-

napari-kld napari .

Kernel Learning Deconvolution (KLD)

KLD ,
R - L D (R LD) - (R) -
(HR) .

I one sample , two iterations
R LD .

*This napari plugin was generated with copier using the napari-plugin-template.

Installation

napari Y napari-kld .

Install napari

napari Y
:// . / / / # / . .

O , napari P :

```
conda create -y -n napari-env -c conda-forge python=3.10
conda activate napari-env
python -m pip install 'napari[all]'
```

R :// . / / / # / . .

Install napari-kld

napari-kld Y napari :

Plugins >Install/Uninstall Plugins… > - >install .

O napari-kld :

```
pip install napari-kld
```

Instruction

T :

- RL Deconvolution : C R L D (Traditional Guassian Butterworth , Wiener-Butterworth (WB)). T , . ., (P 5), .
- KL Deconvolution : K L D / .

You can download the "test" folder at https://github.com/qiqi-lu/napari-kld for testing, which save some 2D/3D images used for training and testing.

RL Deconvolution

T R L D .

1. O napari napari-kld Plugins >Kernel Learning Deconvolution >RL Deconvolution
2. L - (R) File >Open File(s) >[choose the image to be deconvolved] >[the image will appear in the layer list of napari] , "test/data/simulation/data_128_128_128_gauss_0.0_poiss_0_ratio_1.0/train/raw/0.tif" .
3. C Input RAW data , "0" .
4. P Choose PSF , "test/data/simulation/data_128_128_128_gauss_0.0_poiss_0_ratio_1.0/train/psf.tif" .
5. C Method :
   - Traditional : (. ., P 5).
   - Guassian : G - , F H M W .
   - Butterworth : B - , B .
   - WB : - B W, B W .
6. S R L Iterations *.
7. P run .

. progress bar W 100 . %

9. T {name of input image}_deconv_{Method}_iter_{Iterations} , "0_deconv_traditional_iter_30" .

**The adjustment of parameters of backward kernels should refer to the paper : Guo, M. et al. Rapid image deconvolution and multiview fusion for optical microscopy. Nat Biotechnol 38, 1337–1346 (2020).*

KL Deconvolution

Training data preparation

T :

- A "gt" ( ) , "test/data/real/2D/train/gt" , GT (.).
- A "raw" , "test/data/real/2D/train/raw" , R (.).T "gt" .
- A "train.txt" , "test/data/real/2D/train/train.txt" , "gt"/"raw" .

When yuo have paired LR image and HR image

R W HR , R raw input HR ground truth (GT). W supervised strategy .

Training of Forward Projection

T .

1. O napari napari-kld Plugins >Kernel Learning Deconvolution >KL Deconvolution
2. C Training .
3. C Data Directory , "test/data/real/2D/train" .T Dimension .
4. C Output Directory , "test/data/real/2D" .
5. PSF Directory P .
6. I GT , Preprocess , GT .H , .
7. I Forward Projection , :
   - Epoch : .
   - Batch Size : .
   - Kernel Size (z, xy) : .
   - Optimizer : . D :A .
   - Learning Rate : .
   - Decay Step : . N 0 .
   - Decay Rate : .

. P run . stop Y .

9. progress bar W 100 . %

A , /checkpoints Output Directory , forward_bs_{batch size}_lr_{learning rate}_ks_{kernel size

(z)}_{kernel size (xy)} ,
"test/data/real/2D/checkpoints/forward_bs_1_lr_0.001_ks_1_31" , :

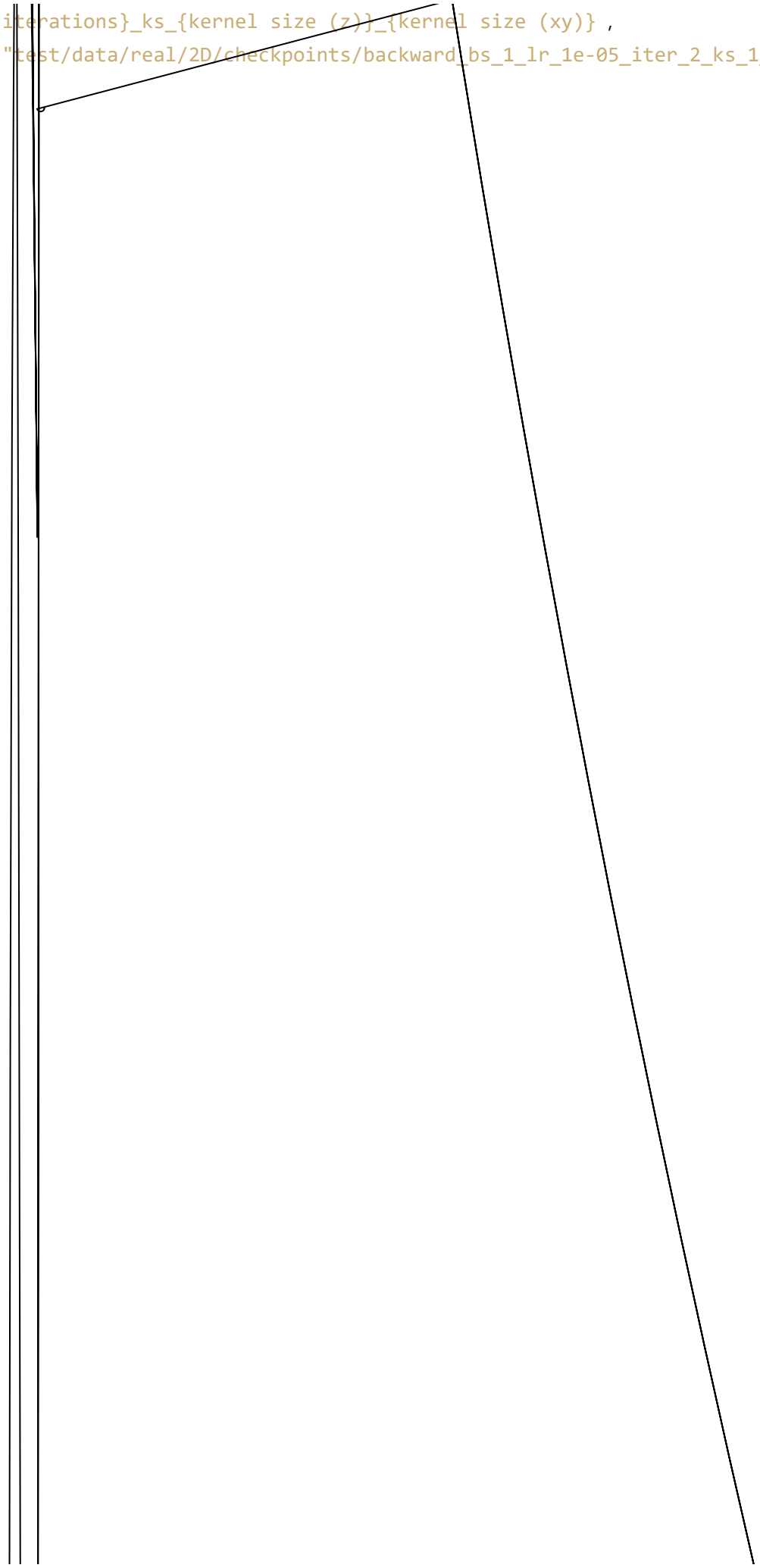
- log Tensorboard , Tensorboard .
- , epoch_{epoch}.pt .
- parameters.json .

Training of Backward Projection

A ,
.

1. O napari napari-kld Plugins >Kernel Learning Deconvolution >KL Deconvolution
2. C Training .
3. C Data Directory , "test/data/2D/real/train" .T Dimension .
4. C Output Directory , "test/data/2D/real" .
5. PSF Directory P Б .
6. I GT , Preprocess , GT .H , .
7. I Backward Projeciton , .
   - Training strategy supervised self-supervised .H , supervised , GT . self-supervised , P Б .
   - Iterations (RL) :T R L . D :2.
   - Epoch :T .
   - Batch Size :T .
   - Kernel Size (z, xy) :T x y .
   - FP directory : - , "test/data/real/2D/checkpoints/forward_bs_1_lr_0.001_ks_1_31/epoch_500_final.pt" ("_final").
   - Optimizer :O . D :A .
   - Learning Rate :T MM .
   - Decay Step : .
   -

```
iterations}_ks_{kernel size (z)}_{kernel size (xy)} ,
"test/data/real/2D/checkpoints/backward_bs_1_lr_1e-05_iter_2_ks_1_31" ,                    :
```



T Output directory ,
"data_{shape_z}_{shape_y}_{shape_x}_gauss_{std of Gaussian noise}_poiss_{whether to add Poisson noise}_ratio_{Ratio}" , :
"test\data\simulation\data_128_128_128_gauss_0.0_poiss_0_ratio_1.0\train"

- "data\train\gt" GT *.
- "data\train\raw" R A W.
- "data\train\parameters.json" .
- "data\train\psf.tif" P Б (P Б).
- "data\train\train.txt .

A , .

**the code was refered to the paper: Li, Y. et al. Incorporating the image formation process into deep learning improves network performance. Nat Methods 19, 1427–1437 (2022).*

You may need to adjust the noise level in the image accordding to the real acuqired data.

Training with known PSF and simulated data

T P Б.

1. O napari napari-kld Plugins >Kernel Learning Deconvolution >KL Deconvolution
2. C Training .
3. C Data Directory , test/data/simulation/data_128_128_128_gauss_0.0_poiss_0_ratio_1.0/train" , :
   - Agt GT
   - Araw R GT
   - Atrain.txt (gt raw).
4. C Output Directory , "test/data/simulation/data_128_128_128_gauss_0.0_poiss_0_ratio_1.0" .
5. C PSF Directory P Б , "test/data/simulation/data_128_128_128_gauss_0.0_poiss_0_ratio_1.0/train/psf.tif" . T Forward Projection P Б. J P Б .
6. I GT , Preprocess , GT .H , .
7. T .

o

7 . I Backward Projeciton ,

- Training strategy supervised self-supervised . S self-supervised , GT .
- Iterations (RL) : R L . D :2.
- Epoch : .
- Batch Size : .
- Kernel Size (z, xy) : x y .
- FP Directory : .H , P Б .
- Optimizer :O . D :A .
- Learning Rate : .
- Decay Step : .
- Decay Rate : .

. P run . stop Y .

9 . progress bar W 100 . %

,W /checkpoints Output Directory , backward_bs_{batch size}_lr_{learning rate}_iter_{num of RL iterations}_ks_{kernel size (z)}_{kernel size (xy)}_ss , "/checkpoints/backward_bs_1_lr_1e-05_iter_2_ks_31_31_ss" , :

- log Tensorboard , Tensorboard .
- , epoch_{epoch}.pt .
- parameters.json .

The performance of self-supervised learning may be inferior to supervised learning according to our experiments.

Prediction

U /

1. O napari napari-kld Plugins >Kernel Learning Deconvolution >KL Deconvolution
2. C Prediction .
3. L - napari File >Open File(s) >[choose the image to be deconvolved] >[the image will appear in the layer list of napari] , "test/data/real/2D/test/raw/2.tif" .
4. C Input RAW data , . .2 .
5. I P Б , PSF directory .
6. I P Б , Forward Projection , "test/data/real/2D/checkpoints/forward_bs_1_lr_0.001_ks_1_31/epoch_500_final.pt" ("_final"). I P Б F P , KL D P Б .

/

7 . C Backward Projeciton ,
"test/data/real/2D/checkpoints/backward_bs_1_lr_1e-
05_iter_2_ks_1_31/epoch_1000_final.pt" ("_final").

. S R L Iterations (RL) . D :2.

9 . P .

10. W 100 . %

T layer list napari , "{input data
name}_deconvo_iter_{number of RL iterations}" , . .,"16_deconv_iter_2" .
.

Others

T log .P clean log .

Notice

- *Currently, the plugin is runned on CPU. We have tried to run the training on GPU, but the training time did not decrease (maybe it is because the FFT-based covnlution was not optimized on GPU). We are trying to make improvements.*
- *The training time may be very long if we set the kernel size or the number of epoches too large, especially for 3D images. Besides, it also depends on the computation capability of your device.*

C

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