In [1]:

```
1 mnist = tf.keras.datasets.mnist
```

<IPython.core.display.Javascript object>

In [2]:

```
1 (train_images,train_labels),(test_images,test_labels) = mnist.load_data()
```

In [3]:

```
1 mnist.load_data()
```

Out[3]:

```
((array([[[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          ...,
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]],

         [[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          ...,
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]],

         [[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
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          [0, 0, 0, ..., 0, 0, 0],
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          [0, 0, 0, ..., 0, 0, 0]],

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          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
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          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]],

         [[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          ...,
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]],

         [[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          ...,
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]]], dtype=uint8),
  array([5, 0, 4, ..., 5, 6, 8], dtype=uint8)),
 (array([[[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          ...,
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0]],

         [[0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
          [0, 0, 0, ..., 0, 0, 0],
```

In [4]:

```
train_images.shape
```

Out[4]:

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

In [5]:

```
train_labels
```

Out[5]:

```
array([5, 0, 4, ..., 5, 6, 8], dtype=uint8)
```

In [6]:

```
plt.figure(figsize=(14,9))
plt.imshow(train_images[5])
plt.colorbar()#Shows the pixel color from 0-250
#plt.grid()
```

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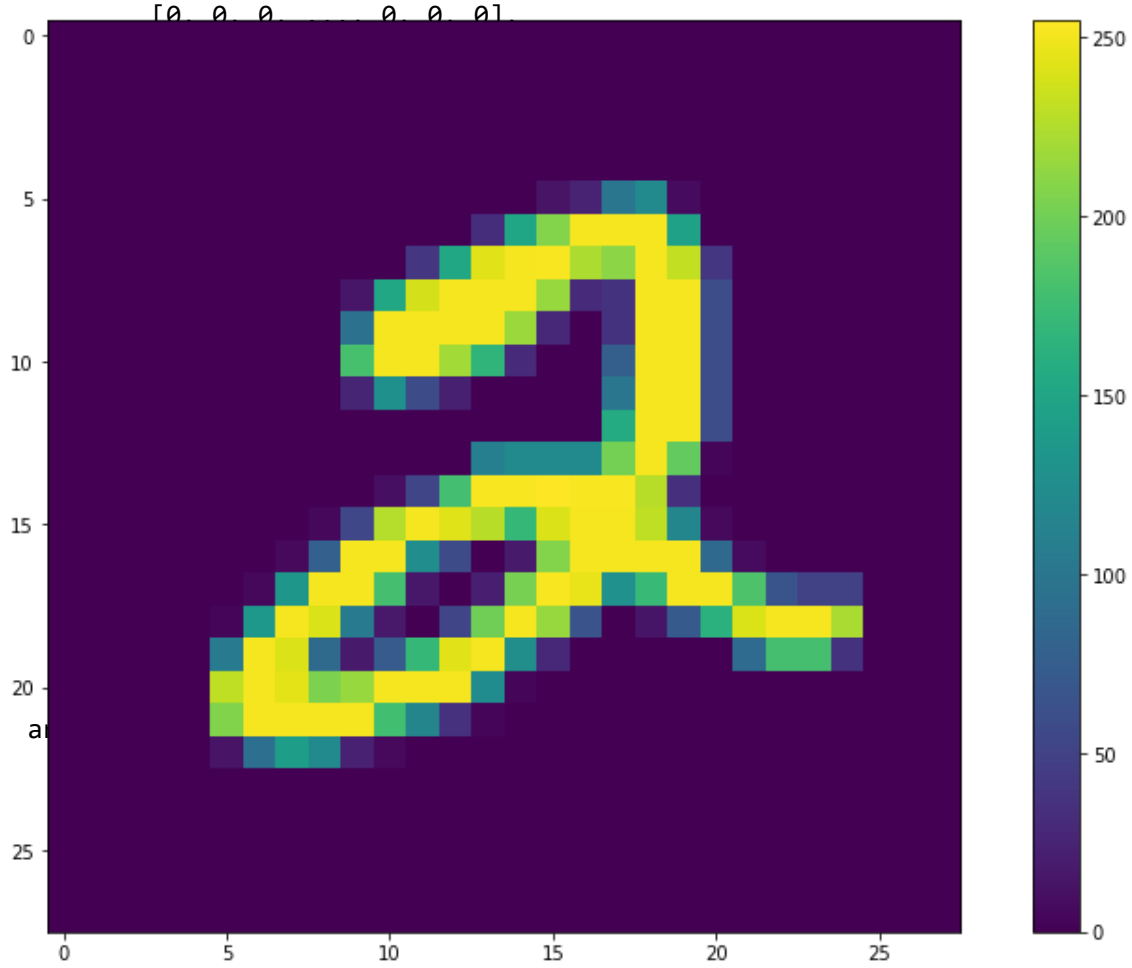
```

Out[6]:

```
<matplotlib.colorbar.Colorbar at 0x1ab761ae7f0>
```



In [7]:

```
train_images,test_images = train_images/255.0,test_images/255.0
```

In [13]:

```
class_names = ['Zero','one','Two','Three',"Four",'Five','Six','Seven','Eight','Nine'
```

In [14]:

```
# Displaying or checking the correct format of the data
plt.figure(figsize = (14,8))
for i in range(25):
    plt.subplot(5,5,i+1)
    #plt.imshow(train_images[i],cmap=plt.cm.binary) gives greyscale images
    plt.imshow(train_images[i])
    plt.xticks([])
    plt.yticks([])
    plt.xlabel(class_names[train_labels[i]])

```

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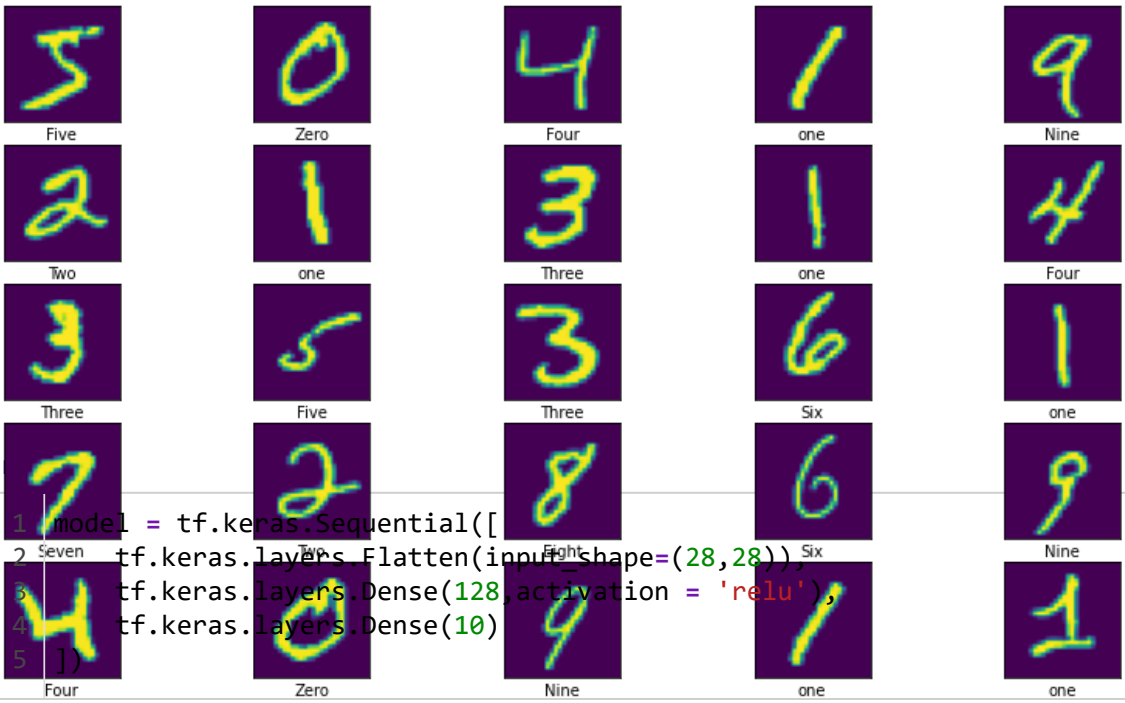

In [ ]:

```
model = tf.keras.Sequential([
    tf.keras.layers.Flatten(input_shape=(28,28)),
    tf.keras.layers.Dense(128,activation = 'relu'),
    tf.keras.layers.Dense(10)
])
```

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In [16]:

```
model.compile(optimizer = 'adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
```

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In [17]:

```
1 model.fit(train_images,train_labels,epochs=10)
```

```
Epoch 1/10
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2637 -
accuracy: 0.9246
Epoch 2/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.1139 -
accuracy: 0.9664
Epoch 3/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0778 -
accuracy: 0.9764
Epoch 4/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0571 -
accuracy: 0.9830
Epoch 5/10
1875/1875 [==============================] - 5s 2ms/step - loss: 0.0450 -
accuracy: 0.9865
Epoch 6/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0353 -
accuracy: 0.9891
Epoch 7/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0277 -
accuracy: 0.9916
Epoch 8/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0235 -
accuracy: 0.9925
Epoch 9/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0184 -
accuracy: 0.9944
Epoch 10/10
1875/1875 [==============================] - 5s 3ms/step - loss: 0.0165 -
accuracy: 0.9950
```

Out[17]:

```
<keras.callbacks.History at 0x1ab6f550c70>
```

In [18]:

```
def plot_image(index, predictions_array, true_labels, images):
    predictions_array, true_label, img = predictions_array[index], true_labels[index
    plt.grid(False)
    plt.xticks([])
    plt.yticks([])
    plt.imshow(img, cmap=plt.cm.binary)

    predicted_label = np.argmax(predictions_array)
    if predicted_label == true_label:
        color = 'blue'
    else:
        color = 'red'

    plt.xlabel("{} ({})".format(class_names[predicted_label], class_names[true_label


def plot_value_array(index, predictions_array, true_label):
    predictions_array, true_label = predictions_array[index], true_label[index]
    plt.grid(False)
    plt.xticks(range(10))
    plt.yticks([])
    thisplot = plt.bar(range(10), predictions_array, color="#777777")
    plt.ylim([0, 1])
    predicted_label = np.argmax(predictions_array)

    thisplot[predicted_label].set_color('red')
    thisplot[true_label].set_color('blue')

```

In [19]:

```
predictions = model.predict(test_images)

```

```
313/313 [==============================] - 1s 2ms/step
```

In [20]:

```
# Define the number of rows and columns in the plot
num_rows = 5
num_cols = 2
num_images = num_rows * num_cols

# Create the plot
plt.figure(figsize=(2 * 2 * num_cols, 2 * num_rows))

for i in range(num_images):
    plt.subplot(num_rows, 2 * num_cols, 2 * i + 1)
    plot_image(i, predictions, test_labels, test_images)
    plt.subplot(num_rows, 2 * num_cols, 2 * i + 2)
    plot_value_array(i, predictions, test_labels)

plt.tight_layout()
plt.show()
```

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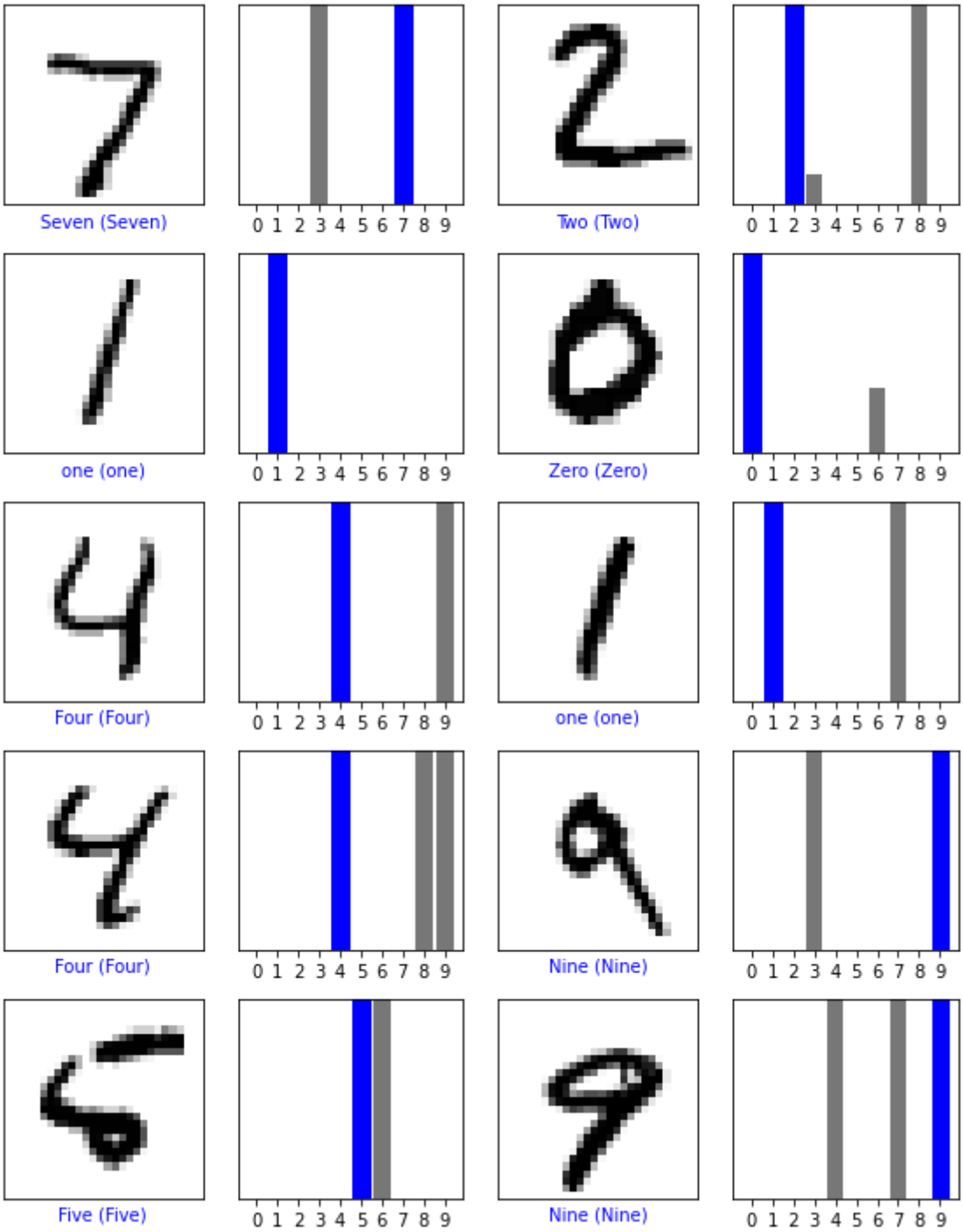
Seven (Seven)
Two (Two)
one (one)
Zero (Zero)
Four (Four)
one (one)
Four (Four)
Nine (Nine)
Five (Five)
Nine (Nine)
0 1 2 3 4 5 6 7 8 9

In [2]:

```
from sklearn.datasets import load_digits
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score

# Load the digits dataset
digits = load_digits()

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(digits.data, digits.target, test

# Train a logistic regression model
model = LogisticRegression(max_iter=10000)
model.fit(X_train, y_train)

# Make predictions on the test set
y_pred = model.predict(X_test)

# Evaluate the model using various metrics
accuracy = accuracy_score(y_test, y_pred)
precision = precision_score(y_test, y_pred, average='weighted')
recall = recall_score(y_test, y_pred, average='weighted')
f1 = f1_score(y_test, y_pred, average='weighted')

# Print the evaluation metrics
print("Accuracy score: ", accuracy)
print("Precision score: ", precision)
print("Recall score: ", recall)
print("F1 score: ", f1)

```

```
Accuracy score:  0.9722222222222222
Precision score:  0.9727915402601087
Recall score:  0.9722222222222222
F1 score:  0.9723127332845016
```