MRI Modality Transformation in Demon Registration

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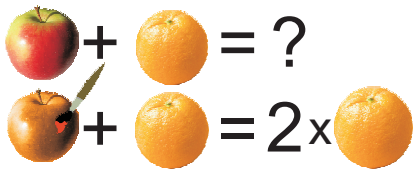


Abstract

Demon registration which behaves likes fluid registration cannot deal with multiple MRI modalities. We introduce a MRI modality transformation which changes the representation of a T1 scan into a T2 scan using the maxima in joint histograms to allow registration.

Thirion: Demon Registration

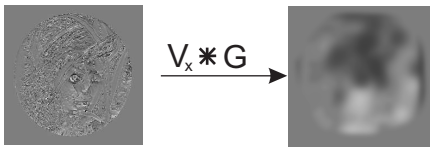
Optical Flow: conservation of the intensity of points under motion can be used to approximate the velocity of points between 2 movie frames f and m.

$$\mathbf{v} = \frac{(f-m)\nabla f}{|\nabla f|^2}$$

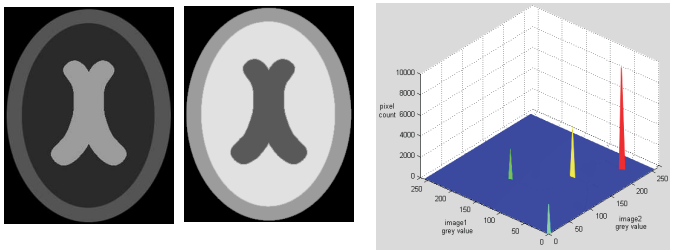
This optical velocity equation is reversed and rewritten by Thirion et al. to define the pixel velocity field which can be used to register two images:

$$\mathbf{u} = \frac{(m-f)\nabla f}{|\nabla f|^2 + \alpha^2(m-f)^2} + \frac{(m-f)\nabla m}{|\nabla m|^2 + \alpha^2(m-f)^2}$$

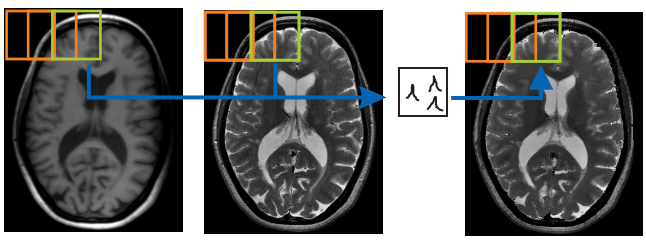
The movement of the pixels is based on very local information during registration. To get global registration, the velocity field is Gaussian smoothed and iteratively used to update the pixel locations.



Modality Transformation



The maxima of a mutual histogram of two images, can be used to convert the region gray level representation in one image into the representation of the other image.



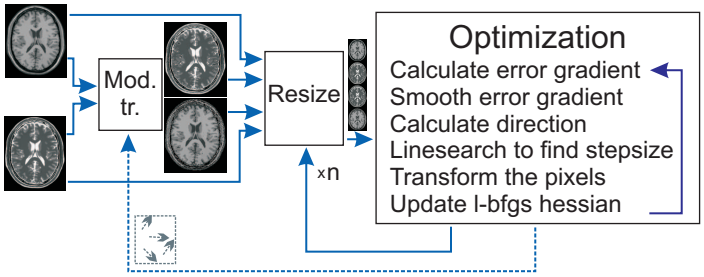
Demon Minimizer Equations

$$E = \frac{1}{2}\|F_T - M \circ (S+U)\|^2 + \frac{1}{2}\|F - M_T \circ (S+U)\|^2 + \frac{\sigma_i^2}{\sigma_x^2}\|U\|^2$$

$$\nabla E = (M_T \circ S - F)\left(\frac{\nabla F}{|\nabla F|^2 + \alpha^2(M_T \circ S - F)^2}\right) + (M \circ S - F_T)\left(\frac{\nabla M}{|\nabla M|^2 + \alpha^2(M \circ S - F_T)^2}\right)$$

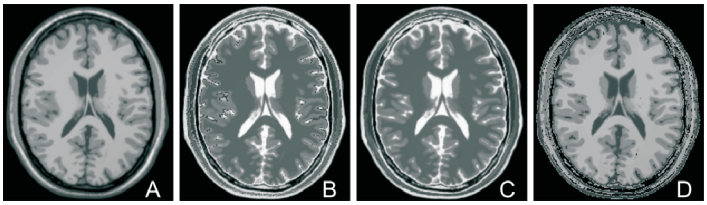
E	Registration error	F_T	Mod. transformed static image
S	Transformation field	M_T	Mod. transformed moving image
U	Trans. field update	$\circ$	Move / translate pixels

Flow Chart

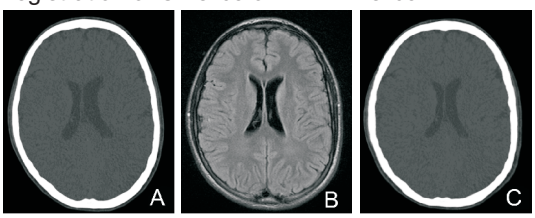


Results

Modality transformation of T1 into T2 and visa versa



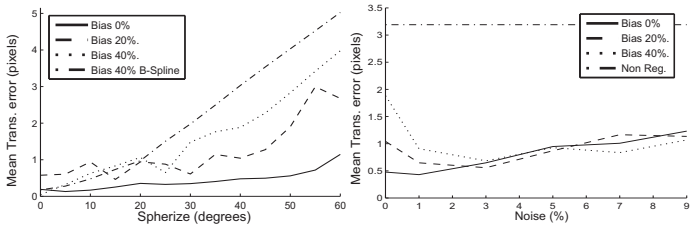
Registration of CT slice on MRI T1 slice



Registration between T1 and T2 brain slice with varying spherical distortion. Different bias fields and comparison to b-spline registration.

Registration of T1 on T2 brain slice with varying noise.

Rician statistical noise. Percentage % is ratio of standard deviation Gaussian noise versus signal reference tissue.



Conclusions

- Demon registration can better deal with non smooth deformations than b-spline registration of Rueckert.
- Registration is robust to noise.
- Registration times are approximately the same as those of b-spline transformation.