



CrEDIBLE Thematic Working Days / October 8-10, 2014

Expressing Medical Image Measurements using Ontologies from the OBO Library

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Agenda

Measurements in Radiology and Pathology

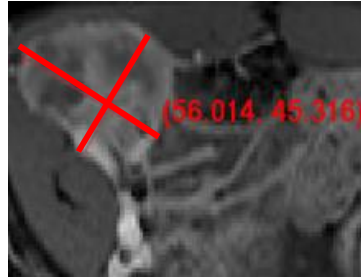
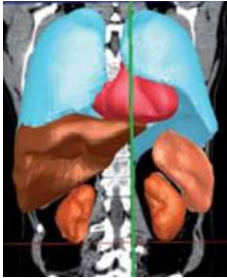
Expressing Measurements

Normal Size Specifications

Applications

Measurements in Radiology

Not comprehensive list



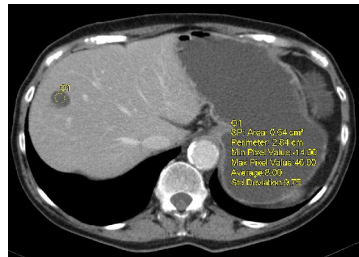
1)

Size

length: 1D, 2D, 3D

area, volume

index (e.g. spleen index = width*height*depth)



Density measured in Hounsfield scale (Hu)

mainly in CT images

minimal, maximal and mean density values for Regions of Interest (ROIs)



Angle

e.g. bone configurations or fractions

Blood flow

e.g. PET: myocardial blood flow and blood flow in brain

...

1) Source: <http://www.recist.com/recist-in-practice/19.html>

Measurements in Pathology

Not comprehensive

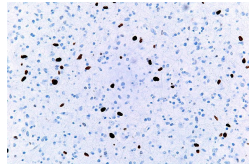
Size

length: 1D, 2D, 3D

area, volume

Weight

weight of resected tissue, nodule or tumor



Ratios

immunohistochemical staining of tumor cells

Other measurements

viscosity of blood, serum, and plasma

mitotic rate

serum concentration

...

Longitudinal Integration

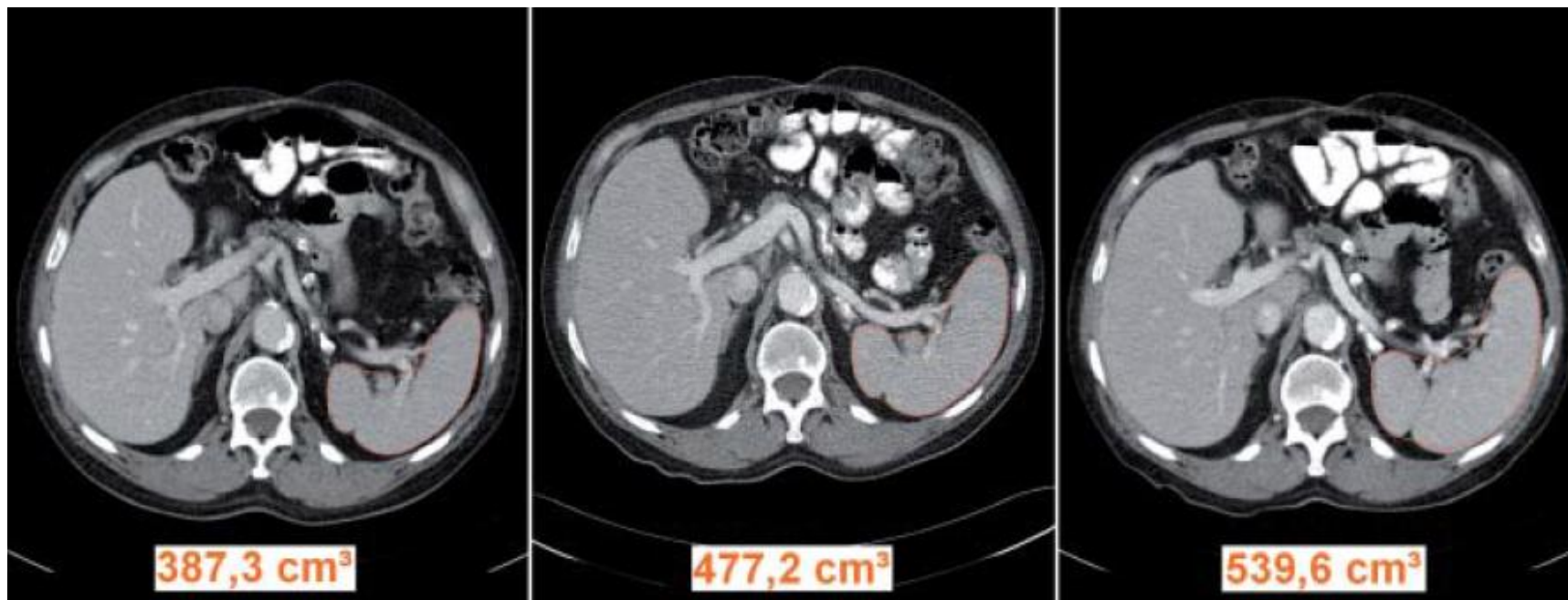


Image source: "Automated Detection and Volumetric Segmentation of the Spleen in CT Scans" M. Hammon, P. Dankerl, M. Kramer, S. Seifert, A. Tsymbol2, M. J. Costa2, R. Janka1, M. Uder1, A. Cavallaro

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Reused Ontologies

The following ontologies are used to express measurement information.

Basic Formal Ontology (BFO2)

Completely domain independent

Relations Ontology (RO)

has_part, has_participant, located_in ...

Information Artifact Ontology (IAO)

document, report, figure, measurement datum ...

Ontology for Biomedical Investigations (OBI)

value specification, study, tissue specimen, plan, prediction, staining, ...

Phenotypic Quality (PATO)

size, length, diameter, mass, color ...

Units Ontology (UO)

units for length, mass and time.

Biological Spatial Ontology (BSPO)

anatomical axis, anatomical plane, ...

Ontology for General Medical Science (OGMS)

basic clinical concepts like, e.g., diagnosis, clinical finding, pathological anatomical structure ...

Integration
and extensions

Model for Clinical Information (MCI)

Used Reference Terminologies:

- Foundational Model of Anatomy (FMA)
- Radiological Lexicon (RadLex)

obi:value specification

The element "1.8 cm" can occur in many different parts of a biomedical investigation.

"1.8 cm" might be part of:

- the data resulting from a measurement of one of John's lymph nodes, made on January 12, 2014 in Berlin
- a protocol, i.e. a specification of a plan to make some measurement
- a prediction of the result a measurement planned for the future
- a rule for classifying measurements
- many more ...

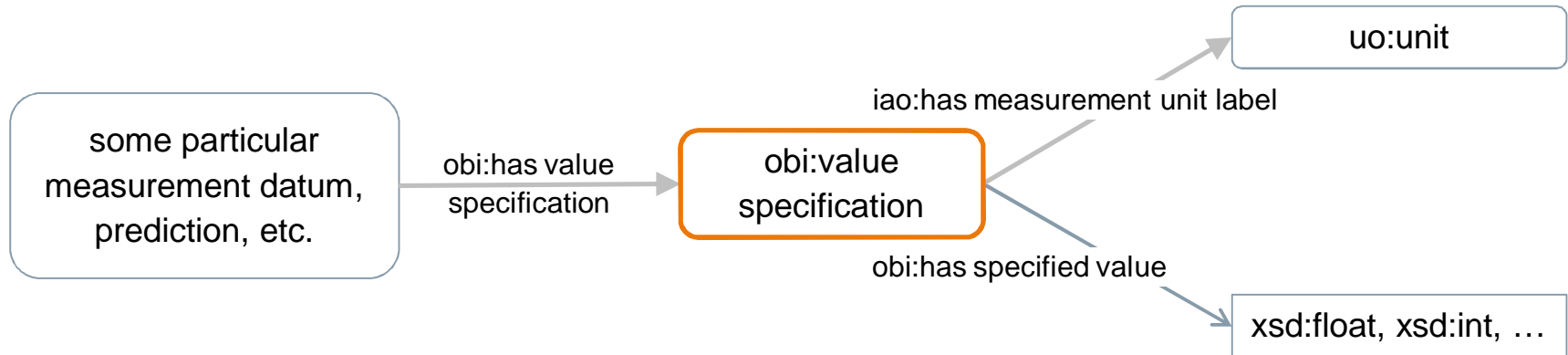
OBI uses the "value specification" approach to capture the shared structure across different uses and allow for easy comparison between them.

obi:value specification

Shared Structure in Different Contexts

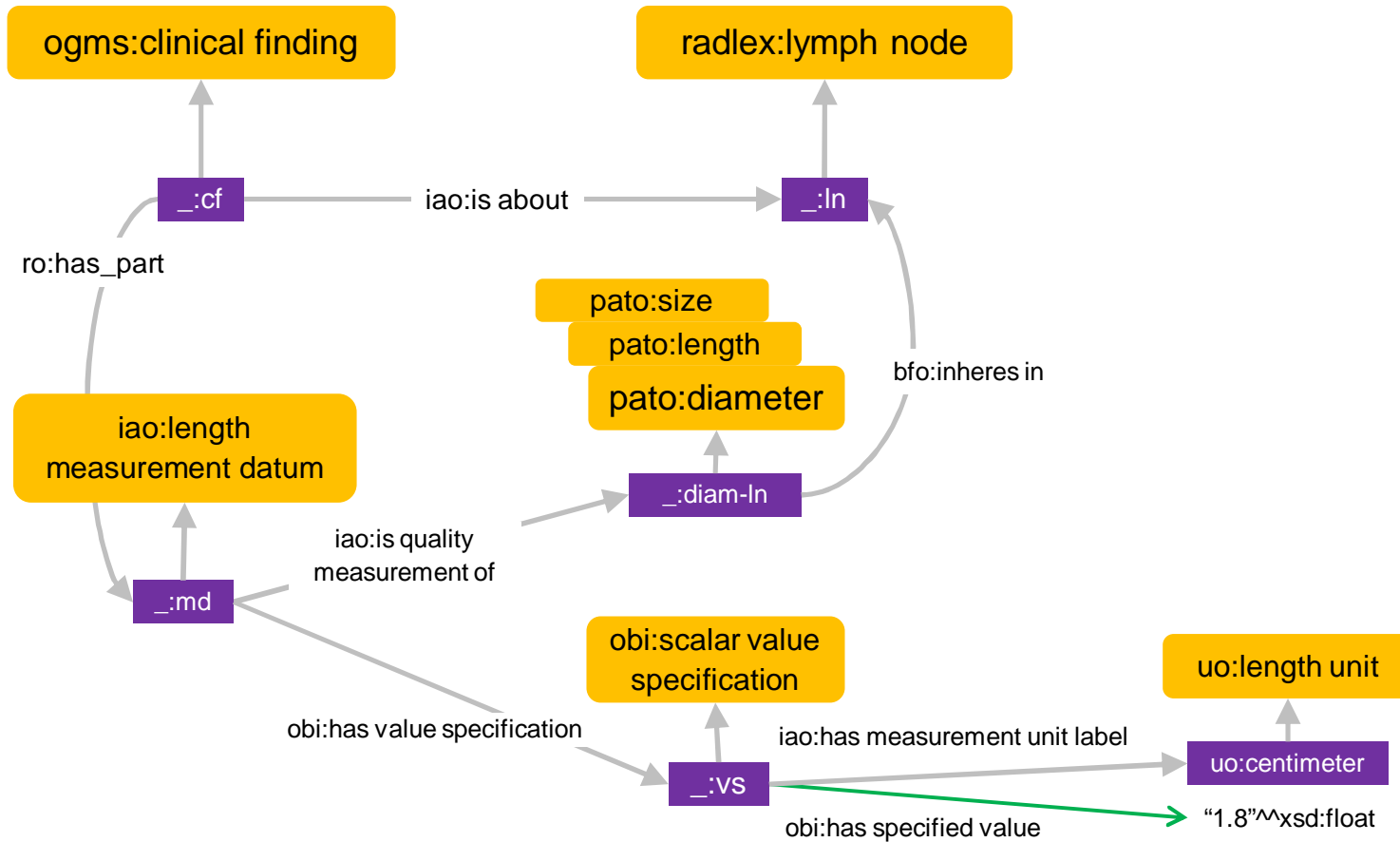
Definition: An information content entity that specifies a value within a classification scheme or on a quantitative scale.

Example of usage: The value of 'positive' in a classification scheme of "positive or negative"; the value of '20g' on the quantitative scale of mass.



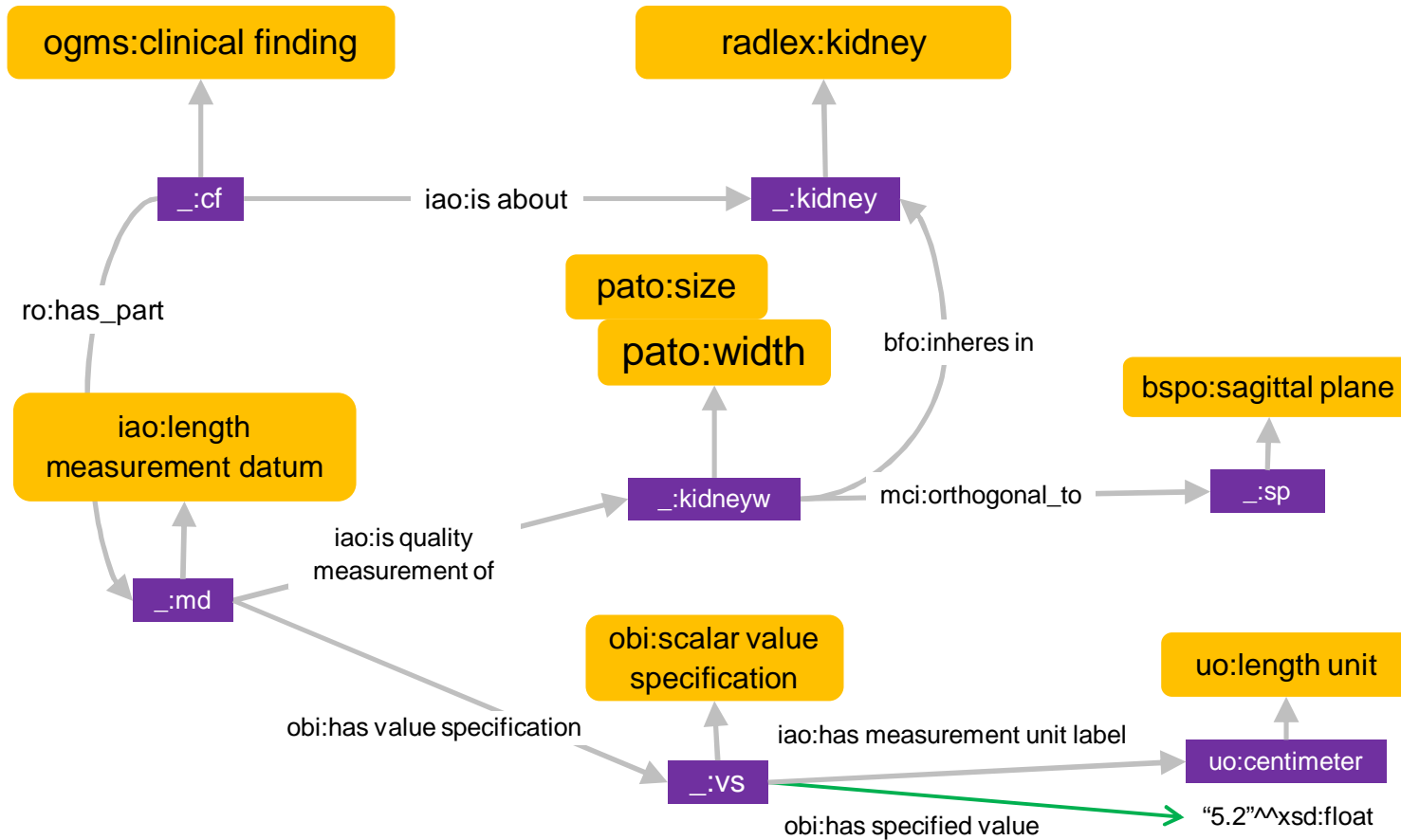
Length Measurements

Example: Lymph node with diameter 1.8 cm.



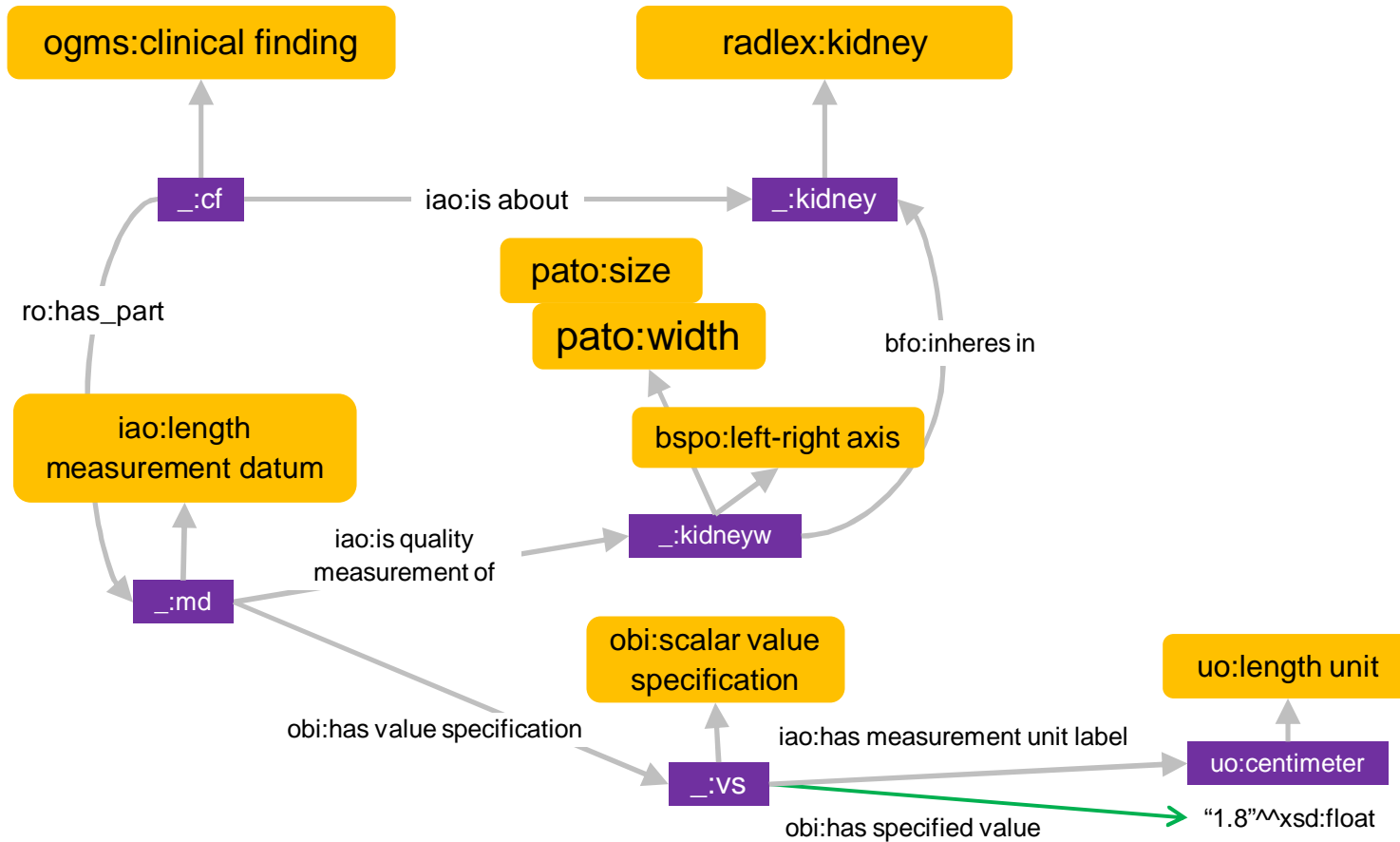
Length Measurements

Example: Width of kidney 5.2 cm.



Length Measurements

Example: Width of kidney 5.2 cm.



2D Measurements

Example with RECIST



Source: <http://www.recist.com/recist-in-practice/19.html>

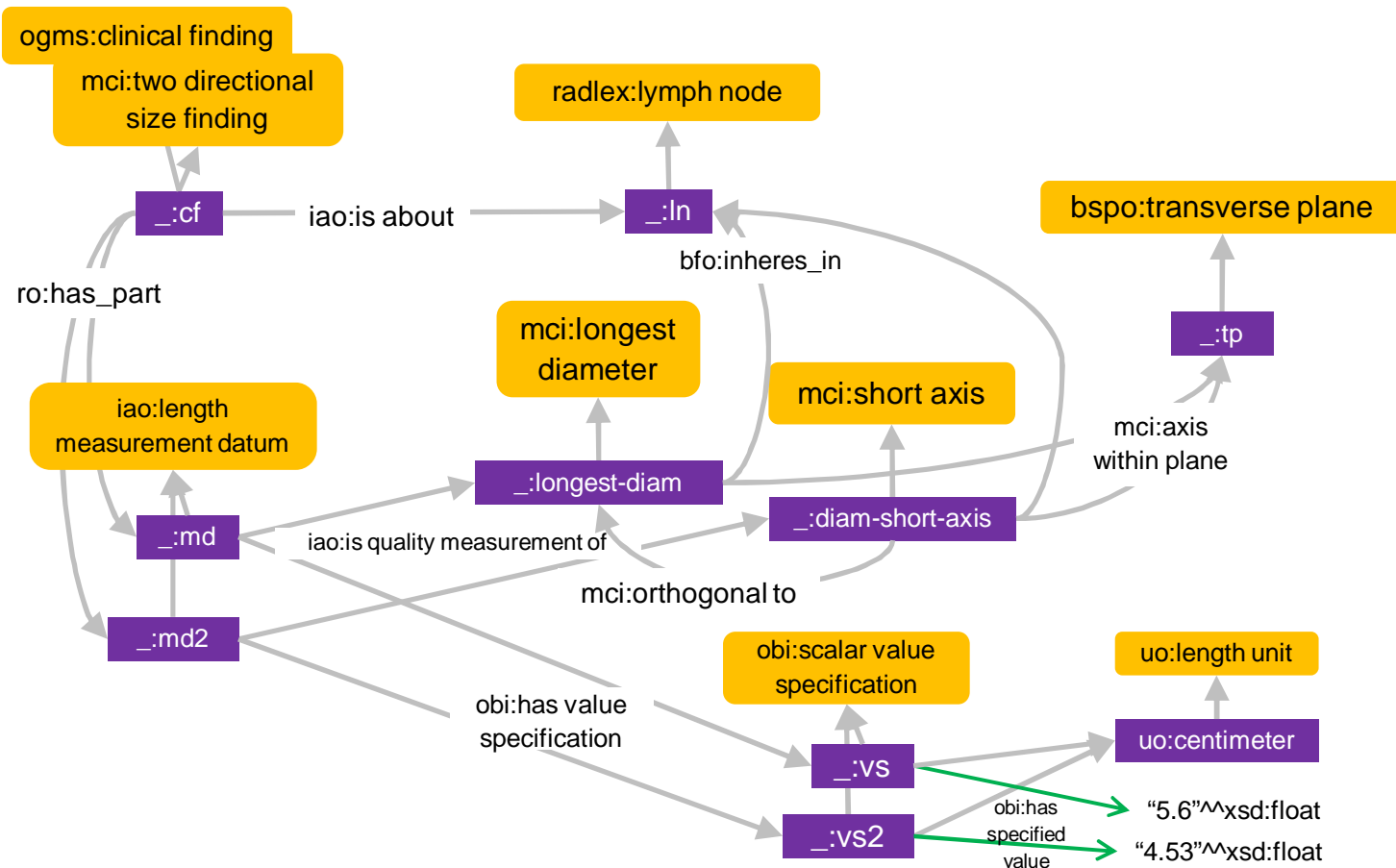
RECIST

(Response Evaluation Criteria In Solid Tumors)

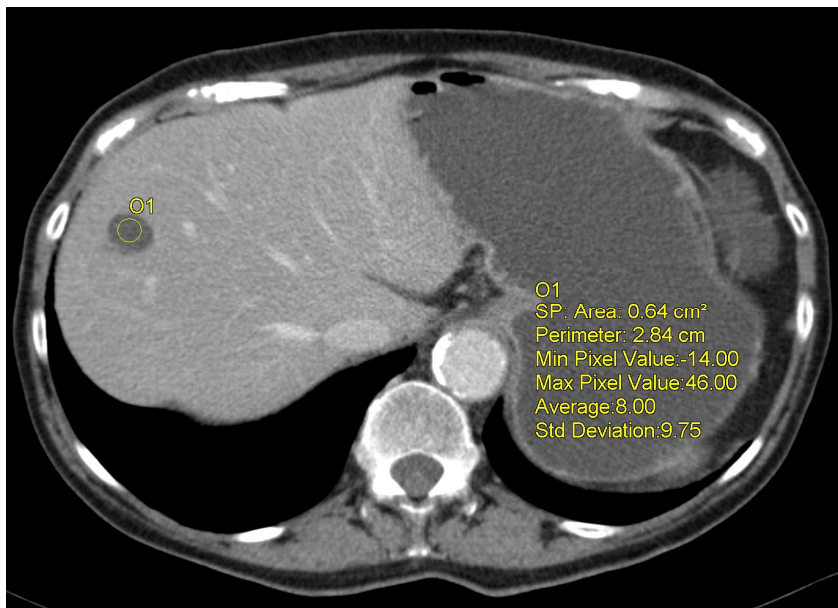
“First you need to identify the longest [in plane] diameter of a lymph node or nodal mass (here 56.0mm) and then choose the longest perpendicular diameter to that as the short axis (here 45.3mm).”

2D Measurements

Example: Lymph node with diameter 56.0 x 45.3 mm.



Density Measurements



Density measurement of a liver cyst

Density is measured in Hounsfield unit (HU)

Density measurements given for a region of interest (ROI)

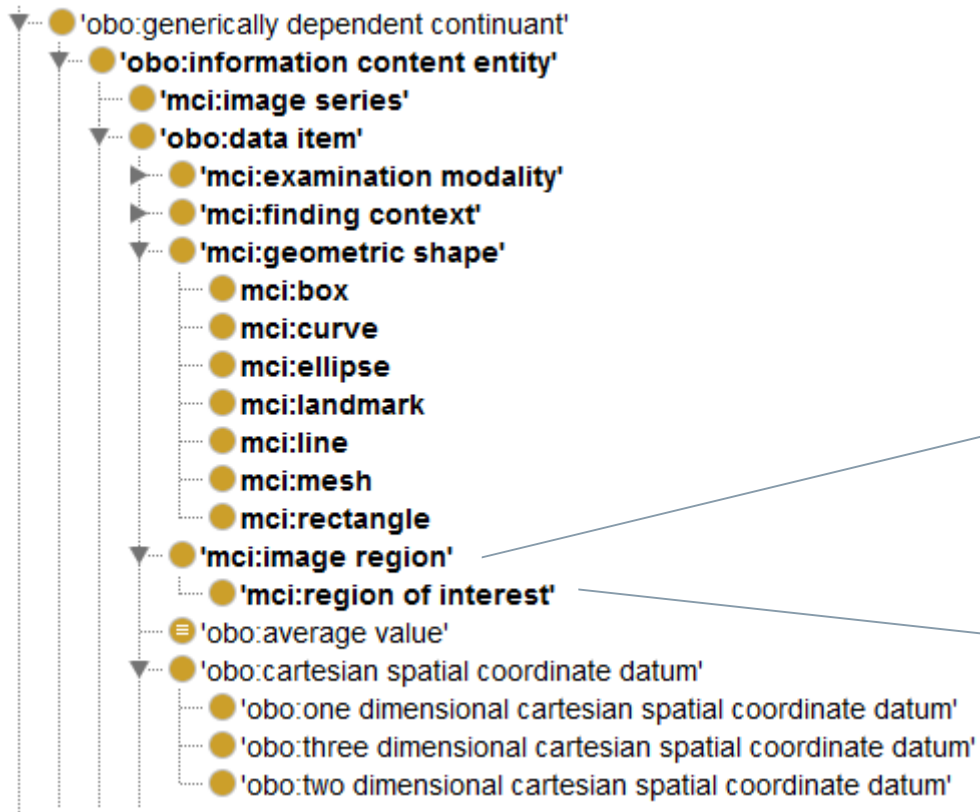
Minimal, maximal and mean values for the pixels of the ROI

Examples:

“Density of a liver cyst 8 HU”

Image Regions

Image regions are not defined in existing ontologies of the OBO Library.



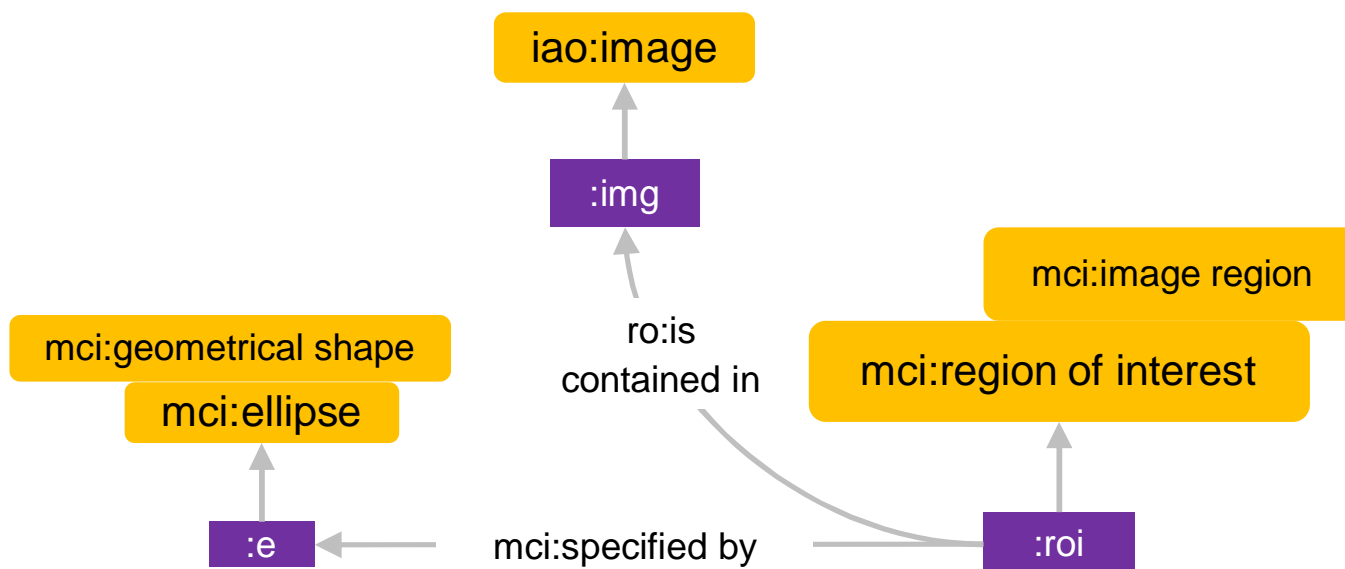
Definitions:

An image region is a data item representing a subset of pixels of some image.

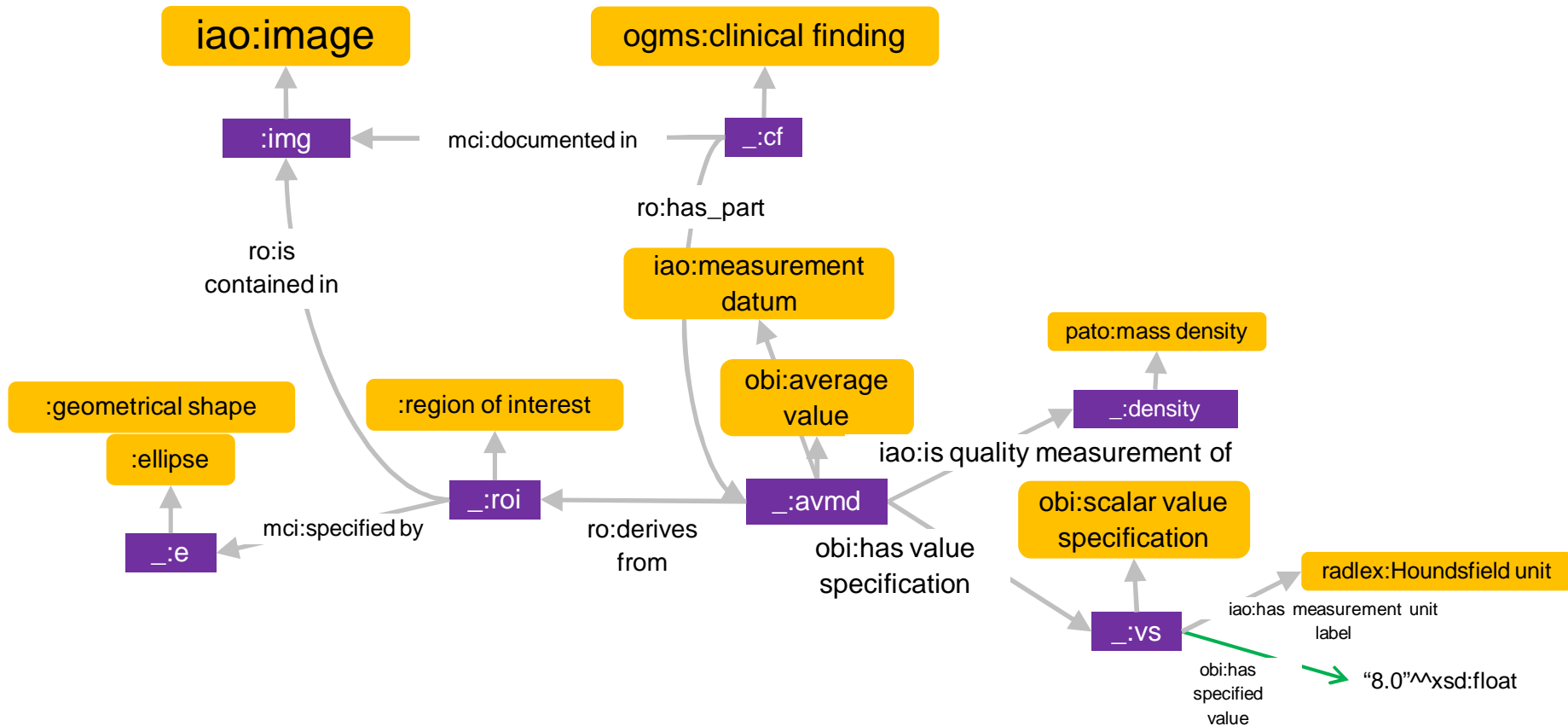
A region of interest is an image region identified for a particular purpose.

Related Work: The Open Microscopy Environment (OME) www.openmicroscopy.org

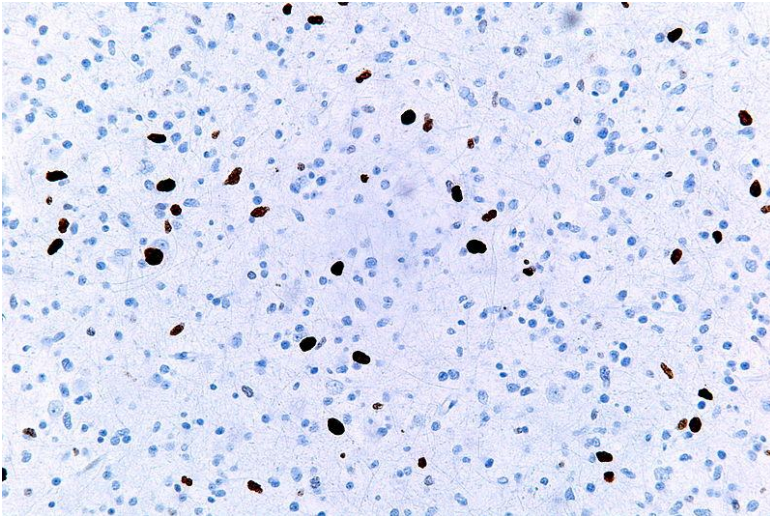
Region of Interest



Density Measurement



Ratio Measurements



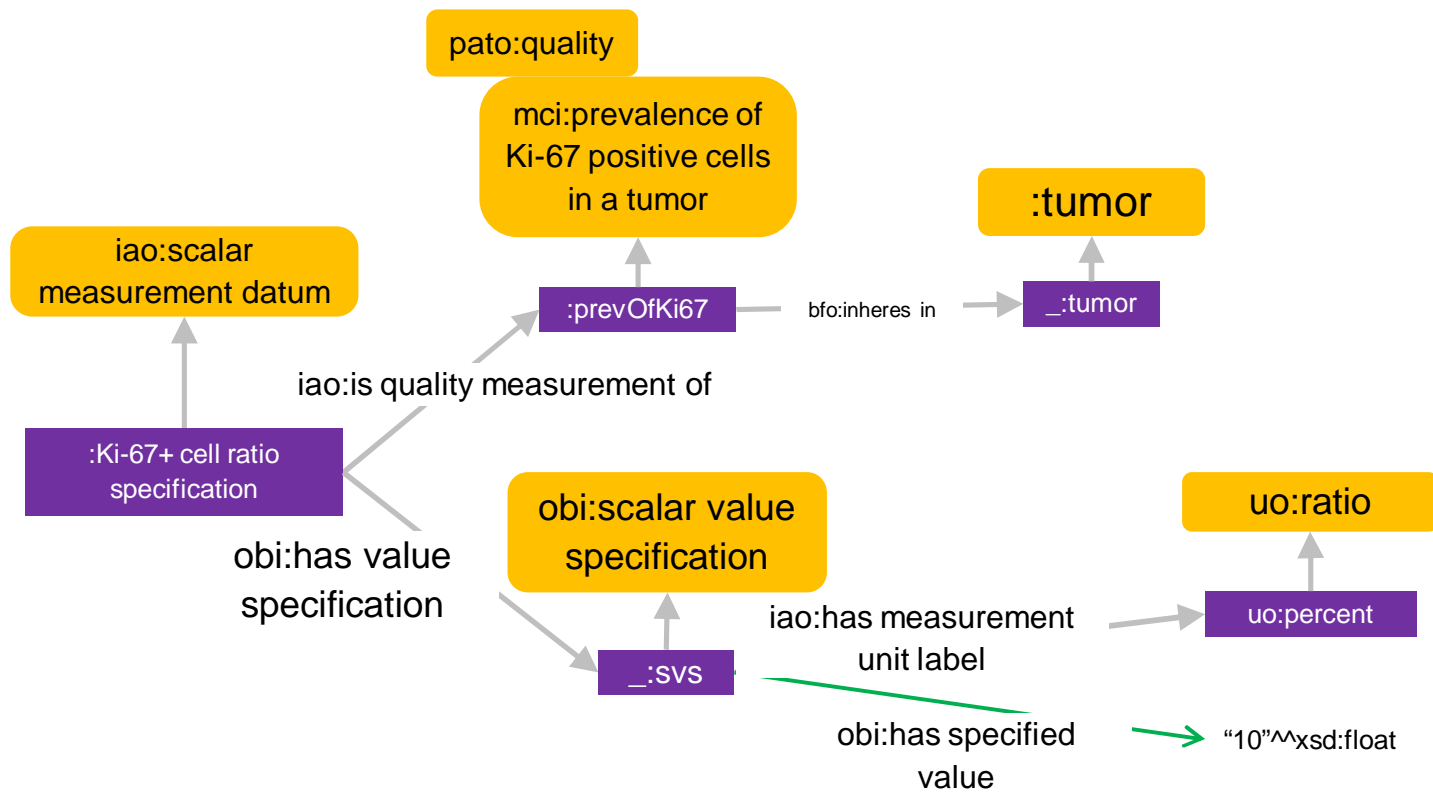
Ki-67 immunostaining of brain tumor cells
Image Source: Wikipedia

Percentage of Ki-67 positive tumor cells

Ki-67 is a protein in cells that increases as they prepare to divide into new cells. A staining process can measure the percentage of tumor cells that are positive for Ki-67. The more positive cells there are, the more quickly they are dividing and forming new cells. In breast cancer, a result of less than 10% is considered low, 10-20% is intermediate/borderline, and more than 20% is considered high.

Representation of Ratio Measurements

Work-in-progress



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Size Specifications

Commonly used types to describe the size of anatomical entities.

Interval

- Anterior-posterior diameter of liver normally 10-13 cm
- Thickness of wall of gallbladder normally 0.1 -0.3 cm

Normal Value with deviation

- Truncus pulmonalis: 1.4 cm +/- 0.4 cm

Upper Bound

- Normal lymph node < 1 cm

Lower Bound

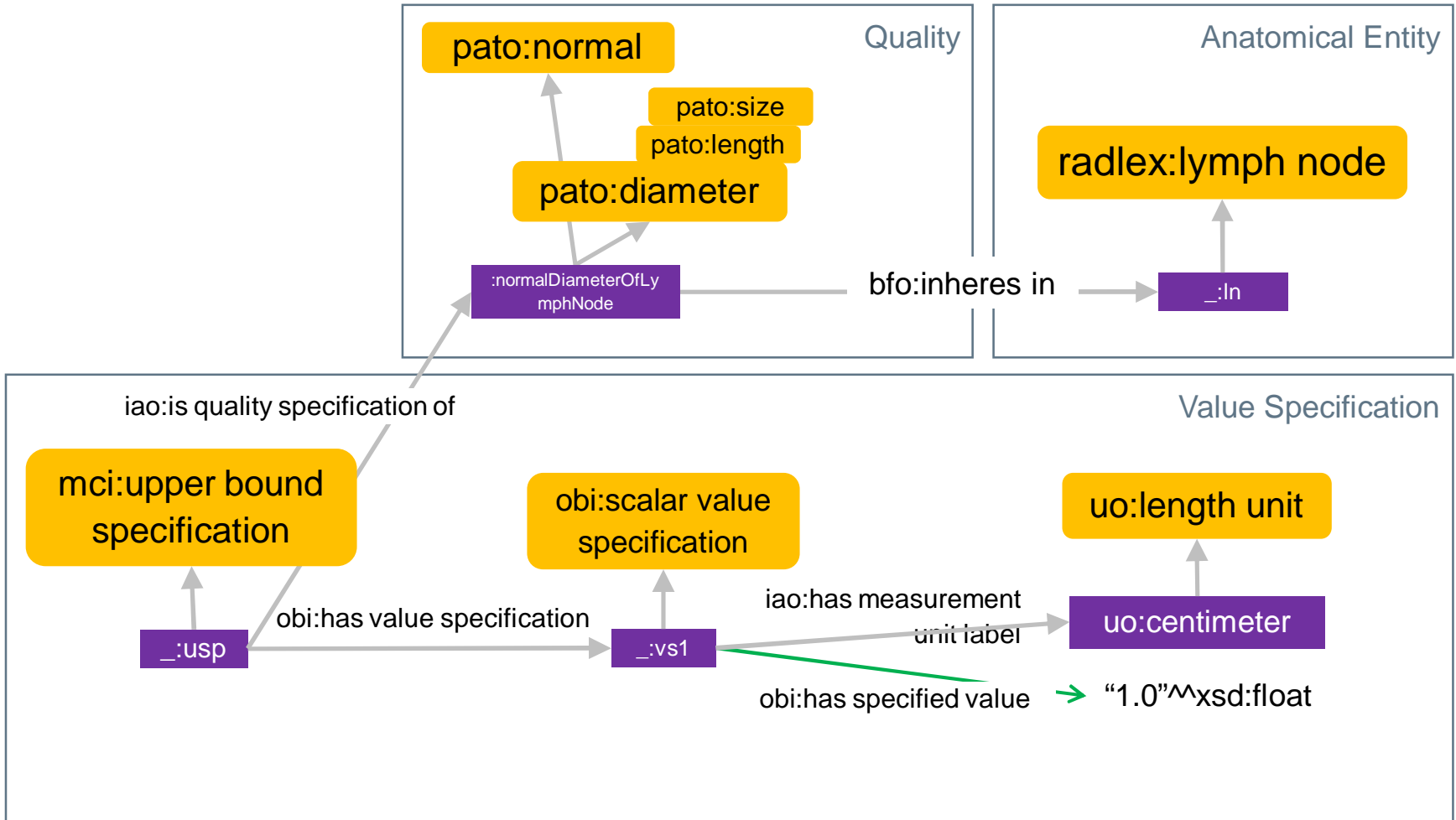
- Normal aorta diameter > 4 cm at root
- Enlarged lymph node > 1 cm

Basic form: anatomical entity, quality, value specification
(additionally specifications might be age or gender specific)

Knowledge Model: 50 size specification about 38 different anatomical entities

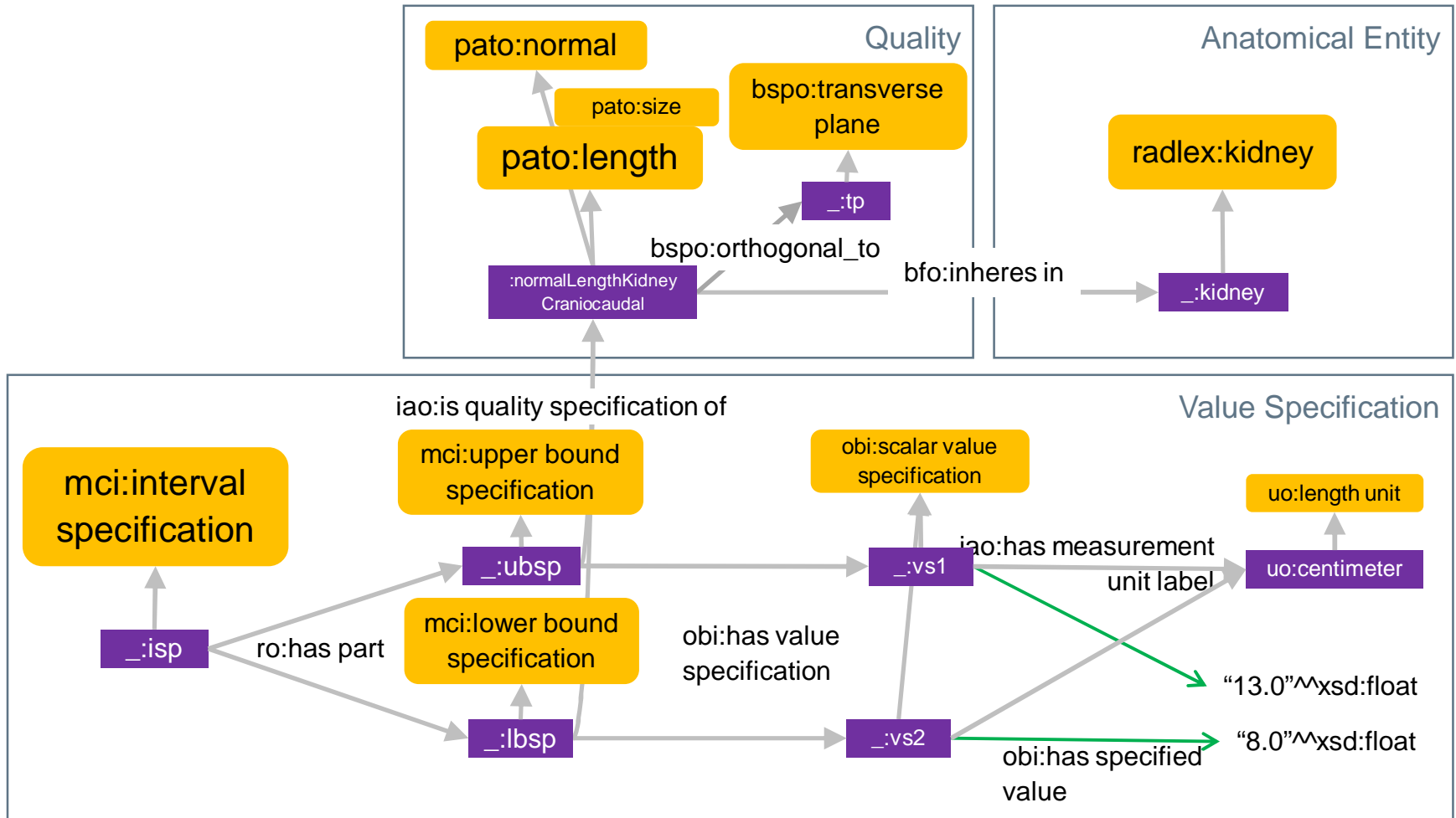
Normal Upper Bound Specification

Example: Lymph nodes are normally < 1 cm.



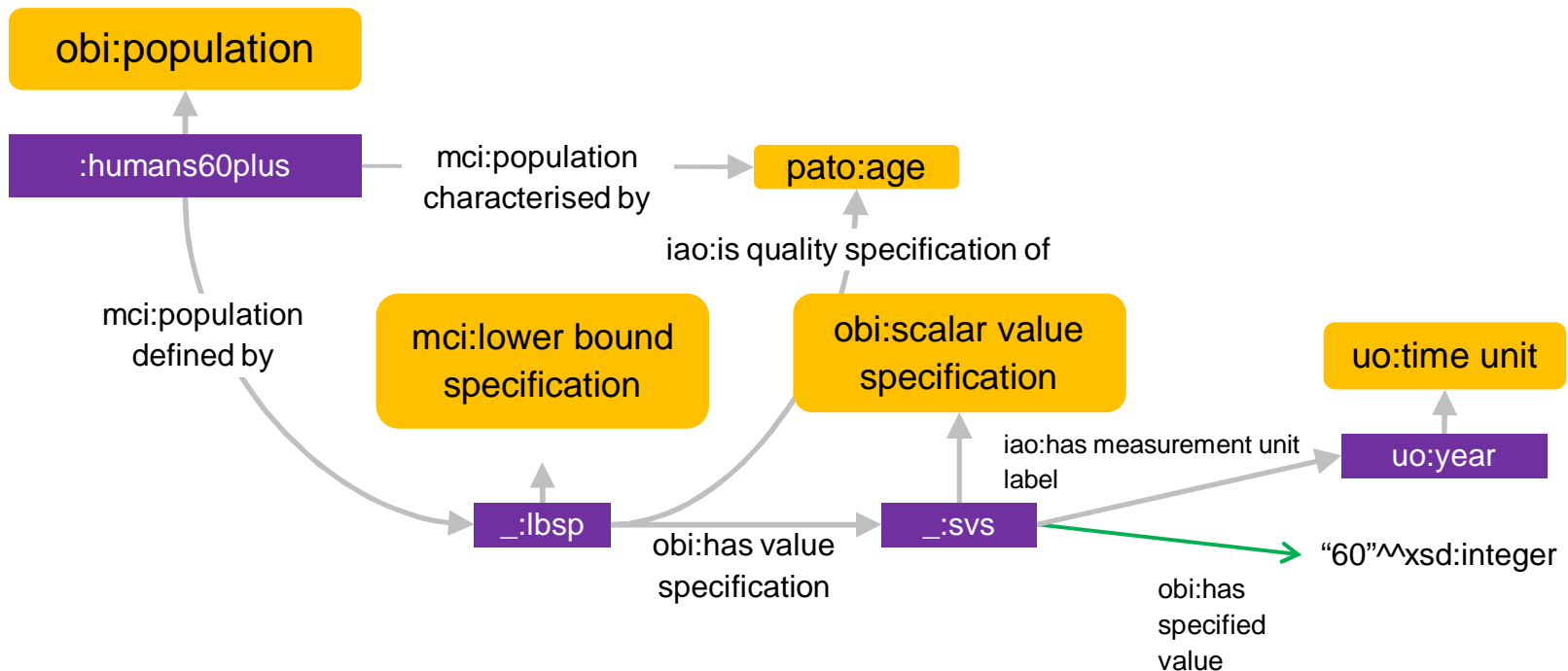
Normal Interval Specification

Example: Normal length of kidney along craniocaudal axis: 8.0 – 13.0 cm.



Expressing a Reference Population

Populations, defined by certain qualities (e.g., age or gender) are represented by punning the respective PATO qualities.



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Size Measurements in Radiology Reports

Example Sentences

Leber mit kranio-kaudalem Durchmesser von **15,5 cm**.

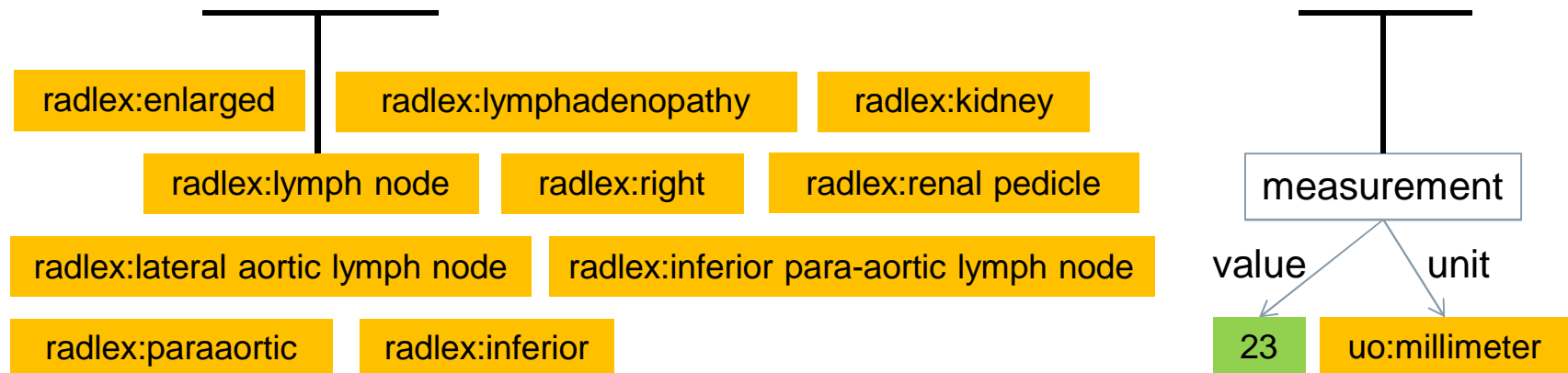
Größenprogrediente, unscharf abgrenzbare Hypodensität links temporal nach kranial bis nach parietobasal reichend (IMA 7-22; aktuell etwa **8 x 7 x 6 cm** - Voruntersuchung etwa **4,5 x 3,5 cm**) mit einzelnen, neu aufgetretenen, stippchenförmigen Hyperdensitäten (IMA 11-14).

Etwas kaudal hiervon im Unterlappen am Lappenspalt zentral ein **1.3 cm** (VU **1.3 cm**) großer Rundherd mit weiterhin deutlich vermehrtem FDG-Uptake (SUV max. 3.9; VU 5.7; IMA 182) im Oberlappen lappenspaltnah ein **1.0 cm** (VU **1.0 cm**) großer Rundherd mit vermehrtem FDG-Uptake (SUV max. **0.8**; VU **1.5**; IMA 199) sowie auf gleicher Höhe im Unterlappen dorsal paravertebral zwei Rundherde mit Ausläufern von **1.5 cm** (VU **1.3 cm**) und lateral hiervon zwei verschmolzene Lymphknoten von zusammen **1.7 cm** Durchmesser (VU **1.5 cm** + Satellit von **0.9 cm**) mit deutlich vermehrtem FDG-Uptake (SUV max. **4.0**; VU **3.2** bzw. SUV max. **6.6**; VU **4.8**; IMA 207) und im costophrenischen Winkel dorsal ein **0.9 cm** (VU **0.5 cm**) großer Rundherd mit vermehrtem FDG-Uptake (SUV max. **1.7**; VU **1.7**; IMA 234).

Extraction of Measurements from Text

Recognition of entities from ontologies and measurements

“Enlarged lymph node right paraaortal below the renal pedicle now 23 mm.”



Knowledge-based measurement-entity resolution¹⁾:



1) Knowledge-based Extraction of Measurement-Entity Relations from German Radiology Reports. Heiner Oberkamp, Claudia Bretschneider, Sonja Zillner, Bernhard Bauer, Matthias Hammon. 2014 IEEE International Conference on Healthcare Informatics (ICHI), Verona, Italy

Normality Classification

Patient-specific classification of normal and abnormal size findings.

Example: 52 years old patient

Given a size finding: 1D, 2D or 3D with corresponding anatomical entity.

mediastinal lymph node 1.6 x 1.2 cm

inguinal lymph node 1.4 cm

spleen 10 x 4.8 cm

head of pancreas 2.8 cm

Retrieve all patient-specific normal size specifications for closest superclass:

mediastinal lymph node → normal diameter of lymph node up to 1 cm

inguinal lymph node → normal diameter of inguinal lymph node up to 1.5 cm

spleen → normal spleen: depth 4-6 cm, width 7-10 cm, length 11-15 cm

head of pancreas → normal size of head of pancreas (for patients from 51-60 years): 21-27 mm

Check whether the values are within normal interval

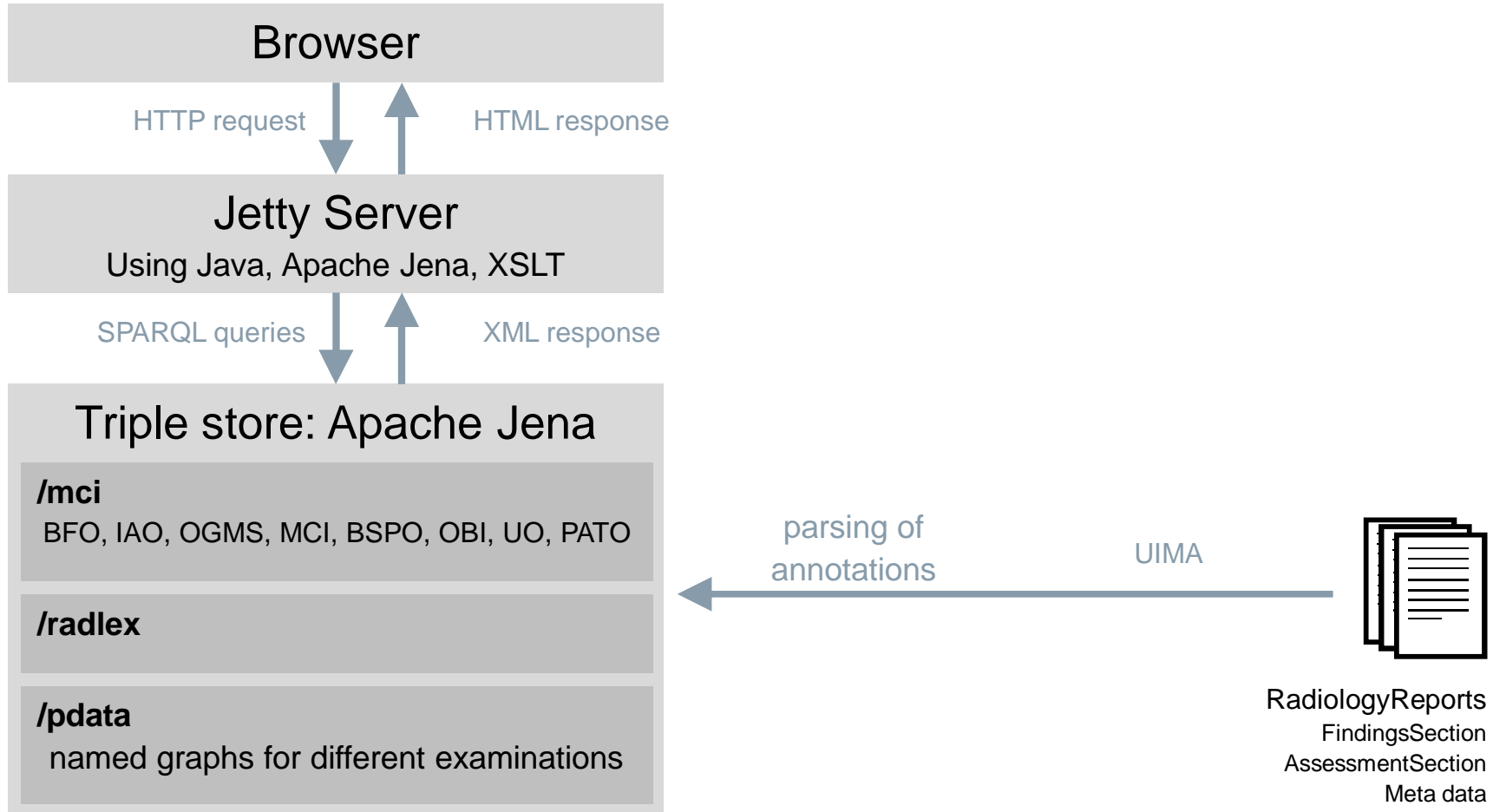
abnormal: mediastinal lymph node 1.6 x 1.2 cm

normal: inguinal lymph node 1.4 cm

normal: spleen 10 x 4.8 cm

abnormal: head of pancreas 2.8 cm

Architecture of Prototype Implementation



Extracted and Classified Size Findings

2006-05-31 computed tomography

Hals-, Thorax- und Abdomen-CT mit KM i.v

1 cm lymph node

Weiterhin mehrere, deutlich unter 1 cm messende Lymphknoten entlang der Halsgefäßnervenscheiden bds..

1 cm axillary lymph node
(1,3 cm)

Rechts axillär größenregredienter Lymphknoten jetzt 1 cm (IMA 9), vormals 1,3 cm.

1 cm axillary lymph node

Bei Z.n. B-NHL residualer, kleiner 1 cm großer Lymphknoten rechts axillär.

2006-02-28 computed tomography

Hals-, Thorax- und Abdomen-CT mit KM i.v

8 mm submental lymph node

Die vorbeschriebenen zervikalen Lymphknoten entlang der Halsgefäßnervenscheide bds. sowie submandibulär, submental und in den Kieferwinkeln sind in Größe und Anzahl deutlich regredient (aktuell noch Durchmesser bis 8 mm IMA 39 li unterhalb des M. sternocleidomastoideus).

1,4 cm axillary lymph node
(3,5 cm)

Deutlicher Größenrückgang auch der axillären Lymphknoten, zuvor bis 3,5 cm durchmessende Lymphknotenpakete rechts axillär durchgemessen aktuell noch maximal 1,4 cm.

5 mm

subpleural im Mittellappen rechts (IMA 35, Durchmesser 5 mm).

5 mm round mass

Im apikalen Unterlappen links zahlreiche Rundherde (IMA 20 bis 31, Durchmesser bis 6 mm), im rechten Unterlappen (IMA 34, Durchmesser 5 mm), im basalen Mittellappen (IMA 47, Durchmesser 5 mm) und in den Oberlappen bds. (jeweils IMA 12, Durchmesser 4 bzw. 5 mm).

5 mm round mass

5 mm round mass

6 mm round mass

1,2 cm lesion

Größenunveränderte, flau hypodense, subkapsulär im Segment 5 gelegene Leberläsion (IMA 66/67, Durchmesser 1,2 cm) mit randständig fraglich diskreter stäbchenförmiger KM-Mehranreicherung.

7 mm lesion

Eine weitere flau hypodense, 7 mm durchmessende Läsion im Segment 5 (IMA 65), die in der VA nicht sicher nachvollziehbar ist.

8,2 x 9,1 x 13 cm spleen

Milz homogen, ausgeprägter Größenrückgang bei vorbestehender Splenomegalie (aktueller Durchmesser 8,2 x 9,1 x 13 cm).

10,5 cm

Cranio-caudaler Durchmesser bds. 10,5 cm, im Vergleich zur VU hierbei rückläufige Schwellung des Nierenparenchyms bei verbesserter Abgrenzbarkeit zum umgebenden Fettgewebe.

8 mm

Bei liegenden Harnleiterschienen bds. mehrere kalkdichte Konkremente innerhalb des Nierenbeckenkelchsystems mit Durchmessern, bds. bis zu 7 bis 8 mm.

Age-specific Classification of Size Findings

Patient TP32

Date of birth: 1955-01-01

[anatomy](#)

[measurements](#)

[changes](#)

Examinations

2007-01-10 computed tomography

Testuntersuchung

2,8 cm

head of pancreas

Durchmesser des Pankreaskopf 2,8 cm.

Pankreas leicht vergrößert

2003-08-18 computed tomography

Testuntersuchung

2,9 cm

head of pancreas

Durchmesser des Pankreaskopf 2,9 cm.

Keine Auffälligkeiten

Summary

My personal experience in using ontologies from the OBO Library

- ✓ upper level ontology BFO used across OBO Library
- ✓ orthogonal ontologies
- ✓ many useful concepts
- ✓ active community

- ✗ learning curve at the beginning
- ✗ time consuming to get new terms in
- ✗ some concepts are “too ontological”

Questions ?

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