In [49]:

```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

In [50]:

```
traindf = pd.read_csv('mnist_train.csv')
testdf = pd.read_csv('mnist_test.csv')
```

In [51]:

```
traindf.head()
```

Out[51]:

| | label | 1x1 | 1x2 | 1x3 | 1x4 | 1x5 | 1x6 | 1x7 | 1x8 | 1x9 | ... | 28x19 | 28x20 | 28x21 | 28x22 | 28x23 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | |
| **2** | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | |
| **3** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | |
| **4** | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 | 0 | |

5 rows × 785 columns

In [52]:

```
traindf.label.unique()
```

Out[52]:

```
array([5, 0, 4, 1, 9, 2, 3, 6, 7, 8])
```

In [53]:

```
# define x train and y train

xtrain = traindf.iloc[:, 1:].to_numpy()
ytrain = traindf.iloc[:, 0].to_numpy()


# reshape and normalize xtrain  => (28x28 pixels and 1 is for black and white)
xtrain = xtrain.reshape([-1, 28, 28, 1])
xtrain = xtrain / 255    # so that it is between 0 to 1 (normalization)
```

In [54]:

```
# define xtest and reshape and normalize this as well


xtest = testdf.iloc[:, 1:].to_numpy()

xtest = xtest.reshape([-1, 28,28, 1])
xtest = xtest / 255


ytest = testdf.iloc[:, 0].to_numpy()
```

In [61]:

```
# MODEL


import tensorflow as tf
models = tf.keras.models
layers = tf.keras.layers


model = models.Sequential()

model.add(layers.Conv2D(filters=64,kernel_size=(3,3),input_shape=(28,28,1),activatic
model.add(layers.MaxPooling2D(pool_size=(2,2)))
model.add(layers.Flatten())

model.add(layers.Dense(units=32, activation='relu'))
model.add(layers.Dense(units=10, activation='softmax'))


model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['ac

model.summary()
```

```
Model: "sequential_9"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_8 (Conv2D)           (None, 26, 26, 64)        640       
                                                                 
 max_pooling2d_8 (MaxPoolin  (None, 13, 13, 64)        0         
 g2D)                                                            
                                                                 
 flatten_6 (Flatten)         (None, 10816)             0         
                                                                 
 dense_16 (Dense)            (None, 32)                346144    
                                                                 
 dense_17 (Dense)            (None, 10)                330       
                                                                 
=================================================================
Total params: 347114 (1.32 MB)
Trainable params: 347114 (1.32 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

In [62]:

```
model.fit(xtrain, ytrain, epochs=3, validation_split=0.05)
```

```
Epoch 1/3
1782/1782 [==============================] - 8s 5ms/step - loss: 0.189
8 - accuracy: 0.9445 - val_loss: 0.0638 - val_accuracy: 0.9833
Epoch 2/3
1782/1782 [==============================] - 8s 5ms/step - loss: 0.070
0 - accuracy: 0.9786 - val_loss: 0.0610 - val_accuracy: 0.9863
Epoch 3/3
1782/1782 [==============================] - 8s 5ms/step - loss: 0.050
7 - accuracy: 0.9846 - val_loss: 0.0516 - val_accuracy: 0.9880
```

Out[62]:

```
<keras.src.callbacks.History at 0x2986eb3d0>
```

In [44]:

```
ypred1 = model.predict(xtest)
ypred = ypred1.argmax(axis = -1)
ypred
```

```
313/313 [==============================] - 0s 1ms/step
```

Out[44]:

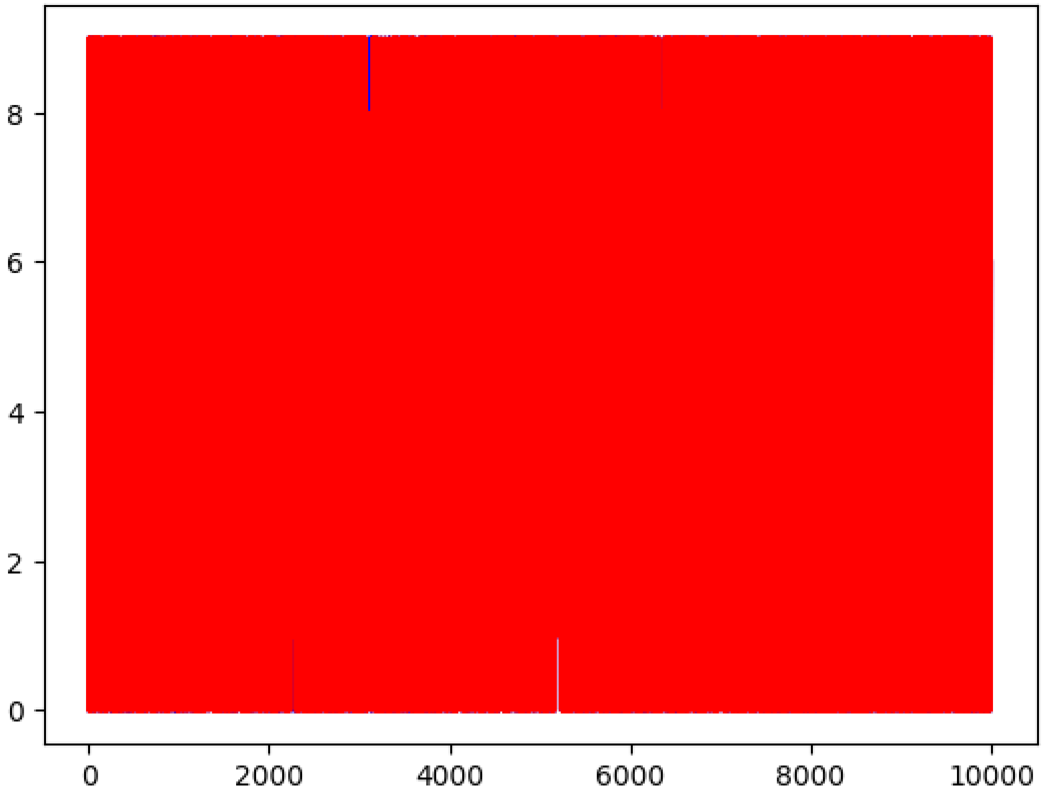
```
array([7, 2, 1, ..., 4, 5, 6])
```

In [46]:

```
plt.plot(ypred, color='blue')
plt.plot(ytest, color='red')
```

Out[46]:

```
[<matplotlib.lines.Line2D at 0x29a86ef90>]
```



In [ ]:

```
```