Multimedia Medical Conceptual Web for Intelligent Information Access

(SERC 052 101 0103)

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Co-PI(s): Dr. Daniel Racoceanu

Start Date: 1 July 2007

End Date: 30 June 2010

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Project Summary

- Objectives:
  - Develop a framework for the semantic structuring and organization of multimedia medical information (images, reports).
  - Implement a prototype system of the framework with user-friendly network tools for navigation and query.
  - Trial integration of MMedWeb with existing medical databases (PACS, RIS, etc.)

Project Summary

- Novelty:
  - Incorporates structured medical knowledge in the form of medical conceptual graph.
  - Provides context-sensitive query and navigation.
  - Supports advanced query using conceptual graph.
  - Supports creation of dynamic links according to a user's query requirements and results.
  - Applicable to multiple disease domains by applying effective image analysis algorithms.

Project Summary

- Scope:
  - Collaboration of multiple institutes.
  - Work closely with hospitals.
  - Focus on medical images and text reports available in large quantities.
  - Apply to multiple disease domains.

Project Summary

- Deliverables:
  - Framework for the conceptual organization, navigation, and query of medical info: MMedWeb.
  - A prototype system with user-friendly navigation and query tools.
  - A suite of medical image analysis algorithms and software.
  - Publications in top conferences and journals.
  - Possibility of patent applications and commercialization.
  - Training of manpower: RF, RA, grad students

Technical Achievements

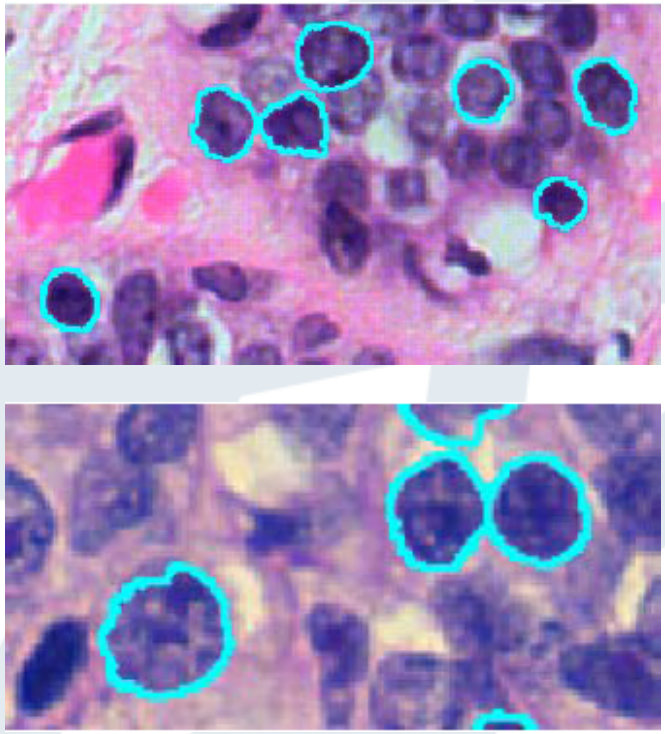
- Achievement 1: Breast Cancer Grading

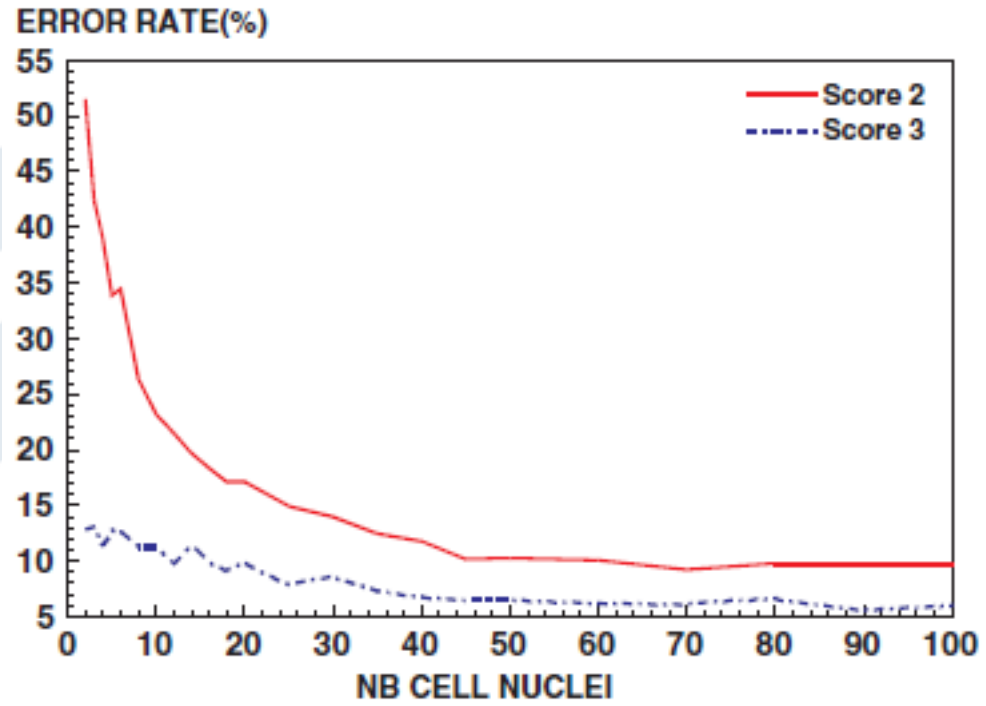
  (Reported last year, refined in this year)

  - Automatic grading of breast cancer micro-images.
  - Multi-resolutional analysis of images.
  - Help pathologists to get more consistent grading results.
  - Refined algorithm:
    selective segmentation of cells reduce computation time.
  - 5 conference papers published.
  - 1 journal paper submitted, 1 in preparation.

Technical Achievements

- No need to segment all cells to get optimal accuracy.





Technical Achievements

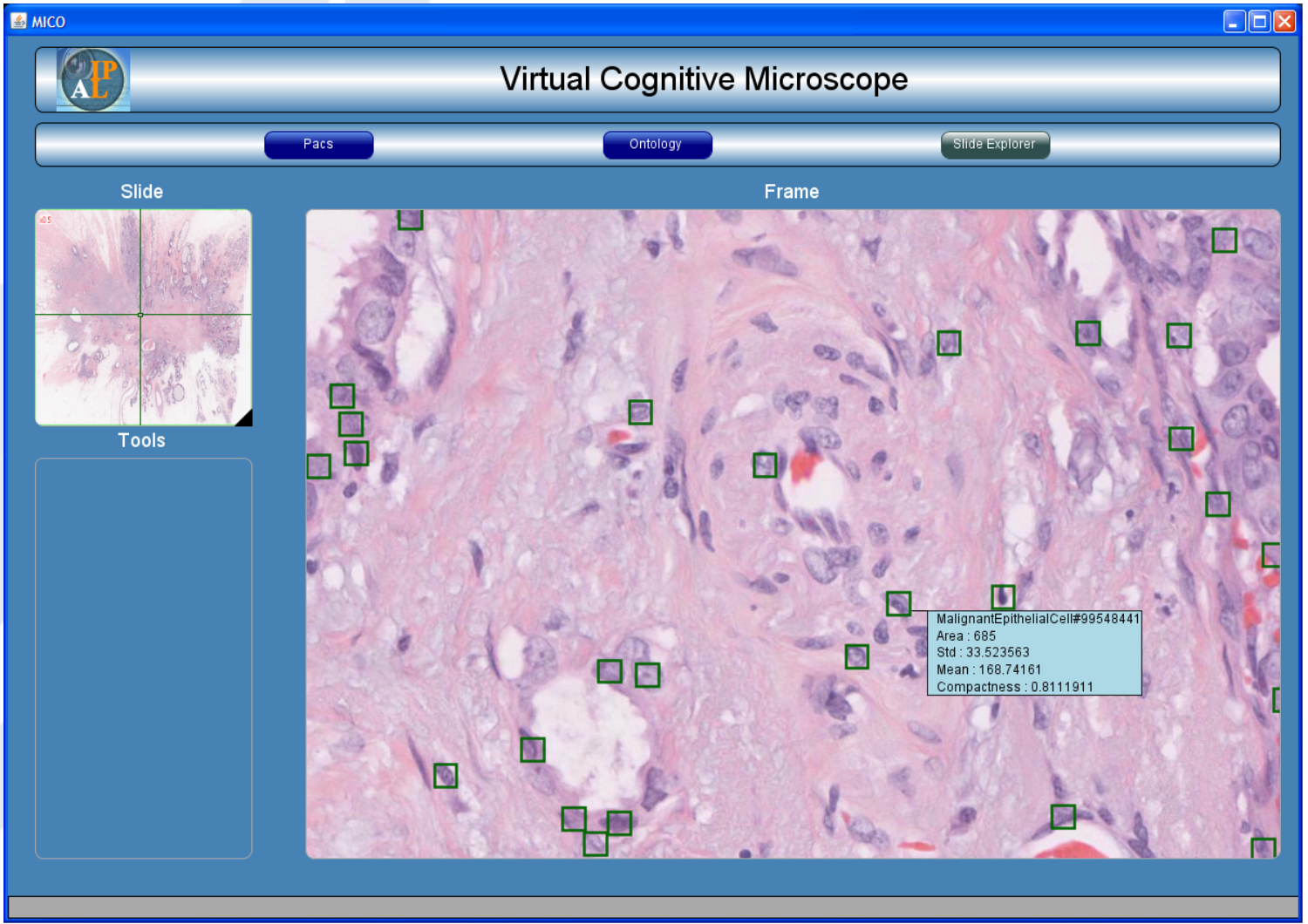
- Achievement 2: Cognitive Virtual Microscope

  (Reported last year, enhanced in this year)

  - Virtual microscope for acquisition, analysis, and retrieval of breast cancer micro-images.
  - Access real microscope over web.
  - Help pathologists to acquire digital micro-images, perform grading, assess grading results.
  - Incorporates cognitive reasoning (knowledge & ontology).
  - Showcased at opening ceremony of I^2R.
  - 3 conference papers submitted,
    1 journal paper submitted.

Technical Achievements

- Screen Capture of Virtual Cognitive Microscope



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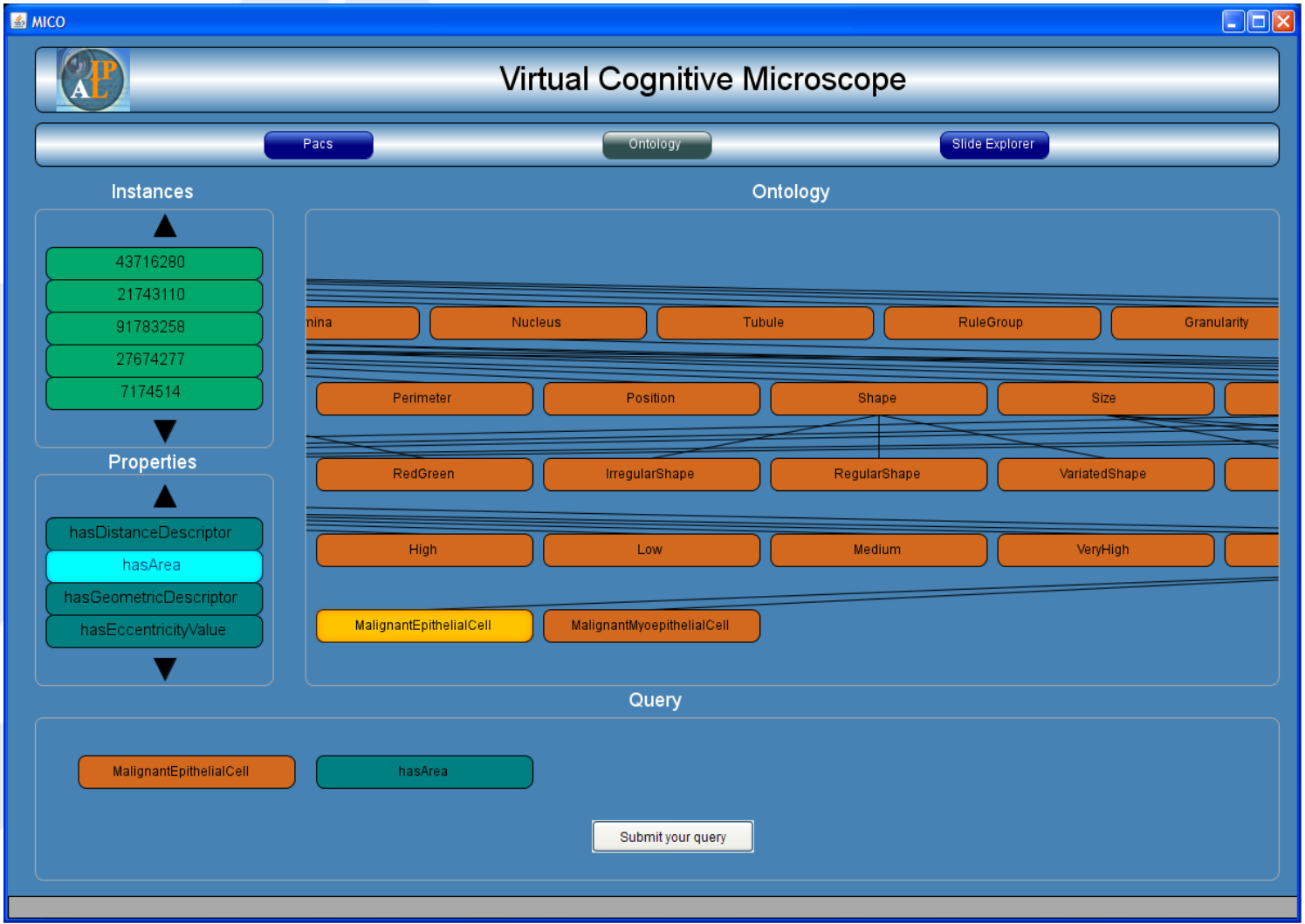
Technical Achievements

- Screen Capture of Ontology of Virtual Microscope



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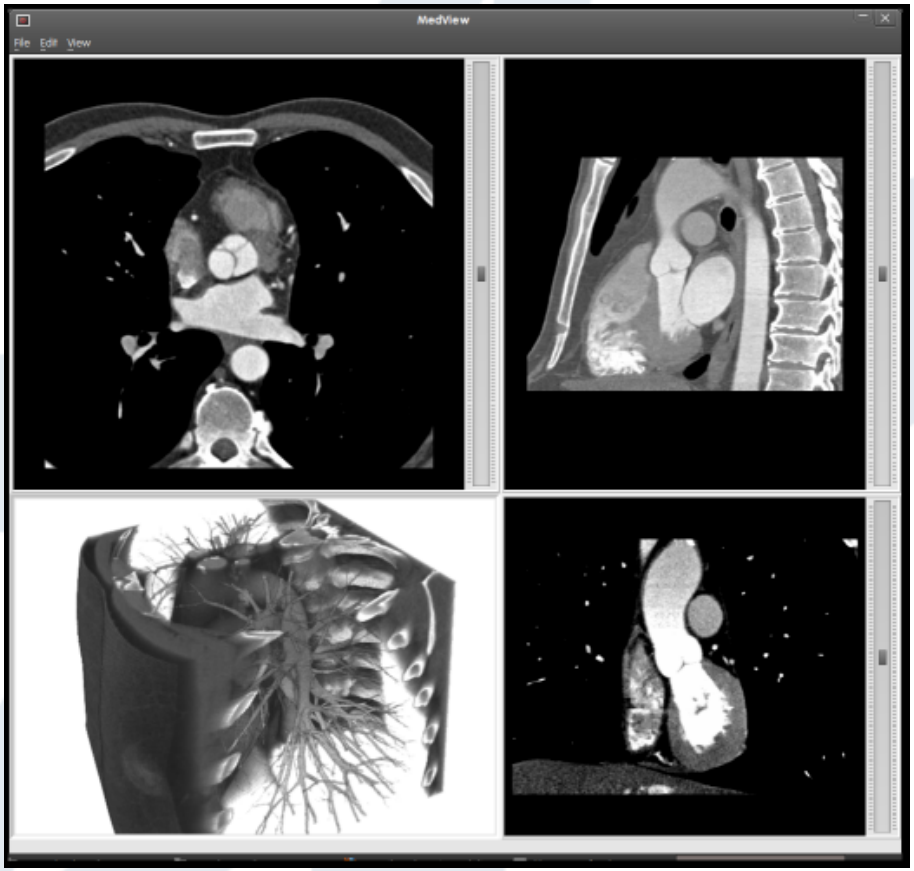
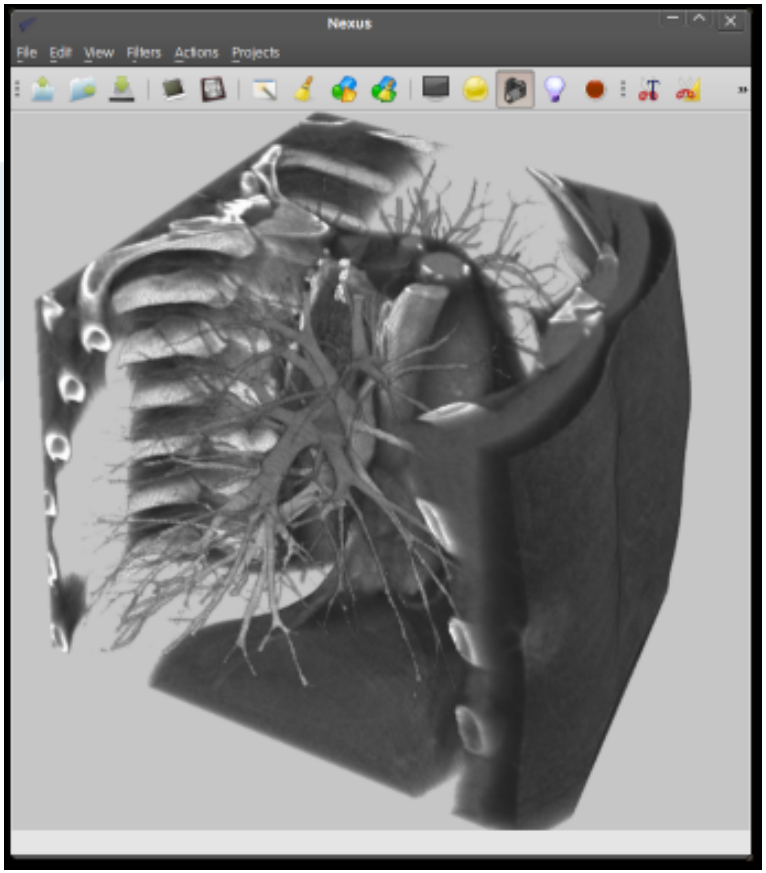
Technical Achievements

- Achievement 3a: Volume Image Analyzer
  - Neural-network-based image analysis.
  - Soft segmentation to highlight object of interest.
  - Summarization of 3D volume image into single 2D image.
  - Automatically determines most informative view.
  - Save space and network transmission time.
  - 2 conference papers published.

Technical Achievements

- Soft segmentation of 3D volume image





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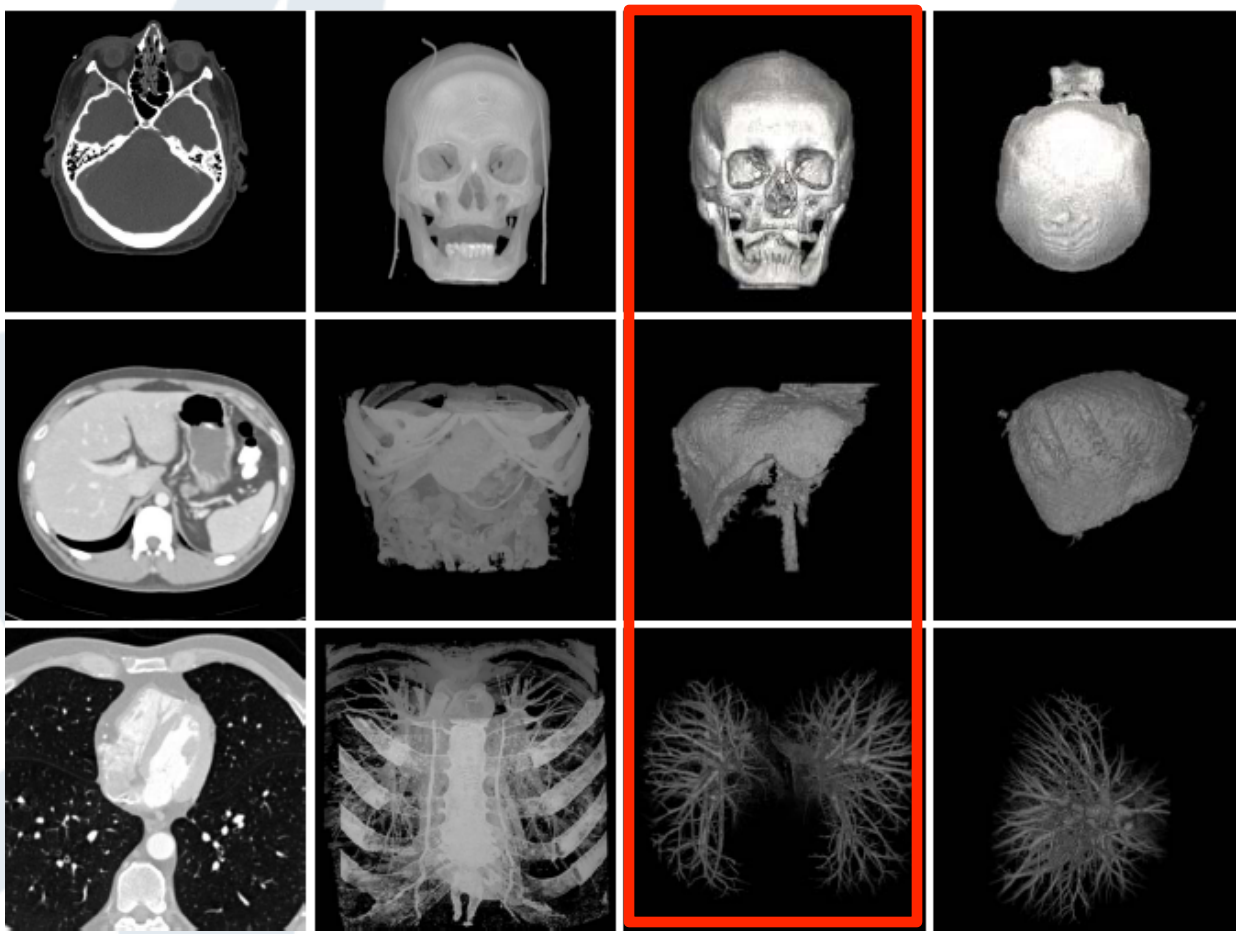
Technical Achievements

- Comparison of summarization with existing method.



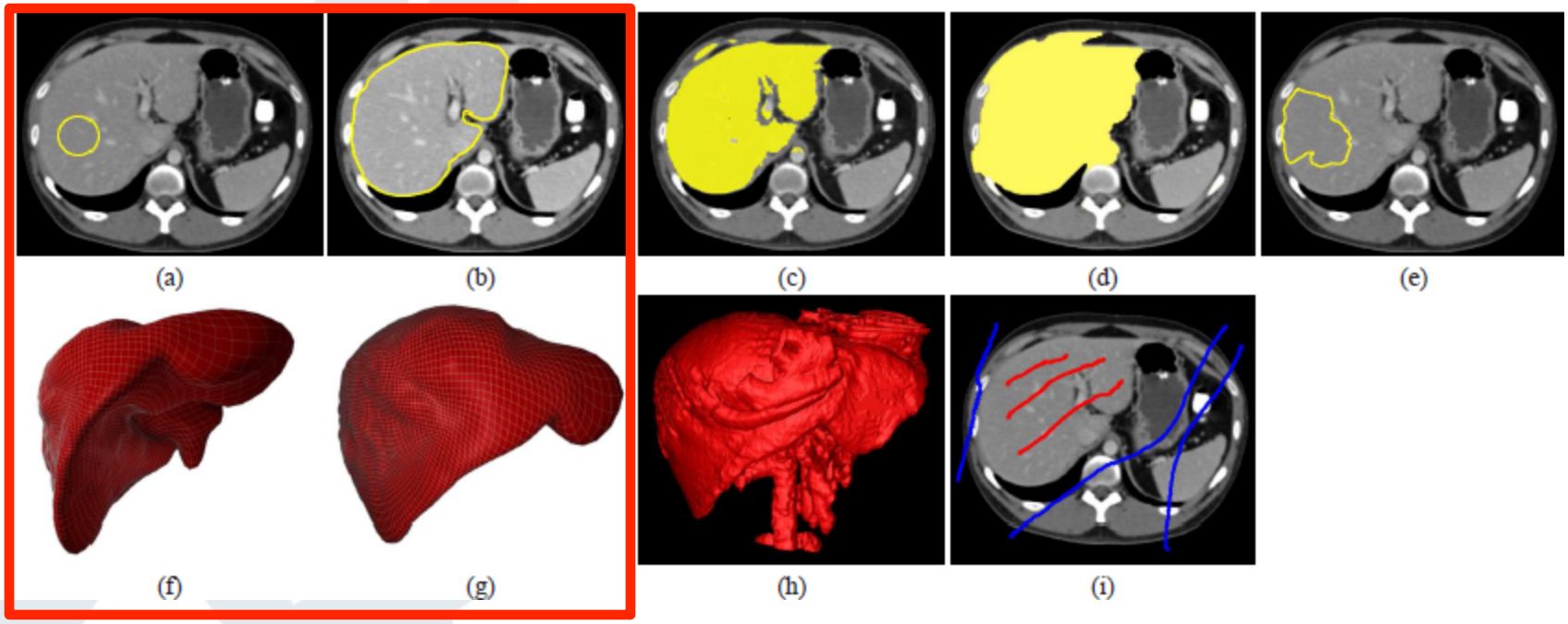
Our method

Technical Achievements

- Achievement 3b: Volume Image Analyzer
  - 3D segmentation of volume images.
  - Use flipping-free mesh deformation.
  - Efficient and noise-resilient compared to existing methods.
  - 3 conference papers published.

Technical Achievements

- Comparison of segmentation results



Our method

Existing methods

Technical Achievements

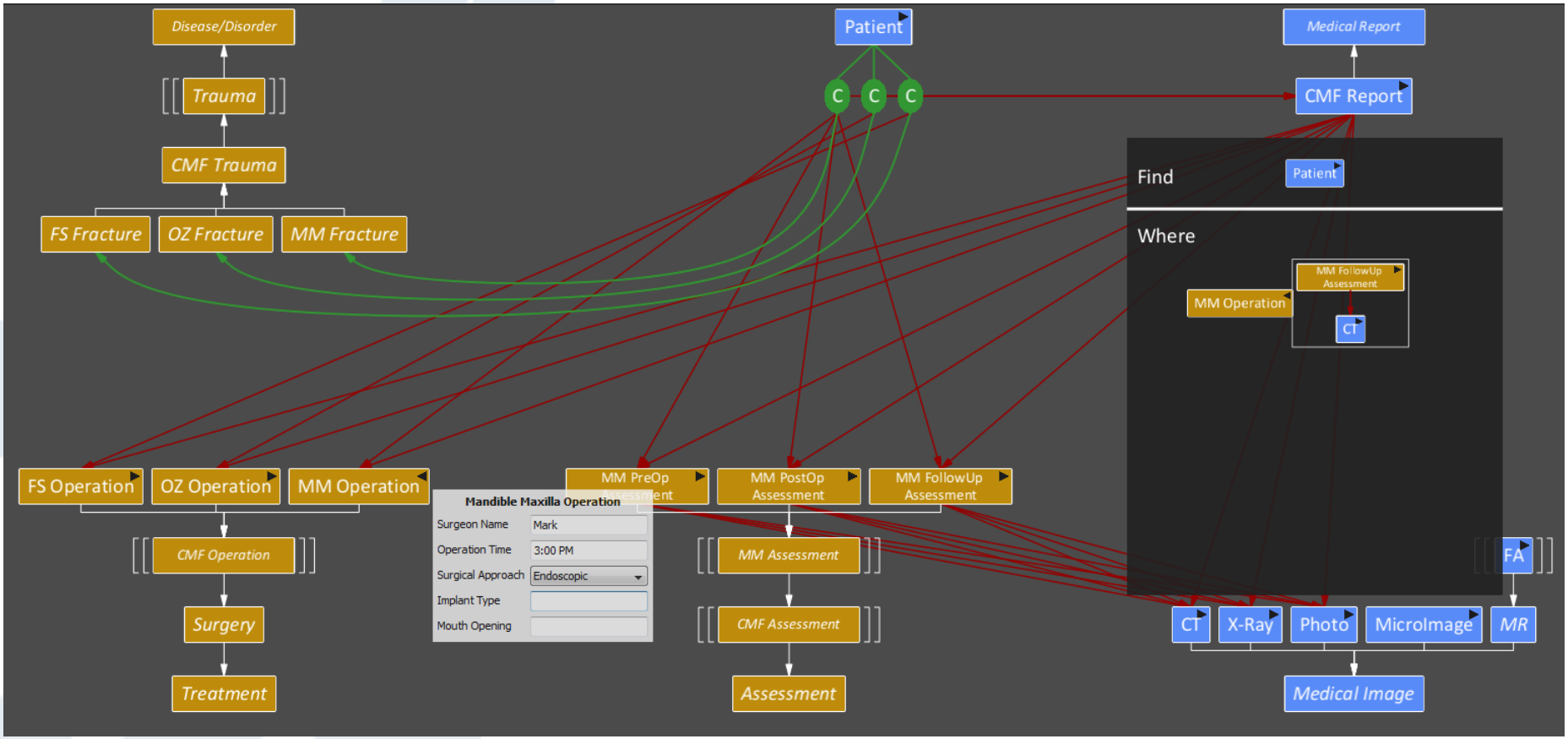
- Achievement 4: MMedWeb Framework

  (Reported last year, enhanced in this year)

  - Framework for the conceptual organization and access.
  - User-friendly, easy-to-understand GUI.
  - Visual query: visual logical operations: and, or, subtract
  - High-order query: query by paths.
  - Integration with PACS and SQL databases.
  - User can post query and get retrieval results over Internet.
  - 1 conference paper submitted.

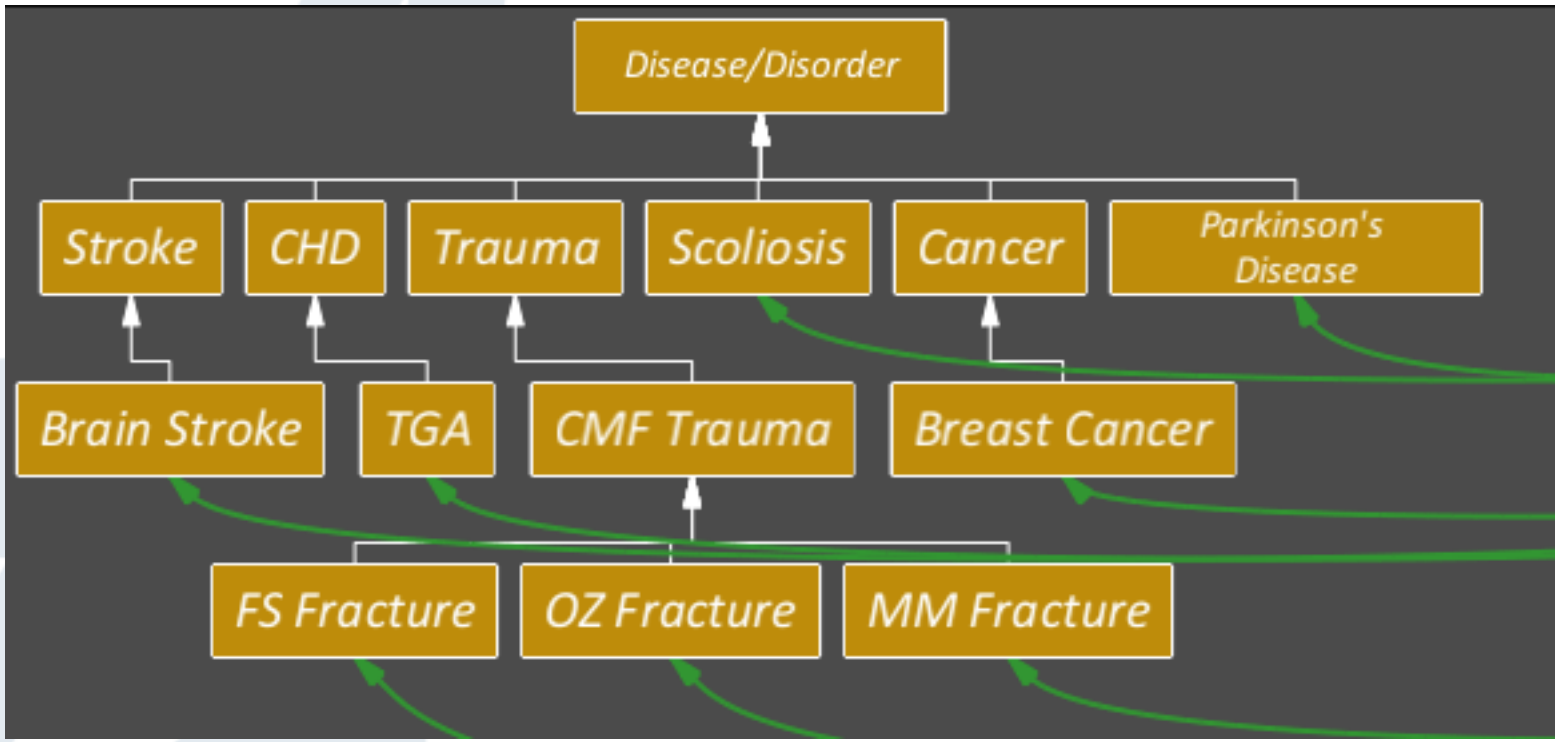
Technical Achievements

- Conceptual Graph GUI



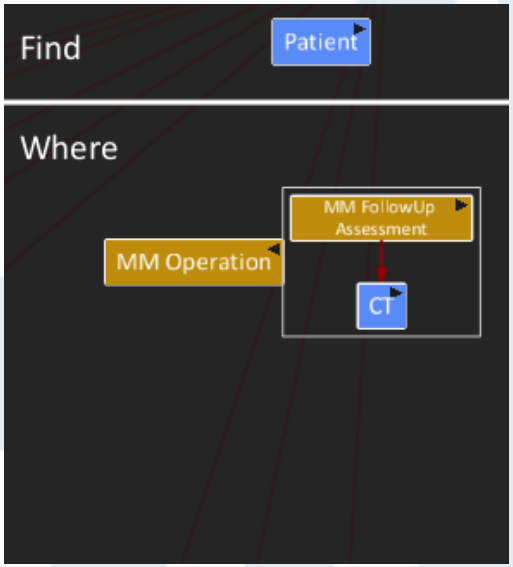
Technical Achievements

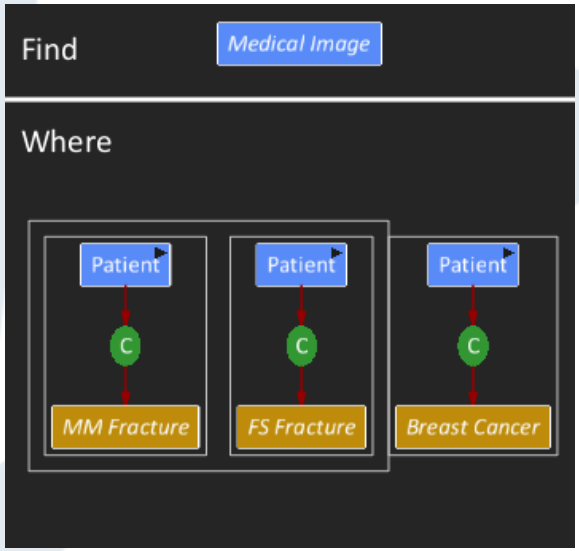
- Expanded conceptual subgraph

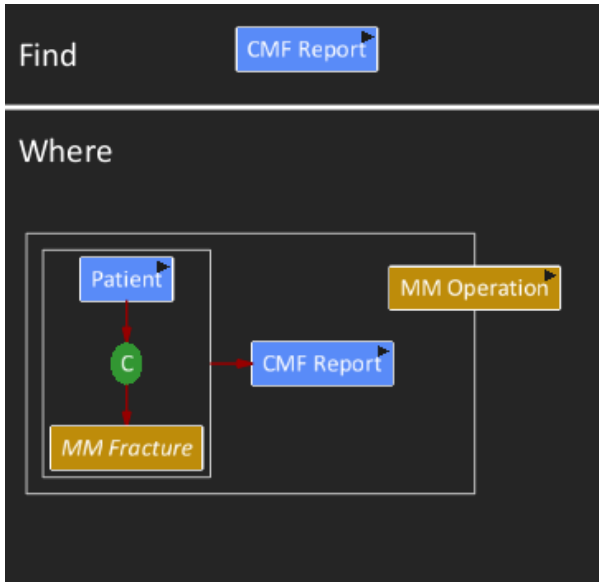


Technical Achievements

- Visual Query Examples







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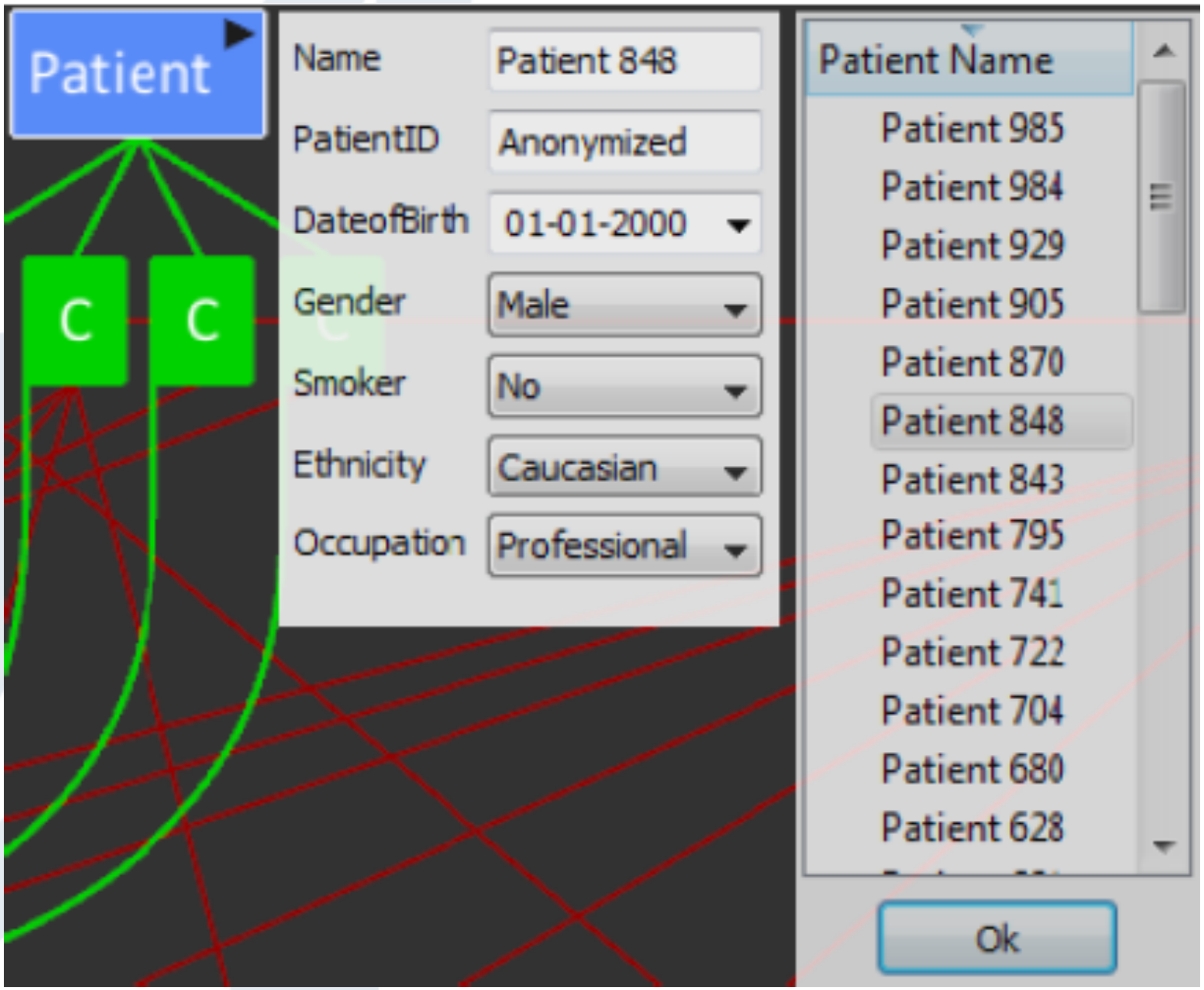
Technical Achievements

- Query Results



Technical Achievements

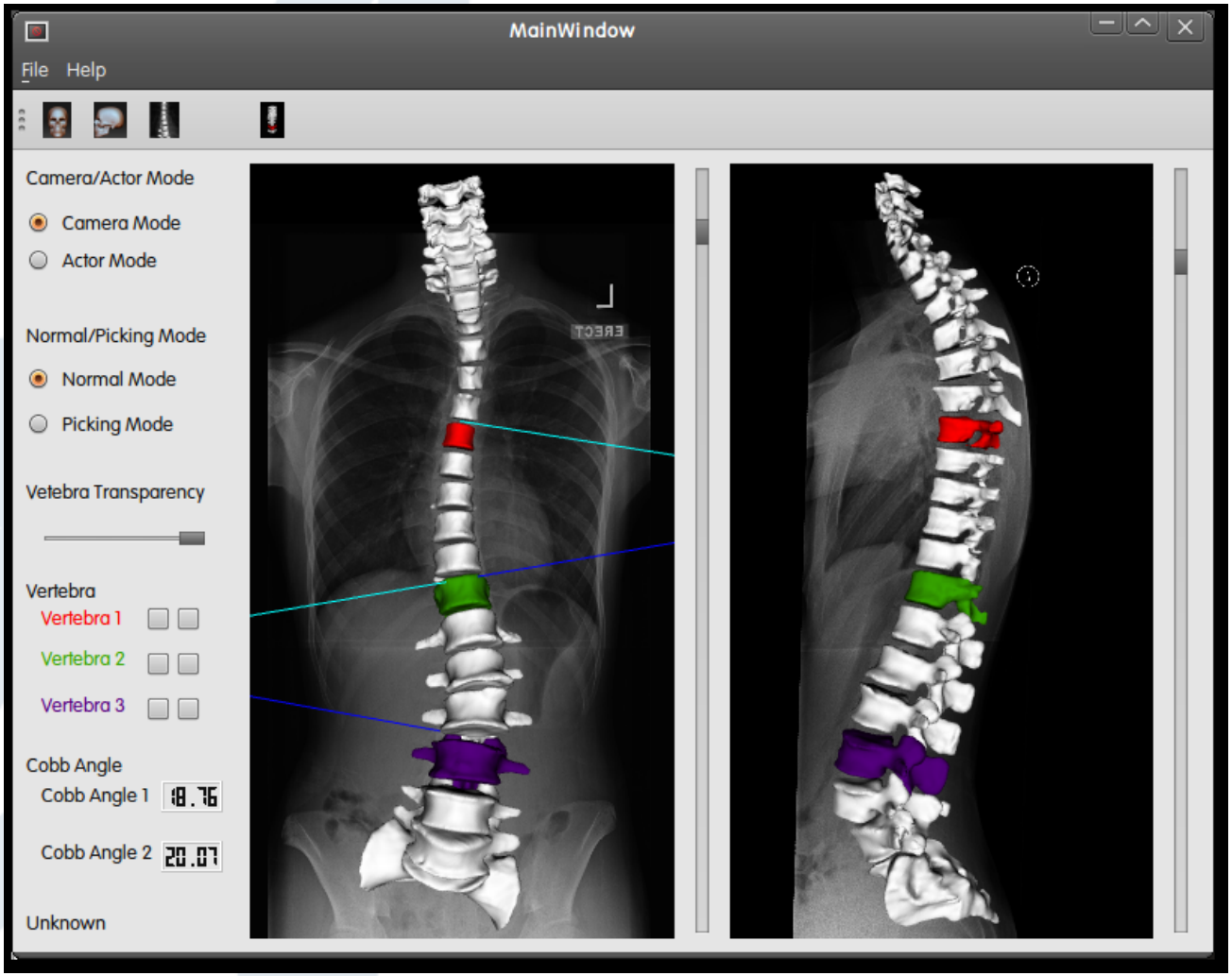
- Achievement 5: Analysis of Scoliosis

  (Reported last year, enhanced in this year)

  - Reconstruct 3D model of scoliotic spine from 2D images.
  - Apply physically correct model of spinal centreline.
  - Measure 2D Cobb angle (standard clinical measurement).
  - Measure 3D bending and twisting of spine.
  - 1 conference paper published.

Technical Achievements

- Scoliosis Analysis Tool



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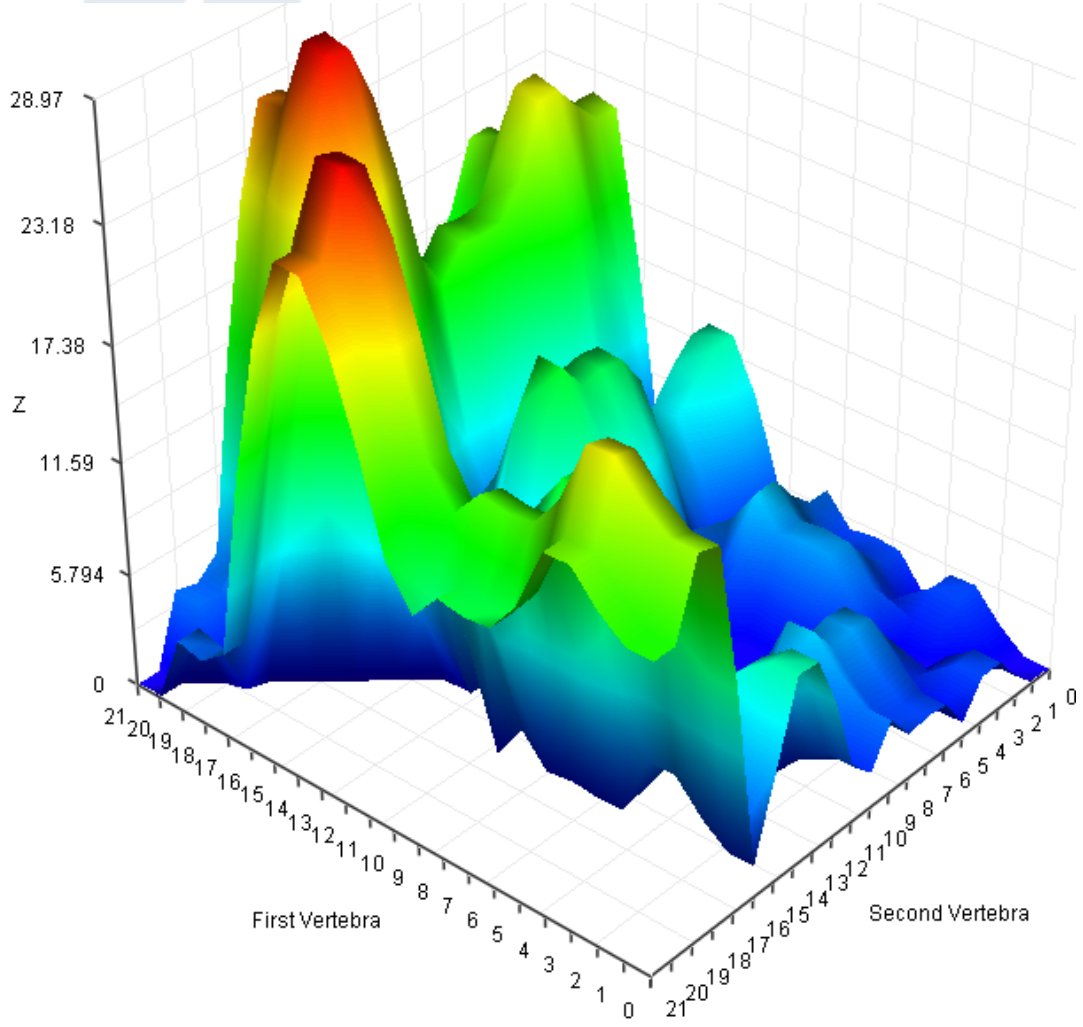
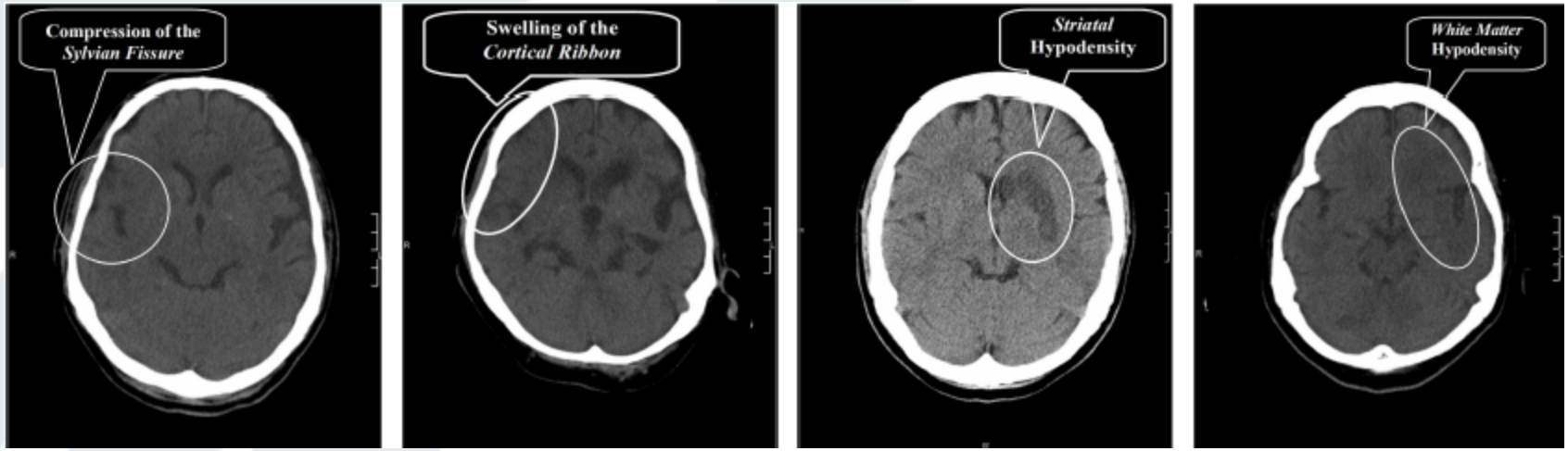
Technical Achievements

- Vertebra Angle Profile: Peak angle = Cobb angle



Technical Achievements

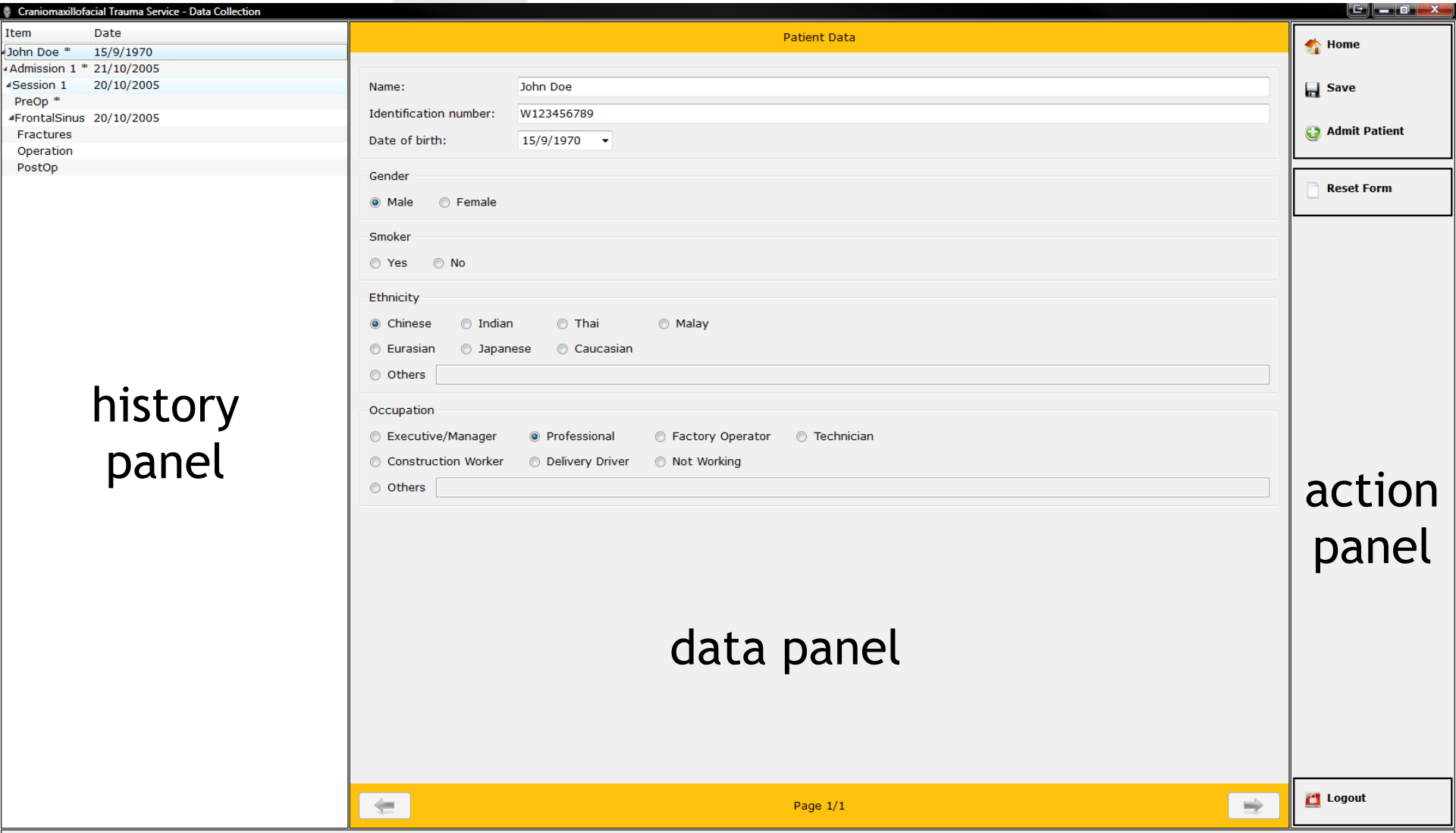
- Achievement 6: Detection of Stroke in CT Images.
  - Early detection of stroke in brain CT images.
  - Rule-based comparison of left-right asymmetry.
  - 1 journal paper submitted.



Technical Achievements

- Achievement 7: CranioMex
  - Multimedia System for Management and Exploration of Craniomaxillofacial (head, jaw, face) Data.
  - Integrated with PACS and SQL databases.
  - Integrated with MMedWeb server.
  - User can upload data and retrieve results over Internet.
  - Novel user-friendly GUI for upload and retrieval.

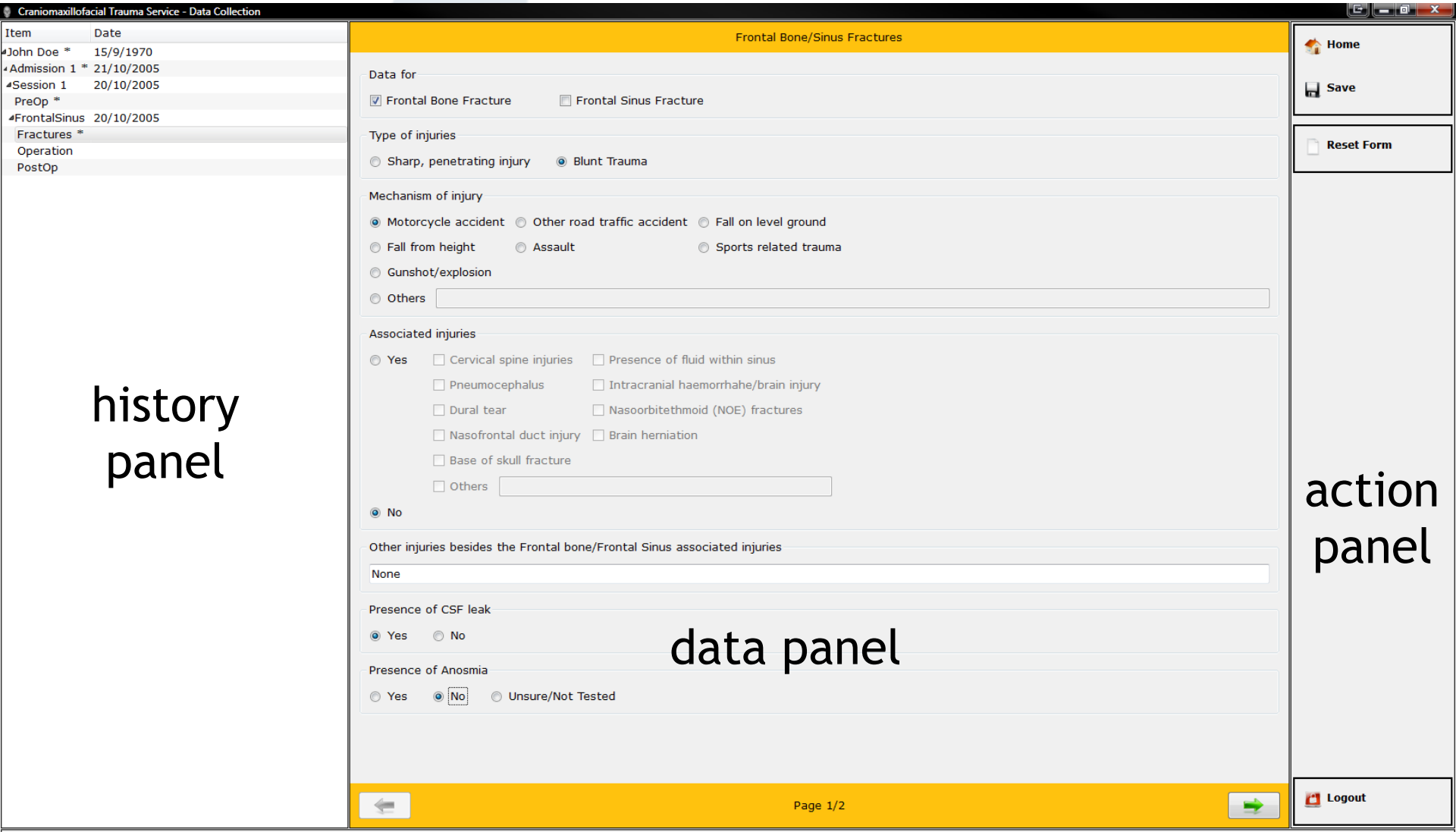
Technical Achievements



Department of Computer Science,
School of Computing,
National University of Singapore

Division of Plastic Reconstructive & Aesthetic Surgery,
National University Health System

Technical Achievements



Department of Computer Science, School of Computing, National University of Singapore
Division of Plastic Reconstructive & Aesthetic Surgery, National University Health System

Results

- **Deliverables achieved**:
  1. Trained 2 RFs, 4 RAs, 2 student assistants
  2. Conference papers: published 13, submitted 2 (11 rank-2)
  3. Journal papers: submitted 2, preparing 1 (all rank-1)

- **Capabilities developed**:
  1. Trained 2 RFs, 4 RAs, 2 student assistants, 3 Master students, 2 PhD students
  2. Suite of algorithms and software for medical image analysis.

- **Areas dropped (if any)**:
  1. Conceptualization of breast cancer text reports. Text reports are not made available.

- **Directions changed (if any)**:
  1. No change. Applied to additional disease domains.

Budget Utilization

	Approved Budget	Expense (Actual)	Expense (Committed)	Expense (Actual + Committed)	Balance	Utilization Rate	Remarks (deviations, problems etc)
EOM	$452,840	$319,029		$319,029	$133,811	70%	Initial late employment of RFs and RAs
EQPT	$30,000	$27,610		$27,610	$2,390	92%	
OOE	$30,000	$24,115		$24,115	$5,885	80%	
TRAVEL	$18,000	$17,705		$17,705	$295	98%	Insufficient fund to reimburse conference attended. Varying from EOM, EQPT and OOE.
TOTAL	$530,840	$388,459	$0	$388,459	$142,381	73%	

	Original Targets	Revised Targets (if any)	Actual
Post-Docs	1	2	2
Research Fellows	0	0	0
Research Assistants	1	4	4
Student Assistants	0	2	2

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New Project Change Requests (if applicable)

- **Extension**
  - Request extension of project completion date by one year.
  - CranioMex and Virtual Microscope have potential for commercialization:
    - NUH pushes for CranioMex
    - Changi Hospital is interested in Virtual Microscope
- **Virement** (submitted request)
  - Move $7000 from EOM, $2000 from Equipment, $3000 from OOE to Travel.
  - Current travel funding is insufficient to reimburse conferences already attended and to be attended.

Project Progress

No	Research Milestones	Years		
		1	2	3
1	Design of MMedWeb framework and conceptual structure	☑		
2	Design and development of medical image analysis and conceptualization module	☑	☑	☑
3	Development and integration of MMedWeb prototype		☑	☑
4	Testing and refinement of MMedWeb prototype		☑	🗠
5	Integration with PACS, SQL		☑	
6	Application of MMedWeb to other medical domains			🗠

☐: Planned

☑: Completed 🗠: Completed but enhancing

Please show a schedule of planned task vs. completed task

Future Plans

- Further development of CranioMex
  - Develop PDA-implementation of front-end GUI.
  - Develop fracture analysis tools.
- Further development of Virtual Microscope
  - Apply to tuberculosis bacteria detection and analysis
- Further refinement of MMedWeb framework
  - Allow user to insert new Concepts and Relations
- Publication in top conferences and journals
  - Planned: additional 3 conferences, 2 journals
- Invention disclosure, patent filing

Additional Supporting Slides

Human Capital

S/N	Name	Designation (Please see note below)	Start Date (dd/mm/yyyy)	End Date (dd/mm/yyyy)
1	Dennis Lim Sher Ee	Research Assistant	16-Oct-2006	31-Jan-2007
2	Jean-Romain Dalle	Research Assistant	12-Nov-2007	31-Jan-2010
3	Adina Eunice Tutac	Student Assistant	17/03/2008	17/06/2008
4	Andrei Coronel	Student Assistant	07/04/2008	07/07/2008
5	Huang Chao-Hui	Post-Doctoral Researcher	1-Jul-2008	30-Jun-2010
6	Saraubh Garg	Research Assistant	15-Dec-2008	30-Jun-2010
7	Li Hao	Research Assistant	21/07/2009	30/06/2010
8	Chen Yan	Post-Doctoral Researcher	01/10/2009	30/06/2010
1	Ee Xian He	Master's Research Student	01/08/2006	03/09/2008
2	Qi Yingyi	Master's Research Student	01/07/2007	01/08/2008
3	Song Zhiyuan	Master's Research Student	01/01/2009	31/12/2009
4	Ding Feng	Ph. D. Student	01/01/2009	31/12/2009
5	Cheng Yuan	Ph. D. Student	01/01/2009	31/12/2009

Conference Publications

S/N	Title	Name of Conference	Status
1	Knowledge-Guided Semantic Indexing of Breast Cancer Histopathology Images	Int. Conf. on Biomedical Engineering and Informatics	Published
2	The use of medical ontology in a semantic-based fusion system	Int. Conf. on Technical Informatics	Published
3	The use of the medical ontology for a semantic-based fusion system in biomedical informatics	IEEE Int. Conf. on Inteligent Computer Comunication and Processing	Published
4	Automatic Breast Cancer Grading of Histopathological Images	Int. Conf. of IEEE Engineering in Medicine and Biology Society	Published
5	Translational Approach for Semi-Automatic Breast Cancer Grading Using a Knowledge-	Int. Conf. on Medical Image Computing and Computer Assisted Intervention	Published
6	Toward Translational Incremental Similarity-Based Reasoning in Breast Cancer Grading	SPIE	Published
7	The Cellular Neural Network as a Principal Component Analyzer	Int. Joint Conf. Neural Networks	Published
8	Modeling and Measurement of 3D Deformations of Scoliotic Spine Using 2D X-ray Images	Int. Conf. on Computer Analysis of Images and Patterns	Published
9	A Cognitive Virtual Microscopic Framework for Knowledge-Based Exploration of Large	Int. Conf. of IEEE Engineering in Medicine and Biology Society	Published
10	Removal of Abdominal Wall for 3D Visualization and Segmentation of Inner Organs in CT Volume	Int. Conf. on Image Processing	Published
11	Medical Volume Image Summarization	Workshop on Applications of Computer Vision	Published
12	Nuclear Pleomorphism Scoring by Selective Cell Nuclei Detection	Workshop on Applications of Computer Vision	Published
13	3D Organ Segmentation using Flipping-Free Deformable Model	Workshop on Applications of Computer Vision	Published
14	3D Segmentation of Soft Organs by Flipping-Free Mesh Deformation	European Congress of Radiology	Submitted
15	High-Order Visual Query of Medical Information System by Conceptual Graph	Int. Conf. on Multimedia and Exposition	Submitted

Journal Publications

S/N	Title	Name of Journal	Status
1	StrokePrediCT – an Incremental Image-Based Reasoning System for Hyperacute Middle	IEEE Transactions on Medical Imaging	Submitted
2	MICO - A Cognitive Virtual Microscopic Platform for Multi-Scale Analysis and Visual Reasoning	IEEE Transactions on Medical Imaging	Submitted
3	Breast Cancer Scoring by Selective Cell Nuclei Detection	IEEE Transactions on Medical Imaging	In preparation