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Step by Step guide for Collab Notebook “PUBLIC_yolov8_fire_and_smoke_retrain.ipynb”

Complete training pipeline to train YOLOv8 classifier for fire & smoke detection based on images.

Prerequisite Steps:

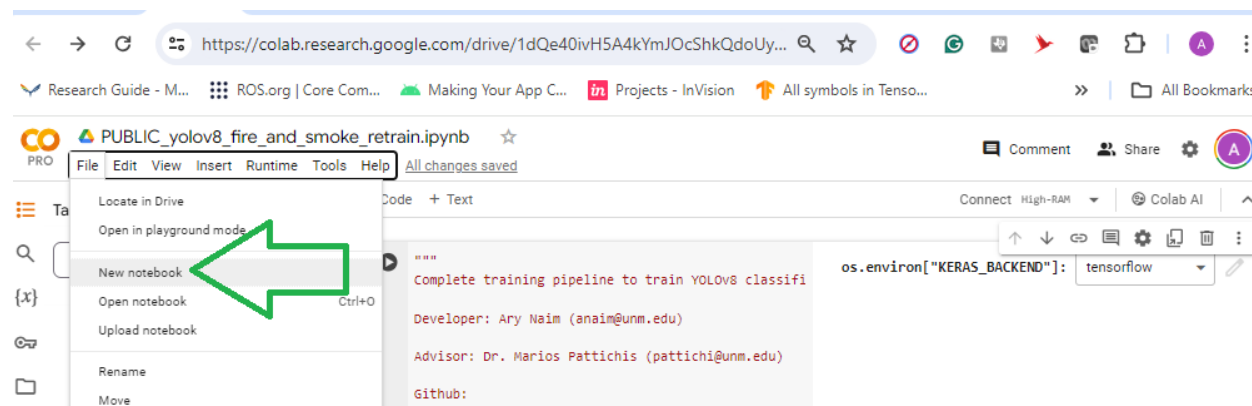
1. Create a Gmail account, in order to have a Google Drive for cloud storage.
2. Create a Google Collab account.
This is online programming environment that gives you access to GPUs, CPUs, and can be shared with other people.

Note: Google is not free after the 1st several hours and has both monthly cost and hourly cost for GPUs.

3. Navigate to “PUBLIC_yolov8_fire_and_smoke_retrain.ipynb” at

<https://colab.research.google.com/drive/1dQe40ivH5A4kYmJOcShkQdoUyl0sH5F0?usp=sharing>

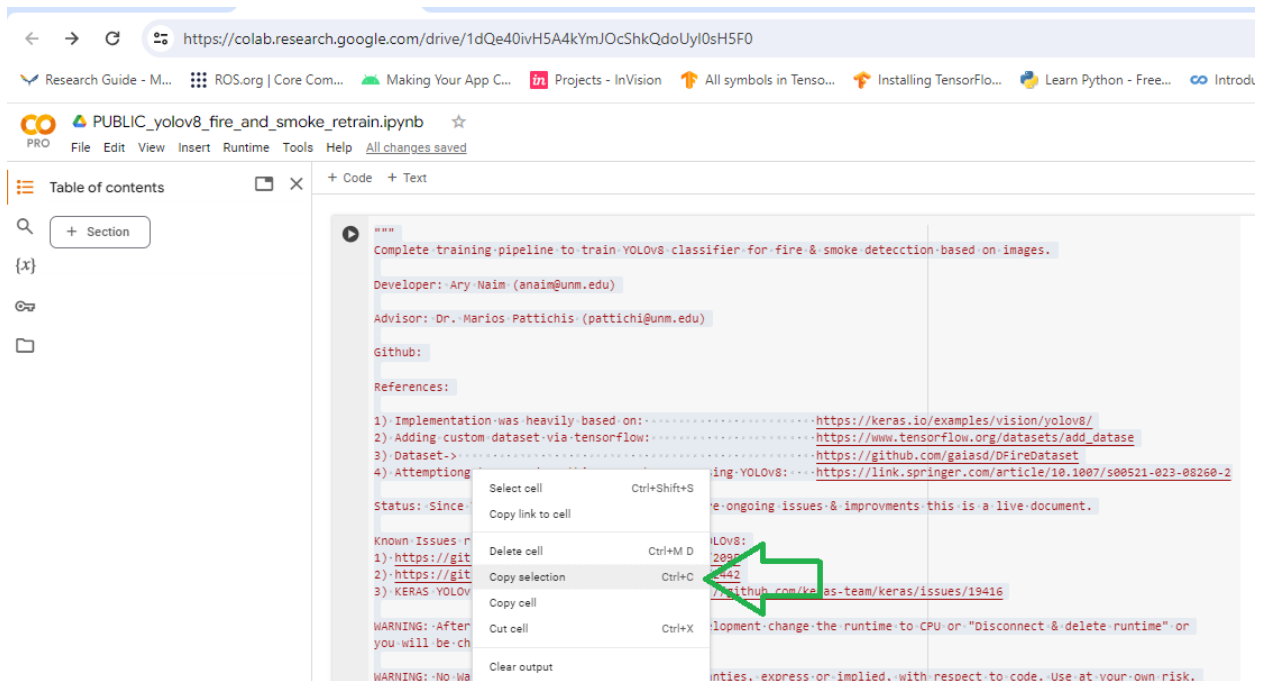
This notebook can only be viewed or read therefore in order to make modifications create your own Notebook in Collab.



Let's start:

Step 0:

Copy all of the code from “PUBLIC_yolov8_fire_and_smoke_retrain.ipynb” into your own notebook.



Step 1:

Since we are going to run long running tasks we need a way to keep Google Collab alive even after hours of running. Even if you sign for Google Collab's "professional" version the browser will timeout after ~30 min of inactivity.

Do this hack to keep your browser alive:

<https://www.codeease.net/programming/javascript/keep-colab-from-disconnecting>

Step 2:

Based on the Python code in “PUBLIC_yolov8_fire_and_smoke_retrain.ipynb” install the required Python libraries.

High & run the installation only:

```
#PLEASE READ & EXECUTE STEP BY STEP.
""" STEP 1) To avoid reconnects read: https://www.c
"""

""" Step 2) Installation steps"""
#installations--START
!pip install tensorflow==2.15.0 --# Upgrade to Tensor
!pip install keras==2.15.0
!pip install keras-cv
!pip install h5py
!pip install matplotlib
#installations--END

""" Step 3) Mount Drive"""
#MOUNT DRIVE - START
from google.colab import drive
drive.mount('/content/gdrive')
#link your path to create
!ln -s /content/gdrive/My\
#MOUNT DRIVE - END

""" Step 4) Mount imports"""
#imports - START
import os
import sys
sys.path.append('.')
sys.path.append('..')
```

1) highlight & select

2) run selection

Step 3:

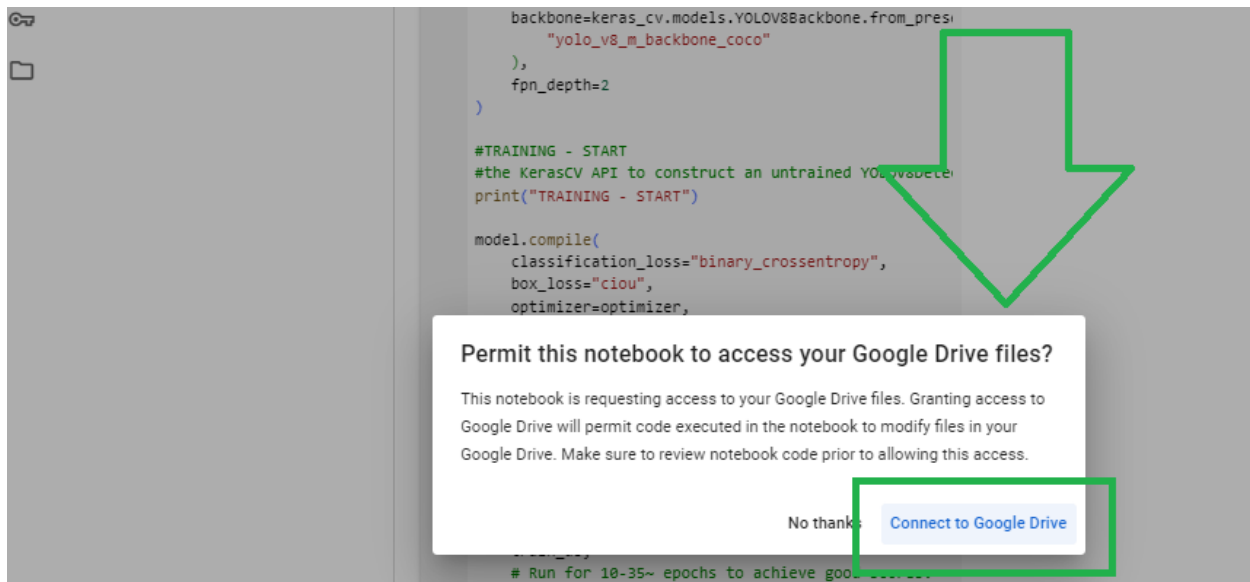
Mount your Google Drive

```
""" Step 3) Mount Drive"""
#MOUNT DRIVE - START
from google.colab import drive
drive.mount('/content/gdrive')
#link your path to create a symbolic link
!ln -s /content/gdrive/My\Drive/ /mydrive
#MOUNT DRIVE - END

""" Step 4) Mount imports"""
#imports - START
import os
import sys
sys.path.append('.')
sys.path.append('..')
import custom
from my_fire_smoke import *
os.environ["KERAS_BACKEND"] = "tensorflow"
import tensorflow as tf
import tensorflow.keras as keras
print("TF Version: ", tf.__version__)
import keras_cv
```

2) run selection

You will be asked for permissions via several dialog boxes. Approve them.



Continue to step 4 on the next page.

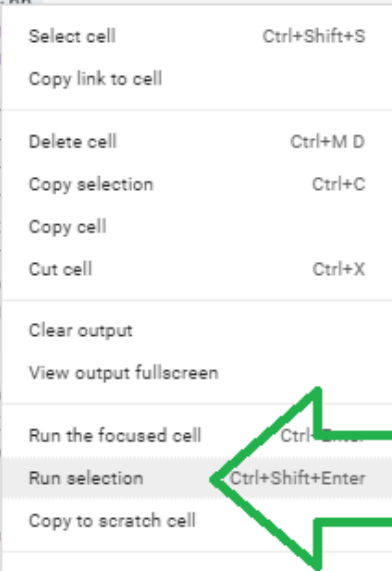
Step 4: Import the required libraries.

```
#MOUNT DRIVE - END

""" Step 4) Run imports"""
#imports--START
import os
import sys
sys.path.append('.')
sys.path.append '..')
sys.path.append('/content/gdrive/MyDrive/my_fire_smoke')
#import custom dataset
from my_fire_smoke_dataset import MyFireSmokeDataset
os.environ["KERAS_BACKEND"] = "tensorflow" # @param
from tensorflow import data as tf_data
import tensorflow_datasets as tfds
import tensorflow as tf
print("TF VERSION:", tf.__version__)
import keras
print("Keras VERSION:", keras.__version__)
import keras_cv
import numpy as np
from keras_cv import layers
from keras_cv import models
import tqdm
from sklearn.metrics import accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
import matplotlib.pyplot as plt
from sklearn.datasets import load_digits
from sklearn.preprocessing import StandardScaler
from keras.preprocessing.image import ImageDataGenerator
from PIL import Image
import random
from sklearn.metrics import confusion_matrix
keras.backend.clear_session()
keras.backend.set_learning_phase(1)
#imports--END

""" Step 5) A"""

IMPORTANT:
```



Select cell	Ctrl+Shift+S
Copy link to cell	
Delete cell	Ctrl+M D
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Copy cell	
Cut cell	Ctrl+X
Clear output	
View output fullscreen	
Run the focused cell	Ctrl+Enter
Run selection	Ctrl+Shift+Enter
Copy to scratch cell	
Add a comment	Ctrl+Alt+M

There should be no errors. If there are any installation or import errors do not proceed until all of the errors are resolved.

Step 5) ADVANCED - Optional for Custom Datasets.

If you are using dataset from Keras or just want to run the Collab notebook as is, you can skip this step #5 & go to step 6.

a) Create a folder in Google drive to upload your data & write a custom Python ()

The screenshot shows the Google Colab interface for a notebook titled 'yolov8_fire_and_smoke_retrain.ipynb'. On the left, the 'Files' pane displays the directory structure of the user's Google Drive. A green arrow labeled '1)' points to the 'MyDrive' folder. Another green arrow labeled 'my directory' points to the 'Smoke_and_Fire_Datasets' folder. A third green arrow labeled 'my data' points to the 'my_fire_smoke_dataset' folder, which contains 'test' and 'train' subfolders. On the right, the code editor shows a Python script for training a YOLOv8 model. The script includes a license notice, a description of the training pipeline, the developer's name (Ary Naim), the advisor's name (Dr. Marios Pattichis), and a list of references. The script also includes a warning about potential charges for running the experiment.

```
Suggested code may be subject to a license | github.com/mit
"""
Complete training pipeline to train YOLOv8

Developer: Ary Naim (anaim@unm.edu)

Advisor: Dr. Marios Pattichis (pattichi@unm.edu)

Github:

References:

1) Implementation was heavily based on:
2) Adding custom dataset via tensorflow:
3) Dataset->
4) Attempting to reproduce this paper how

Status: Since YOLOv8 is relatively new & t
Known Issues related Keras's implementatio
1) https://github.com/keras-team/keras-cv/
2) https://github.com/keras-team/keras-cv/
3) KERAS YOLOv8 DOESN'T traditional metrics:

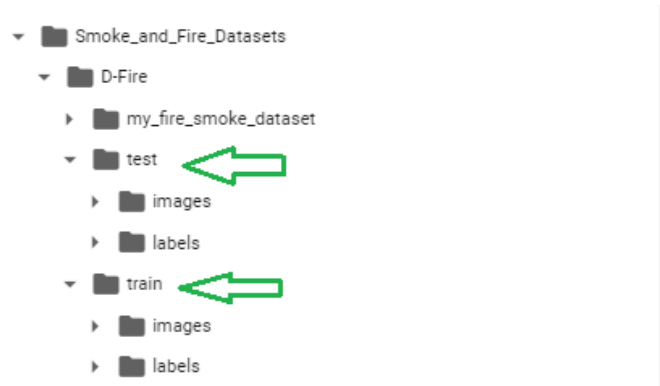
WARNING: After running the experiment or a
you will be charged pet hour by Google.
```

The path to my data is. Your can be different.

/content/gdrive/MyDrive/Smoke_and_Fire_Datasets

Darknet/YOLOv1-4 data format:

In this specific example, the original dataset was preprocessed to be in “test” & “train” folders and each of those folders has a “image” and “labels” subfolder:



YOLO versions v1 to v4 were trained using Darknet neural network framework (<https://pjreddie.com/darknet/>) therefore a lot of datasets have the above format of test/images, test/labels, train/images, and train/labels.

The “images” folder has image files with corresponding text label files under “labels” folder, with same file name.

```
/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/images# ls | head -5
AoF06723.jpg
AoF06724.jpg
AoF06725.jpg
AoF06726.jpg
AoF06727.jpg

/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test# cd labels/
/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/labels# ls | head -5
AoF06723.txt
AoF06724.txt
AoF06725.txt
AoF06726.txt
AoF06727.txt
```

image files

label files

A closer inspection of the labels shows files that have no data indicating no classification and label files with label data in the format <class,x,y,width,height>. See below:

```
Terminal X
/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/labels# ls | head -5
AoF06723.txt
AoF06724.txt
AoF06725.txt
AoF06726.txt
AoF06727.txt

/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/labels# cat AoF06723.txt
No class. No fire or Smoke.

/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/labels# ls | tail -5
WEB11802.txt
WEB11803.txt
WEB11804.txt
WEB11805.txt
WEB11806.txt

/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire/test/labels# cat WEB11802.txt
1 0.22213855421686748 0.7373068432671082 0.44427710843373497 0.40176600441501104
1 0.5805722891566265 0.8631346578366446 0.17319277108433737 0.1986754966887417
0 0.6536144578313253 0.2803532008830022 0.6656626506024097 0.5253863134657837
1 0.9766566265060241 0.7295805739514348 0.03463855421686747 0.08609271523178808
```

No class. No fire or Smoke.

1=fire
0= Smoke

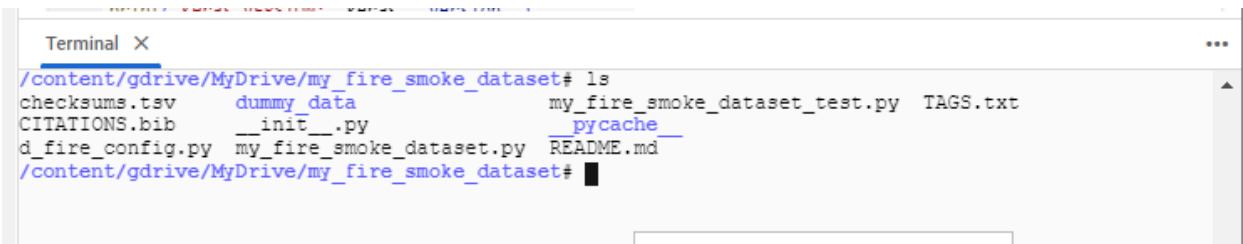
b) Open the online browser terminal:



c) Navigate to where you uploaded your data

For example:

```
cd /content/gdrive/MyDrive/my_fire_smoke_dataset
```

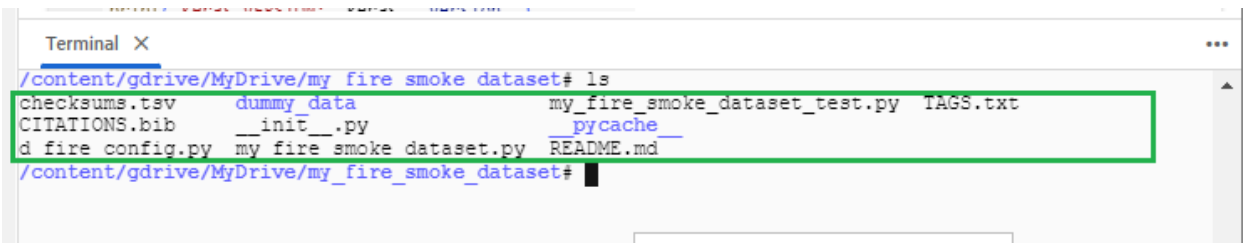


All the files you see here are auto generated & you see them after executing the next command.

d) In the same path execute this command:

```
tfd new <THE_NAME_OF_YOUR_DATASET>
```

You should see bunch of files & folders appear:



(Writing custom datasets) Follow this guide step by step:

READ carefully & then come back to this guide:

https://www.tensorflow.org/datasets/add_dataset

- e) Open the autogenerated “my_dataset_dataset_builder.py” file in one browser & keep the (https://www.tensorflow.org/datasets/add_dataset) guide open in another window as a guide.

Your custom data handling class must implement [tfds.core.DatasetBuilder](#)

Change the class name to match your dataset. Our dataset has fire & smoke images there we named it MyFireSmokeDataset:

The screenshot shows a Jupyter Notebook on the left and the TensorFlow Datasets documentation on the right. The Jupyter Notebook code defines a class `MyFireSmokeDataset` that inherits from `tfds.core.GeneratorBasedBuilder`. A green box highlights this class name, and a green arrow points from it to the text "change the class name to suite your dataset" on the documentation page. The documentation page shows a minimal example of a dataset builder class, also inheriting from `tfds.core.GeneratorBasedBuilder`, with a green box around the class name `Builder` and the same green text annotation.

```
1 my_fire_smoke_dataset.py x Terminal
2 1
3 2 """my_fire_smoke_dataset dataset."""
4 3
5 4 import os
6 5 import numpy as np
7 6 from numpy import bool_ as np_bool
8 7 import tensorflow_datasets as tfds
9 8 from tensorflow import data as tf_data
10 9 import tensorflow_datasets as tfds
11 10 import tensorflow as tf
12 11 from d_fire_config import DFireConfig
13 12 from PIL import Image
14 13
15 14 #Author: Ary Naim (anaim.unm.edu)
16 15 #Reference guide: https://www.tensorflow.org/datasets/add_dataset
17 16 #Adapted based on VOC example:https://github.com/chasojeong/bbox_dataset/blob/master/t
18 17
19 18 class MyFireSmokeDataset(tfds.core.GeneratorBasedBuilder):
20 19     """DatasetBuilder for my_fire_smoke_dataset dataset."""
21 20
22 21     MANUAL_DOWNLOAD_INSTRUCTIONS = """
23 22     Data is in <YOUR_PATH>/Smoke_and_Fire_Datasets/D-Fire
24 23     """
```

- f) Since we are load the data from folder rather from a web service, then hard code the path to your data:

/ed

+ Code + Text

my_fire_smoke_dataset.py x Terminal

```
1
2 """my_fire_smoke_dataset dataset."""
3
4 import os
5 import numpy as np
6 from numpy import bool_ as np_bool
7 import tensorflow_datasets as tfds
8 from tensorflow import data as tf_data
9 import tensorflow_datasets as tfds
10 import tensorflow as tf
11 from d_fire_config import DFireConfig
12 from PIL import Image
13
14 #Author: Ary Naim (anaim.unm.edu)
15 #Reference guide: https://www.tensorflow.org/datasets/add\_dataset
16 #Adapted based on VOC example:https://github.com/chasojeong/bbox\_dataset/blob/master/tensorflow\_dat
17
18 class MyFireSmokeDataset(tfds.core.GeneratorBasedBuilder):
19     """DatasetBuilder for my_fire_smoke_dataset dataset."""
20
21     MANUAL_DOWNLOAD_INSTRUCTIONS = """
22     Data is in <YOUR_PATH>/Smoke_and_Fire_Datasets/D-Fire
23     """
24
25     DATA_PATH = "/content/gdrive/MyDrive/Smoke_and_Fire_Datasets/D-Fire"
26
27     VERSION = tfds.core.Version('1.0.0')
28     RELEASE_NOTES = {
29         '1.0.0': 'Initial release.',
30     }
31
32     class_ids = ("Fire", "Smoke",)
33
34     _DESCRIPTION = """
35     D-Fire is an image dataset of fire and smoke occurrences designed for machine learning and object
36     References: https://github.com/gaiasd/DFireDataset
37     """
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```

- h) Implement the functions minimum required functions that are inherited from `tfds.core.GeneratorBasedBuilder`. Therefore you must implement at the minimum:

```
_info()
_split_generators()
_generate_examples():
_generate_example():
```

For example, for `_info`, this was our implementation:

```
"""
function: _info(self)
Input: None
Output: tfds.core.DatasetInfo
Description:
Returns tfds.core.DatasetInfo which is the class that describes our
dataset.
"""
def _info(self):
    return tfds.core.DatasetInfo(
        builder=self,
        description=self._DESCRIPTION,
        features=tfds.features.FeaturesDict({
            "image": tfds.features.Image(),
            "image/filename": tfds.features.Text(),
            "objects": tfds.features.Sequence({
                "label": tfds.features.ClassLabel(names=self.class_ids),
                "bbox": tfds.features.BBoxFeature(),
                "is_truncated": np_bool,
                "is_difficult": np_bool,
            }),
            "labels": tfds.features.Sequence(
                tfds.features.ClassLabel(names=self.class_ids)
            ),
            "labels_no_difficult": tfds.features.Sequence(
                tfds.features.ClassLabel(names=self.class_ids)
            ),
        }),
        homepage="https://github.com/gaiasd/DFireDataset",
        citation="""Pedro Vinícius Almeida Borges de Venâncio,
        Adriano Chaves Lisboa, Adriano Vilela Barbosa:
        An automatic fire detection system based on deep
        convolutional neural networks for low-power,
        resource-constrained devices.
        In: Neural Computing and Applications, 2022""",
    )
```

For the function `_split_generators()`

```
def _split_generators(self, dl_manager: tfds.download.DownloadManager):
    """Returns SplitGenerators."""
    extracted_path = (self.DATA_PATH)
    return {
        'train': self._generate_examples(
            images_path=str(extracted_path)+str("/train/images"),
            labels_path=str(extracted_path)+str("/train/labels"),
        ),
        'test': self._generate_examples(
            images_path=str(extracted_path)+str("/test/images"),
            labels_path=str(extracted_path)+str("/test/labels"),
        ),
    }
```

For the function `_generate_examples()`:

```
def _generate_examples(self, images_path, labels_path):
    """Yields examples."""
    image_files = []
    labels_files = []
    # Yields (key, example) tuples from the dataset
    #1) step 1 - get images & labels (which have class & bounding boxes )
    image_files = self.get_jpeg_files(images_path)
    labels_files = self.get_txt_files(labels_path)
    image_files = image_files[0:500]
    labels_files = labels_files[0:500]
    #2) for each image & label get the files
    for img_f, lbl_f in zip(image_files, labels_files):
        #return the image bytes & bounding box info
        filename = os.path.basename(img_f)
        image, bounding_boxes = self.load_image_bounding_box(img_f, lbl_f, DFireConfig.image_size_1)
        if bounding_boxes is not None:
            print("_generate_examples(), DATA:", bounding_boxes)
            yield filename, self._generate_example(img_f, bounding_boxes, bounding_boxes["class"])
        else:
            continue
```

limit for testing. Remove in production.

For the function `_generate_example`:

```
.09
.10 def _generate_example(self, image_filepath, bbox, label):
.11     objects = []
.12     labels = []
.13     labels_no_difficult = []
.14     label = bbox["class"]
.15     x = bbox["x"]
.16     y = bbox["y"]
.17     w = bbox["width"]
.18     h = bbox["height"]
.19     #convert from YOLO to relative BBox
.20     image_w, image_h = self.get_image_dimensions(image_filepath)
.21     yolo_box = (x,y,w,h)
.22     pixel_coords = self.yolo2pixel((image_w, image_h), [x,y,w,h])
.23     x1 = pixel_coords[0]/image_w
.24     y1 = pixel_coords[1]/image_h
.25     x2 = pixel_coords[2]/image_w
.26     y2 = pixel_coords[3]/image_h
.27     if x2 > 1:
.28         x2 = 1.0
.29     if y2 > 1:
.30         y2 = 1.0
.31     if label == "0":
.32         label = self.class_ids[0]
.33     if label == "1":
.34         label = self.class_ids[1]
.35     #References: https://www.tensorflow.org/datasets/api\_docs/python/tfds/features/BBBox
.36     objects.append({
.37         "label": label,
.38         "bbox": tfds.features.BBox(x1,y1,x2,y2),
.39         "is_truncated": False,
.40         "is_difficult": False,
.41     })
.42     return {
.43         "image": image_filepath,
.44         "image/filename": os.path.basename(image_filepath),
.45         "objects": objects,
.46         "labels": np.array([label]),
.47         "labels_no_difficult": labels_no_difficult,
.48     }
```



- i) After the implementation is complete then go the terminal & type

```
tfds build --register_checksums
```

This may take a while depending on the size of your dataset. It took ~10 min for a dataset of size 500 & many hours for dataset of size 5000.

There should be no errors.

Step 6) Lets go back to the actual experiment “PUBLIC_yolov8_fire_and_smoke_retrain.ipynb”.

If you chose to do the Step 5 then make sure you can import your custom Python script at the top of the imports.

```
""" Step 4) Mount imports"""  
#imports - START  
import os  
import sys  
sys.path.append('.')  
sys.path.append('..')  
sys.path.append('/content/gdrive/MyDrive/my_fire_smoke_dataset') #You  
#import custom dataset  
from my_fire_smoke_dataset import MyFireSmokeDataset  
os.environ["KERAS_BACKEND"] = "tensorflow" # @param ["tensorflow",  
from tensorflow import data as tf_data  
import tensorflow_datasets as tfds
```

Else run the section associated with declaring variables & functions.

```
"""step 6) declare variables & functions"""  
  
#VARIABLES.  
#IMPORTANT: change the labels here to reflect the actual labels you have based on your dataset.  
class_ids = [  
    "Fire",  
    "Smoke",  
]  
  
image_size_1 = (640,640)  
image_size_2 = (320,320)  
image_size_3 = (160,160)  
  
class_mapping = dict(zip(range(len(class_ids)), class_ids))  
  
# FUNCTION DECLARATIONS - START  
def visualize_dataset(inputs, value_range, rows, cols, bounding_box_format):  
    inputs = next(iter(inputs.take(1)))
```

Step 7) Start the experiment & load data

step 7) Start the experiment & load data

Noe that we have imported all the required imports and declared all the required functions. Lets run the experiment.

**YOU NEED A GPU.* *Makesure to switch the runtime to a GPU that you can afford (start with L4). You may need re-run previous steps as the runtime is restarted.

```
"""step 7) Start the experiment & load data"""
#PARAMETERS
BATCH_SIZE = 4
#hyperparameters - START
#hyperparameters
LEARNING_RATE = 0.005 #try 0.001 to 0.005
EPOCHS = 50 # 50 is not enough, the original paper ran epoches frpm 5,000 to 30,000
MOMENTUM = 0.9
#hyperparameters - END

#GET DATA
print("GET DATA - START ")
#original
```

You should start seeing the dataset being loaded. This will take a while even though we are only using 500 images which is not enough for building an accurate model.


```
*** GET DATA - START
Downloading and preparing dataset Unknown size (download: Unknown size, generated: Unknown size, total: Unknown size) to /root/tensorflow_
Generating splits...: 0% 0/2 [00:00<?, ? splits/s]

Generating train examples...: 287/? [13:12<00:00, 1.51s/ examples]
bounding_box: {'class': 'Fire', 'x': 0.4852941176470588, 'y': 0.25416666666666665, 'width': 0.8823529411764706, 'height': 0.4583333333333333}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.4852941176470588, 'y': 0.25416666666666665, 'width': 0.8823529411764706, 'height': 0.4583333333333333}
bounding_box: {'class': 'Fire', 'x': 0.41150000000000003, 'y': 0.33066666666666666, 'width': 0.8130000000000001, 'height': 0.6453333333333333}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.41150000000000003, 'y': 0.33066666666666666, 'width': 0.8130000000000001, 'height': 0.6453333333333333}
bounding_box: {'class': 'Fire', 'x': 0.5024509803921569, 'y': 0.2, 'width': 0.8970588235294118, 'height': 0.35000000000000003}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.5024509803921569, 'y': 0.2, 'width': 0.8970588235294118, 'height': 0.35000000000000003}
bounding_box: {'class': 'Fire', 'x': 0.3802931596091205, 'y': 0.2305194805194805, 'width': 0.7312703583061889, 'height': 0.4307359307359307}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.3802931596091205, 'y': 0.2305194805194805, 'width': 0.7312703583061889, 'height': 0.4307359307359307}
bounding_box: {'class': 'Fire', 'x': 0.546875, 'y': 0.4847222222222222, 'width': 0.246875, 'height': 0.25277777777777777}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.546875, 'y': 0.4847222222222222, 'width': 0.246875, 'height': 0.25277777777777777}
bounding_box: {'class': 'Fire', 'x': 0.46718750000000003, 'y': 0.49444444444444446, 'width': 0.15937500000000002, 'height': 0.19444444444444444}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.46718750000000003, 'y': 0.49444444444444446, 'width': 0.15937500000000002, 'height': 0.19444444444444444}
bounding_box: {'class': 'Fire', 'x': 0.45625000000000004, 'y': 0.5458333333333334, 'width': 0.096875, 'height': 0.13611111111111113}
_generate_examples(), DATA: {'class': 'Fire', 'x': 0.45625000000000004, 'y': 0.5458333333333334, 'width': 0.096875, 'height': 0.13611111111111113}
bounding_box: {'class': 'Fire', 'x': 0.6078125000000001, 'y': 0.3875, 'width': 0.371875, 'height': 0.2638888888888889}
```

If you want to load the entire 20,000 images open the Python file title "my_fire_smoke_dataset.py" and make an update in the function:

Terminal my_fire_smoke_dataset.py X

```
77 | return {
78 |     'train': self._generate_examples(
79 |         images_path=str(extracted_path)+str("/train/images"),
80 |         labels_path=str(extracted_path)+("/train/labels"),
81 |     ),
82 |     'test': self._generate_examples(
83 |         images_path=str(extracted_path)+str("/test/images"),
84 |         labels_path=str(extracted_path)+("/test/labels"),
85 |     ),
86 | }
87 |
88 | def _generate_examples(self, images_path, labels_path):
89 |     """Yields examples."""
90 |     image_files = []
91 |     labels_files = []
92 |     # Yields (key, example) tuples from the dataset
93 |     #1) step 1 - get images & labels (which have class & bounding boxes )
94 |     image_files = self.get_jpeg_files(images_path)
95 |     labels_files = self.get_txt_files(labels_path)
96 |     image_files = image_files[0:500]
97 |     labels_files = labels_files[0:500]
98 |     #2) for each image & label get the files
99 |     for img_f, lbl_f in zip(image_files, labels_files):
100 |         #return the image bytes & bounding box info
101 |         filename = os.path.basename(img_f)
102 |         image, bounding_boxes = self.load_image_bounding_box(img_f, lbl_f, DFireConfig.image_size_1)
103 |         if bounding_boxes is not None:
104 |             print("_generate_examples(), DATA:", bounding_boxes)
105 |             yield filename, self._generate_example(img_f, bounding_boxes, bounding_boxes["class"])
106 |         else:
107 |             continue
108 |
```



change or remove this.

Now you should see training results such as epoch, some metrics per each epoch, and visualizations.

You can also see the model training per each epoch:

```
+ Code + Text

...
box_outputs (Activation)      (None, None, 66)      0      ['tf.concat_16[0][0]']
tf.__operators__.getitem (   (None, None, 64)      0      ['box_outputs[0][0]']
SlicingOpLambda)
tf.__operators__.getitem_1    (None, None, 2)        0      ['box_outputs[0][0]']
(SlicingOpLambda)
box (Concatenate)             (None, None, 64)      0      ['tf.__operators__.getitem[0][
0]']
class (Concatenate)           (None, None, 2)        0      ['tf.__operators__.getitem_1[0
][0]']
non_max_suppression_1 (Non   multiple      0      []
MaxSuppression)
yolov8_label_encoder (YOLO   multiple      0      []
V8LabelEncoder)

=====
Total params: 25890582 (98.76 MB)
Trainable params: 25857462 (98.64 MB)
Non-trainable params: 33120 (129.38 KB)

Epoch 1/50
76/124 [=====>.....] - ETA: 7s - loss: 200.3011 - box_loss: 3.5762 - class_loss: 196.7249
```

Step 8) Inference