OPTICAL PROJECTION TOMOGRAPHY:
3D MICROSCOPY OF EMBRYOS & ORGANS

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Optical Projection Tomography (OPT) [1] is a recently developed implementation of computed tomography (CT) techniques at optical frequencies. A series of 2D optical projections through a sample are generated at varying orientations, from which the 3D structure of the sample can be computationally reconstructed.

OPT is especially suitable for samples from about 0.5 mm to 15 mm in size, which fills an important “imaging gap” between techniques such as confocal microscopy (useful for smaller samples) and large-sample methods such as x-ray CT or microscopic magnetic resonance imaging (µMRI). In addition, since OPT can function in both fluorescence and transmission modes, it can take advantage of the great variety of general and feature-specific contrast mechanisms that have been developed in optical microscopy over the last century. This enables, for example, the visualization of multi-dimensional gene expression patterns in whole mouse embryos (see Fig. 1), which has been a valuable tool for the progress of the Edinburgh Mouse Atlas Project. [2]

The general principles of OPT, including the optical implementation and data processing required for generation of the 3D reconstructions, will be described. Applications, including imaging fixed, cleared vertebrate embryos and adult organs, and monitoring the 4D development of live embryonic tissue, will be given.

Figure 1. Left: orthogonal projections through the reconstructed volumetric data set of a neurofilament-labelled E11.5 mouse embryo. Right: virtual tomographic sections through the 3D reconstruction at planes A & B, indicated by the arrowheads to the left.