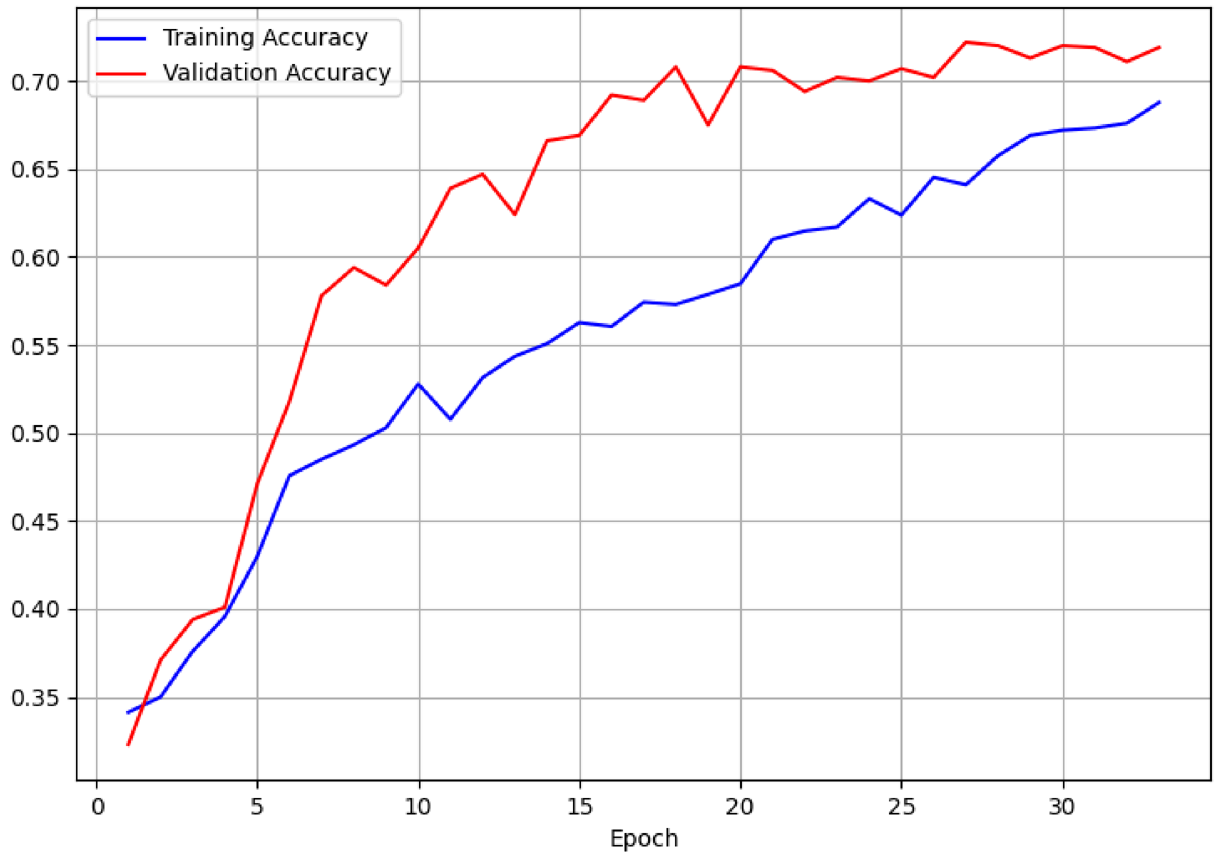
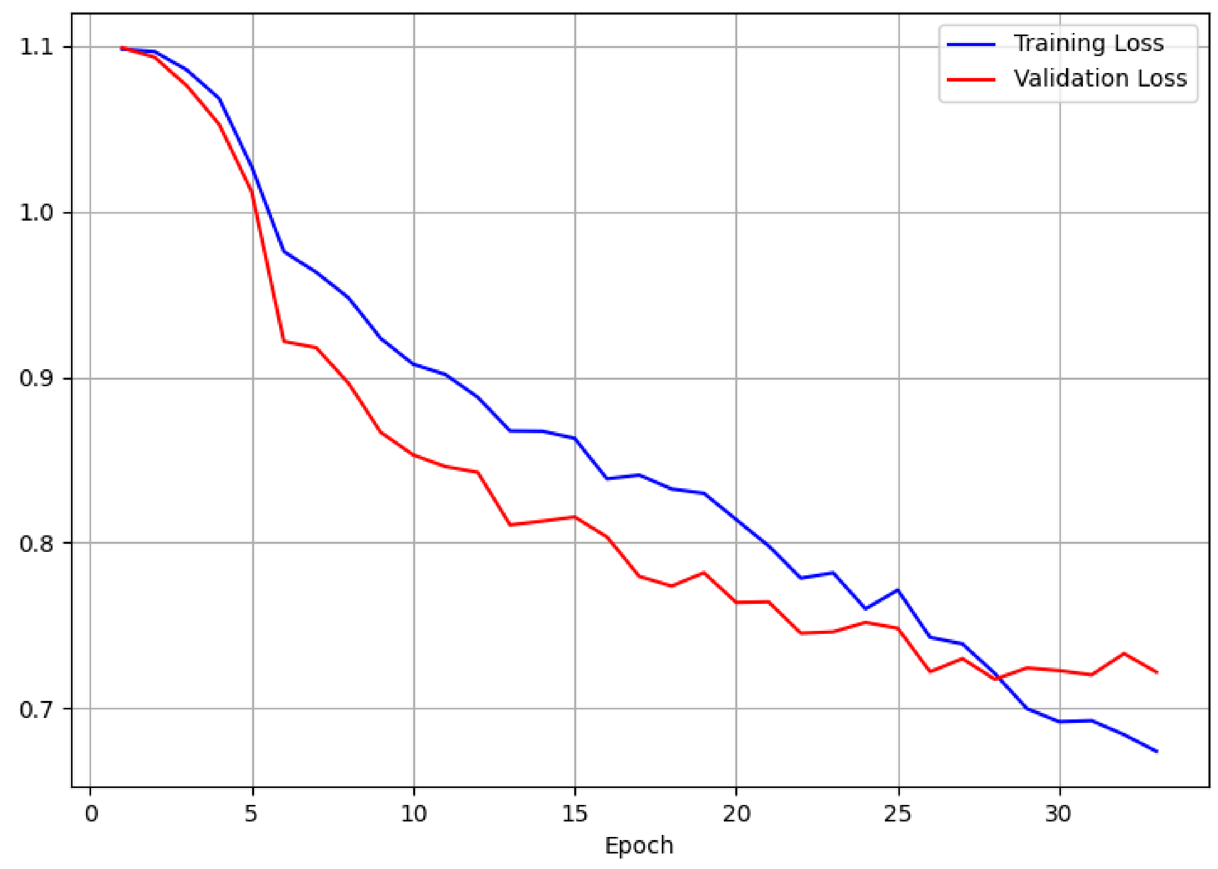
Part 5

- **Initial Network**

```
Model: "sequential"
+-----------------------------------------------------------------------------------------
+
| Layer (type)                        | Output Shape                 |         Param #
|
|-------------------------------------+-----------------------------+-----------------
|
| rescaling (Rescaling)               | (None, 150, 150, 3)          |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| conv2d (Conv2D)                     | (None, 150, 150, 8)          |             224
|
|-------------------------------------+-----------------------------+-----------------
|
| max_pooling2d (MaxPooling2D)        | (None, 75, 75, 8)            |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| conv2d_1 (Conv2D)                   | (None, 75, 75, 16)           |           1,168
|
|-------------------------------------+-----------------------------+-----------------
|
| max_pooling2d_1 (MaxPooling2D)      | (None, 37, 37, 16)           |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| conv2d_2 (Conv2D)                   | (None, 37, 37, 32)           |           4,640
|
|-------------------------------------+-----------------------------+-----------------
|
| max_pooling2d_2 (MaxPooling2D)      | (None, 18, 18, 32)           |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| conv2d_3 (Conv2D)                   | (None, 18, 18, 64)           |          18,496
|
|-------------------------------------+-----------------------------+-----------------
|
| max_pooling2d_3 (MaxPooling2D)      | (None, 9, 9, 64)             |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| flatten (Flatten)                   | (None, 5184)                 |               0
|
|-------------------------------------+-----------------------------+-----------------
|
| dense (Dense)                        | (None, 16)                  |          82,960
|
|--------------------------------------+-----------------------------+-----------------
|
| dense_1 (Dense)                      | (None, 3)                   |              51
|
+-------------------------------------------------------------------------------------
+
 Total params: 107,539 (420.07 KB)
 Trainable params: 107,539 (420.07 KB)
 Non-trainable params: 0 (0.00 B)
```

- 

-



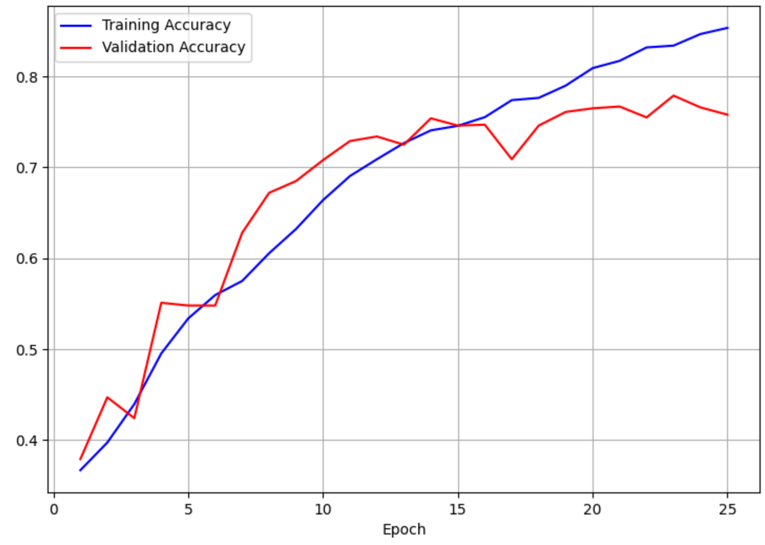
-

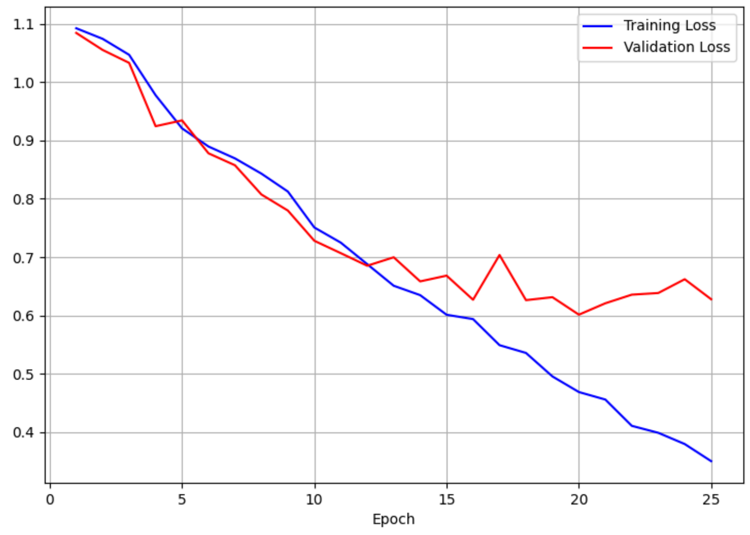
```
* Evaluating basic_model
30/30 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 3s 90ms/step - accuracy: 0.7296 - loss: 0.7036
```

Part 6

- **Initial Network**

```
Model: "sequential"
+---------------------------------------------------------------------------------------
+
| Layer (type)                          | Output Shape                | Param #
|
|--------------------------------------+-----------------------------+------------------
|
| rescaling (Rescaling)                 | (None, 150, 150, 3)         |              0
|
|--------------------------------------+-----------------------------+------------------
|
| conv2d (Conv2D)                       | (None, 150, 150, 8)         |            224
|
|--------------------------------------+-----------------------------+------------------
|
| max_pooling2d (MaxPooling2D)          | (None, 75, 75, 8)           |              0
|
|---------------------------------------+------------------------------+-----------------
|
| conv2d_1 (Conv2D)                     | (None, 75, 75, 16)           |           1,168
|
|---------------------------------------+------------------------------+-----------------
|
| max_pooling2d_1 (MaxPooling2D)        | (None, 37, 37, 16)           |               0
|
|---------------------------------------+------------------------------+-----------------
|
| conv2d_2 (Conv2D)                     | (None, 37, 37, 32)           |           4,640
|
|---------------------------------------+------------------------------+-----------------
|
| max_pooling2d_2 (MaxPooling2D)        | (None, 18, 18, 32)           |               0
|
|---------------------------------------+------------------------------+-----------------
|
| conv2d_3 (Conv2D)                     | (None, 18, 18, 64)           |          18,496
|
|---------------------------------------+------------------------------+-----------------
|
| max_pooling2d_3 (MaxPooling2D)        | (None, 9, 9, 64)             |               0
|
|---------------------------------------+------------------------------+-----------------
|
| conv2d_4 (Conv2D)                     | (None, 9, 9, 128)            |          73,856
|
|---------------------------------------+------------------------------+-----------------
|
| max_pooling2d_4 (MaxPooling2D)        | (None, 4, 4, 128)            |               0
|
|---------------------------------------+------------------------------+-----------------
|
| flatten (Flatten)                     | (None, 2048)                 |               0
|
|---------------------------------------+------------------------------+-----------------
|
| dense (Dense)                         | (None, 16)                   |          32,784
|
|---------------------------------------+------------------------------+-----------------
|
| dropout (Dropout)                     | (None, 16)                   |               0
|
|---------------------------------------+------------------------------+-----------------
|
| dense_1 (Dense)                       | (None, 3)                    |              51
|
+-----------------------------------------------------------------------------
+
 Total params: 131,219 (512.57 KB)
 Trainable params: 131,219 (512.57 KB)
 Non-trainable params: 0 (0.00 B)
```

- 

- 

```
 * Evaluating basic_model
 30/30 ━━━━━━━━━━━━━━━━━━━━ 3s 85ms/step - accuracy: 0.7398 - loss: 0.6369
```

- I changed the amount of convolutional by adding a final convolutional layer with 128 filters/kernels to the already 4 convolutional layers (8, 16, 32, 64 filters/kernels respectively).
- I also cut the learning rate in half to avoid overfitting.
- I added a dropout layer with 0.3 dropout rate after the one and only dense layer (dense layer has 16 filters/kernels)

Part 7

Game trace:

```
| | | |
| | | |
| | | |
Turn: X
Player X took position (2, 1).
| | | |
| | | |
| |X| |
Turn: O
reference:
row 0 is neutral.
row 1 is happy.
row 2 is surprise.

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 83ms/step
Emotion detected as happy (row 1). Enter 'text' to use text input instead (0, 1 or 2). Otherwise, press Enter to continue.

reference:
col 0 is neutral.
col 1 is happy.
col 2 is surprise.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 64ms/step
Emotion detected as neutral (col 0). Enter 'text' to use text input instead (0, 1 or 2). Otherwise, press Enter to continue.

Player O took position (1, 0).
| | | |
|O| | |
| |X| |
Turn: X
Player X took position (0, 0).
|X| | |
|O| | |
| |X| |
Turn: O
reference:
row 0 is neutral.
row 1 is happy.
row 2 is surprise.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
Emotion detected as happy (row 1). Enter 'text' to use text input instead (0, 1 or 2). Otherwise, press Enter to continue.
```

```
reference:
col 0 is neutral.
col 1 is happy.
col 2 is surprise.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 64ms/step
Emotion detected as happy (col 1). Enter 'text' to use text input instead (0, 1 or 2). Otherwise,
press Enter to continue.

Player O took position (1, 1).
|X| | |
|O|O| |
| |X| |
Turn: X
Player X took position (2, 2).
|X| | |
|O|O| |
| |X|X|
Turn: O
reference:
col 0 is neutral.
col 1 is happy.
col 2 is surprise.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
Emotion detected as neutral (col 0). Enter 'text' to use text input instead (0, 1 or 2). Otherwise,
press Enter to continue.

reference:
col 0 is neutral.
col 1 is happy.
col 2 is surprise.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 62ms/step
Emotion detected as happy (col 1). Enter 'text' to use text input instead (0, 1 or 2). Otherwise,
press Enter to continue.
text
2
Player O took position (1, 2).
|X| | |
|O|O|O|
| |X|X|
Player O has won!
```

<u>Questions</u>

1. How well did your interface work?

It didn’t work as anticipated, but worked enough to win the game.

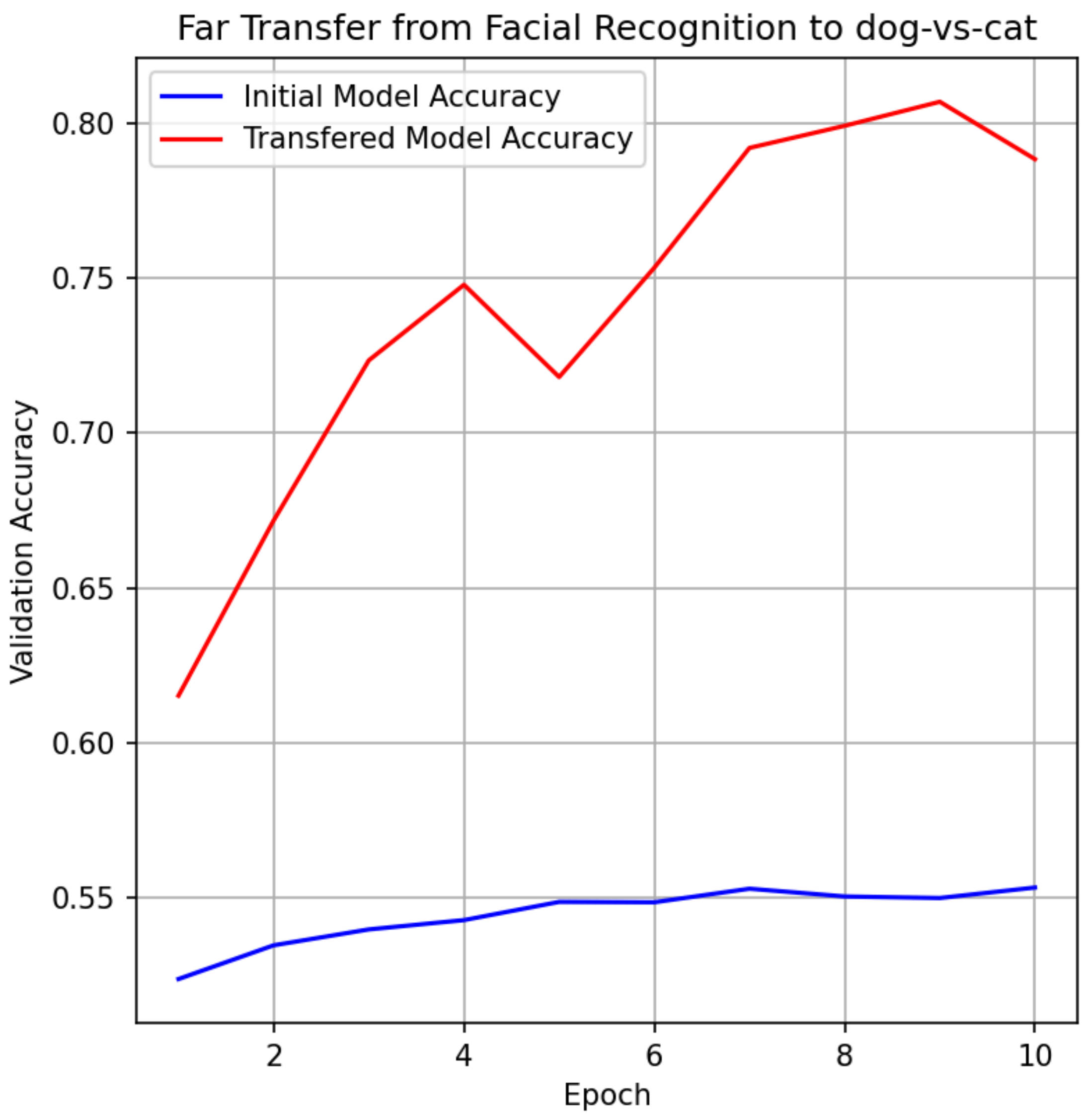
2. Did it recognize your facial expressions with the same accuracy as it achieved against the test set?
   Not really.

3. If not, why not?
   We spent some time trying to understand why the bot could somewhat recognize neutral and happy expressions but struggled completely with surprised faces. After repeatedly swapping out the base model it loaded, we deduced that the bot likely "cheats" to achieve the desired results in other steps. To reach 80% accuracy, it doesn’t actually matter much what it selects for surprised faces, assuming the test dataset is evenly distributed. This is because if it correctly identifies neutral and happy faces nearly 100% of the time, it wouldn’t need to adjust the base probability of random selection significantly to maintain 80% accuracy overall. The math behind this is: {⅓ + ⅓ + (⅓ * ⅓)= 7/9 = 0.7777…} This means the bot only needs to be about 3% more accurate than random guessing to achieve 80% accuracy.

Code for _get_emotion

```
def _get_emotion(self, img) -> int:
        model = models.load_model('TicTacToeModel/game_model.keras')
        img_resized = cv2.resize(img, tuple(image_size))
        img_resized = img_resized / 255.0
        img_resized = np.repeat(img_resized[:, :, np.newaxis], 3, axis=-1)
        img_resized = np.expand_dims(img_resized, axis=0)
        predictions = model.predict(img_resized)
        emotion = int(np.argmax(predictions))
        return emotion
```

Part 8



<u>Final Accuracy</u>

```
Restoring model weights from the end of the best epoch: 10.
* Evaluating transfered_model
98/98 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 5s 45ms/step - accuracy: 0.5108 - loss:
1.3916

Restoring model weights from the end of the best epoch: 9.
* Evaluating random_model
98/98 ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 6s 61ms/step - accuracy: 0.4762 - loss:
1.9867
```

Facial recognition image categories

happy

neutral

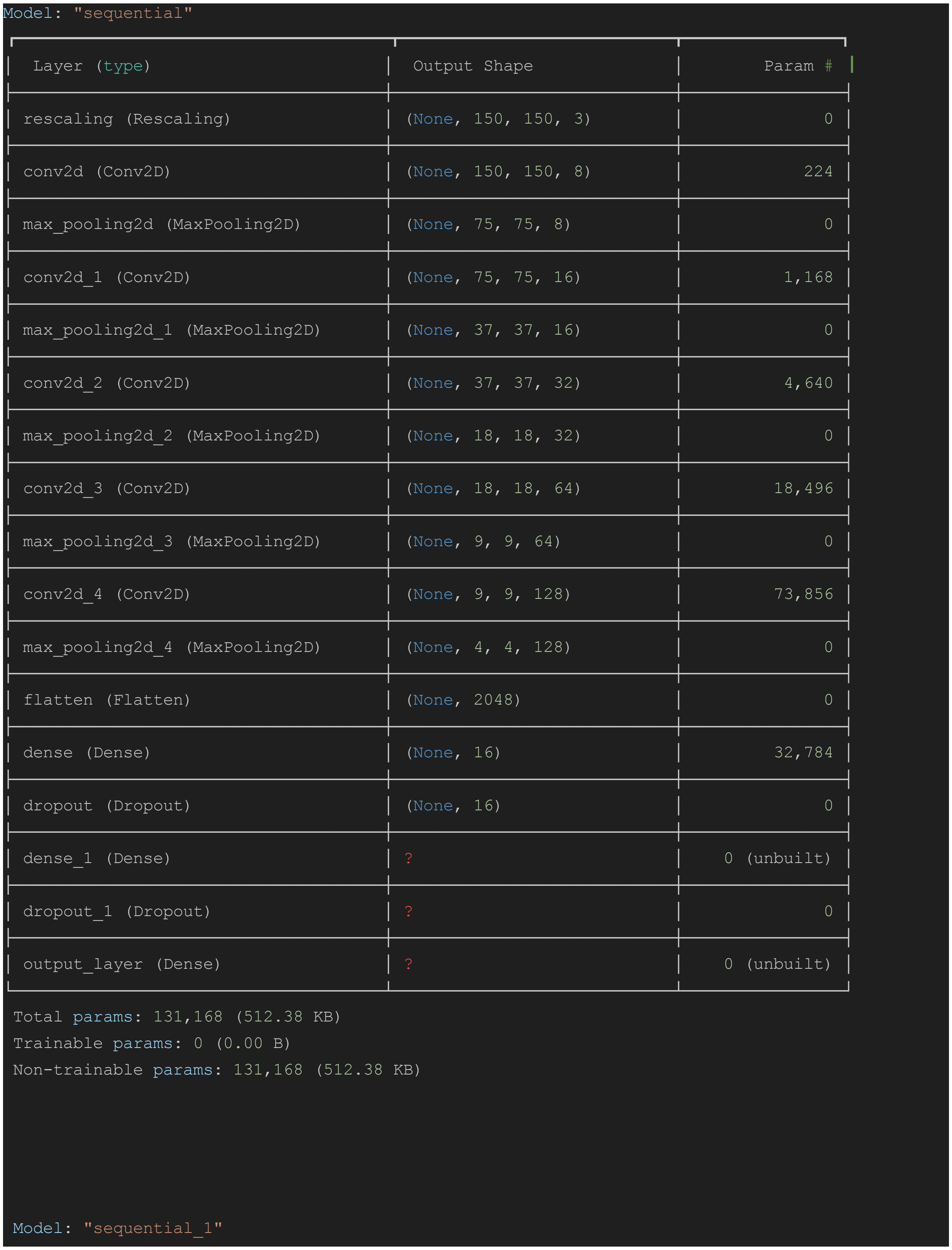
surprise

Dog-Vs-Cat image categories

dog

cat

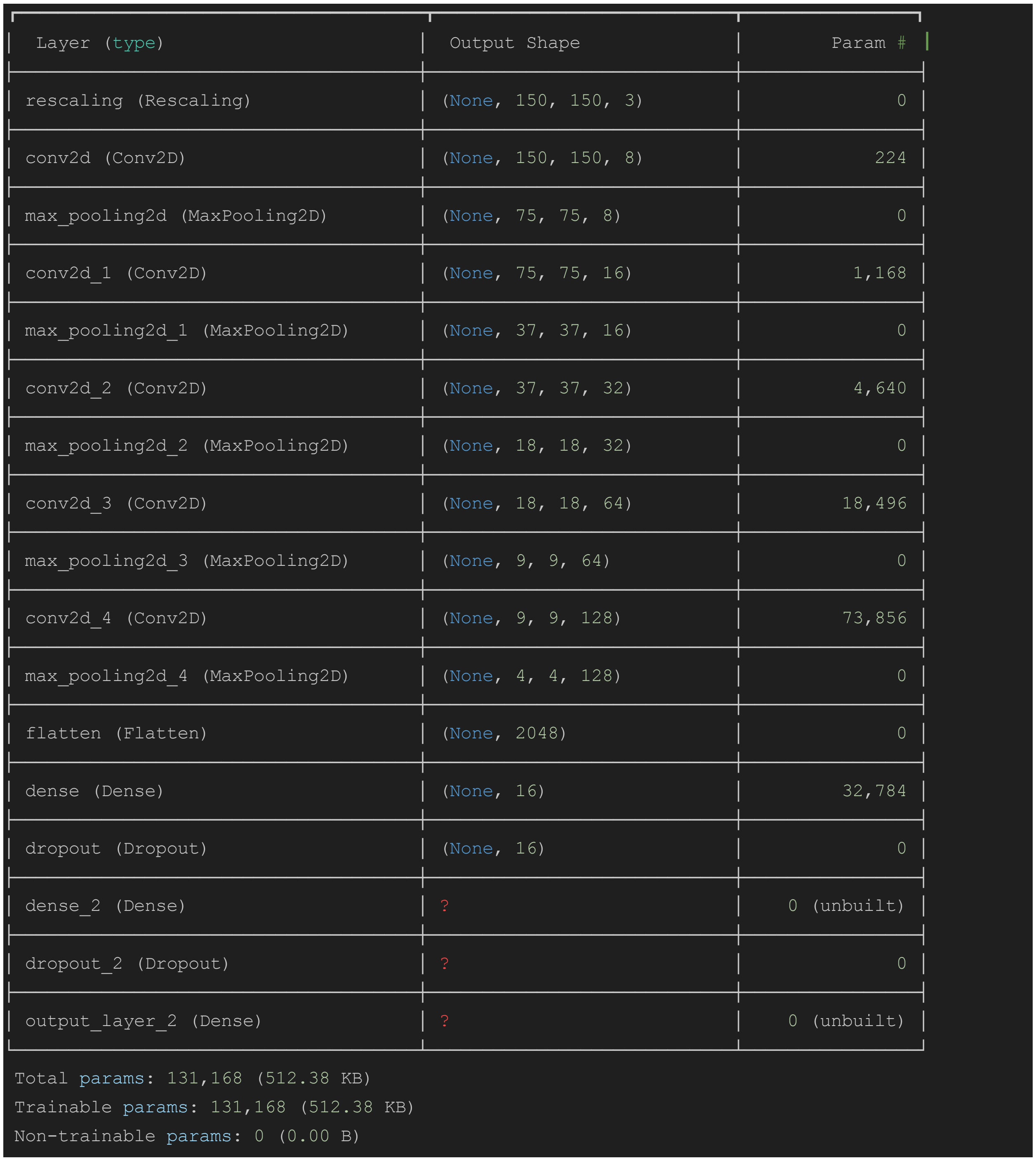
Summaries



```
Model: "sequential"
┏━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━┓
┃ Layer (type)                         ┃ Output Shape               ┃        Param # ┃
┡━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━┩
│ rescaling (Rescaling)                │ (None, 150, 150, 3)        │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d (Conv2D)                      │ (None, 150, 150, 8)        │            224 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d (MaxPooling2D)         │ (None, 75, 75, 8)          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_1 (Conv2D)                    │ (None, 75, 75, 16)         │          1,168 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_1 (MaxPooling2D)       │ (None, 37, 37, 16)         │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_2 (Conv2D)                    │ (None, 37, 37, 32)         │          4,640 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_2 (MaxPooling2D)       │ (None, 18, 18, 32)         │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_3 (Conv2D)                    │ (None, 18, 18, 64)         │         18,496 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_3 (MaxPooling2D)       │ (None, 9, 9, 64)           │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_4 (Conv2D)                    │ (None, 9, 9, 128)          │         73,856 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_4 (MaxPooling2D)       │ (None, 4, 4, 128)          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ flatten (Flatten)                    │ (None, 2048)               │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dense (Dense)                        │ (None, 16)                 │         32,784 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dropout (Dropout)                    │ (None, 16)                 │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dense_1 (Dense)                      │ ?                          │    0 (unbuilt) │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dropout_1 (Dropout)                  │ ?                          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ output_layer (Dense)                 │ ?                          │    0 (unbuilt) │
└──────────────────────────────────────┴────────────────────────────┴────────────────┘
 Total params: 131,168 (512.38 KB)
 Trainable params: 0 (0.00 B)
 Non-trainable params: 131,168 (512.38 KB)




Model: "sequential_1"
```



```
┌──────────────────────────────────────┬────────────────────────────┬────────────────┐
│ Layer (type)                         │ Output Shape               │        Param # │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ rescaling (Rescaling)                │ (None, 150, 150, 3)        │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d (Conv2D)                      │ (None, 150, 150, 8)        │            224 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d (MaxPooling2D)         │ (None, 75, 75, 8)          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_1 (Conv2D)                    │ (None, 75, 75, 16)         │          1,168 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_1 (MaxPooling2D)       │ (None, 37, 37, 16)         │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_2 (Conv2D)                    │ (None, 37, 37, 32)         │          4,640 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_2 (MaxPooling2D)       │ (None, 18, 18, 32)         │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_3 (Conv2D)                    │ (None, 18, 18, 64)         │         18,496 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_3 (MaxPooling2D)       │ (None, 9, 9, 64)           │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ conv2d_4 (Conv2D)                    │ (None, 9, 9, 128)          │         73,856 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ max_pooling2d_4 (MaxPooling2D)       │ (None, 4, 4, 128)          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ flatten (Flatten)                    │ (None, 2048)               │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dense (Dense)                        │ (None, 16)                 │         32,784 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dropout (Dropout)                    │ (None, 16)                 │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dense_2 (Dense)                      │ ?                          │    0 (unbuilt) │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ dropout_2 (Dropout)                  │ ?                          │              0 │
├──────────────────────────────────────┼────────────────────────────┼────────────────┤
│ output_layer_2 (Dense)               │ ?                          │    0 (unbuilt) │
└──────────────────────────────────────┴────────────────────────────┴────────────────┘
Total params: 131,168 (512.38 KB)
Trainable params: 131,168 (512.38 KB)
Non-trainable params: 0 (0.00 B)
```