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

by

Fei Ma, M.Sc.
School of Computer Science, Engineering and Mathematics,
Faculty of Science and Engineering

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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.
Publications


Certification

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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Dated

Fei Ma
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