In [ ]:
```
# Install TensorFlow
# !pip install -q tensorflow-gpu==2.0.0-beta1

try:
  %tensorflow_version 2.x  # Colab only.
except Exception:
  pass

import tensorflow as tf
print(tf.__version__)
```

```
     |████████████████████████████████| 348.9MB 52kB/s
     |████████████████████████████████| 3.1MB 49.1MB/s
     |████████████████████████████████| 501kB 54.6MB/s
2.0.0-beta1
```

In [ ]:
```
# Load in the data
mnist = tf.keras.datasets.mnist

(x_train, y_train), (x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0
print("x_train.shape:", x_train.shape)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.
npz
11493376/11490434 [==============================] - 0s 0us/step
x_train.shape: (60000, 28, 28)
```

In [ ]:
```
# Build the model
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

In [ ]:
```
# Compile the model
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

In [ ]:
```
# Train the model
r = model.fit(x_train, y_train, validation_data=(x_test, y_test), epochs=10)
```

```
WARNING: Logging before flag parsing goes to stderr.
W0718 16:30:06.976897 139639418169216 deprecation.py:323] From /usr/local/lib/python3.6/
dist-packages/tensorflow/python/ops/math_grad.py:1250: add_dispatch_support.<locals>.wra
pper (from tensorflow.python.ops.array_ops) is deprecated and will be removed in a futur
e version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
Train on 60000 samples, validate on 10000 samples
Epoch 1/10
60000/60000 [==============================] - 7s 111us/sample - loss: 0.2949 - accurac
y: 0.9134 - val_loss: 0.1339 - val_accuracy: 0.9594
```

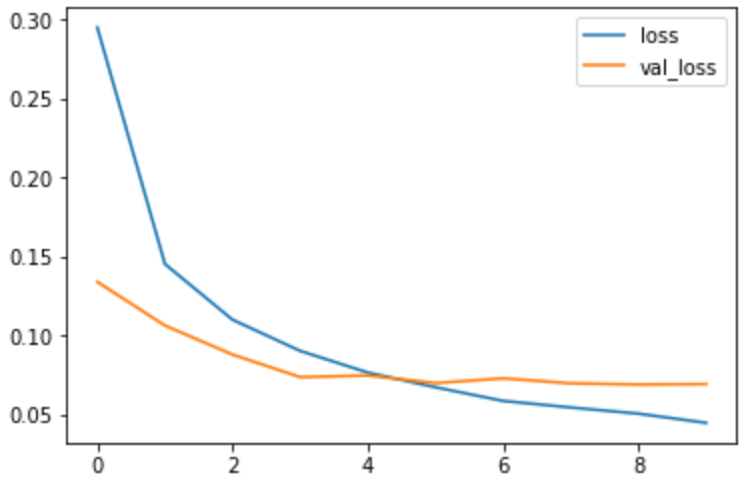
```
Epoch 2/10
60000/60000 [==============================] - 6s 93us/sample - loss: 0.1452 - accuracy:
0.9564 - val_loss: 0.1063 - val_accuracy: 0.9681
Epoch 3/10
60000/60000 [==============================] - 6s 95us/sample - loss: 0.1100 - accuracy:
0.9664 - val_loss: 0.0879 - val_accuracy: 0.9722
Epoch 4/10
60000/60000 [==============================] - 6s 94us/sample - loss: 0.0902 - accuracy:
0.9721 - val_loss: 0.0737 - val_accuracy: 0.9766
Epoch 5/10
60000/60000 [==============================] - 6s 93us/sample - loss: 0.0765 - accuracy:
0.9758 - val_loss: 0.0747 - val_accuracy: 0.9748
Epoch 6/10
60000/60000 [==============================] - 6s 94us/sample - loss: 0.0672 - accuracy:
0.9789 - val_loss: 0.0699 - val_accuracy: 0.9772
Epoch 7/10
60000/60000 [==============================] - 6s 93us/sample - loss: 0.0586 - accuracy:
0.9820 - val_loss: 0.0729 - val_accuracy: 0.9781
Epoch 8/10
60000/60000 [==============================] - 6s 94us/sample - loss: 0.0544 - accuracy:
0.9815 - val_loss: 0.0697 - val_accuracy: 0.9780
Epoch 9/10
60000/60000 [==============================] - 6s 93us/sample - loss: 0.0505 - accuracy:
0.9834 - val_loss: 0.0690 - val_accuracy: 0.9789
Epoch 10/10
60000/60000 [==============================] - 6s 93us/sample - loss: 0.0447 - accuracy:
0.9850 - val_loss: 0.0692 - val_accuracy: 0.9806
```

In [ ]:

```
# Plot loss per iteration
import matplotlib.pyplot as plt
plt.plot(r.history['loss'], label='loss')
plt.plot(r.history['val_loss'], label='val_loss')
plt.legend()
```

Out[ ]:

```
<matplotlib.legend.Legend at 0x7effe00f2ac8>
```

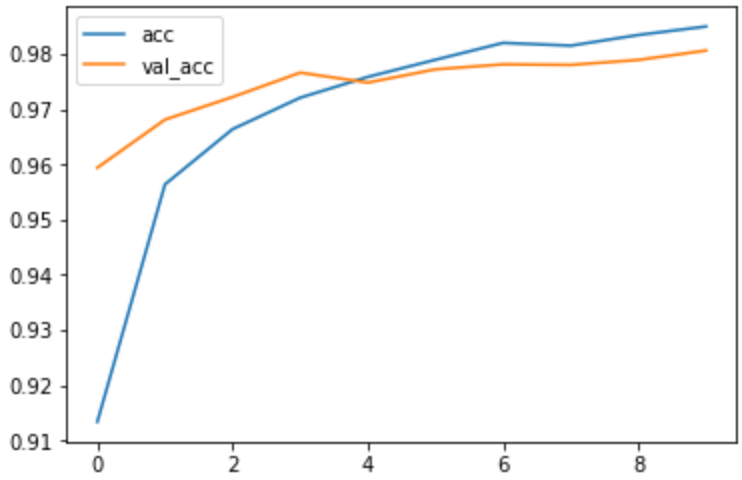


In [ ]:

```
# Plot accuracy per iteration
plt.plot(r.history['accuracy'], label='acc')
plt.plot(r.history['val_accuracy'], label='val_acc')
plt.legend()
```

Out[ ]:

```
<matplotlib.legend.Legend at 0x7effe0092518>
```



In [ ]:

```
# Evaluate the model
print(model.evaluate(x_test, y_test))
```

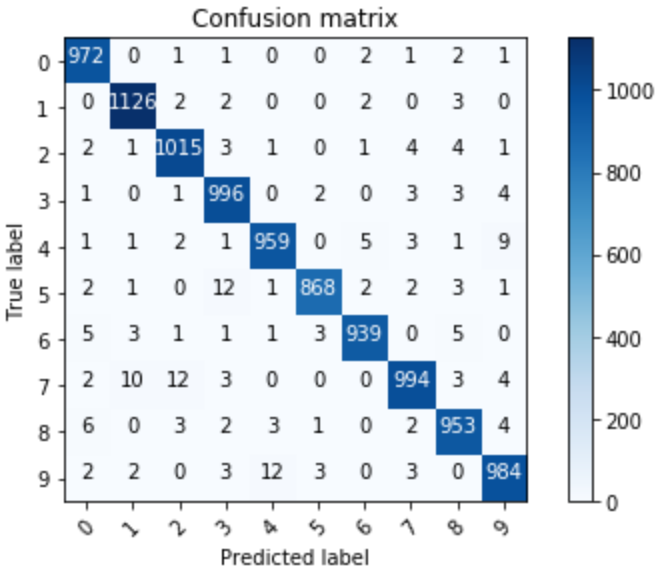
```
10000/10000 [==============================] - 1s 55us/sample - loss: 0.0692 - accuracy:
0.9806
[0.06924617666350968, 0.9806]
```

In [ ]:

```
# Plot confusion matrix
from sklearn.metrics import confusion_matrix
import numpy as np
import itertools

def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
  """
  This function prints and plots the confusion matrix.
  Normalization can be applied by setting `normalize=True`.
  """
  if normalize:
      cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
      print("Normalized confusion matrix")
  else:
      print('Confusion matrix, without normalization')

  print(cm)

  plt.imshow(cm, interpolation='nearest', cmap=cmap)
  plt.title(title)
  plt.colorbar()
  tick_marks = np.arange(len(classes))
  plt.xticks(tick_marks, classes, rotation=45)
  plt.yticks(tick_marks, classes)

  fmt = '.2f' if normalize else 'd'
  thresh = cm.max() / 2.
  for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
      plt.text(j, i, format(cm[i, j], fmt),
               horizontalalignment="center",
               color="white" if cm[i, j] > thresh else "black")
```

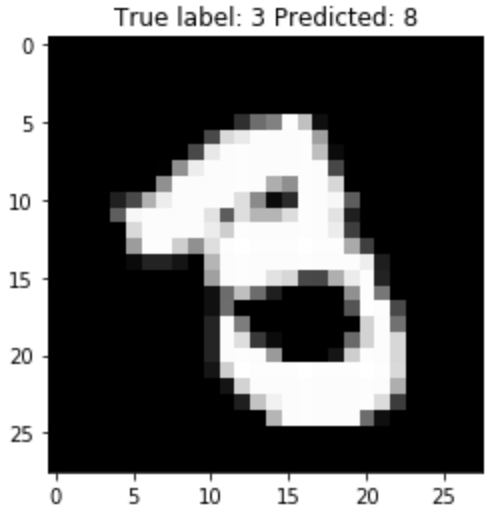
```
  plt.tight_layout()
  plt.ylabel('True label')
  plt.xlabel('Predicted label')
  plt.show()


p_test = model.predict(x_test).argmax(axis=1)
cm = confusion_matrix(y_test, p_test)
plot_confusion_matrix(cm, list(range(10)))

# Do these results make sense?
# It's easy to confuse 9 <--> 4, 9 <--> 7, 2 <--> 7, etc.
```

```
Confusion matrix, without normalization
[[ 972    0    1    1    0    0    2    1    2    1]
 [   0 1126    2    2    0    0    2    0    3    0]
 [   2    1 1015    3    1    0    1    4    4    1]
 [   1    0    1  996    0    2    0    3    3    4]
 [   1    1    2    1  959    0    5    3    1    9]
 [   2    1    0   12    1  868    2    2    3    1]
 [   5    3    1    1    1    3  939    0    5    0]
 [   2   10   12    3    0    0    0  994    3    4]
 [   6    0    3    2    3    1    0    2  953    4]
 [   2    2    0    3   12    3    0    3    0  984]]
```



In [ ]:

```
# Show some misclassified examples
misclassified_idx = np.where(p_test != y_test)[0]
i = np.random.choice(misclassified_idx)
plt.imshow(x_test[i], cmap='gray')
plt.title("True label: %s Predicted: %s" % (y_test[i], p_test[i]));
```


True label: 3 Predicted: 8
0
5
10
15
20
25
0
5
10
15
20
25