OUTPUT SCREENSHOTS

jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (unsaved changes)

Logout

File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

IMPORT LIBRARIES/DATASETS

In [30]:
```
import matplotlib.pyplot as plt
import numpy as np
import tensorflow as tf
import pandas as pd
import seaborn as sns
import pickle
import random
```

jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

File Edit View Insert Cell Kernel Help

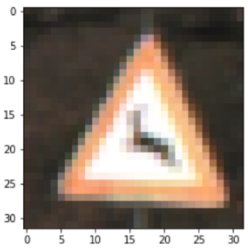
Trusted | Python 3

Run Code

IMAGES VISUALIZATION

In [35]:
```
i = np.random.randint(1, len(X_train))
plt.imshow(X_train[i])
y_train[i]
```

Out[35]: 31



jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

CONVERT IMAGES TO GRAYSCALE AND PERFORM NORMALIZATION

In [39]:
```
from sklearn.utils import shuffle
X_train, y_train = shuffle(X_train, y_train)
```

In [40]:
```
X_train_gray = np.sum(X_train/3,axis = 3,keepdims = True)
X_test_gray = np.sum(X_test/3,axis = 3,keepdims = True)
X_valid_gray = np.sum(X_valid/3,axis = 3,keepdims = True)
```

In [41]:
```
X_train_gray.shape
```

Out[41]: (34799, 32, 32, 1)

In [42]:
```
X_train_gray_norm = (X_train_gray-128)/128
X_test_gray_norm = (X_test_gray-128)/128
X_valid_gray_norm = (X_valid_gray-128)/128
```

In [43]:
```
X_train_gray_norm
```

Out[43]:
```
array([[[[-0.11197917],
         [-0.078125  ],
         [-0.03385417],
         ...,
         [-0.90885417],
```

jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

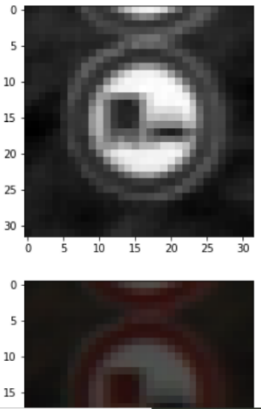
File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

```
plt.imshow(X_train[i])
plt.figure()
plt.imshow(X_train_gray_norm[i].squeeze(), cmap = 'gray')
```

Out[13]: <matplotlib.figure.AxesImage at 0x278c09a82c8>



jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

```
CNN.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 28, 28, 6)         156
_________________________________________________________________
average_pooling2d (AveragePo (None, 14, 14, 6)         0
_________________________________________________________________
dropout (Dropout)            (None, 14, 14, 6)         0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 10, 10, 16)        2416
_________________________________________________________________
average_pooling2d_1 (Average (None, 5, 5, 16)          0
_________________________________________________________________
flatten (Flatten)            (None, 400)               0
_________________________________________________________________
dense (Dense)                (None, 120)               48120
_________________________________________________________________
dense_1 (Dense)              (None, 84)                10164
_________________________________________________________________
dense_2 (Dense)              (None, 43)                3655
=================================================================
Total params: 64,511
Trainable params: 64,511
Non-trainable params: 0
_________________________________________________________________
```

jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (unsaved changes)

Logout

File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Markdown

COMPILE AND TRAIN DEEP CNN MODEL

In [15]:
```
CNN.compile(optimizer = 'Adam', loss = 'sparse_categorical_crossentropy',metrics = ['accuracy'])
```

In [25]:
```
history = CNN.fit(X_train_gray_norm,
                  y_train,
                  batch_size = 500,
                  epochs = 5,
                  verbose = 1,
                  validation_data = (X_valid_gray_norm,y_valid))
```

```
Train on 34799 samples, validate on 4410 samples
Epoch 1/5
34799/34799 [==============================] - 14s 404us/sample - loss: 0.1667 - accuracy: 0.9516 - val_loss: 0.4397 - val_accu
racy: 0.8916
Epoch 2/5
34799/34799 [==============================] - 14s 403us/sample - loss: 0.1531 - accuracy: 0.9569 - val_loss: 0.4216 - val_accu
racy: 0.8961
Epoch 3/5
34799/34799 [==============================] - 14s 404us/sample - loss: 0.1426 - accuracy: 0.9604 - val_loss: 0.4287 - val_accu
racy: 0.8934
Epoch 4/5
34799/34799 [==============================] - 14s 406us/sample - loss: 0.1331 - accuracy: 0.9626 - val_loss: 0.4252 - val_accu
racy: 0.8912
Epoch 5/5
34799/34799 [==============================] - 14s 405us/sample - loss: 0.1282 - accuracy: 0.9648 - val_loss: 0.4208 - val_accu
racy: 0.8982
```

jupyter PDE PROJECT Last Checkpoint: Last Saturday at 11:37 PM (unsaved changes)

Logout

File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

```
                validation_data = (X_valid_gray_norm,y_valid))
34799/34799 [==============================] - 11s 330us/sample - loss: 0.0021 - accuracy: 0.9994 - val_loss: 0.5305 - val_ac
curacy: 0.9556
Epoch 745/750
34799/34799 [==============================] - 11s 320us/sample - loss: 0.0016 - accuracy: 0.9994 - val_loss: 0.6542 - val_ac
curacy: 0.9442
Epoch 746/750
34799/34799 [==============================] - 12s 340us/sample - loss: 0.0016 - accuracy: 0.9995 - val_loss: 0.6546 - val_ac
curacy: 0.9456
Epoch 747/750
34799/34799 [==============================] - 12s 332us/sample - loss: 0.0018 - accuracy: 0.9994 - val_loss: 0.6054 - val_ac
curacy: 0.9506
Epoch 748/750
34799/34799 [==============================] - 11s 323us/sample - loss: 0.0033 - accuracy: 0.9994 - val_loss: 0.5238 - val_ac
curacy: 0.9569
Epoch 749/750
34799/34799 [==============================] - 11s 330us/sample - loss: 0.0010 - accuracy: 0.9997 - val_loss: 0.6362 - val_ac
curacy: 0.9476
Epoch 750/750
34799/34799 [==============================] - 12s 335us/sample - loss: 8.2629e-04 - accuracy: 0.9997 - val_loss: 0.6426 - va
l_accuracy: 0.9512
```

In [25]:
```
score = CNN.evaluate(X_test_gray_norm, y_test)
print('Test Accuracy: {}'.format(score[1]))
```

```
12630/12630 [==============================] - 1s 112us/sample - loss: 1.1149 - accuracy: 0.9315
Test Accuracy: 0.9315122961997986
```

jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (unsaved changes)

Logout

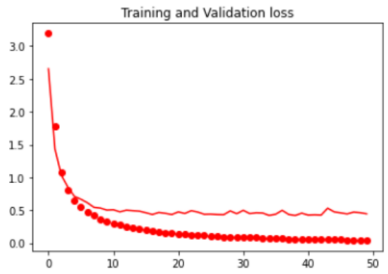
File Edit View Insert Cell Kernel Help

Trusted | Python 3

Run Code

In [32]:
```
epochs = range(len(accuracy))
plt.plot(epochs,loss,'ro',label = 'Training loss')
plt.plot(epochs,val_loss,'r',label = 'Validation loss')
plt.title ('Training and Validation loss')
```

Out[32]: Text(0.5, 1.0, 'Training and Validation loss')



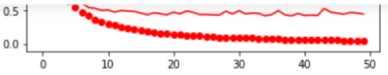
jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

File Edit View Insert Cell Kernel Help

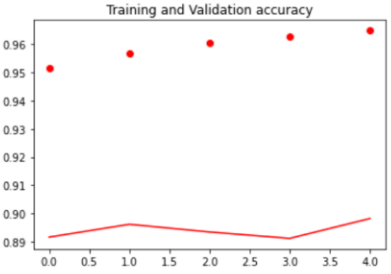
Trusted | Python 3

Run Code



In [29]:
```
epochs = range(len(accuracy))
plt.plot(epochs,accuracy,'ro',label = 'Training accuracy')
plt.plot(epochs,val_accuracy,'r',label = 'Validation accuracy')
plt.title ('Training and Validation accuracy')
```

Out[29]: Text(0.5, 1.0, 'Training and Validation accuracy')



jupyter PDE PROJECT Last Checkpoint: Last Wednesday at 10:31 PM (autosaved)

Logout

File Edit View Insert Cell Kernel Help

Trusted Python 3

Run Code