Fast Random Walker with Priors using Precomputation for Interactive Medical Image Segmentation

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THINKING OF THE WORLD

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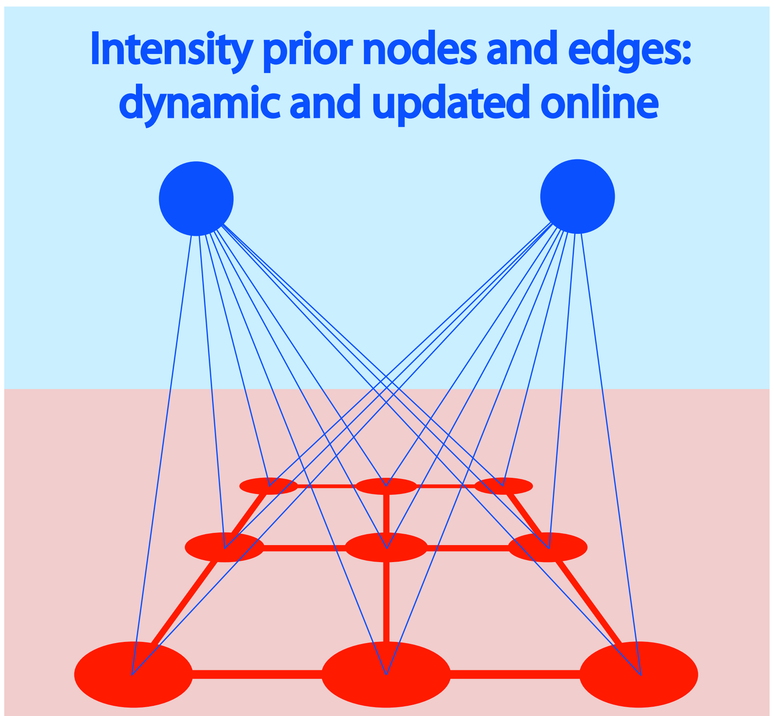
Random Walker with Priors



- Random walker (RW) algorithm [1, 2] segments images using user-given seed pixels
- RW calculates random walk probabilities on a weighted graph constructed from an image, and includes intensity priors as new nodes
- Without priors, [3] shows how to speed this calculation using offline precomputation
- This allows the user to update seeds and see the results interactively
- With intensity priors, the graph changes as the seeds change, so a new precomputation scheme is needed to maintain interactivity

Key Contributions

- By extending the precomputation method from [3] to work with a dynamic image graph, we achieve interactive speeds while still incorporating intensity priors
- Using additional precomputation, we minimize the number of computations between matrices of size O(# of unseeded pixels).
- Code available at **fastrw.cs.sfu.ca**

References

[1] L. Grady. Multilabel random walker image segmentation using prior models. *IEEE CVPR*, 1:763–770, June 2005.

[2] L. Grady. Random walks for image segmentation. *IEEE TPAMI*, 28(11):1768–1783, 2006.

[3] L. Grady and L. Kemal Sinop. Fast approximation random walker segmentation using eigenvector precomputation. *IEEE TPAMI*, 2008.

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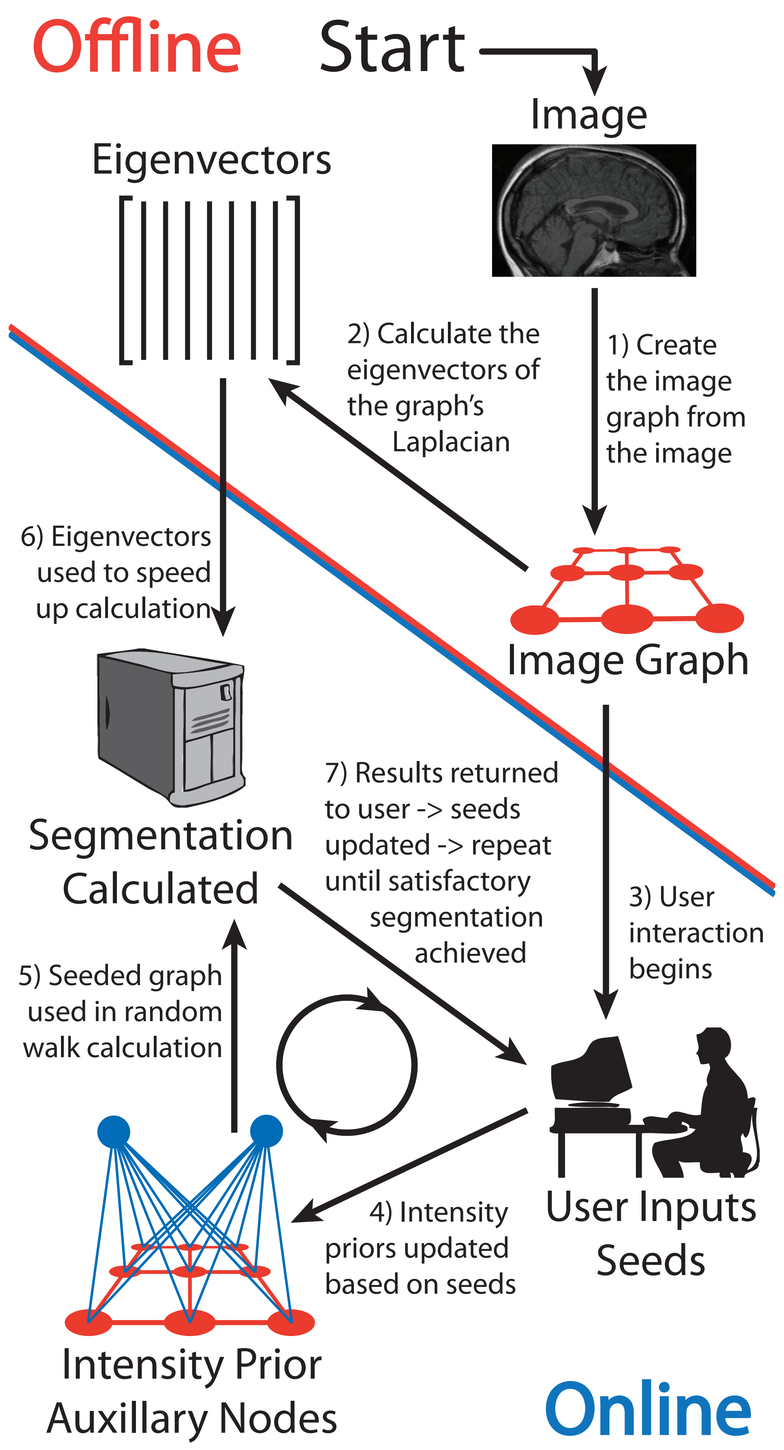
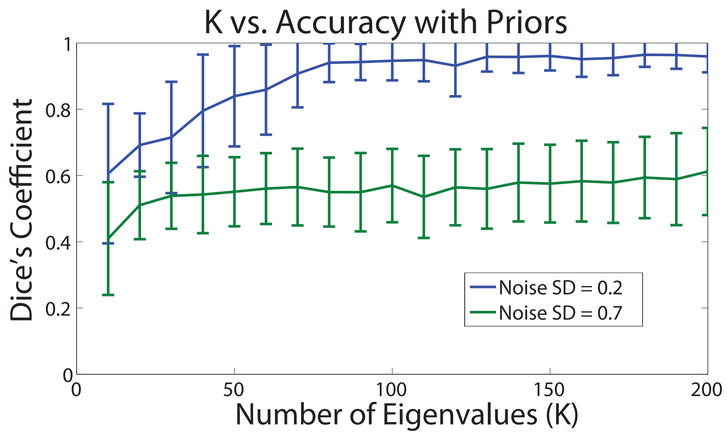
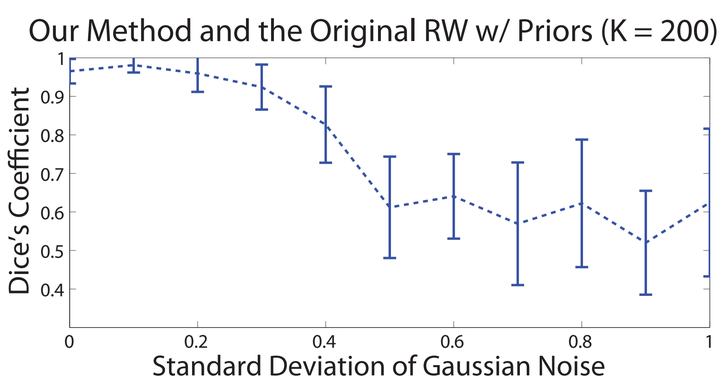
Process



Noise Analysis



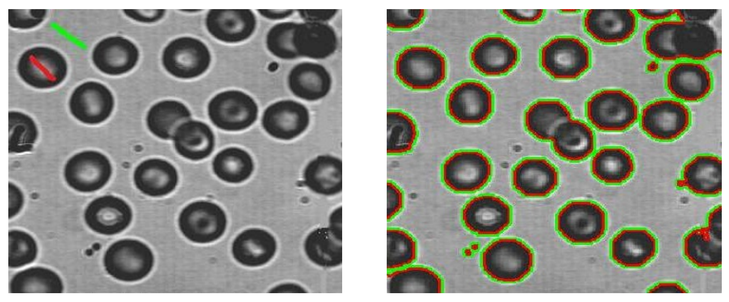
(a) Dice vs. K



(b) Dice vs. Noise

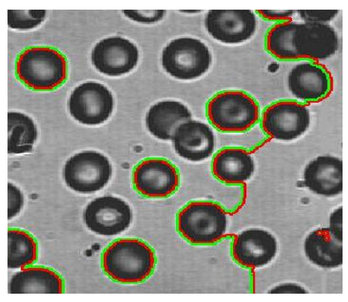
Effect of K and noise on segmentation accuracy. (a) compares the Dice similarity coefficient between the segmentations found using the original method and our method. (b) shows the Dice similarity coefficient between the segmentations at varying levels of noise.

2D Results

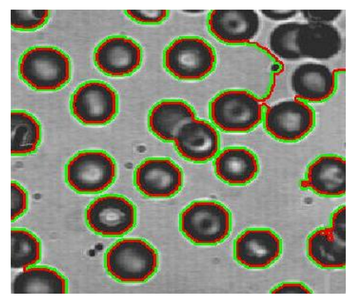


Seeds

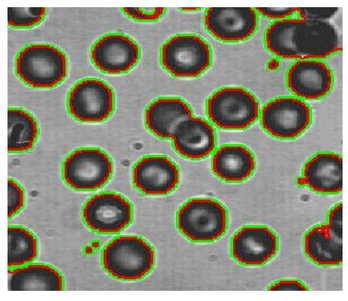
Without Precomp.
Time taken $= 0.552$ s



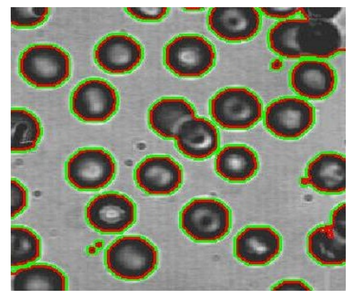
$K = 20$, $Dice = 0.585$
Time taken $= 0.043$ s



$K = 40$, $Dice = 0.962$
Time taken $= 0.063$ s



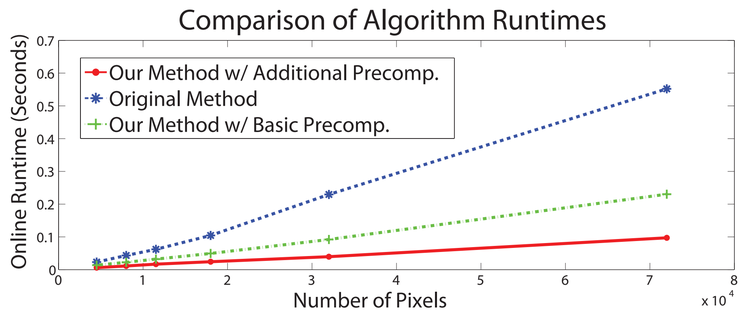
$K = 80$, $Dice = 0.996$
Time taken $= 0.097$ s



$K = 160$, $Dice = 0.998$
Time taken $= 0.178$ s

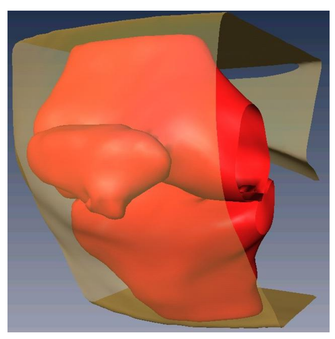
A comparison of results with and without precomputation. Note that for $K = 80$, our method finds a segmentation with Dice similarity coefficient 0.996 to the original RW in about $1/6^{th}$ the time.

Runtimes

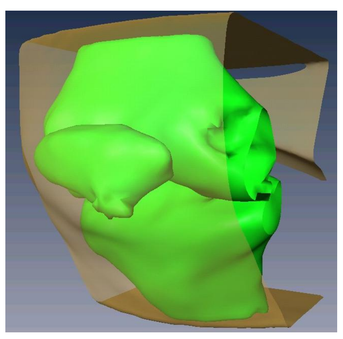


Runtimes of original and proposed methods.

3D Results



(a) Without Precomp.



(b) With Precomp.

The CT scan of a femur, tibia, and patella segmented with seeds placed only in the tibia.The original RW finds (a) in 40.5 sec and for $K = 350$, our method finds (b) with Dice similarity coefficient 0.975 to (a) in 1.56 sec, $1/25^{th}$ the time.