Computational optimisation of optical projection tomography for 3D image analysis
Tang, X.

Citation
Tang, X. (2020, June 10). *Computational optimisation of optical projection tomography for 3D image analysis*. Retrieved from https://hdl.handle.net/1887/106088

Version:	Publisher's Version
License:	[Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)
Downloaded from:	https://hdl.handle.net/1887/106088

Note: To cite this publication please use the final published version (if applicable).

Cover Page

The handle http://hdl.handle.net/1887/106088 holds various files of this Leiden University dissertation.

Author: Tang, X.
Title: Computational optimisation of optical projection tomography for 3D image analysis
Issue Date: 2020-06-10

Summary

Optical projection tomography (OPT) is a tomographic 3D imaging technique used for specimens in the millimetre scale. 3D images are computed from a tomogram and therefore OPT is considered as computational imaging. In order to provide imaging and image analysis solutions for large scale biomedical research, optimisation of the OPT reconstruction is required. The aim of the optimisation presented in this thesis includes: (1) accelerate the reconstruction process; (2) reduce the reconstruction artefacts; (3) improve the image quality of 3D image; (4) Find optimal parameters for the iterative reconstruction.

Starting from the optimisations that we have elaborated and implemented in the OPT imaging workflow, we have worked on case studies in zebrafish imaging. In this thesis we present one such particular case study (5) as it falls nicely in the order of magnitude for specimens in OPT imaging. The case study is on quantification of tumours in zebrafish and it is explored with image segmentation and object detection using artificial intelligence (AI) techniques.

The acceleration of the reconstruction process (ad. 1) aims to reduce the time of imaging process from tomogram to reconstruction. This supports biomedical research in high-throughput or large-scale imaging. In our work, we accelerate the OPT 3D reconstruction by implementing filtered back projection (FBP) in a parallel manner. In this thesis, we refer to this approach as fast reconstruction. With our (current) computational resources users are able to acquire a millimetre scale whole-mount 3D image in several minutes.

The reduction of the artefacts in OPT reconstruction (ad. 2) aims to provide a 3D solution of reconstruction with less artefacts that are introduced during the reconstruction process as a result of limitations of the reconstruction algorithm and the imaging setup. In this thesis, two different types of artefacts are covered, i.e. ring artefacts and streak artefacts. With respect to these artefacts, both the cause and the solution are addressed in this thesis. In the FBP algorithm, the ring artefacts are introduced by the misalignment of centre of rotation (CoR), whilst the streak artefacts are results of absence of sufficient signal in a tomogram. As a solution, a CoR correction algorithm is proposed in the FBP reconstruction framework. In order to eliminate the streak artefacts, iterative reconstruction is explored in OPT imaging.

The improvement of the image quality of an OPT 3D image (ad. 3) in this thesis aims to find a method for deblurring of the reconstructed images. This is done by deconvolving the 3D image with an empirically derived point spread function (PSF). The qualitative and quantitative comparisons of the results that are obtained with our deconvolution method illustrate the effectiveness of the improvements that are accomplished.

The Optimisation of the parameters for iterative reconstruction (ad. 4) aims at gaining the best possible 3D images suitable for segmentation and detection of structures within the sample. This is essential for the signal quantification, e.g. tumour quantification in the later developmental stages. The most customary parameters including iteration number and initial reconstruction are explored and optimised based on the segmentation performance of corresponding reconstructions.

The case study on tumour quantification (ad. 5) demonstrates an application of the optimised OPT imaging system. Compared to 2D quantification, we expect to provide some new insights to the tumour quantification in 3D for drug research. Based on the samples we have available for tumour quantification, we conclude that the relative ratio of tumour to a specific organism or organ in 3D, is much smaller than that in 2D. This to a large extent justifies the reason why the OPT 3D imaging is necessary for specimens in the millimetre scale. Supported by more computational resources and advanced analytical techniques, we are confident about its prospect and popularity of OPT in the area of biomedical research.