Deep Learning Practical Assignment 3B

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Importing Dataset & Libraries

[120]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

[121]:
```
class_names=['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat', 'Sandal',␣
↪'Shirt', 'Sneaker', 'Bag', 'Ankleboot']
```

[122]:
```
df1 = pd.read_csv(r'D:\DL Practical\fashion-mnist_train.csv')
```

[123]:
```
df1
```

[123]:

	label	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	\
0	2	0	0	0	0	0	0	0	0	
1	9	0	0	0	0	0	0	0	0	
2	6	0	0	0	0	0	0	0	5	
3	0	0	0	0	1	2	0	0	0	
4	3	0	0	0	0	0	0	0	0	
…	…	…	…	…	…	…	…	…	…	
59995	9	0	0	0	0	0	0	0	0	
59996	1	0	0	0	0	0	0	0	0	
59997	8	0	0	0	0	0	0	0	0	
59998	8	0	0	0	0	0	0	0	0	
59999	7	0	0	0	0	0	0	0	0	

	pixel9	…	pixel775	pixel776	pixel777	pixel778	pixel779	\
0	0	…	0	0	0	0	0	
1	0	…	0	0	0	0	0	
2	0	…	0	0	0	30	43	
3	0	…	3	0	0	0	0	
4	0	…	0	0	0	0	0	
…	…	…	…	…	…	…	…	
59995	0	…	0	0	0	0	0	
59996	0	…	73	0	0	0	0	
59997	0	…	160	162	163	135	94	
59998	0	…	0	0	0	0	0	

```
59999       0  …          0          0          0          0          0

       pixel780  pixel781  pixel782  pixel783  pixel784
0             0         0         0         0         0
1             0         0         0         0         0
2             0         0         0         0         0
3             1         0         0         0         0
4             0         0         0         0         0
…           …         …         …         …         …
59995         0         0         0         0         0
59996         0         0         0         0         0
59997         0         0         0         0         0
59998         0         0         0         0         0
59999         0         0         0         0         0

[60000 rows x 785 columns]
```

[124]:
```
x_train = df1.drop("label", axis=1).values
y_train = df1["label"].values
```

[125]:
```
print("x_train shape: ",x_train.shape)
print("y_train shape: ",y_train.shape)
```

```
x_train shape:  (60000, 784)
y_train shape:  (60000,)
```

[126]:
```
 np.unique(y_train)
```

[126]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], dtype=int64)
```

[127]:
```
df2 = pd.read_csv(r'D:\DL Practical\fashion-mnist_test.csv')
```

[128]:
```
df2
```

[128]:
```
      label  pixel1  pixel2  pixel3  pixel4  pixel5  pixel6  pixel7  pixel8  \
0         0       0       0       0       0       0       0       0       9
1         1       0       0       0       0       0       0       0       0
2         2       0       0       0       0       0       0      14      53
3         2       0       0       0       0       0       0       0       0
4         3       0       0       0       0       0       0       0       0
…       …       …       …       …       …       …       …       …       …
9995      0       0       0       0       0       0       0       0       0
9996      6       0       0       0       0       0       0       0       0
9997      8       0       0       0       0       0       0       0       0
9998      8       0       1       3       0       0       0       0       0
9999      1       0       0       0       0       0       0       0     140

      pixel9  …  pixel775  pixel776  pixel777  pixel778  pixel779  pixel780  \
```

```
0          8  …       103        87        56         0         0         0
1          0  …        34         0         0         0         0         0
2         99  …         0         0         0         0        63        53
3          0  …       137       126       140         0       133       224
4          0  …         0         0         0         0         0         0
…        …  …       …         …         …         …       …         …
9995       0  …        32        23        14        20         0         0
9996       0  …         0         0         0         2        52        23
9997       0  …       175       172       172       182       199       222
9998       0  …         0         0         0         0         0         1
9999     119  …       111        95        75        44         1         0

      pixel781  pixel782  pixel783  pixel784
0            0         0         0         0
1            0         0         0         0
2           31         0         0         0
3          222        56         0         0
4            0         0         0         0
…          …       …         …         …
9995         1         0         0         0
9996        28         0         0         0
9997        42         0         1         0
9998         0         0         0         0
9999         0         0         0         0

[10000 rows x 785 columns]
```

[129]:
```
x_test = df2.drop("label", axis=1).values
y_test = df2["label"].values
```

[130]:
```
print("x_test shape: ",x_test.shape)
print("y_test shape: ",y_test.shape)
```

```
x_test shape:  (10000, 784)
y_test shape:  (10000,)
```

28*28=784 Pixels

[131]:
```
x_train = x_train.reshape(60000, 28, 28)
x_test = x_test.reshape(10000, 28, 28)
```

[132]:
```
print(x_train[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   0   0   4   0   0   0   0   0  62  61  21  29  23  51 136  61
   0   0   0   0   0   0   0   0   0   0]
[  0   0   0   0   0   0   0  88 201 228 225 255 115  62 137 255 235 222
 255 135   0   0   0   0   0   0   0   0]
[  0   0   0   0   0  47 252 234 238 224 215 215 229 108 180 207 214 224
 231 249 254  45   0   0   0   0   0   0]
[  0   0   1   0   0 214 222 210 213 224 225 217 220 254 233 219 221 217
 223 221 240 254   0   0   1   0   0   0]
[  1   0   0   0 128 237 207 224 224 207 216 214 210 208 211 221 208 219
 213 226 211 237 150   0   0   0   0   0]
[  0   2   0   0 237 222 215 207 210 212 213 206 214 213 214 213 210 215
 214 206 199 218 255  13   0   2   0   0]
[  0   4   0  85 228 210 218 200 211 208 203 215 210 209 209 210 213 211
 210 217 206 213 231 175   0   0   0   0]
[  0   0   0 217 224 215 206 205 204 217 230 222 215 224 233 228 232 228
 224 207 212 215 213 229  31   0   4   0]
[  1   0  21 225 212 212 203 211 225 193 139 136 195 147 156 139 128 162
 197 223 207 220 213 232 177   0   0   0]
[  0   0 123 226 207 211 209 205 228 158  90 103 186 138 100 121 147 158
 183 226 208 214 209 216 255  13   0   1]
[  0   0 226 219 202 208 206 205 216 184 156 150 193 170 164 168 188 186
 200 219 216 213 213 211 233 148   0   0]
[  0  45 227 204 214 211 218 222 221 230 229 221 213 224 233 226 220 219
 221 224 223 217 210 218 213 254   0   0]
[  0 157 226 203 207 211 209 215 205 198 207 208 201 201 197 203 205 210
 207 213 214 214 214 213 208 234 107   0]
[  0 235 213 204 211 210 209 213 202 197 204 215 217 213 212 210 206 212
 203 211 218 215 214 208 209 222 230   0]
[ 52 255 207 200 208 213 210 210 208 207 202 201 209 216 216 216 216 214
 212 205 215 201 228 208 214 212 218  25]
[118 217 201 206 208 213 208 205 206 210 211 202 199 207 208 209 210 207
 210 210 245 139 119 255 202 203 236 114]
[171 238 212 203 220 216 217 209 207 205 210 211 206 204 206 209 211 215
 210 206 221 242   0 224 234 230 181  26]
[ 39 145 201 255 157 115 250 200 207 206 207 213 216 206 205 206 207 206
 215 207 221 238   0   0 188  85   0   0]
[  0   0   0  31   0 129 253 190 207 208 208 208 209 211 211 209 209 209
 212 201 226 165   0   0   0   0   0   0]
[  2   0   0   0   0  89 254 199 199 192 196 198 199 201 202 203 204 203
 203 200 222 155   0   3   3   3   2   0]
[  0   0   1   5   0   0 255 218 226 232 228 224 222 220 219 219 217 221
 220 212 236  95   0   2   0   0   0   0]
[  0   0   0   0   0   0 155 194 168 170 171 173 173 179 177 175 172 171
 167 161 180   0   0   1   0   1   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]
```

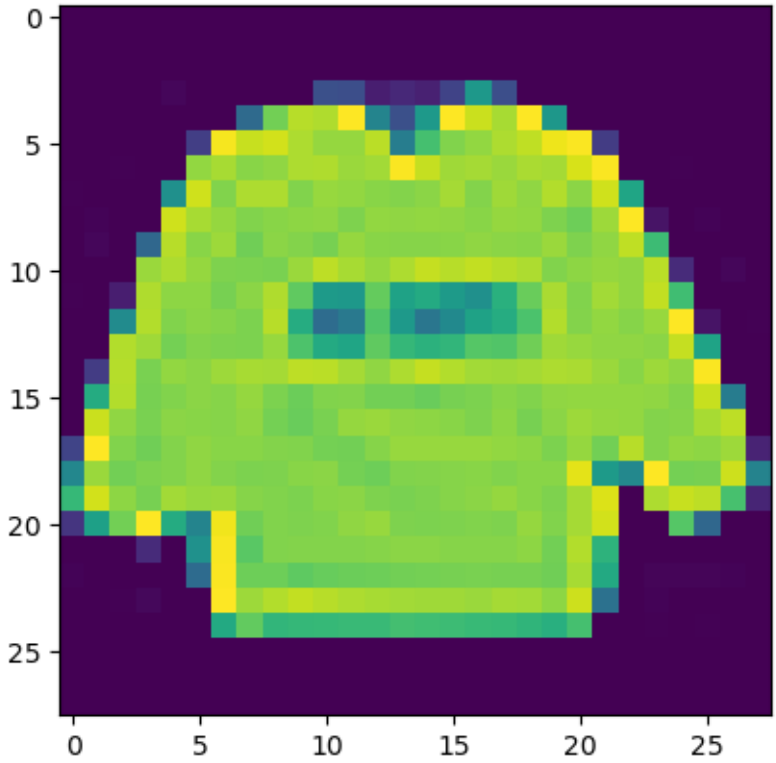
```
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
    0   0   0   0   0   0   0   0   0   0]]
```

[133]:
```
y_train[0]
```

[133]:
```
2
```

[134]:
```
plt.imshow(x_train[0])
```

[134]:
```
<matplotlib.image.AxesImage at 0x1ac505a1070>
```



[135]:
```
x_test[10]
```

[135]:
```
array([[  0,   0,   0,   0,   0,   0,   0,   1,   0,   0,  83, 142,  50,
          0,   0,   0,   0,  85, 145,  31,   0,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   0,   0,   0, 215, 210, 208, 255,
        254, 225, 227, 255, 221, 199, 211, 129,   0,   0,   0,   0,   0,
          0,   0],
       [  0,   0,   0,   0,   0,   0,   2,   0, 105, 213, 187, 187, 204,
        223, 230, 227, 221, 188, 183, 188, 188,   7,   0,   0,   0,   0,
          0,   0],
```

```
[  0,   0,   0,   0,   0,   0,   0,   0, 169, 206, 185, 193, 189,
 230, 219, 229, 205, 180, 186, 181, 201,  61,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0, 206, 214, 190, 185, 177,
 204, 244, 215, 174, 181, 177, 187, 209, 118,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   8, 196, 219, 178, 184, 183,
 177, 222, 181, 173, 184, 173, 203, 210, 177,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,  64, 211, 219,  83, 199, 197,
 184, 201, 201, 185, 206, 153, 150, 223, 205,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 128, 217, 220,  61, 205, 196,
 188, 194, 211, 199, 203, 159, 112, 226, 194,  30,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 165, 222, 253,   0, 203, 197,
 193, 185, 194, 204, 211, 155,  73, 233, 203,  71,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 174, 234, 207,   0, 219, 201,
 196, 207, 190, 194, 230, 105,   0, 255, 210,  90,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 157, 243, 163,   0, 245, 203,
 215, 209, 215, 182, 231, 142,   0, 255, 223, 109,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 150, 241, 142,   0, 230, 192,
 234, 198, 236, 199, 203, 144,   0, 228, 222, 111,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 166, 251, 132,  52, 236, 191,
 204, 182, 236, 210, 190, 226,   0, 216, 240, 150,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0, 146, 223,  87, 132, 223, 192,
 196, 186, 215, 201, 184, 231,  55, 122, 218, 112,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   0,   0, 210, 207, 195,
 200, 186, 212, 208, 188, 210, 147,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   2,   0,  44, 237, 205, 197,
 204, 190, 211, 208, 201, 191, 207,   0,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   2,   0, 110, 208, 208, 199,
 207, 193, 207, 213, 211, 188, 234,  24,   0,   3,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,   0, 184, 203, 212, 199,
 212, 193, 208, 223, 216, 185, 205,  71,   0,   3,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,   0, 224, 198, 226, 199,
 215, 191, 210, 231, 216, 170, 209, 110,   0,   2,   0,   0,   0,
```

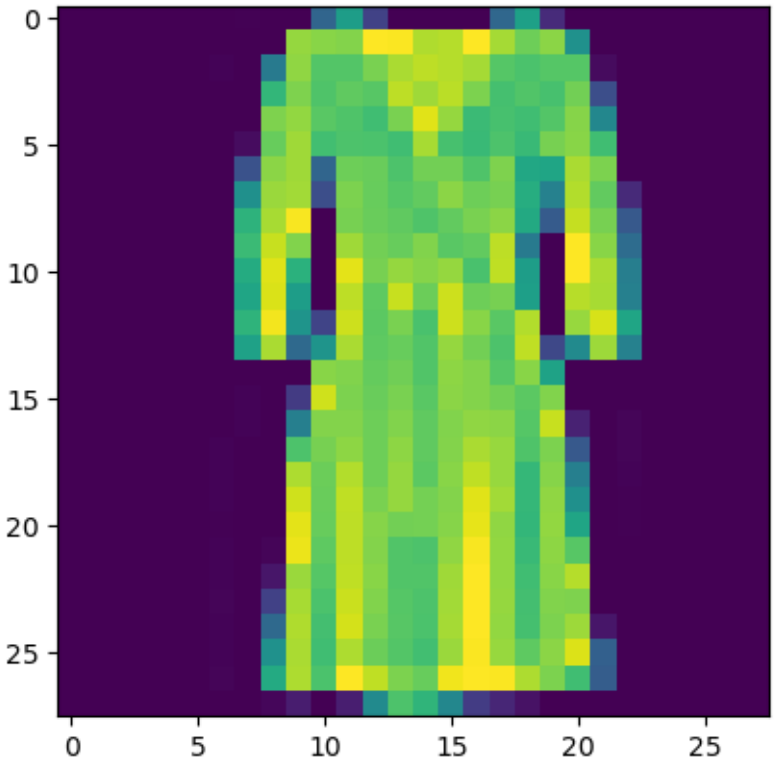
```
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,   0, 237, 197, 231, 204,
 215, 202, 208, 244, 220, 170, 213, 128,   0,   1,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   1,   0,   0, 245, 196, 230, 209,
 201, 202, 209, 246, 213, 169, 214, 150,   0,   1,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,   3, 248, 192, 230, 208,
 186, 184, 213, 253, 214, 173, 212, 189,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,  15, 217, 188, 231, 210,
 186, 186, 219, 255, 214, 177, 210, 227,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   3,   0,  49, 222, 183, 235, 207,
 188, 184, 220, 255, 215, 179, 207, 206,   0,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0,  87, 225, 179, 239, 204,
 189, 183, 221, 255, 214, 180, 205, 218,  15,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   2,   0, 129, 223, 177, 224, 198,
 187, 178, 217, 254, 216, 192, 211, 242,  78,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   3,   0, 156, 224, 183, 255, 231,
 205, 196, 250, 255, 254, 224, 205, 177,  75,   0,   0,   0,   0,
   0,   0],
[  0,   0,   0,   0,   0,   0,   0,   0,   4,  20,   0,  21, 122,
 184, 167, 118,  45,  27,  12,   0,   0,   0,   0,   0,   0,   0,
   0,   0]], dtype=int64)
```

[136]:
```
y_test[10]
```

[136]:
```
3
```

[137]:
```
plt.imshow(x_test[10])
```

[137]:
```
<matplotlib.image.AxesImage at 0x1ac4fa5af10>
```



Normalization & Reshaping

[138]:
```
x_train = x_train/255
x_test = x_test/255
```

[139]:
```
x_train = x_train.reshape(60000, 28, 28, 1)
x_test = x_test.reshape(10000, 28, 28, 1)
```

[140]:
```
print("Train Shape :",x_train.shape)
print("Test Shape :",x_test.shape)
print("y_train shape :",y_train.shape)
print("y_test shape :",y_test.shape)
```

```
Train Shape : (60000, 28, 28, 1)
Test Shape : (10000, 28, 28, 1)
y_train shape : (60000,)
y_test shape : (10000,)
```

Building our Model

[141]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, MaxPooling2D, Flatten
```

[142]:
```
model=Sequential()
model.add(Conv2D(64, (3,3), activation='relu', input_shape=(28,28,1)))
model.add(MaxPooling2D((2,2)))
model.add(Conv2D(64, (3,3), activation='relu'))
model.add(MaxPooling2D((2,2)))
model.add(Flatten())
model.add(Dense(128,activation='relu'))
model.add(Dense(10,activation='softmax'))
model.compile(optimizer='adam',␣
 ↪loss='sparse_categorical_crossentropy',metrics=['accuracy'])
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_4 (Conv2D)           (None, 26, 26, 64)        640

 max_pooling2d_4 (MaxPooling  (None, 13, 13, 64)       0
 2D)

 conv2d_5 (Conv2D)           (None, 11, 11, 64)        36928

 max_pooling2d_5 (MaxPooling  (None, 5, 5, 64)         0
 2D)

 flatten_2 (Flatten)         (None, 1600)              0

 dense_4 (Dense)             (None, 128)               204928

 dense_5 (Dense)             (None, 10)                1290

=================================================================
Total params: 243,786
Trainable params: 243,786
Non-trainable params: 0
_________________________________________________________________
```

Training our Model

[143]:
```
model.fit(x_train, y_train, epochs=3, verbose=1,␣
 ↪validation_data=(x_test,y_test))
```

```
Epoch 1/3
1875/1875 [==============================] - 77s 40ms/step - loss: 0.4444 -
accuracy: 0.8382 - val_loss: 0.3375 - val_accuracy: 0.8805
Epoch 2/3
1875/1875 [==============================] - 78s 42ms/step - loss: 0.2976 -
accuracy: 0.8914 - val_loss: 0.2788 - val_accuracy: 0.8975
```

```
Epoch 3/3
1875/1875 [==============================] - 83s 44ms/step - loss: 0.2519 -
accuracy: 0.9071 - val_loss: 0.2578 - val_accuracy: 0.9033
```

[143]:
```
<keras.callbacks.History at 0x1ac4fab7be0>
```

Testing our Model

[144]:
```
predictions = model.predict(x_test)
```

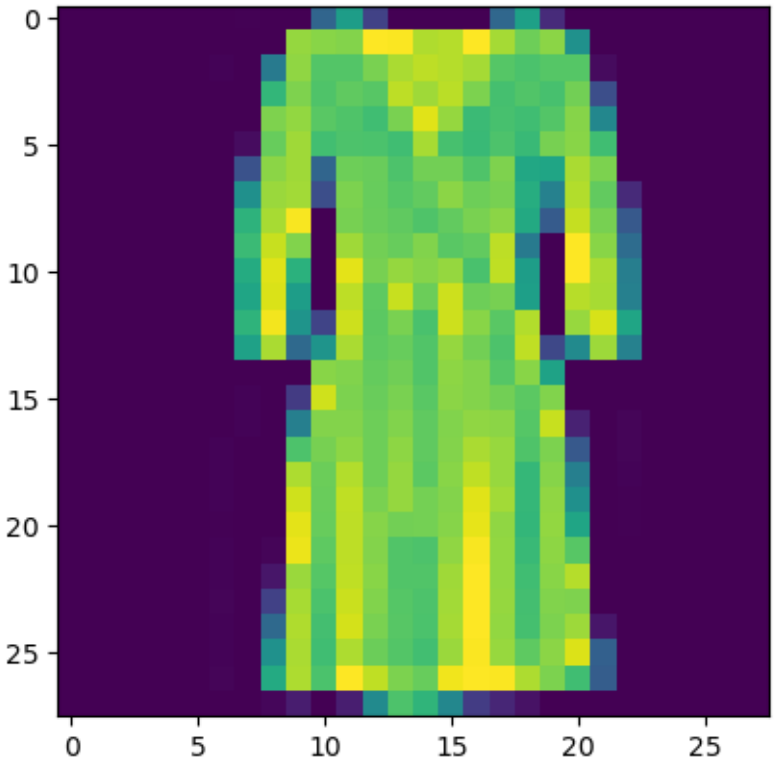
```
313/313 [==============================] - 4s 12ms/step
```

[154]:
```
import numpy as np
index=10
print(predictions[index])
final_value=np.argmax(predictions[index])
print("Actual label :",y_test[index])
print("Predicted label :",final_value)
print("Class :",class_names[final_value])
```

```
[3.09113297e-03 1.21354446e-04 7.97794724e-04 9.88401592e-01
 5.05621359e-03 3.44485943e-06 2.31067184e-03 3.31540491e-06
 1.84096454e-04 3.02996905e-05]
Actual label : 3
Predicted label : 3
Class : Dress
```

[155]:
```
plt.imshow(x_test[10])
```

[155]:
```
<matplotlib.image.AxesImage at 0x1ac4fc2a5b0>
```



Evaluating our Model

[146]:
```
loss, accuracy = model.evaluate(x_test, y_test)
print("Loss :",loss)
print("Accuracy (Test Data) :",accuracy*100)
```

```
313/313 [==============================] - 4s 12ms/step - loss: 0.2578 -
accuracy: 0.9033
Loss : 0.2578291893005371
Accuracy (Test Data) : 90.32999873161316
```