# Ray Tracing for Refractive Index Matching Free Optical Projection Tomography

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Optical projection tomography (OPT) is a three-dimensional (3D) volumetric imaging technique that looks into the internal structures and details of an object such as the shapes of biological tissues [1], the dose distribution of a gel dosimeter [2], the flow maps of blood cells in a circulatory system [3] etc. It is well-known as the optical version of x-ray computed tomography (XCT), which reconstructs the object in 3D from the projection views collected from different viewing angles.

OPT is normally operated using visible or near-infrared light instead of x-rays which can penetrate through the objects in straight lines, which means that it is subject to refraction effects. This is usually overcome by immersing the target in an index matching material which has the same or at least a very similar refractive index to the target, so that light travels through the object along straight paths. However, depending on the object's refractive index, such an index matching material may not be easy to obtain, and the preparation procedure can be complex. We are investigating reconstruction techniques with the aid of ray tracing for a custom-built OPT system operated without applying index matching material to strongly refracting objects.

A conventional OPT system consists of a collimated light source for illumination, a motion control system to rotate the object, and a camera for image capturing. In our custom-built OPT, the normal camera object lens is replaced by a telecentric lens. This allows to minimize the optical distortion and more importantly, all the light received by the camera can be treated as parallel beams. This benefits our OPT system in ray tracing process because we can trace the rays backwards from the known, parallel exit ray directions. All the light paths through the object are detected and calculated so that the projection data can be back projected along the right ray paths. From there on out it is a matter of applying known reconstruction techniques like FBP [4] or iterative reconstruction [5] to reconstruct a volumetric rendering of the sample.

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[3] A. Bassi, L. Fieramonti, C. D'Andrea, M. Mione and G. Valentini, "In vivo label-free three-dimensional imaging of zebrafish vasculature with optical projection tomography," *Journal of Biomedical Optics,* vol. 16, no. 10, p. 100502, 2011.

[4] G. L. Zeng, "Basic Principles of Tomography," in *Medical Image Reconstruction: A Conceptual Tutorial*, Springer, 2010, pp. 1-19.

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