

Automatic generation of consistency constraints for an OWL representation of the FMA

Olivier Dameron, Julie Chabaliier



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Université de Rennes 1, France

<http://www.ea3888.univ-rennes1.fr>

Context

- Integrate human anatomical knowledge into applications
 - diagnosis of bullet injuries [Virtual Soldier Project]
 - grading tumors (lung, glioma)
 - localization of biological entities (iron metabolism)
 - ↗ ontologies
- Integrate ontologies of anatomy with other ontologies
 - physiology
 - pathology
 - cellular components
- Perform automatic reasoning

Requirements

- Ontology of anatomy
 - Anatomy = fundamental discipline for medicine
- Representation formalism
 - usable by applications
 - supporting imports
 - supporting reasoning

Available resources

- FMA = reference ontology for anatomical knowledge
 - 75,000 classes + 2.5 millions relations
 - represented in frames
- Previous work on the conversion of the FMA into OWL
 - Golbreich, Zhang and Bodenreider [Web Semantics 2006]
 - Dameron, Rubin and Musen [AMIA 2005]
 - Noy and Rubin [SMI technical report 2007]

Objective

- **Guarantee consistency**
 - no internal contradiction
 - this is the least that we can expect
 - requires OWL-specific constraints (disjunction...)
 - adequately represents reality
- **Generate OWL-specific constraints to improve reasoning**
 - complement to the work by Noy and Rubin
 - focus on what is implicit in the FMA-frames ontology

Methods

- Leverage the FMA building principles
 - in the hierarchies and relations
 - in the naming conventions
- 1 building principle -> 1 pattern
 - Check consistency
 - e.g.: direct subclass of “Region of chest wall”
 - Generate additional OWL-specific constraints
 - e.g.: Lung / Left_lung / Right_lung
- Python script for applying pattern

FMA-OWL core architecture

Core architecture

- fma-core.owl = straightforward conversion of the FMA in owl
- 1 owl file / constraint type
 - fma-disjunction.owl
 - imports fma-core.owl
 - import fma-disjunction-lateralization.owl
 - imports fma-disjunction-enumeration.owl ...
 - fma-multipleInheritance.owl
 - imports ...

Taxonomy

Original FMA taxonomy

- Single inheritance
- We reused the method by Noy and Rubin
 - frame classes become OWL classes
 - FMAID are used as `rdf:ID` (prefixed by `fma`)
 - class name and synonyms become `rdfs:label`



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- SYSTEM CLASS
- Anatomical entity
 - Physical anatomical entity
 - Material anatomical entity
 - Anatomical structure
 - Body
 - Cardinal body part
 - Subdivision of cardinal body part
 - Subdivision of head
 - Subdivision of body proper
 - Neck
 - Subdivision of neck
 - Trunk
 - Subdivision of trunk
 - Thorax
 - Subdivision of thorax
 - Chest
 - Chest wall
 - Region of chest wall
 - Thoracic wall
 - Anterior chest wall
 - Superficial chest wall

CLASS EDITOR

For Class: Physical anatomical entity (instance of Anatomical entity template)

Name

Physical anatomical entity

Documentation

2.13.01 We include boundary relationship at physical anatomical entity level because non-material physical anatomical entities (surface and line) have boundaries. We will deactivate the "has boundary"

Constraints

Role

Concrete

Template Slots

| Name | Cardinality | Type | Other Facets |
|------------------------|--------------|------------------------------|--|
| constitutional part of | multiple | Class with superclass Mat... | inverse-slot=constitutional part |
| definition | single | String | |
| dimension | single | Symbol | allowed-values={3-dimension,2-dimension,1-dimen... |
| FMAID | required ... | String | |
| has boundary | single | Boolean | value=false |
| has dimension | single | Boolean | value=true |
| Non-English equivalent | multiple | Instance of Concept name | |
| part | multiple | Class with superclass Ana... | inverse-slot=part of |
| part of | multiple | Class with superclass Ana... | inverse-slot=part |

Definition

t, inferior margin of liver, apex of lung.

Part

Non-English Equiva

- KB_AUTO-INSERT(3)_4641
- ONARD_Instance_580710

Definition

t, inferior margin of liver, apex of lung.

Part

Non-English Equiva

- KB_AUTO-INSERT(3)_4641
- ONARD_Instance_580710

FMAID

61775

SUBCLASS EXPLORER

For Project: fma-core

Asserted Hierarchy

- owl:Thing
 - Physical anatomical entity
 - Immaterial physical anatomical entity
 - Anatomical surface
 - Body surface region
 - Surface of principal body part
 - Surface of head
 - Surface of neck
 - Surface of limb
 - Surface of upper limb
 - Surface of right upper limb
 - Surface of left upper limb
 - Surface of lower limb

CLASS EDITOR

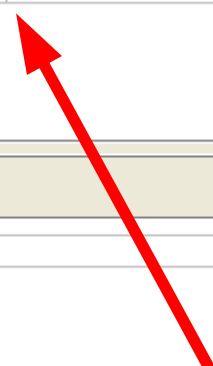
For Class: Physical anatomical entity - Internal name: fma:fma61775 (instance of owl:Class) Inferred View

| Property | Value | Lang |
|--------------|----------------------------|------|
| rdfs:comment | | |
| rdfs:label | Physical anatomical entity | en |

Annotations

Asserted Conditions

- NECESSARY & SUFFICIENT
- NECESSARY



Metadata (fma-core.owl) OWLClasses Properties Individuals Forms

SUBCLASS EXPLORER

For Project: fma-core

Asserted Hierarchy

- owl:Thing
 - Physical anatomical entity
 - Immaterial physical anatomical entity
 - Surface of hand
 - Surface of right hand
 - Surface of left hand
 - Subdivision of surface of hand
 - Surface of back of hand
 - Surface of back of

CLASS EDITOR

For Class: Physical anatomical entity - Internal name: fma:fma61775

| Property | Value |
|--------------|----------------------------|
| rdfs:comment | |
| rdfs:label | Physical anatomical entity |

Multiple inheritance

- Left/right and male/female
 - 3 classes (Breast, Areola, Nipple)
- Left/right and enumeration
 - 65 classes (e.g. Left first cervical nerve)
- Upper/lower and enumeration
 - 5 classes (e.g. Upper first molar socket)



Classes Slots Forms Instances Queries

CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Subdivision of trunk
 - Thorax
 - Subdivision of thorax
 - Chest
 - Chest wall
 - Region of chest wall
 - Anterior chest
 - Region of anterior chest
 - Pectoral part of chest
 - Inframammary part of chest
 - Sternal part of chest
 - Region of pectoral part of chest
 - Breast**
 - Right breast
 - Left breast
 - Female breast
 - Right female breast
 - Left female breast
 - Male breast
 - Right male breast
 - Left male breast
 - Region of breast
 - Accessory breast
 - Lateral pectoral region
 - Infraclavicular part of chest
 - Pectoral part proper of male
 - Lateral part of chest
 - Right side of chest
 - Left side of chest

- Inframammary part of chest
- Sternal part of chest
- Region of pectoral part of chest
- Breast**
 - Right breast
 - Left breast
 - Female breast
 - Right female breast
 - Left female breast
 - Male breast
 - Right male breast
 - Left male breast

Breast

Superclasses

Concrete

Inherent 3-D Shape

Has Shape

Part

Instances



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- ▶ Parenchymatous organ
- ▼ Nonparenchymatous organ
 - ▶ Muscle organ
 - ▶ Ligament organ
 - ▶ Cartilage organ
 - ▶ Membrane organ
 - ▼ Neural tree organ
 - ▶ Cranial nerve
 - ▼ Spinal nerve
 - ▼ Cervical nerve
 - ▼ First cervical nerve
 - ▶ Right first cervical nerve
 - ▶ Left first cervical nerve
 - ▼ Second cervical nerve
 - ▶ Right second cervical nerve
 - ▶ Left second cervical nerve
 - ▶ Third cervical nerve
 - ▶ Fourth cervical nerve
 - ▶ Fifth cervical nerve
 - ▶ Sixth cervical nerve
 - ▶ Seventh cervical nerve
 - ▶ Eighth cervical nerve
 - ▶ Thoracic nerve
 - ▶ Lumbar nerve
 - ▶ Sacral nerve
 - ▶ Coccygeal nerve
 - ▶ Variant spinal nerve
 - ▶ Spinal accessory nerve
 - ▶ Peripheral nerve

Cervical nerve

- ▼ First cervical nerve
 - ▶ Right first cervical nerve
 - ▶ Left first cervical nerve
- ▼ Second cervical nerve
 - ▶ Right second cervical nerve
 - ▶ Left second cervical nerve
- ▶ Third cervical nerve
- ▶ Fourth cervical nerve
- ▶ Fifth cervical nerve
- ▶ Sixth cervical nerve
- ▶ Seventh cervical nerve
- ▶ Eighth cervical nerve

Founded By

Generic Part

Generic Part Of

es

first cervical nerve

ous Drainage

left first

Superclasses

Concrete

Inherent 3-D Shape

Has Shape

Part

Attributed Continuo

OWL-specific constructs

Disjunction

Two classes are disjoint iff they do not have any instance in common

- By default in the FMA, all siblings are disjoint



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Upper trunk
- Lower trunk
- Body wall
- Anterior body wall
- Posterior body wall
- Waist
- ▶ Limb segment
- ▶ Organ system
- ▶ Organ system subdivision
- ▼ Organ
 - ▶ Solid organ
 - ▶ Cavitated organ
- ▶ Cardinal organ part
- ▶ Tissue
- ▶ Cardinal tissue part
- ▶ Cell
- ▶ Cell part
- ▶ Biological macromolecule
- ▶ Acellular anatomical structure
- ▶ Anatomical cluster
- ▶ Anatomical junction
- ▶ Gestational structure
- ▶ Vestigial embryonic structure
- ▶ Variant anatomical structure
- ▶ Body substance
- ▶ Anatomical set
- ▼ Immaterial physical anatomical entity
 - ▶ Anatomical space
 - ▶ Anatomical surface
 - ▶ Anatomical line

organ

Superclasses

CLASS EDITOR

For Class: Organ (instance of Anatomical structure)

Definition

ear, skin, tracheobronchial tree, ovary.

FMAID
67498

- ▶ Organ system subdivision
- ▶ Organ
- ▶ Solid organ
- ▶ Cavitated organ

Has Mass

Part

Organ component

Dimension

3-dimension

Physical State

Concrete

Role

Concrete

Inherent 3-D Shape

Has Shape

Regional Part

Continuous With

Venous Drainage

Part

Organ component

Dimension

3-dimension

Physical State

Concrete

Role

Concrete

Inherent 3-D Shape

Has Shape

Regional Part

Constraints

Part Of

Organ system

Instances

Cavitated organ

Solid organ

Has Shape

Regional Part

Location



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Upper trunk
- Lower trunk
- Body wall
 - Anterior body wall
 - Posterior body wall
 - Waist
- Limb segment
- Organ system
 - Organ system subdivision
 - Organ
 - Solid organ
 - Parenchymatous organ
 - Nonparenchymatous organ
 - Cavitated organ
 - Cardinal organ part
 - Tissue
 - Cardinal tissue part
 - Cell
 - Cell part
 - Biological macromolecule
 - Acellular anatomical structure
 - Anatomical cluster
 - Anatomical junction
 - Gestational structure
 - Vestigial embryonic structure
 - Variant anatomical structure
- Body substance
- Anatomical set
- Immaterial physical anatomical entity
- Anatomical space

organ

Superclasses

CLASS EDITOR

For Class: Solid organ (instance of Organ)

Definition Develops From Systemic Part Of

organ), meninx, superficial fascia, skin.

FMAID
55670

Organ

- Solid organ
- Parenchymatous organ
- Nonparenchymatous organ
- Cavitated organ

Dimension: 3-dimension Physical State: Solid

Role: Concrete Part Attributed Part

Inherent 3-D Shape

Has Shape Part Of Constraints



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Upper trunk
- Lower trunk
- Body wall
 - Anterior body wall
 - Posterior body wall
- Waist
- Limb segment
- Organ system
- Organ system subdivision
- Organ
 - Solid organ
 - Parenchymatous organ
 - Nonparenchymatous organ
 - Cavitated organ
- Cardinal organ part
- Tissue
 - Cardinal tissue part
- Cell
 - Cell part
- Biological macromolecule
- Acellular anatomical structure

organ

Superclasses

- Organ
 - Solid organ
 - Parenchymatous organ
 - Nonparenchymatous organ
 - Muscle organ
 - Ligament organ
 - Cartilage organ
 - Membrane organ
 - Neural tree organ
 - Fascia organ
 - Skin
 - Tongue
 - Viscerocranial mucosa
- Cavitated organ

Disjunction

Two classes are disjoint iff they do not have any instance in common

- By default in the FMA, all siblings are disjoint
- Sometimes they are not :-)

Disjunction patterns

- X / NonX or X / Non-X (84)
 - Non-nucleated cell
- Left X / Right X (3736)
 - Left lung
- X left Y / X right Y (13989)
 - Skin of right breast
- Male X / Female X (25)
 - Male breast
- X male Y / X female Y (75)
 - Right side of male chest
- enumerations (140)
 - First cervical nerve
- upper / (middle) / lower (99)
 - Upper lobe of lung



Metadata (fma-disjun...zation.owl) OWLClasses

SUBCLASS EXPLORER

For Project: fma-disjunction-lateralization

Asserted Hierarchy

- ▶ Upper hemithorax
- ▶ Lower hemithorax
- ▼ Region of anterior chest
 - ▶ Inframammary part of chest
 - ▶ Sternal part of chest
 - ▶ Pectoral part of chest
 - ▼ Region of pectoral part of chest
 - ▶ Pectoral part proper of male ches
 - ▶ Infraclavicular part of chest
 - ▶ Lateral pectoral region
 - ▶ Region of breast
 - ▶ Accessory breast
 - ▼ Breast
 - Right breast
 - Left breast
 - ▶ Female breast
 - ▶ Male breast
 - ▶ Lateral part of chest
 - ▶ Right side of chest
 - ▶ Left side of chest
 - ▶ Subdivision of back of thorax
- Waist
- Subdivision of pelvis
- Front of trunk
- Back of trunk
- Abdominopelvis
- Anterior body wall
- Posterior body wall
- Thorax
- Abdomen
- Pelvis

CLASS EDITOR

For Class:

- ▶ rdfs:cc
- ▶ rdfs:la



Breast



Right breast

- Right breast
- Left breast
- ▶ Female breast
- ▶ Male breast
- Lateral part of chest
- Right side of chest
- Left side of chest
- Subdivision of back of thorax
- Subdivision of pelvis
- of trunk
- of trunk
- minopelvis
- ior body wall

- Right breast



View

ons

ons

NT

RY

Disjoints

Coverage

The subclasses of a class provide an exhaustive decomposition of this class (partition)

- Most of the time, using the union of all the direct subclasses is enough



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- ▶ Tendon
- ▶ Parenchyma
- ▶ Stroma
- ▶ Medulla
- ▶ Trabecula
- ▶ Capillary bed
- ▶ Cortex
- ▶ Follicle of ovary
- ▶ Corpus luteum
- ▶ Corpus albicans
- ▶ Cumulus oophorus
- ▶ Corona radiata
- ▶ Lactiferous terminal ductal lobula
- ▼ Organ chamber
 - ▼ Cardiac chamber
 - ▼ Cardiac atrium
 - ▶ Right atrium
 - ▶ Left atrium
 - ▼ Cardiac ventricle
 - ▶ Right ventricle
 - ▶ Left ventricle
 - ▶ Chamber of eyeball
- ▶ Nucleus pulposus of intervertebra
- ▶ Anulus fibrosus of intervertebra
- ▶ Leaf of epiglottis
- ▶ Stalk of epiglottis
- ▶ Thyroid follicle
- ▶ Uriniferous tubule
- ▶ Spiral organ of cochlea

cardiac chamber

Superclasses

Lactiferous terminal ductal lobula

▼ Organ chamber

▼ Cardiac chamber

▼ Cardiac atrium

▶ Right atrium

▶ Left atrium

▼ Cardiac ventricle

▶ Right ventricle

▶ Left ventricle

▶ Chamber of eyeball

Dimension Physical State

3-dimension

Role

Concrete

Inherent 3-D Shape

Has Shape

Nerve Supply

Attributed Continuat

Part

Attributed Part

Coverage

The subclasses of a class provide an exhaustive decomposition of this class (partition)

- Most of the time, using the union of all the direct subclasses is enough
- But sometimes this is sub-optimal (but still logically valid)



SUBCLASS EXPLORER

For Project: fma-coverage

Asserted Hierarchy

- ▶ Biological macromolecule
- ▼ Subdivision of cardinal body part
 - ▼ Subdivision of body proper
 - ▼ Subdivision of trunk
 - Waist
 - ▶ Thorax
 - ▶ Perineum
 - ▶ Pelvis
 - Abdomen
 - Upper trunk
 - Lower trunk
 - ▶ Subdivision of perineum
 - ▶ Subdivision of abdomen
 - ▼ Subdivision of thorax
 - ▼ Region of anterior chest
 - ▶ Left side of chest
 - ▶ Right side of chest
 - ▼ Region of pectoral part of chest
 - ▶ Breast
 - Left breast
 - Right breast
 - ▼ Female breast
 - Right female breast
 - Left female breast
 - ▼ Male breast
 - Left male breast
 - Right male breast

CLASS EDITOR

For Class: Breast - Internal name: fma:fma9601 (instance of owl:Class) Inferred View

| Property | Value | Lang |
|--------------|--------|------|
| rdfs:comment | | |
| rdfs:label | Breast | en |

Asserted Conditions

- Female breast or Male breast NECESSARY & SUFFICIENT
- Right breast or Right breast NECESSARY & SUFFICIENT
- Region of pectoral part of chest NECESSARY

Disjoints

Empty area for disjoints.

breast

Coverage patterns

- Left / right
 - Breast
 - Male / female
 - Breast
 - Enumeration
 - Internal intercostal muscle (1 - 11)
- Upper / (middle) / lower
 - Lobe of lung
 - X / Non-X
 - Cell (nucleated vs Non-nucleated)

We reused the multiple inheritance patterns

Consistency checking

Consistency

check that among the direct XXX parts of an anatomical entity, none is a superclass of the other

- part: 118
- constitutional part: 26
- regional part: 86
- systemic part: 34

Consistency

- If we consider the regional parts of "Body", we find :
 - "Head",
 - "Body proper",
 - "Upper limb", "Left upper limb", "Right upper limb",
 - "Lower limb", "Left lower limb", "Right lower limb".



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- :THING
 - ▶ • :SYSTEM-CLASS
 - ▶ • :SYSTEM-CLASS
 - ▶ • Anatomical entity
 - ▼ • Physical anatomical entity
 - ▼ • Material anatomical entity
 - ▼ • Anatomical structure
 - ▶ • Body
 - ▶ • Cardinal body part
 - ▼ • Subdivision of cardinal body part
 - ▶ • Subdivision of head
 - ▼ • Subdivision of body proper
 - Neck
 - ▶ • Subdivision of neck
 - ▶ • Trunk
 - ▼ • Subdivision of trunk
 - ▶ • Thorax
 - ▼ • Subdivision of thorax
 - ▶ • Chest
 - ▶ • Chest wall
 - ▶ • Region of chest wall
 - ▶ • Anterior chest
 - ▼ • Region of anterior chest
 - ▶ • Pectoral part of chest
 - ▶ • Inframammary part of chest

body

Superclasses

- Anatomical structure

CLASS EDITOR

For Class: Body (instance of Anatomical structure)

| | | |
|---|--|--|
| <input checked="" type="checkbox"/> Has Mass

Dimension: 3-dimension
Physical State: Solid

Role: Concrete

Inherent 3-D Shape: <input type="text"/>

Has Shape: <input type="text"/>

Preferred Name: KB_INSTANCE_25739

Documentation: <input type="text"/>

Arterial Supply: <input type="text"/> | Part: <ul style="list-style-type: none"> • Respiratory system • Cardiovascular system • Musculoskeletal system • Alimentary system • Urinary system | Constraints: <input type="text"/>

Instances: <ul style="list-style-type: none"> • Male body • Female body |
| Part Of: <input type="text"/> | Regional Part: <ul style="list-style-type: none"> • Head • Body proper • Upper limb • Right upper limb • Left upper limb • Lower limb • Right lower limb • Left lower limb | Location: <input type="text"/>

Regional Part Of: <input type="text"/> |
| Subclasses: <ul style="list-style-type: none"> • Male body • Female body | Orientation: <input type="text"/> | Non-Ex: <ul style="list-style-type: none"> • KB_A • ONA • ONA • ONA • ONA |

Consistency

- If we consider that this represents one exhaustive decomposition of the body into regional parts, it makes sense to specify that there has to be one left lower limb and one right lower limb and one left upper limb... But then, "Upper limb" and "Lower limb" are not necessary (but still correct).
- Now, if we consider that these are the only possible elements of this partition, we only need "Head", "Body proper", "Upper limb" and "Lower limb"... and the left/right upper/lower limbs are again not necessary (but admittedly again still correct).

Consistency

check that among the direct XXX parts of an anatomical entity, none is a part (possibly indirect) of the other

- ex: Areola has among its parts "Skin of areola", "Sebaceous gland" and "Areolar gland". It turns out that "Sebaceous gland" and "Areolar gland" are already parts of "Skin of areola"



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- ▶ Pectoral part of chest
- ▶ Inframammary part of chest
- ▶ Sternal part of chest
- ▼ Region of pectoral part of chest
 - ▶ Breast
 - ▼ Region of breast
 - ▶ Nipple
 - ▶ **Areola**
 - ▶ Breast proper
 - ▶ Quadrant of breast
 - ▶ Superior region of breast
 - ▶ Medial region of breast
 - ▶ Lateral region of breast
 - ▶ Central region of breast
 - ▶ Subareolar region of breast
 - ▶ Accessory breast
 - ▶ Lateral pectoral region
 - ▶ Infraclavicular part of chest
 - ▶ Pectoral part proper of male
- ▶ Lateral part of chest
- ▶ Right side of chest
- ▶ Left side of chest
- ▶ Back of thorax
 - ▶ Subdivision of back of thorax
- ▶ Hemithorax

areola

Superclasses

- ▶ Region of breast

CLASS EDITOR

For Class: Areola (instance of Region of breast)

 Has Mass

Dimension

3-dimension

Physical State

Solid

Role

Concrete

Inherent 3-D Shape

Has Shape

Preferred Name

fm-live_12915

Documentation

Arterial Supply

Lymphatic Drainage

- ▶ Lymphatic tree of subareolar part of
- ▶ Lymphatic tree of areola

Nerve Supply

Part

- ▶ Skin of areola
- ▶ **Areolar gland**
- ▶ Sebaceous gland of areola
- ▶ Sweat gland of areola

Part Of

- ▶ Female breast
- ▶ Breast

Regional Part

Attributed Part

- ▶ fm-live_12918
- ▶ fm-live_12919
- ▶ fm-live_12924
- ▶ fm-live_12925

Constraints

Instances

- ▶ Right areola
- ▶ Left areola
- ▶ Male areola
- ▶ Female areola

Location

Non-English Equiv:

- ▶ su_incus_38303
- ▶ KB_AUTO-INSERT(3)_4604



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Organ segment
- Zone of organ
 - Zone of eyeball
 - Zone of nerve
 - Zone of skin
 - Zone of skin of head
 - Zone of skin of neck
 - Zone of skin of trunk
 - Zone of skin of thorax
 - Skin of chest
 - Zone of skin of chest
 - Skin of anterior chest
 - Zone of skin of anterior chest
 - Skin of pectoral part of chest
 - Zone of skin of pectoral part of chest
 - Skin of infraclavicular part of chest
 - Skin of breast
 - Zone of skin of subdivision of breast
 - Skin of breast
 - Skin of areola
 - Skin of nipple
 - Skin of quadrate part of breast
 - Skin of inframammary part of breast
 - Skin of sternal part of breast
 - Skin of lateral pectoral part of breast

skin of areola

Superclasses

- Skin of subdivision of breast

CLASS EDITOR

For Class: Skin of areola (instance of Skin of subdivision of breast)

Has Mass

Dimension: 3-dimension
Physical State: [dropdown]

Role: Concrete

Inherent 3-D Shape: [text box]

Has Shape: [text box]

Preferred Name: KB_INSTANCE_63202

Documentation: [text box]

Arterial Supply: [text box]

Attaches To: [text box]

Cutaneous lymphatic tree of areola

Member Of: [text box]

Nerve Supply: [text box]

Part: Sebaceous gland of areola, Areolar gland, Areolar tubercle

Part Of: Areola, Skin of breast

Receives Input From: [text box]

[text box]

Attributed Continuation: [text box]

Attributed Part: fm-live_12245, fm-live_12463

Constraints: [text box]

Instances: Skin of right areola, Skin of left areola

Location: [text box]

Consistency (cont.)

- For the subclasses of "Subdivision of thorax":
 - part: 24 inconsistencies (8 classes)
- For the subclasses of "Subdivision of trunk":
 - part: 42 inconsistencies (13 classes)
 - constitutional part: 4 inconsistencies (1 class)
 - regional part: 8 inconsistencies (1 class)

Consistency

check that the parts of X and the subclasses of “Part of X ” (if it exists) are consistent

- ex: “Region of chest wall” and the regional parts of “Chest wall”
- Procedure:
 - all the parts of X are subclasses of “Part of X ”
 - all the subclasses of “Part of X ” are actually parts of X



CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Material anatomical entity
 - Anatomical structure
 - Body
 - Cardinal body part
 - Subdivision of cardinal body part
 - Subdivision of head
 - Subdivision of body proper
 - Neck
 - Subdivision of neck
 - Trunk
 - Subdivision of trunk
 - Thorax
 - Subdivision of thorax
 - Chest
 - Chest wall**
 - Region of chest wall
 - Thoracic wall
 - Anterior chest wall
 - Superficial chest wall
 - Anterior superficial chest
 - Lateral chest wall
 - Lateral thoracic wall
 - Lateral superficial chest w
 - Anterior chest
 - Region of anterior chest

Region of a

Superclasses

- Subdivision of thorax

CLASS EDITOR

For Class: Chest wall (instance of Subdivision of thorax)

Has Mass

Dimension: 3-dimension Physical State: Solid

Role: Concrete

Inherent 3-D Shape

Has Shape

Preferred Name: KB_INSTANCE_63214

Documentation: 5.30.01: We find it difficult to define a wall, which is a subdivision of an organ or a body part, in terms of boundaries. 5.30.01: We distinguish the

Part:

- Right lateral chest wall
- Left lateral chest wall
- Superficial chest wall
- Thoracic wall

Constraints

Part Of:

- Chest

Instances:

- Male chest wall
- Female chest wall

Location

Regional Part (circled in red):

- Anterior chest wall
- Right lateral chest wall
- Left lateral chest wall

Regional Part Of

Arterial Supply

Subclasses:

- Male chest wall
- Female chest wall

Orientation

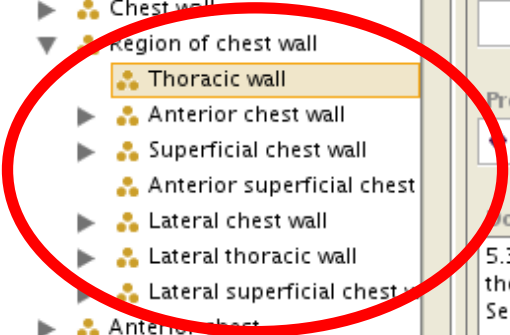


CLASS BROWSER

For Project: fma-local

Class Hierarchy

- Material anatomical entity
 - Anatomical structure
 - Body
 - Cardinal body part
 - Subdivision of cardinal body part
 - Subdivision of head
 - Subdivision of body proper
 - Neck
 - Subdivision of neck
 - Trunk
 - Subdivision of trunk
 - Thorax
 - Subdivision of thorax
 - Chest
 - Chest wall
 - Region of chest wall
 - Thoracic wall**
 - Anterior chest wall
 - Superficial chest wall
 - Anterior superficial chest
 - Lateral chest wall
 - Lateral thoracic wall
 - Lateral superficial chest
 - Anterior chest
 - Region of anterior chest



CLASS EDITOR

For Class: Thoracic wall (instance of Region of chest wall)

Has Mass

Dimension: 3-dimension Physical State: Solid

Role: Concrete

Inherent 3-D Shape

Has Shape

Preferred Name: KB_INSTANCE_09362

Documentation: 5.30.01: We distinguish the thoracic wall from the chest wall. See definition of each.

Arterial Supply

- Part
- Endothoracic fascia
 - Right lateral chest wall
 - Left lateral chest wall
 - Rib cage

- Part Of
- Chest wall
 - Thorax

- Regional Part
- Posterior thoracic wall
 - Lateral thoracic wall
 - Anterior thoracic wall
 - Right lateral thoracic wall
 - Left lateral thoracic wall

Subclasses

Constraints

Instances

Location

Regional Part Of

Orientation

Region of a

- Superclasses
- Region of chest wall

Consistency

check that the parts of X and the subclasses of “Part of X ” (if it exists) are consistent

- part: 24 inconsistencies
- regional parts: 11008 inconsistencies

Synthesis

Discussion

- Patterns “manually” generated
 - coverage for Vertebra
- Auxiliary classes (Part_of_X, Region_of_Y, ...):
 - exist in FMA-frames so should also exist in FMA-OWL
 - should only be defined
- FMA complex class/metaclass architecture
- Closure

Conclusion

- Consistency checking
 - is needed (the bigger your onto, the more you need it)
 - should be automated
 - detect current mistakes
 - avoid new mistakes during updates
 - ... toward semi-automatic correction?
- Generating the OWL-specific part of the FMA
 - automatic + ad hoc