Multilabel Random Walker Image Segmentation Using Prior Models

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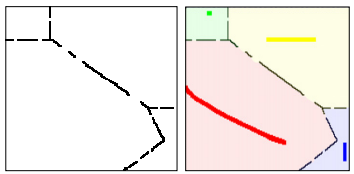
Multilabel Random Walker image segmentation

Recently developed seeded segmentation algorithm

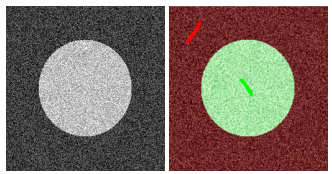
Saturated colors indicate seeds
Color shading or orange lines indicate segmentation result

Properties

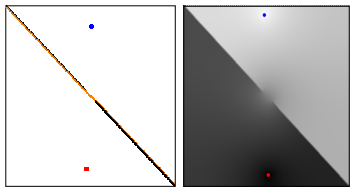
Finds weak (missing) boundaries



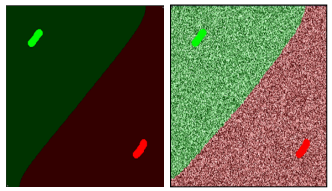
Provably robust to noise



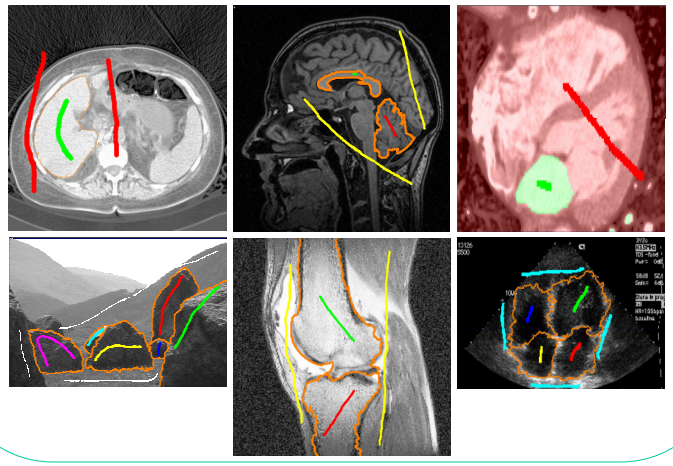
Provides confidence of segmented pixel/voxel



For uniform or pure noise, finds central partition



Examples



Problem

An image with many objects requires seeding in each object

Main idea

Build intensity model, formulate as quadratic energy term:

$$x_i^s = \frac{\lambda_i^s}{\sum_{q=1}^{k} \lambda_i^q}$$

x_i^s probability that node v_i belongs to label s (of k total labels/objects)

λ_i^s prior probability that the intensity at node v_i belongs to label s

In vector notation: $$\left(\sum_{q=1}^{k} \Lambda^q\right) x^s = \lambda^s$$

$$E^s_{\text{prior}}(x^s) = \sum_{q=1, q\neq s}^{k} x^{qT} \Lambda^q x^q + (x^s - 1)^T \Lambda^s (x^s - 1)$$

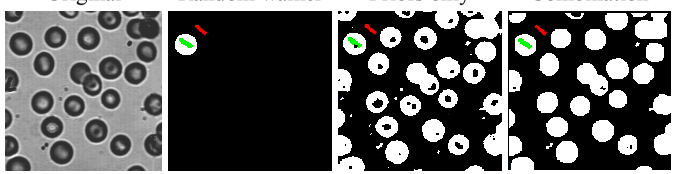
Joint energy minimization with original random walker:

$$E^s_{\text{Total}} = E^s_{\text{random walker}} + \gamma E^s_{\text{prior}}$$

$$E^s_{\text{random walker}} = x^{sT} L x^s$$

Minimum achieved by solving a SPD system of linear equations

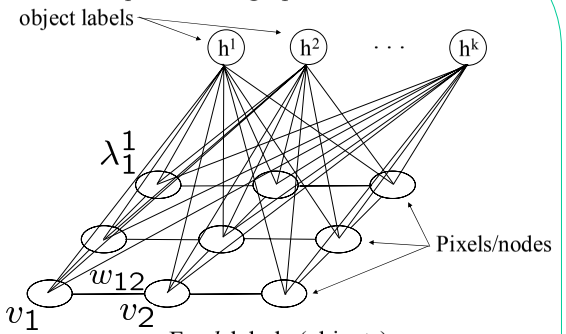
Original | Random walker | Priors only | Combination



Given priors, no seeds are necessary!

Graph interpretation

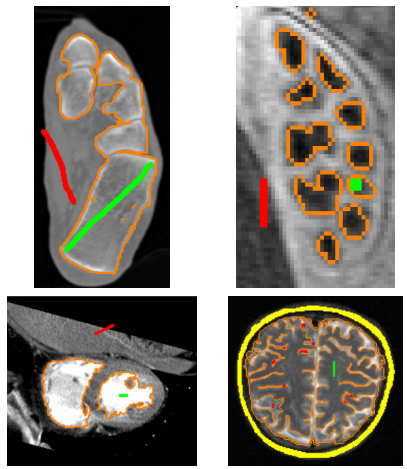
Equivalent to graph modification



For k labels (objects)

v_i node/pixel i

λ_1^1 prior probability that node v_1 belongs to label h^1

w_{12} weight between nodes v_1 and v_2

Results