Base Model

In [81]:

```
%load_ext autoreload
%autoreload 2
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

In [82]:

```
import os
import sys
from shutil import copyfile

import numpy as np
from PIL import Image
import matplotlib.pyplot as plt
import matplotlib.patches as patches
import torch
import torch.optim as optim
from torch.utils.data import TensorDataset, DataLoader
from torch_snippets import Report
import time
```

In [83]:

```
base_model_path = '../src/base-model/'

module_path = os.path.abspath(os.path.join('../src/base-model/'))
if module_path not in sys.path:
    sys.path.append(module_path)

import utils
import rcnn
```

In [84]:

```
## sample of 135 images
## resized by a factor of 4 from 2048x1024 to 512x256
imgs_path = '../sample-dataset/'
```

In [85]:

```
## load annotations of 135 images
anno_dict = np.load('../data/anno-big.npy', allow_pickle='TRUE').item()
imgs_person = list(anno_dict.keys())
len(imgs_person)
```

Out[85]:

```
135
```

In [86]:

```
## resize annotations by factor SCALE
SCALE = 4
res_anno_dict = {}
for img_name in imgs_person:
    res_bboxes = []
    for bbox in anno_dict[img_name]:
        res_bbox = bbox / SCALE
        res_bbox = res_bbox.astype('int32')
        res_bboxes.append(res_bbox)
    res_anno_dict[img_name] = res_bboxes
anno_dict = res_anno_dict # keep only the resized dict
```

In [87]:

```
## get simple regions
regions = utils.get_simple_regions(SCALE)
```

In [26]:

```
i = 0
img_name = imgs_person[i]
img_path = imgs_path + img_name
img = Image.open(img_path)
bboxes = anno_dict[img_name]
```

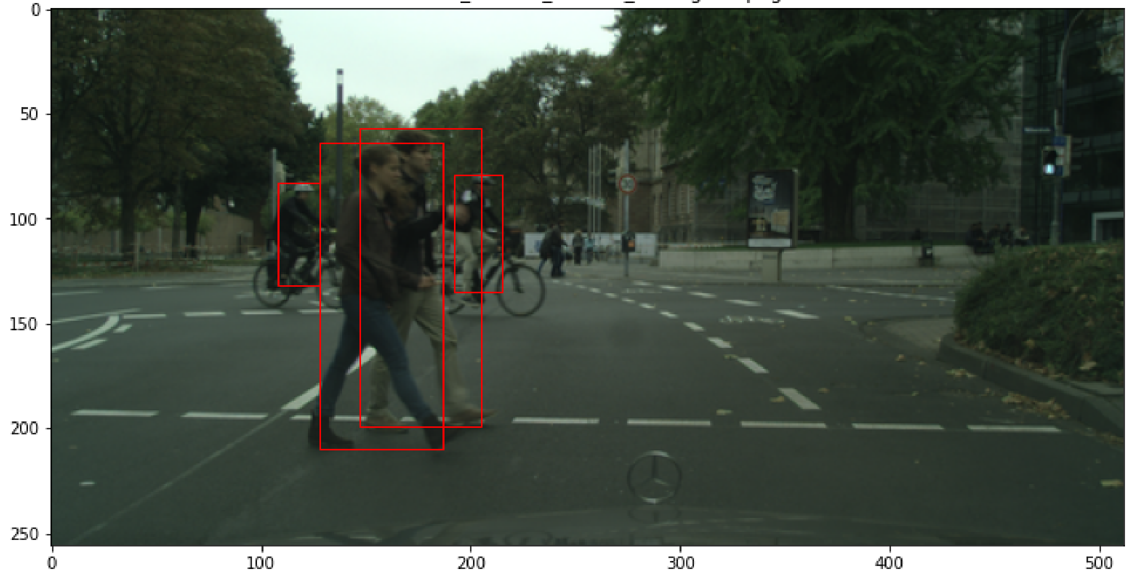
In [27]:

```
plt.rcParams['figure.figsize'] = [12, 8]
```

In [28]:

```
fig, ax = plt.subplots()
```

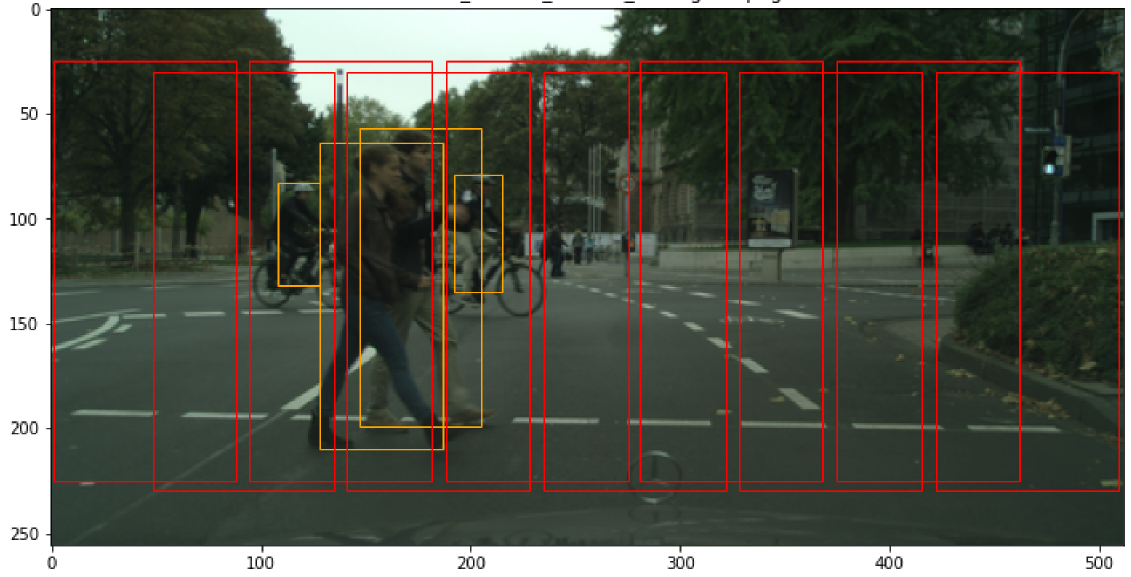
```
ax.imshow(img)

for bbox in bboxes:
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor='r', facecolor='none')

    ax.add_patch(rect)

plt.title(img_name)
plt.show()
```



aachen_000031_000019_leftImg8bit.png

In [29]:

```
fig, ax = plt.subplots()
ax.imshow(img)

for bbox in bboxes:
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor='orange', facecolor='none')
    ax.add_patch(rect)

for bbox in regions:
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor='red', facecolor='none')
    ax.add_patch(rect)

plt.title(img_name)
plt.show()
```



aachen_000031_000019_leftImg8bit.png

In [30]:

```
img_np = np.array(img)
H, W = img_np.shape[:2]
```

In [31]:

```
H,W
```

Out[31]:

```
(256, 512)
```

Prepare data

In [32]:

```
all_img_names, all_labels, all_diffs, all_rois, all_bboxes = utils.get_data(
    imgs_person, anno_dict, regions, W, H)
```

In [33]:

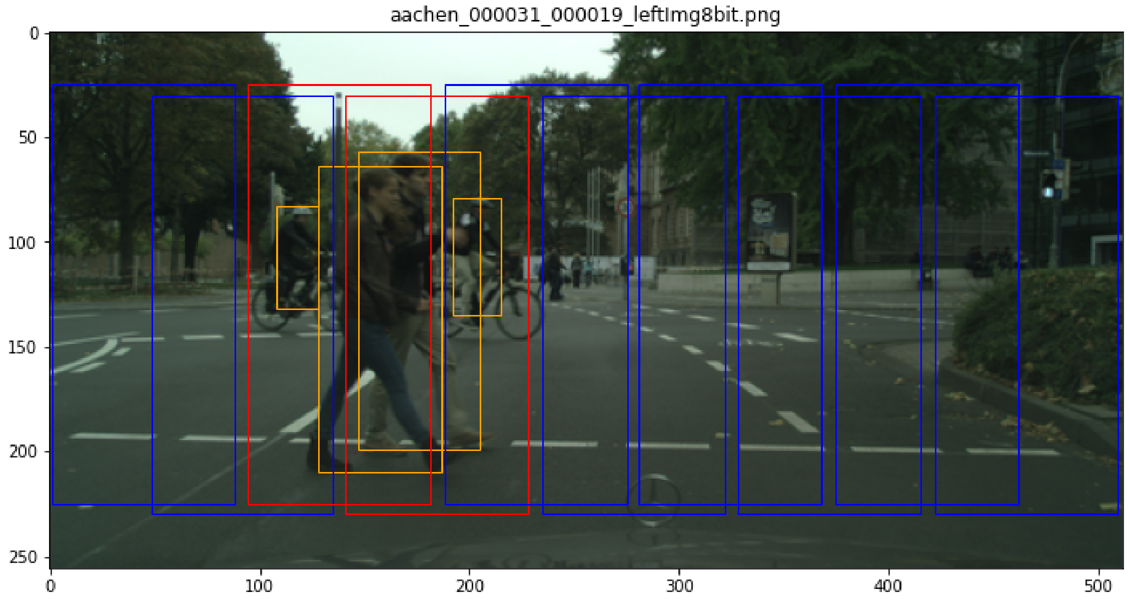
```
len(all_img_names), len(all_labels)
```

Out[33]:

```
(135, 135)
```

In [34]:

```
## check results
i = 0
img_name = all_img_names[i]
bboxes = all_bboxes[i]

img_path = imgs_path + img_name
img = Image.open(img_path)

fig, ax = plt.subplots()
ax.imshow(img)

labels = all_labels[i]
colors = ['b', 'r']

for i, bbox in enumerate(bboxes):
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor='orange', facecolor='none')
    ax.add_patch(rect)

for i, bbox in enumerate(regions):
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor=colors[labels[i]], facecolor='none')
    ax.add_patch(rect)

plt.title(img_name)
plt.show()
```

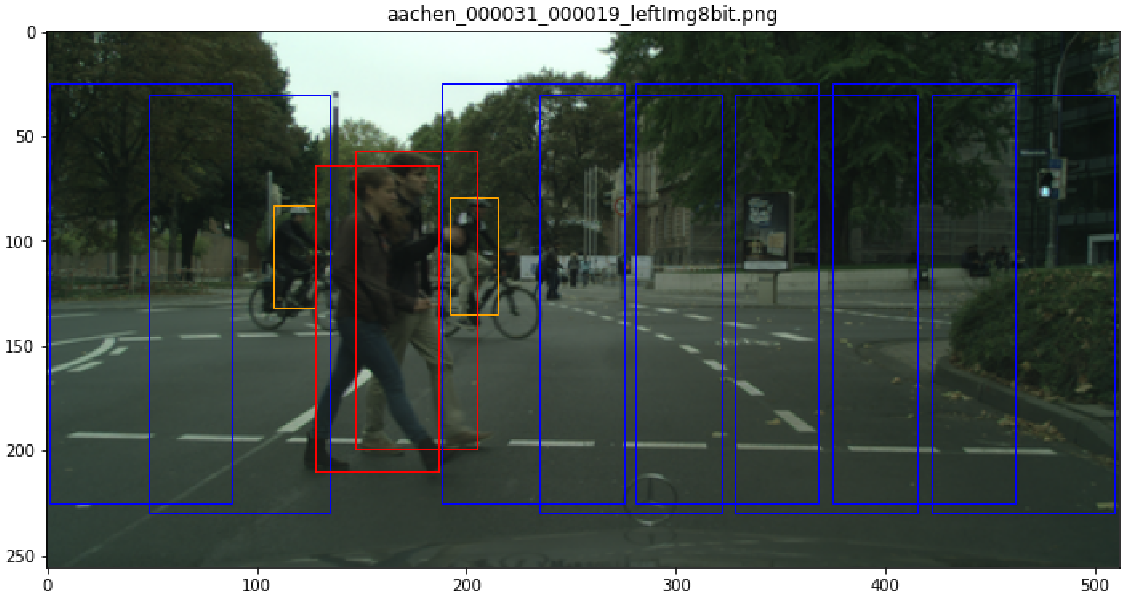


In [35]:

```
img_region = np.array([W, H, W, H]) # for scaling
diffs0 = all_diffs[0] * img_region
diffs0
```

Out[35]:
```
array([[-146.,  -32.,   29.,   58.],
       [ -60.,  -53.,   67.,  151.],
       [ -34.,  -39.,   28.,   54.],
       [  -6.,  -27.,   29.,   58.],
       [  41.,  -32.,   29.,   58.],
       [  88.,  -27.,   29.,   58.],
       [ 134.,  -32.,   29.,   58.],
       [ 181.,  -27.,   29.,   58.],
       [ 228.,  -32.,   29.,   58.],
       [ 275.,  -27.,   29.,   58.]])
```

In [36]:
```python
i = 0
img_name = all_img_names[i]
bboxes = all_bboxes[i]
img_path = imgs_path + img_name
img = Image.open(img_path)

fig, ax = plt.subplots()
ax.imshow(img);

labels = all_labels[i]
colors = ['b', 'r']

# bbox = [x, y, w, h]
for i, bbox in enumerate(bboxes):
    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor='orange', facecolor='none')
    ax.add_patch(rect)

for i, bbox in enumerate(regions):
    if labels[i] == 1:
        bbox = bbox - diffs0[i] # add the diffs

    rect = patches.Rectangle(
        (bbox[0], bbox[1]), bbox[2], bbox[3],
        linewidth=1, edgecolor=colors[labels[i]], facecolor='none')
    ax.add_patch(rect)

plt.title(img_name)
plt.show()
```



Prepare train and test sets

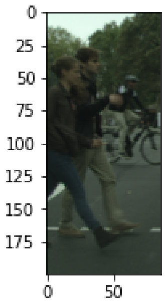
In [37]:
```python
img_paths = [(imgs_path + img_name) for img_name in all_img_names]
n_train = 8 * len(img_paths) // 10
n_train
```

Out[37]:
```
108
```

In [38]:
```python
## img_paths, rois, labels, diffs, bboxes
train_set = rcnn.Dataset(
    img_paths[:n_train], all_rois[:n_train], all_labels[:n_train],
    all_diffs[:n_train], all_bboxes[:n_train])

test_set = rcnn.Dataset(
    img_paths[n_train:], all_rois[n_train:], all_labels[n_train:],
    all_diffs[n_train:], all_bboxes[n_train:])
```

In [57]:

```
## check the results
image, crops, roi_bboxes, labels, diffs, bboxes, img_path = train_set[0]


plt.rcParams['figure.figsize'] = [5, 3]
fig, ax = plt.subplots()
ax.imshow(crops[3])
plt.show()

print(labels[3])
```



```
1
```

In [40]:

```
train_loader = DataLoader(
    train_set, batch_size=2, collate_fn=train_set.collate_fn, drop_last=True)
```

In [41]:

```
test_loader = DataLoader(
    test_set, batch_size=2, collate_fn=test_set.collate_fn, drop_last=True)
```

Define the backbone

In [42]:

```
backbone = utils.get_backbone()
```

In [43]:

```
device = 'cuda' if torch.cuda.is_available() else 'cpu'
device
```

Out[43]:

```
'cpu'
```

In [44]:

```
backbone.eval().to(device)
```

Out[44]:

```
VGG(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU(inplace=True)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU(inplace=True)
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU(inplace=True)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU(inplace=True)
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (11): ReLU(inplace=True)
    (12): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (13): ReLU(inplace=True)
    (14): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (15): ReLU(inplace=True)
    (16): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (17): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (18): ReLU(inplace=True)
    (19): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (20): ReLU(inplace=True)
    (21): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (22): ReLU(inplace=True)
```

```
      (23): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
      (24): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (25): ReLU(inplace=True)
      (26): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (27): ReLU(inplace=True)
      (28): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (29): ReLU(inplace=True)
      (30): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    )
    (avgpool): AdaptiveAvgPool2d(output_size=(7, 7))
    (classifier): Sequential()
  )
```

Train the model

In [45]:

```
model = rcnn.BaseModel(backbone).to(device)
criterion = model.calc_loss
optimizer = optim.SGD(model.parameters(), lr=1e-3)
```

In [46]:

```
n_epochs = 5

## log for plot training and validation metrics
log = Report(n_epochs)
tstart = time.time()
for epoch in range(n_epochs):

    _n = len(train_loader)
    for i, inputs in enumerate(train_loader):
        loss, loc_loss, regr_loss, accs = rcnn.train_batch(
            inputs, model, optimizer, criterion)
        pos = (epoch + (i + 1)/_n)
        log.record(pos,
                   trn_loss=loss.item(),
                   trn_loc_loss=loc_loss,
                   trn_regr_loss=regr_loss,
                   trn_acc=accs.mean(),
                   end='\r')

    _n = len(test_loader)
    for i, inputs in enumerate(test_loader):
        _clss, _diffs, loss, \
        loc_loss, regr_loss, accs = rcnn.validate_batch(
            inputs, model, criterion)
        pos = (epoch + (i + 1)/_n)
        log.record(
            pos,
            val_loss=loss.item(),
            val_loc_loss=loc_loss,
            val_regr_loss=regr_loss,
            val_acc=accs.mean(),
            end='\r')

tend = time.time()
```

```
EPOCH: 5.000    val_loss: 0.043 val_loc_loss: 0.043     val_regr_loss: 0.000    val_acc: 1.000  (79
7.54s - 0.00s remaining))))
```

Training took about 13.3 minutes on 8th Gen Intel i5 cpu (i5-9500T CPU @ 2.20GHz):

In [50]:

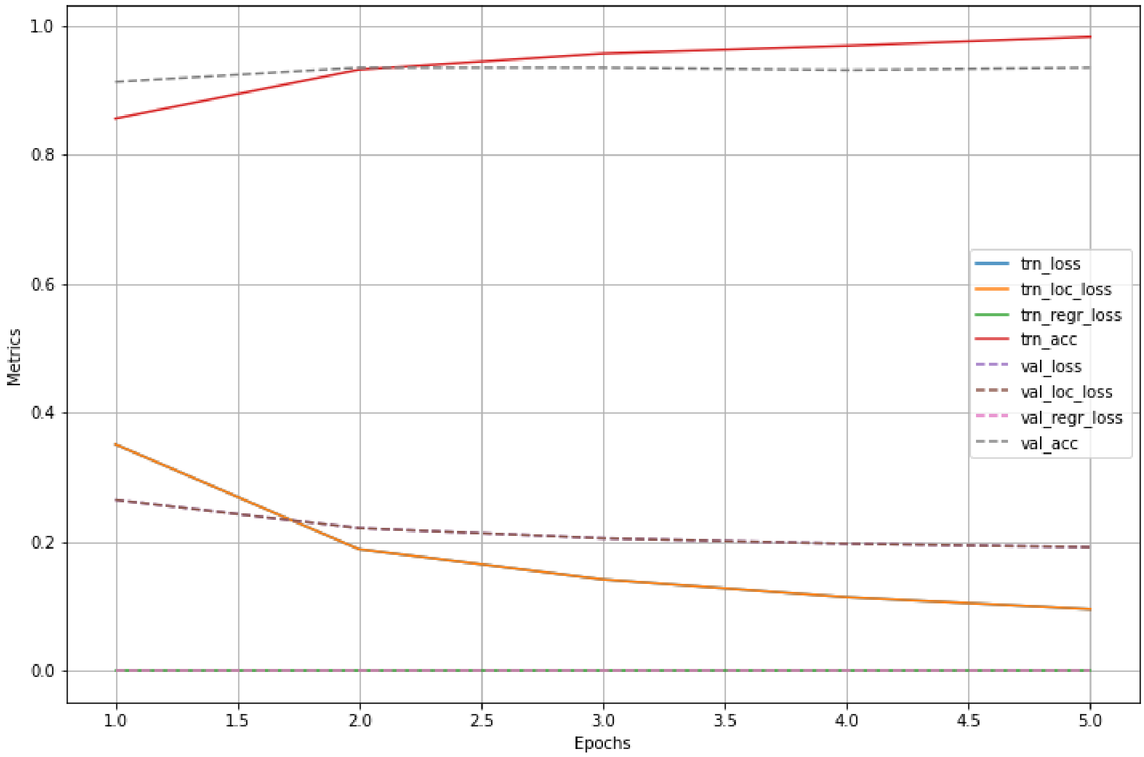
```
print('Time elapsed = %.2f min' % ((tend - tstart)/60))
```

```
Time elapsed = 13.33 min
```

In [47]:

```
plt.rcParams['figure.figsize'] = [12, 8]
fig, ax = plt.subplots()
log.plot_epochs(ax=ax)
```

```
100%|██████████| 106/106 [00:00<00:00, 4272.01it/s]
```

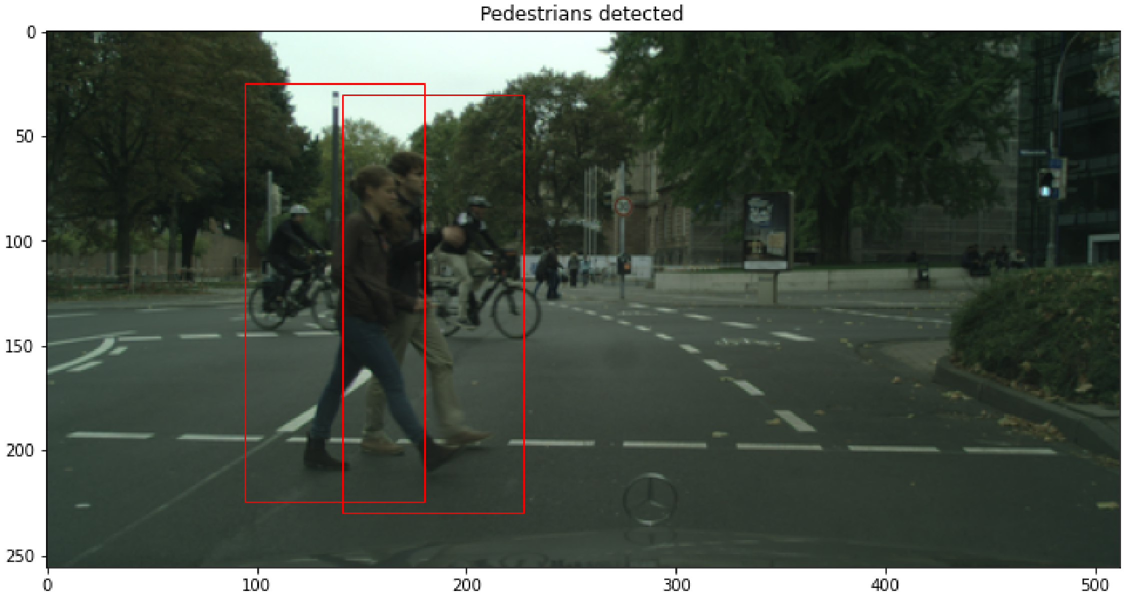


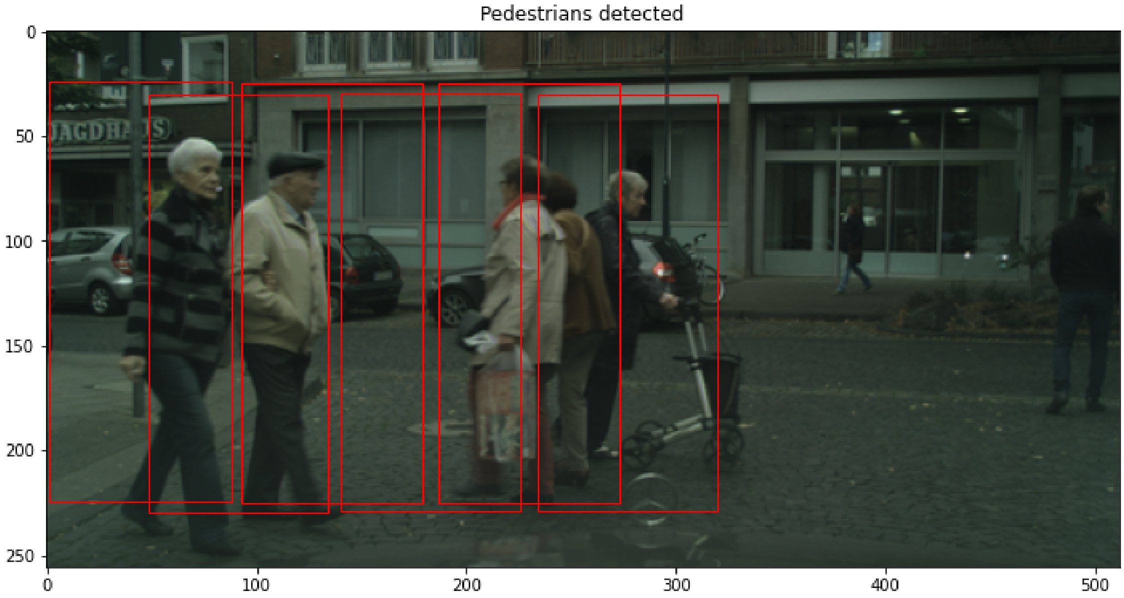
In [91]:

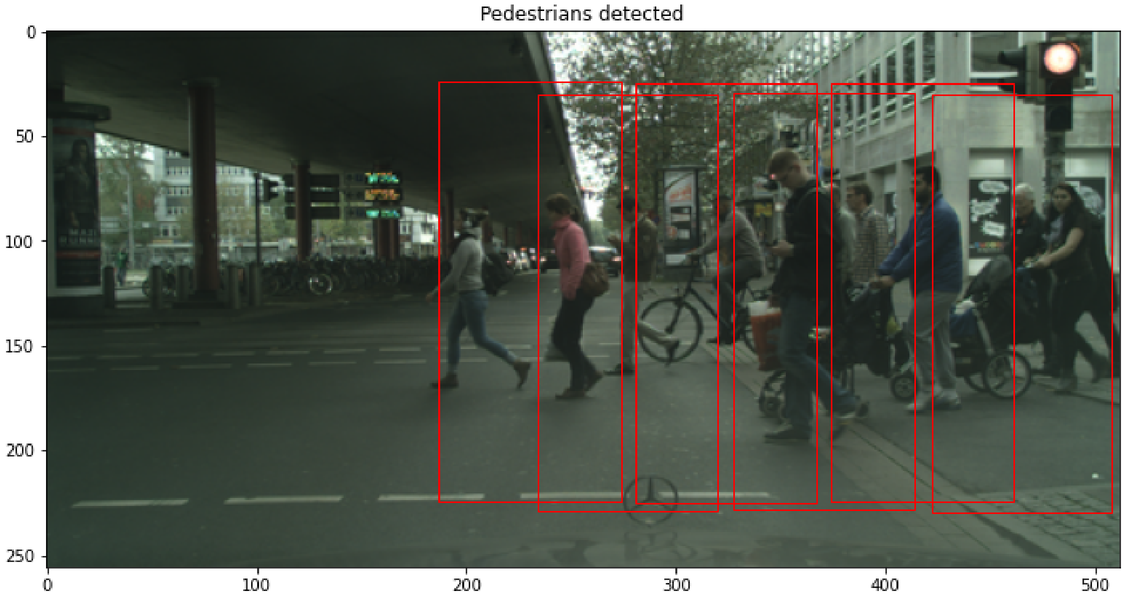
```
def show_results(i):
    img_name = all_img_names[i]
    img_path = imgs_path + img_name
    img = Image.open(img_path)
    np_image = np.array(img)

    ## reverse the code from before
    regions = utils.get_simple_regions(SCALE)
    input = []
    crops = []
    for region in regions:
        x, y, w, h = region
        x0, y0, x1, y1 = x, y, x + w, y + h
        crop = np_image[y0:y1, x0:x1]
        crops.append(crop)

    newsize = (224, 224)
    crops = [Image.fromarray(crop, 'RGB') for crop in crops]
    crops = [crop.resize(newsize) for crop in crops]
    crops = [utils.preprocess_image(crop)[None] for crop in crops]

    input = torch.cat(crops).to(device)
    with torch.no_grad():
        model.eval()
        probs, diffs = model(input)
        probs = torch.nn.functional.softmax(probs, -1)
        confs, classes = torch.max(probs, -1)

    regions = np.array(regions)
    confs, classes, probs, diffs = [
        tensor.detach().cpu().numpy() for tensor in [confs, classes, probs, diffs]]

    # TODO: use nms to lower the recall
    ## adding predicted diffs
    detected_bboxes = (regions + diffs).astype(np.uint16)

    plt.rcParams['figure.figsize'] = [12, 8]
    fig, ax = plt.subplots()

    plt.title('Pedestrians detected')
    ax.imshow(img)

    classes = classes.tolist()
    for i, bbox in enumerate(detected_bboxes):
        if classes[i] == 1:
            rect = patches.Rectangle(
                (bbox[0], bbox[1]), bbox[2], bbox[3],
                linewidth=1, edgecolor='r', facecolor='none')
            ax.add_patch(rect)
    plt.show()
```

In [92]:

```
for i in range(3):
    show_results(i)
```







Using more anchor boxes, we get larger training set and tighter detections. TODO: show example for 20 and then 2000.

In [ ]:

```
```