In [7]:
```
import tensorflow as tf
```

Task:2 The dataset

Import MNIST

In [10]:
```
from tensorflow.keras.datasets import mnist
(x_train,y_train),(x_test,y_test)=mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/
mnist.npz
11490434/11490434 [==============================] - 3s 0us/step
```

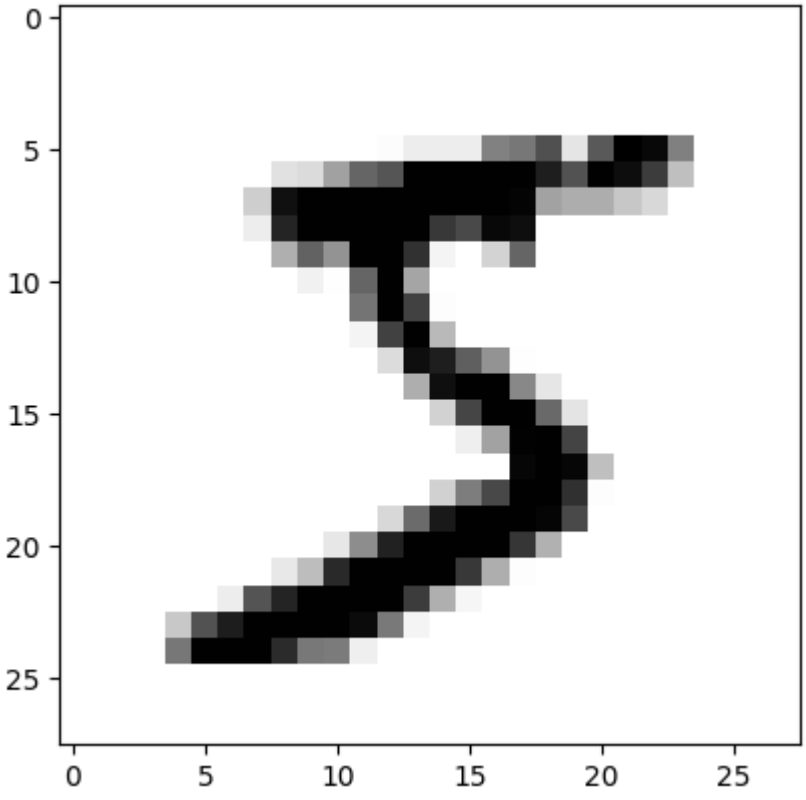
shapes of Imported Arrays

In [12]:
```
print('x_train shape',x_train.shape)
print('y_tains shape',y_train.shape)
print('x_test shape',x_test.shape)
print('y_test shape',y_test.shape)
```

```
x_train shape (60000, 28, 28)
y_tains shape (60000,)
x_test shape (10000, 28, 28)
y_test shape (10000,)
```

Plot an Image Example

In [18]:
```
from matplotlib import pyplot as plt
%matplotlib inline

plt.imshow(x_train[0], cmap='binary')
plt.show()
```



Display labels

In [19]:
```
y_train[0]
```

Out[19]:
```
5
```

In [20]:
```
print(set(y_train))
```

```
{0, 1, 2, 3, 4, 5, 6, 7, 8, 9}
```

One Hot Encoding

Encoding Labels

In [21]:
```
from tensorflow.keras.utils import to_categorical
```

In [23]:
```
y_train_encoded= to_categorical(y_train)
y_test_encoded= to_categorical(y_test)
```

Validated Shapes

In [24]:
```
print('y_train_encoded shape:',y_train_encoded.shape)
print('y_test_encoded  shape:', y_test_encoded.shape)
```

```
y_train_encoded shape: (60000, 10)
y_test_encoded  shape: (10000, 10)
```

Display Encoded Labels

In [26]:
```
y_train_encoded[0]
```

Out[26]:
```
array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)
```

Task 4: Neural Networks

Linear Equations

Task5 : Preprocessing the Examples

Inrolling N-dimensional Arrays to Vectors

In [30]:
```
import numpy as np
x_train_reshaped=np.reshape(x_train, (60000,784))
x_test_reshaped=np.reshape(x_test,(10000,784))

print('x_train_reshaped',x_train_reshaped)
print('x_train_reshaped',x_test_reshaped)
```

```
x_train_reshaped [[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]]
x_train_reshaped [[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]]
```

Display Pixel Values

In [40]:
```
print(set(x_test_reshaped[0]))
```

```
{0, 129, 1, 3, 133, 5, 9, 140, 14, 17, 18, 19, 21, 22, 151, 159, 31, 163, 36, 35,
166, 38, 40, 170, 44, 52, 182, 185, 58, 59, 60, 187, 62, 57, 61, 66, 67, 198, 72,
75, 203, 205, 77, 207, 209, 83, 84, 219, 221, 222, 224, 225, 121, 227, 126, 229, 2
33, 106, 236, 238, 240, 241, 114, 115, 242, 248, 249, 250, 251, 253, 254, 255}
```

Data Normalization

In [43]:
```
x_mean=np.mean(x_train_reshaped)
x_std=np.std(x_train_reshaped)
epsilon =1e-10

x_train_norm=(x_train_reshaped-x_mean)/(x_std+epsilon)
x_test_norm=(x_test_reshaped-x_mean)/(x_std + epsilon)
```

Display Normalized Pixel Values

In [44]:
```
print(set(x_train_norm[0]))
```

```
{-0.38589016215482896, 1.306921966983251, 1.17964285952926, 1.803310486053816, 1.6
887592893452241, 2.8215433456857437, 2.719720059722551, 1.1923707702746593, 1.7396
709323268205, 2.057868700961798, 2.3633385588513764, 2.096052433197995, 1.76512675
38176187, 2.7960875241949457, 2.7451758812133495, 2.45243393406917, 0.021402981697
94222, -0.22042732246464067, 1.2305545025108566, 0.2759611966059242, 2.21060362990
6587, 2.6560805059955555, 2.6051688630139593, -0.4240738943910262, 0.4668798577869
107, 0.1486820891519332, 0.3905123933145161, 1.0905474843114664, -0.09314821501064
967, 1.4851127174188385, 2.7579037919587486, 1.5360243604004349, 0.072314624679538
61, -0.13133194724684696, 1.294194056237852, 0.03413089244334132, 1.34510569921944
83, 2.274243183633583, -0.24588314395543887, 0.772349715676489, 0.75962180493109,
0.7214380726948927, 0.1995937321335296, -0.41134598364562713, 0.5687031437501034,
0.5941589652409017, 0.9378125553666773, 0.9505404661120763, 0.6068868759863008, 0.
4159682148053143, -0.042236572029053274, 2.7706317027041476, 2.1342361654341926,
0.12322626766113501, -0.08042030426525057, 0.16140999989733232, 1.892405861271609
7, 1.2560103240016547, 2.185147808415789, 0.6196147867316999, 1.943317504253206, -
0.11860403650144787, -0.30952269768243434, 1.9942291472348024, -0.284066876191636
2, 2.6306246845047574, 2.286971094378982, -0.19497150097384247, -0.398618072900228
05, 0.2886891073513233, 1.7523988430722195, 2.3887943803421745, 2.681536327486354,
1.4596568959280403, 2.439706023323771, 2.7833596134495466, 2.490617666305367, -0.1
0587612575604877, 1.5614801818912332, 1.9051337720170087, 1.6123918248728295, 1.26
8738234747054, 1.9560454149986053, 2.6433525952501564, 1.026907930584471}
```

Task6: Creatin a Model

Creating the model

In [48]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense



model= Sequential([

    Dense(128,activation='relu',input_shape=(784,)),
    Dense(128,activation='relu'),
    Dense(10,activation='softmax')

                ])
```

```
2023-12-13 17:27:54.618855: E external/local_xla/xla/stream_executor/cuda/cuda_dri
ver.cc:274] failed call to cuInit: CUDA_ERROR_NO_DEVICE: no CUDA-capable device is
detected
```

Compiling the Model

In [53]:
```
model.compile(
    optimizer='sgd',
    loss='categorical_crossentropy',
    metrics=['accuracy']
)
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 128)               100480

 dense_1 (Dense)             (None, 128)               16512

 dense_2 (Dense)             (None, 10)                1290

=================================================================
Total params: 118282 (462.04 KB)
Trainable params: 118282 (462.04 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Task7: Training the Model

Training the Model

In [54]:
```
model.fit(x_train_norm,y_train_encoded,epochs=3)
```

```
Epoch 1/3
1875/1875 [==============================] - 9s 4ms/step - loss: 0.3760 - accurac
y: 0.8899
Epoch 2/3
1875/1875 [==============================] - 7s 4ms/step - loss: 0.1853 - accurac
y: 0.9459
Epoch 3/3
1875/1875 [==============================] - 7s 4ms/step - loss: 0.1398 - accurac
y: 0.9592
```

Out[54]:
```
<keras.src.callbacks.History at 0x7fb54a2b7370>
```

Evaluating the Model

In [57]:
```
_, accuracy=model.evaluate(x_test_norm,y_test_encoded)
print('Test set accuracy:',accuracy*100)
```

```
313/313 [==============================] - 1s 4ms/step - loss: 0.1359 - accuracy:
0.9585
Test set accuracy: 95.85000276565552
```

Task 8 : Predictions

Prediction on Test Set

In [58]:
```
preds=model.predict(x_test_norm)
print('Shape of preds:',preds.shape)
```

```
313/313 [==============================] - 1s 3ms/step
Shape of preds: (10000, 10)
```

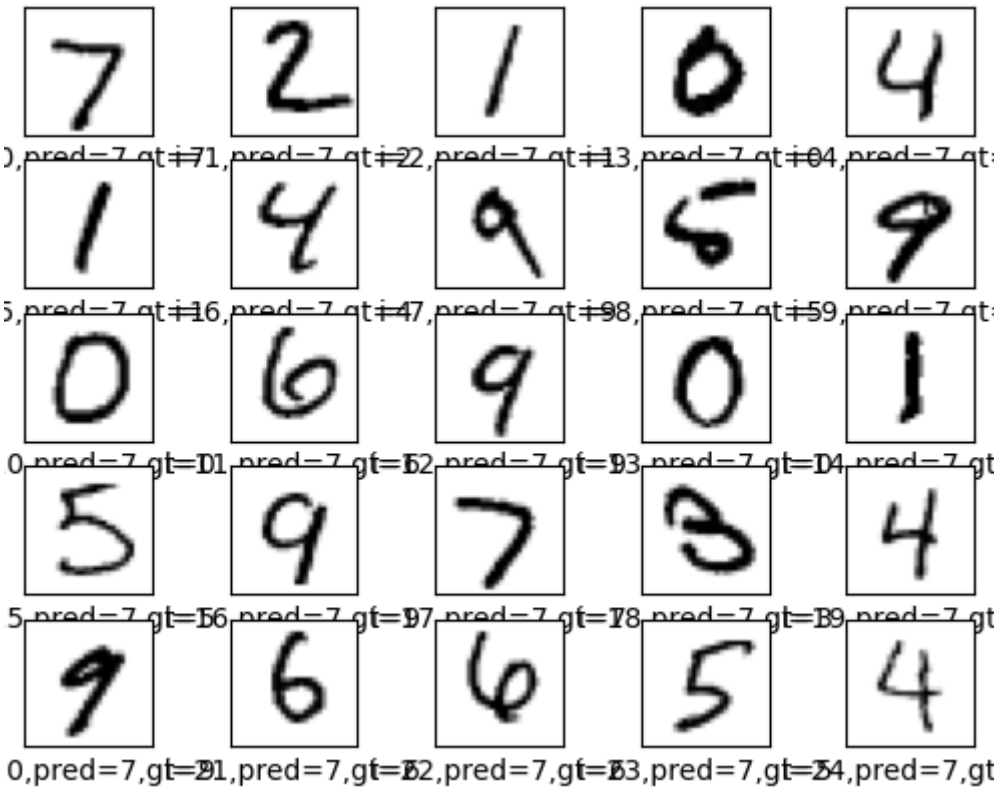
Plotting the result

In [59]:
```
plt.figure(figsize=(12,12))
```

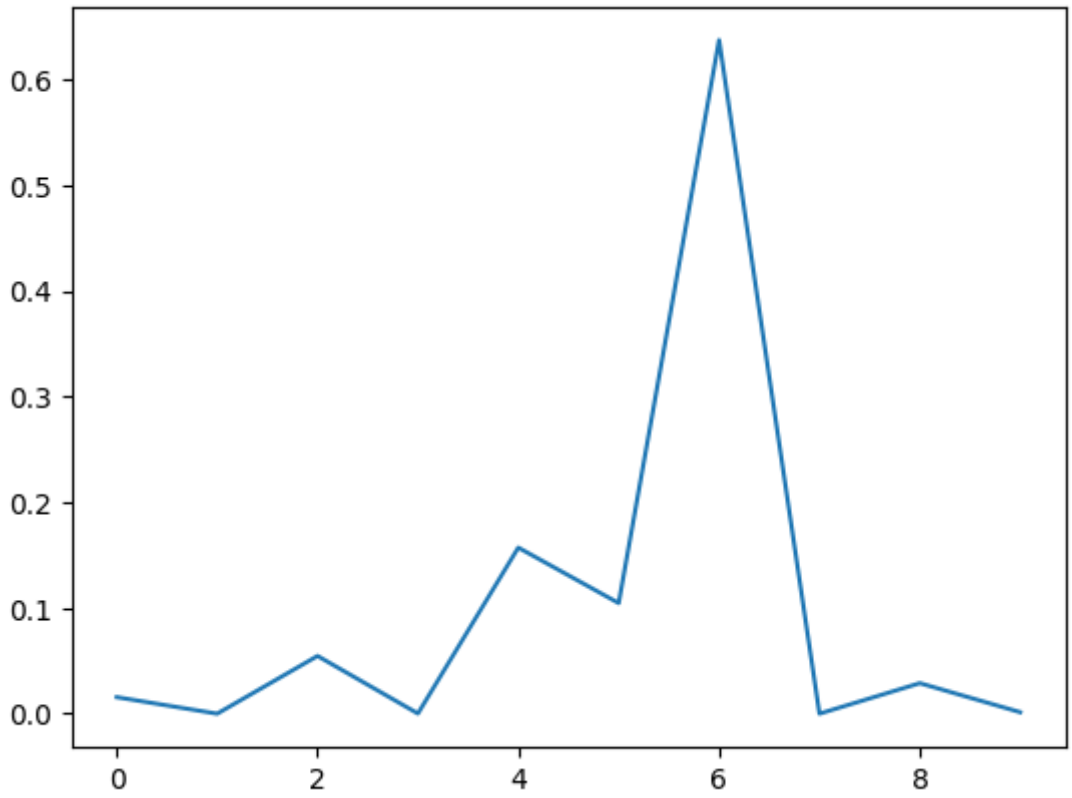
Out[59]:
```
<Figure size 1200x1200 with 0 Axes>
```


```
<Figure size 1200x1200 with 0 Axes>
```


In [64]:
```
start_index=0

for i in range(25):
    plt.subplot(5,5,i+1)
    plt.grid(False)
    plt.xticks([])
    plt.yticks([])

    pred=np.argmax(preds[start_index])
    gt =y_test[start_index+i]

    col='g'
    if pred != gt:
        col='r'


    plt.xlabel('i={},pred={},gt={}'.format(start_index+i,pred,gt))
    plt.imshow(x_test[start_index+i],cmap='binary')
plt.show()
```



In [67]:
```
plt.plot(preds[8])
plt.show()
```



In [ ]: