DEFORMABLE REGISTRATION:

WHAT TO ASK WHEN ASSESSING THE OPTIONS

White Paper

MIRADA

The Imaging Software People

Deformable Registration:
What to ask when assessing the options

This document is intended to address some of the key questions to consider when investigating deformable image registration.

These questions were compiled by Dr. Marc Kessler, University of Michigan, and Dr. Jean Pouliot, University of California, and discussed during their talk entitled 'Deformable Image Registration, Contour Propagation and Dose Mapping: 101 and 201', presented at the AAPM 2013[1].

1 http://amos3.aapm.org/abstracts/pdf/77-22594-311436-91622.pdf

General Questions

Is your method freeform or based on a mathematical model (e.g. B-Splines)?

At Mirada, we believe that a single approach to registration cannot adequately address all registration problems. Therefore, we have developed two classes of registration algorithms, and have carefully tuned these to be appropriate for different registration tasks.

Mirada's "CT Deformable" algorithm uses a freeform deformation.

Mirada's "Multi-modal Deformable" uses a Radial Basis Function model.

What are the degrees of freedom of the approach (e.g. 3x# B-spline knots, DVF)?

Both algorithms are adaptive in the degrees of freedom used depending on field-of-view, modality pair, and image resolution. Mirada optimizes each algorithm preset per use-case based on data provided by clinical customers.

What is the "goodness of match" metric that drives the registration?

Mirada's "CT Deformable" algorithm uses a robust least squares similarity measure. This is robust to variations in Hounsfield units and imaging artifacts. Mirada's "Multi-modal Deformable" uses a Mutual Information like similarity function.

What type of regularization do you use to keep the transformation "reasonable" and "useable"?

Both algorithms use diffusion partial differential equations (PDE) to keep the deformation field regularized. This is similar to elastic registration constraints. The degree of regularization is optimized for each clinical use-case. For example atlas-based contouring requires fewer constraints than dose warping.

Is there any other "secret sauce" you want to explain or even allude to?

Mirada introduced the first clinical deformable registration engine in 2002, and since then we have been working with users to continuously improve our registration. Consequently, there is a huge amount of internal optimization present to make the algorithms fast and importantly robust to a wide variety of use-cases and data. Both algorithms have many adaptive parameters that adjust according to the image pair (e.g. their resolution, dynamic range, etc.). We also have many registration presets that are tuned to specific use-cases (e.g. CT-MR) based on data provided by clinical customers.

Do you transfer / map structure outlines?

Yes. Mirada's unique Dynamic Contour Transformation technology enables us to map structures in real time, as you contour, allowing you to make use of all images while contouring.

Specific Questions

Do you transfer dose from one scan to another?

Yes. Mirada can transfer dose from one scan to another in either direction.

Do you support multiple registrations per pair of datasets? Rigid and Deformable?

Yes. Multiple registrations can be performed for each pair of datasets. This can be saved, loaded and switched between.

Do you support "limited field of view" clip boxes? Can these be based on anatomic structures?

Yes. Any shaped region of interest can be defined, including existing RT Structure sets, and used for local registration.

How do you map / interpolate doses between datasets?

Tri-linear interpolation is used to map doses between datasets. This can be performed at the resolution of the new dataset, or at the same resolution as the original dose volume.

Can you export the resulting transformation? What about the interpolated image data?

Yes. Transformations (both rigid and deformable) can be exported in the DICOM format, following the Spatial Registration Object specification. Resampled images can be exported in DICOM format.

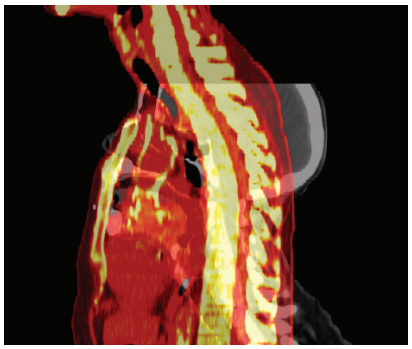
What tools do you have to assess the accuracy of registration?

Since Fusion 7D was released in 2002, Mirada has provided tools for assessing deformable registration. These tools include overlays, insets, deformation field displays and measurements.

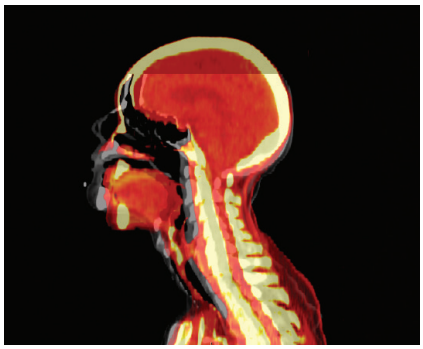
Do you provide tools to document the results? Can you "lock and sign" a registration?

We provide built-in reporting tools that can be used to document the result. We can write immutable registration objects that cannot be changed and also session objects that can be "signed" and never changed. These objects are stored in DICOM format and can be archived in PACS or similar.

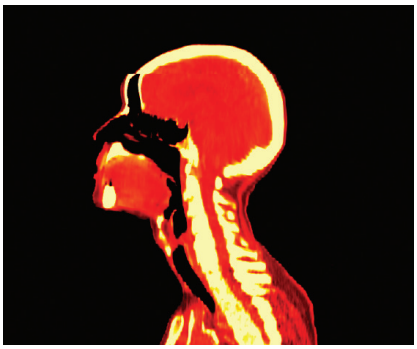
A comparison of Mirada's registration to other commercial algorithms can be found in the 'Why Mirada registration' document.



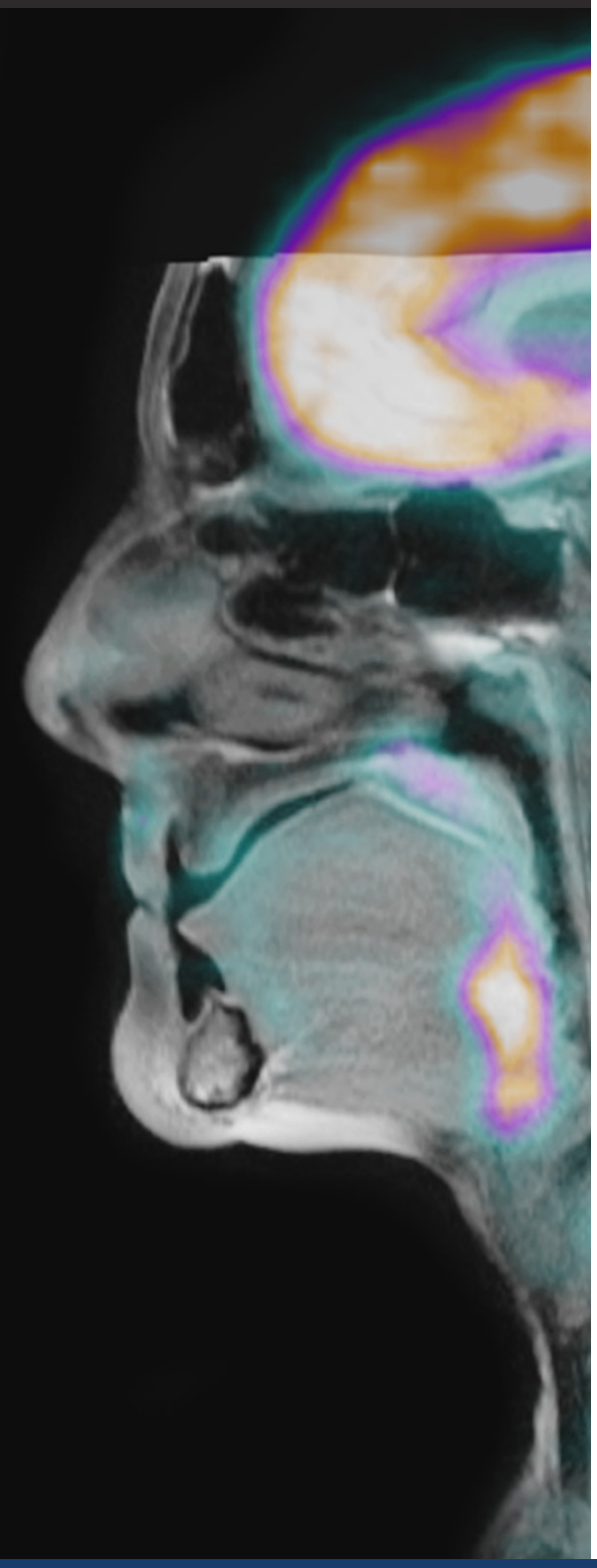
Un-registered planning CT and diagnostic CT



After rigid registration



After deformable registration



About Mirada

Mirada Medical develops medical imaging software applications that provide simple and accessible solutions to complex image analysis problems in the diagnosis and treatment of cancer and other diseases. Through automation, our products improve consistency and productivity while enabling clinicians to deliver more personalized care. By combining deep learning technology with our thorough understanding of the challenges faced in oncology today, Mirada is leading the development of next generation imaging software and decision support products. Our staff are passionate about using their expertise to help our customers provide better healthcare for more patients.

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