Multi-resolution Parameterization for Texture Classification and Its Use in the Scintigraphic Image Analysis

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Thesis Summary

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Article presents the abstract of the dissertation [4] which studies multi-resolution approach for texture parameterization.

Povzetek: Članek predstavlja povzetek disertacije [4], ki preučuje uporabo večresolucijskega pristopa pri parametrizaciji tekstur.

1 Introduction

This dissertation [4, 2] addresses multi-resolution texture parameterization and proposes an original algorithm ARes for finding more informative resolutions in the sense of classification accuracy. ARes is designed to be used in combination with the existing parameterization algorithm ArTex [3]. The results obtained using the ArTex parameterization algorithm in combination with ARes are compared with standard parameterization methods such as Gabor filters, Haar and Laws wavelets and Image Processor. Primary application areas include whole-body bone scintigraphy for pathology detection and heart scintigraphy for diagnosing ishaemic heart disease.

2 Thesis overview

The idea on multi-resolution approach is based on the algorithm SIFT [1]. SIFT is a computer vision algorithm for extracting distinctive features from images, to be used in algorithms for tasks like matching different views of an object or scene and object recognition. The major step in the computation of the image features is scale-space extrema detection, which can be directly applied to the search of resolutions at which a geometric parameterization algorithm captures most textural information inside a certain region. The observed pixel neighborhood size in case of geometric algorithms is limited due to the time and computational complexity. To extract most rules inside a certain region the resolutions at which the most extremes take place should be used. This enables the parameterization algorithm to describe local characteristics which can be covered with the predefined region size.

Our study explores the multi-resolution texture parameterization approach based on the image content with regard to the parameterization quality, especially in case of the ArTex algorithm. ARes finds resolutions at which most local intensity peaks appear. It searches the scale space with a certain step calculated from the attributes of the used parameterization algorithm. ARes is, to our knowledge, the first algorithm to detect resolutions depending on the properties of the learning set for improving the classification quality. The tested parameterization algorithms (geometric algorithms, signal processing methods and statistical methods) using multi-resolution approach have demonstrated significant improvements in results over one scale parameterization. This supports the hypothesis that the resolution selection is important for texture parameterization.

2.1 Applications

For the multi-resolution parameterization applicative domain two medical cases have been used, sequential diagnostics of coronary artery disease (CAD) and diagnostics of whole-body bone scintigraphy.

The whole-body scintigraphy segmentation process is presented which uses reference points detected with local cumulative uptake extremes. Some standard image processing algorithms were tailored and used in combination to achieve the best reference point detection accuracy on scintigraphic images. In order to work satisfactorily, the presence of artifacts, pathologies and poor resolution of scintigraphic images, compared to radiography, requires algorithms to use as much background knowledge on anatomy and spatial relations of bones as possible (see example in fig. 2.1). This combination gives good results

and we expect that further studies on automatic scintigram diagnostics using reference points for image segmentation will improve the accuracy and reliability of results regarding previous approaches.

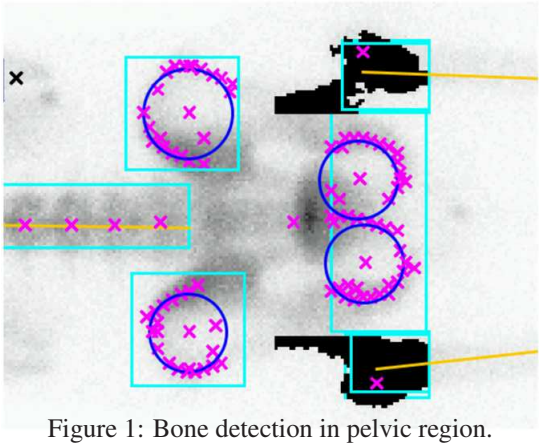

Figure 1: Bone detection in pelvic region.

In the case of coronary artery disease we have shown that multi-resolution ArTex parameterization using machine learning techniques can be successfully used as an intelligent tool for image evaluation, as well as as a part of the sequential diagnostic process. Automatic image parameterization and machine learning methods can help physicians to evaluate medical images and thus improve their combined performance (in terms of accuracy, sensitivity and specificity).

3 Results and conclusion

The developed algorithm ARes in combination with the ArTex algorithm achieves statistically significant improvements over single resolution and also over equidistant resolutions. ARes in many cases also improves the performance of other parameterization algorithms in comparison to single resolution approach, whereas compared to the equidistant resolution approach it usually shows no significant improvement. We have confirmed that the use of the equidistant resolution space when parameterizing textures significantly outperforms the use of the exponential resolution space, which is used by majority of authors.

The presented computer-aided system for bone scintigraphy is a step towards automating the routine medical procedures. This approach can be used as an additional tool for radiologists as it can point out some unregistered pathologies or even give some new insight on the patient condition. The reference point detection is evaluated on a clinical data-set and two methods for bone segmentation using the proposed reference points are presented.

The most significant contribution of our CAD study is the improvement of the predictive power of the sequential diagnostic process. Almost 10% improvement of positive and negative diagnosis of patients who would not need to be examined with costly additional tests, represents a significant contribution in quality and potential rationalization of the existing CAD diagnostic procedures.

References

[1] D. Lowe (2003) Distinctive image features from scale-invariant keypoints, *International Journal of Computer Vision*, pp. 91–110.

[2] L. Šajn, M. Kukar, I. Kononenko, M. Milčinski (2005) Computerized segmentation of whole- body bone scintigrams and its use in automated diagnostics, *Computer Methods and Programs in Biomedicine*, 80(1):47–55.

[3] M. Bevk (2005) *Feature extraction from textures with association rules*, PhD Thesis, University of Ljubljana, Faculty of Computer and Information Science.

[4] L. Šajn (2007) *Multi-resolution parameterization for texture classification and its use in the scintigraphic image analysis*, PhD Thesis, University of Ljubljana, Faculty of Computer and Information Science.