



Imaging Researcher's Workshop Annotation and Imaging Markup

Eliot Siegel, M.D.

Professor and Vice Chair University of Maryland
Department of Diagnostic Radiology and Nuclear Medicine

Director MIRTL (Maryland Imaging Research and
Technologies Lab)

Chief Imaging VA Maryland Healthcare System

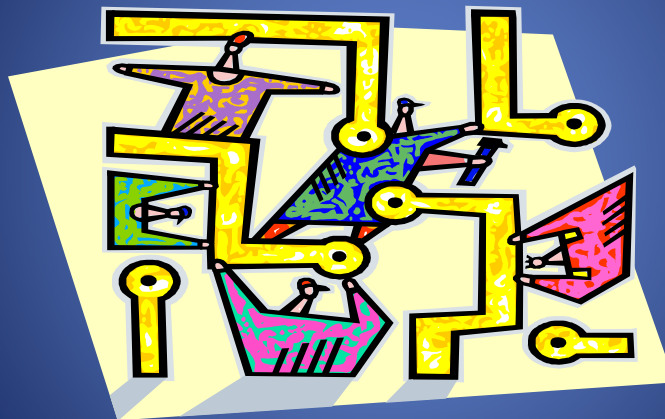
Introduction

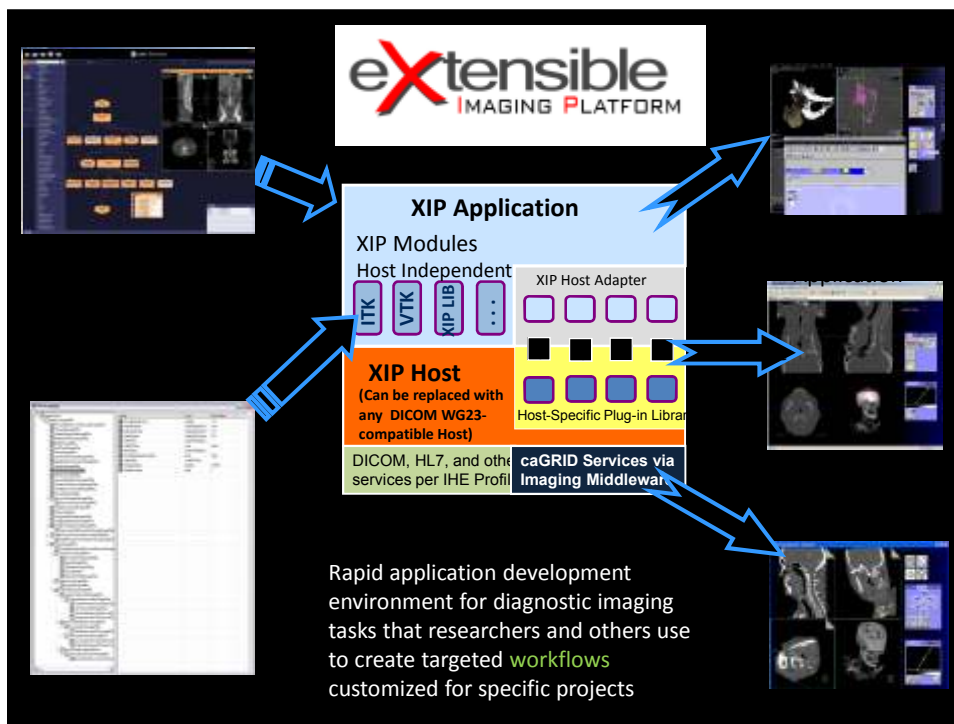
- One of the major original goals of caBIG was to determine out how to create a system that would enable **extraction** of data for research or clinical decision support that would:
 - Allow access to a **variety** of types and sources of data including genomic, proteomic, clinical, lab, demographic, and diagnostic imaging
 - Take advantage of **analytic** potential of grid computing to combine and cross-reference these for analysis for research and clinical care

Introduction to the caBIG in Vivo Imaging Workspace

- caBIG in vivo Imaging workspace established April 2005 a little more than a year after the establishment of the other caBIG workspaces
 - NCI funded effort by far the biggest and most productive effort in imaging informatics today
- Subject matter experts from around country with representation from major Universities, informatics experts, industry, NCI

Review of Relevant Workspace Projects XIP, AIM, Middleware, NBIA

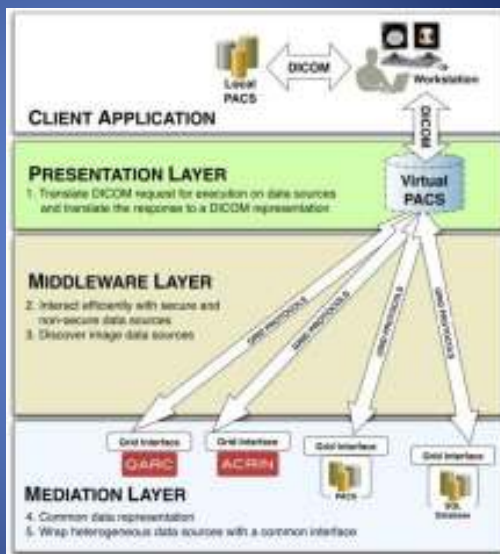




Imaging Middleware (including GridCAD and Virtual PACS)

Grid computing has received surprisingly little attention. One application has been to allow multiple computers to work in parallel on a single task such as **CAD detection of lung nodules** or to give multiple opinions using multiple algorithms

Middleware software is used to create interoperability between DICOM devices and the caGRID which uses a service oriented architecture



NBIA: National Cancer Imaging Archive

- Initially designed as repository for LIDC and RIDER CT lung nodule studies
- Expanded to include multiple additional types of image collections with role based security to share with public or a selected group or to support ongoing clinical trials or other reader studies
- Open source and free
- Meant to be “federated” to create virtual database across multiple instances of NCIA software

NBIA Demo: Home Page

National Cancer Institute U.S. National

NCIA National Cancer Imaging Archive

TOOLS HOME SEARCH IMAGES MANAGE DATA BASKET HELP

RECORD Viewer

ORCID LINKS

READ NEWS

NEW USER'S GUIDE

FAQ HOME

RSNA

an image repository tool

WELCOME TO NATIONAL CANCER IMAGING ARCHIVE

USER LOGIN

EMAIL:

PASSWORD:

NEW USER REGISTRATION

New users are asked to complete a one-time registration form. Please make note of your username and password for future visits. Registration will ensure that we can inform you about important changes and new data.

Need NCIA now offering web-based image visualization and markup of archived image data.
[more information](#)

Welcome to the National Cancer Imaging Archive (NCIA). NCIA is a searchable repository of in vivo cancer images that provides the cancer research community, industry, and academia with access to image archives to be used in the development and validation of analytical software tools that support:


- Lesion detection and classification
- Accelerated diagnostic imaging decision
- Quantitative imaging assessment of drug response

NCIA provides access to imaging resources that will improve the use of imaging in today's cancer research and practice by:

- Increasing the efficiency and reproducibility of imaging cancer detection and diagnosis
- Leveraging imaging to provide an objective assessment of therapeutic response

Slide 8

- E1** We should try to avoid confusion in this slide between our own NCIA which is "now offering we-based image visualization and mark-up" and the NCIA suite of software which does not
Eliot, 3/2/2008




AIM

Annotation & Image Markup

Slides Courtesy Adam Flanders Daniel Rubin

Annotation and Image Markup (AIM)



Markup

Image

Annotation

"Irregular mass in the right lobe of the liver, likely a metastasis."

- **Markup:** Graphical symbols associated with an image and optionally with one or more annotations of that same image
- **Annotation:** Explanatory or descriptive information, generated by humans or machines, directly related to the content of a referenced image

Courtesy DL Rubin MD

AIM is “Semantic Annotation”

- Images lack information about their *contents*
- Machines cannot access/process them
- “Semantics” is the *meaning* of pixels
- “Semantic Annotation” makes *image meaning* accessible to computers

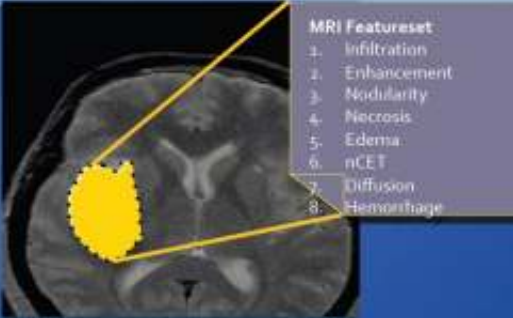


Annotation Imaging Markup (AIM)

- Tool developed through caBIG initiative to create a “standard” method for adding information or knowledge to an existing clinical image such that this additional information can be subsequently searched for, discovered and analyzed.
- Distinction between *annotation* and a *markup*.
- Provides a workable solution for the challenges:
 - No agreed upon syntax for annotation or markup.
 - No agreed upon semantic to described annotations.
 - No standard format (DICOM, XML, HL7) for annotation/markup.

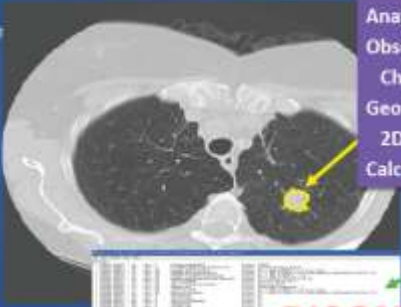
Capabilities of AIM

- Open standard – XML based schema.
- Can represent a wide variety of man-made annotations (e.g. lines, polygons, ellipses).
- Relationship of the annotation to image and mapped to three dimensional space.
- Multiple annotations and markups can be reconciled by reader, date, study etc.
- AIM data can be remapped to original imaging data.
- Pixel data defined by annotations can be used for subsequent analysis.




Mapped to DICOM Instance UID, pixel by pixel, x y z spatial coordinates


An Image, A Markup, and an Annotation



Anatomic Entity: Upper lobe of left lung (RID1327)
 Observation: Mass (RID3874)
 Characteristic: Microlobulated margin (RID5712)
 Geometric Shape: Polyline
 2D coordinates: {{x,y}, {x,y},...}
 Calculation: Largest diameter result: 2.8 cm



DICOM SR



XML

HL7 CDA

Courtesy DL Rubin MD

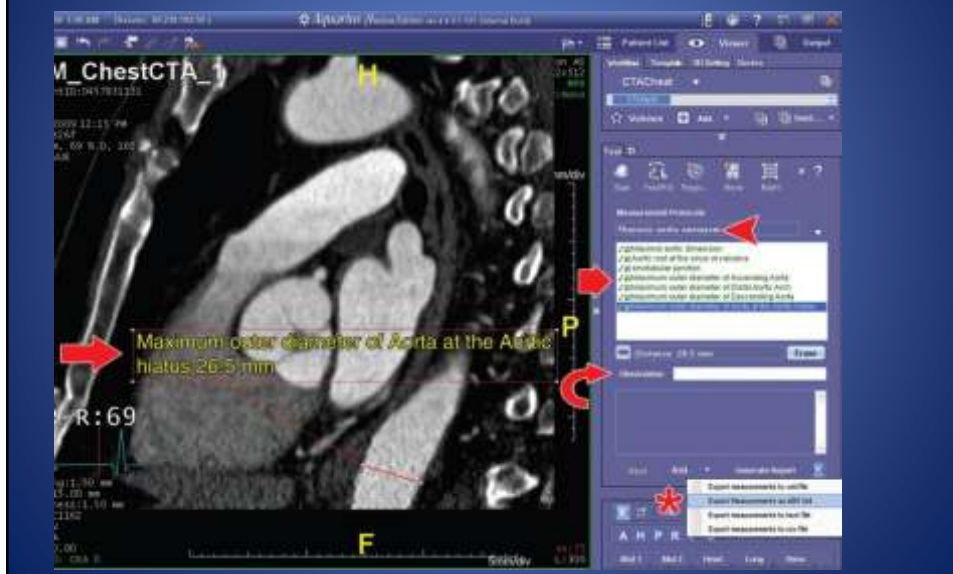
AIM captures...

- **ImageAnnotation**
 - Describe a single object
 - Annotation and markup information on one or multiple images
- **AnnotationOfAnnotation**
 - Annotation information on one or multiple AIM annotations
 - Grouping
 - Comparing

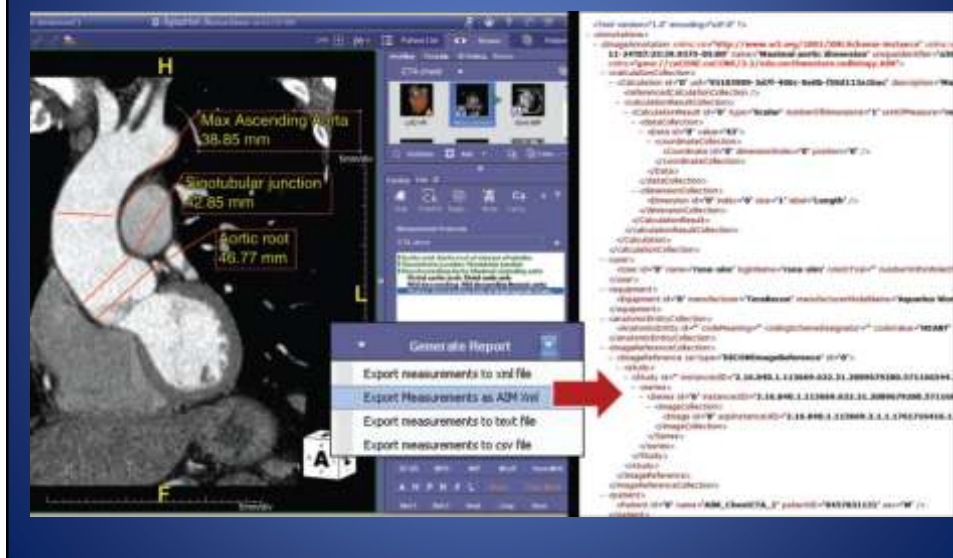
Courtesy DL Rubin MD

Create An AIM Annotation

The user selected the "Thoracic aortic aneurysm" measurement protocol (arrowhead), below which a list of required measurements is displayed (short straight arrow). As the user manipulates the 3D volume and performs measurements according to the protocol, annotations with text labels are automatically applied to the image (long straight arrow). Additional descriptive RadLex terms can be applied to each annotation using the "Observation" text box (curved arrow). When all measurements have been completed, annotation data are exported in AIM-XML format by selecting the appropriate entry (*) from the drop-down menu under "Generate Report." The data are then automatically sent to the reporting software and may also be sent to a research database.



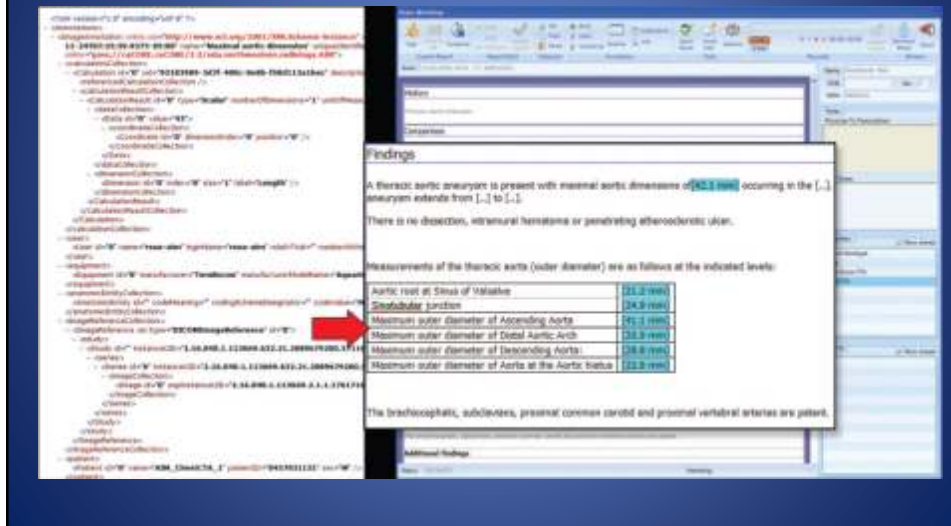
Exporting quantitative imaging data in AIM-XML format
 AIM report-generating function
 An AIM-XML file is created that includes quantitative and descriptive data in a standardized format.



Screen shot of reporting software (M*Modal) shows how quantitative data (blue) are automatically imported into the reporting template from the AIM-XML file

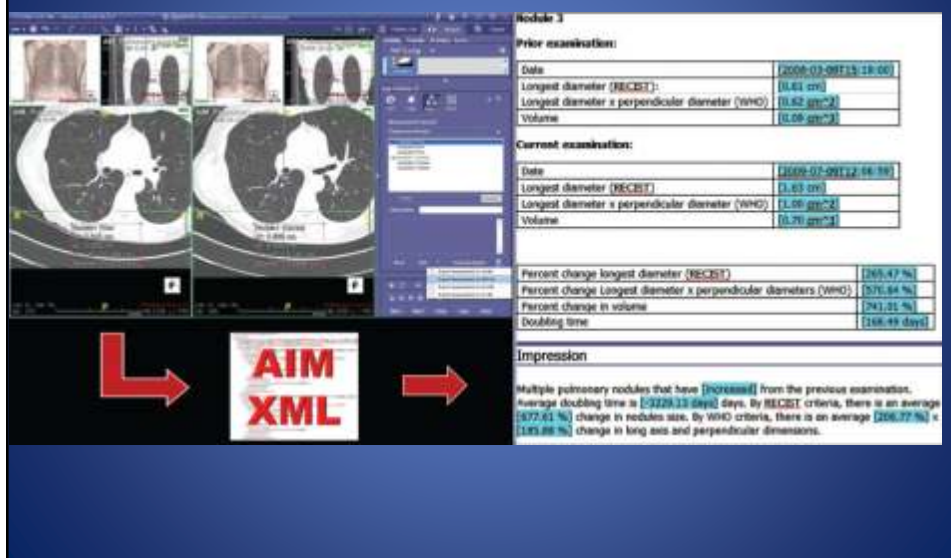
After the quantitative data are imported into the template, the radiologist dictates the qualitative findings and finalizes the report

He or she is able to complete the report without having to type or dictate the quantitative findings, thereby reducing the chances for error and streamlining work flow.



Lung nodule follow-up work flow
Lung nodules that are part of a comparison study are automatically segmented, with maximal diameters and volumes calculated with a single button click

These data are exported to an AIM-XML file that is then sent to the reporting software
The reporting software incorporates the data into a reporting template and performs simple calculations, such as doubling time and percent change in lesion size (blue), and can automatically report information using a variety of standard criteria (WHO [World Health Organization] or RECIST [Response Evaluation Criteria in Solid Tumors] criteria).



Traumatic Brain Injury Research Using the caBIG AIM Model

Dzung L. Pham¹, Ashish Hinger¹, Pattanasak
Mongkolwat², John Butman¹

¹ Image Processing Core, Center for Neuroscience and Regenerative Medicine

² Department of Radiology, Northwestern University



August 29, 2011



Summary

Problem: How do we standardize collection and storage of imaging findings in TBI imaging data?



Solution: Use caBIG AIM with customized TBI templates

Traumatic Brain Injury (TBI)



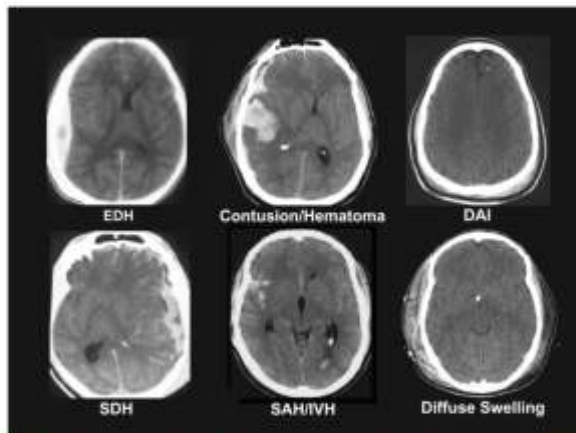
TBI is an intracranial injury caused by an external impact or event

Clinical Diagnosis

- **Mild TBI:** loss or alteration of consciousness < 30 minutes, post-traumatic amnesia < 24 hours, and/or Glasgow Coma Score (GCS) of 13-15.
- **Moderate TBI:** loss of consciousness 30 mins-24 hrs, post-traumatic amnesia 1-7 days, and an initial GCS of 9-12.
- **Severe TBI:** GCS less than 9

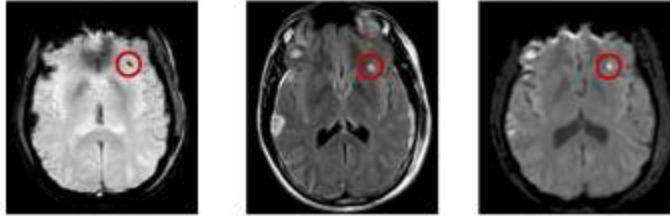
TBI is associated with a variety of short-term and potentially long-term physical, cognitive, and behavioral effects

Imaging of TBI



6 CTs from patients diagnosed with severe TBI
(Saatman et al., J. Neurotrauma 2008)

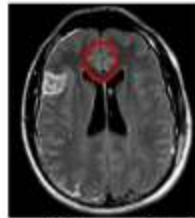
MR Imaging of TBI



Traumatic Axonal Injury in one subject



Diffuse Axonal Injury

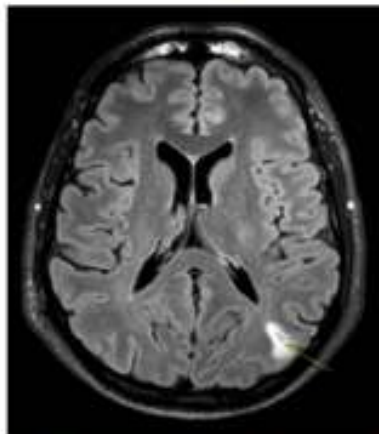


Extra-axial Hemorrhage



Contusion

Image Interpretation



Radiological Reading

- FINDINGS: "...wedge shaped region of FLAIR hyperintensity centered at the left temporo-occipital junction..."
- IMPRESSION: Cortical contusion likely secondary to traumatic brain injury.

Challenge: How do we standardize TBI investigational data collection in a consistent and rigorous fashion?

How to implement CDEs?

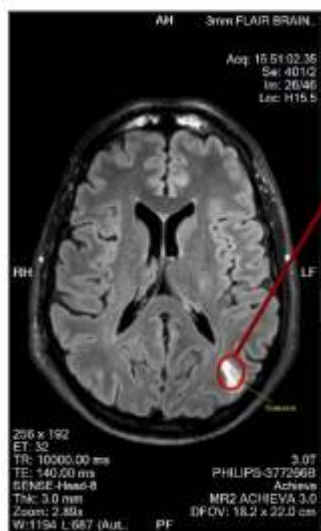


FINDINGS: "...wedge shaped region of FLAIR hyperintensity centered at the left temporo-occipital junction..."

IMPRESSION: Cortical contusion likely secondary to traumatic brain injury.

- No details about the lesion location or size
- Difficult to index

CDEs and AIM Model



Anatomic Entity: Occipital lobe
Observation: Contusion
Characteristic: FLAIR Hyperintense
Geometric Shape: point
2D coordinates: {{25,-30}}
Calculation: 80mm²

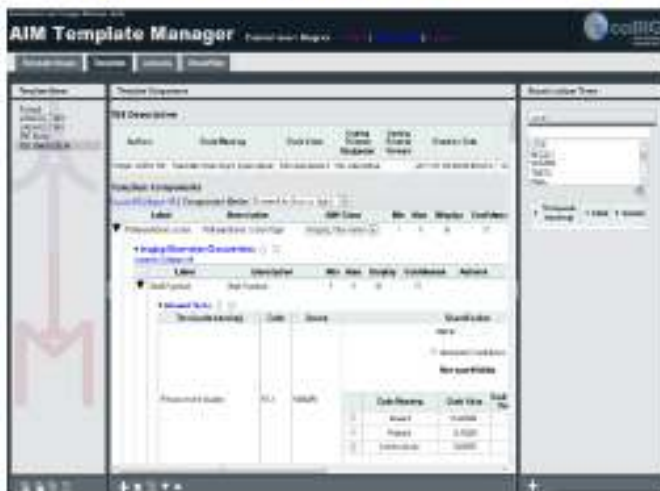
Dicom SR



XML

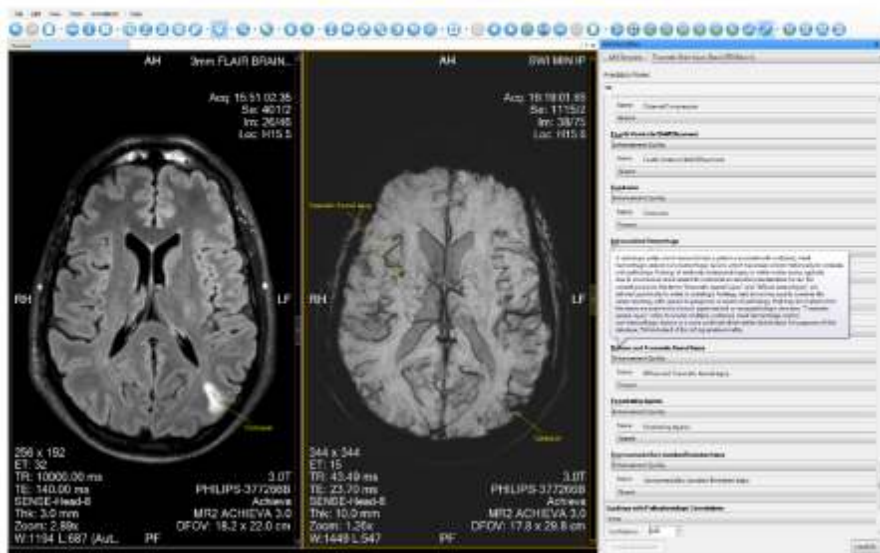


AIM Template Creation



- Web-based editor available (<http://bmir-vm9.stanford.edu>)
- Alternatively, any XML editor

AIM Template Example

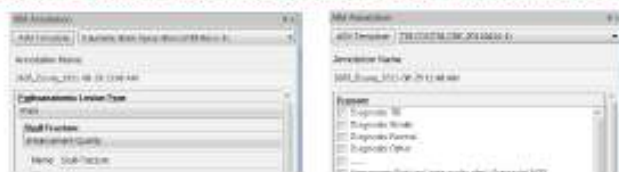


TBI Templates

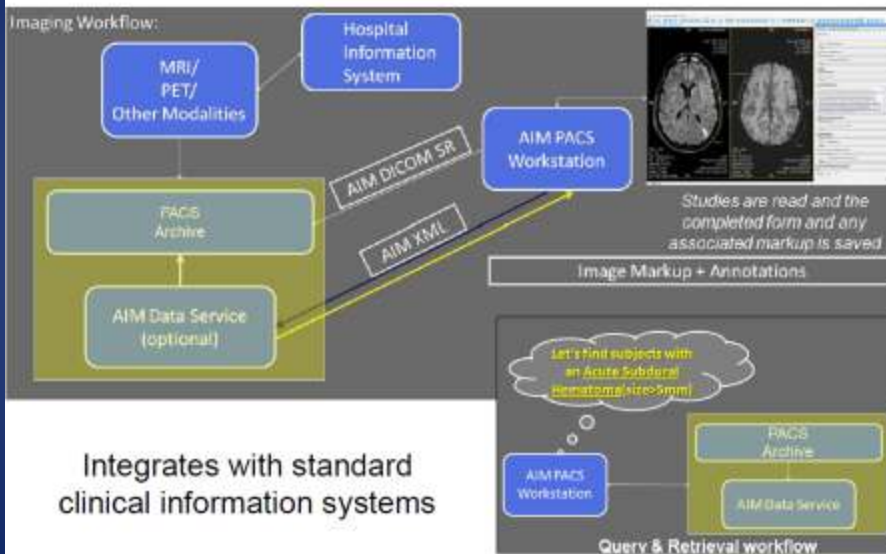
TBI templates were implemented to define structured reading forms based on the three CDE categories:

- **Basic template** probes the simple presence or absence of structural abnormalities, such as hemorrhages or contusions.
- **Descriptive template** augments this information and includes a simple grading scale to provide a sense of extent and location of pathology.
- **Advanced template** involves in-depth measurements and interpretations of morphology.

Customized templates tailored to specific research questions are also possible



AIM Integration



Template Variations

- Ordered reading vs. Unordered
- Drop down boxes vs. check boxes
- One form per subject vs. multiple forms
- Single markup vs. multiple markups

Ordered

Unordered

Conclusions and Future Work

- Employing AIM as both a data model and software framework for collecting and managing imaging markups and annotations in TBI research studies
- Valuable for indexing imaging results in research studies and clinical trials
- Additional testing and validation
- Some enhancements to the UI can improve reading efficiency and flexibility
- Some enhancements to the model to better capture findings
- Integrating with automated image processing
- Management of non-reading based computational analysis results

Ongoing Work

- Translation of proprietary LIDC and RIDER annotations to AIM format in NBIA
- Creation of high level AIM model for images
- Applied to:
 - Radiology
 - Nuclear Medicine
 - Pathology
 - Cell biology
 - Baggage screening
 - Satellite reconnaissance imagery
 - Etc.
- Creation of API
 - For those using software such as Slicer, NIH Image, Clinical trial purpose build applications, commercial software
 - Initially for RECIST measurements
 - Will be generalized