MNIST

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1 Intro to TensorFlow & Keras

1.1 MNIST Dataset Classification

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[1]:
```
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras as tfk
```

[2]:
```
mnist = tfk.datasets.mnist
```

[3]:
```
(x_train, y_train), (x_test, y_test) = mnist.load_data()
```

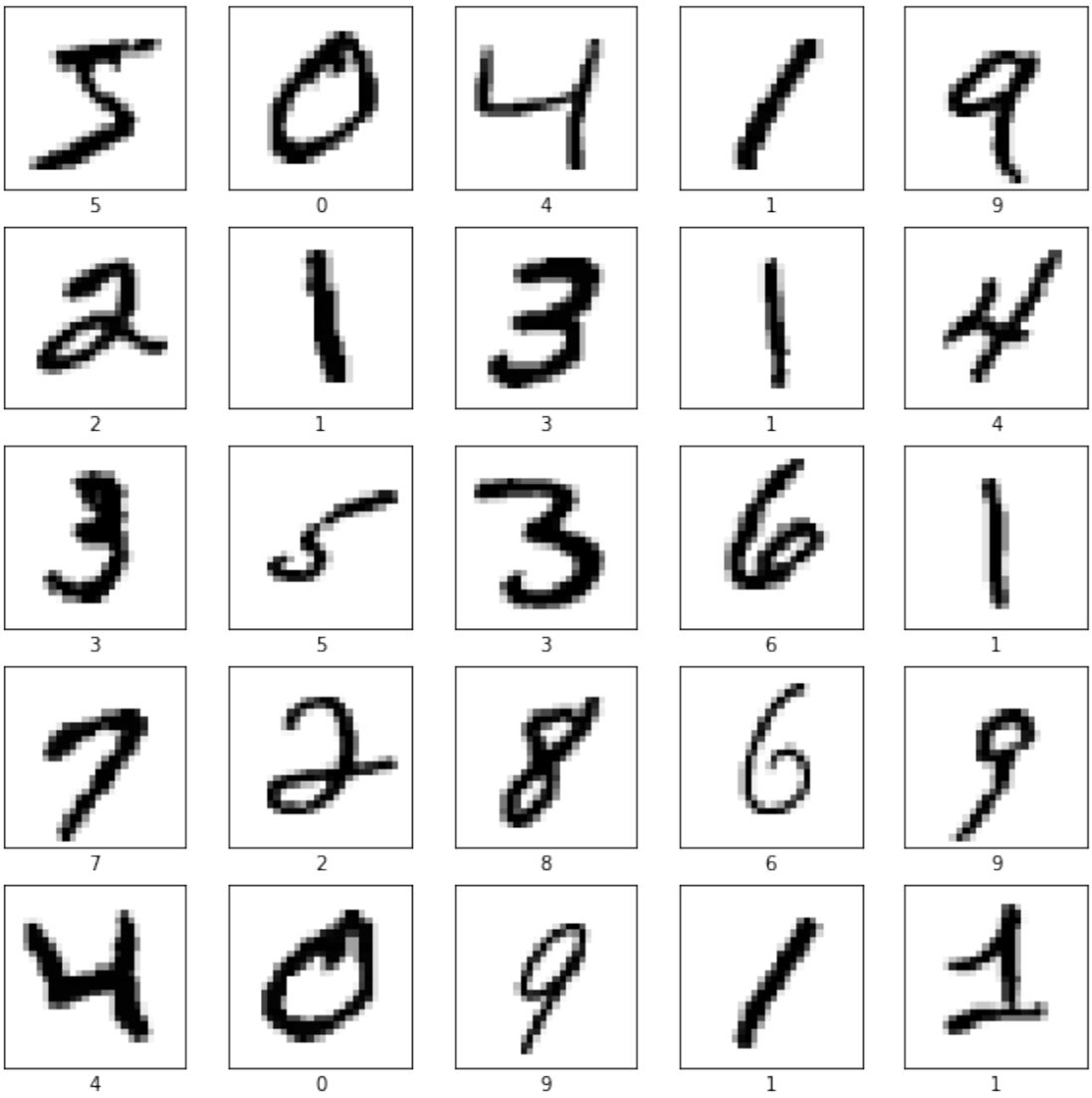
```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/mnist.npz
11493376/11490434 [==============================] - 0s 0us/step
11501568/11490434 [==============================] - 0s 0us/step
```

[4]:
```
print(x_train.shape, y_train.shape, x_test.shape, y_test.shape)
```

```
(60000, 28, 28) (60000,) (10000, 28, 28) (10000,)
```

- Plotting some examples and their labels from dataset:

[5]:
```
plt.figure(figsize=(10, 10))
for i in range(25):
    plt.subplot(5,5,i+1)
    plt.imshow(x_train[i], cmap=plt.cm.binary)
    plt.xticks([])
    plt.yticks([])
    plt.xlabel(y_train[i])
```



- Normalizing values:

[6]:
```
np.max(x_train)
```

[6]:
```
255
```

[7]:
```
x_train = x_train/255
x_text = x_test/255
```

- Constructing our model:

[15]:
```
model = tfk.models.Sequential([
            tfk.layers.Flatten(input_shape=(28,28)),
            tfk.layers.Dense(300, activation='relu'),
```

```
            tfk.layers.Dense(10, activation='relu'),
])
```

[16]:
```
model.summary()
tfk.utils.plot_model(model)
```

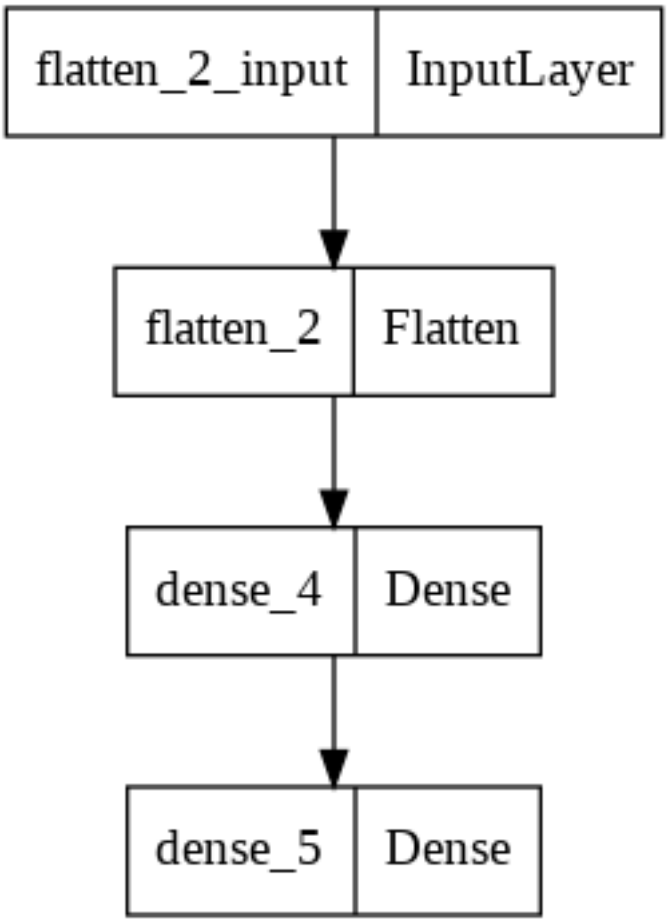
```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 flatten_2 (Flatten)          (None, 784)               0

 dense_4 (Dense)              (None, 300)               235500

 dense_5 (Dense)              (None, 10)                3010

=================================================================
Total params: 238,510
Trainable params: 238,510
Non-trainable params: 0
_________________________________________________________________
```

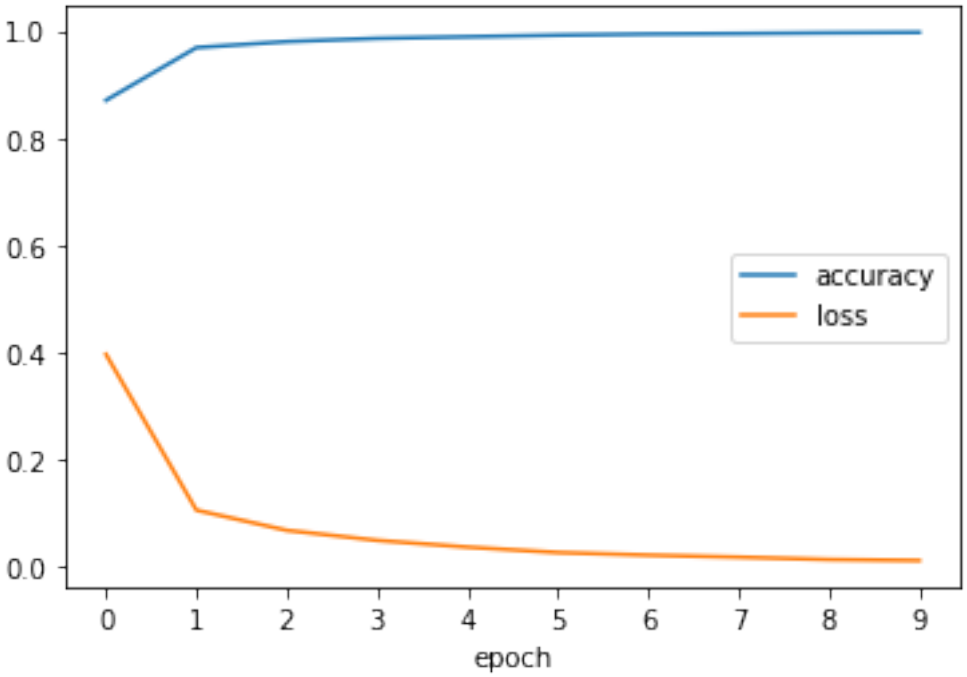
[16]:



[17]:
```
model.compile(optimizer='adam',
              loss=tf.keras.losses.
 ↪SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy']
)
log = model.fit(x_train, y_train, epochs=10, batch_size=50)
```

```
Epoch 1/10
1200/1200 [==============================] - 3s 2ms/step - loss: 0.3959 -
accuracy: 0.8703
Epoch 2/10
1200/1200 [==============================] - 3s 2ms/step - loss: 0.1051 -
accuracy: 0.9686
Epoch 3/10
1200/1200 [==============================] - 3s 2ms/step - loss: 0.0674 -
accuracy: 0.9798
Epoch 4/10
1200/1200 [==============================] - 2s 2ms/step - loss: 0.0486 -
accuracy: 0.9858
Epoch 5/10
1200/1200 [==============================] - 3s 2ms/step - loss: 0.0361 -
accuracy: 0.9888
Epoch 6/10
1200/1200 [==============================] - 2s 2ms/step - loss: 0.0259 -
accuracy: 0.9918
Epoch 7/10
1200/1200 [==============================] - 2s 2ms/step - loss: 0.0211 -
accuracy: 0.9939
Epoch 8/10
1200/1200 [==============================] - 2s 2ms/step - loss: 0.0173 -
accuracy: 0.9948
Epoch 9/10
1200/1200 [==============================] - 3s 2ms/step - loss: 0.0129 -
accuracy: 0.9962
Epoch 10/10
1200/1200 [==============================] - 2s 2ms/step - loss: 0.0110 -
accuracy: 0.9970
```

[30]:
```
plt.plot(log.history['accuracy'], label='accuracy')
plt.plot(log.history['loss'], label='loss')
plt.xlabel('epoch')
plt.xticks(range(10))
plt.legend()
plt.show()
```



[18]:
```
model.evaluate(x_test, y_test, verbose=1)
```

```
313/313 [==============================] - 1s 2ms/step - loss: 14.2285 -
accuracy: 0.9812
```

[18]:
```
[14.228517532348633, 0.9811999797821045]
```

[19]:
```
pred = model.predict(x_test)
pred.shape
```

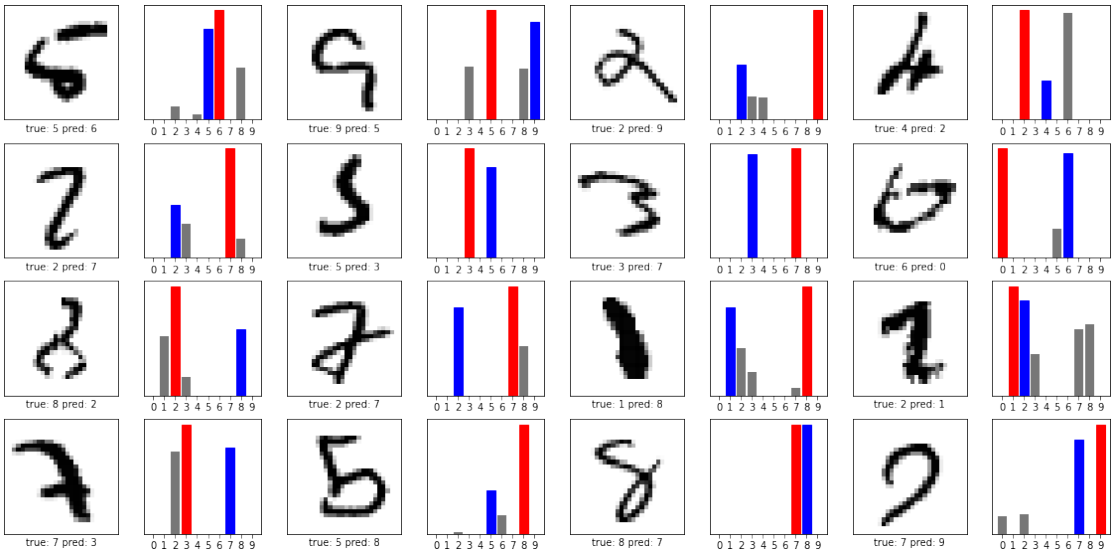
[19]:
```
(10000, 10)
```

[20]:
```
f = np.where(np.argmax(pred.T, axis=0) != y_test)[0]
```

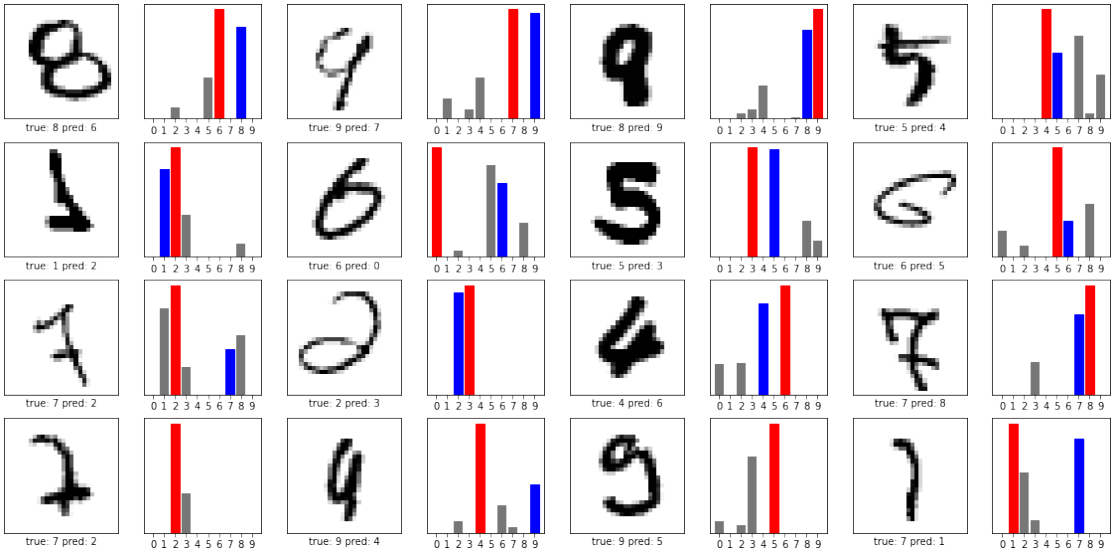
- Plotting some misclassified examples:

[21]:
```
plt.figure(figsize=(20, 20))
j = 1
for i in range(16):
    plt.subplot(8,8,j)
    plt.imshow(x_test[f[i]], cmap=plt.cm.binary)
    plt.xticks([])
    plt.yticks([])
    plt.xlabel('true: '+str(y_test[f[i]])+' pred: '+str(np.argmax(pred[f[i]])))
    plt.subplot(8,8,j+1)
    fig = plt.bar(range(10), pred[f[i]], color="#777777")
```

```
    plt.xticks(range(10))
    plt.yticks([])
    fig[np.argmax(pred[f[i]])].set_color("red")
    fig[y_test[f[i]]].set_color("blue")
    j += 2
```

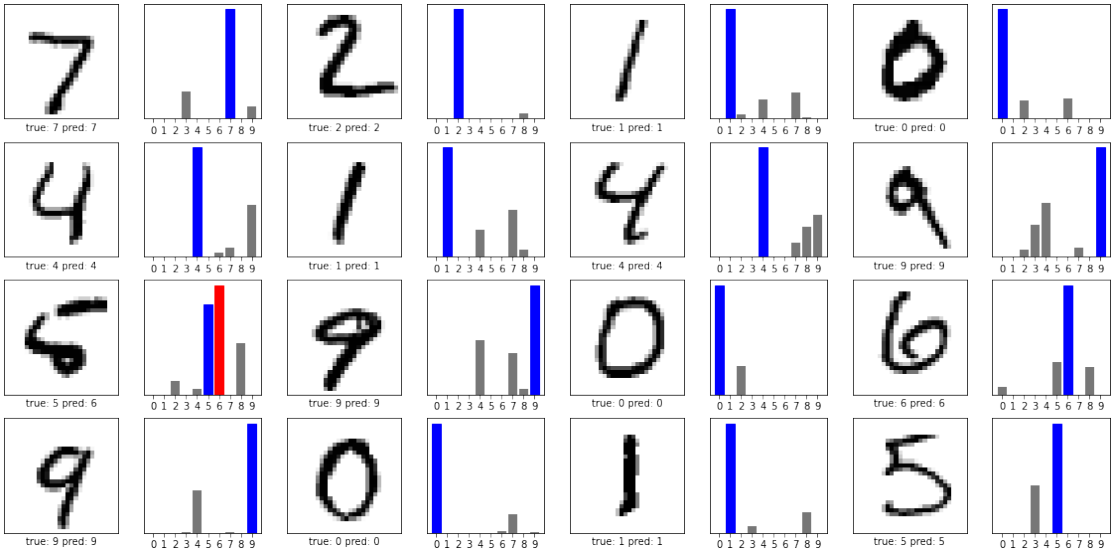


[22]:
```
plt.figure(figsize=(20, 20))
j = 1
for i in range(16, 32):
    plt.subplot(8,8,j)
    plt.imshow(x_test[f[i]], cmap=plt.cm.binary)
    plt.xticks([])
    plt.yticks([])
    plt.xlabel('true: '+str(y_test[f[i]])+' pred: '+str(np.argmax(pred[f[i]])))
    plt.subplot(8,8,j+1)
    fig = plt.bar(range(10), pred[f[i]], color="#777777")
    plt.xticks(range(10))
    plt.yticks([])
    fig[np.argmax(pred[f[i]])].set_color("red")
    fig[y_test[f[i]]].set_color("blue")
    j += 2
```



- Plotting some correctly classified items:

[23]:
```
plt.figure(figsize=(20, 20))
j = 1
for i in range(16):
    plt.subplot(8,8,j)
    plt.imshow(x_test[i], cmap=plt.cm.binary)
    plt.xticks([])
    plt.yticks([])
    plt.xlabel('true: '+str(y_test[i])+' pred: '+str(np.argmax(pred[i])))
    plt.subplot(8,8,j+1)
    fig = plt.bar(range(10), pred[i], color="#777777")
    plt.xticks(range(10))
    plt.yticks([])
    fig[np.argmax(pred[i])].set_color("red")
    fig[y_test[i]].set_color("blue")
    j += 2
```


true: 7 pred: 7
true: 2 pred: 2
true: 1 pred: 1
true: 0 pred: 0
true: 4 pred: 4
true: 1 pred: 1
true: 4 pred: 4
true: 9 pred: 9
true: 5 pred: 6
true: 9 pred: 9
true: 0 pred: 0
true: 6 pred: 6
true: 9 pred: 9
true: 0 pred: 0
true: 1 pred: 1
true: 5 pred: 5
0 1 2 3 4 5 6 7 8 9

[ ]: