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APPLICATION NOTE

Automated morphological analysis of bone marrow samples for leukemia diagnosis

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INTRODUCTION

Figure 1: Automated bone marrow analysis system

In order to analyze variations in a blood smear, a cytological bone marrow examination is required. This morphological evaluation is also used for the clarification of anemia, as exclusion of bone marrow affection of lymphoma and if there is suspicion of leukemia. Developments such as the demographic change and rising costs in the health care sector require the centralization and automation of the correspondent cytological examinations which are not possible at the moment. In order to support these processes for the analysis of bone marrow a prototypical microscope scanning and image analysis system has been developed.

MATERIALS AND METHODS

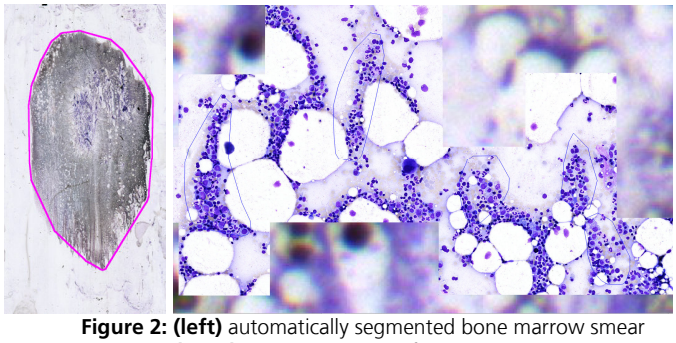

Figure 2: (left) automatically segmented bone marrow smear **(right)** virtual slide view of selected cell regions

The basis of the analysis system is an automated microscopy system for the scanning of MGG-stained bone marrow samples which are digitized as so-called virtual slides. At first the sample is scanned in low-resolution (1x objective). The bone marrow smear is localized automatically by a dedicated algorithm and the respective area on the slide is scanned again in intermediate resolution (5x). Based on these images suitable image regions are selected for further examination and are scanned in high resolution (40x).
Single bone marrow cells in cell clusters are located through a combination of numerical techniques for tracking interfaces and shapes, color segmentation algorithms and optimization strategies.

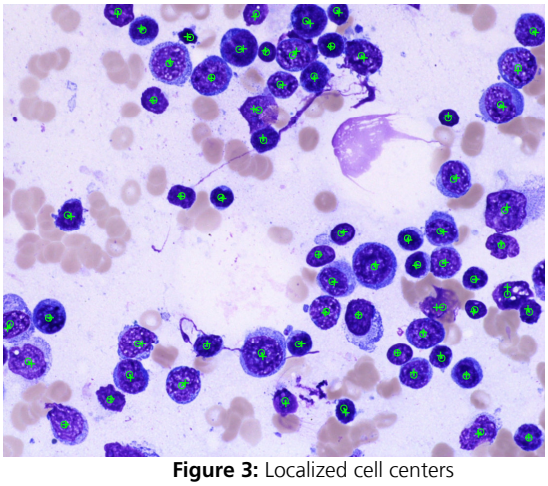

Figure 3: Localized cell centers
(+: automatically detected; o: manually annotated ground truth)

RESULTS

Our localization algorithm was evaluated with 400 high resolution images (40x) from 200 different bone marrow samples.
The annotated image database contains 57 cells per image on average and the manually selected cell positions are compared to the result of the automatic localization.
For that data set the sensitivity of the proposed algorithm was determined to be 97% with a false discovery rate of 7%.
The automatic nucleus / plasma segmentation (see Figure 4) is based on a patented level-set segmentation approach which is robust concerning color fluctuations in the bone marrow images [3].

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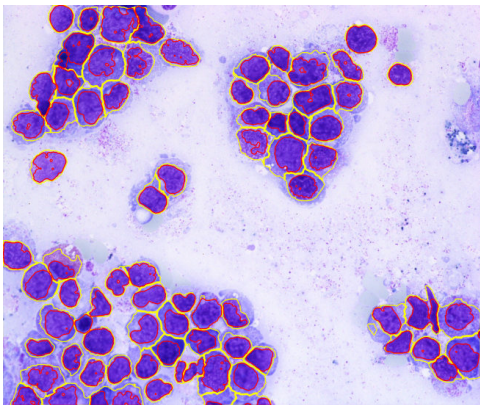

Figure 4: Automatic nucleus / plasma segmentation of bone marrow cell clusters

DISCUSSION AND CONCLUSION

The detected cells will be used as the starting point for the further bone marrow analysis where each localized cell is automatically divided into nucleus and plasma components.
The maturation stages of blood cells can then be characterized, classified and evaluated by a variety of features which describe the cell morphology.
Through such a system a quicker and more objective diagnosis becomes possible.
Furthermore, cell-based documentation of results can be used for quality assurance and accreditation.
Training and further qualification of personnel is a secondary benefit of the system.

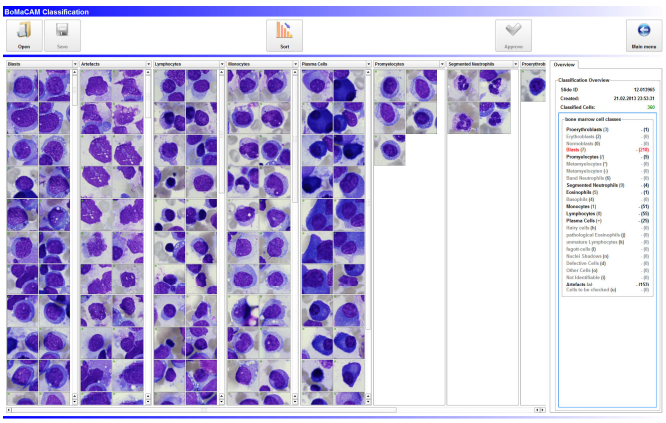

Figure 5: Column-based classification view of analyzed bone marrow cells

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