

DETR - Detection Transformer

Reference: [https://github.com/NielsRogge/Transformers-Tutorials/blob/master/DETR/Fine_tuning_DetrForObjectDetection_on_custom_dataset_\(balloon\).ipynb](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: pip in /usr/local/lib/python3.10/dist-
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  Downloading pip-23.3.2-py3-none-any.whl (2.1 MB)
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    Successfully uninstalled pip-23.1.2
Successfully installed pip-23.3.2
Collecting supervision==0.3.0
  Downloading supervision-0.3.0-py3-none-any.whl (21 kB)
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Requirement already satisfied: opencv-python in
/usr/local/lib/python3.10/dist-packages (from supervision==0.3.0)
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>supervision==0.3.0) (2.8.2)
Requirement already satisfied: six>=1.5 in
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>matplotlib>supervision==0.3.0) (1.16.0)
Installing collected packages: supervision
Successfully installed supervision-0.3.0
WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
Requirement already satisfied: transformers in
/usr/local/lib/python3.10/dist-packages (4.35.2)
Requirement already satisfied: filelock in
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Requirement already satisfied: packaging<=20.0 in
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Requirement already satisfied: regex!=2019.12.17 in
/usr/local/lib/python3.10/dist-packages (from transformers) (2023.6.3)
Requirement already satisfied: requests in
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Requirement already satisfied: tokenizers<0.19,>=0.14 in
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Requirement already satisfied: safetensors<=0.3.1 in
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WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
<https://pip.pypa.io/warnings/venv>
Collecting pytorch-lightning
 Downloading pytorch_lightning-2.1.3-py3-none-any.whl.metadata (21
kB)
Requirement already satisfied: numpy<=1.17.2 in
/usr/local/lib/python3.10/dist-packages (from pytorch-lightning)
(1.23.5)
Requirement already satisfied: torch<=1.12.0 in
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(2.1.0+cu121)
Requirement already satisfied: tqdm<=4.57.0 in
/usr/local/lib/python3.10/dist-packages (from pytorch-lightning)
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Requirement already satisfied: networkx in
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Requirement already satisfied: multidict<7.0,>=4.5 in
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Requirement already satisfied: yarl<2.0,>=1.0 in
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Requirement already satisfied: frozenlist>=1.1.1 in
/usr/local/lib/python3.10/dist-packages (from aiohttp!=4.0.0a0,!
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Requirement already satisfied: async-timeout<5.0,>=4.0 in
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Requirement already satisfied: MarkupSafe>=2.0 in
/usr/local/lib/python3.10/dist-packages (from jinja2->torch>=1.12.0-
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2.1.3 torchmetrics-1.3.0
WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
Collecting timm
  Downloading timm-0.9.12-py3-none-any.whl.metadata (60 kB)
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Requirement already satisfied: pyyaml in

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/usr/local/lib/python3.10/dist-packages (from requests->huggingface-
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/usr/local/lib/python3.10/dist-packages (from sympy->torch>=1.7->timm)
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m
Successfully installed timm-0.9.12
WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
Requirement already satisfied: cython in
/usr/local/lib/python3.10/dist-packages (3.0.7)
WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
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/usr/local/lib/python3.10/dist-packages (2.0.7)
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/usr/local/lib/python3.10/dist-packages (from matplotlib>=2.1.0-
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Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.10/dist-packages (from matplotlib>=2.1.0-
>pycocotools) (4.47.0)
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>pycocotools) (1.4.5)
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/usr/local/lib/python3.10/dist-packages (from matplotlib>=2.1.0-
>pycocotools) (23.2)
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/usr/local/lib/python3.10/dist-packages (from matplotlib>=2.1.0-
>pycocotools) (2.8.2)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7-
>matplotlib>=2.1.0->pycocotools) (1.16.0)
WARNING: Running pip as the 'root' user can result in broken
permissions and conflicting behaviour with the system package manager.
It is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv
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 is recommended to use a virtual environment instead:
https://pip.pypa.io/warnings/venv

!pip --version

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

import torch
torch.__version__

{"type": "string"}

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), set it as
secret in your Google Colab and restart your session.
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(

{"model_id": "4b25c6effa7d4083bc241c15556af414", "version_major": 2, "vers
ion_minor": 0}

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 annotations
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

```



```
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 initialized because the shapes did not match:

- class_labels_classifier.weight: found shape torch.Size([92, 256]) in the checkpoint and torch.Size([101, 256]) in the model instantiated
- 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.

```
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_EPOCHS), gradient_clip_val=0.1,
accumulate_grad_batches=6, log_every_n_steps=5)
```

```
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)
```

```
{"model_id": "28bbc0af7a414154a8f70db74915529f", "version_major": 2, "version_minor": 0}
```

```
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/
connectors/data_connector.py:441: The 'val_data_loader' does not have
many workers which may be a bottleneck. Consider increasing the value
of the `num_workers` argument` to `num_workers=1` in the `DataLoader`
```

to improve performance.
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/utilities/data.py:77: Trying to infer the `batch_size` from an ambiguous collection. The batch size we found is 4. To avoid any miscalculations, use `self.log(..., batch_size=batch_size)`.
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/connectors/data_connector.py:441: The 'train_dataloader' does not have many workers which may be a bottleneck. Consider increasing the value of the `num_workers` argument` to `num_workers=1` in the `DataLoader` to improve performance.

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{"model_id": "9d7d079d70ae4f9d8f044d20fe7124d4", "version_major": 2, "version_minor": 0}
```

```
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```

/usr/local/lib/python3.10/dist-packages/pytorch_lightning/utilities/data.py:77: Trying to infer the `batch_size` from an ambiguous collection. The batch size we found is 2. To avoid any miscalculations, use `self.log(..., batch_size=batch_size)`.

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```

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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 annotations
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')

axs[1].imshow(cv2.cvtColor(frame_detections, cv2.COLOR_BGR2RGB))
axs[1].axis('off')
axs[1].set_title('Detections')

plt.show()
```

Image #2

Ground Truth



Detections

