DETR - Detection Transformer

Reference: https://github.com/NielsRogge/Transformers-Tutorials/blob/master/DETR/Fine_tuning_DetrForObjectDetection_on_custom_dataset_(balloon).ipynb

Original DETR paper: https://arxiv.org/abs/2005.12872

Original DETR repo: https://github.com/facebookresearch/detr

```
from google.colab import drive
drive.mount('/content/drive')
```

```
     Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
!python --version
```

```
     Python 3.10.12
```

```
!python -m pip install --upgrade pip
```

```
!pip install supervision==0.3.0
```

```
!pip install transformers
```

```
!pip install pytorch-lightning
```

```
!pip install timm
```

```
!pip install cython
```

```
!pip install pycocotools
```

```
!pip install scipy
```

```
    Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages (1.11.4)
    Requirement already satisfied: numpy<1.28.0,>=1.21.6 in /usr/local/lib/python3.10/dist-packages (from scipy) (1.23.5)
    WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It
```

```
!pip --version
```

```
    pip 23.3.2 from /usr/local/lib/python3.10/dist-packages/pip (python 3.10)
```

```
import torch
torch.__version__
```

```
    '2.1.0+cu121'
```

```
import supervision as sv
import transformers

# supervision.__version__ , transformers.__version__
```

```
import pytorch_lightning
print(pytorch_lightning.__version__)
```

```
    2.1.3
```

Create COCO data loaders

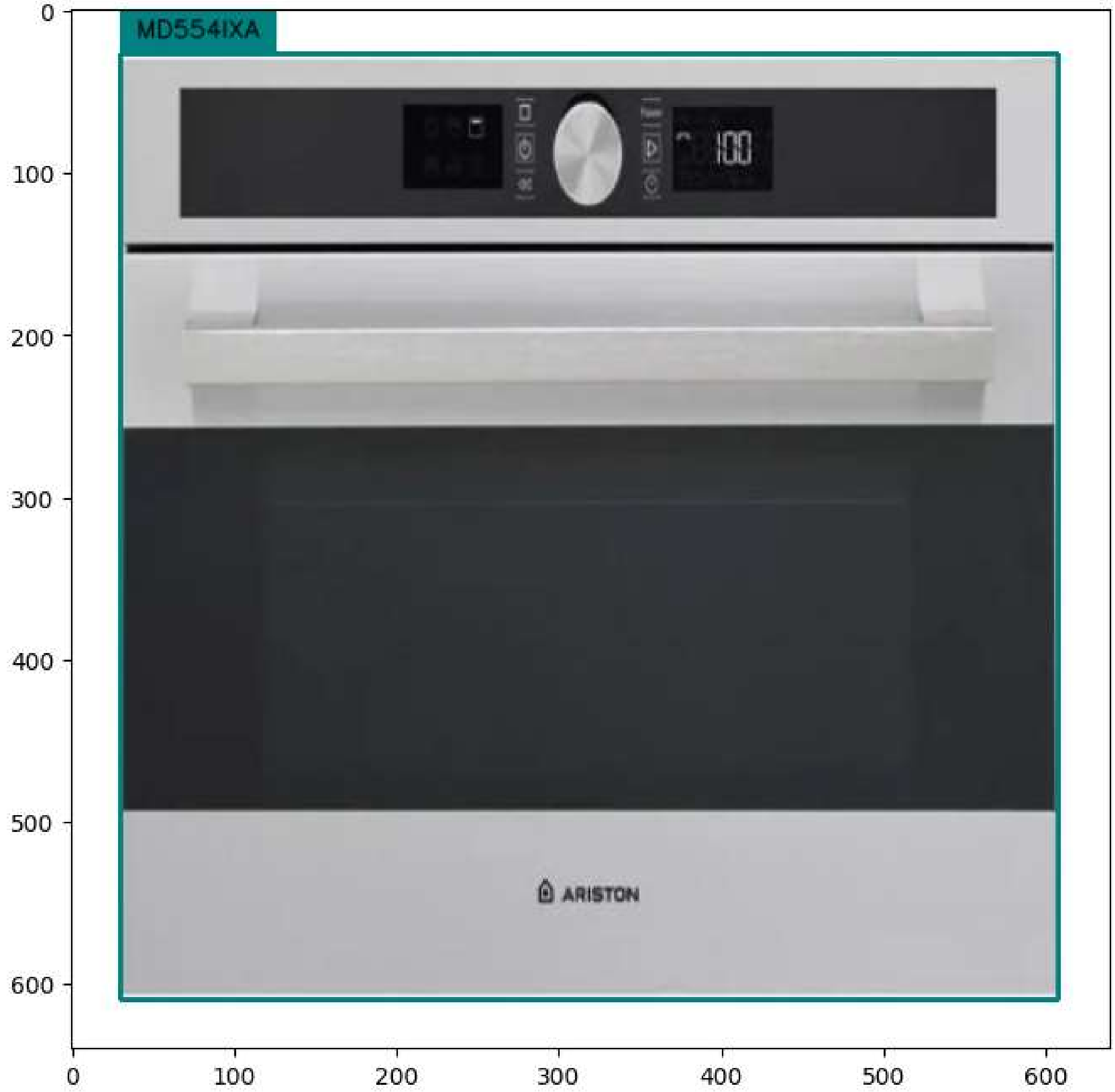
```
import os
import torch
import torchvision.transforms as T
import torchvision

dataset = '/content/drive/MyDrive/Detect'

ANNOTATION_FILE_NAME = "annotations.json"
TRAIN_DIRECTORY = os.path.join(dataset, "train")
VAL_DIRECTORY = os.path.join(dataset, "valid")
TEST_DIRECTORY = os.path.join(dataset, "test")

# Instantiate the image processor
from transformers import DetrImageProcessor
image_processor = DetrImageProcessor.from_pretrained("facebook/detr-resnet-50")

class CocoDetection(torchvision.datasets.CocoDetection):
    def __init__(
        self,
        image_directory_path: str,
        image_processor,
        train: bool = True
    ):
        annotation_file_path = os.path.join(image_directory_path, ANNOTATION_FILE_NAME)
        if not os.path.exists(annotation_file_path):
            raise FileNotFoundError(f"Annotation file not found: {annotation_file_path}")

        super(CocoDetection, self).__init__(image_directory_path, annotation_file_path)
        self.image_processor = image_processor

    def __getitem__(self, idx):
        images, annotations = super(CocoDetection, self).__getitem__(idx)
        image_id = self.ids[idx]
        annotations = {'image_id': image_id, 'annotations': annotations}
        encoding = self.image_processor(images=images, annotations=annotations, return_tensors="pt")
        pixel_values = encoding["pixel_values"].squeeze()
        target = encoding["labels"][0]

        return pixel_values, target

# Now you can use the image_processor
try:
    TRAIN_DATASET = CocoDetection(image_directory_path=TRAIN_DIRECTORY, image_processor=image_processor, train=True)
    VAL_DATASET = CocoDetection(image_directory_path=VAL_DIRECTORY, image_processor=image_processor, train=False)
```

```
        TEST_DATASET = CocoDetection(image_directory_path=TEST_DIRECTORY, image_processor=image_processor, train=False)

        print("Number of training examples:", len(TRAIN_DATASET))
        print("Number of validation examples:", len(VAL_DATASET))
        print("Number of test examples:", len(TEST_DATASET))

    except FileNotFoundError as e:
        print(f"Error: {e}")
    except Exception as e:
        print(f"An unexpected error occurred: {e}")
```

```
/usr/local/lib/python3.10/dist-packages/huggingface_hub/utils/_token.py:88: UserWarning:
The secret `HF_TOKEN` does not exist in your Colab secrets.
To authenticate with the Hugging Face Hub, create a token in your settings tab (https://huggingface.co/settings/tokens
You will be able to reuse this secret in all of your notebooks.
Please note that authentication is recommended but still optional to access public models or datasets.
  warnings.warn(
preprocessor_config.json: 100%                                    274/274 [00:00<00:00, 17.4kB/s]
The `max_size` parameter is deprecated and will be removed in v4.26. Please specify in `size['longest_edge'] instead`.
loading annotations into memory...
Done (t=0.66s)
creating index...
index created!
loading annotations into memory...
Done (t=0.39s)
creating index...
index created!
loading annotations into memory...
Done (t=0.63s)
creating index...
index created!
Number of training examples: 267
Number of validation examples: 10
Number of test examples: 5
```

```
# Visualize if dataset is loaded properly

import random
import cv2
import numpy as np


# select random image
image_ids = TRAIN_DATASET.coco.getImgIds()
image_id = random.choice(image_ids)
print('Image #{}'.format(image_id))

# load image and annotatons
image = TRAIN_DATASET.coco.loadImgs(image_id)[0]
annotations = TRAIN_DATASET.coco.imgToAnns[image_id]
image_path = os.path.join(TRAIN_DATASET.root, image['file_name'])
image = cv2.imread(image_path)

# annotate
detections = sv.Detections.from_coco_annotations(coco_annotation=annotations)

# we will use id2label function for training
categories = TRAIN_DATASET.coco.cats
id2label = {k: v['name'] for k,v in categories.items()}

labels = [
    f"{id2label[class_id]}"
    for _, _, class_id, _
    in detections
]

box_annotator = sv.BoxAnnotator()
frame = box_annotator.annotate(scene=image, detections=detections, labels=labels)

%matplotlib inline
sv.show_frame_in_notebook(image, (8, 8))
```

```
Image #186
```


MD554IXA
ARISTON
100
0
100
200
300
400
500
600
0
100
200
300
400
500
600

```
from torch.utils.data import DataLoader

def collate_fn(batch):
    pixel_values = [item[0] for item in batch]
    encoding = image_processor.pad(pixel_values, return_tensors="pt")
    labels = [item[1] for item in batch]
    return {
        'pixel_values': encoding['pixel_values'],
        'pixel_mask': encoding['pixel_mask'],
        'labels': labels
    }

TRAIN_DATALOADER = DataLoader(dataset=TRAIN_DATASET, collate_fn=collate_fn, batch_size=4, shuffle=True)
VAL_DATALOADER = DataLoader(dataset=VAL_DATASET, collate_fn=collate_fn, batch_size=4)
TEST_DATALOADER = DataLoader(dataset=TEST_DATASET, collate_fn=collate_fn, batch_size=4)
```

Train model with PyTorch Lightning

The DETR model is loaded using the Hugging Face Transformers library

```
import pytorch_lightning as pl
from transformers import DetrForObjectDetection
import torch


class Detr(pl.LightningModule):

    def __init__(self, lr, lr_backbone, weight_decay):
        super().__init__()
        self.model = DetrForObjectDetection.from_pretrained(
            pretrained_model_name_or_path="facebook/detr-resnet-50",
            revision="no_timm",
            num_labels=len(id2label),
            ignore_mismatched_sizes=True
        )

        self.lr = lr
        self.lr_backbone = lr_backbone
        self.weight_decay = weight_decay

    def forward(self, pixel_values, pixel_mask):
        return self.model(pixel_values=pixel_values, pixel_mask=pixel_mask)

    def common_step(self, batch, batch_idx):
        pixel_values = batch["pixel_values"]
        pixel_mask = batch["pixel_mask"]
        labels = [{k: v.to(self.device) for k, v in t.items()} for t in batch["labels"]]

        outputs = self.model(pixel_values=pixel_values, pixel_mask=pixel_mask, labels=labels)

        loss = outputs.loss
        loss_dict = outputs.loss_dict

        return loss, loss_dict

    def training_step(self, batch, batch_idx):
        loss, loss_dict = self.common_step(batch, batch_idx)
        # logs metrics for each training_step, and the average across the epoch
        self.log("training_loss", loss)
        for k,v in loss_dict.items():
            self.log("train_" + k, v.item())

        return loss
    def validation_step(self, batch, batch_idx):
        loss, loss_dict = self.common_step(batch, batch_idx)
        self.log("validation/loss", loss)
        for k, v in loss_dict.items():
            self.log("validation_" + k, v.item())

        return loss

    def configure_optimizers(self):
        # DETR authors decided to use different learning rate for backbone
        # you can learn more about it here:
        # - https://github.com/facebookresearch/detr/blob/3af9fa878e73b6894ce3596450a8d9b89d918ca9/main.py#L22-L23
        # - https://github.com/facebookresearch/detr/blob/3af9fa878e73b6894ce3596450a8d9b89d918ca9/main.py#L131-L139
        param_dicts = [
            {
                "params": [p for n, p in self.named_parameters() if "backbone" not in n and p.requires_grad]},
            {
                "params": [p for n, p in self.named_parameters() if "backbone" in n and p.requires_grad],
                "lr": self.lr_backbone,
            },
        ]
        return torch.optim.AdamW(param_dicts, lr=self.lr, weight_decay=self.weight_decay)

    def train_dataloader(self):
        return TRAIN_DATALOADER

    def val_dataloader(self):
        return VAL_DATALOADER


model = Detr(lr=1e-4, lr_backbone=1e-5, weight_decay=1e-4)

batch = next(iter(TRAIN_DATALOADER))
outputs = model(pixel_values=batch['pixel_values'], pixel_mask=batch['pixel_mask'])
```

```
Some weights of DetrForObjectDetection were not initialized from the model checkpoint at facebook/detr-resnet-50 and are newly initializ
- class_labels_classifier.weight: found shape torch.Size([92, 256]) in the checkpoint and torch.Size([101, 256]) in the model instantiat
- class_labels_classifier.bias: found shape torch.Size([92]) in the checkpoint and torch.Size([101]) in the model instantiated
You should probably TRAIN this model on a down-stream task to be able to use it for predictions and inference.
```

MAX_EPOCHS: 250

```
from pytorch_lightning import Trainer

# settings
MAX_EPOCHS = "250" # @param [2, 5,10,15,50,75,100,150,200,250,300]

trainer = Trainer(devices=1, accelerator="gpu", max_epochs=int(MAX_EP(

trainer.fit(model)
```

```
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda), used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, using: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, using: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, using: 0 HPUs
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_DEVICES: [0]
INFO:pytorch_lightning.callbacks.model_summary:
  | Name  | Type                   | Params
-------------------------------------------------
0 | model | DetrForObjectDetection | 41.5 M
-------------------------------------------------
18.1 M    Trainable params
23.5 M    Non-trainable params
41.5 M    Total params
166.108   Total estimated model params size (MB)
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/connectors/data_connector.py:441: The 'val_dataloade
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/utilities/data.py:77: Trying to infer the `batch_size` from
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/connectors/data_connector.py:441: The 'train_dataloa
Epoch 249: 100%                                              67/67 [00:35<00:00, 1.91it/s, v_num=1]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/utilities/data.py:77: Trying to infer the `batch_size` from
INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max_epochs=250` reached.
```

Save and load model

```
MODEL_PATH = '/content/drive/MyDrive/Detect/custom-model'
model.model.save_pretrained(MODEL_PATH)
```

Inference on test dataset

Let's visualize the predictions of DETR on the first image of the validation set.

```
import random
import cv2
import numpy as np
import matplotlib.pyplot as plt
from transformers import DetrForObjectDetection
import torch
import supervision as sv
import transformers

# loading model
model = DetrForObjectDetection.from_pretrained("/content/drive/MyDrive/Detect/custom-model")
# model.to(DEVICE)

# utils
categories = TEST_DATASET.coco.cats
id2label = {k: v['name'] for k,v in categories.items()}
box_annotator = sv.BoxAnnotator()

# select random image
image_ids = TEST_DATASET.coco.getImgIds()
image_id = random.choice(image_ids)
print('Image #{}'.format(image_id))

# load image and annotatons
image = TEST_DATASET.coco.loadImgs(image_id)[0]
annotations = TEST_DATASET.coco.imgToAnns[image_id]
image_path = os.path.join(TEST_DATASET.root, image['file_name'])
image = cv2.imread(image_path)

# Annotate ground truth
detections = sv.Detections.from_coco_annotations(coco_annotation=annotations)
labels = [f"{id2label[class_id]}" for _, _, class_id, _ in detections]
frame_ground_truth = box_annotator.annotate(scene=image.copy(), detections=detections, labels=labels)




# Annotate detections
with torch.no_grad():

    # load image and predict
    inputs = image_processor(images=image, return_tensors='pt')
    outputs = model(**inputs)

    # post-process
    target_sizes = torch.tensor([image.shape[:2]])
    results = image_processor.post_process_object_detection(
        outputs=outputs,
        threshold=0.20,
        target_sizes=target_sizes
    )[0]


    detections = sv.Detections.from_transformers(transformers_results=results)
    labels = [f"{id2label[class_id]} {confidence:.2f}" for _, confidence, class_id, _ in detections]
    frame_detections = box_annotator.annotate(scene=image.copy(), detections=detections, labels=labels)


# %matplotlib inline # Remove this line, we won't use it anymore

# Combine both images side by side and display
fig, axs = plt.subplots(1, 2, figsize=(20, 10))
axs[0].imshow(cv2.cvtColor(frame_ground_truth, cv2.COLOR_BGR2RGB))
axs[0].axis('off')
axs[0].set_title('Ground Truth')
```