

### Problem 1 (25 points)

Please consider the following example of a Convolutional Neural Network (CNN) for image classification found in

5.2-Training\_a\_convnet\_from\_scratch\_on\_a\_small\_dataset.ipynb:

```
model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu',
                        input_shape=(150, 150, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(128, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Flatten())
model.add(layers.Dense(512, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))
```

Make sure you can run the code found in the notebook. Explain where do the numbers of unknown parameters 896, 0, and 18496 on the summary display below for the `conv2d_1`, `conv2d_1` (Conv2D), and `conv2d_2` (Conv2D) layers come from. Please be specific.

```
model.summary()
```

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 148, 148, 32)	896
max_pooling2d_1 (MaxPooling2D)	(None, 74, 74, 32)	0
conv2d_2 (Conv2D)	(None, 72, 72, 64)	18496
max_pooling2d_2 (MaxPooling2D)	(None, 36, 36, 64)	0
conv2d_3 (Conv2D)	(None, 34, 34, 128)	73856
max_pooling2d_3 (MaxPooling2D)	(None, 17, 17, 128)	0
conv2d_4 (Conv2D)	(None, 15, 15, 128)	147584
max_pooling2d_4 (MaxPooling2D)	(None, 7, 7, 128)	0
flatten_1 (Flatten)	(None, 6272)	0
dense_1 (Dense)	(None, 512)	3211776
dense_2 (Dense)	(None, 1)	513

=====  
Total params: 3,453,121

Trainable params: 3,453,121  
Non-trainable params: 0

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### SOLUTION:

a) `conv2d_1` is the first layer. It is a 3x3 filter for each color. Since input has 3 colors.  
No. of parameter in each filter =  $3*3*3+1$ . (3 – 3x3 filter and a bias term) = 28 parameters.  
The output is specified to have 32 maps, each map has 28 parameters.  
So the total parameters for `conv2d_1` layer =  $28*32=896$ .

Because of sliding of the filter, output size will be 148x148x32.

b) `max_pooling2d_1` is the second layer. It makes signals stronger and reduces the dimensionality. Max of each 2x2 pixel is taken, and then maximum of next 2x2 pixel is considered. Here, there are no parameters to learn as only maximum of 2x2 pixel are taken.  
output size will be 74x74x32.  
Total parameters for `max_pooling2d_1` layer = 0.

c) `conv2d_2` – the third layer.  
For each map in this layer, parameters =  $3*3*32+1=289$ . 3x3 size of filter, total 32 colours and at last a bias term.

The output is specified to have 64 maps, So total parameters =  $289*64=18,496$ .  
Output size of this layer is, 72x72x64.

### Problem 2 (40 points)

Experiment with various optimizers and corresponding hyperparameters. Please try at least four alternatives and plot the validation/train accuracy in each case. Present the best validation accuracy found in each case as a table indicating considered optimizers and hyperparameters. Discuss.

### SOLUTION:

- a) Table indicating considered optimizers and hyperparameters and the corresponding max. validation accuracy.

Model #	Optimizer	Hyperparameters	Max. Val. Accuracy
Model 1	RMSProp	lr=0.00005	74.5
Model 2	RMSProp	lr=0.0002, rho=0.8	75.3
Model 3	Adam	lr=0.0001	74.3
Model 4	Adam	lr=0.00005, beta_1=0.8	74.4
Model 5	Adam	lr=0.00005, beta_1=0.8, beta_2=0.98	73.7
Model 6	Adam	lr=0.00002, beta_1=0.7, beta_2=0.85	73.9

b) Train and validation accuracy for the various models. Model parameters are as shown in the table above.

