A method for archival and analysis of multi-modal imaging data in a clinical and pre-clinical research environment

Tuhin Sinha
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Overview

- Introduction to VUIIS
- Informatics requirements
- Our design and implementation
- Current experiences
- Future plans
The VUIIS

The Vanderbilt University Institute of Imaging Science aims to support and integrate advances in physics, engineering, chemistry, computing, and other basic sciences for the development and application of new and enhanced imaging techniques to address problems and stimulate new research directions in biology and medicine, in health and disease.
Vital Statistics

- Started in 2002; Directed by John Gore
- Has grown to about 30 faculty members; 30 post-docs; 35 graduate students; 10-15 staff
- 25+ imaging (data acquisition) devices
- Many active in-house and collaborative research projects in pre-clinical and clinical realms.
Organization

Human Imaging Core

CSAI Core

Data Analysis Core
A broad theme

- Images can be acquired within the institute and be processed and delivered to researchers so they may focus on the science and not the process.
Internal considerations

- Project auditing
- Regulatory conformance
- Service tracking
- Storage/archiving demands
2D, 3D,... $nD$

Imaging Data

- Data units are voxels (volume elements)
- Spacing is generally important
- Dynamic range is variable
- Images can be hyper-spectral
- Images can be temporally encoded
- Multi-modal data can be across scales and/or derivative
Derivative Data is Essential

- Clinical systems present imaging data in a “final” state
- Our data generally undergoes many stages of post-processing
- These derivative data are critical in our research
- Derivative data need not be images.
Our solution: VUIIS-PACS

• Database system powered by MySQL
• Data neutral
• Extensible design to accommodate primary and derivative data
A generalized database schema

- Master tables for fundamental data
- Linking tables for many-to-many relationships
- Fundamental data areas:
  - Grants, People, Projects, DatasetTypes, DatasetAttributes...
Interfacing with the Database

- Web based
- Interactive
- Must be able to upload, manage, download from database
Our attempt at a Web 2.0 Application...

- AJAX (Asynchronous Javascript And XML)
- Use the Google Web Toolkit (GWT) with PHP talking to the MySQL database
- Use asynchronous HTTP requests to a PHP script on the server.
- Write the PHP script to return JSON (Javascript Object Notation) objects
- Parse the JSON object in a callback and update the webpage
Our experiences to date

- 19 different active projects
- 30 different dataset types
- 30+ users
- 80 different attributes
Some example projects

- Wholly internal projects focused on PET/CT/MR co-registration
- Collaborative projects focused on *in vivo* and *ex vivo* imaging
CT/MR/PET co-registration

• Do cellularity measures from MR correlate with cellular proliferation markers in PET, on a voxel-by-voxel basis?

• Fundamental Data
  • MR diffusion weighted data
  • CT volume for co-registration
  • PET data for cellular proliferation
CT/MR/PET co-registration

• Derivative data
  • Parametric image maps (apparent diffusion coefficients)
• Co-registered/Resampled image data
• Meta-data includes:
  • Animal ID, contrast agent, contrast dosage
An example MR/PET result...

MR cellularity

PET cellular proliferation
In vivo / Ex vivo co-registration

- *In vivo* MR contrast is affected by underlying tissue composition. What specific features of tissue protein profile correlate with MR contrast variations?

- Fundamental data
  - *In vivo* MR images
  - Blockface images for co-registration
  - *Ex vivo* protein profile images from MALDI imaging mass spectrometry
In vivo / Ex vivo co-registration

- Derivative data
- Parametric MR maps (T1, T2, ADC)
- Blockface volume
- Co-registered MR/MALDI Data
- Meta-data
  - Animal ID, weighted image #s, section-to-blockface numbers
MALDI/MRI Co-registration
Forthcoming work

- Extending our current GUI design
- Python/QT for data interaction
- Real-time hardware accelerated visualization
- PostgreSQL backend for pluggable authentication
- Pipelined processing
- CUDA and Beowulf integration
- SLURM resource management
- Copy-on-write filesystem data storage
- ZFS
Conclusions

• The VUIIS presents a unique environment for medical imaging informatics.
• Pre-clinical and clinical, multi-modal research with post-processing
• We have implemented a first-pass data storage application for data management within the VUIIS
• Our current aims are to refine our approach to satisfy our remaining needs
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