Project: traffic signs classification

Step 1: Import packages

In [138]:
```
import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt
import random
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler
import tensorflow as tf
from tensorflow import keras
import cv2
from sklearn.metrics import classification_report
import seaborn as sn
```

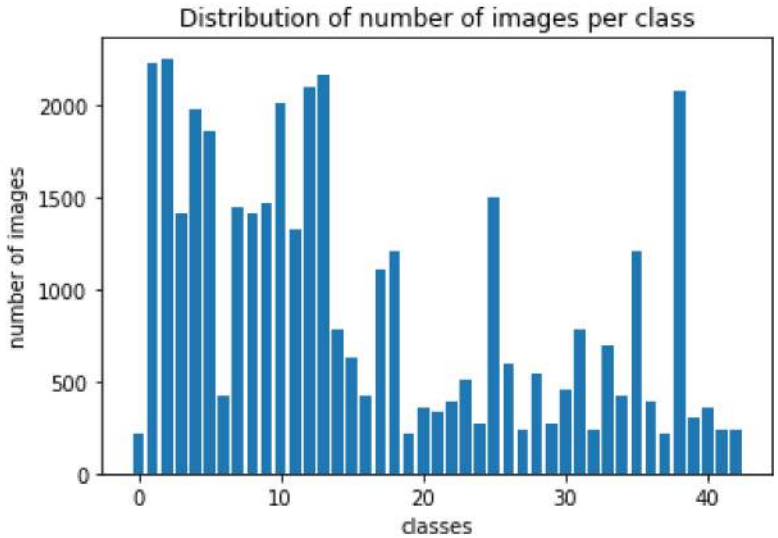
Step 2: Explore the data size distribution in classes

In [6]:
```
# Create a list that has lists of file names in each class as its elements
list_of_classes = []
for number in range(43):
    a = []
    for image_name in os.listdir('C:\\Users\\smart\\Desktop\\GitHub\\Traffic_Sig
        a.append(image_name)
    list_of_classes.append(a)
series_of_classes = pd.Series(list_of_classes)
```

In [8]:
```
# Store the class names in x
x = list(series_of_classes.index)

# Store the number of files/images in each class in y
y = []
for i in x:
    y.append(len(list_of_classes[i]))

print('x:',x)
print('y:',y)
```

```
x: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 2
1, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
41, 42]
y: [210, 2220, 2250, 1410, 1980, 1860, 420, 1440, 1410, 1470, 2010, 1320, 2100,
2160, 780, 630, 420, 1110, 1200, 210, 360, 330, 390, 510, 270, 1500, 600, 240,
540, 270, 450, 780, 240, 689, 420, 1200, 390, 210, 2070, 300, 360, 240, 240]
```

In [9]:
```
# plot
plt.bar(x,y)
plt.title('Distribution of number of images per class')
plt.xlabel('classes')
plt.ylabel('number of images')
plt.show()
```



In [10]:
```
# import the csv file with the meaning of the signs/classes
signs_meanings = pd.read_csv(r'C:\Users\smart\Desktop\GitHub\Traffic_Signs\signs_
signs_meanings
```

Out[10]:

	sign_number	sign_meaning
0	0	Max Speed 20 km/h
1	1	Max Speed 30 km/h
2	2	Max Speed 50 km/h
3	3	Max Speed 60 km/h
4	4	Max Speed 70 km/h
5	5	Max Speed 80 km/h
6	6	End of Max Speed 80 km/h
7	7	Max Speed 100 km/h
8	8	Max Speed 120 km/h
9	9	No Passing (for any vehicle type)
10	10	No Passing (by vehicles over 3,5 t)
11	11	Priority to through-traffic at the next inters...
12	12	Priority Road
13	13	Yield
14	14	Stop
15	15	No vehicles of any kind permitted
16	16	No Lkw(trucks) Permitted
17	17	Do Not Enter
18	18	Danger
19	19	Curve (left)
20	20	Curve (right)
21	21	Double curve
22	22	Uneven surfaces ahead, bumpy road
23	23	Slippery road
24	24	Road narrows on the right
25	25	Construction area
26	26	Traffic lights
27	27	Pedestrian crosswalk
28	28	Children
29	29	Bicycles
30	30	Slipperiness due to snow or ice
31	31	Wild animals
32	32	End of previous limitation

	sign_number	sign_meaning
33	33	You must turn right ahead, yield appropriately
34	34	You must turn left ahead, yield appropriately
35	35	You must go straight ahead, yield appropriately
36	36	You must go straight or turn right
37	37	You must go straight or turn left
38	38	Keep right of traffic barrier/divider
39	39	Keep left of traffic barrier/divider
40	40	Roundabout
41	41	End of No Passing (for any vehicle type)
42	42	End of No Passing (by vehicles over 3,5 t)

Step 3: Read, resize, and normalize the images

In [11]:
```
# Define a function to read, resize and label the images


def process_resize_image(path_to_folder):
    '''
    retruns two arrays:
    X is an array of images
    Y is an array of labels
    path formate: 'C:\\Users\\smart\\Desktop\\GitHub\\Traffic_Signs\\Train'

    '''
    X = [] #images
    Y = [] #labels
    label = 0

    for number in range(43):
        path_to_files = path_to_folder+'\\{}'.format(str(number))
        for image_name in os.listdir(path_to_files):
            X.append(cv2.resize(cv2.imread(os.path.join(path_to_files,image_name
            Y.append(label)
        label += 1

    return (X,Y)
```

In [13]:
```
resized_images, labels = process_resize_image('C:\\Users\\smart\\Desktop\\GitHub
```

In [14]:
```
# Split the data into train and test subsets

X_train, X_test, y_train, y_test = train_test_split (resized_images, labels, tes
```

In [15]:
```
# Check the lenth of the train and test subsets

ltr = len(y_train)
print("ltr: ",ltr)
lt = len(y_test)
print("lt: ",lt)
```

```
ltr:  29406
lt:  9803
```

In [16]:
```
# Double-check the unique values of labels for the train and test subsets

uniq_test_labels = np.unique(y_test)
print("test labels: ",uniq_test_labels)
uniq_training_labels = np.unique(y_train)
print("training labels:", uniq_training_labels)
```

```
test labels:  [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 2
1 22 23
 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42]
training labels: [ 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 2
0 21 22 23
 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42]
```

In [17]:
```
# Convert the subsets to numpy arrays

X_train = np.array(X_train)
print('training images np array shape:',X_train.shape)

y_train = np.array(y_train)
y_train.shape = (ltr,1)
print('training labels np array shape:',y_train.shape)

X_test = np.array(X_test)
print('testing images np array shape:',X_test.shape)

y_test = np.array(y_test)
y_test.shape = (lt,1)
print('testing labels np array shape:',y_test.shape)
```

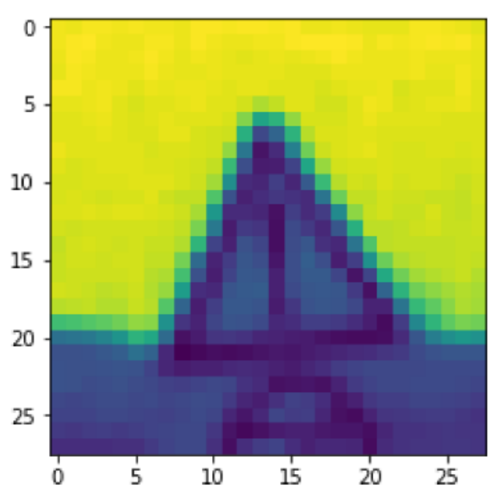
```
training images np array shape: (29406, 28, 28)
training labels np array shape: (29406, 1)
testing images np array shape: (9803, 28, 28)
testing labels np array shape: (9803, 1)
```

In [21]:
```
# Normalize the train and test image subsets

min_train = np.min(X_train)
print("min pixel value, train: ",min_train)
max_train = np.max(X_train)
print("max pixel value, train: ",max_train)
min_test = np.min(X_test)
print("min pixel value, test: ",min_test)
max_test = np.max(X_test)
print("max pixel value, test: ",max_test)

X_train_normalized = (X_train - min_train)/(max_train - min_train)
X_test_normalized = (X_test - min_test)/(max_test - min_train)

min_train_n = np.min(X_train_normalized)
print("min pixel value, train_normalized: ",min_train_n)
max_train_n = np.max(X_train_normalized)
print("max pixel value, train_normalized: ",max_train_n)
min_test_n = np.min(X_test_normalized)
print("min pixel value, test_normalized: ",min_test_n)
max_test_n = np.max(X_test_normalized)
print("max pixel value, test_normalized: ",max_test_n)
```

```
min pixel value, train:  3
max pixel value, train:  255
min pixel value, test:  3
max pixel value, test:  255
min pixel value, train_normalized:  0.0
max pixel value, train_normalized:  1.0
min pixel value, test_normalized:  0.0
max pixel value, test_normalized:  1.0
```

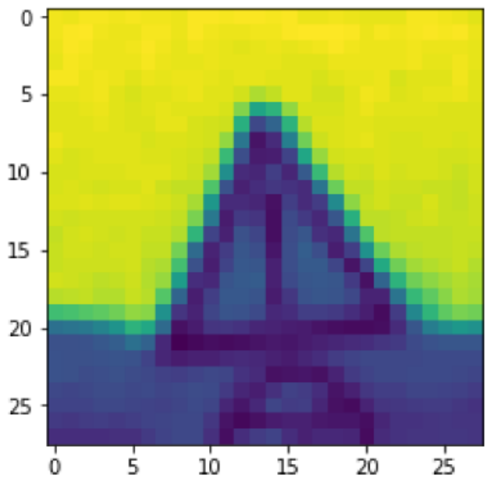
In [22]:
```
# Example image before nomalization

plt.imshow(X_train[100])
print(y_train[100])
```

```
[18]
```



In [23]:
```
# Example image after nomalization

plt.imshow(X_train_normalized[100])
print(y_train[100])
```

```
[18]
```



Step 4: Define, Compile and Fit the Convolutional Neural Network Model

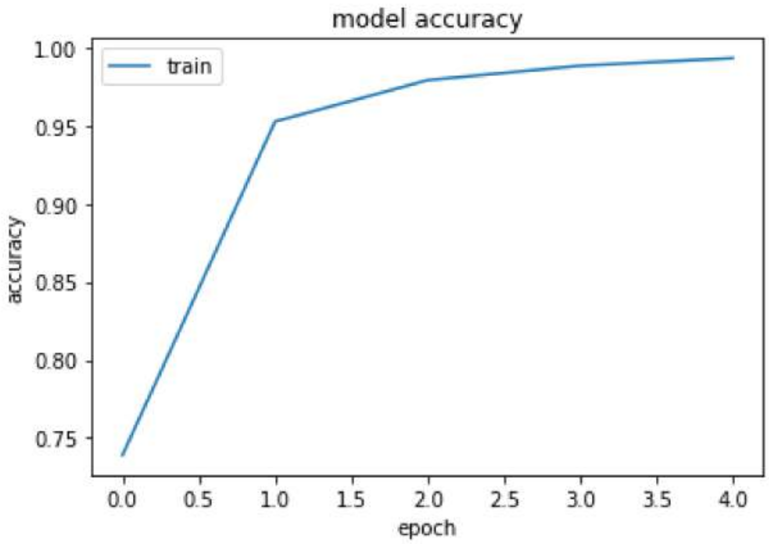
In [57]:
```
#CNN Model set to stop training after reaching 99% accuray

class Mycallback2 (tf.keras.callbacks.Callback):
    def on_epoch_end (self,epoch, logs = {}):
        if logs.get("acc") > 0.99:
            print("\n accuracy is greater than 0.99 now \n")
            self.model.stop_training = True

training_images_c = X_train_normalized.reshape(29406,28,28,1)
test_images_c = X_test_normalized.reshape(9803,28,28,1)

callbacks = Mycallback2()
model_ts = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(16,(3,3),activation = tf.nn.relu,input_shape = (28,28
                           tf.keras.layers.Conv2D(32, (3,3), activation='relu'),
                           tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
                           tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
                           tf.keras.layers.Flatten(),
                           tf.keras.layers.Dense(512, activation = tf.nn.relu),
                           tf.keras.layers.Dense(43, activation = 'softmax')])

model_ts.compile(optimizer = tf.keras.optimizers.RMSprop(lr=0.0001),loss = "spar
results = model_ts.fit(training_images_c, y_train, epochs = 15,callbacks = [call
```

```
Epoch 1/15
29406/29406 [==============================] - 131s 4ms/sample - loss: 1.0724 -
acc: 0.7301
Epoch 2/15
29406/29406 [==============================] - 130s 4ms/sample - loss: 0.1947 -
acc: 0.9495
Epoch 3/15
29406/29406 [==============================] - 128s 4ms/sample - loss: 0.0908 -
acc: 0.9760
Epoch 4/15
29406/29406 [==============================] - 127s 4ms/sample - loss: 0.0478 -
acc: 0.9873
Epoch 5/15
29376/29406 [============================>.] - ETA: 0s - loss: 0.0273 - acc: 0.
9924
 accuracy is greater than 0.99 now

29406/29406 [==============================] - 127s 4ms/sample - loss: 0.0273 -
acc: 0.9924
```

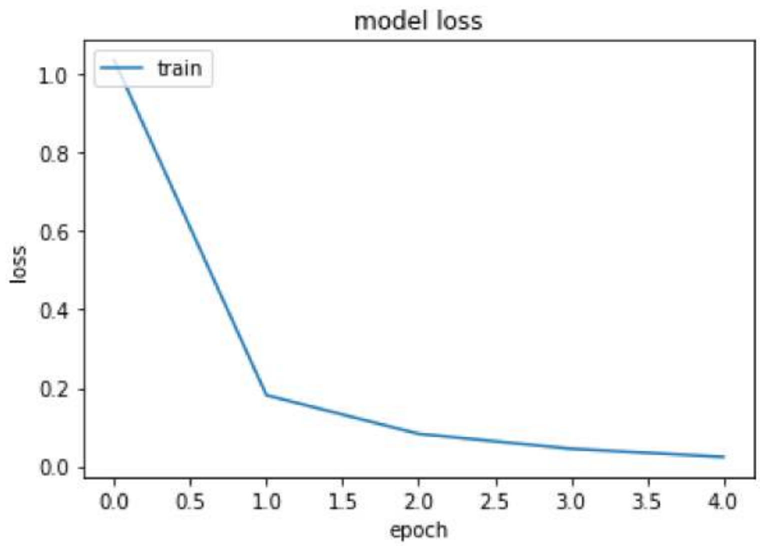
In [25]:
```
print(results.history.keys())
```

```
dict_keys(['loss', 'acc'])
```

In [26]:
```
# summarize history for accuracy
plt.plot(results.history['acc'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```



In [27]:
```
# summarize history for loss
plt.plot(results.history['loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
```



Step 5: Evaluate the model

In [59]:
```
model_ts.evaluate(test_images_c,y_test)
```

```
9803/9803 [==============================] - 8s 823us/sample - loss: 0.0791 - a
cc: 0.9826
```

Out[59]:
```
[0.07905799278253012, 0.98255634]
```

In [60]:
```
prediction = model_ts.predict(test_images_c)
```

In [62]:
```
# Transform the test labels into a list of label values
labels_list = []
for i in range(len(y_test)):
    labels_list.append(int(y_test[i]))

print(labels_list[:10])
```

```
[26, 15, 13, 10, 15, 12, 25, 2, 11, 35]
```

In [63]:
```
# Transform the prediction into a list of label values
predictions_list = []
for i in range(len(prediction)):
    predictions_list.append(np.argmax(prediction[i]))
print(predictions_list[:10])
```

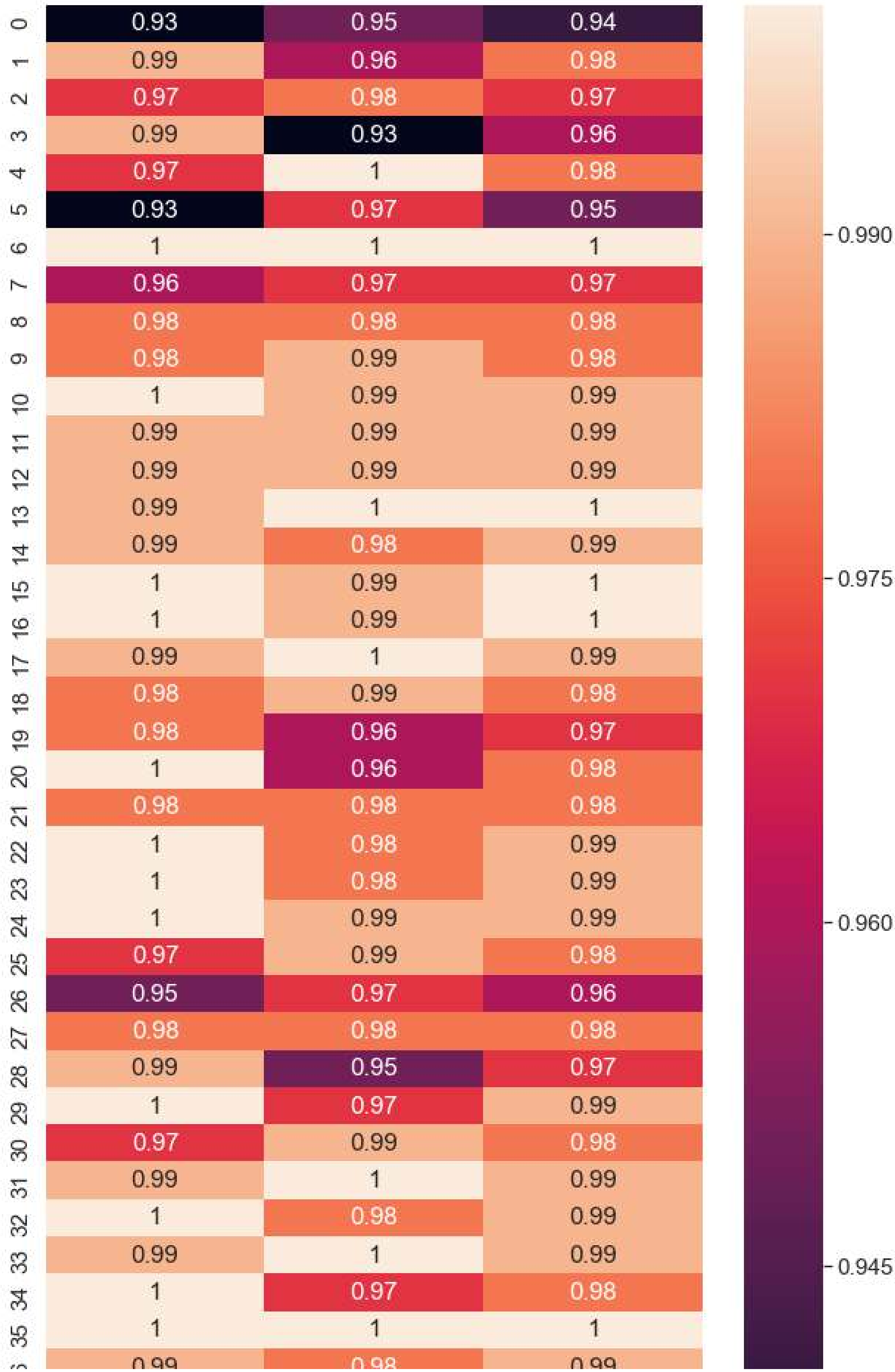
```
[26, 15, 13, 10, 15, 12, 25, 2, 11, 35]
```

In [66]:
```python
# Print precision, recall, f1-score and support for all classes
# support: the number of occurrences of each label (in y_test)

evaluation_report = classification_report(labels_list,predictions_list)
print(evaluation_report)
```

```
              precision    recall  f1-score   support

           0       0.93      0.95      0.94        44
           1       0.99      0.96      0.98       594
           2       0.97      0.98      0.97       560
           3       0.99      0.93      0.96       348
           4       0.97      1.00      0.98       529
           5       0.93      0.97      0.95       462
           6       1.00      1.00      1.00        81
           7       0.96      0.97      0.97       336
           8       0.98      0.98      0.98       385
           9       0.98      0.99      0.98       359
          10       1.00      0.99      0.99       461
          11       0.99      0.99      0.99       291
          12       0.99      0.99      0.99       548
          13       0.99      1.00      1.00       549
          14       0.99      0.98      0.99       197
          15       1.00      0.99      1.00       152
          16       1.00      0.99      1.00       108
          17       0.99      1.00      0.99       286
          18       0.98      0.99      0.98       288
          19       0.98      0.96      0.97        53
          20       1.00      0.96      0.98        90
          21       0.98      0.98      0.98        82
          22       1.00      0.98      0.99       107
          23       1.00      0.98      0.99       138
          24       1.00      0.99      0.99        68
          25       0.97      0.99      0.98       369
          26       0.95      0.97      0.96       152
          27       0.98      0.98      0.98        60
          28       0.99      0.95      0.97       129
          29       1.00      0.97      0.99        77
          30       0.97      0.99      0.98       118
          31       0.99      1.00      0.99       201
          32       1.00      0.98      0.99        48
          33       0.99      1.00      0.99       182
          34       1.00      0.97      0.98       117
          35       1.00      1.00      1.00       290
          36       0.99      0.98      0.99       105
          37       1.00      1.00      1.00        60
          38       1.00      1.00      1.00       517
          39       1.00      1.00      1.00        69
          40       0.97      0.99      0.98        77
          41       1.00      0.97      0.98        60
          42       1.00      0.98      0.99        56

   micro avg       0.98      0.98      0.98      9803
   macro avg       0.99      0.98      0.98      9803
weighted avg       0.98      0.98      0.98      9803
```

In [189]:
```
# Create a function to visualize the classification report

def plot_classification_report(cr):

    '''
    Visualizes the output of the classification_report
    cr: classification_report
    '''

    lines = evaluation_report.split('\n')
    #print('measures:',measures)
    classes = []
    plot_mat = []

    for line in lines[2 : (len(lines) - 5)]:
        t = line.split()
        classes.append(t[0])
        v = [float(x) for x in t[1: len(t)-1]]
        plot_mat.append(v)

    df_cm = pd.DataFrame(plot_mat, index = [i for i in classes],
                  columns = [i for i in ['precision', 'recall', 'f1-score']])
    plt.figure(figsize = (10,20))
    sn.heatmap(df_cm, annot=True)
```

In [190]:
```
plot_classification_report(evaluation_report)
```



In [164]:

```python
# Print some prediction vs true value comparisons

for i in range(5):
    print("example",i)
    temporary_list = list(prediction[i])
    print('Predicted value:',temporary_list.index(max(temporary_list)))
    print('meaning:',signs_meanings['sign_meaning'][temporary_list.index(max(tem
    print()
    print('Actual value:',y_test[i])
    print("_"*30)
```

```
example 0
Predicted value: 26
meaning: Traffic lights

Actual value: [26]
______________________________
example 1
Predicted value: 15
meaning: No vehicles of any kind permitted

Actual value: [15]
______________________________
example 2
Predicted value: 13
meaning: Yield

Actual value: [13]
______________________________
example 3
Predicted value: 10
meaning: No Passing (by vehicles over 3,5 t)

Actual value: [10]
______________________________
example 4
Predicted value: 15
meaning: No vehicles of any kind permitted

Actual value: [15]
______________________________
```

Step 6: Creat a function to read any new image and return

its meaning

In [29]:
```
# Define a function to read,resize,normalize and predict a new image


def resize_normalize_predict (path_to_file):
    '''
    retruns one arrays:
    x is an array of images
    path formate: 'C:\\Users\\smart\\Desktop\\GitHub\\Traffic_Signs\\Train\\file_

    '''
    x = cv2.resize(cv2.imread(path_to_file,cv2.IMREAD_GRAYSCALE),(28,28), interp
    x = np.array(x)
    ma = np.max(x)
    mi = np.min(x)
    x_n = (x - mi)/(ma - mi)
    x_reshape = x_n.reshape(1,28,28,1)
    prediction_array = model_ts.predict(x_reshape)
    prediction_list = prediction_array.tolist()
    predicted_label = prediction_list[0].index(max(prediction_list[0]))
    meaning = signs_meanings['sign_meaning'][predicted_label]
    return (meaning)
```

In [30]:
```
#C:\Users\smart\Desktop\GitHub\Traffic_Signs_Original\Test

resize_normalize_predict("C:\\Users\\smart\\Desktop\\GitHub\\Traffic_Signs_Origi
```

Out[30]: 'Max Speed 60 km/h'