Lab 4 Deep Learning 1

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Homework 1

I built a new model and added 3 convolutional leyers, two of them with relu activation function and the other one with softmax activation function. I flattened the layers and add one dense layer (size 64) and relu activation function and one dense layer (size 10) and softmax activation function. Rest of the parameters were unchanged and model was fitted with 15 epochs and with batch size of 128.

```
model_1 = models.Sequential()
model_1.add(layers.Conv2D(64, (3, 3), activation='relu', input_shape=(28, 28, 1)))
model_1.add(layers.MaxPooling2D((2, 2)))
model_1.add(layers.Conv2D(64, (3, 3), activation='softmax'))
model_1.add(layers.MaxPooling2D((2, 2)))
model_1.add(layers.Conv2D(64, (3, 3), activation='relu'))
```

```
model_1.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_9 (Conv2D)           (None, 26, 26, 64)        640

 max_pooling2d_6 (MaxPooling  (None, 13, 13, 64)       0
 2D)

 conv2d_10 (Conv2D)          (None, 11, 11, 64)        36928

 max_pooling2d_7 (MaxPooling  (None, 5, 5, 64)         0
 2D)

 conv2d_11 (Conv2D)          (None, 3, 3, 64)          36928

=================================================================
Total params: 74,496
Trainable params: 74,496
Non-trainable params: 0
_________________________________________________________________
```

```
model_1.add(layers.Flatten())
model_1.add(layers.Dense(64, activation='relu'))
model_1.add(layers.Dense(10, activation='softmax'))
```

```
train_images_conv = train_images.reshape((60000, 28, 28, 1))
train_images_conv = train_images_conv.astype('float32') / 255
test_images_conv = test_images.reshape((10000, 28, 28, 1))
test_images_conv = test_images_conv.astype('float32') / 255
```

```
model_1.compile(optimizer='rmsprop',
loss='categorical_crossentropy',
metrics=['accuracy'])
```

Below I present training accuracy.

```
model_1.fit(train_images_conv, train_labels, epochs=15, batch_size=128)
```

```
Train on 60000 samples
Epoch 1/15
60000/60000 [==============================] - 7s 121us/sample - loss: 0.1973 - accuracy: 0.9263
Epoch 2/15
60000/60000 [==============================] - 7s 116us/sample - loss: 0.1882 - accuracy: 0.9306
Epoch 3/15
60000/60000 [==============================] - 7s 114us/sample - loss: 0.1813 - accuracy: 0.9322
Epoch 4/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1741 - accuracy: 0.9352
Epoch 5/15
60000/60000 [==============================] - 7s 117us/sample - loss: 0.1674 - accuracy: 0.9380
Epoch 6/15
60000/60000 [==============================] - 7s 119us/sample - loss: 0.1616 - accuracy: 0.9401
Epoch 7/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1556 - accuracy: 0.9426
Epoch 8/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1492 - accuracy: 0.9450
Epoch 9/15
60000/60000 [==============================] - 7s 116us/sample - loss: 0.1446 - accuracy: 0.9452
Epoch 10/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1386 - accuracy: 0.9491
Epoch 11/15
60000/60000 [==============================] - 7s 116us/sample - loss: 0.1338 - accuracy: 0.9502
Epoch 12/15
60000/60000 [==============================] - 7s 116us/sample - loss: 0.1293 - accuracy: 0.9515
Epoch 13/15
60000/60000 [==============================] - 7s 116us/sample - loss: 0.1246 - accuracy: 0.9539
Epoch 14/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1183 - accuracy: 0.9552
Epoch 15/15
60000/60000 [==============================] - 7s 115us/sample - loss: 0.1142 - accuracy: 0.9578
<keras.callbacks.History at 0x7fef7b1c1e90>
```

Below one can see that the test accuracy of 0.907 is similar to training accuracy showed above (0.9578).

```
[44] test_loss, test_acc = model_1.evaluate(test_images_conv, test_labels)
     print(test_loss, test_acc)
```

```
0.33180018522739413 0.9071
```

Homework 2

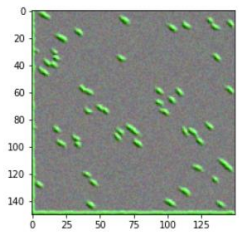
Below I present a function that takes as arguments the name of the layer and filter index and outputs the displayable filter response.

```python
#homework2 function
def function(arg1, arg2):
  layer_name = arg1
  filter_index = arg2
  layer_output = model.get_layer(layer_name).output
  loss = K.mean(layer_output[:, :, :, filter_index])
  grads = K.gradients(loss, model.input)[0]
  grads /= (K.sqrt(K.mean(K.square(grads))) + 1e-5)
  iterate = K.function([model.input], [loss, grads])
  loss_value, grads_value = iterate([np.zeros((1, 150, 150, 3))])
  #print(grads)
  #print(grads_value)

  input_img_data = np.random.random((1, 150, 150, 3)) * 20 + 128.
  step = 1.
  for i in range(40):
    loss_value, grads_value = iterate([input_img_data])
    input_img_data += grads_value * step

  #print(grads_value)
  x= input_img_data[0]
  x -= x.mean()
  x /= (x.std() + 1e-5)
  x *= 0.1

  x += 0.5
  x = np.clip(x, 0, 1)

  x *= 255
  x = np.clip(x, 0, 255).astype('uint8')
  return x
```

Filter response examples

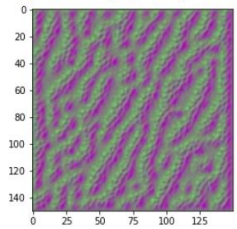
```python
plt.imshow(function("block1_conv1",11))
```

```
<matplotlib.image.AxesImage at 0x7fc6feb1bf90>
```



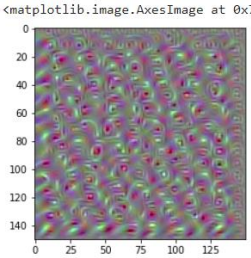
```python
plt.imshow(function('block2_conv2', 20))
```

```
<matplotlib.image.AxesImage at 0x7fc6ffe52550>
```



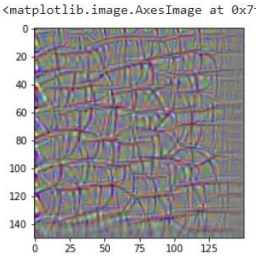
```python
plt.imshow(function('block3_conv2', 20))
```

```
<matplotlib.image.AxesImage at 0x7fc6ffd700d0>
```



```python
plt.imshow(function('block4_conv2', 37))
```

```
<matplotlib.image.AxesImage at 0x7fc6fec1f250>
```



```python
plt.imshow(function('block2_conv2', 2))
```

```
<matplotlib.image.AxesImage at 0x7fc6ff88a890>
```