XIII JORNADA DE JÓVENES INVESTIGADORES/AS DEL I3A

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EPDIFF-JF-NET: ADJOINT JACOBI FIELDS FOR DIFFEOMORPHIC REGISTRATION NETWORKS

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(1) Large deformations diffeomorphic metric mapping (LDDMM)

•Diffeomorphism that minimizes energy E(v) between images I_0 (source) and I_1 (target):

$$E(v_0) = \langle L v_0, v_0 \rangle_{L^2} + \frac{1}{\sigma^2} \| I_0 \circ (\phi_1^v)^{-1} - I_1 \|_{L^2}^2,$$

s.t. Euler-Poincare differential equation (EPDiff):

$$\partial_t v_t + ad_{v_t}^{\dagger} v_t = 0 \text{ in } \Omega \times (0,1],$$

•High computational complexity. Current deep-learning aproaches are either supervised or non-geodesic.

(2) Adjoint Jacobi Fields

•Computing $\nabla_{v_0} E(v_0)$ is costly, but computing $\nabla_{v_1} E(v_0)$ is straightforward.

•Perform Parallel Transport with Reduced Adjoint Jacobi Fields:

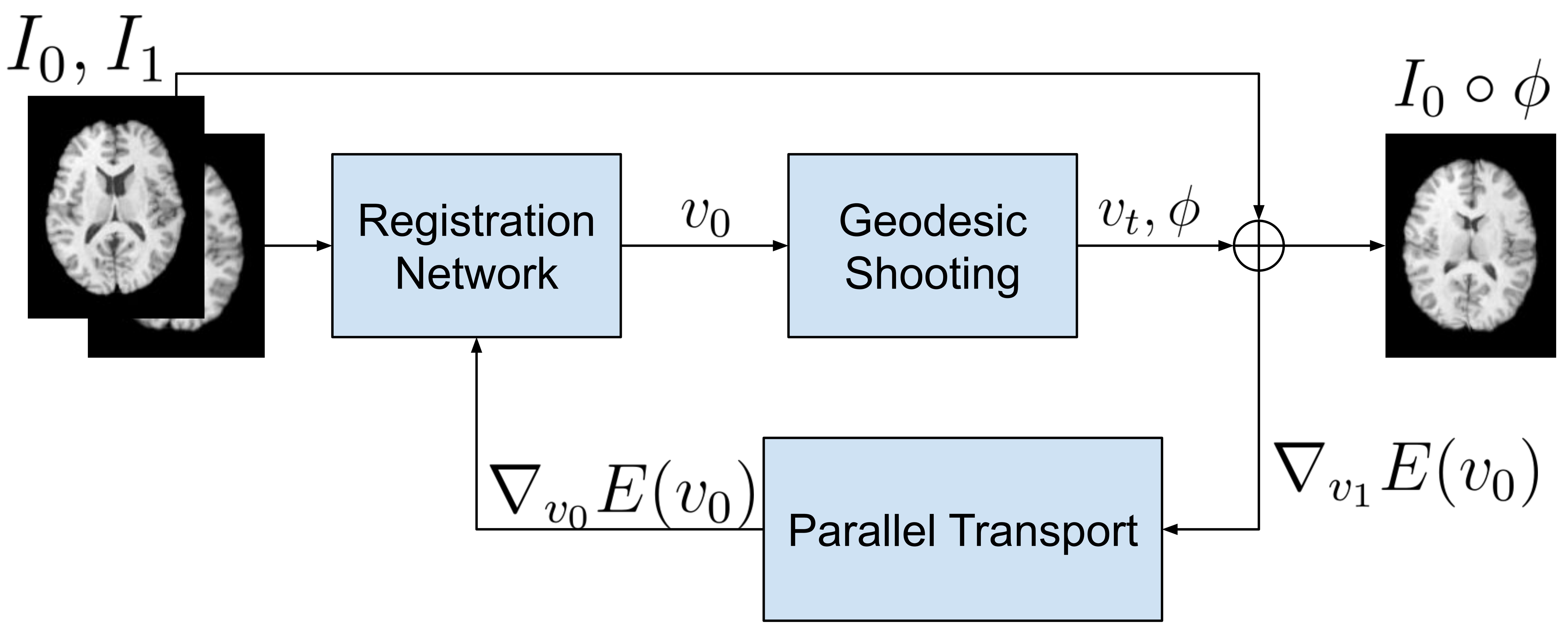
$$\partial_t U_t + ad_{v_t}^{\dagger} U_t = 0 \text{ in } \Omega \times (0,1],$$

$$\partial_t w_t - ad_{v_t} w_t + ad_{w_t}^{\dagger} v_t + U_t = 0 \text{ in } \Omega \times (0,1],$$

•Final gradient expresion:

$$\nabla_{v_0} E(v_0) = 2 v_0 + w(0).$$

(3) Parallel Transport Registration Framework



•Registration Network predicts initial velocity field v_0.

•Use geodesic shooting to compute v_t and ϕ, use parallel transport to compute final gradient $\nabla_{v_0} E(v_0)$.

•Back-propagate gradient through the network as usual to train it.

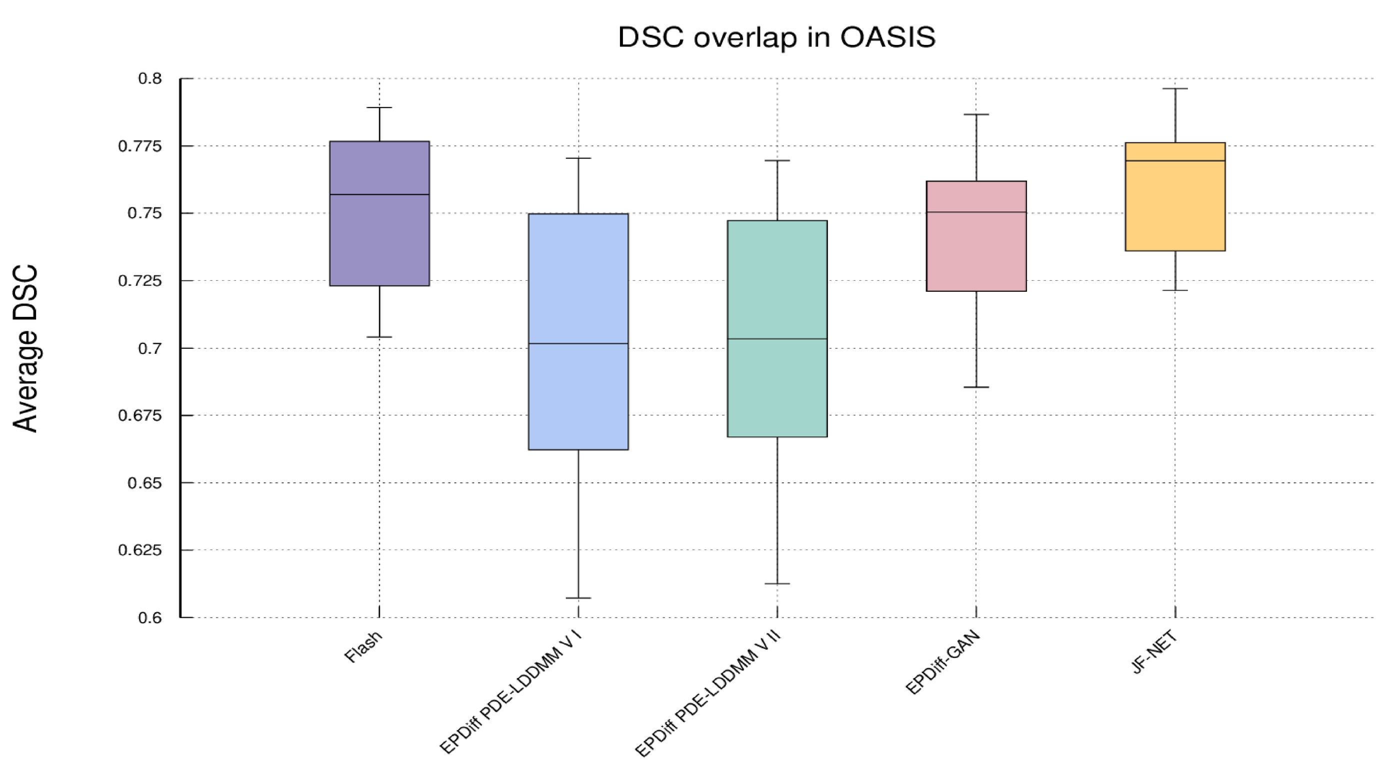
•Multi-resolution CNN architecture, 3 identical levels, each level takes results from the previous level:

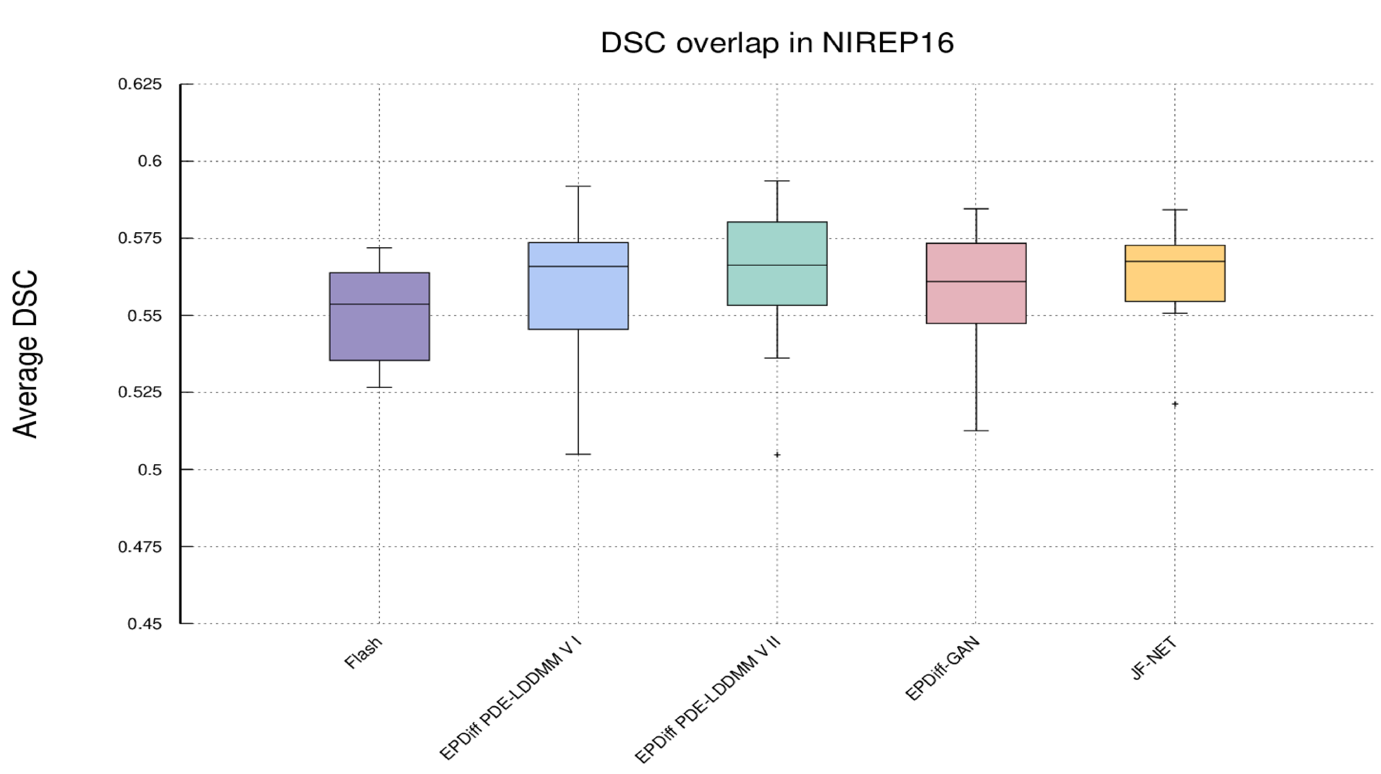
$$L(I_1, I_0, v_0) = \sum_{\ell \in [1..3]}^{\ell} L_{JF}(I_1^{\ell}, I_0^{\ell}, v_0^{\ell}),$$

$$L_{JF}(I_1, I_0, v_0) = \langle L v_0, v_0 \rangle_{L^2} + \frac{1}{\sigma^2} lNCC(I_1, I_w),$$

(4) Experiments and Results

•OASIS dataset with 414 T1-weighted brain MRI images, with automatic segmentations. NIREP16 dataset 16 images, with manual segmentations.





•We obtain State-of-the-art results on two independent brain MRI datasets.

•Our method features low inference times making it a promising tool for large-scale computational anatomy studies.