

## Project Development Phase Sprint - II

Date	05 November 2022
Team ID	PNT2022TMID25575
Project Name	Natural Disasters Intensity Analysis And Classification Using Artificial Intelligence
Maximum Marks	4 Marks

### Building the CNN Model for Natural Disaster Classification, Training and Validating it, and Testing results

The screenshot shows the IBM Watson Studio interface. The top navigation bar includes the IBM Watson Studio logo, a search bar, and user account information (Raakesh Kumar C's Account, Dallas). The breadcrumb trail indicates the project is "Natural Disaster Intensity Analysis" under "Disaster Classification".

The main workspace displays a Jupyter notebook with the following code and output:

```
In [27]: #Model Fitting - training and validation
history=model.fit_generator(x_train,steps_per_epoch=len(x_train),epochs=20,validation_data=x_val,validation_steps=len(x_val))
#steps_per_epoch = no of train images/batch size
#validation_steps = no of test images/batch size
```

The output shows the training progress over 15 epochs (displayed up to epoch 15 in the image):

Epoch	Time	loss	accuracy	val_loss	val_accuracy	
Epoch 1/20	310/310	384s	1.1158	0.5341	1.0172	0.6244
Epoch 2/20	310/310	380s	0.7026	0.7391	0.6189	0.7862
Epoch 3/20	310/310	378s	0.6090	0.7785	0.5414	0.8032
Epoch 4/20	310/310	378s	0.5252	0.8082	0.5541	0.8133
Epoch 5/20	310/310	375s	0.4850	0.8205	0.5834	0.7805
Epoch 6/20	310/310	376s	0.4537	0.8305	0.4234	0.8450
Epoch 7/20	310/310	378s	0.4294	0.8437	0.4307	0.8529
Epoch 8/20	310/310	379s	0.4033	0.8524	0.3810	0.8767
Epoch 9/20	310/310	379s	0.3695	0.8631	0.3842	0.8586
Epoch 10/20	310/310	383s	0.3419	0.8760	0.3953	0.8620
Epoch 11/20	310/310	380s	0.3305	0.8728	0.4521	0.8541
Epoch 12/20	310/310	383s	0.3426	0.8731	0.4412	0.8529
Epoch 13/20	310/310	378s	0.3359	0.8763	0.4537	0.8541
Epoch 14/20	310/310	384s	0.3157	0.8834	0.4474	0.8439
Epoch 15/20	310/310	380s	0.2992	0.8967	0.5975	0.8213

The right sidebar shows the "Data" panel with a "Files" section. It indicates that one file can be uploaded at a time, with a maximum file size of 5 GB. A file named "Cyclone\_Wildfi...ake\_Database.zip" is listed, and an "Insert to code" button is available.

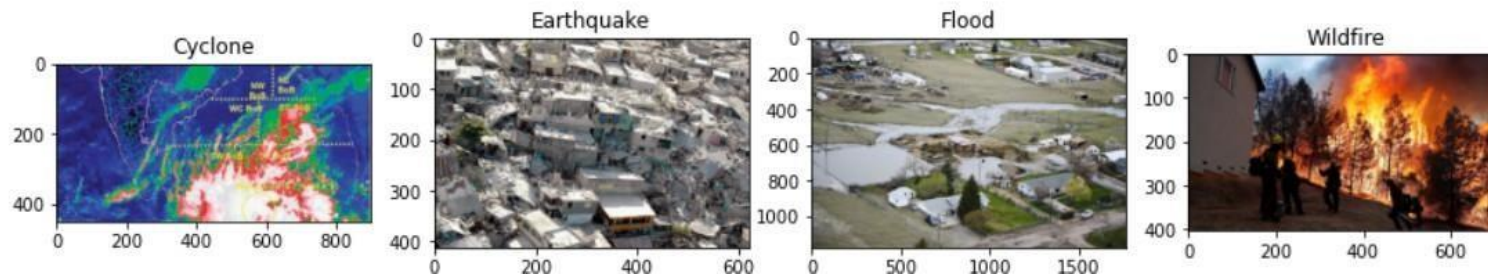
#### 1. Indexing Disaster Classes

```
In [19]: #Classes of Disasters  
x_train.class_indices
```

```
Out[19]: {'Cyclone': 0, 'Earthquake': 1, 'Flood': 2, 'Wildfire': 3}
```

## 2. Sample Plot for each of the Classes

```
In [20]: #Sample Plot for each of the Classes  
from skimage import io  
f=['/home/wsuser/work/dataset/train/Cyclone/1.jpg', '/home/wsuser/work/dataset/train/Earthquake/0.jpg', '/home/wsuser/work/dataset/train/Flood/0.jpg', '/home/wsuser/work/dataset/train/Wildfire/0.jpg']  
class_names=['Cyclone', 'Earthquake', 'Flood', 'Wildfire']  
x, axarr = plt.subplots(1,4,figsize=(15,15))  
for i in range(4):  
    axarr[i].imshow(io.imread(f[i]))  
    axarr[i].title.set_text(class_names[i])
```



## 3. CNN Model Architecture

```
In [21]: model=Sequential()
```

```
In [22]: #Input Convolution Layer
model.add(Convolution2D(32,kernel_size=(3,3),input_shape=(299,299,3),strides=(1,1),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
#Convolution Layer 2
model.add(Convolution2D(64,kernel_size=(3,3),input_shape=(299,299,3),strides=(1,1),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.3))
#Convolution Layer 3
model.add(Convolution2D(32,kernel_size=(3,3),input_shape=(299,299,3),strides=(1,1),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.3))
#Flattening of Output
model.add(Flatten())
#FCN or Dense Layer
model.add(Dense(units=256,kernel_initializer="random_uniform",activation="relu"))
model.add(Dropout(0.4))
#Output Layer
model.add(Dense(units=4,activation="softmax"))
```

## 4. Summary of the Model

```
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 297, 297, 32)	896
max_pooling2d (MaxPooling2D)	(None, 148, 148, 32)	0
conv2d_1 (Conv2D)	(None, 146, 146, 64)	18496
max_pooling2d_1 (MaxPooling2D)	(None, 73, 73, 64)	0
dropout (Dropout)	(None, 73, 73, 64)	0
conv2d_2 (Conv2D)	(None, 71, 71, 32)	18464
max_pooling2d_2 (MaxPooling2D)	(None, 35, 35, 32)	0
dropout_1 (Dropout)	(None, 35, 35, 32)	0
flatten (Flatten)	(None, 39200)	0
dense (Dense)	(None, 256)	10035456
dropout_2 (Dropout)	(None, 256)	0
dense_1 (Dense)	(None, 4)	1028

Total params: 10,074,340

## 5. Compiling the Model

```
In [24]: #Compiling the Model
model.compile(loss="categorical_crossentropy",optimizer="adam",metrics=["accuracy"])
```

## 6. Training and Validating the Model

```
In [27]: #Model Fitting - training and validation
history=model.fit_generator(x_train,steps_per_epoch=len(x_train),epochs=20,validation_data=x_val,validation_steps=len(x_val),
#steps_per_epoch = no of train images/batch size
#validation_steps = no of test images/batch size
<
Epoch 1/20
310/310 [=====] - 384s 1s/step - loss: 1.1158 - accuracy: 0.5341 - val_loss: 1.0172 - val_accuracy: 0.6244
Epoch 2/20
310/310 [=====] - 380s 1s/step - loss: 0.7026 - accuracy: 0.7391 - val_loss: 0.6189 - val_accuracy: 0.7862
Epoch 3/20
310/310 [=====] - 378s 1s/step - loss: 0.6090 - accuracy: 0.7785 - val_loss: 0.5414 - val_accuracy: 0.8032
Epoch 4/20
310/310 [=====] - 378s 1s/step - loss: 0.5252 - accuracy: 0.8082 - val_loss: 0.5541 - val_accuracy: 0.8133
Epoch 5/20
310/310 [=====] - 375s 1s/step - loss: 0.4850 - accuracy: 0.8205 - val_loss: 0.5834 - val_accuracy: 0.7805
Epoch 6/20
310/310 [=====] - 376s 1s/step - loss: 0.4537 - accuracy: 0.8305 - val_loss: 0.4234 - val_accuracy: 0.8450
Epoch 7/20
310/310 [=====] - 378s 1s/step - loss: 0.4294 - accuracy: 0.8437 - val_loss: 0.4307 - val_accuracy: 0.8529
Epoch 8/20
310/310 [=====] - 379s 1s/step - loss: 0.4033 - accuracy: 0.8524 - val_loss: 0.3810 - val_accuracy: 0.8767
Epoch 9/20
310/310 [=====] - 379s 1s/step - loss: 0.3695 - accuracy: 0.8631 - val_loss: 0.3842 - val_accuracy: 0.8586
Epoch 10/20
310/310 [=====] - 383s 1s/step - loss: 0.3419 - accuracy: 0.8760 - val_loss: 0.3953 - val_accuracy: 0.8760
```

---



```

Epoch 11/20
310/310 [=====] - 380s 1s/step - loss: 0.3305 - accuracy: 0.8728 - val_loss: 0.4521 - val_ac
curacy: 0.8541
Epoch 12/20
310/310 [=====] - 383s 1s/step - loss: 0.3426 - accuracy: 0.8731 - val_loss: 0.4412 - val_ac
curacy: 0.8529
Epoch 13/20
310/310 [=====] - 378s 1s/step - loss: 0.3359 - accuracy: 0.8763 - val_loss: 0.4537 - val_ac
curacy: 0.8541
Epoch 14/20
310/310 [=====] - 384s 1s/step - loss: 0.3157 - accuracy: 0.8834 - val_loss: 0.4474 - val_ac
curacy: 0.8439
Epoch 15/20
310/310 [=====] - 380s 1s/step - loss: 0.2992 - accuracy: 0.8967 - val_loss: 0.5975 - val_ac
curacy: 0.8213
Epoch 16/20
310/310 [=====] - 380s 1s/step - loss: 0.2774 - accuracy: 0.8999 - val_loss: 0.4088 - val_ac
curacy: 0.8597
Epoch 17/20
310/310 [=====] - 384s 1s/step - loss: 0.2534 - accuracy: 0.9109 - val_loss: 0.3894 - val_ac
curacy: 0.8643
Epoch 18/20
310/310 [=====] - 379s 1s/step - loss: 0.2779 - accuracy: 0.9015 - val_loss: 0.4040 - val_ac
curacy: 0.8665
Epoch 19/20
310/310 [=====] - 379s 1s/step - loss: 0.2430 - accuracy: 0.9093 - val_loss: 0.4831 - val_ac
curacy: 0.8529
Epoch 20/20
310/310 [=====] - 381s 1s/step - loss: 0.2490 - accuracy: 0.9073 - val_loss: 0.4113 - val_ac
curacy: 0.8801

```

## 7. Saving the Model as .h5 file and json file

```
In [28]: len(x_train)
```

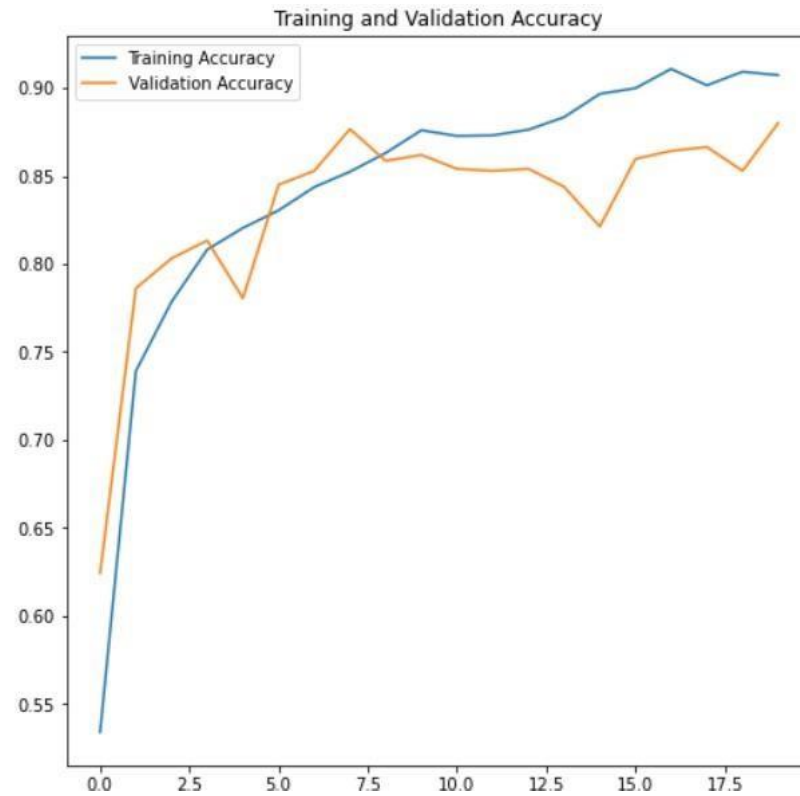
```
Out[28]: 310
```

```
In [29]: #saving the Model
model.save('Disaster_Classifier.h5')
model_json=model.to_json()
with open("model-bw.json","w") as json_file:
    json_file.write(model_json)
```

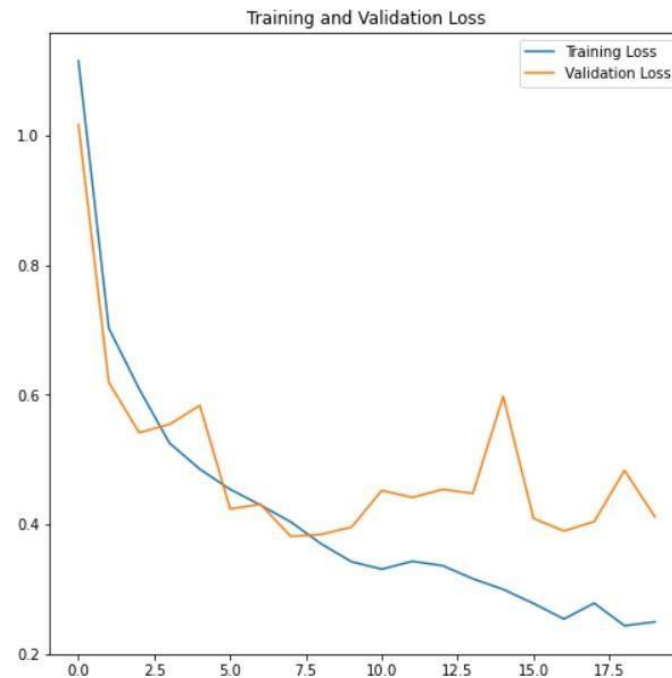
## 8. Plots for training vs validation accuracies and losses

```
In [30]: #Training and Validation Accuracy Plots
epochs_range = range(20)

plt.figure(figsize=(8, 8))
plt.plot(epochs_range, history.history['accuracy'], label='Training Accuracy')
plt.plot(epochs_range, history.history['val_accuracy'], label='Validation Accuracy')
plt.legend()
plt.title('Training and Validation Accuracy')
plt.show()
```



```
In [31]: #Training and Validation Loss Plot
plt.figure(figsize=(8, 8))
plt.plot(epochs_range, history.history['loss'], label='Training Loss')
plt.plot(epochs_range, history.history['val_loss'], label='Validation Loss')
plt.legend()
plt.title('Training and Validation Loss')
plt.show()
```



## 9. Testing the CNN Model with test data

```
In [35]: #Testing the CNN Model with test data
test_generator=test_datagen.flow_from_directory(r"/home/wsuser/work/dataset/test",
                                                target_size=(299,299),
                                                batch_size=447,
                                                color_mode='rgb',
                                                class_mode='categorical')
```

Found 447 images belonging to 4 classes.

```
In [36]: x_test, y_test = test_generator.__getitem__(0)
```

```
In [37]: y_test
```

```
Out[37]: array([[1., 0., 0., 0.],
                [0., 1., 0., 0.],
                [0., 0., 0., 1.],
                ...,
                [0., 0., 0., 1.],
                [0., 0., 0., 1.],
                [0., 0., 1., 0.]], dtype=float32)
```

```
In [38]: #predicting the labels of test data
y_pred = model.predict(x_test)
```

```
In [39]: y_pred = np.argmax(y_pred,axis=1)
```

```
In [40]: y_pred
```

```
Out[40]: array([0, 1, 3, 3, 1, 3, 2, 1, 1, 0, 0, 2, 3, 0, 2, 3, 3, 1, 1, 2, 2, 3,
                2, 0, 1, 3, 1, 3, 0, 1, 3, 0, 1, 3, 0, 1, 3, 2, 2, 1, 3, 1, 1, 0,
                2, 3, 2, 3, 2, 1, 3, 1, 2, 0, 1, 3, 0, 3, 3, 0, 0, 2, 0, 2, 0, 1,
                3, 1, 3, 0, 0, 0, 2, 1, 0, 1, 1, 0, 2, 2, 1, 0, 1, 0, 3, 3, 3, 2,
                2, 1, 1, 2, 2, 1, 1, 3, 1, 2, 3, 3, 1, 3, 0, 0, 1, 1, 1, 0, 0, 1,
                1, 2, 1, 0, 0, 1, 2, 2, 1, 2, 3, 1, 1, 2, 2, 1, 0, 1, 1, 1, 2, 1,
                3, 1, 0, 3, 2, 1, 2, 1, 3, 2, 2, 0, 1, 2, 0, 1, 1, 3, 0, 1, 0, 1,
                3, 1, 2, 1, 1, 1, 0, 1, 0, 3, 2, 0, 3, 0, 0, 0, 1, 0, 0, 2, 3, 2,
                0, 0, 1, 0, 0, 2, 2, 1, 0, 3, 1, 1, 1, 2, 0, 3, 1, 2, 3, 2, 0, 0,
                3, 1, 2, 1, 3, 3, 2, 0, 0, 2, 3, 1, 2, 2, 3, 1, 3, 1, 0, 0, 3, 1,
                3, 0, 1, 2, 2, 3, 1, 2, 2, 1, 1, 2, 1, 0, 1, 1, 2, 2, 2, 1, 0, 2,
                2, 3, 0, 1, 1, 3, 1, 0, 2, 2, 3, 0, 0, 3, 1, 0, 1, 1, 1, 1, 2, 0,
                3, 2, 0, 0, 3, 2, 3, 1, 1, 0, 1, 1, 2, 3, 1, 2, 0, 3, 3, 3, 1, 2,
                2, 2, 2, 2, 3, 3, 2, 1, 1, 1, 1, 3, 2, 3, 2, 1, 2, 2, 3, 2, 3, 2,
                2, 1, 3, 2, 2, 1, 1, 2, 0, 1, 2, 2, 3, 1, 2, 1, 2, 1, 2, 1, 3, 2,
                3, 2, 2, 3, 1, 3, 1, 3, 1, 0, 1, 2, 2, 2, 3, 0, 0, 2, 3, 3, 3, 1,
                2, 1, 3, 1, 1, 2, 0, 3, 2, 2, 0, 3, 1, 1, 1, 1, 0, 1, 2, 0, 3,
                2, 0, 2, 2, 0, 1, 3, 3, 3, 2, 2, 2, 1, 1, 2, 0, 3, 1, 2, 1, 1, 1,
                2, 0, 3, 1, 2, 0, 2, 1, 3, 2, 3, 3, 1, 3, 2, 2, 1, 0, 3, 0, 0, 1,
                3, 3, 2, 2, 0, 1, 0, 2, 1, 2, 0, 1, 2, 1, 1, 3, 2, 3, 3, 1, 1, 1,
                3, 3, 0, 0, 3, 3, 2])
```

```
In [41]: y_test = np.argmax(y_test, axis=1)
```



```
In [42]: y_test
Out[42]: array([0, 1, 3, 3, 1, 3, 2, 1, 1, 0, 0, 2, 3, 0, 2, 3, 3, 2, 1, 3, 2, 3,
 0, 0, 1, 3, 1, 3, 0, 1, 3, 0, 1, 3, 0, 1, 3, 1, 2, 1, 3, 1, 1, 0,
 2, 3, 1, 3, 2, 1, 3, 0, 2, 0, 1, 3, 2, 3, 3, 0, 0, 2, 0, 2, 0, 1,
 3, 1, 3, 0, 0, 0, 2, 1, 0, 1, 1, 0, 2, 2, 1, 0, 1, 0, 3, 3, 3, 2,
 2, 1, 1, 2, 2, 2, 1, 3, 1, 2, 3, 3, 1, 3, 0, 0, 1, 1, 1, 0, 0, 3,
 1, 2, 1, 0, 0, 1, 2, 2, 1, 2, 3, 1, 1, 2, 2, 2, 0, 1, 2, 1, 1, 0,
 3, 1, 0, 3, 2, 1, 2, 1, 3, 2, 2, 3, 1, 2, 0, 1, 3, 2, 3, 1, 0, 1,
 3, 3, 3, 1, 1, 1, 0, 1, 0, 3, 2, 0, 3, 0, 0, 0, 2, 0, 0, 2, 3, 2,
 0, 0, 1, 0, 0, 2, 2, 1, 0, 3, 1, 1, 1, 2, 0, 3, 1, 3, 3, 2, 0, 0,
 3, 1, 2, 1, 3, 3, 2, 0, 1, 1, 3, 1, 2, 0, 1, 1, 3, 3, 0, 0, 3, 0,
 3, 0, 2, 2, 2, 3, 1, 2, 2, 1, 1, 2, 1, 0, 1, 1, 2, 2, 2, 1, 0, 2,
 2, 3, 0, 2, 1, 3, 1, 0, 2, 1, 3, 0, 0, 3, 0, 0, 1, 0, 1, 1, 2, 0,
 3, 2, 1, 0, 3, 2, 3, 1, 1, 0, 1, 1, 1, 3, 1, 2, 0, 3, 3, 3, 1, 2,
 3, 2, 2, 1, 3, 3, 3, 1, 1, 1, 1, 3, 2, 3, 1, 1, 2, 3, 3, 2, 3, 2,
 2, 1, 3, 2, 2, 1, 1, 1, 0, 1, 2, 2, 3, 1, 2, 1, 2, 1, 2, 1, 3, 1,
 3, 2, 2, 3, 1, 3, 1, 3, 1, 0, 1, 2, 2, 2, 3, 0, 0, 2, 3, 0, 3, 1,
 2, 2, 3, 1, 1, 2, 0, 3, 2, 2, 0, 3, 1, 0, 0, 1, 1, 0, 1, 2, 0, 3,
 2, 0, 2, 2, 0, 1, 3, 3, 3, 1, 2, 2, 1, 1, 2, 0, 3, 1, 2, 1, 1, 1,
 2, 0, 3, 2, 2, 0, 0, 1, 3, 2, 3, 3, 1, 3, 2, 2, 1, 0, 3, 0, 0, 1,
 3, 3, 2, 2, 0, 1, 0, 2, 1, 1, 0, 1, 2, 1, 1, 3, 1, 3, 3, 1, 1, 1,
 3, 3, 0, 0, 3, 3, 2])
```

## 10. Generating Classification Report with F1 Score

```
In [44]: import keras.backend as K
def accuracy(y_true, y_pred):
    '''Calculates the mean accuracy rate across all predictions for binary
    classification problems.
    '''
    return K.mean(K.equal(y_true, K.round(y_pred)))
```

```
In [45]: #Classification report with Accuracy (F1 Score) for each Class
print("CNN Disaster Classification Model Accuracy on test set: {:.4f}".format(accuracy(y_test, y_pred)))
print(classification_report(y_test, y_pred))
```

```
CNN Disaster Classification Model Accuracy on test set: 0.8881
              precision    recall  f1-score   support

     0           0.94       0.88        0.91         94
     1           0.86       0.88        0.87        136
     2           0.82       0.90        0.85        108
     3           0.97       0.89        0.93        109

   accuracy                   0.89         447
  macro avg           0.90       0.89        0.89         447
 weighted avg           0.89       0.89        0.89         447
```

## 11. Weighted Accuracy of the model

```
In [50]: #Weighted Accuracy of the model
accu = np.count_nonzero(np.equal(y_pred,y_test))/x_test.shape[0]
print("Accuracy: {} %".format(accu*100))
```

Accuracy: 88.81431767337807 %

## 12. Confusion Matrix for test data

```
In [50]: #Weighted Accuracy of the model
accu = np.count_nonzero(np.equal(y_pred,y_test))/x_test.shape[0]
print("Accuracy: {} %".format(accu*100))
```

Accuracy: 88.81431767337807 %

```
In [51]: classes = list(x_train.class_indices.keys())
```

```
In [53]: #Confusion matrix for test data Classification
import pandas as pd
df_cmatrix = pd.DataFrame(confusion_matrix(y_test, y_pred),index=classes, columns=classes)
sns.set(font_scale=1.0)
fig,ax = plt.subplots(figsize=(16,12))
sns.heatmap(df_cmatrix, annot=True,annot_kws={"size": 15},fmt='2g')
```

