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Registration of 3-Dimensional Image Stacks showing Rapidly Contracting Muscles

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Summary

Motorized fluorescence microscopy systems allow biologists to visualize the morphological changes of living cells and tissues during development. However, rapid movements of certain tissues such as muscles result in misalignments between successive optical sections even if the 3D stacks are acquired with high speed laser scanning confocal microscopes. Most of the existing image stacks alignment software are aimed at the alignment of images displaying rigid objects on single channel or converted graylevel images. However, live muscles are non-rigid objects and their contractions and dilations represent non-linear transformations that cannot be properly corrected by applying purely linear registration methods. Moreover, conversion from color images to grayscale makes individual channels information lost, hence the registration based on converted grayscale images are inaccurate. We used live fluorescent marker proteins to label the cytoplasm and nucleus of muscle cells in different colors, and recorded two-channel images stacks of muscles during metamorphosis in the fruit fly Drosophila melanogaster. To improve the alignment of image stacks for our application, we developed a dual-channel image stack registration method that is based on the Thin Plate Spline transformation function which consists of both linear and non-linear transformation. In our experiments, our algorithm outperforms several evaluated commercial and non-commercial image registration software.