Slicer annotations for the Quantitative Imaging Network

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QIN

- 13 centers of imaging excellence:
  - https://wiki.nci.nih.gov/display/CIP/QIN
- Goal: to promote research and development of quantitative imaging methods for the measurement of tumor response to therapies in clinical trial settings, with the overall goal of facilitating clinical decision making
- *Support creation of public registries and image database resources to support clinical decision making for therapies by the broader oncology community*

Scope of work

- Supplement to BWH QIN grant
- “implement support of AIM in 3D Slicer, including storage of annotations produced by 3D Slicer in AIM format and importing AIM annotations into 3D Slicer.”

Why DICOM SR/AIM?

- “Structure” of most common radiologic reports: “Finding” and “Impression” sections dictated
- Difficult to use for research, data mining, confusion possible even while exchanging reports amongradiologists
- No explicit connection of the report to the image finding
- Need structure, vocabulary, connection to the finding in the image

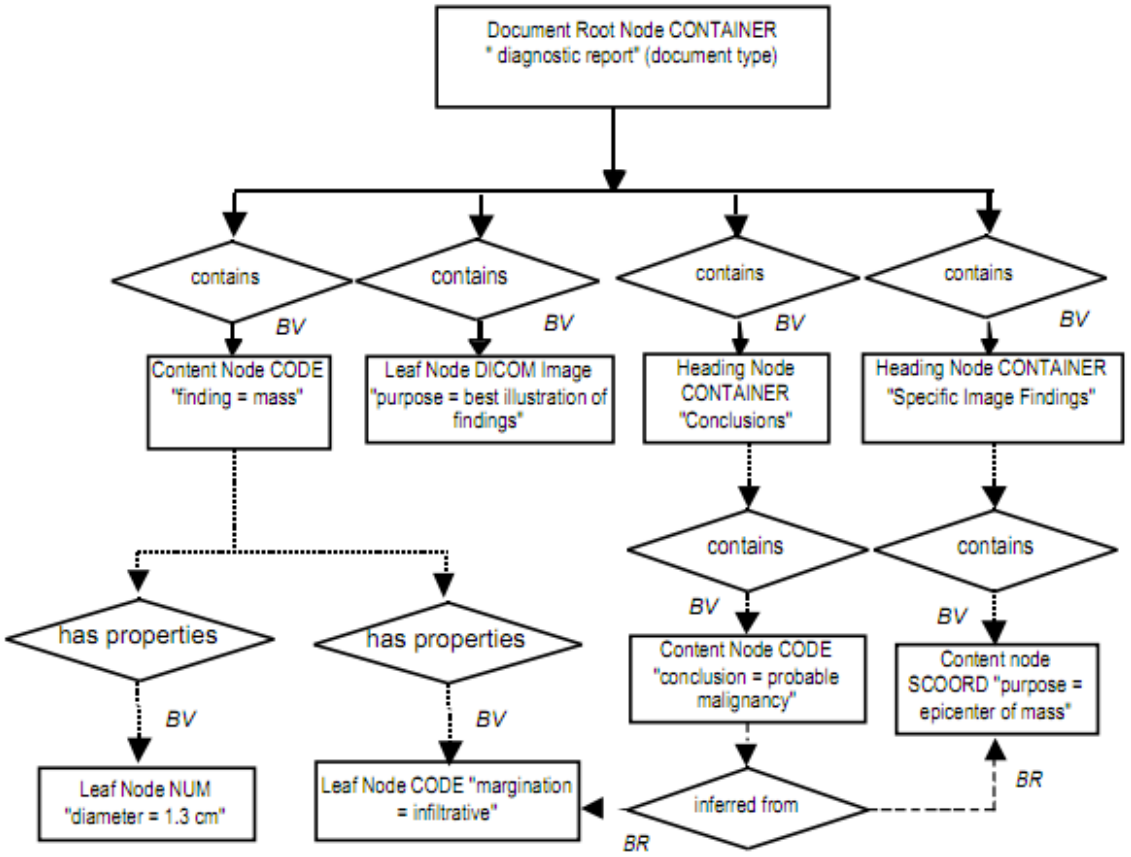
DICOM SR basics

- Designed to be self-describing information structure
- Support templates and context-dependent terminology
- DICOM Supplement 23
- Supported by vendors
  - Siemens Syngo.via
  - Others?

Tree of content

C.Z.4 SR Content Tree Example (Informative)

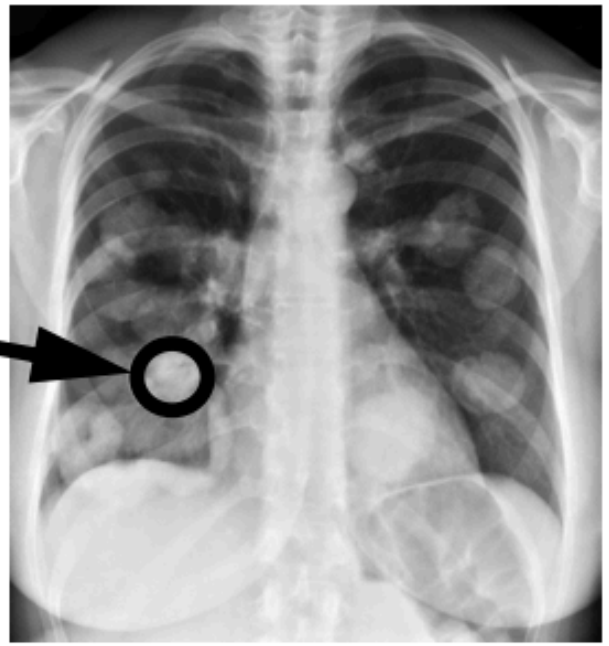
Figure C.Z.4-1 depicts the content of an example diagnostic interpretation.



http://medical.nema.org/Dicom/supps/sup23_lb.pdf, p.288

Clinical user view

Chest X-ray Report:
Observer: Clunie^David^A^Dr.
History: malignant melanoma excised 1Y
Findings:
- finding: multiple masses in both lung fields
- best illustration of findings:



Conclusions:
- conclusion: cannon-ball metastases
- conclusion: recurrent maligant melanoma
Diagnosis Codes:
- diagnosis: 172.9/ICD9
- diagnosis: 197.0/ICD9

FIGURE 1. Simple example of a DICOM Structured Report

Clunie, D. (2000). DICOM Structured Reporting. PixelMed Publishing, p.30

Tree elements

- Value types (CONTAINER, CODE, TEXT, SCOORD)
- Relationships (“contains”, “has properties”, “inferred from”)
- Markup: SCOORD
  - POINT, MULTIPOINT, POLYLINE, CIRCLE, ELLIPSE
  - Pixel coordinates
  - POLYLINE is always closed!

Annotation Image Markup (AIM) basics

- Information model
- Described by XML schema
- Serialized using XML
- Terminology:
  - An image *annotation* is the explanatory or descriptive information about the pixel data of an image that is generated by a human or machine observer.
  - An image *markup* is the graphical symbols placed over the image to depict an annotation.

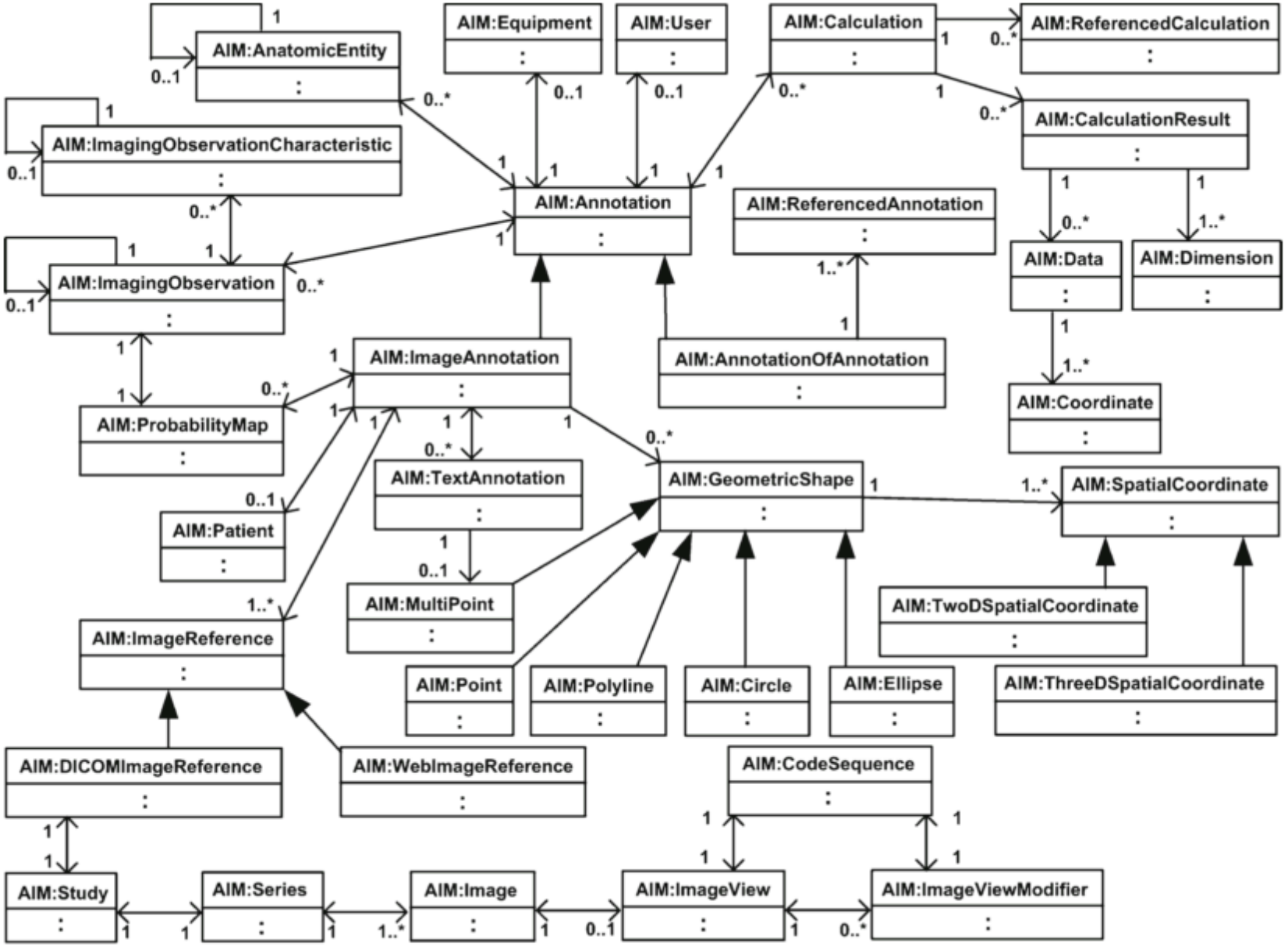


Fig 1. AIM UML Class diagram.

Channin et al. (2010). The caBIG annotation and image Markup project. Journal of digital imaging : the official journal of the Society for Computer Applications in Radiology, 23(2), 217-25

AIM Markup

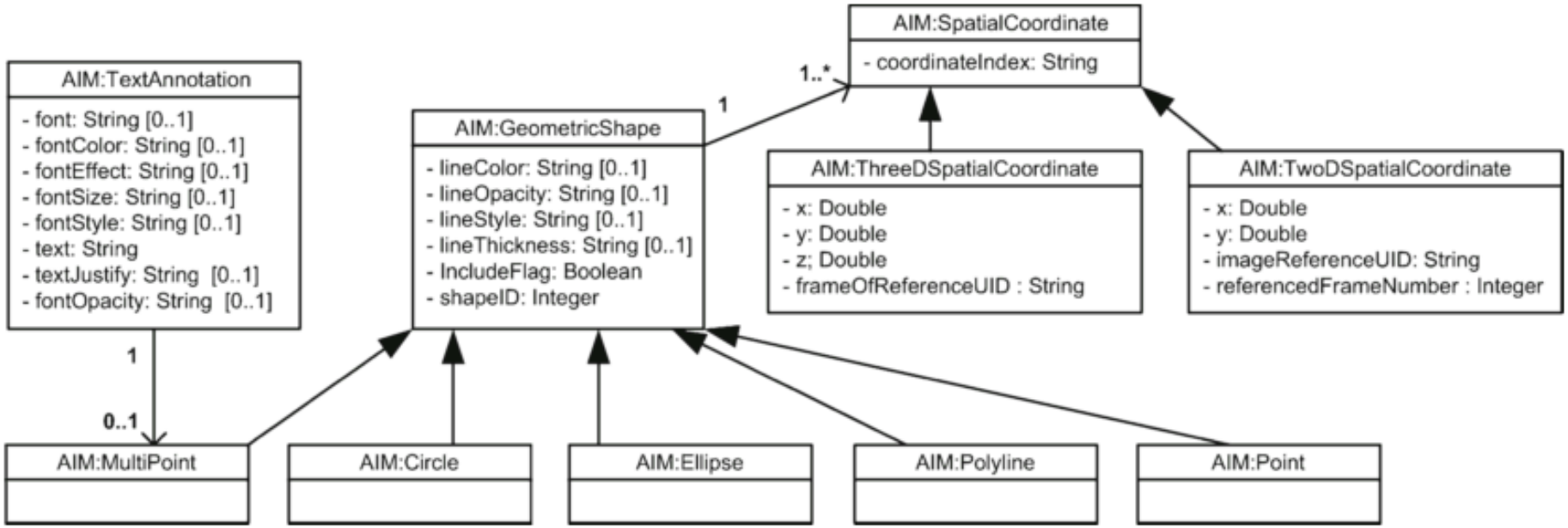


Fig 5. Markup group.

Annotation templates

- The AIM template XML schema allows to create an XML document containing controlled questions and answers based on known vocabularies such as SNOMED CT, RadLex, LOINC, etc. as well as user-defined terminologies.
- DICOM SR templates – similar purpose, vocabularies

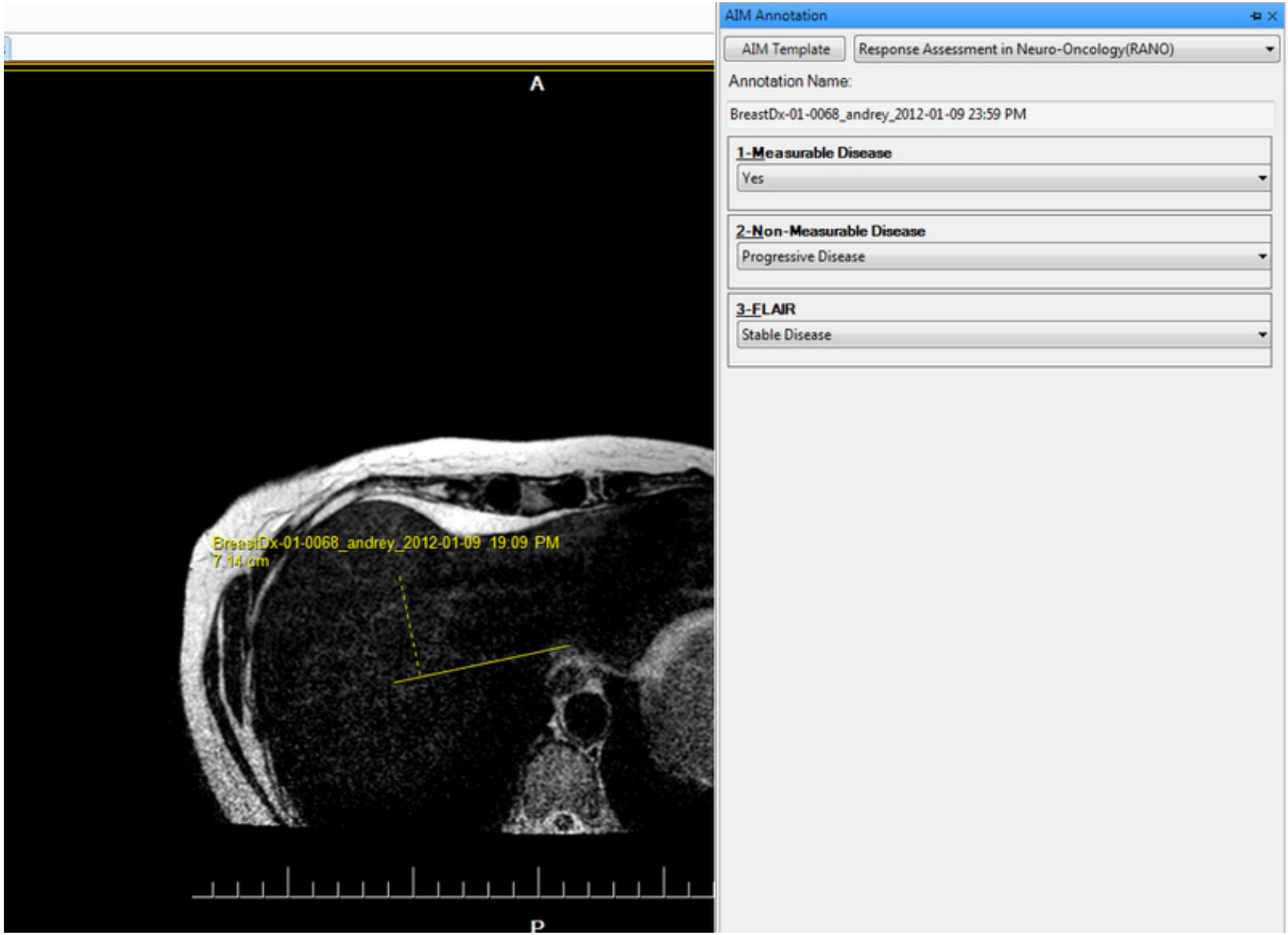
Example

RANO Template

```
<?xml version="1.0" encoding="UTF-8"?>
<TemplateContainer authors="oslo_mgh" name="RANO_NEW"
     version="1.0" description="RANO WITHOUT MEASURABLE DISEASE ASSESSMENT"
     creationDate="2011-11-18" xsi:schemaLocation="gme://caCORE.caCORE/3.2/edu.northwestern.radiology.AIMTemplate AIMTemplate_v1rv18.xsd"
     xmlns="gme://caCORE.caCORE/3.2/edu.northwestern.radiology.AIMTemplate"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <Template name="RANO_NEW" version="1.0" authors="oslo_mgh"
      description="Response Assessment in Neuro-Oncology" uid="123.987.32156.8454.1213156464.87987"
      codeValue="RANO" codeMeaning="Response Assessment in Neuro-Oncology" codingSchemeDesignator="RANO"
      creationDate="2011-11-18">
    <Component label="2-Non-Measurable Disease" minCardinality="1" maxCardinality="1" itemNumber="1" shouldDisplay="true"
        explanatoryText="Evaluation of Non-Measurable Disease" authors="mcpinho77">
      <Inference annotatorConfidence="false"/>
      <AllowedTerm codeMeaning="Stable Disease" codeValue="RANO1" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Progressive Disease" codeValue="RANO4" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Baseline" codeValue="RANO0" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Not Present" codeValue="RANO5" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Non-evaluable" codeValue="RANO6" codingSchemeDesignator="RANO">
      </AllowedTerm>
    </Component>
    <Component label="3-FLAIR" minCardinality="1" maxCardinality="1" itemNumber="2" shouldDisplay="true"
        explanatoryText="Tumor Evaluation on FLAIR" authors="mcpinho77">
      <Inference annotatorConfidence="false"/>
      <AllowedTerm codeMeaning="Stable Disease" codeValue="RANO1" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Progressive Disease" codeValue="RANO4" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Baseline" codeValue="RANO0" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Not Present" codeValue="RANO5" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Non-evaluable" codeValue="RANO6" codingSchemeDesignator="RANO">
      </AllowedTerm>
    </Component>
    <Component label="1-Measurable Disease" minCardinality="1" maxCardinality="1" itemNumber="0"
        shouldDisplay="true" explanatoryText="Presence or Absence of Measurable Lesions" authors="mcpinho77">
      <Inference annotatorConfidence="false"/>
      <AllowedTerm codeMeaning="Yes" codeValue="RANO7" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="No" codeValue="RANO8" codingSchemeDesignator="RANO">
      </AllowedTerm>
      <AllowedTerm codeMeaning="Not Evaluable" codeValue="RANO6" codingSchemeDesignator="RANO">
      </AllowedTerm>
    </Component>
  </Template>
</TemplateContainer>
```

Courtesy Jayashree Kalpathy-Cramer, MGH

ClearCanvas TCGA WS



AIM Annotation

<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<ImageAnnotation xmlns="gme://caCORE.caCORE/3.2/edu.northwestern.radiology.AIM" aimVersion="3.0" cagridId="0" codeMeaning="Response Assessment in Neuro-Oncology" codeValue="RANO" codingSchemeDesignator="RANO" dateTime="2012-01-09T19:09:58" name="BreastDx-01-0068_andrey_2012-01-09 19:09 PM" uniqueIdentifier="1.3.6.1.4.1.25403.879675056567 4.2788.20120109070958.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="gme://caCORE.caCORE/3.2/edu.northwestern.radiology.AIM AIM_v3_rv11_XML.xsd">

AIM Annotation cont.

```
<calculationCollection>
  <Calculation cagridId="0" codeMeaning="Length" codeValue="G-A22A" codingSchemeDesignator="SRT" description="Length"
uid="1.3.6.1.4.1.25403.8796750565674.2788.20120109070958.1">
    <referencedCalculationCollection/>
    <calculationResultCollection>
      <CalculationResult cagridId="0" numberOfDimensions="1" type="Scalar" unitOfMeasure="mm">
        <calculationDataCollection>
          <CalculationData cagridId="0" value="71.3865693161104">
            <coordinateCollection>
              <Coordinate cagridId="0" dimensionIndex="0" position="0"/>
            </coordinateCollection>
          </CalculationData>
        </calculationDataCollection>
        <dimensionCollection>
          <Dimension cagridId="0" index="0" label="Value" size="1"/>
        </dimensionCollection>
      </CalculationResult>
    </calculationResultCollection>
    <referencedGeometricShapeCollection>
      <ReferencedGeometricShape cagridId="0" referencedShapeIdentifier="0"/>
    </referencedGeometricShapeCollection>
  </Calculation>
</calculationCollection>
```

AIM Annotation cont.

```
<inferenceCollection>
  <Inference cagridId="0" codeMeaning="Yes" codeValue="RANO7" codingSchemeDesignator="RANO" codingSchemeVersion="" imageEvidence="true"/>
  <Inference cagridId="0" codeMeaning="Progressive Disease" codeValue="RANO4" codingSchemeDesignator="RANO" codingSchemeVersion="" imageEvidence="true"/>
  <Inference cagridId="0" codeMeaning="Stable Disease" codeValue="RANO1" codingSchemeDesignator="RANO" codingSchemeVersion="" imageEvidence="true"/>
 </inferenceCollection>

 <user>
  <User cagridId="0" loginName="andrey" name="andrey" numberWithinRoleOfClinicalTrial="1" roleInTrial="Performing"/>
 </user>

 <equipment>
  <Equipment cagridId="0" manufacturerModelName="AIM_TCGA_v3" manufacturerName="Northwestern University" softwareVersion="3.0.0.3"/>
 </equipment>

 <imageReferenceCollection>
  <ImageReference cagridId="0" xsi:type="DICOMImageReference">
   <imageStudy>
    <ImageStudy cagridId="0" instanceUID="1.3.6.1.4.1.14519.5.2.1.4792.2001.200235584781096359647374535914" startDate="2008-06-27T00:00:00"
startTime="000000">
     <imageSeries>
      <ImageSeries cagridId="0" instanceUID="1.3.6.1.4.1.14519.5.2.1.4792.2001.170977198031148408225883336860">
       <imageCollection>
        <Image cagridId="0" sopClassUID="1.2.840.10008.5.1.4.1.1.4" sopInstanceUID="1.3.6.1.4.1.14519.5.2.1.4792.2001.149982482708499901857882575988"/>
       </imageCollection>
      </ImageSeries>
     </imageSeries>
    </ImageStudy>
   </imageStudy>
  </ImageReference>
 </imageReferenceCollection>
```

AIM Annotation cont.


```
 <geometricShapeCollection>
   <GeometricShape cagridId="0" includeFlag="true" shapeIdentifier="0" xsi:type="MultiPoint">
     <spatialCoordinateCollection>
       <SpatialCoordinate cagridId="0" coordinateIndex="0"
imageReferenceUID="1.3.6.1.4.1.14519.5.2.1.4792.2001.149982482708499901857882575988"
referencedFrameNumber="1" x="170.666656494141" xsi:type="TwoDimensionSpatialCoordinate"
y="359.489318847656"/>
       <SpatialCoordinate cagridId="0" coordinateIndex="1"
imageReferenceUID="1.3.6.1.4.1.14519.5.2.1.4792.2001.149982482708499901857882575988"
referencedFrameNumber="1" x="274.156005859375" xsi:type="TwoDimensionSpatialCoordinate"
y="337.702087402344"/>
     </spatialCoordinateCollection>
   </GeometricShape>
 </geometricShapeCollection>

 <person>
   <Person cagridId="0" id="BreastDx-01-0068" name="" sex="F"/>
 </person>

</ImageAnnotation>
```

Corresponding DICOM SR

```
# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 200                              #   4, 1 FileMetaInformationGroupLength
(0002,0001) OB 00\01                            #   2, 1 FileMetaInformationVersion
(0002,0002) UI =ComprehensiveSRStorage          #  30, 1 MediaStorageSOPClassUID
(0002,0003) UI [1.2.276.0.7230010.3.1.4.768493426.2904.1326154540.4] #  52, 1 MediaStorageSOPInstanceUID
(0002,0010) UI =LittleEndianExplicit            #  20, 1 TransferSyntaxUID
(0002,0012) UI [1.2.276.0.7230010.3.0.3.5.4]    #  28, 1 ImplementationClassUID
(0002,0013) SH [OFFIS_DCMTK_354]                #  16, 1 ImplementationVersionName

# Dicom-Data-Set
# Used TransferSyntax: Little Endian Explicit
(0008,0005) CS [ISO_IR 100]                     #  10, 1 SpecificCharacterSet
(0008,0012) DA [20120109]                       #   8, 1 InstanceCreationDate
(0008,0013) TM [191540]                         #   6, 1 InstanceCreationTime
(0008,0014) UI [1.2.276.0.7230010.3.0.3.5.4]    #  28, 1 InstanceCreatorUID
(0008,0016) UI =ComprehensiveSRStorage          #  30, 1 SOPClassUID
(0008,0018) UI [1.2.276.0.7230010.3.1.4.768493426.2904.1326154540.4] #  52, 1 SOPInstanceUID
(0008,0020) DA (no value available)             #   0, 0 StudyDate
(0008,0023) DA [20120109]                       #   8, 1 ContentDate
(0008,0030) TM (no value available)             #   0, 0 StudyTime
(0008,0033) TM [191540]                         #   6, 1 ContentTime
(0008,0050) SH (no value available)             #   0, 0 AccessionNumber
(0008,0060) CS [SR]                             #   2, 1 Modality
(0008,0070) LO [Northwestern University]        #  24, 1 Manufacturer
(0008,0090) PN (no value available)             #   0, 0 ReferringPhysicianName
(0008,103e) LO [AIM DICOM SR]                   #  12, 1 SeriesDescription
(0008,1090) LO [AIM_TCGA_v3]                    #  12, 1 ManufacturerModelName
(0008,1111) SQ (Sequence with explicit length #=0)     #   0, 1 ReferencedPerformedProcedureStepSequence
(fffe,e0dd) na (SequenceDelimitationItem for re-encod.) #   0, 0 SequenceDelimitationItem
(0010,0010) PN (no value available)             #   0, 0 PatientName
(0010,0020) LO [BreastDx-01-0068]               #  16, 1 PatientID
(0010,0030) DA (no value available)             #   0, 0 PatientBirthDate
(0010,0040) CS [F]                              #   2, 1 PatientSex
(0010,2160) SH (no value available)             #   0, 0 EthnicGroup
(0018,1020) LO [3.0.0.3]                        #   8, 1 SoftwareVersions
(0020,000d) UI [1.3.6.1.4.1.14519.5.2.1.4792.2001.200235584781096359647374535914] #  64, 1 StudyInstanceUID
(0020,000e) UI [1.2.276.0.7230010.3.1.3.768493426.2904.1326154540.5] #  52, 1 SeriesInstanceUID
(0020,0010) SH (no value available)             #   0, 0 StudyID
(0020,0011) IS [1]                              #   2, 1 SeriesNumber
(0020,0013) IS [1]                              #   2, 1 InstanceNumber
(0040,a040) CS [CONTAINER]                      #  10, 1 ValueType
(0040,a043) SQ (Sequence with explicit length #=1)     #  70, 1 ConceptNameCodeSequence
```

Questions and common needs

- Specialized module or plugin for DICOM module?
- Support of conversion bw RAS and DICOM slice image IJ coordinates (connect DICOM image UIDs with Slicer volumes)?
- DICOM SR or AIM?
- Import and export of DICOM SR?
- Validation/verification? Reference implementations?

Followup

- Main page for the project:
  - http://wiki.na-mic.org/Wiki/index.php/Projects:QIN:3D_Slicer_Annotation_Image_Markup