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Medical Image Registering: A Matlab Based Approach

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***Abstract:-* This paper shows the image registering with multi model 3-D medical images by the use of the Matlab inbuilt functions like imregister, imregtform and imwarp to automatically align two volumetric datasets: a CT image and a T1 weighted MR image collected from the same patient at different times. Unlike some other techniques, imregister and imregtform do not find features or use control points. Intensity-based registration is often well-suited for medical and remotely sensed imagery. Also, use imregister to automatically align two magnetic resonance images (MRI) to a common coordinate system using intensity-based image registration. Unlike some other techniques, it does not find features or use control points. Intensity-based registration is often well-suited for medical and remotely sensed imagery.**

***Keywords:--* 3-D Geometric Transformation, Initial Registration, Intensity-based registration, Retrospective Image Registration Evaluation(RIRE)..**

I. INTRODUCTION

The goal of registration is to align the moving image with the fixed image. In this example, the fixed image is a T1 weighted MRI image. The moving image that we want to register is a CT image. The data is stored in the file format used by the Retrospective Image Registration Evaluation (RIRE) Project.

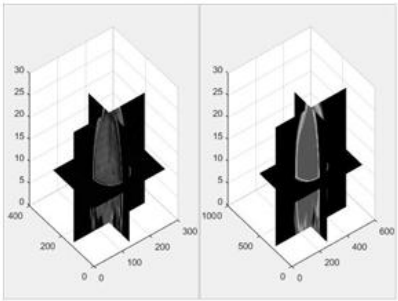
A. Registering Multimodal 3-D Medical Images

Intensity-based registration is often well-suited for medical and remotely sensed imagery.

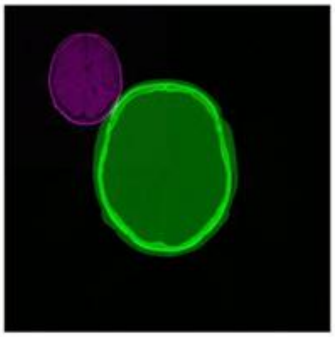
Intensity-based image registration Algorithm:
Step 1: Load Images
Step 2: Set up the Initial Registration
Step 3: Get 3-D Geometric Transformation That Aligns Moving With Fixed.
Step 4: Apply Geometric Transformation Estimate To Moving Image Volume.

Step 1: Load Images

This example uses two 3-D images of the same patient's head. In registration problems, we consider one image to be the fixed image and the other image to be the moving image. The goal of registration is to align the moving image with the fixed image. In this example, the fixed image is a T1 weighted MRI image. The moving image that we want to register is a CT image. The data is stored in the file format used by the Retrospective Image Registration Evaluation (RIRE) Project. Use multiband read to read the binary files that contain image data.



By using imshowpair to look at single planes from the fixed and moving volumes to get a sense of the overall alignment of the volumes. In the overlapping image from imshowpair, gray areas correspond to areas that have similar intensities, while magenta and green areas show places where one image is brighter than the other. Use imshowpair to observe the misregistration of the image volumes along an axial slice taken through the center of each volume.



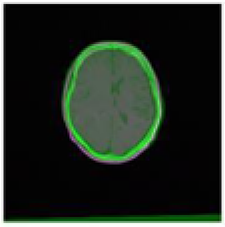
Step 2: Set up the Initial Registration

The imregconfig function makes it easy to pick the correct optimizer and metric configuration to use with imregister. These two images are from two different modalities, MRI and CT, so the 'multimodal' option is appropriate. The algorithm used by imregister will converge to better results more quickly when spatial referencing information about the resolution and/or location of the input imagery is specified. In this case, the resolution of the CT and MRI datasets is defined in the image metadata. Use this metadata to construct imref3d spatial referencing objects that we will pass as input arguments for registration.

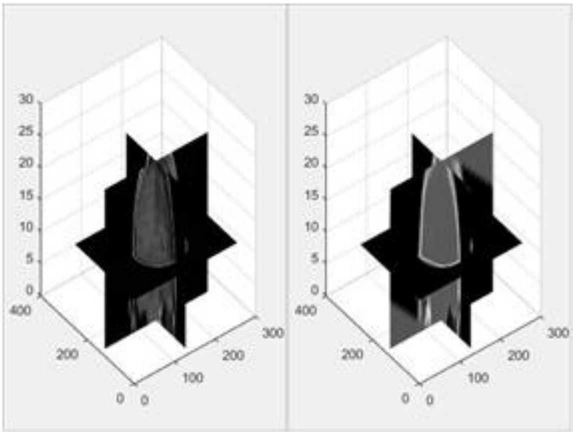
The properties of the spatial referencing objects define where the associated image volumes are in the world coordinate system and what the pixel extent in each dimension is. The XWorld Limits property of Rmoving defines the position of the moving volume in the X dimension. The PixelExtentInWorld property defines the size of each pixel in world units in the X dimension (along columns). The moving volume extends from 0.3269 to 334.97 in the world X coordinate system and each pixel has an extent of 0.6536mm. Units are in millimeters because the header information used to construct the spatial referencing was in millimeters. The ImageExtentInWorldX property determines the full extent in world units of the moving image volume in world units.

The misalignment between the two volumes includes translation, scaling, and rotation. Use a similarity transformation to register the images.Start by using imregister to obtain a registered output image volume that you can view and observe directly to access the quality of registration results.Specify a non-default setting for the InitialRadius property of the optimizer to achieve better convergence in registration results.

Use of imshowpair function again and repeat the process of examining the alignment of an axial slice taken through the center of the registered volumes to get a sense of how successful the registration is.



From the axial slice above, it looks like the registration was successful. Use helper Volume Registration again to view registered volume to continue judging success of registration.



Step 3: Get 3-D Geometric Transformation That Aligns Moving With Fixed.

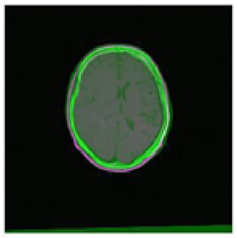
The imregtform function can be used when you are interested in the geometric transformation estimate that is used by imregister to form the registered output image. Imrege formuses the samealgorithm as imregister and takes the same input arguments as imregister. Since visual inspection of the resulting volume from imregister indicated that the registration was successful, you can call imregtform with the same input arguments to get the geometric transformation associated with this registration result. The result of imregtform is a geometric transformation object. This object includes a property, T, that defines the 3-D affine transformation matrix.

The transform Points Forward method of the geometric transformation can be used to determine where a point [u,v,w] in the moving image maps as a result of the registration. Because spatially referenced inputs were specified to imregtform, the geometric transformation maps points in the world coordinate system from moving to fixed. The transformPointsForward method is used below to determine the transformed location of the center of the moving image in the world coordinate system.

Use of the worldToSubscript method of Rfixed to determine the element of the fixed volume that aligns with the center of the moving volume.

Step 4: Apply Geometric Transformation Estimate To Moving Image Volume.

The imwarp function can be used to apply the geometric transformation estimate from imregtform to a 3-D volume. The 'OutputView' Name/Value is used to define a spatial referencing argument that determines the world limits and resolution of the output resampled image. You can produce the same results given by imregister by using the spatial referencing object associated with the fixed image. This creates an output volume in which the world limits and resolution of the fixed and moving image are the same. Once the world limits and resolution of both volumes are the same, there is pixel to pixel correspondence between each sample of the moving and fixed volumes.

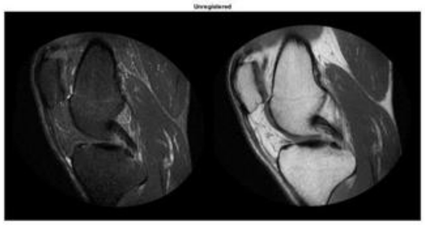


B. Registering Multimodal MRI Images

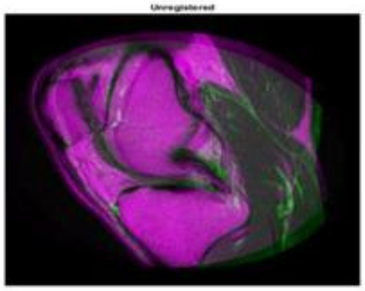
Intensity-based image registration Algorithm:
Step 1: Load Images
Step 2: Set up the Initial Registration
Step 3: Improve the Registration
Step 4: Use Initial Conditions to Improve Registration
Step 5: Deciding When Enough is Enough Step 6: Alternate Visualizations

Step 1: Load Images

This example uses two magnetic resonance (MRI) images of a knee. The fixed image is a spin echo image, while the moving image is a spin echo image with inversion recovery. The two sagittal slices were acquired at the same time but are slightly out of alignment. The imshowpair function is a useful function for visualizing images during every part of the registration process. Use it to see the two images individually in a montage fashion or display them stacked to show the amount of misregistration.

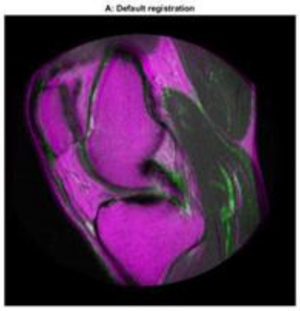


In the overlapping image from imshowpair, gray areas correspond to areas that have similar intensities, while magenta and green areas show places where one image is brighter than the other.



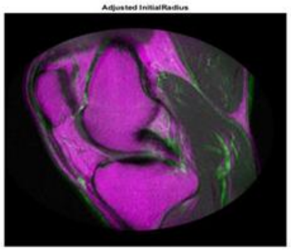
Step 2: Set up the Initial Registration

The imregconfig function makes it easy to pick the correct optimizer and metric configuration to use with imregister. These two images have different intensity distributions, which suggests a multimodal configuration. The distortion between the two images includes scaling, rotation, and (possibly) shear. Use an affine transformation to register the images.It's very, very rare that imregister will align images perfectly with the default settings. Nevertheless, using them is a useful way to decide which properties to tune first.



Step 3: Improve the Registration

The initial registration is not very good. There are still significant regions of poor alignment, particularly along the right edge. Try to improve the registration by adjusting the optimizer and metric configuration properties.The optimizer and metric variables are objects whose properties control the registration. The InitialRadius property of the optimizer controls the initial step size used in parameter space to refine the geometric transformation. When multi-modal registration problems do not converge with the default parameters, the InitialRadius is a good first parameter to adjust. Start by reducing the default value of InitialRadius by a scale factor of 3.



Adjusting the Initial Radius had a positive impact. There is a noticeable improvement in the alignment of the images at the top and right edges.The MaximumIterations property of the optimizer controls the maximum number of iterations that the optimizer will be allowed to take. Increasing the MaximumIterations allows the registration search to run longer and potentially find better registration results.

Further improvement in registration were achieved by reusing the InitialRadius optimizer setting from the previous registration and allowing the optimizer to take a large number of iterations.

Step 4: Use Initial Conditions to Improve Registration

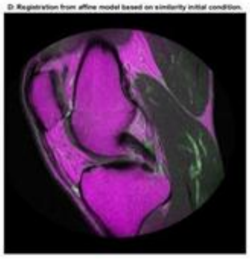
Optimization based registration works best when a good initial condition can be given for the registration that relates the moving and fixed images. A useful technique for getting improved registration results is to start with more simple transformation types like 'rigid', and then use the resulting transformation as an initial condition for more complicated transformation types like 'affine'.[5]

The function imregtform uses the same algorithm as imregister, but returns a geometric transformation object as output instead of a registered output image. Use imregtform to get an initial transformation estimate based on a 'similarity' model (translation,rotation, and scale).

The previous registration results showed in improvement after modifying the MaximumIterations and InitialRadius properties of the optimizer. Keep these optimizer settings while using initial conditions while attempting to refine the registration further.

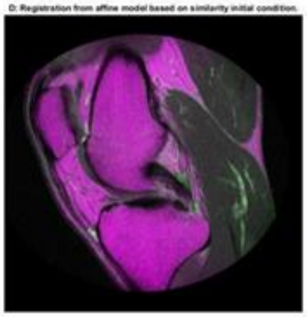
Because the registration is being solved in the default MATLAB coordinate system, also known as the intrinsic coordinate system, obtain the default spatial referencing object that defines the location and resolution of the fixed image.

Use imwarp to apply the geometric transformation output from imregtform to the moving image to align it with the fixed image. Use the 'OutputView' option in imwarp to specify the world limits and resolution of the output resampled image. Specifying Rfixed as the 'OutputView' forces the resampled moving image to have the same resolution and world limits as the fixed image.


D: Registration from affine model based on similarity initial condition.

The "T" property of the output geometric transformation defines the transformation matrix that maps points in moving to corresponding points in fixed.

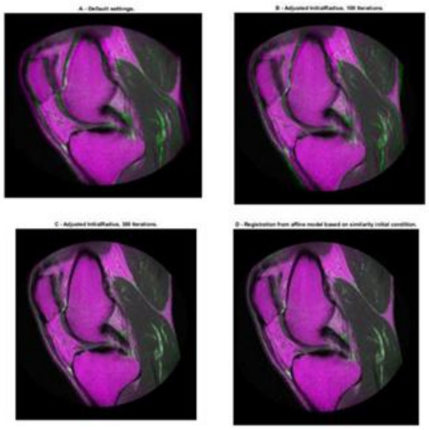
Use the 'Initial Transformation' Name/Value in imregister to refine this registration by using an 'affine' transformation model with the 'similarity' results used as an initial condition for the geometric transformation. This refined estimate for the registration includes the possibility of shear.


D: Registration from affine model based on similarity initial condition.

Using the 'InitialTransformation' to refine the 'similarity' result of imregtform with a full affine model has also yielded a nice registration result.

Step 5: Deciding When Enough is Enough

Comparing the results of running imregister with different configurations and initial conditions, it becomes apparent that there are a large number of input parameters that can be varied in imregister, each of which may lead to different registration results.


A - Default settings.
B - Adjusted InitialRadius, 100 Iterations.
C - Adjusted InitialRadius, 300 Iterations.
D - Registration from affine model based on similarity initial condition.

It can be difficult to quantitatively compare registration results because there is no one quality metric that accurately describes the alignment of two images. Often, registration results must be judged qualitatively by visualizing the results. In The results above, the registration results in C) and D) are both very good and are difficult to tell apart visually.[6]

Step 6: Alternate Visualizations

Often as the quality of multimodal registrations improve it becomes more difficult to judge the quality of registration visually. This is because the intensity differences can obscure areas of misalignment. Sometimes switching to a different display mode for imshowpair exposes hidden details.[7]

CONCLUSION

Thus, this paper describes the use of imregister Matlab inbuilt function to automatically align two magnetic resonance images (MRI) to a common coordinate system using intensity-based image registration. Unlike some other techniques, it does not find features or use control points. Intensity-based registration is often well-suited for medical and remotely sensed imagery.

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