Automatic Segmentation of Skin Lesions Using Multiscale Skeletons

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Aim
Automatic segmentation of skin lesions (e.g. naevi, melanoma) from surrounding healthy skin tissue is essential for designing effective and efficient computer-based methods for diagnosis and prognosis of melanocytic diseases.

Challenges
Fully automatic tumor segmentation is hard due to variability of several factors:
- tumor morphology (shape, size, structure, occluding hair)
- intrinsic image attributes (skin pigmentation, color, contrast)
- acquisition parameters (imaging devices, image resolution, lens deformation)

Contribution
We present a fully automatic method for skin lesion segmentation from healthy tissue. The method is based on a novel image representation: multiscale skeletons. We compared our automatic segmentation results with manual segmentations performed by dermatologists. The comparison showed a high similarity in terms of obtained segmentation results for all tested input images.

Discussion
Ease of use: Our proposed method is entirely automatic, requiring no user input.
Robustness: Testing all possible segmentations \( T_i \) of the input image eliminates all possible image acquisition biases (contrast, illumination, tint variation) and captures a wide tumor-structure variability. Smoothness: Inherent small-scale noise (e.g. small fractal-like boundary details [3]) is automatically eliminated by skeleton simplification but keeps key tumor features (e.g. size, outline, and shape [1,2,3]). Efficiency: Our entire pipeline is implemented using parallel graphics hardware, which delivers a performance of roughly 20 image-segmentations / second on a modern PC (for details, see [4]).

Ongoing Work
Quantification: Skeleton descriptors are arguably effective instruments to quantify all aggregated tumor features (e.g. ABCDE criteria). In particular they directly measure the ‘fractal dimension’ [3,5,6]. Analysis: The proposed multiscale segmentation and skeletal representation could be used to detect and measure more specific, finer-scale, tumor properties, e.g. the presence of specific structures (e.g. globular, cobblestone, atypical network and blue/grey pepper-like patterns). Comparison: Hausdorff distance metrics can be directly used to measure the segmentation quality [7].

Materials and Methods
We acquired over 50 images of a wide variety of naevi types using a Handyscope device at 2448 x 3264 pixels. After conversion to grayscale luminance images, we compute all possible segmentations \( T_i \) (1<i<255) of each image by luminance thresholding. Small islands (few pixels size) are next eliminated. Each possible segmentation \( T_i \) is next reduced to its so-called skeleton \( S_i \) [1]. Simplifying skeletons further removes small-scale noise from the segment boundary [2].

To validate our automatic segmentation pipeline, we compare our automatic segmentations \( I_{auto} \) with tumor segmentations \( I_{man} \) manually performed by dermatologists directly on the input images \( I \). A qualitative comparison of the two shows a high similarity, resistance to image-acquisition noise, insensitivity to the type of tumor structures, occlusion artifacts (hairs), image limits, and image acquisition parameters. The automatically computed segments exhibit the same smooth borders and tumor inclusion features shown by the manual segmentations - compare e.g. the segment \( A \) (automatically found) with the manually obtained segmentation \( I_{man} \) shown in the example below.

References
3. The Universal Dynamics of Tumor Growth (A. Bru, S. Albertos, J. Subiza, J. Garcia-Asenjo, I. Bru, Biophysical J., 85, 2948-2961)
5. Fractals and Cancer (J. Baish, R. Jain, Cancer Research 60, 2000, 3683-3688)

More details and software: http://www.cs.rug.nl/svcg/Shapes/SkinImaging