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OSSI proposal: WarpSpeed to accessible registration

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Motivation

The registration of biological images is a crucial part of many analyses. This proposed work will make state-of-the art image registration methods more FAIR (findable, accessible, inoperable, reusable). Especially important is our goal of making these tools more accessible to non-expert users by improving user-interfaces, software infrastructure, and documentation.

Automated registration methods work well for some applications but not others, especially inter-modality (e.g. CLEM) tasks. Most tools do not provide convenient user-interfaces, relying on command-line tools or APIs with software developers in mind. Finally, parameter tuning is usually necessary to achieve good results, but to do so effectively requires specialized knowledge and experience with the algorithm. As a result, these methods are not accessible to non-experts.

Manual registration is necessary for users and tasks where automatic methods are inadequate. We developed BigWarp, a tool for non-linear manual registration (Bogovic, Hanslovsky, Wong, and Saalfeld 2016). BigWarp has played a critical role for many Janelia projects across several labs and imaging modalities (Zheng et al. 2018; Gao et al. 2019; Wan et al. 2019; Hoffman et al. 2020; Scheffer et al. 2020; Weigel et al. 2021). Most of these research projects required custom scripts to perform their analyses. Time constraints prevent these useful features from being documented or integrated into BigWarp as built-in features. Dedicated support by the Open Source Software Initiative would remove this constraint, inform new users of those currently undocumented features, and empower them to perform analyses without expert help or customization.

Finally, software for registration and spatial transformations are not interoperable. Tedious and technical steps are required to import transformations created in one library to another. This proposal will begin the integration of currently disparate software, starting with BigWarp, TrakEM2 (Cardona et al. 2012), and elastix (Klein et al. 2010).

Goals and milestones

The proposed work will expose advanced features of BigWarp and elastix to users in an accessible way.

Findability / Accessibility

Features that already exist as will be integrated into BigWarp, and documented such that they are findable and accessible. We also propose UI improvements that will make applying transformations more user-friendly and accessible.

1. Document / integrate existing features (1 month).
    (a) Deformation visualization and analysis.
    (b) Transform points and regions-of-interest.
    (c) Visualization and quantification of deformation.
2. Improve UI for image export (1 month).

Interoperability

The tasks below will make BigWarp, TrakEM2, and elastix more interoperable by making transformation generated by elastix and TrakEM2 readable by BigWarp. This will make the usability improvements proposed for BigWarp applicable to TrakEM2 and elastix users as well.

1. Import transformations from (1 month):
    (a) Affine transformations manually defined in Bigdataviewer
    (b) Transformations created in TrakEM2.
    (c) Affine and deformable transformations from elastix.
    (d) Displacement fields (stored as flat images or our H5 specification)
    (e) Transformations stored using the upcoming NGFF specification.
2. Built-in export of transformations to displacement fields and NGFF specification (1 month).

New features

This work will add new capabilites to BigWarp, making it applicable to new tasks, and speeding up common workflows for typical users (1–3). We will integrate with and extend the work of (Chiaruttini 2021) to remove the technical and conceptual hurdles making elastix accessible (4–5). We chose elastix because we have found it provides accurate automatic registration at high speed.

1. Enable manual 2D to 3D registration (1 month).
2. Add automatic methods (e.g. SIFT) to generate initial landmarks (1 month).
3. Enable users to interact with / concatenate transformations from new and external sources via converters described in Interoperability (1 month).
4. Develop an accessible user-interface enabling interactively running elastix from BigWarp. (2.5 months).*

5. Develop a system enabling the tuning of elastix's parameters by non-experts by using intuitive terms: "close/far from correct", "over/under-warped" (2.5 months).

Requirements, synergies, and scope

We estimate this proposal is one person-year's worth of work, with about half of that effort spent on the most challenging and high risk task of making elastix more accessible (points 4 and 5 in *New features*. The work involved requires programming experience in Java, best practices for software development, writing for both technical and general audiences, and some exposure to image analysis.

A lower-risk, smaller scope project could be derived from this by omitting the high risk task 4 and 5 in *New features* (marked by asterisks) which account for about half of the effort.

The proposed work synergizes well with the 4D Cellular Physiology research area. Currently challenging CLEM registration tasks, essential for 4DCP, will be simplified and accelerated for Janelia researchers as well as visitors collecting CLEM images at the AIC. The proposed interoperability improvements will accelerate and simplify the distortion correction workflow for confocal microscopy that is in regular use by the FlyLight team; thereby providing another notable benefit to the wider Janelia community.

References

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