In [1]:
```
import os
os.environ["KERAS_BACKEND"] = "jax"
```

In [2]:
```
import keras
import keras_hub
import os, shutil, pathlib

images_path ="coco_dataset/datasets/coco/"
annotations_path="coco_dataset/datasets/annotations/annotations/"

# Create the folder if it doesn't exist
#os.makedirs(new_dir, exist_ok=True)

#images_path = keras.utils.get_file(
#    "coco",
#    "http://images.cocodataset.org/zips/train2017.zip",
#    extract=True,
#    cache_dir=new_dir
#)
#annotations_path = keras.utils.get_file(
#    "annotations",
#    "http://images.cocodataset.org/annotations/annotations_trainval2017.zip",
#    extract=True,
#    cache_dir=new_dir
#)
```

In [3]:
```
import json

with open(f"{annotations_path}instances_train2017.json", "r") as f:
    annotations = json.load(f)

images = {image["id"]: image for image in annotations["images"]}
```

In [4]:
```
def scale_box(box, width, height):
    scale = 1.0 / max(width, height)
    x, y, w, h = [v * scale for v in box]
    x += (height - width) * scale / 2 if height > width else 0
    y += (width - height) * scale / 2 if width > height else 0
    return [x, y, w, h]

metadata = {}
for annotation in annotations["annotations"]:
    id = annotation["image_id"]
    if id not in metadata:
        metadata[id] = {"boxes": [], "labels": []}
    image = images[id]
    box = scale_box(annotation["bbox"], image["width"], image["height"])
    metadata[id]["boxes"].append(box)
    metadata[id]["labels"].append(annotation["category_id"])
    metadata[id]["path"] = images_path + "train2017/" + image["file_name"]
metadata = list(metadata.values())
```

In [5]:
```
len(metadata)
```

Out[5]:
```
117266
```

In [6]:
```
min([len(x["boxes"]) for x in metadata])
```

Out[6]:
```
1
```

In [7]:
```
max([len(x["boxes"]) for x in metadata])
```

Out[7]:
```
93
```

In [8]:
```
max(max(x["labels"]) for x in metadata) + 1
```

Out[8]:
```
91
```

In [9]:
```
metadata[433]
```

Out[9]:
```
{'boxes': [[0.00322, 0.12796, 0.69678, 0.55484],
  [0.33708, 0.34887999999999997, 0.46180000000000004, 0.51742]],
 'labels': [17, 70],
 'path': 'coco_dataset/datasets/coco/train2017/000000241876.jpg'}
```

In [10]:
```
[keras_hub.utils.coco_id_to_name(x) for x in metadata[433]["labels"]]
```

Out[10]:
```
['cat', 'toilet']
```

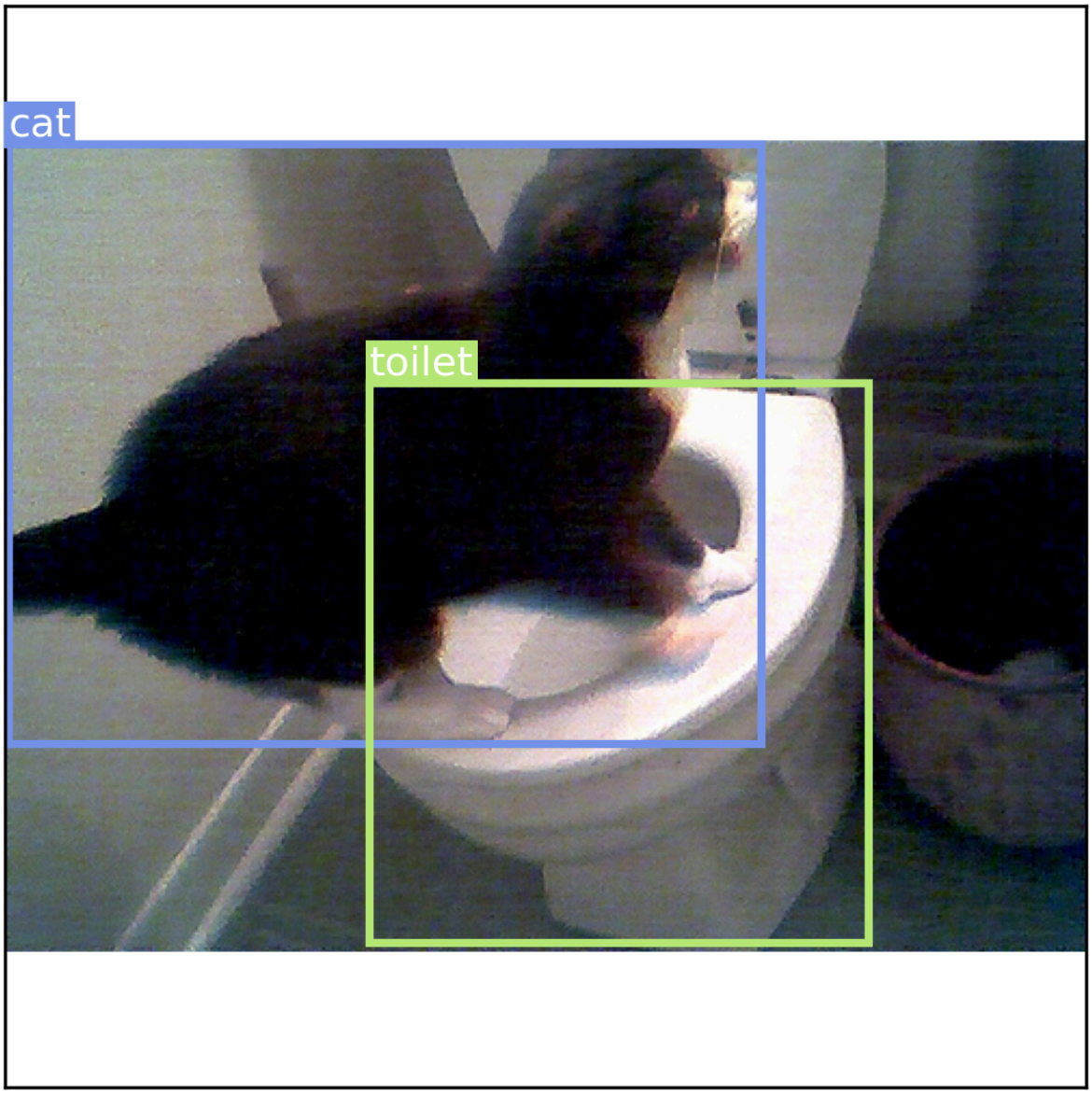
In [11]:
```
keras_hub.utils.coco_id_to_name(0)
```

Out[11]:
```
'unlabeled'
```

In [12]:
```
import matplotlib.pyplot as plt
from matplotlib.colors import hsv_to_rgb
from matplotlib.patches import Rectangle

color_map = {0: "gray"}

def label_to_color(label):
    if label not in color_map:
        h, s, v = (len(color_map) * 0.618) % 1, 0.5, 0.9
        color_map[label] = hsv_to_rgb((h, s, v))
    return color_map[label]

def draw_box(ax, box, text, color):
    x, y, w, h = box
    ax.add_patch(Rectangle((x, y), w, h, lw=2, ec=color, fc="none"))
    textbox = dict(fc=color, pad=1, ec="none")
    ax.text(x, y, text, c="white", size=10, va="bottom", bbox=textbox)

def draw_image(ax, image):
    ax.set(xlim=(0, 1), ylim=(1, 0), xticks=[], yticks=[], aspect="equal")
    image = plt.imread(image)
    height, width = image.shape[:2]
    hpad = (1 - height / width) / 2 if width > height else 0
    wpad = (1 - width / height) / 2 if height > width else 0
```

```
    extent = [wpad, 1 - wpad, 1 - hpad, hpad]
    ax.imshow(image, extent=extent)
```

In [13]:
```
sample = metadata[433]
ig, ax = plt.subplots(dpi=300)
draw_image(ax, sample["path"])
for box, label in zip(sample["boxes"], sample["labels"]):
    label_name = keras_hub.utils.coco_id_to_name(label)
    draw_box(ax, box, label_name, label_to_color(label))
plt.show()
```



In [15]:
```
import random

metadata = list(filter(lambda x: len(x["boxes"]) <= 4, metadata))
random.shuffle(metadata)
```

In [16]:
```
image_size = 448

backbone = keras_hub.models.Backbone.from_preset(
```

```
    "resnet_50_imagenet",
)
preprocessor = keras_hub.layers.ImageConverter.from_preset(
    "resnet_50_imagenet",
    image_size=(image_size, image_size),
)
```

```
Downloading from https://www.kaggle.com/api/v1/models/keras/resnetv1/keras/resnet_50
_imagenet/3/download/config.json...
100%|██████████| 841/841 [00:00<00:00, 1.32MB/s]
Downloading from https://www.kaggle.com/api/v1/models/keras/resnetv1/keras/resnet_50
_imagenet/3/download/model.weights.h5...
100%|██████████| 90.3M/90.3M [00:03<00:00, 29.7MB/s]
Downloading from https://www.kaggle.com/api/v1/models/keras/resnetv1/keras/resnet_50
_imagenet/3/download/image_converter.json...
100%|██████████| 873/873 [00:00<00:00, 1.61MB/s]
```

In [17]:
```
from keras import layers

grid_size = 6
num_labels = 91

inputs = keras.Input(shape=(image_size, image_size, 3))
x = backbone(inputs)
x = layers.Conv2D(512, (3, 3), strides=(2, 2))(x)
x = keras.layers.Flatten()(x)
x = layers.Dense(2048, activation="relu", kernel_initializer="glorot_normal")(x)
x = layers.Dropout(0.5)(x)
x = layers.Dense(grid_size * grid_size * (num_labels + 5))(x)
x = layers.Reshape((grid_size, grid_size, num_labels + 5))(x)
box_predictions = x[..., :5]
class_predictions = layers.Activation("softmax")(x[..., 5:])
outputs = {"box": box_predictions, "class": class_predictions}
model = keras.Model(inputs, outputs)
```

In [18]:
```
model.summary()
```

Model: "functional"

Layer (type)	Output Shape	Param #	Connected to
input_layer_1 (InputLayer)	(None, 448, 448, 3)	0	-
res_net_backbone (ResNetBackbone)	(None, 14, 14, 2048)	23,561,152	input_layer_1[0]…
conv2d (Conv2D)	(None, 6, 6, 512)	9,437,696	res_net_backbone…
flatten (Flatten)	(None, 18432)	0	conv2d[0][0]
dense (Dense)	(None, 2048)	37,750,784	flatten[0][0]
dropout (Dropout)	(None, 2048)	0	dense[0][0]
dense_1 (Dense)	(None, 3456)	7,081,344	dropout[0][0]
reshape (Reshape)	(None, 6, 6, 96)	0	dense_1[0][0]
get_item_1 (GetItem)	(None, 6, 6, 91)	0	reshape[0][0]
get_item (GetItem)	(None, 6, 6, 5)	0	reshape[0][0]
activation (Activation)	(None, 6, 6, 91)	0	get_item_1[0][0]

Total params: 77,830,976 (296.90 MB)

Trainable params: 77,777,856 (296.70 MB)

Non-trainable params: 53,120 (207.50 KB)

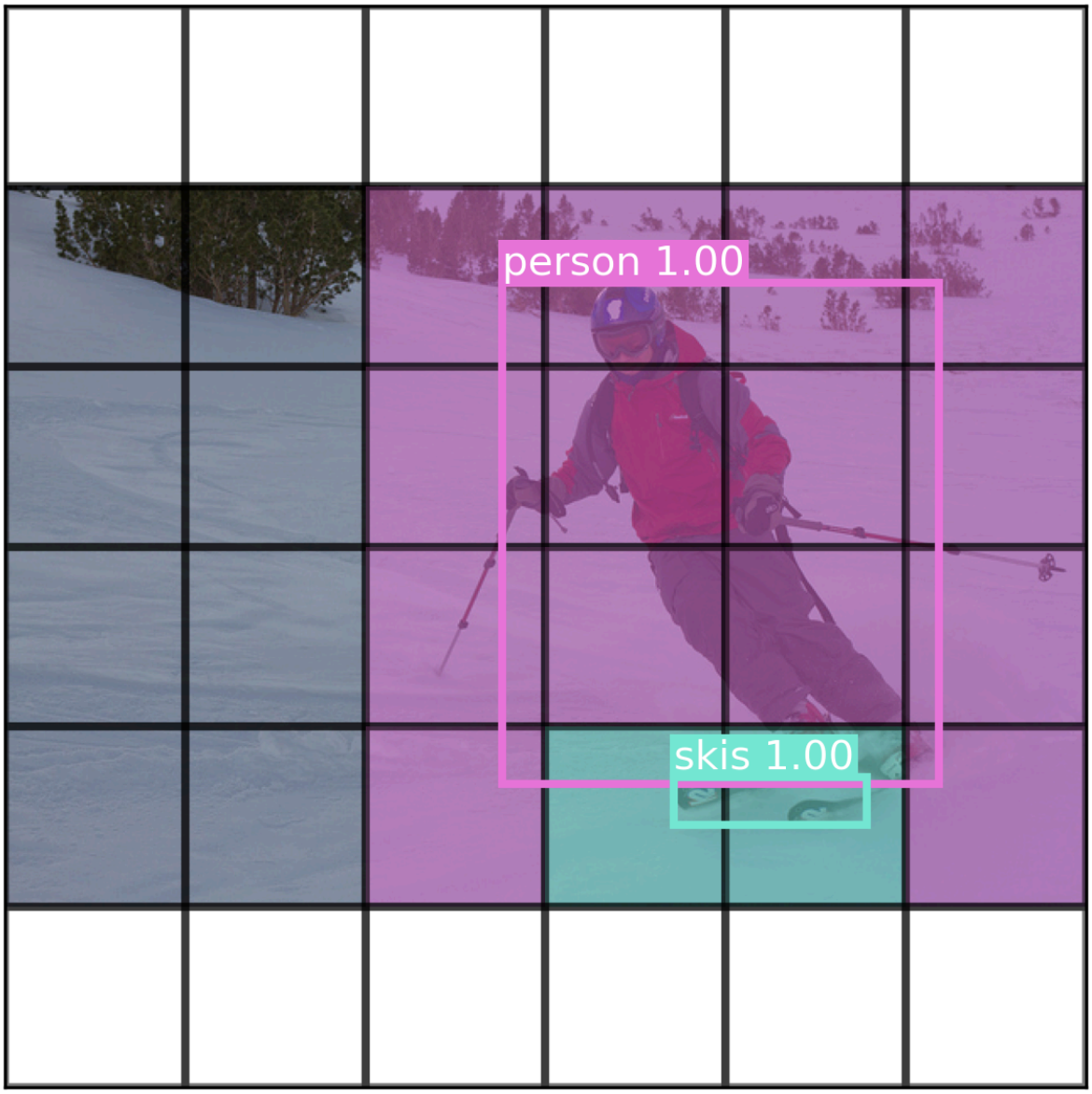
In [19]:
```
def to_grid(box):
    x, y, w, h = box
    cx, cy = (x + w / 2) * grid_size, (y + h / 2) * grid_size
    ix, iy = int(cx), int(cy)
    return (ix, iy), (cx - ix, cy - iy, w, h)

def from_grid(loc, box):
    (xi, yi), (x, y, w, h) = loc, box
    x = (xi + x) / grid_size - w / 2
    y = (yi + y) / grid_size - h / 2
    return (x, y, w, h)
```

In [20]:
```
import numpy as np
import math

class_array = np.zeros((len(metadata), grid_size, grid_size))
box_array = np.zeros((len(metadata), grid_size, grid_size, 5))

for index, sample in enumerate(metadata):
    boxes, labels = sample["boxes"], sample["labels"]
    for box, label in zip(boxes, labels):
```

```
        (x, y, w, h) = box
        left, right = math.floor(x * grid_size), math.ceil((x + w) * grid_size)
        bottom, top = math.floor(y * grid_size), math.ceil((y + h) * grid_size)
        class_array[index, bottom:top, left:right] = label

for index, sample in enumerate(metadata):
    boxes, labels = sample["boxes"], sample["labels"]
    for box, label in zip(boxes, labels):
        (xi, yi), (grid_box) = to_grid(box)
        box_array[index, yi, xi] = [*grid_box, 1.0]
        class_array[index, yi, xi] = label
```

In [21]:

```
def draw_prediction(image, boxes, classes, cutoff=None):
    fig, ax = plt.subplots(dpi=300)
    draw_image(ax, image)
    for yi, row in enumerate(classes):
        for xi, label in enumerate(row):
            color = label_to_color(label) if label else "none"
            x, y, w, h = (v / grid_size for v in (xi, yi, 1.0, 1.0))
            r = Rectangle((x, y), w, h, lw=2, ec="black", fc=color, alpha=0.5)
            ax.add_patch(r)
    for yi, row in enumerate(boxes):
        for xi, box in enumerate(row):
            box, confidence = box[:4], box[4]
            if not cutoff or confidence >= cutoff:
                box = from_grid((xi, yi), box)
                label = classes[yi, xi]
                color = label_to_color(label)
                name = keras_hub.utils.coco_id_to_name(label)
                draw_box(ax, box, f"{name} {max(confidence, 0):.2f}", color)
    plt.show()

draw_prediction(metadata[0]["path"], box_array[0], class_array[0], cutoff=1.0)
```



In [22]:
```python
import tensorflow as tf

def load_image(path):
    x = tf.io.read_file(path)
    x = tf.image.decode_jpeg(x, channels=3)
    return preprocessor(x)

images = tf.data.Dataset.from_tensor_slices([x["path"] for x in metadata])
images = images.map(load_image, num_parallel_calls=8)
labels = {"box": box_array, "class": class_array}
labels = tf.data.Dataset.from_tensor_slices(labels)

dataset = tf.data.Dataset.zip(images, labels).batch(16).prefetch(2)
val_dataset, train_dataset = dataset.take(500), dataset.skip(500)
```

In [23]:
```python
from keras import ops

def unpack(box):
    return box[..., 0], box[..., 1], box[..., 2], box[..., 3]
```

```
def intersection(box1, box2):
    cx1, cy1, w1, h1 = unpack(box1)
    cx2, cy2, w2, h2 = unpack(box2)
    left = ops.maximum(cx1 - w1 / 2, cx2 - w2 / 2)
    bottom = ops.maximum(cy1 - h1 / 2, cy2 - h2 / 2)
    right = ops.minimum(cx1 + w1 / 2, cx2 + w2 / 2)
    top = ops.minimum(cy1 + h1 / 2, cy2 + h2 / 2)
    return ops.maximum(0.0, right - left) * ops.maximum(0.0, top - bottom)

def intersection_over_union(box1, box2):
    cx1, cy1, w1, h1 = unpack(box1)
    cx2, cy2, w2, h2 = unpack(box2)
    intersection_area = intersection(box1, box2)
    a1 = ops.maximum(w1, 0.0) * ops.maximum(h1, 0.0)
    a2 = ops.maximum(w2, 0.0) * ops.maximum(h2, 0.0)
    union_area = a1 + a2 - intersection_area
    return ops.divide_no_nan(intersection_area, union_area)
```

In [24]:

```
def signed_sqrt(x):
    return ops.sign(x) * ops.sqrt(ops.absolute(x) + keras.config.epsilon())

def box_loss(true, pred):
    xy_true, wh_true, conf_true = true[..., :2], true[..., 2:4], true[..., 4:]
    xy_pred, wh_pred, conf_pred = pred[..., :2], pred[..., 2:4], pred[..., 4:]
    no_object = conf_true == 0.0
    xy_error = ops.square(xy_true - xy_pred)
    wh_error = ops.square(signed_sqrt(wh_true) - signed_sqrt(wh_pred))
    iou = intersection_over_union(true, pred)
    conf_target = ops.where(no_object, 0.0, ops.expand_dims(iou, -1))
    conf_error = ops.square(conf_target - conf_pred)
    error = ops.concatenate(
        (
            ops.where(no_object, 0.0, xy_error * 5.0),
            ops.where(no_object, 0.0, wh_error * 5.0),
            ops.where(no_object, conf_error * 0.5, conf_error),
        ),
        axis=-1,
    )
    return ops.sum(error, axis=(1, 2, 3))
```

In [ ]:

```
model.compile(
    optimizer=keras.optimizers.Adam(2e-4),
    loss={"box": box_loss, "class": "sparse_categorical_crossentropy"},
)
model.fit(
    train_dataset,
    validation_data=val_dataset,
    epochs=4,
)
```

```
Epoch 1/4
3201/3201 ━━━━━━━━━━━━━━━━━━━━ 1095s 326ms/step - box_loss: 3.2123 - class_loss: 2.2
231 - loss: 5.4354 - val_box_loss: 2.1632 - val_class_loss: 1.8190 - val_loss: 3.982
2
Epoch 2/4
3201/3201 ━━━━━━━━━━━━━━━━━━━━ 976s 299ms/step - box_loss: 2.1935 - class_loss: 1.66
45 - loss: 3.8580 - val_box_loss: 2.5930 - val_class_loss: 1.4453 - val_loss: 4.0383
Epoch 3/4
3201/3201 ━━━━━━━━━━━━━━━━━━━━ 1027s 316ms/step - box_loss: 1.9224 - class_loss: 1.4
001 - loss: 3.3226 - val_box_loss: 2.0531 - val_class_loss: 1.2939 - val_loss: 3.347
1
Epoch 4/4
3201/3201 ━━━━━━━━━━━━━━━━━━━━ 1010s 311ms/step - box_loss: 1.6655 - class_loss: 1.2
281 - loss: 2.8936 - val_box_loss: 1.9786 - val_class_loss: 1.1641 - val_loss: 3.142
7
```

Out[ ]:
```
<keras.src.callbacks.history.History at 0x7f09a06d6270>
```

In [ ]:
```
# Save the trained model (Keras 3 format works with JAX backend)
model.save('trained_yolo_model.keras')

print("Model saved successfully! You can load it next time with:")
print("model = keras.models.load_model('trained_yolo_model.keras', custom_objects={
```

```
Model saved successfully! You can load it next time with:
model = keras.models.load_model('trained_yolo_model.keras', custom_objects={'box_los
s': box_loss})
```