data_noise_injection

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1 Noise injection into data

If you plan on using this implementation, please cite our work (https://www.mdpi.com/2072-4292/13/8/1532):

@Article{Nalepa2021RemoteSens, AUTHOR = {Nalepa, Jakub and Myller, Michal and Cwiek, Marcin and Zak, Lukasz and Lakota, Tomasz and Tulczyjew, Lukasz and Kawulok, Michal}, TITLE = {Towards On-Board Hyperspectral Satellite Image Segmentation: Understanding Robustness of Deep Learning through Simulating Acquisition Conditions}, JOURNAL = {Remote Sensing}, VOLUME = {13}, YEAR = {2021}, NUMBER = {8}, ARTICLE-NUMBER = {1532}, URL = {https://www.mdpi.com/2072-4292/13/8/1532}, ISSN = {2072-4292}, DOI = {10.3390/rs13081532}}

This example presents how the the noise can be injected into any part of the dataset: train, test and validation. There are three types of noise implemented:

- Gaussian
- Impulsive
- Shot

There are a few parameters which indicate how a given noise behaves:

- *pa* - Fraction of noisy pixels, the number of affected samples is calculated by: floor(n_samples * pa).
- *pb* - Fraction of noisy bands. When established the number of samples that undergo noise injection, for each sample the: floor(n_bands * pb) bands are affected.
- *bc* - Boolean indicating whether the indexes of affected bands, are constant for each sample. When set to: False, different bands can be augmented with noise for each pixel.
- *mean* - Gaussian noise parameter, the mean of the normal distribution.
- *std* - Gaussian noise parameter, standard deviation of the normal distribution.
- *pw* - Impulsive noise parameter, ratio of whitened pixels for the affected set of samples.

[1]:
```
import os
import sys
sys.path.append(os.path.dirname(os.getcwd()))
```

[ ]:
```
import os
import shutil
import re
from copy import copy
```

```python
import clize
import mlflow
import tensorflow as tf
from clize.parameters import multi

from scripts import evaluate_model, prepare_data, train_model
from ml_intuition.data.utils import plot_training_curve, show_statistics
```

Specify path to the `.npy` dataset and ground truth, as well as the output path to store all the artifacts.

[3]:
```python
DEST_PATH = 'data_noise_injection_results'
DATA_FILE_PATH = os.path.join(os.path.dirname(os.getcwd()), 'datasets/pavia/
 ↪pavia.npy')
GT_FILE_PAT = os.path.join(os.path.dirname(os.getcwd()), 'datasets/pavia/
 ↪pavia_gt.npy')
experiment_dest_path = os.path.join(DEST_PATH, 'experiment_0')
os.makedirs(experiment_dest_path, exist_ok=True)
```

2 Prepare the data

To fit into the the pipeline, the data has to be preprocessed. It is achieved by the `prepare_data.main` function. It accepts a path to a `.npy` file with the original cube as well as the corresponding ground truth. In this example, we randomly extract 250 samples from each class (balanced scenario), use 10% of them as validation set, and extract only spectral information of a pixel. The returned object is a dictionary with three keys: `train`, `test` and `val`. Each of them contains an additional dictionary with `data` and `labels` keys, holding corresponding `numpy.ndarray` objects with the data. For more details about the parameters, refer to the documentation of `prepare_data.main` function (located in `scripts/prepare_data`).

[4]:
```python
data = prepare_data.main(data_file_path=DATA_FILE_PATH,
                         ground_truth_path=GT_FILE_PAT,
                         output_path=None,
                         train_size=250,
                         val_size=0.1,
                         stratified=True,
                         background_label=0,
                         channels_idx=2,
                         neighborhood_size=None,
                         save_data=False,
                         seed=0)
```

3 Train the model with nosiy training set

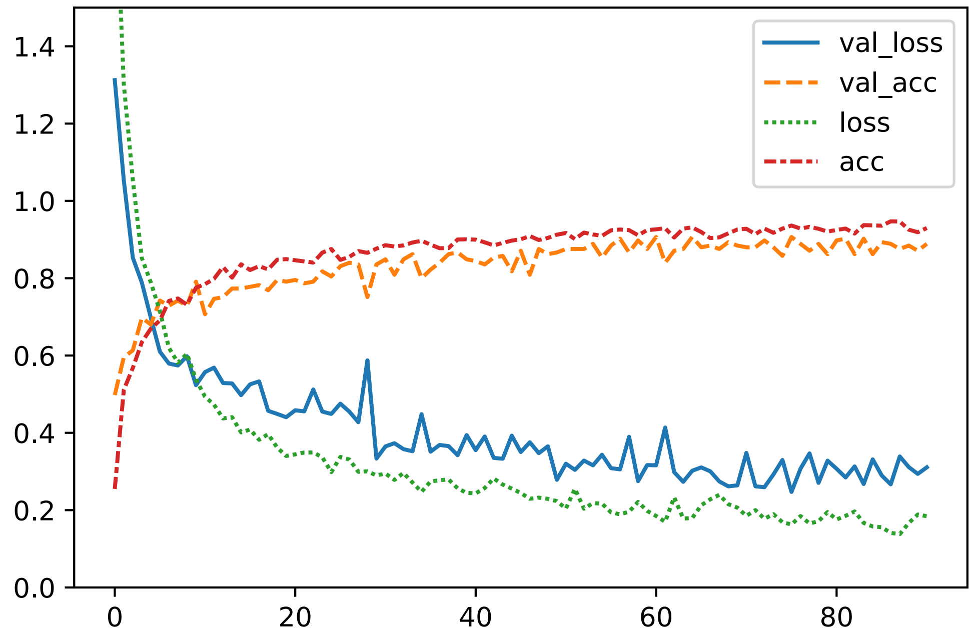
The function `trian_model.train` executed the trainig procedure. In order to inject noise into the training set, provide `noise` with a name of the noise type, `noise_sets` with the set you would like to augment, and `noise_params` with the noise parameters. Trained model will be stored under `experiment_dest_path` folder path.

[5]:
```
train_model.train(model_name='model_2d',
                    kernel_size=5,
                    n_kernels=200,
                    n_layers=1,
                    dest_path=experiment_dest_path,
                    data=data,
                    sample_size=103,
                    n_classes=9,
                    lr=0.001,
                    batch_size=128,
                    epochs=200,
                    verbose=0,
                    shuffle=True,
                    patience=15,
                    noise=['gaussian'],
                    noise_sets=['train'],
                    noise_params="{\"mean\": 0, \"std\": 1, \"pa\": 0.1, \"pb\":
 ↪ 1}")
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 99, 1, 200)        1200
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 32, 1, 200)        200200
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 14, 1, 200)        200200
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 5, 1, 200)         200200
_________________________________________________________________
flatten (Flatten)            (None, 1000)              0
_________________________________________________________________
dense (Dense)                (None, 200)               200200
_________________________________________________________________
dense_1 (Dense)              (None, 128)               25728
_________________________________________________________________
dense_2 (Dense)              (None, 9)                 1161
=================================================================
Total params: 828,889
Trainable params: 828,889
Non-trainable params: 0
```

----

[6]:
```
plot_training_curve(os.path.join(experiment_dest_path, "training_metrics.csv"),␣
↪['val_loss', 'val_acc', 'loss', 'acc'])
```



4 Evaluate the model

Evaluate the model, calculating all metrics. All arfticats will be stored under provided `experiment_dest_path`. In this step, it is also possible to inject nosie into the `test` set, similarly to the previous function call. But first, let's evaluate the model on original test dataset:

[ ]:
```
evaluate_model.evaluate(
    model_path=os.path.join(experiment_dest_path, 'model_2d'),
    data=copy(data),
    dest_path=experiment_dest_path,
    n_classes=9,
    batch_size=1024,
    noise=[],
    noise_sets=[])
tf.keras.backend.clear_session()
```

[8]:
```
show_statistics(os.path.join(experiment_dest_path, "inference_metrics.csv"))
```

[8]:
```
   accuracy_score  balanced_accuracy_score  cohen_kappa_score   Class_0  \
0        0.859942                 0.902939           0.816331  0.865068

    Class_1   Class_2   Class_3   Class_4   Class_5   Class_6   Class_7  \
0  0.827382  0.825311  0.955935  0.999087  0.862733  0.924074  0.868298

    Class_8  inference_time
0  0.998565        6.757337
```

And now let's evaluate the model on the noisy test set, using Gaussian noise with mean 0 and std 1 affecting only 10% of the pixels

[9]:
```
evaluate_model.evaluate(
    model_path=os.path.join(experiment_dest_path, 'model_2d'),
    data=copy(data),
    dest_path=os.path.join(experiment_dest_path, "noisy"),
    n_classes=9,
    batch_size=1024,
    noise=['gaussian'],
    noise_sets=['test'],
    noise_params="{\"mean\": 0, \"std\": 1, \"pa\": 0.1, \"pb\": 1}")
```

[10]:
```
show_statistics(os.path.join(experiment_dest_path, "noisy", "inference_metrics.
↪csv"))
```

[10]:
```
   accuracy_score  balanced_accuracy_score  cohen_kappa_score   Class_0  \
0        0.792183                 0.836907           0.731185  0.790785

    Class_1   Class_2   Class_3   Class_4  Class_5   Class_6   Class_7  \
0  0.763085  0.763656  0.889126  0.968037  0.79117  0.844444  0.786422

    Class_8  inference_time
0  0.935438        6.741781
```

We can see that the accuracy of the model droped in comparison with the original one.