Finding patterns of shallow organization

or

The application of a trained machine learning model by means of an example

This is a very specific analysis and probably need to be adapted vastly for other machine learning applications.

During an effort of the atmospheric department at MPI and LMD, patterns/forms of organization of shallow convection were labeled in 10.000 satellite images (https://arxiv.org/abs/1906.01906). These labels have been used to train a machine learning model to identify these patterns autonomously. In the following, the application of this trained model is shown.

Step-by-step

1. Login to mistral

```
ssh -L <port>:localhost:<port> user_name@mistral.dkrz.de
```

Choose a `port` for forwarding, like 8888 and use the same throughout this tutorial.

2. Allocate GPU node see also
https://www.dkrz.de/up/services/analysis/visualization/visualization-on-mistral

```
salloc -N 1 -n 6 --mem=128000 -p gpu -A <project> -t10:00:00 -- /bin/bash -c
'ssh -L <port>:localhost:<port> -X $SLURM_JOB_NODELIST'
```

After the allocation of the GPU your prompt should indicate that you are now on an GPU node, like `mg101`.

3. Activate the appropriate conda environment

```
source activate environment_with_keras_installed
```

4. Open `jupyter lab` to interactively run the following commands on the GPU node.

```
jupyter-lab --port=<port> --no-browser
```

5. Load the necessary packages

```
%load_ext autoreload
%autoreload 2
%matplotlib inline

from pyclouds.imports import *
from pyclouds.helpers import *
from pyclouds.zooniverse import *
from pyclouds.plot import *
from PIL import Image
from tqdm import tqdm_notebook as tqdm
import pickle
from itertools import combinations
import imghdr

import keras_retinanet
import keras
from keras_retinanet import models
from keras_retinanet.utils.image import read_image_bgr, preprocess_image,
resize_image
from keras_retinanet.utils.visualization import draw_box, draw_caption
from keras_retinanet.utils.colors import label_color

# import miscellaneous modules
import matplotlib.pyplot as plt
import cv2
import os
import numpy as np
import time
import pandas as pd
import glob

import tensorflow as tf
```

Most of these modules should be installed with

```
conda install --file requirements.txt
```

requirements.txt

and the additional modules that we have written for this specific case you need to clone from github and install with:

```
python setup.py install
```

6. Configure the paths to the input images, the output images and the trained model

```
img_input_format = './InputImageFolder/*.png'
model_path = './exp5_resnet50_csv_20_inference.h5'
```

```
classification_file = 'Classifications.pkl'
```

You can download pretrained models at https://zenodo.org/record/2565146 (currently deactivated due to our Kaggle competition).

```
def get_session():
    config = tf.ConfigProto()
    config.gpu_options.allow_growth = True
    return tf.Session(config=config)

# use this environment flag to change which GPU to use
os.environ["CUDA_VISIBLE_DEVICES"] = "0"

# set the modified tf session as backend in keras
keras.backend.tensorflow_backend.set_session(get_session())
```

7. Load the machine learning model

If you download the model from https://zenodo.org/record/2565146 you need to convert it to an inference model first with

```
keras_retinanet/bin/convert_model.py /path/to/training/model.h5
/path/to/save/inference/model.h5
```

The training model is in this case the one downloaded from the archive. Please have a look at https://github.com/fizyr/keras-retinanet#converting-a-training-model-to-inference-model as well.

Otherwise, you can directly use

```
model = models.load_model(model_path, backbone_name='resnet50')
```

8. Load label to names mapping for visualization purposes

```
labels_to_names = {i: l for i, l in enumerate(['Flower', 'Fish', 'Gravel',
'Sugar'])}
```

9. Load the file listing

```
files = sorted(glob.glob(img_input_format))

** 10.Define main function**
that loads the image, applies the algorithm and returns for each identified
cloud pattern a score together with the bounding box.

<code python>
def get_retinanet_preds(model, fn, thresh=0.3, min_side=800, max_side=1050):
    image = read_image_bgr(fn)
    image = preprocess_image(image)
    image, scale = resize_image(image, min_side, max_side)
    boxes, scores, labels = [o[0] for o in
model.predict_on_batch(np.expand_dims(image, axis=0))]
```

```
    boxes /= scale
    boxes = boxes[scores > thresh]
    boxes = [xy2wh(*b) for b in boxes]
    labels = labels[scores > thresh]
    labels = [labels_to_names[i] for i in labels]
    scores = scores[scores > thresh]
    return np.array(boxes), labels, scores
```

11. Create function for visualization purposes only

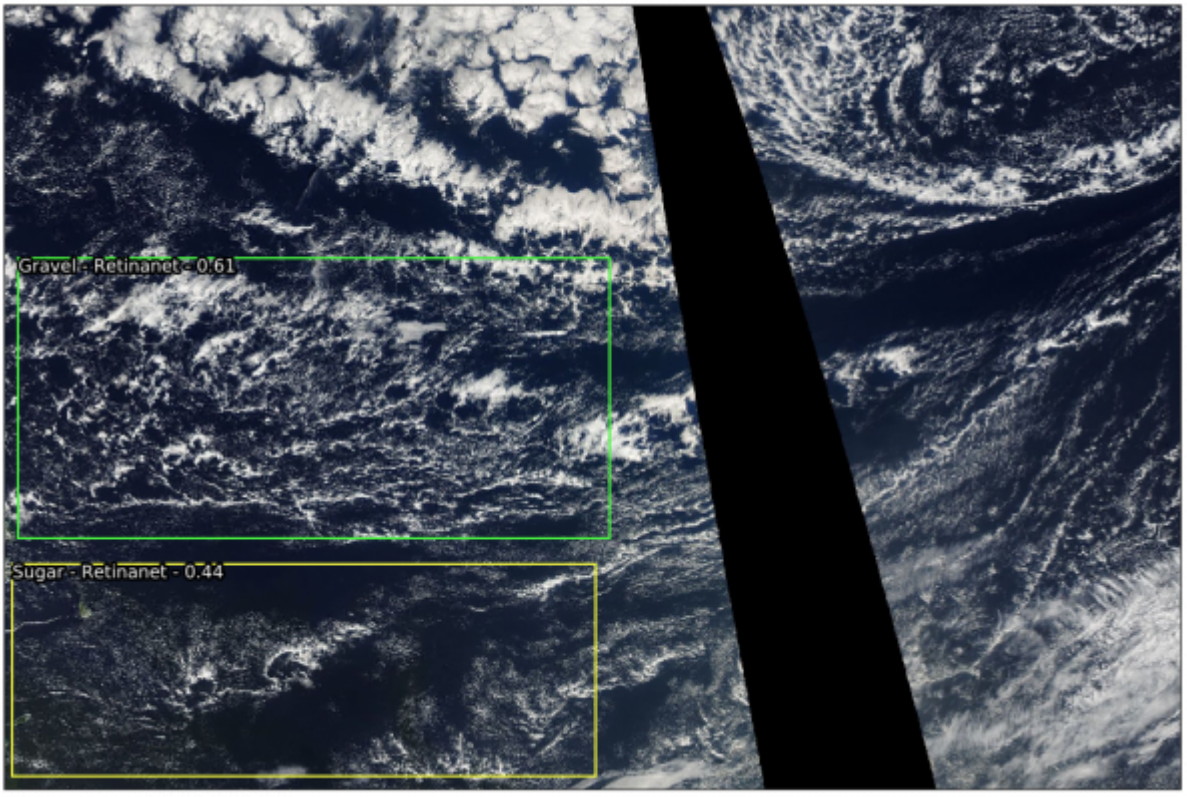
```
def plot_img_from_fn_and_boxes(fn, boxes, labels, scores, figsize=(18, 15),
show_labels=True):
    fig, ax = plt.subplots(1, 1, figsize=figsize)
    img = Image.open(fn)
    ax.imshow(img)
    ax.set_xticks([])
    ax.set_yticks([])
    for i in range(boxes.shape[0]):
        rect = patches.Rectangle((boxes[i, 0], boxes[i, 1]), boxes[i, 2],
boxes[i, 3],
                                 facecolor='none',
                                 edgecolor=np.array(l2c[labels[i]]) / 255,
lw=2)
        ax.add_patch(rect)
        if show_labels:
            s = labels[i] + ' - Retinanet - ' + str(scores[i])[:4]
            txt = ax.text(boxes[i, 0], boxes[i, 1], s, color='white',
fontsize=15, va='top')
            txt.set_path_effects([PathEffects.withStroke(linewidth=5,
foreground='k')])
    return fig

def plot_retinanet(model, fn, thresh=0.5):
    boxes, labels, scores = get_retinanet_preds(model, fn, thresh)
    fig=plot_img_from_fn_and_boxes(fn, boxes, labels, scores)
    return fig
```

12. Apply algorithm on your first image

```
fig=plot_retinanet(model, files[0], 0.4)
```

The result hopefully looks similar to:



This is of course only one image and can easily be applied to further images

```
result_dict ={}
c = 0
for file in tqdm(files[:]):
    boxes, labels, score = get_retinanet_preds(model, file, thresh=0.4)
    for b,box in enumerate(boxes):
        x,y,w,h = box
        result_dict[c] = {'labels':labels[b], 'x':x, 'y':y, 'w':w, 'h':h,
                          'score':score[b],'file':file}
        c+=1
df=pd.DataFrame.from_dict(result_dict,orient='index')
df.to_pickle(classification_file)
```