - Precision: 0.8214
    - Recall: 0.9583
    - F1 Score: 0.8846