Qualitative Comparison of Multiscale Skin Tumor Segmentation Methods

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Context
Several computer-based methods exist for automatic segmentation of skin lesions (e.g. naevi, melanoma) from surrounding healthy tissue. However, a comparative study of the effectiveness and efficiency of such methods still lacks.

Aim
To better assess the pro’s and con’s of such methods, we performed a comparative qualitative study of four recent skin segmentation methods along three criteria:

- level of detail (how well the small-scale tumor-boundary details are captured)
- localization (how close is the segmentation to the perceived tumor boundary)
- ease of use (amount of manual input required and computational speed)

Materials and Methods
We acquired over 100 images of a wide variety of naevi types by several dermatoscopic imaging modalities. Next, we segmented the visible skin lesions using four computer-based techniques:

1. Dense multiscale skeletons (DMS) [1]
2. Learning vector quantization (LVQ) [9]
3. Gradient vector flow (GVF) [8]
4. Image foresting transform (IFT) [8]

Next, we compared the segmentation results between themselves, and also with manual lesion segmentations (MAN) performed by dermatologists. We also compared the computational time required for segmentation and the amount of user input needed by the computer-based methods.

Comparison Results

Discussion
Level of detail: IFT and DMS capture fine-grained tumor-border detail even for low-contrast images. In comparison, GVF - and even more so LVQ - considerably smooth out such details (similar to MAN).

Localization: The IFT and GVF contours follow the tumor borders best. In contrast, DMS yields a loose segmentation (quite far outside the tumor). LVQ has the loosest segmentation, which misses important tumor areas and/or encloses healthy skin (i.e. produce many false-positive and false-negative areas).

Ease of use: IFT requires some manual input (2..3 mouse clicks inside and outside the tumor), DMS also requires the user to manually select 2..3 peaks in its contour histogram [1]. In contrast, LVQ and GVF work fully automatically, with no user intervention whatsoever.

Speed: We benchmarked all methods on a 2.33 GHz PC (4 GB RAM, NVidia 690 GTX, Windows 7). For an image of 2448 x 3264 pixels (Handyscope [10]), the segmentation times are:

- GVF: 0.6 seconds (using a parallel CUDA implementation of [8])
- IFT: 3 seconds (using a CPU single-threaded implementation of [8])
- DMS: 5 seconds (using a parallel CUDA implementation of [1])
- LVQ: over 1 hour (using a Matlab implementation of [9])

Concluding, IFT and GVF offer the best prospects for fully automatic, near-real-time, and accurate segmentation of high-resolution skin lesion imagery to support future automatic diagnostic research.

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More details, results, and software tools: http://www.istuff.ro/research/melanoimage