

Instructions for numerical exercises with the Core Imaging Library (CIL), 6 Nov 2023, DTU course 22485

In these exercises we will see how to use the Core Imaging Library (CIL) to do advanced regularization-based reconstruction to improve reconstruction quality in cases where the data quality (signal-to-noise level, number of projections) is insufficient for filtered back-projection (FBP). CIL is an open-source python package available from anaconda, the main website is: <https://ccpi.ac.uk/cil/>

In the exercises we will use a DTU JupyterLab server called LearnMore, which means that no installation is necessary as you simply log in to the server using your web browser.

Part 1: Setting up

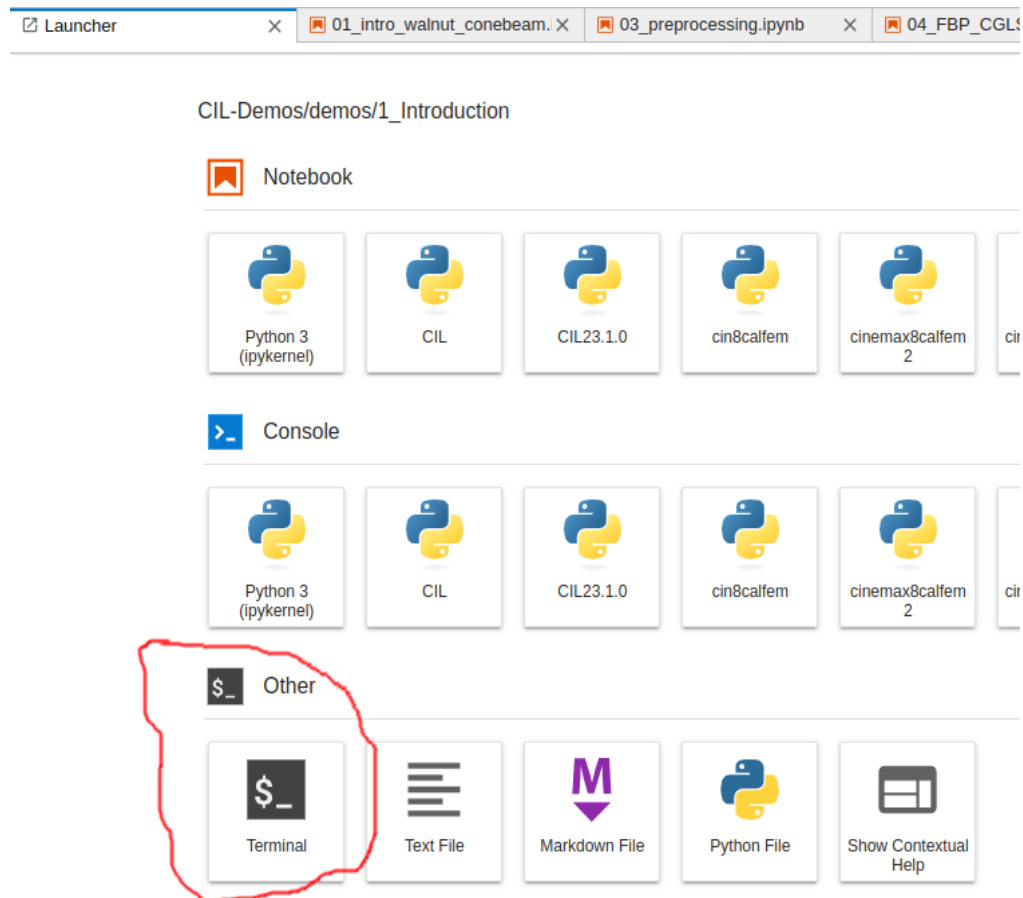
1. Please go to either (if you date of birth is on an odd number day of the Month e.g. January 13, go to learnmore1; if on an even number day, eg January 14, please use learnmore2. This is to distribute the load evenly.)

<https://learnmore1.compute.dtu.dk/>

<https://learnmore2.compute.dtu.dk/>

A list of user names and passwords will be available on the day of the exercises. Log in.

2. Once in, you should see the launcher tab, start by opening a terminal

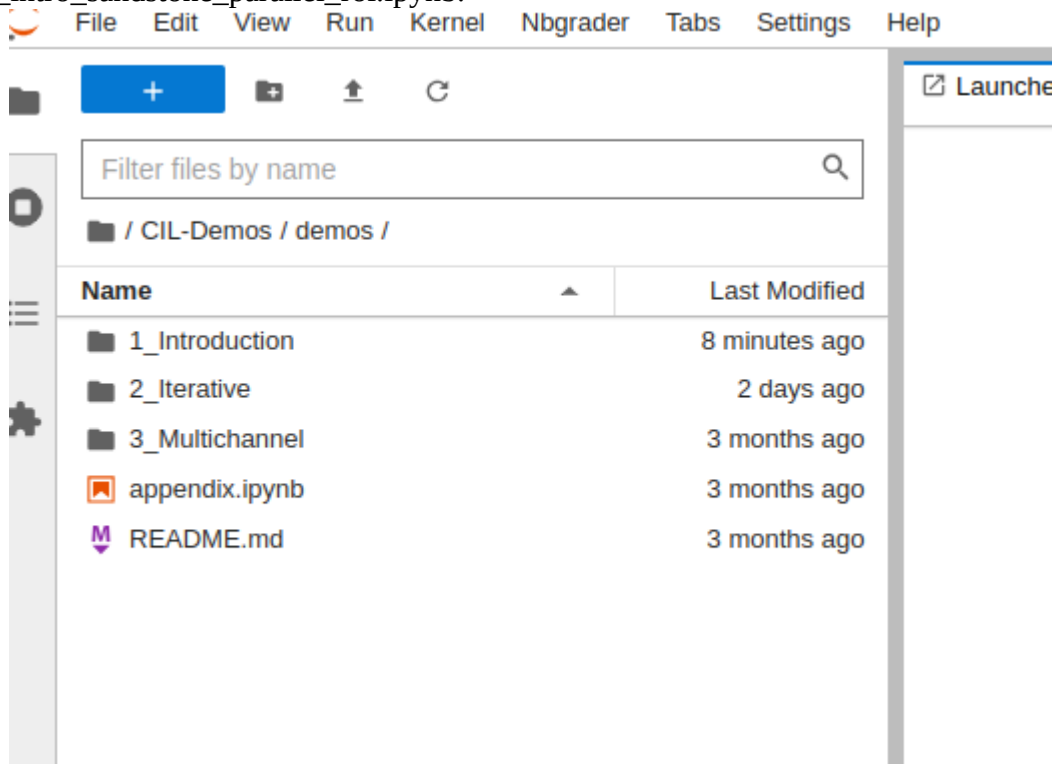


In the terminal type

```
git clone https://github.com/TomographicImaging/CIL-Demos.git
```

This will copy the collection of CIL Demos to your personal home directory on learnmore. In the file directory to the left, navigate to the folder CIL-Demos/demos/1_Introduction:

3. In the folder 1_Introduction you will see a number of Jupyter notebooks. Double click the 02_intro_sandstone_parallel_roi.ipynb.



Learnmore has a number of different “kernels” available, each with different software installed. To tell it to use the kernel with CIL installed, go to the top right corner, click and in the menu select “CIL23.1.0”



4. You can now run the notebook. You can use Shift+ENTER to run a cell and advance to next. The first time you open a new notebook, you need to specify the kernel to be used as CIL23.1.0.
5. To load the data set, update the datapath to:
`datapath = "/sets/CIL/SandStone/"`

Part 2: Getting familiar with CIL, filtered back-projection and data preprocessing

6. Work through the notebook 02_intro_sandstone_parallel_roi.ipynb, make sure to read the explanations and feel free to experiment.
7. Work through one or more of the other notebooks in 1_Introduction such as
03_preprocessing.ipynb: for more on preprocessing data
04_FBP_CGLS_SIRT.ipynb: for comparison between FBP and iterative CGLS/SIRT methods
05_usb_limited_angle_fbp_sirt.ipynb: see the effect of limited angle data on a large real dataset

Part 3: Exploring more iterative reconstruction methods with regularization

8. In the folder 2_Iterative, work through the notebook 01_optimisation_gd_fista.ipynb, make sure to read all instructions and do any exercises such as completing missing code.
9. Work through one or more notebooks in the 2_Iterative folder, such as
02_tikhonov_block_framework.ipynb: to see how one can construct other optimization problems such as tikhonov regularization using the building blocks of CIL.
05_Laminography_with_TV.ipynb: see a non-standard scan configuration and the improvements enabled by TV regularization on a large 3D real-data set of a LEGO phantom.

Optional part 4: Multichannel CT and User Showcase notebooks

10. If interested, feel free to explore the notebook in the folder 3_Multichannel that demonstrate how to do colour image reconstruction, time-resolved/dynamic CT with regularization and hyperspectral (energy-resolved) CT.
11. The CIL has started a collection of user-contributed showcase notebooks, demonstrating interesting use cases and applications using CIL, feel free to explore here:
<https://github.com/TomographicImaging/CIL-User-Showcase/>

Some tips:

12. CIL can use either of two other libraries for the GPU-accelerated forward and back projection computations, the ASTRA or TIGRE libraries. At the time of writing, there seems to be an issue with the TIGRE installation on the Learnmore server and notebooks using TIGRE may not run. You may try to modify any such notebook (such as the walnut one) to run with ASTRA instead.
13. There are also currently issues running some of the larger datasets such as the walnut. You can try changing to use the datasets: USB, wizard, korn, rubrics. In a terminal use
`ls /sets/CIL`
to list the contents of the shared data directory.
14. If you get errors when trying to run notebooks, it may be because we are many accessing the same GPU on the servers. On each of learnmore1 and learnmore2 there are four GPUs, indexed 0-3, but by default only GPU 0 will be used. When using CIL with ASTRA, we can explicitly ask the notebook to use a different GPU, such as GPU id 3, by the following call in the beginning of the notebook:
`import astra`
`astra.astra.set_gpu_index(3)`
You can also check how busy each of the four GPUs on each of learnmore1 and learnmore2 are, but opening a terminal from the launcher tab and running the command:
`nvidia-smi`
This will print information for each GPU including how much memory is used out of what is available, and if one is very full, you can choose another one.
15. Some of the notebooks use real data sets, but the path needs to be updated to where the data sets are stored on learnmore. All the data sets are stored under
`/sets/CIL`
for example to use the walnut dataset you can use
`path = '/sets/CIL/Walnut/walnut'`
16. The interactive CIL viewer called islicer is currently not working on learnmore1 and learnmore2. Use instead the non-interactive show2D to display slices.