Segmentation of Cell Images

With Application to

Cervical Cancer Screening

Pascal Christopher Bamford

M.Eng (Hons I, Electronics Engineering), Bristol University

Cooperative Research Centre for
Sensor Signal and Information Processing,
Department of Computer Science
and Electrical Engineering,
University of Queensland,
Brisbane, Queensland 4072, Australia.

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Statement of Originality

The work contained in this thesis is, to the best of my knowledge and belief, original, except as aknowledged in the text. This material has not been submitted, either in whole or in part, for a degree at this or any other university.

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Pascal Bamford

Abstract

This thesis develops image segmentation methods for the application of automated cervical cancer screening. The traditional approach to automating this task has been to emulate the human method of screening, where every one of the hundreds of thousands of cells on each slide is analysed for abnormality. However, due to the complexity of cervical smear images and the low error tolerance imposed upon the segmentation stage, only limited success has previously been found. A different approach is to detect *malignancy associated changes* (MACs) in a relatively small sample of the total population of cells. Under this paradigm, the requirement to segment every cell is loosened, but delineation accuracy and error checking become essential.

Following a review of generic and cervical smear segmentation, it is concluded that prior work on the traditional approach to automation is not suitable for a MACs solution. However, the previously proposed framework of a dual-magnification system is found to be relevant and is therefore adopted. Here, scene images are first captured at low resolution in order to rapidly locate the cells on a slide. Cells that are deemed to be suitable for further analysis are then imaged at high resolution for the more accurate segmentation of their nuclei.

A *water immersion* algorithm is developed for low resolution scene segmentation. This method achieves a rapid and robust initial segmentation of the scene without the requirement of incorporating extensive *a priori* knowledge of the image objects. A *global minimum searching contour* is presented as a *top-down* method for segmenting the high resolution cell nucleus images where the image objects are well characterised by shape and appearance. This latter method is tested upon 20,000 images and found to achieve an accurate segmentation rate of 99.47%. An error checking method, that uses segmentation *stability* as an indicator of segmentation success, is developed that is capable of detecting 100% of the failures of the nucleus segmenter, at the expense of discarding only 9% of the data.

Throughout this work, contemporary issues in the field of generic image segmenta-

tion are presented and some of these are addressed for the cervical smear application. Finally, an avenue of future work is proposed which may lead to the much wider proliferation of computer vision solutions to everyday problems.

Contents

List of Figures

List of Tables

Publications

The following is a list of publications that have been produced by the author during his Ph.D. candidacy:

Patents

1. Method of Unsupervised Cell Nuclei Segmentation. *International Patent Application No. PCT/AU99/00231.* International Filing date: 30/3/99. Priority date: 3/4/98 (PP2786)

Refereed Journal Papers

2. Pascal Bamford and Brian Lovell. Unsupervised cell nucleus segmentation with active contours. *Signal Processing Special Issue: Deformable Models and Techniques for Image and Signal Processing*, **71**(2), 1998.

3. P. Bamford and B. Lovell. A methodology for quality control in cell nucleus segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, In preparation.

Invited Refereed Conference Papers

4. Pascal Bamford, Paul Jackway, and Brian Lovell. Progress in the robust automated segmentation of real cell images. In *B. Pham and M. Braun and A. J. Maeder and M. Eckert, eds, 'Proceedings of the ARC Special Research Workshop on Automated Medical Image Analysis'*, Ballarat, Australia, July 1998. SPIE, Bellingham USA, pages 34–56.

Refereed Conference Papers

5. P. Bamford and B. Lovell. A methodology for quality control in cell nucleus segmentation. In *Proceedings of DICTA-99, Digital Image Computing: Techniques and Applications*, pages 21–25, Perth, December 1999.

6. P. Bamford and B. Lovell. Improving the robustness of cell nucleus segmentation. In Paul H. Lewis and Mark S. Nixon, editors, *Proceedings of the Ninth British Machine Vision Conference, BMVC '98*, pages 518–524, University of Southampton, England, UK, September 1998.

7. P. Bamford and B. Lovell. Bayesian analysis of cell nucleus segmentation by a viterbi search based active contour. In *Proceedings of the 14th International Conference On Pattern Recognition, ICPR'98*, pages 133–135, Brisbane, Australia, August 1998. IEEE Computer Society Press.

8. P. Bamford and B. Lovell. A two stage scene segmentation scheme for the automatic collection of cervical cell images. In *Proceedings of IEEE Tencon '97*, pages 683–686, Queensland University of Technology, Brisbane, December 1997.

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Refereed Workshops

10. P. Bamford and B. Lovell. A water immersion algorithm for cytological image segmentation. In *Proceedings of the APRS Image Segmentation Workshop*, pages 75–79, University of Technology Sydney, Sydney, December 1996.

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