Registration of mass-like objects in sequential mammograms using graph matching

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List of Abbreviations

CAD	Computer-Aided Detection
MLO	Medio-Lateral Oblique
CC	Cranial-Caudal
ROI	Region of Interest
ROC	Receiver Operating Characteristic
A_Z	Area under the ROC Curve
AP	Adaptive Pyramid
MI	Mutual Information
SV	Shift Variance
MST	Minimum Spanning Tree
CSI	Common Subgraph Isomorphism
RMSD	Root Mean Square Difference
Av. dif	Average Difference
STD	Standard Deviation
Mini-MIAS	Mammographic Image Analysis Society Database
ARBE	Average Right Boundary Error
FP	False Positive
FN	False Negative
RNE	Row Normalized Error
ROW	Real Orthogonal Wavelets
MRF	Markov Random Field
ICM	Iterated Conditional Modes
GT	Ground Truth
LDA	Linear Discriminant Analysis
cmr	Correct Match Rate
me	Match Efficiency

Summary

Sequential mammograms contain important information, such as changes of the breast or developments of the masses, for diagnosis of disease. Comparison of sequential mammograms plays an important part for radiologists in identifying malignant masses. However, currently computer-aided detection (CAD) programs can not use such information efficiently. The difficulties lie in the registration of sequential mammograms.

Most of current methods register sequential mammograms based on control points and image transformations. For these methods to work, extraction and correspondence of the control points is essential. This thesis presents a new approach in registering mammograms. The proposed method registers mammograms by associating mass-like objects in sequential mammograms directly. The mass-like objects appear in the images of normal breasts as well as images of breast with cancer. When the mass-like objects in sequential mammograms are accurately associated, measurements of changes in mass-like objects over time become possible. This is an important way to distinguish mass-like objects associated with cancer from cysts or other benign objects.

The proposed method is based on graph matching. It uses the internal structure of the breast represented by the spatial relation between the mass-like objects to establish a correspondence between the sequential mammograms. In this method, the mammogram is firstly segmented into separate components using an adaptive pyramid (AP) segmentation algorithm. A series of filters, based on the features of components, is then applied to the components to remove the undesired ones. The remaining components, the mass-like objects, are represented by a complete graph. The spatial relations between the remaining mass-like objects are expressed by fuzzy spatial relation representation and are associated to the edges of the graph as weights. Association of the mass-like objects of two sequential mammograms is realized by finding a common subgraph of the corresponding two graphs using the backtrack algorithm.

The segmentation methods developed in the course of this work were tested on a separate problem in computer-aided detection of breast cancer, namely the automatic extraction of the pectoral muscle.

The graph matching method was tested independently of the segmentation method on artificially distorted mammograms and the full process, including the segmentation and the graph matching, was evaluated on 95 temporal mammogram pairs. The present implementation indicates only a small improvement in cancer detection rates but also presents opportunities for a substantial development of the basic method in the future.

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Fei Ma

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