

## Model Development Phase Template

Date	July 7 2024
Team ID	SWTID1719935963
Project Title	Automated Weather Classification using Transfer Learning
Maximum Marks	10 Marks

### Initial Model Training Code, Model Validation and Evaluation Report

The initial model training code will be showcased in the future through a screenshot. The model validation and evaluation report will include a summary and training and validation performance metrics for multiple models, presented through respective screenshots.

#### Initial Model Training Code (5 marks):

```
model.compile(  
    loss='categorical_crossentropy',  
    optimizer='adam',  
    metrics=['accuracy']  
)
```

```
history = model.fit(  
    training_set,  
    validation_data=test_set,  
    epochs=20,  
    steps_per_epoch=len(training_set),  
    validation_steps=len(test_set)  
)
```

## Model Validation and Evaluation Report (5 marks):

Model	Summary	Training and Validation Performance Metrics																																												
Model 1	<div>Model: "model"</div> <table><thead><tr><th>Layer (type)</th><th>Output Shape</th><th>Param #</th></tr></thead><tbody><tr><td>input_1 (InputLayer)</td><td>[(None, 180, 180, 3)]</td><td>0</td></tr><tr><td>block1_conv1 (Conv2D)</td><td>(None, 180, 180, 64)</td><td>1792</td></tr><tr><td>block1_conv2 (Conv2D)</td><td>(None, 180, 180, 64)</td><td>36928</td></tr><tr><td>block1_pool (MaxPooling2D)</td><td>(None, 90, 90, 64)</td><td>0</td></tr><tr><td>block2_conv1 (Conv2D)</td><td>(None, 90, 90, 128)</td><td>73856</td></tr><tr><td>block2_conv2 (Conv2D)</td><td>(None, 90, 90, 128)</td><td>147584</td></tr><tr><td>block2_pool (MaxPooling2D)</td><td>(None, 45, 45, 128)</td><td>0</td></tr><tr><td>block3_conv1 (Conv2D)</td><td>(None, 45, 45, 256)</td><td>295168</td></tr><tr><td>block3_conv2 (Conv2D)</td><td>(None, 45, 45, 256)</td><td>590080</td></tr><tr><td>block3_conv3 (Conv2D)</td><td>(None, 45, 45, 256)</td><td>590080</td></tr><tr><td>block3_conv4 (Conv2D)</td><td>(None, 45, 45, 256)</td><td>590080</td></tr></tbody></table> <div>... Total params: 33137733 (126.41 MB) Trainable params: 13113349 (50.02 MB) Non-trainable params: 20024384 (76.39 MB)</div>	Layer (type)	Output Shape	Param #	input_1 (InputLayer)	[(None, 180, 180, 3)]	0	block1_conv1 (Conv2D)	(None, 180, 180, 64)	1792	block1_conv2 (Conv2D)	(None, 180, 180, 64)	36928	block1_pool (MaxPooling2D)	(None, 90, 90, 64)	0	block2_conv1 (Conv2D)	(None, 90, 90, 128)	73856	block2_conv2 (Conv2D)	(None, 90, 90, 128)	147584	block2_pool (MaxPooling2D)	(None, 45, 45, 128)	0	block3_conv1 (Conv2D)	(None, 45, 45, 256)	295168	block3_conv2 (Conv2D)	(None, 45, 45, 256)	590080	block3_conv3 (Conv2D)	(None, 45, 45, 256)	590080	block3_conv4 (Conv2D)	(None, 45, 45, 256)	590080	<div>epoch 1/30 19/19 [=====] - 32s 1s/step - loss: 4.0534 - accuracy: 0.4475 - val_loss: 0.7768 - val_accuracy: 0.6867 epoch 2/30 19/19 [=====] - 16s 844ms/step - loss: 0.5519 - accuracy: 0.8000 - val_loss: 0.5901 - val_accuracy: 0.8067 epoch 3/30 19/19 [=====] - 16s 831ms/step - loss: 0.3770 - accuracy: 0.8603 - val_loss: 0.4675 - val_accuracy: 0.8533 epoch 4/30 19/19 [=====] - 16s 836ms/step - loss: 0.2711 - accuracy: 0.9158 - val_loss: 0.4457 - val_accuracy: 0.8700 epoch 5/30 19/19 [=====] - 16s 838ms/step - loss: 0.2068 - accuracy: 0.9383 - val_loss: 0.3503 - val_accuracy: 0.8667 epoch 6/30 19/19 [=====] - 16s 833ms/step - loss: 0.1623 - accuracy: 0.9583 - val_loss: 0.3503 - val_accuracy: 0.8933 epoch 7/30 19/19 [=====] - 16s 843ms/step - loss: 0.1464 - accuracy: 0.9583 - val_loss: 0.3686 - val_accuracy: 0.8767 epoch 8/30 19/19 [=====] - 16s 852ms/step - loss: 0.1167 - accuracy: 0.9758 - val_loss: 0.3623 - val_accuracy: 0.8933 epoch 9/30 19/19 [=====] - 16s 846ms/step - loss: 0.1056 - accuracy: 0.9742 - val_loss: 0.3402 - val_accuracy: 0.9000 epoch 10/30 19/19 [=====] - 16s 832ms/step - loss: 0.0896 - accuracy: 0.9833 - val_loss: 0.3414 - val_accuracy: 0.8900 epoch 11/30 19/19 [=====] - 16s 834ms/step - loss: 0.0742 - accuracy: 0.9892 - val_loss: 0.3756 - val_accuracy: 0.8900 epoch 12/30 19/19 [=====] - 16s 829ms/step - loss: 0.0752 - accuracy: 0.9825 - val_loss: 0.3396 - val_accuracy: 0.9133 epoch 13/30 ... epoch 29/30 19/19 [=====] - 17s 875ms/step - loss: 0.0239 - accuracy: 0.9950 - val_loss: 0.3987 - val_accuracy: 0.9233 epoch 30/30 19/19 [=====] - 16s 832ms/step - loss: 0.0171 - accuracy: 0.9967 - val_loss: 0.4031 - val_accuracy: 0.8867 Output is truncated. View as a scrollable element or open in a text editor. Adjust cell output settings.</div>								
Layer (type)	Output Shape	Param #																																												
input_1 (InputLayer)	[(None, 180, 180, 3)]	0																																												
block1_conv1 (Conv2D)	(None, 180, 180, 64)	1792																																												
block1_conv2 (Conv2D)	(None, 180, 180, 64)	36928																																												
block1_pool (MaxPooling2D)	(None, 90, 90, 64)	0																																												
block2_conv1 (Conv2D)	(None, 90, 90, 128)	73856																																												
block2_conv2 (Conv2D)	(None, 90, 90, 128)	147584																																												
block2_pool (MaxPooling2D)	(None, 45, 45, 128)	0																																												
block3_conv1 (Conv2D)	(None, 45, 45, 256)	295168																																												
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Model 2	<table><tbody><tr><td>conv5_block3_1_relu (Activation)</td><td>(None, 6, 6, 512)</td><td>0</td><td>['conv5_block3_1_bn[0][0]']</td></tr><tr><td>conv5_block3_2_conv (Conv2D)</td><td>(None, 6, 6, 512)</td><td>2359808</td><td>['conv5_block3_1_relu[0][0]']</td></tr><tr><td>conv5_block3_2_bn (Batch Normalization)</td><td>(None, 6, 6, 512)</td><td>2048</td><td>['conv5_block3_2_conv[0][0]']</td></tr><tr><td>conv5_block3_2_relu (Activation)</td><td>(None, 6, 6, 512)</td><td>0</td><td>['conv5_block3_2_bn[0][0]']</td></tr><tr><td>conv5_block3_3_conv (Conv2D)</td><td>(None, 6, 6, 2048)</td><td>1050624</td><td>['conv5_block3_2_relu[0][0]']</td></tr><tr><td>conv5_block3_3_bn (Batch Normalization)</td><td>(None, 6, 6, 2048)</td><td>8192</td><td>['conv5_block3_3_conv[0][0]']</td></tr><tr><td>conv5_block3_add (Add)</td><td>(None, 6, 6, 2048)</td><td>0</td><td>['conv5_block2_out[0][0]', 'conv5_block3_3_bn[0][0]']</td></tr><tr><td>conv5_block3_out (Activation)</td><td>(None, 6, 6, 2048)</td><td>0</td><td>['conv5_block3_add[0][0]']</td></tr><tr><td>flatten_1 (Flatten)</td><td>(None, 73728)</td><td>0</td><td>['conv5_block3_out[0][0]']</td></tr><tr><td>dense_2 (Dense)</td><td>(None, 1024)</td><td>75498496</td><td>['flatten_1[0][0]']</td></tr><tr><td>dense_3 (Dense)</td><td>(None, 5)</td><td>5125</td><td>['dense_2[0][0]']</td></tr></tbody></table> <div>... Total params: 90091333 (378.00 MB) Trainable params: 75503621 (288.02 MB) Non-trainable params: 23587712 (89.98 MB)</div>	conv5_block3_1_relu (Activation)	(None, 6, 6, 512)	0	['conv5_block3_1_bn[0][0]']	conv5_block3_2_conv (Conv2D)	(None, 6, 6, 512)	2359808	['conv5_block3_1_relu[0][0]']	conv5_block3_2_bn (Batch Normalization)	(None, 6, 6, 512)	2048	['conv5_block3_2_conv[0][0]']	conv5_block3_2_relu (Activation)	(None, 6, 6, 512)	0	['conv5_block3_2_bn[0][0]']	conv5_block3_3_conv (Conv2D)	(None, 6, 6, 2048)	1050624	['conv5_block3_2_relu[0][0]']	conv5_block3_3_bn (Batch Normalization)	(None, 6, 6, 2048)	8192	['conv5_block3_3_conv[0][0]']	conv5_block3_add (Add)	(None, 6, 6, 2048)	0	['conv5_block2_out[0][0]', 'conv5_block3_3_bn[0][0]']	conv5_block3_out (Activation)	(None, 6, 6, 2048)	0	['conv5_block3_add[0][0]']	flatten_1 (Flatten)	(None, 73728)	0	['conv5_block3_out[0][0]']	dense_2 (Dense)	(None, 1024)	75498496	['flatten_1[0][0]']	dense_3 (Dense)	(None, 5)	5125	['dense_2[0][0]']	<div>Epoch 1/10 19/19 [=====] - 20s 1s/step - loss: 16.6076 - accuracy: 0.2908 - val_loss: 3.2137 - val_acc epoch 2/10 19/19 [=====] - 17s 914ms/step - loss: 2.1575 - accuracy: 0.2942 - val_loss: 1.6380 - val_a epoch 3/10 19/19 [=====] - 16s 865ms/step - loss: 1.5863 - accuracy: 0.3567 - val_loss: 1.5285 - val_a epoch 4/10 19/19 [=====] - 16s 847ms/step - loss: 1.4209 - accuracy: 0.3958 - val_loss: 1.1392 - val_a epoch 5/10 19/19 [=====] - 18s 939ms/step - loss: 1.2681 - accuracy: 0.4700 - val_loss: 1.1623 - val_a epoch 6/10 19/19 [=====] - 16s 850ms/step - loss: 1.2477 - accuracy: 0.4625 - val_loss: 1.1414 - val_a epoch 7/10 19/19 [=====] - 18s 933ms/step - loss: 1.2004 - accuracy: 0.5075 - val_loss: 1.2824 - val_a epoch 8/10 19/19 [=====] - 16s 856ms/step - loss: 1.2198 - accuracy: 0.4842 - val_loss: 1.0277 - val_a epoch 9/10 19/19 [=====] - 18s 929ms/step - loss: 1.1595 - accuracy: 0.5200 - val_loss: 1.2110 - val_a epoch 10/10 19/19 [=====] - 16s 854ms/step - loss: 1.1737 - accuracy: 0.5283 - val_loss: 0.9906 - val_a</div>
conv5_block3_1_relu (Activation)	(None, 6, 6, 512)	0	['conv5_block3_1_bn[0][0]']																																											
conv5_block3_2_conv (Conv2D)	(None, 6, 6, 512)	2359808	['conv5_block3_1_relu[0][0]']																																											
conv5_block3_2_bn (Batch Normalization)	(None, 6, 6, 512)	2048	['conv5_block3_2_conv[0][0]']																																											
conv5_block3_2_relu (Activation)	(None, 6, 6, 512)	0	['conv5_block3_2_bn[0][0]']																																											
conv5_block3_3_conv (Conv2D)	(None, 6, 6, 2048)	1050624	['conv5_block3_2_relu[0][0]']																																											
conv5_block3_3_bn (Batch Normalization)	(None, 6, 6, 2048)	8192	['conv5_block3_3_conv[0][0]']																																											
conv5_block3_add (Add)	(None, 6, 6, 2048)	0	['conv5_block2_out[0][0]', 'conv5_block3_3_bn[0][0]']																																											
conv5_block3_out (Activation)	(None, 6, 6, 2048)	0	['conv5_block3_add[0][0]']																																											
flatten_1 (Flatten)	(None, 73728)	0	['conv5_block3_out[0][0]']																																											
dense_2 (Dense)	(None, 1024)	75498496	['flatten_1[0][0]']																																											
dense_3 (Dense)	(None, 5)	5125	['dense_2[0][0]']																																											

## Model 3

```
model.summary()

Model: "model"
```

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[(None, 180, 180, 3)]	0
block1_conv1 (Conv2D)	(None, 180, 180, 64)	1792
block1_conv2 (Conv2D)	(None, 180, 180, 64)	36928
block1_pool (MaxPooling2D)	(None, 90, 90, 64)	0
block2_conv1 (Conv2D)	(None, 90, 90, 128)	73856
block2_conv2 (Conv2D)	(None, 90, 90, 128)	147584
block2_pool (MaxPooling2D)	(None, 45, 45, 128)	0
block3_conv1 (Conv2D)	(None, 45, 45, 256)	295168
block3_conv2 (Conv2D)	(None, 45, 45, 256)	590880
block3_conv3 (Conv2D)	(None, 45, 45, 256)	590880
block3_pool (MaxPooling2D)	(None, 22, 22, 256)	0
block4_conv1 (Conv2D)	(None, 22, 22, 512)	1180160
block4_conv2 (Conv2D)	(None, 22, 22, 512)	2359808
block4_conv3 (Conv2D)	(None, 22, 22, 512)	2359808
block4_pool (MaxPooling2D)	(None, 11, 11, 512)	0
block5_conv1 (Conv2D)	(None, 11, 11, 512)	2359808
block5_conv2 (Conv2D)	(None, 11, 11, 512)	2359808
block5_conv3 (Conv2D)	(None, 11, 11, 512)	2359808
block5_pool (MaxPooling2D)	(None, 5, 5, 512)	0
Flatten (Flatten)	(None, 12800)	0
dense (Dense)	(None, 1024)	13108224
dense_1 (Dense)	(None, 5)	5125

```

Total params: 27828037 (106.16 MB)
Trainable params: 13113349 (50.02 MB)
Non-trainable params: 14714688 (56.13 MB)

```

```
Epoch 1/20
18/19 [=====] - 18s 892ms/step - loss: 0.0400 - accuracy: 0.9933 - val_loss: 0.2201 - val_accuracy: 0.9267
Epoch 2/20
18/19 [=====] - 16s 853ms/step - loss: 0.0343 - accuracy: 0.9958 - val_loss: 0.2215 - val_accuracy: 0.9300
Epoch 3/20
18/19 [=====] - 16s 864ms/step - loss: 0.0269 - accuracy: 0.9958 - val_loss: 0.2360 - val_accuracy: 0.9233
Epoch 4/20
18/19 [=====] - 18s 952ms/step - loss: 0.0276 - accuracy: 0.9958 - val_loss: 0.2220 - val_accuracy: 0.9300
Epoch 5/20
18/19 [=====] - 16s 860ms/step - loss: 0.0256 - accuracy: 0.9958 - val_loss: 0.2227 - val_accuracy: 0.9233
Epoch 6/20
18/19 [=====] - 16s 856ms/step - loss: 0.0258 - accuracy: 0.9958 - val_loss: 0.2525 - val_accuracy: 0.9233
Epoch 7/20
18/19 [=====] - 17s 872ms/step - loss: 0.0208 - accuracy: 0.9975 - val_loss: 0.2665 - val_accuracy: 0.9300
Epoch 8/20
18/19 [=====] - 17s 870ms/step - loss: 0.0187 - accuracy: 0.9983 - val_loss: 0.2542 - val_accuracy: 0.9200
Epoch 9/20
18/19 [=====] - 16s 852ms/step - loss: 0.0192 - accuracy: 0.9967 - val_loss: 0.2272 - val_accuracy: 0.9267
Epoch 10/20
18/19 [=====] - 17s 914ms/step - loss: 0.0136 - accuracy: 0.9992 - val_loss: 0.2248 - val_accuracy: 0.9367
Epoch 11/20
18/19 [=====] - 17s 936ms/step - loss: 0.0120 - accuracy: 0.9992 - val_loss: 0.2322 - val_accuracy: 0.9300
Epoch 12/20
18/19 [=====] - 16s 840ms/step - loss: 0.0126 - accuracy: 0.9992 - val_loss: 0.2666 - val_accuracy: 0.9100
Epoch 13/20
18/19 [=====] - 17s 895ms/step - loss: 0.0197 - accuracy: 0.9967 - val_loss: 0.2421 - val_accuracy: 0.9267
Epoch 14/20
18/19 [=====] - 16s 863ms/step - loss: 0.0101 - accuracy: 1.0000 - val_loss: 0.2657 - val_accuracy: 0.9100
Epoch 15/20
18/19 [=====] - 17s 922ms/step - loss: 0.0101 - accuracy: 0.9992 - val_loss: 0.2369 - val_accuracy: 0.9333
Epoch 16/20
18/19 [=====] - 16s 845ms/step - loss: 0.0084 - accuracy: 0.9992 - val_loss: 0.2150 - val_accuracy: 0.9367
Epoch 17/20
18/19 [=====] - 16s 826ms/step - loss: 0.0074 - accuracy: 0.9992 - val_loss: 0.2240 - val_accuracy: 0.9367
Epoch 18/20
18/19 [=====] - 16s 838ms/step - loss: 0.0085 - accuracy: 0.9983 - val_loss: 0.2185 - val_accuracy: 0.9433
Epoch 19/20
18/19 [=====] - 16s 863ms/step - loss: 0.0057 - accuracy: 1.0000 - val_loss: 0.2150 - val_accuracy: 0.9400
Epoch 20/20
18/19 [=====] - 17s 923ms/step - loss: 0.0056 - accuracy: 1.0000 - val_loss: 0.2313 - val_accuracy: 0.9367
```