cloud_thresholding

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If you plan on using this implementation, please cite our work:

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1 Demo of the cloud detection using thresholding algorithm on panchromatic data

This document presents the cloud detection on example Landsat 8 panchromatic images using thresholding algorithm. The full script can be found in cloud_detection/scripts/panchromatic_thresholding.py.

The algorithm works in the following way:

- The threshold 0 T 1 as well as an input image X are set.
- The minimum (min_X) and maximum (max_X) values of the pixels are extracted from the image X (please note that for panchromatic data, all pixels have only one value). The border, black pixels are excluded from this operation.
- The image threshold T_X is calculated using the following formula: T_X = min_X + (max_X - min_X) * T
- The image threshold T_X is used to classify the pixels. More specifically, all pixels with value greater or equal to T_X are classified as clouds. The rest is classified as non-clouds.

First, we import neccessary libraries.

[ ]:
```
import numpy as np
import matplotlib.pyplot as plt
from IPython.display import display
from PIL import Image
from pathlib import Path
from collections import defaultdict
from sklearn.metrics import normalized_mutual_info_score, adjusted_rand_score
from tensorflow.keras.metrics import binary_crossentropy, binary_accuracy

from cloud_detection.scripts.panchromatic_thresholding import ThresholdingClassifier
```

```
from cloud_detection import losses
from cloud_detection.utils import (
    open_as_array, load_l8cca_gt, get_metrics_tf
)
```

Next, we set the parameters for the experiment. These parameters are the following:

- dpath - path to the dataset.
- rpath - path to directory where results should be stored.
- eval_imgs - types and IDs of images to evaluate.
- thresholds - threshold values to perform panchromatic thresholding.
- metric_fns - non-Tensorflow metric functions to run evaluation of the thresholding. It must be of the form func(labels_true, labels_pred).
- tf_metric_fns - TensorFlow metric functions to run evaluation of the thresholding. It must be of the form func(labels_true, labels_pred).
- band_num - band to load (in this case, panchromatic band is loaded).
- band_name - name of the band to load.
- normalize - whether to normalize the data.
- standardize - whether to standardize the data.

[2]:
```
dpath = Path("datasets/clouds/
 ↪Landsat-Cloud-Cover-Assessment-Validation-Data-Partial")
rpath = Path("artifacts/cloud_thresholding_demo/")
eval_imgs = [["Water", "LC82150712013152LGN00"],
             ["Snow-ice", "LC81321192014054LGN00"]]
thresholds = [0.1, 0.5]
metric_fns = [normalized_mutual_info_score,
              adjusted_rand_score]
tf_metric_fns = [losses.JaccardIndexLoss(),
                 losses.JaccardIndexMetric(),
                 losses.DiceCoefMetric(),
                 losses.recall,
                 losses.precision,
                 losses.specificity,
                 binary_crossentropy,
                 binary_accuracy]
band_num = 8
band_name = "panchromatic"
normalize = False
standardize = False
```

We define the function to load the image as well as its ground truth.

[3]:
```
def load_data(img_path, band_name, band_num, normalize, standardize):
    # Load gt
    gt = load_l8cca_gt(img_path)
    # Load img
    channel_files = {}
```

```
    channel_files[band_name] = list(
        img_path.glob(f"*_B{band_num}.TIF"))[0]
    img = open_as_array(
        channel_files=channel_files,
        channel_names=(band_name,),
        size=gt.shape,
        normalize=normalize,
        standardize=standardize,
        )
    return img, gt
```

Next, we define the function to get thresholding algorithm prediction given threshold value and image.

[4]:
```
def get_thr_pred(thr, img):
    # Create & fit classifier
    thr_classifier = ThresholdingClassifier(thr_prop=thr).fit(img)
    # Predict cloud mask
    mask = thr_classifier.predict(img)
    return mask
```

We define the function to calculate desired metrics given ground truth and the cloud mask predicted by the algorithm.

[5]:
```
def get_metrics(gt, mask, tf_metric_fns, metric_fns, metrics_aggr):
    metrics = get_metrics_tf(gt, mask, tf_metric_fns)
    for metric_fn in metric_fns:
        metrics[f"{metric_fn.__name__}"] = metric_fn(
            gt.reshape(-1),
            mask.reshape(-1)
        )
    print(metrics)
    for k, v in metrics.items():
        metrics_aggr[k].append(v)
    return metrics_aggr
```

Lastly, we define the function to make visualisations of the results, and then save them to rpath dir.

[6]:
```
def make_vis(img_type, img_name, gt, mask, rpath, thr):
    fig, axs = plt.subplots(1, 2, sharex=True, sharey=True)
    fig.suptitle(f"{img_type}-{img_name}")
    axs[0].imshow(gt[:, :, 0])
    axs[0].set_title("GT")
    axs[1].imshow(mask[:, :, 0])
    axs[1].set_title("pred")
    fig.savefig(
        rpath / f"thr_{int(thr*100)}" /
```

```
        f"{img_type}-{img_name}.png")
    plt.close(fig)
```

The full pipeline as well as the output can be seen below.

[7]:
```
rpath.mkdir(parents=True, exist_ok=False)
img_paths = [dpath / id_[0] / id_[1] for id_ in eval_imgs]
for thr in thresholds:
    print("THRESHOLD:", thr)
    (rpath / f"thr_{int(thr*100)}").mkdir(
        exist_ok=False, parents=True
    )
    metrics_aggr = defaultdict(list)
    for img_path in img_paths:
        img_type, img_name = img_path.parent.name, img_path.name
        print(img_type, img_name)
        img, gt = load_data(img_path, band_name, band_num,
                            normalize, standardize)
        mask = get_thr_pred(thr, img)
        metrics_aggr = get_metrics(gt, mask, tf_metric_fns,
                                   metric_fns, metrics_aggr)
        make_vis(img_type, img_name, gt, mask, rpath, thr)
    metrics_mean = {}
    for k, v in metrics_aggr.items():
        metrics_mean[k] = np.mean(v)
    print("Mean metrics")
    print(metrics_mean)
    print("")
```

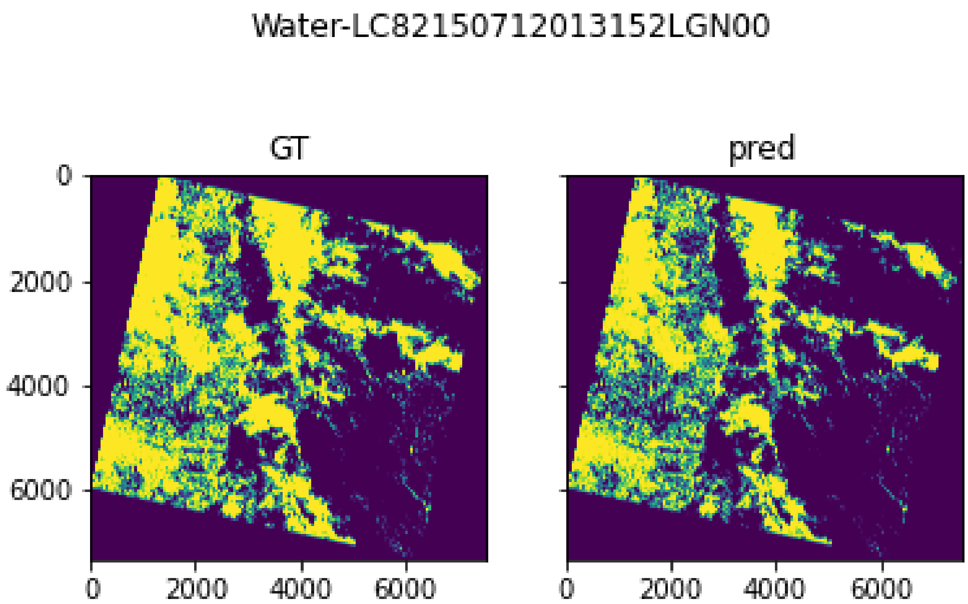
```
THRESHOLD: 0.1
Water LC82150712013152LGN00
{'jaccard_index_loss': 0.1802644, 'jaccard_index_metric': 0.8197357,
'dice_coeff_metric': 0.8962242, 'recall': 0.8337768, 'precision': 0.99521667,
'specificity': 0.99814063, 'binary_crossentropy': 0.86546046, 'binary_accuracy':
0.9460512, 'normalized_mutual_info_score': 0.7096062523934302,
'adjusted_rand_score': 0.7896431784010113}
Snow-ice LC81321192014054LGN00
{'jaccard_index_loss': 0.7884275, 'jaccard_index_metric': 0.21157268,
'dice_coeff_metric': 0.3369484, 'recall': 1.0, 'precision': 0.20104995,
'specificity': 0.108434066, 'binary_crossentropy': 11.650334, 'binary_accuracy':
0.2718083, 'normalized_mutual_info_score': 0.04866410820201292,
'adjusted_rand_score': -0.08714989509556287}
Mean metrics
{'jaccard_index_loss': 0.48434594, 'jaccard_index_metric': 0.5156542,
'dice_coeff_metric': 0.6165863, 'recall': 0.91688836, 'precision': 0.5981333,
'specificity': 0.5532873, 'binary_crossentropy': 6.2578974, 'binary_accuracy':
0.60892975, 'normalized_mutual_info_score': 0.3791351802977216,
'adjusted_rand_score': 0.35124664165272423}
```

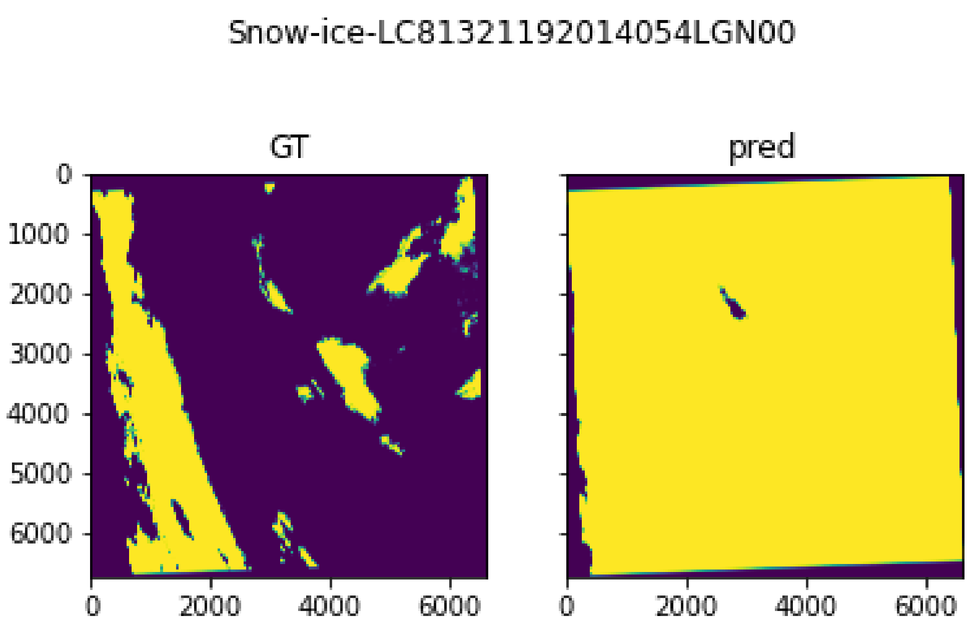
```
THRESHOLD: 0.5
Water LC82150712013152LGN00
{'jaccard_index_loss': 0.97147137, 'jaccard_index_metric': 0.02852854,
'dice_coeff_metric': 0.04909828, 'recall': 0.02178731, 'precision': 0.99956125,
'specificity': 0.9999956, 'binary_crossentropy': 4.9625635, 'binary_accuracy':
0.6899858, 'normalized_mutual_info_score': 0.023914799274914578,
'adjusted_rand_score': 0.016074578318395913}
Snow-ice LC81321192014054LGN00
{'jaccard_index_loss': 0.40893096, 'jaccard_index_metric': 0.5910691,
'dice_coeff_metric': 0.73464245, 'recall': 0.82439446, 'precision': 0.6622798,
'specificity': 0.9056833, 'binary_crossentropy': 1.7475678, 'binary_accuracy':
0.89078766, 'normalized_mutual_info_score': 0.3881726358362276,
'adjusted_rand_score': 0.5584558541567802}
Mean metrics
{'jaccard_index_loss': 0.69020116, 'jaccard_index_metric': 0.3097988,
'dice_coeff_metric': 0.39187035, 'recall': 0.42309088, 'precision': 0.8309205,
'specificity': 0.95283943, 'binary_crossentropy': 3.3550656, 'binary_accuracy':
0.79038674, 'normalized_mutual_info_score': 0.20604371755557108,
'adjusted_rand_score': 0.28726521623758805}
```

The generated images are displayed below.

[8]:
```
for thr in thresholds:
    print("THRESHOLD:", thr)
    for img_type, img_name in eval_imgs:
        display(Image.open(rpath / f"thr_{int(thr*100)}" /␣
↪f"{img_type}-{img_name}.png", "r"))
```

```
THRESHOLD: 0.1
```


Water-LC82150712013152LGN00
GT
pred
0
2000
4000
6000
0
2000
4000
6000


Snow-ice-LC81321192014054LGN00
GT
pred
0
1000
2000
3000
4000
5000
6000
0
2000
4000
6000

THRESHOLD: 0.5