Postprocessing and Cross Validation

Basics of Imaging Processing

Basics of Image Processing: Image Registration and Object Tracking

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Learning Objectives:

To learn about the following aspects of image registration:

- Image transformations (rigid and nonrigid)
- Image similarity metrics and optimization
- Motion correction and deformation analysis
- Multimodal registration and visualization

To learn about the following aspects of object tracking:

- Particle detection and tracking methods
- Cell segmentation and tracking methods
- Supra-analysis of tracking results
- Applications of tracking in microscopy

Imaging is playing an increasingly important role in both medicine and biology. Structural imaging modalities such as MRI, CT, and ultrasound provide detailed depictions of anatomy. PET, SPECT, and specialized MRI protocols add functional information. Optical imaging modalities, such as bioluminescence imaging and various types of light microscopy, offer an unprecedented sensitivity in visualizing molecular processes in living cells and organisms. The heterogeneity and sheer bulk of image data generated by the wealth of imaging possibilities make it impossible for a human observer to interpret and quantify the complex relationships between molecular processes and the structural and functional changes they cause. Molecular imaging studies typically involve data from multiple imaging modalities, covering a wide range of spatial and temporal scales. Differences in imaging geometry, posture, and information content occur between modalities, but also between time points in follow-up studies using the same modality. In this educational session we will discuss two important image processing techniques required to interrelate imaging data and to study dynamic phenomena occurring in these data: image registration and object tracking. Rather than going into details about available software tools, the focus will be on understanding the underlying image processing principles used by many software tools.

Relevant Publications:
The following publications are useful reviews on image registration (first three) and object tracking (last three):

1. Pluim JPW, Maintz JBA, Viergever MA. Mutual-information-based registration of medical images: A survey. IEEE Transactions on Medical Imaging 22(8):986-1004, August 2003.

2. Zitová B, Flusser J. Image registration methods: A survey. Image and Vision Computing 21(11):977-1000, October 2003.
3. Hill DLG, Batchelor PG, Holden M, Hawkes DJ. Medical image registration. Physics in Medicine and Biology 46(3):R1-R45, March 2001.
4. Meijering E, Dzyubachyk O, Smal I. Methods for cell and particle tracking. Methods in Enzymology 504:183-200, February 2012.
5. Meijering E, Dzyubachyk O, Smal I, van Cappellen WA. Tracking in cell and developmental biology. Seminars in Cell and Developmental Biology 20(8):894-902, October 2009.
6. Dorn JF, Danuser G, Yang G. Computational processing and analysis of dynamic fluorescence image data. Methods in Cell Biology 85:497-538, 2008.

This educational session is the second in a series of three sessions on the basics of image processing: 1) image segmentation (presented by Wiro Niessen in Session 1), 2) image registration and object tracking (presented by Erik Meijering in Session 2), and 3) basics of image processing (presented by Arvind Pathak in Session 3).

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