**COMPENDIUM FOR THE**

**MASTER PROJECT IN DPC SPIRAL CT**

**1) Publications / readings:**

The following is a list of readings that we recommend / suggest to read in order to achieve the necessary theoretical background. Moreover, it is specified whether the reading is strongly recommended and should be considered a point of reference or whether you are dealing with an “optional” reading to just broaden your knowledge of the topic.

* **Principles of Computerized Tomographic Imaging , chapter 2, 3, 5.**

Chapter 2 offers a nice summary signal processing fundamentals that are useful for tomography; chapter 3 deals with the basics of tomographic reconstruction for parallel and fan beam geometry; chapter 5 is about the artifacts that can affect tomographic reconstruction and the performance of reconstruction algorithms under noise. Strongly recommended.

* **The Katsevich Inversion Formula for Cone-Beam Computed Tomography**

This is the PhD thesis of Adam Wunderlich (Department of mathematics, Oregon State University) available on the web at the address:

<http://people.oregonstate.edu/~faridana/preprints/WunderlichMSpaperNoCode.pdf>

The thesis is focused on all the mathematical aspects of Katsevich formula and

shows how to achieve an implementation of the code for flat and curved detector geometries. It is the best available material, in which the Katsevich formula gets mapped into well explained computational steps. Moreover, the text does not present the complexity that usually characterize purely mathematical works. Strongly recommended.

* **“Direct computed tomographic reconstruction for directional derivative projections of computeted tomography of diffraction enhanced imaging”,**

**Z. Huang et al., paper, Applied Physics Letters, 2006.** This paper introduces the Hilbert filter that is used for FBP to reconstruct DPC data. Strongly recommended.

* **“Region-of-interest tomography for grating-based X-ray differential phase contrast imaging”, F. Pfeiffer et al., paper, Physical Review Letters, 2008.**

This paper introduces the Hilbert filter that is used for FBP to reconstruct DPC data. Strongly recommended.

* **“A theoretically exact reconstruction algorithm for helical cone-beam differential phase-contrast computed tomography”, J. Li, paper, Phys. Med. Biol., 2013.** This is the first (and so far the only one) paper that discusses the application of the Katsevich algorithm to DPC helical cone beam tomography. Strongly recommended.
* **“An improved exact filtered backprojection algorithm for spiral computed tomography”, A. Katsevich, Advances in Applied Mathematics, 2004.**

Recommended.

* **“Studies on implementation of the Katsevich algorithm for spiral cone-beam CT”, H. Yu et al., paper, Journal of X-ray Science and Technology, 2004.** Recommended.
* **“Katsevich's exact reconstruction algorithm and its application to various X-ray source scanning trajectories”, A. Kingston and T. Varslot, presentation available at:**

[**http://xrsi.cmit.csiro.au/Tomowkshop/PDFs/Kingston.pdf**](http://xrsi.cmit.csiro.au/Tomowkshop/PDFs/Kingston.pdf)

Recommended.

* **“Feldkamp-type reconstruction algorithms for spiral cone-beam CT with variable pitch”, J. Zhao et al., paper, Hournal of X-ray Science and Tech., 2007.** Optional.
* **“Single slice rebinning reconstruction in spiral con-beam computed tomography”, H. Bruder et al., paper, IEEE Trans. On Med. Imag., 2000.**
* **“3PI algorithms for helical computer tomography”, A. Katsevich, paper, Advances in Applied Mathematics, 2006.** Optional.
* **“A solution to the long object problem in helical cone-beam tomography”,**

**M. Defrise et al., paper, Phys. Med. Biol., 1999.** Optional.

**2) Grating interferometry:**

All papers are available in the dropbox folder “SpiralCT”, or in the “Bibliography” folder in the ms\_dpc\_spiral\_ct repository.

- “CT\_Basics”:

- “Technical aspects of spiral CT”: Some basic concepts/issues of spiral CT (apbsorption). Highly recommended.

- Flohr et al. and Prokop: More detailes aspects of sCT (including does considerations), but focusing on multi-detector CT. To broaden the general understanding of sCT: Recommended.

- “DPC\_Basics”: Highly recommended for understanding the basic principles of DPC

- “Main folder”: A bit redundant, but the different images show the phase stepping technique quite well, and cover the most important formulae.

- “Pfeiffer et al. 2007”: Introduces the DPC CT reconstruction, highly recommended (as a first starting point).

- “ReverseProjection”: Background information on the image formation of the reverse projection technique. Recommended.

- “ScanninDPC”: Background information on the image formation if the sample and not the gratings are scanned over the fringes. Recommended.

- “DPC\_fan\_and\_cone\_beam”: Cone and fan beam examples for standard DPC CT reconstruction, recommended as background information.

**3) First computational tasks:**

The following is a collection of exercises that can help as warm-up and to get some feeling with tomographic reconstruction problems.

* **Radon transform and FBP for parallel beam geometry:** this exercise can simply consist in making use of the Matlab / Python built-in functions “radon” and “iradon”, respectively, to create sinograms or to reconstruct sinograms of the Shepp-Logan phantom, while giving a look to the codes and try to understand them. This work can be useful to map the formulas of Ch.3 of Principles of Computerized Tomographic Imaging into the actual numerical implementation.
* **Reconstruction of DPC sinograms in parallel beam geometry:** just take some experimental sinograms produced at the beamline and try to reconstruct them with GRIDREC by making use of the specific built-in Hilbert filter.
* **Creation of a simulated spiral cone-beam tomographic dataset:** it is available on the web page:

<https://code.google.com/p/cphcttoolbox/downloads/detailname=spiral-shepp-logan-128x512.zip&can=2&q>=

This dataset can be used to test the implementations of Katsevich algorithm for absorption tomographic datasets.

* **Experiments with Niftyrec and Cphcttoolbox:** Niftyrec and cphcttoolbox are reconstruction toolboxes that contain implementations of the Katsevich algortihms in C++. Both toolboxes offer a user-friendly python interface to run the reconstructions. This exercise can be useful to test the simulated spiral cone beam dataset and to get a feeling with reconstructions dealing with non parallel beam geometries. The packages are available at the following web-pages:

<http://www0.cs.ucl.ac.uk/staff/M.Modat/Marcs_Page/Software.html>

<https://pypi.python.org/pypi/cphcttoolbox/1.0.4>

* **Re-implementation of the Wunderlich's Matlab code for the Katsevich algorithm:** at the end of Wunderlich's thesis, there is a pure Matlab implementation of the Katsevich algorithm (and also the Feldkamp one). This code should be re-implemented and tested on simulated data, because it can represent the computational baseline to start the Master project.

**4) Python basics:**

If you want to take a first look at python, I advise you to get Enthought Canopy (<https://www.enthought.com/products/canopy/>, sign up with your ETH mail address, it will be free then) which is a nice program to edit python code and manage all the packages you’ll need.

Via the package manager you can add the following packages, which will be used to “mimic” matlab environment: NumPy (matlab like arrays and operators) and matplotlib (for matlab like plots and figures) or just SciPy (which contains the previous ones and more...). Once you added the packages, you can import them (type “import package\_name”, similar to the “#include header\_name” in C/C++).

Take a look at the following tutorials (very brief, you will see that it is very straight forward...):

<http://www.decalage.info/en/python/tutorial>

<http://www.stavros.io/tutorials/python/>

We will use a specific code format in Python, PEP8, which you can learn about here: <http://legacy.python.org/dev/peps/pep-0008/>

Most importantly:

- Do not have more than 79 characters per line

- Set tab width (very crucial in python ;) to 4 spaces

- Comply to the name conventions (for classes, function, modules/packages etc) and have the names make sense (crystal clear what the variable is)

- ALWAYS write doc strings (for functions, classes etc.) with a general description and input/output variables

- comment as much as necessary, but not redundantly!