A Fully Automatic Random Walker Segmentation for Skin Lesions in a Supervised Setting

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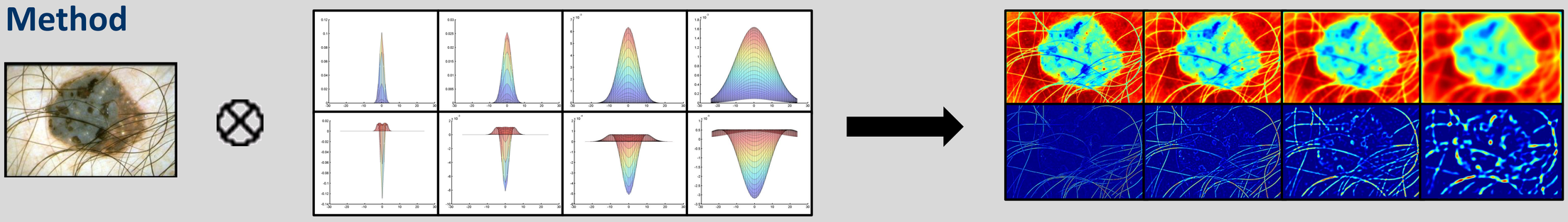
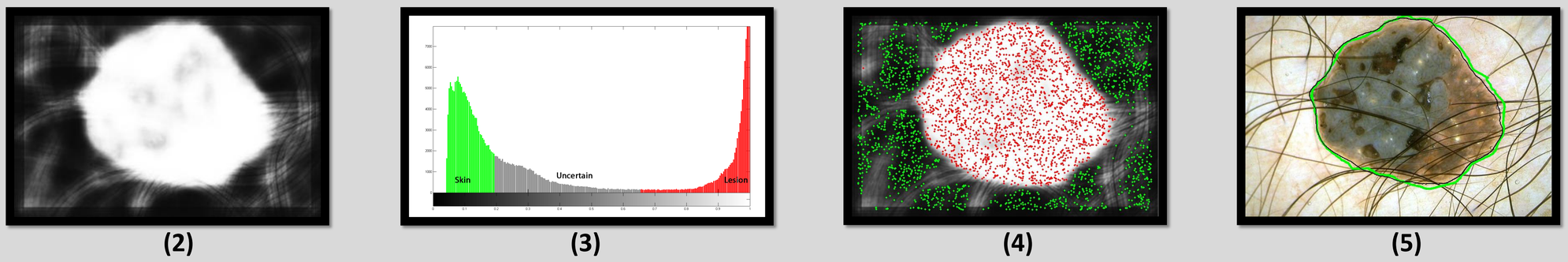
Introduction

1. **We've developed a fully automatic skin lesion segmentation method by leveraging:**
   - **Texture metrics**
   - **Supervised learning**
   - **The random walker algorithm [1]**
2. **We validate our method using a challenging set of images where:**
   - **Contrast between skin and lesion is low**
   - **Lesion border is not clearly defined (Fuzzy Border)**
   - **The entire border is not visible in the lesion**
   - **There is considerable occlusion (hair or oil)**
   - **There are many different colours present**

Method



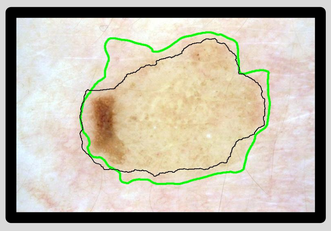
1. **Texture features are created by convolving the images with a filterbank consisting of Gaussian and Laplacian of Gaussian filters.**

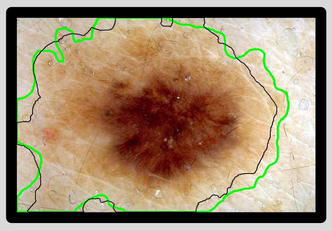


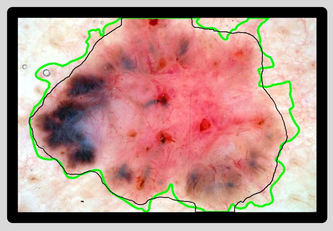
(2) (3) (4) (5)

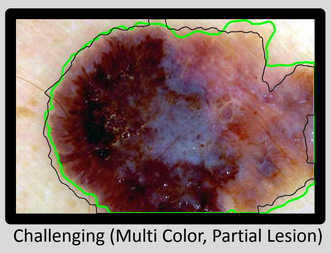
2. **Using expertly labeled ground truth and Linear Discriminant Analysis (LDA) the optimal linear combination of texture features which separates the groups of pixels (into lesion/background) is determined. The probability that each pixel belongs to the lesion is computed.**
3. **A histogram analysis of these 'probability images' determines candidate seed points. We fit a Gaussian Mixture Model to the histogram and extract the dominant Gaussians that represent the certain skin and lesion boundaries.**
4. **Seed points are placed and the random walker algorithm [1] is used to segment the lesion.**
5. **For the uncertain values Random Walker method labels the pixels.**

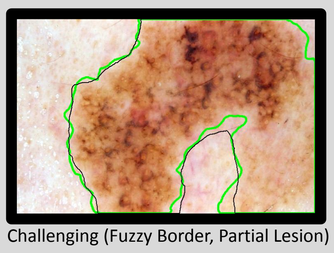
Results

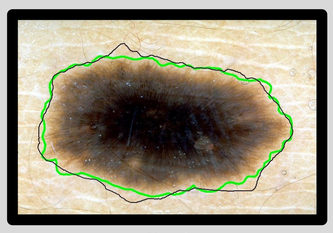

Challenging (Low Contrast, Multi Color)

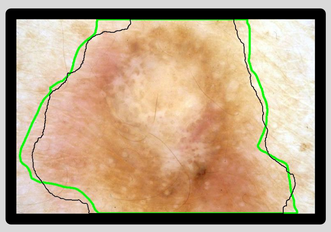

Challenging (Fuzzy Border)

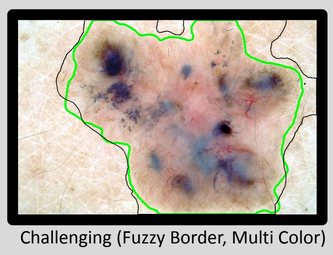

Challenging (Multi Color)


Challenging (Multi Color, Partial Lesion)


Challenging (Fuzzy Border, Partial Lesion)


Simple


Challenging (Low Contrast, Fuzzy Border)


Challenging (Fuzzy Border, Multi Color)

Legend
- Results
- Ground Truth

Comparison	Imageset	n	Precision	Recall	F-measure	Mean BE	Std BE
Ours vs. Derm	Simple	20	0.96	0.95	0.95	0.079	0.024
Ours vs. Derm	Challenging	100	0.83	0.90	0.85	0.31	0.19
Ours vs. Derm	Whole	120	0.87	0.92	0.88	0.24	0.18
Otsu vs. Derm	Simple	20	0.99	0.86	0.91	0.15	0.083
Ostu vs. Derm	Challenging	100	0.88	0.68	0.71	0.44	0.40
Otsu vs. Derm	Whole	120	0.91	0.74	0.78	0.34	0.36
Derm vs. Derm	Intra	10	0.95	0.91	0.93	0.085	0.036

Comparing the results of our method (Ours) to that of Otsu's thresholding method [2] (Otsu), and a dermatologist's manual segmentation which acts as ground truth (Derm). Comparisons are performed over simple and challenging imagesets taken from atlases of dermoscopy [3,4]. Border Error (BE) is defined in [5]. Remarks:

1. **The Otsu method consistently achieves a higher precision, however its recall is much worse. This implies that the Otsu method consistently underestimates the lesion border, labeling many pixels as 'skin' that ought to be labeled as 'lesion'.**
2. **When examining the more comprehensive metrics such as F-measure or border error, it is apparent that our method outperforms Otsu's method.**
3. **The poorer F-measure and border error results for the Otsu method on the challenging imageset is an indication its difficulty, as is the intra-observer agreement of two experts.**

References

1. Grady, L.: "Random walks for image segmentation". IEEE Transactions on Pattern Analysis and Machine Intelligence 28(11) (2006) 1768-1783
2. Otsu, N.: "A threshold selection method from gray-level histograms". IEEE Transactions on Systems, Man and Cybernetics 9(1) (Jan. 1979) 62-66
3. Argenziano, G., Soyer, H., et. al.: "Interactive Atlas of Dermoscopy (Book and CD-ROM)". Edra medical publishing and new media (2000)
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5. Hance, G., Umbaugh, S., Moss, R., Stoecker, W.: "Unsupervised color image segmentation: with application to skin tumor borders". Engineering in Medicine and Biology Magazine, IEEE 15(1) (Jan/Feb 1996) 104–111

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