

Purpose

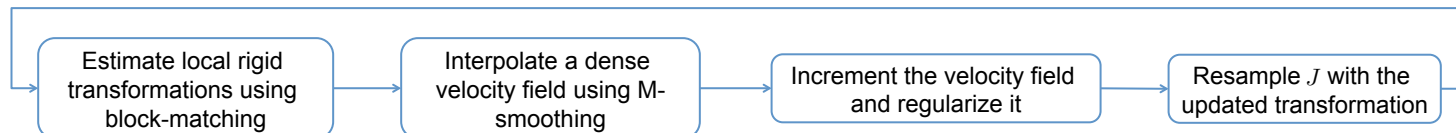
New approach towards the registration of anatomical structures with rigid parts

- Able to handle large rotations (e.g. cervical MRI in different positions)
- Robust estimation of a diffeomorphic transformation.



Material and Methods

Overall block-matching algorithm to register image J onto image I



Details

Local rigid transformations estimation [1]

$$R = (R_1, \dots, R_m) \leftarrow \text{block-matching}(I, J \circ T^{l-1})$$

- Constrained, derivative-free optimization: BOBYQA [2]

Resampling of J for next iteration: $J \circ \exp(LT^l)$

- Addition of velocity fields [4]: $LT^l = LT^{l-1} + \delta LT$
- Elastic-like regularization: $LT^l \leftarrow G_\nu * LT^l$

M-smoothing interpolation $\delta LT \leftarrow \text{M-smooth}(R)$

- Output: dense field of rigid transformations logarithms $\log S_i$
- Computations in the log-Euclidean framework [3]
- Robust to local outliers among R

M-smoothing iterative update equation

$$\log S_i^{k+1} = \frac{\sum_{j \in V_i} w_j \rho'(\|\log S_i^k - \log R_j\|^2) d(\|v_i - v_j\|^2) \log R_j}{\underbrace{\sum_{j \in V_i} w_j \rho'(\|\log S_i^k - \log R_j\|^2)}_{\text{Tonal weights}} \underbrace{d(\|v_i - v_j\|^2)}_{\text{Spatial weights}}}$$

Experiments

Dynamic cervical MRI

- T2 datasets (384x384x14, 0.8x0.8x3 mm³)
- 10 patients with traumatic cervical cord injury
- Acquired in flexion, neutral and extension positions
- Reference landmarks placed on vertebrae
- C1 – C3 – C6 – T1 (T4 when available)

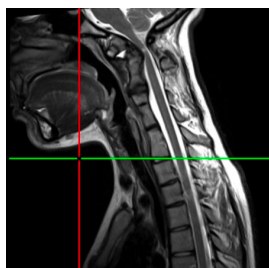
Comparison of 4 registration methods

- M1 : global rigid registration
- M2 : M1 followed by diffeomorphic demons [4]
- M3 : M1 followed by our method
- M4 : M2 followed by our method

Results



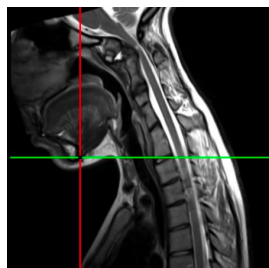
Reference Image



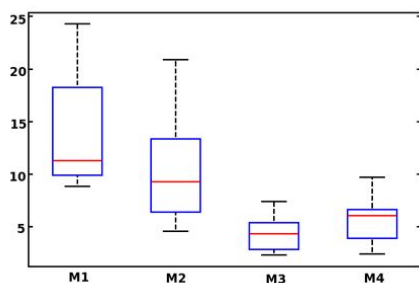
Floating Image (M1)



Floating Image (M2)



Floating Image (M3)



Landmark registration errors (mm)

Conclusion

- Registration of structures with rigid parts
- Block-matching with rigid transformations
- M-smoothing: robust extrapolation of update velocity field
- Log-Euclidean framework [3]
 - Diffeomorphic transformation
- Quantitatively better than other methods on longitudinal cervical MRI registration
- Future works
 - Other regions (e.g. brain)
 - Combination with other regularization techniques

[1] Commowick et al. Block-Matching Strategies for rigid registration of multimodal medical images. ISBI 2012, pp. 700-703.

[2] M.J.D. Powell. The BOBYQA algorithm for bound constrained optimization without derivatives. Technical Report. 2009.

[3] V. Arsigny et al. A Fast and Log-Euclidean Polyaffine Framework for Locally Linear Registration. JMIV, 33(2):222-238, 2009.

[4] T. Vercauteren et al. Symmetric log-domain diffeomorphic registration: A demons-based approach. MICCAI 2008, pp 754-761.