Designing Grid-Enabled Image Registration Services for MIAKT

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MIAKT

- **Aim:** to develop a collaborative problem solving environment in medical informatics
- **Application:** support surgeons, radiologists, pathologists and oncologists in the detection, diagnosis and management of breast cancer
Image Registration

- To establish spatial correspondence between images and possibly physical space
- Application: Contrast-enhanced breast MRI

pre-contrast  post-contrast  difference  after registration

AHM’04, Nottingham
Image registration of contrast-enhanced breast MR images

- User friendly
- Integrated with other standard assessment tools
- Accessible from many hospitals
- Acceptable response time for a small number of cases
- Consistent and well validated
Design of Image Registration Service
Non-rigid registration is based on evenly spaced control points interpolated by B-Splines


Accuracy for registering contrast-enhanced breast MR images has been carefully validated


http://www-ipg.umds.ac.uk
http://www.imageregistration.com
A simple and validated workflow is provided for registering breast MR images:
- Individual registration of left and right side
- Lesion alignment: rigid registration followed by non-rigid registration with 40mm control point spacing (~0.5 hours)
- Whole breast alignment: 10mm multi-resolution registration (rigid -> 20mm non-rigid -> 10mm non-rigid) (~2.8 hours)
- Optimal parameter as defaults

Makes service consistent and user-friendly
Workflow

Target Image

Source Image

Left Side Target

Left Side Source

Rigid Registration (reg)

End

need

Yes

NonRigid Registration (40mm)

End

NonRigid Registration (20mm)

End

need

Yes

NonRigid Registration (10mm)

End

Right Side Target

Right Side Source

as above
Response Time Requirement

- 30 minutes to 3 hours per side x 2 sides x 5 images = 5 hours to 30 hours on single machine
- BUT, want results within hours not days
- 10 individual jobs -> distribute them on 10 machines
- Condor 6.4.5
  - Distributes jobs to available machines
  - Job priority and dependency
  - Fault tolerance (checkpointing, rollback recovery)
Accessibility Requirement

- Many hospitals
- Service and images at different sites
- Globus Toolkit 2.4
  - Security
  - Resource Management
- Combine condor and globus (Condor-G)
Security Requirement

- Communications among organizations over Internet are *essential* for Grid applications, but Internet may be *untrusted*

- **Globus with Firewall**
  - Configurations on firewall are required on both Client and Server sides to allow communications between them
  - **Issues:**
    - System admin should gain experiences for open ports required by Globus, e.g., 2811, 2119 and others
    - Great care should be taken to ensure security
      - Von Welch, *Globus Toolkit Firewall Requirements*
Integrated Service

- Tomcat Web Server, JSP/Servlet
- WSDL file defines registration service
- Clients can dynamically invoke the services
  - Registration submission
  - Registration monitoring
- MIAKT calls it via SOAP through a Web-Service invocation architecture
Configuration Overview

- Globus Server (Job Manager, GSI-FTP etc.)
- Condor Central Manager
- Tomcat Web Server Engine
- Condor Submit Machine
- Condor Execute Machine
- Condor Submit Machine
- Condor Execute Machine
- Condor Execute Machine
- Condor Execute Machine
- Globus Client Machine
- Server Side Firewall (KCL)
- Client Side Firewall
- Web Interface
- MR Image Data
Successfully integrated with MIAKT demonstrator (Southampton booth)
Multi-Centre Trial

MARIBS: to test if MRI is an effective way of screening young women with high risk of breast cancer

- 1500 women (35-49 yrs old) with high breast cancer risk
- Annual MRI as well as X-ray mammograms for up to five years
- 17 major screening centres
MIAKT Overview
Segmentation refinement and classification of MR breast lesions
Classification of MR Breast Lesions

Features
- Shape
- Margins
- Enhancement Pattern
- Contrast-change Characteristics
Motivation

- **Segmentation Refinement**
  - Feature extraction requires segmentation of MR breast lesion
  - Manual segmentation labour-intensive and difficult for 4D data
  - Derive most probable region from crude outline of lesion

- **Overall**
  - Support radiologists in the diagnosis of MR breast lesions
  - Ease creation of large databases of annotated MR breast lesions with known ground truth (pathology / follow up)
Functionality & Design

- Extract most probable region from 4D data of crude outline
  - Tanner C., MICCAI, September 2004
- Derive features from segmented region
- Classifier: Linear discriminate analysis and leave-one-out ROC training
- Online retraining of classifier
- MATLAB program called from a Tomcat Web-Service implementation
Results

- **Segmentation**
  - Initial
  - Refined
  - Gold Standard

- **Classification Accuracy**
  - 10 benign, 16 malignant cases from MARIBS data set
  - 69% for features from gold standard segmentation
  - 82% for features from refined segmentation
Conclusions

- KCL services
  - GRID-enabled Image Registration Service
  - Segmentation Refinement and Classification Service for MR Breast Lesions
- Services were successfully integrated with the MIAKT demonstrator
- Future: from demonstrator to clinical usability
Thank you!

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