

In radiotherapy, a deformable image registration method will be one of the key components that pave the road to the implementation of 4D treatment planning and dose delivery. An easy to use, robust, no control points, no user intervention required, voxel-to-voxel, 3-dimensional deformable image registration program called 3D optical flow method (OFM) has been developed. The 3D OFM algorithm is based on two constraints: 1. the intensity of a point does not change between images; 2. nearby points move in a similar manner. The program has been benchmarked with a 4D phantom image set with 1D motion of known displacement. The maximum error of voxel's motion estimate is 1.1 mm or approximately one third of the z-dimension voxel size. The program has been used in many radiotherapy applications, including mapping of contours for tumors and anatomical structures over 4D CT image sets, the summing of dose from component 3D dose distributions calculated on 4D CT (multi-phase) image sets for 4D dosimetry, the mapping of the dose distribution from treatment planning CT to post-treatment PET/CT. 3D OFM can also provide a tool in 4D CT data QA, in which the residual motion in each phase data set can be measured by the widths of the peaks in the displacement histogram calculated by OFM. In summary, the 3D OFM algorithm provides a link from 4D back to 3D for a variety of radiotherapy applications.