Performance Summary Display Ontology

User Documentation

DISPLAY Lab
Ann Arbor, MI
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Table of Contents

1. Introduction

This document makes a few assumptions. It assumes basic familiarity with computer ontology development, specifically Basic Formal Ontology. As such, it does not describe ontology (computer science applications or philosophical background) at all. For a robust introduction please see one of the following:

> Poli R, editor. Computer applications. Dordrecht: Springer; 2010. 576 p. (Theory and applications of ontology).
>
> Note: for the above, the second chapter entitled Ontological Architectures by Leo Orbst is particularly helpful.
>
> Obrst LJ, Janssen T, Ceusters W, editors. Ontologies and semantic technologies for intelligence. Amsterdam, Netherlands: IOS Press; 2010. 227 p. (Frontiers in artificial intelligence and applications).

It also assumes that the readers are familiar with the academic material listed below. Brief introductions are given concerning basic technologies, tools, and concepts, and further resources are provided to the interested reader. This document is not intended to be an expression of academic opinion, scientific results, or institutional or ontological commitment to a set of particular ideas, concepts, or domain-specific semantics. Rather, this document is intended to be a quick guide to PSDO and very brief background on relevant material. As such, it makes radical simplifications and uses a colloquial tone and language to ease in readability. This work is not peer-reviewed.

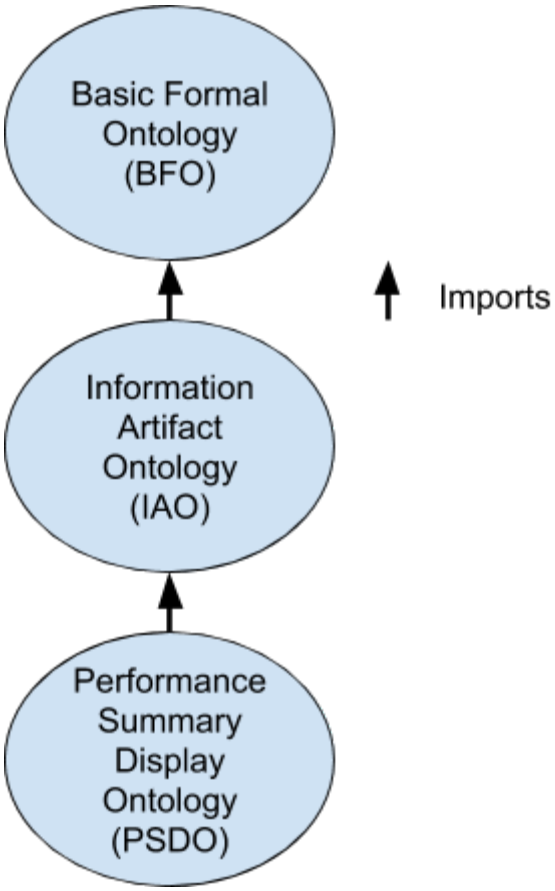
> Zhang J, Norman DA. Representations in distributed cognitive tasks. Cognitive Science. 1994 Jan 1;18(1):87–122.
>
> Zhang J. A representational analysis of relational information displays. International Journal of Human-Computer Studies. 1996 Jul 1;45(1):59–74.
>
> Munzner T. Visualization analysis and design. Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business; 2015. 404 p. (A.K. Peters visualization series).
>
> Arp R, Smith B, Spear AD. Building Ontologies with Basic Formal Ontology. MIT Press; 2015. 245 p.

1.1 Scope

The Performance Summary Display Ontology (PSDO) is an application ontology about charts, tables, and graphs that are used to communicate performance information to employees and teams in organizations. PSDO focuses on the use of performance summary displays in clinical dashboards and feedback interventions. PSDO contains representations of the elements, and element-aggregates of performance summary displays. PSDO also represents the basic entities required to model 'distributed representation' as documented by Norman and Zhang's *Representations in distributed cognitive tasks*. PSDO is deliberately small to facilitate reuse, further customization and extension, and greater interoperability with other ontologies. However, this ontology was constructed primarily for use in an application for tailoring performance reports and testing scientific theories in of behavior change in a reproducible manner. PSDO is not designed as a reference ontology.

1.2 BFO/IAO

PSDO uses Basic Formal Ontology (BFO) as its upper level ontology. In addition, PSDO makes use of the Information Artifact Ontology (IAO) which also uses BFO for upper-level structure. Please refer to the linked resources and Arp. R et al.'s *Building Ontologies with Basic Formal Ontology* for in depth information regarding each ontology. When we say 'uses' we technically mean 'imports.' An ontology import essentially means 'to take as-is and extend.' For further technical documentation regarding 'imports' please refer to the Protege Wiki and the section 'Imports' in this document. PSDO takes the ontological structure of BFO and IAO wholesale and adds valuable classes, definitions, and axioms specifically related to its domain. We chose BFO as our upper-level ontology for a number of reasons: (1) BFO is small, expressive and supports reuse as a fundamental design principle, (2) BFO contains representations of 'the structure of reality' from a nominal realist perspective which is particularly suited for the biomedical sciences, (3) there is community interest in BFO which means that there are more resources for ontological development.



1.21 Summary of Important BFO Structure and Practice

At a high level BFO splits ‘reality’ into two main types of entities: (1) continuants and (2) occurents. Continuants are entities, material or not, that persist through time while occurents are entities that unfold through time. While there are many processes (occurents) related to perception, design, generation, interpretation, and cognition of visual artifacts, these are outside the current scope of PSDO. All of PSDO’s classes are situated under ‘continuant’ in the BFO structure.

BFO further breaks continuants into three major categories: (1) generically dependent, (2) independent, and (3) specifically dependent. The definitions of each are taken from the resolving BFO PURL as found on the OBO Foundry BFO page.

1. **“generically dependent continuant**: A continuant that is dependent on one or other independent continuant bearers. For every instance of A requires some instance of (an independent continuant type) B but which instance of B serves can change from time to time.”[1]
2. **“independent continuant:** A continuant that is a bearer of quality and realizable entity entities, in which other entities inhere and which itself cannot inhere in anything.”[2]
3. **“specifically dependent continuant:** A continuant that inheres in or is borne by other entities. Every instance of A requires some specific instance of B which must always be the same.”[3]

A note on the definitions above: they are formal. Each BFO definition should follow a ‘genus differentia’ definition. This means that the term definition includes the parent class and the features of that class that necessarily differentiate it from its parent classes. These semantic best practices allow for more formal representation during development and use. Among others, this is listed in the OBO Foundry principles for development of BFO-conformant ontologies. PSDO follows this convention. Please refer to the publication below:

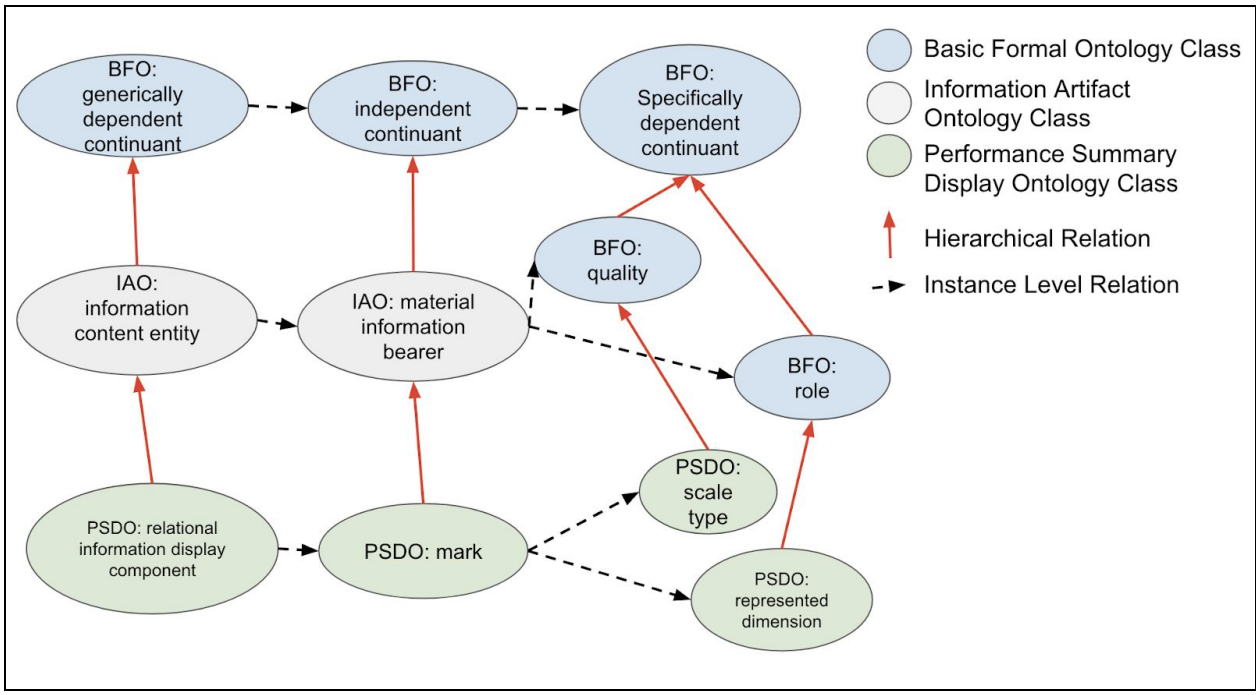
Seppälä S, Ruttenberg A, Smith B. Guidelines for writing definitions in ontologies. 2017;16.

[1] 1. Arp R, Smith B, Spear AD. Building Ontologies with Basic Formal Ontology. MIT Press; 2015. 245 p.
[2] 1. Arp R, Smith B, Spear AD. Building Ontologies with Basic Formal Ontology. MIT Press; 2015. 245 p.
[3] 1. Arp R, Smith B, Spear AD. Building Ontologies with Basic Formal Ontology. MIT Press; 2015. 245 p.

1.22 Representational Implications

Readers not interested in ontological design choices and BFO-specific implications are encouraged to skip this section.

Below is a diagram showing the basic, core structure of PSDO and it's relation to BFO and IAO. We will not define the specific relations (instance level) here. The distinction between 'hierarchical relations' and 'instance level relations' refers to relations that hold between 'universals (classes)' and 'instances (particulars).' The hierarchical, or universal level relations are parent-child relations, often called 'is_a.' This means that IAO: information content entity ***is_a*** BFO: generically dependent continutant and particulars of these classes have specified relations between them. The most important distinction of the diagram below is that there is a clear separation between 'material' and 'information' that is inherited from the BFO/IAO structure. For BFO/IAO, 'information' is independent from its ***concretization***, meaning that the independent entity (here we are speaking of material entities) *makes the information real*, but the material is separate from the 'information content.'



A pedagogical example: writing a short poem on a chalkboard. The content of the poem, that we recognize and have opinions about is the 'IAO: information content entity.' The physical material, chalk, is it's IAO: material information bearer. The chalk is independent from the 'information' in the poem. The poem, however, is made real (***concretized***) by the chalk.

Another important construct to notice is that IAO: information content entities cannot have ‘qualities’ or ‘roles’ without having a independent continuant that concretizes them. In other word, information does not have ‘qualities’ directly, rather the qualities of information and information content speak about the same entity: BFO: independent continuant. We adapt the term ‘mark’ from Munzner’s work (cited in the introduction) to refer to the independent continuants that make visual information real.

This has important implications for modeling information visualizations such as graphs or tables. When we talk about the length of a line, we must speak about the length of the mark, and the information that the mark concretizes distinctly. A ‘mark’ is the bridge between the information content and the qualities of instance level concretization of that information content.

ADD MAPT MANUSCRIPT: Manuscript forthcoming.

2. GitHub Basics

If you are familiar with GitHub, skip this section (you only need the link). This section is not comprehensive and does not cover development strategies. There are many great GitHub tutorials available online. Here is a great Cheat Sheet for those looking to get started on the command line. The rest of this section will be devoted to accessing the files using the Web page and is intended for users without programming experience.

“Git” is an open-source version-control system that allows multiple users to collaborate on shared files simultaneously. GitHub is a cloud-based file sharing system that hosts public ‘repositories’ (essentially file directories). “Git” is the system and protocols for updating, managing, and reversing changes to files. “GitHub” is where the files are stored, and where files can be accessed. This document covers only the basics of “GitHub.”

2.1 Downloading the File

The DISPLAY Lab maintains it’s projects in an open-source platform accessed through the link below[4]:

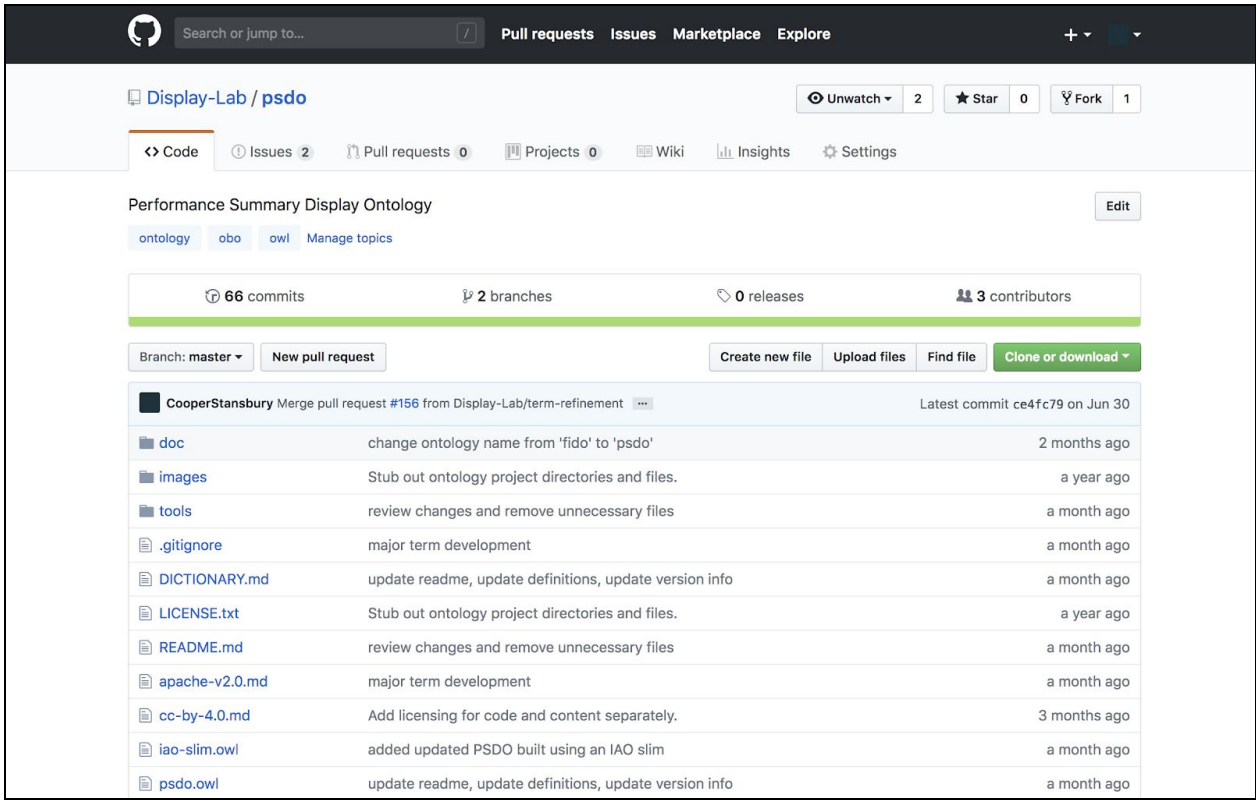
https://github.com/Display-Lab

While there are many projects, the focus here is only on PSDO:

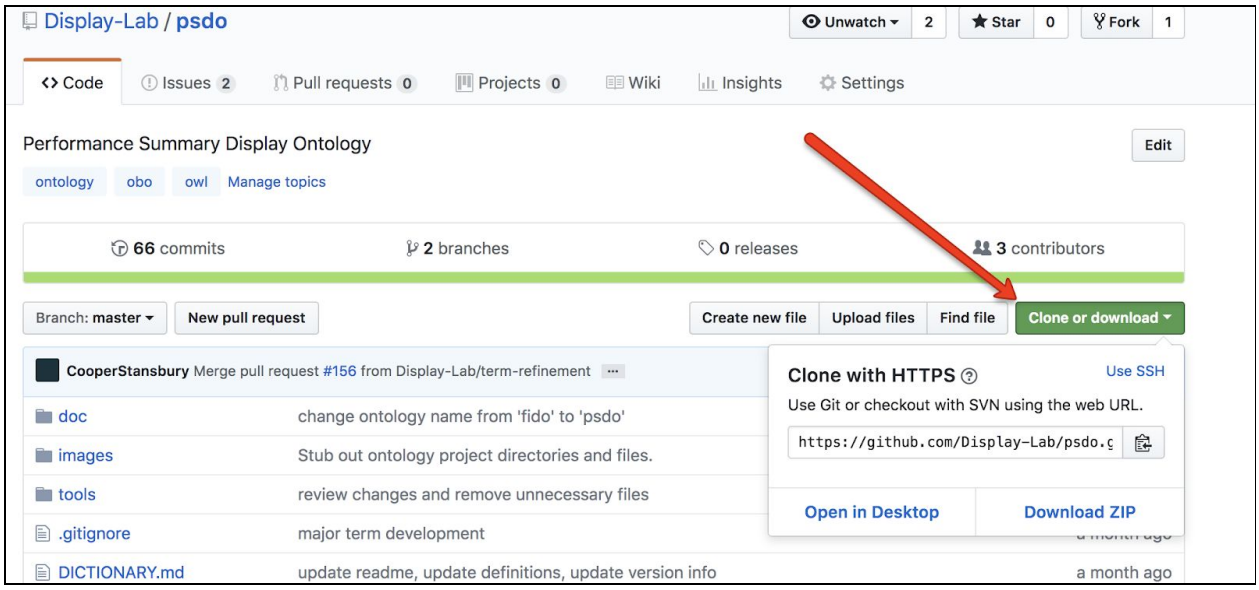
https://github.com/Display-Lab/psdo

[4] Please note that we do have Creative Commons licenses.

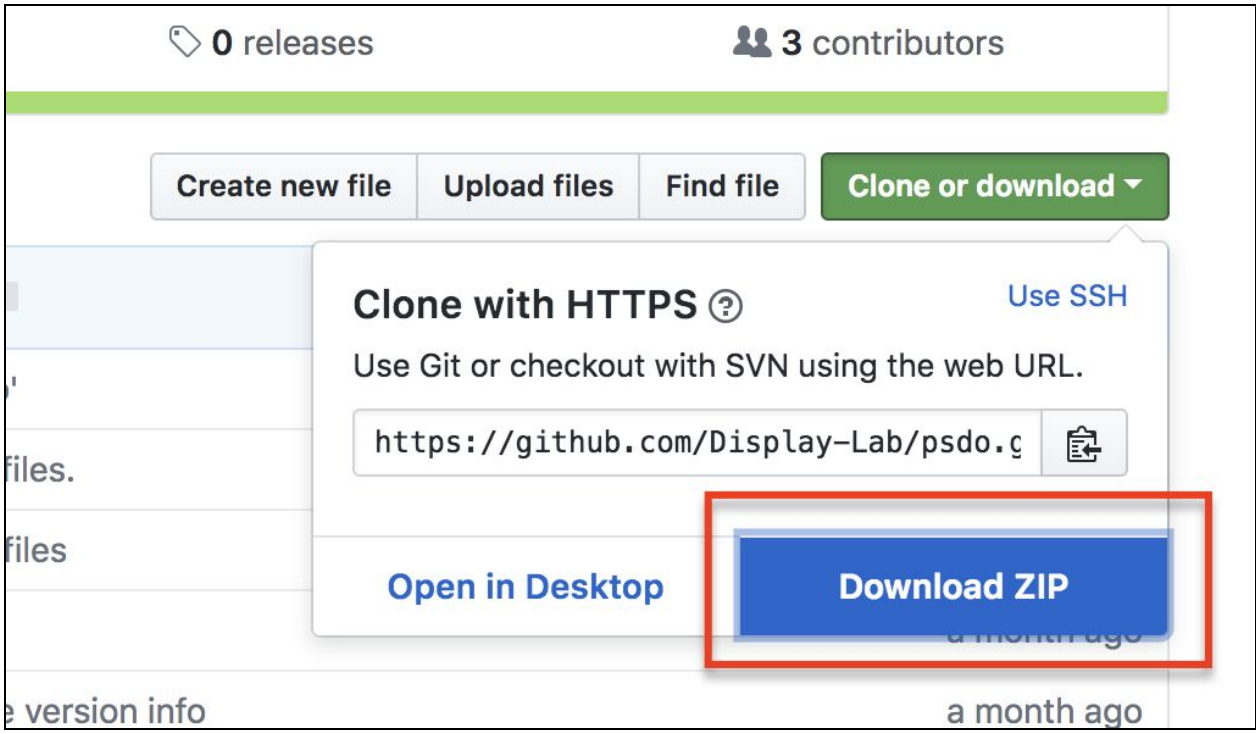
When navigating to this URL you will land on a page that looks something like this:



From here, click on the green button labeled ‘Clone or download’ on the mid-right-hand side of the screen:

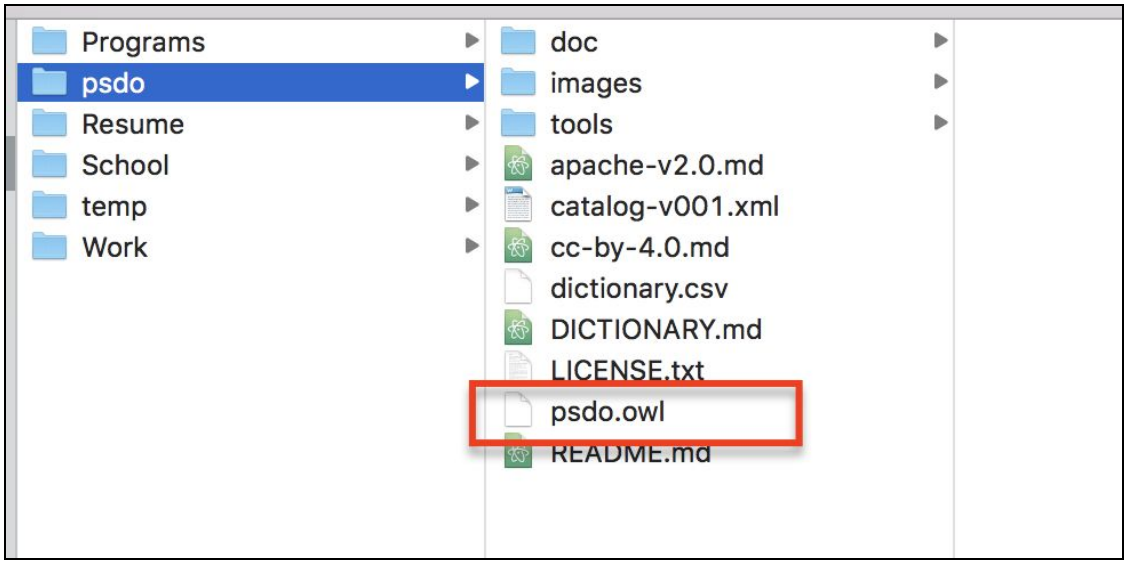


There are a number of ways to access the file. We recommend clicking ‘Download ZIP.’ You will be prompted to select a location on your computer to save the file.



Once downloaded, open the ZIP file using your preferred method (likely double-clicking on the package).

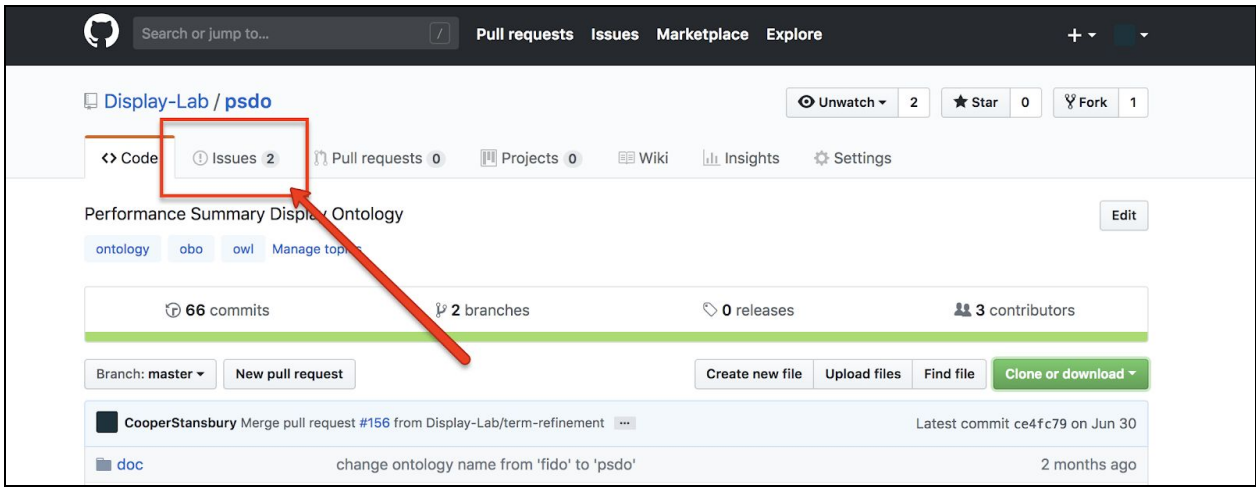
You will see a folder label psdo, and inside it will look something like this:



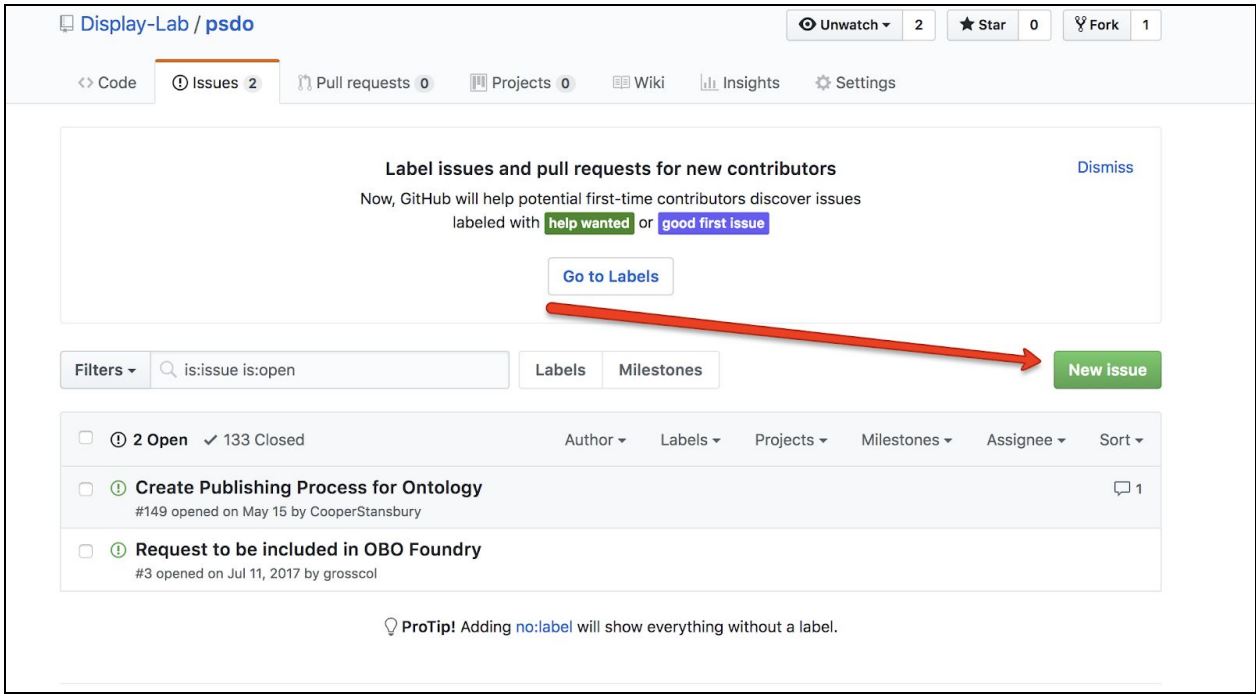
The psdo.owl file is the ontology. Please refer to the Protege section for opening the ontology with Protege. Otherwise open the file using your ontology or text editor of choice.

2.2 Requesting Changes

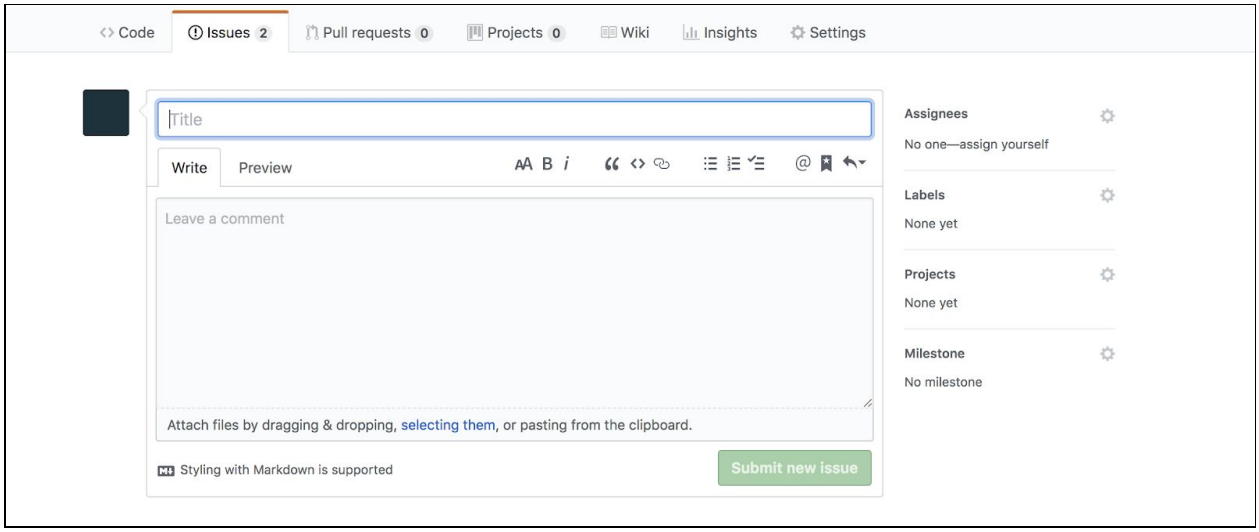
The best way to recommend changes is to use the GitHub issue tracker. From the GitHub web page there is a tab on the main menu labeled ‘Issues.’



From here, click on the green button on the mid-right-hand side of the screen labeled ‘New issue:’



Give the issue a good title. An Example: ‘Term: performance summary display definition change.’ In the body of the issue describe the change request further. The green button at the bottom-right-hand side of the screen will light up. When finished, click ‘submit new issue.’



We will try to address your issue in a timely manner, but we cannot promise expedient responses to every issue. Please follow-up if you have questions. This can be done by submitting a comment under the original issue.

3. The OWL file

3.1 Core Technologies

There are three core technologies for managing and creating ontologies listed below. Each hyperlink points to the W3C introduction that explains that technology in depth.

1. Web Ontology Language (OWL): a logical computer language used to express entities, their properties, and their relationships to other entities.
2. Resource Description Framework (RDF): a computer language for expressing subject-predicate-object triples. RDF is a graph language for representing information.
3. SPARQL: a query language for RDF.

Below are recommended resources for learning more about each of these technologies:

> Allemang D, Hendler JA. Semantic Web for the working ontologist: effective modeling in RDFS and OWL. 2nd ed. Waltham, MA: Morgan Kaufmann/Elsevier; 2011. 354 p.
>
> DuCharme B. Learning SPARQL: querying and updating with SPARQL 1.1. Second edition. Sebastopol, CA: O'Reilly Media; 2013. 366 p.

The ontology is stored in a file with the extension: '.owl'. The file is a an xml-like set of nodes that is not human-readable (in OWL). In general, if you wish to view the content of an ontology opening the text file is *not* the best way to do it (this document also discusses Protege, the open-source ontology editor from Stanford). A single OWL node is shown below:

```
<!-- http://purl.obolibrary.org/obo/psdo#psdo_0000062 -->

    <owl:Class rdf:about="http://purl.obolibrary.org/obo/psdo#psdo_0000062">
        <owl:equivalentClass>
            <owl:Class>
                <owl:intersectionOf rdf:parseType="Collection">
                    <rdf:Description rdf:about="http://purl.obolibrary.org/obo/IAO_0000178"/>
                    <owl:Restriction>
                        <owl:onProperty rdf:resource="http://purl.obolibrary.org/obo/RO_0000053"/>
                        <owl:someValuesFrom>
                            <owl:Restriction>
                                <owl:onProperty
rdf:resource="http://purl.obolibrary.org/obo/RO_0000059"/>
                                <owl:someValuesFrom
rdf:resource="http://purl.obolibrary.org/obo/psdo#psdo_0000008"/>
                            </owl:Restriction>
                        </owl:someValuesFrom>
                    </owl:Restriction>
                </owl:intersectionOf>
            </owl:Class>
        </owl:equivalentClass>
        <rdfs:subClassOf rdf:resource="http://purl.obolibrary.org/obo/IAO_0000178"/>
        <obo:IAO_0000112 xml:lang="en">Ink on paper or pixels on a screen
(non-exhaustive).</obo:IAO_0000112>
        <obo:IAO_0000115 xml:lang="en">A material information bearer that is a basic visual element of a
relational information display.</obo:IAO_0000115>
        <obo:IAO_0000119 xml:lang="en">Munzner T. Visualization analysis and design. Boca Raton: CRC
Press, Taylor &amp;amp; Francis Group, CRC Press is an imprint of the Taylor &amp;amp; Francis Group, an informa
business; 2015. 404 p. (A.K. Peters visualization series).</obo:IAO_0000119>
        <rdfs:label xml:lang="en">mark</rdfs:label>
    </owl:Class>
```

3.1.1 URIs

Uniform Resource Identifiers (URIs) are codes used to identify information on the web. URIs (sometimes called IRIs) are used in ontology development to manage semantic information like terms and their definitions. Using URIs allows a community to reuse as much structured knowledge as possible by providing computational ‘pointers’ to shared information. PSDO follows the standards set forth by the OBO Foundry. Please read the OBO Foundry principals for more information regarding namespaces and URIs.

3.2 Protege

3.2.1 About Protege

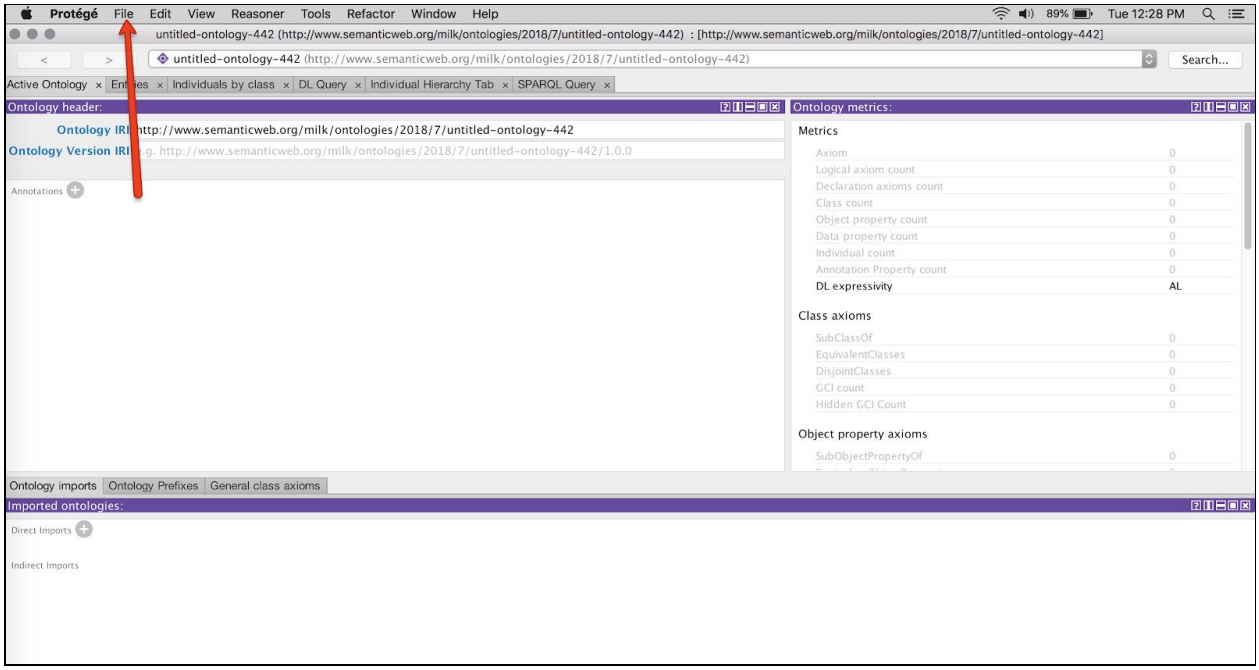
Protege is an open source platform for working with OWL/rdf/SPARQL files. While it is not the only freely available ontology editor, at the time of this writing, it is the most widely used. Protege has a variety of user-friendly documentation that can be found here:

https://protege.stanford.edu/support.php

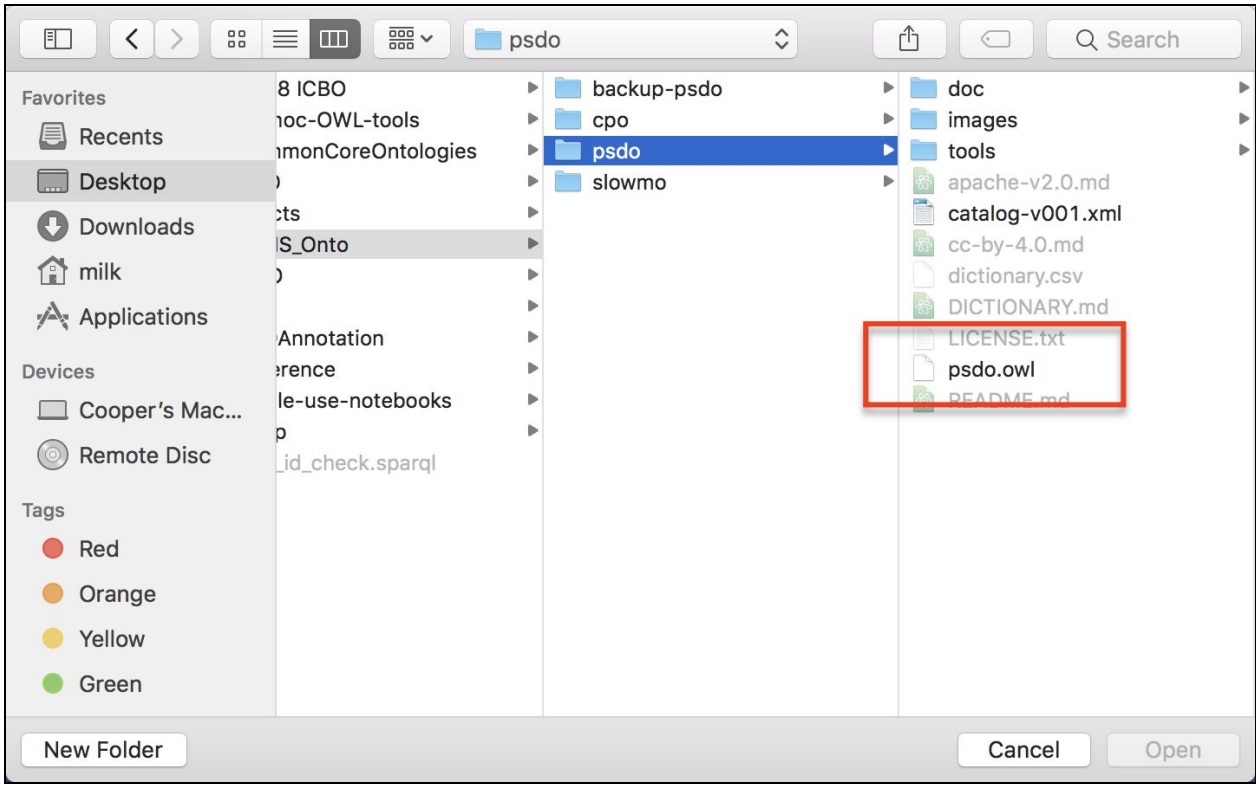
The PSDO user-guide will provide only a very brief overview of Protege. Interested readers are encouraged to research and try other ontology editors.

3.2.2 Opening a File

To open a file, start by opening the Protege application. Once open, navigate to ‘File’ on the main toolbar at the top of the screen.

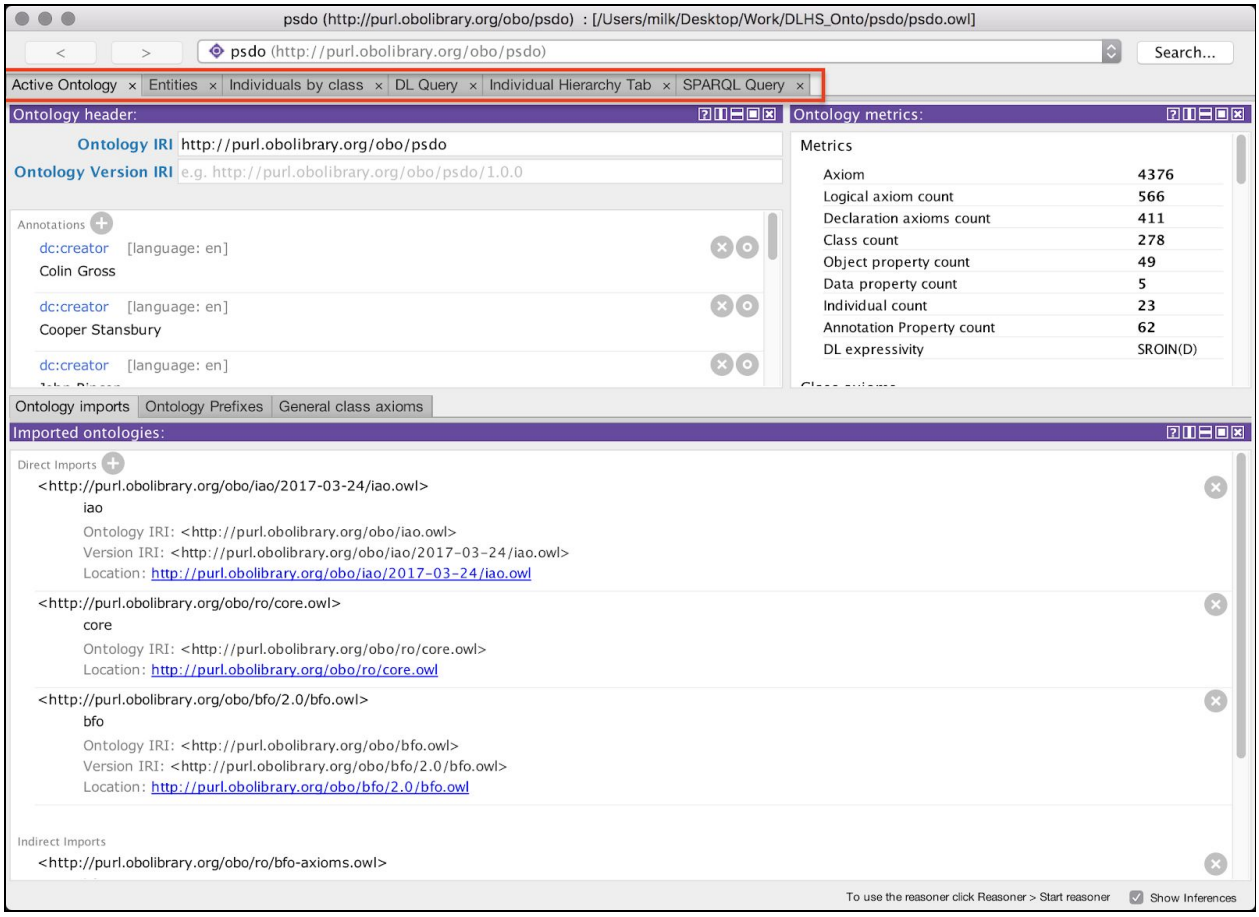


Choose the OWL file in the folder acquired from GitHub (see section 2.1).

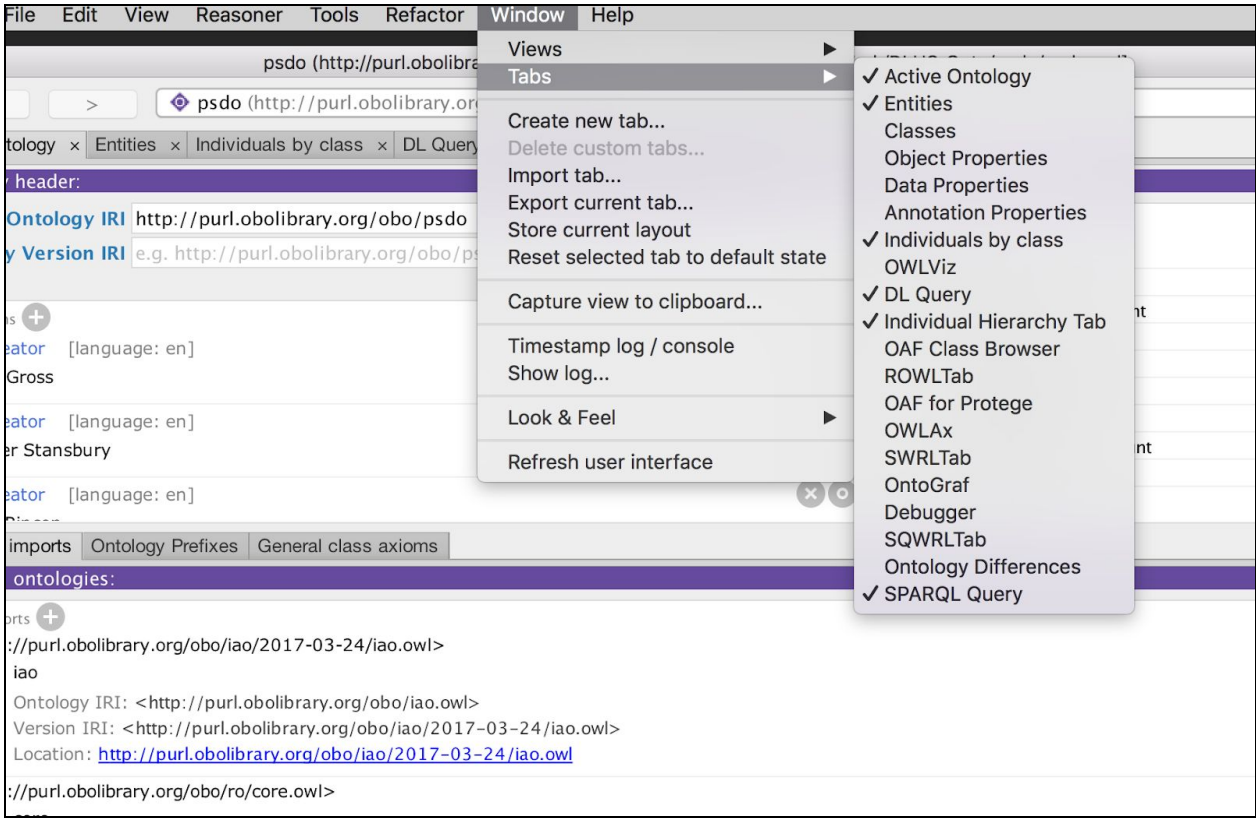

psdo
Search
Favorites
Recents
Desktop
Downloads
milk
Applications
Devices
Cooper's Mac...
Remote Disc
Tags
Red
Orange
Yellow
Green
8 ICBO
noc-OWL-tools
monCoreOntologies
cts
S_Onto
Annotation
erence
le-use-notebooks
id_check.sparql
backup-psdo
cpo
psdo
slowmo
doc
images
tools
apache-v2.0.md
catalog-v001.xml
cc-by-4.0.md
dictionary.csv
DICTIONARY.md
LICENSE.txt
psdo.owl
README.md
New Folder
Cancel
Open

3.2.3 Navigating the File

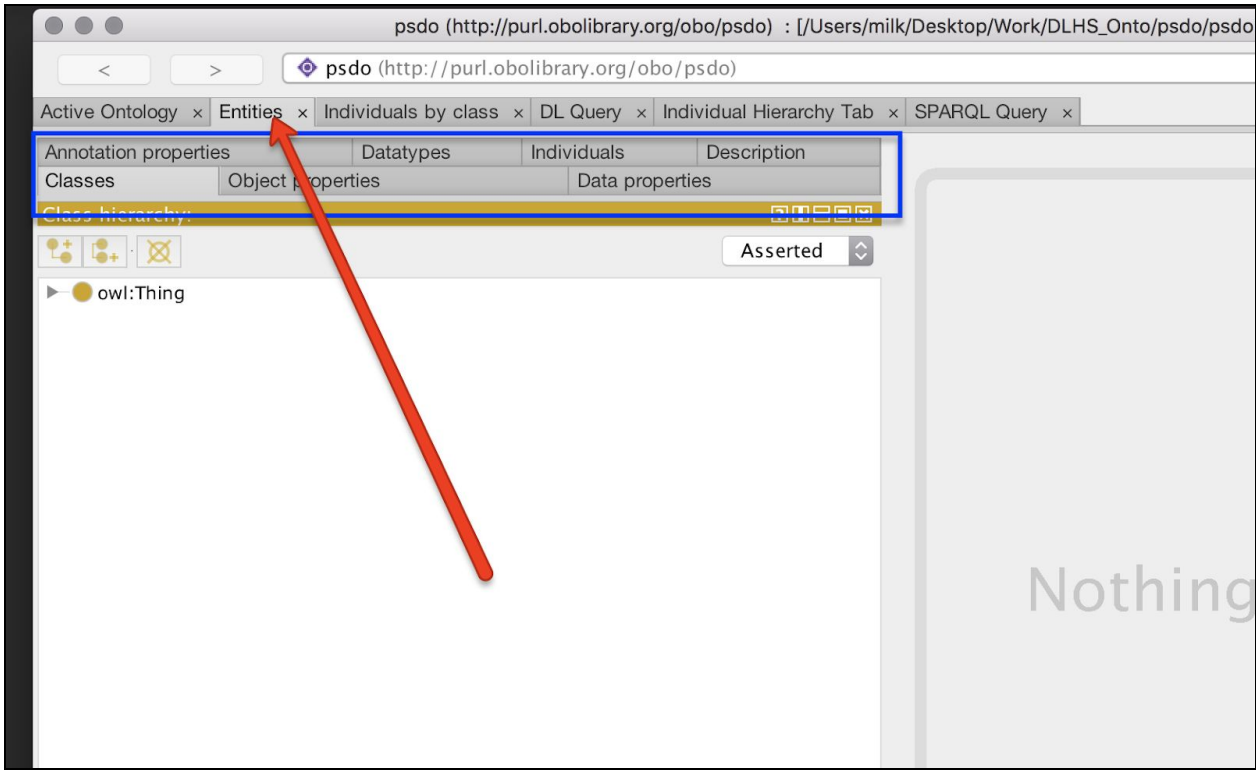
Once a file has been opened a variety of information will be displayed on the screen. The main navigation menu is at the top of the Protege window.



NOTE: If you do not see the tab you are looking for, select 'Window' → 'Tabs' and the tab you wish to see. It will become available in the main navigation toolbar.



The main tab for interacting with ontology content is labeled: 'Entities.' By clicking this tab you will see something similar to the screenshot below. Note: there is a second set of tabs under the 'Entities' tab that is shown by the blue box below. These tabs allow users to manage available data properties, annotation properties, and object properties (relations). This document will only touch on 'Classes,' and the reader is encouraged to visit Protege's documentation for further support.

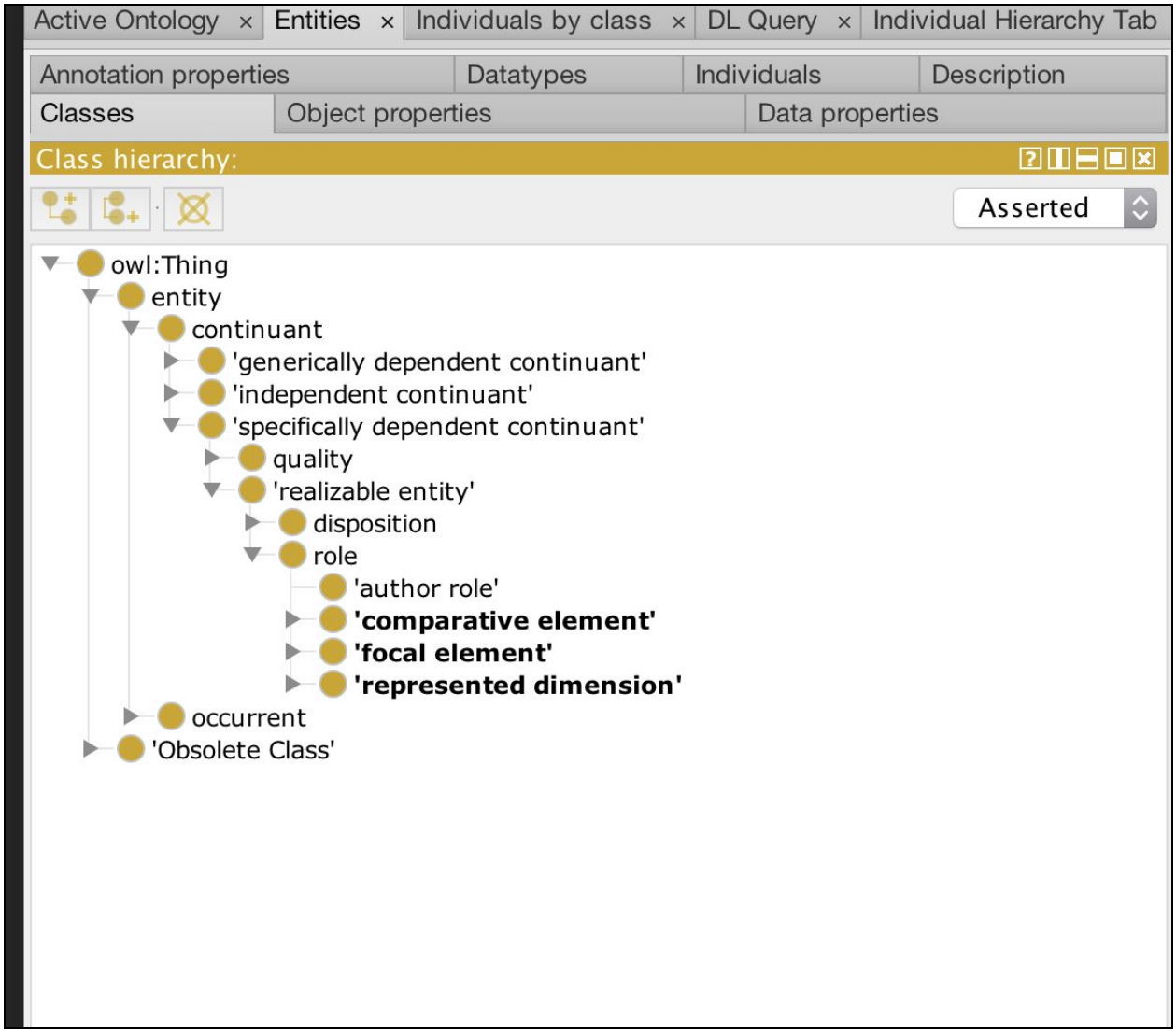


The class hierarchy can be expanded or collapsed by clicking the triangle icons to the right of the class name. Note: the classes in **bold** are members of the active ontology, which means they are the content that is specific to PSDO (in this case). All non-bold class names are *imported* via their URIs from another ontology. These classes should not be edited as the changes made to them will only take place in the local file. The [OBO Foundry] best-practices are to reach out to the curator of an ontology to discuss an imported term label or definition change.

Each level of indentation reflects a ‘is_a’ relation. Thus, ‘role’ ‘is_a’ ‘realizable entity.’ In the ontology file (OWL) this is show syntactically as rdfs:subClassOf. This is a parent-child relation, and as of Protege 5.2.0 this is the only relation that can be view in the ‘Classes’ tab.

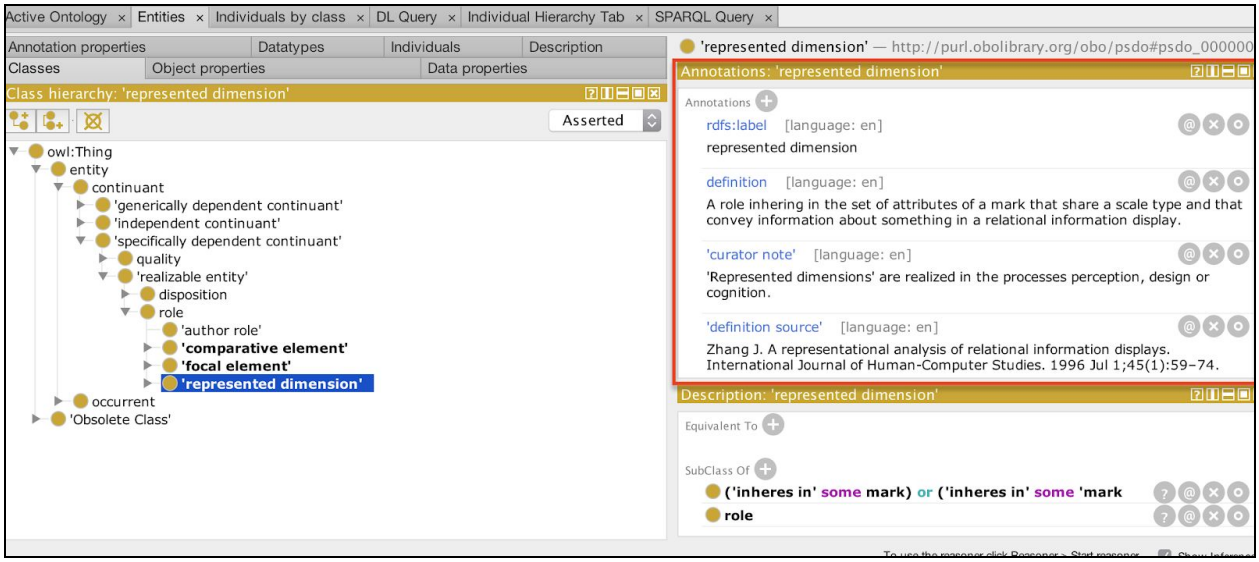
```
  <!-- http://purl.obolibrary.org/obo/psdo#psdo_0000047 -->

    <owl:Class rdf:about="http://purl.obolibrary.org/obo/psdo#psdo_0000047">
        <rdfs:subClassOf rdf:resource="http://purl.obolibrary.org/obo/psdo#psdo_0000019"/>
        <obo:IAO_0000115 xml:lang="en">A comparative element that conveys information about a
predetermined performance value.</obo:IAO_0000115>
        <rdfs:label xml:lang="en">standard comparator</rdfs:label>
    </owl:Class>
```



3.2.4 Annotation properties

By clicking on a term in the class hierarchy you are able to view more information about that term in the window on the right-hand side of Protege. These annotations, including a human-readable textual definition for that term, help the authors of the ontology communicate semantic and non-semantic information to the readers. Often there are examples of usage, licensing information, and term editors.

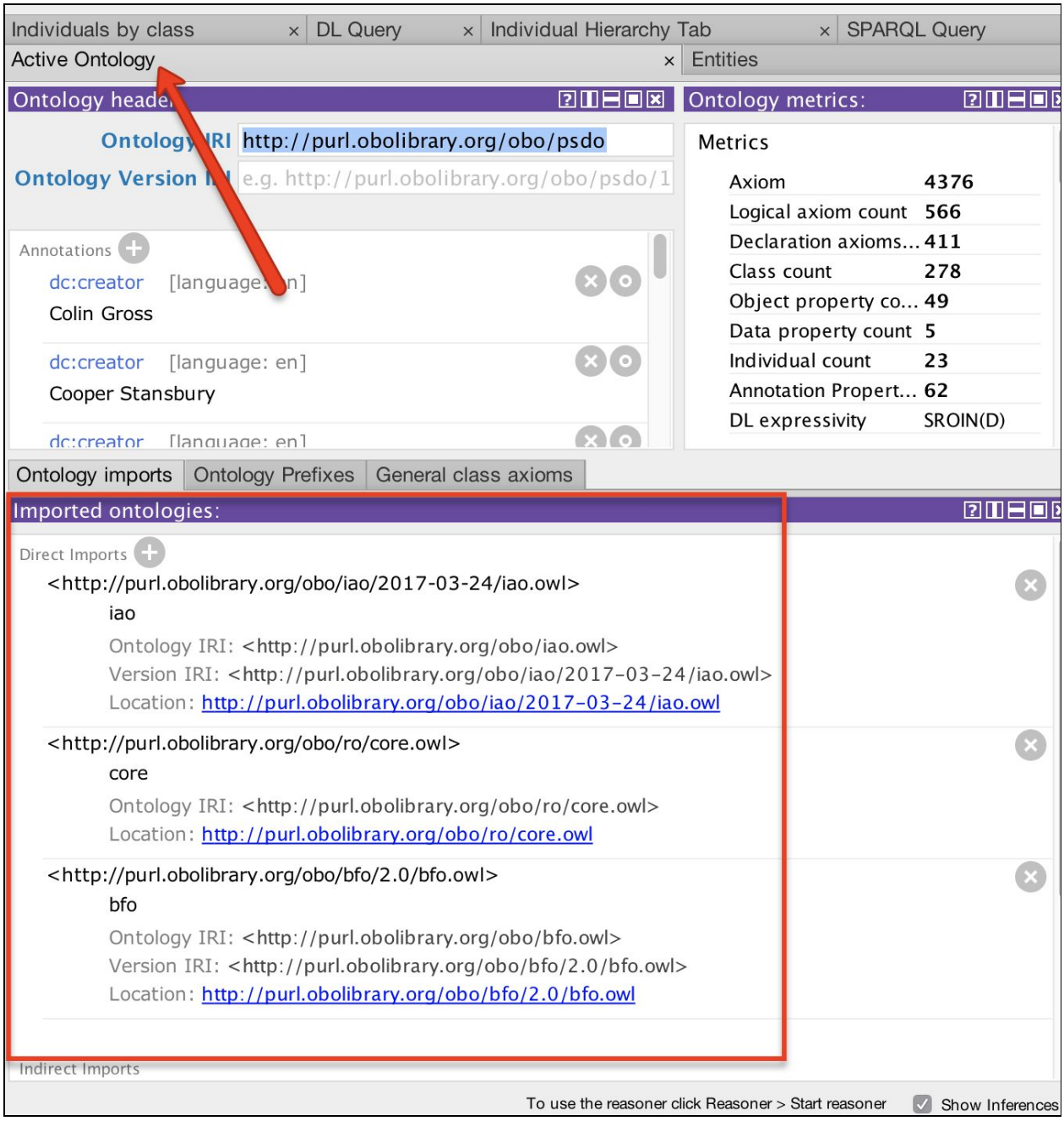


3.2.5 Imports

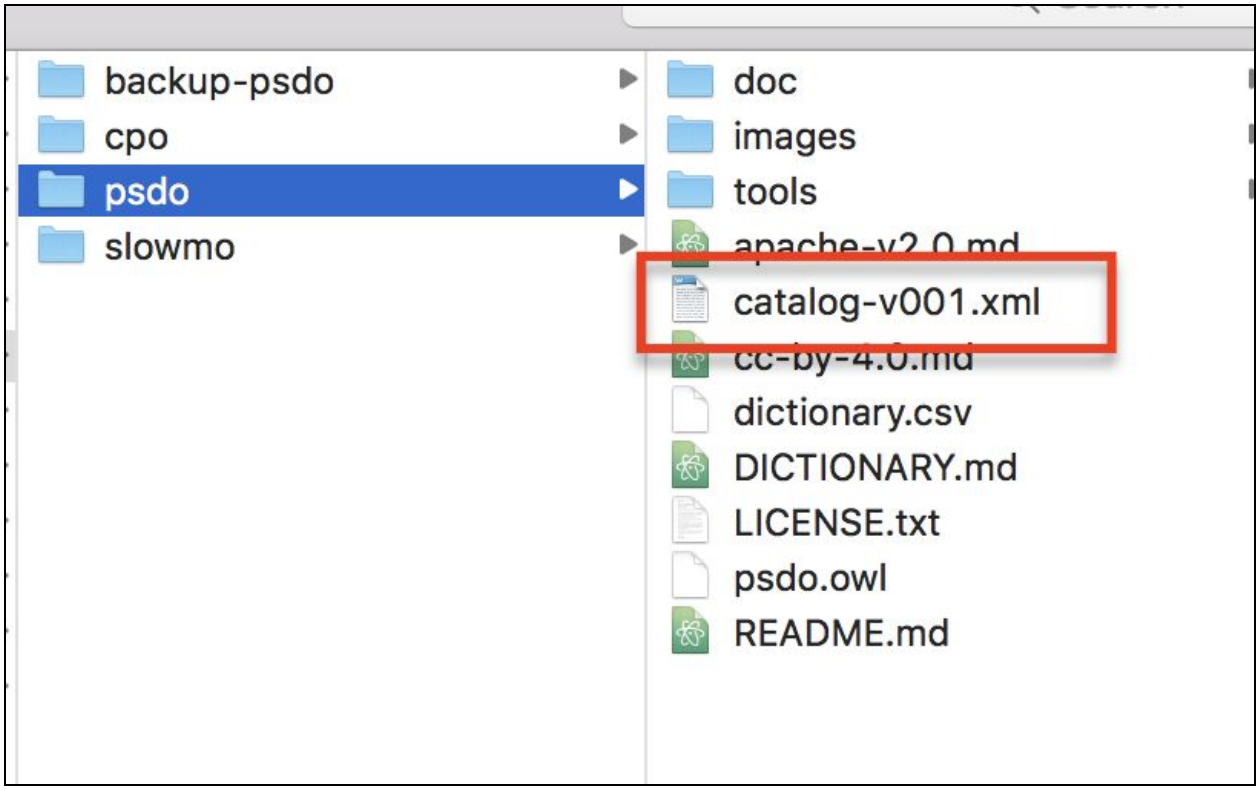
Ontology development best-practice is to reuse as much semantic content as possible via ‘pointing’ to URIs for needed terms that can be shared. OWL supports reusing predefined collections of terms (or entire ontologies) via an import statement.

```
<owl:imports rdf:resource="http://purl.obolibrary.org/obo/iao/2017-03-24/iao.owl"/>
<owl:imports rdf:resource="http://purl.obolibrary.org/obo/ro/core.owl"/>
<owl:imports rdf:resource="http://purl.obolibrary.org/obo/bfo/2.0/bfo.owl"/>
```

These imports can be seen on the ‘Active Ontology’ tab of Protege (see screenshot below).



Once Protege is opened a new file will appear in the same directory as the OWL file with the name: 'catalog-v001.xml.' This file helps to manage import closure and URI mapping for content reuse via the XML Catalog, but can sometimes be problematic during ontology development. For this reason this file is not included with the GitHub files. Please read the Protege Wiki page on imports for more information.



Import closure, and ontology versioning are complex and beyond the scope of this document. Below are some useful resources for learning more about them.

https://protegewiki.stanford.edu/wiki/How_Owl_2.0_Imports_Work
https://protegewiki.stanford.edu/wiki/Importing_Ontologies_in_P41
https://www.w3.org/2007/OWL/wiki/Imports
http://www.obofoundry.org/principles/fp-004-versioning.html

4. Term Table

Below is a list of the terms and definitions (just those terms in the active ontology, not the imported ontologies). Note, this list here is not curated and will likely be out-of-date relatively soon. From the DISPLAY Lab GitHub page the PSDO Repository can be accessed:

https://github.com/Display-Lab/psdo

From here you can view the current terms and definitions:

https://github.com/Display-Lab/psdo/blob/master/DICTIONARY.md

angle

An attribute of the magnitude of the degree of divergence of two things from one another.http://purl.obolibrary.org/obo/psdo#psdo_0000058

ascribee dimension

A represented dimension where the attributes of the mark are about entities that have attributed performance data.http://purl.obolibrary.org/obo/psdo#psdo_0000018

attribute

"An information carrier that can be measured, observed, or logged." http://purl.obolibrary.org/obo/psdo#psdo_0000061

color

An attribute by virtue of which something appears to have a color. http://purl.obolibrary.org/obo/psdo#psdo_0000055

comparative element

A role inhering in a mark that is disjoint with a focal element and that has the same scale type as the focal element.http://purl.obolibrary.org/obo/psdo#psdo_0000019

focal element

A role inhering in a mark that conveys specific information to the recipient of a performance summary report realized through the acts of perception. http://purl.obolibrary.org/obo/psdo#psdo_0000040

goal comparator

A comparative element that conveys information about a desired future performance value.http://purl.obolibrary.org/obo/psdo#psdo_0000046

interval scale

"A scale type with three formal properties that (1) the instances can be distinguished from each other and (2) that one instance on a scale can be judged greater than, less than, or equal to another instance on the same scale and that (3) the magnitude of an instance represented by a unit on the scale is the same regardless of where on the scale the unit falls."http://purl.obolibrary.org/obo/psdo#psdo_0000023

mark collection

A object aggregate of marks. http://purl.obolibrary.org/obo/psdo#psdo_0000079

mark length

the quality of linear magnitude of any thing as measured from end to end. http://purl.obolibrary.org/obo/psdo#psdo_0000060

mark

A material information bearer that is a basic visual element of a relational information display.http://purl.obolibrary.org/obo/psdo#psdo_0000062

nominal scale

A scale type with one formal property that (1) the instances can be distinguished from each other.http://purl.obolibrary.org/obo/psdo#psdo_0000026

ordinal scale

"A scale type with two formal properties that (1) the instances can be distinguished from each other and (2) that one instance on a scale can be judged greater than, less than, or equal to another instance on the same scale."http://purl.obolibrary.org/obo/psdo#psdo_0000025

performance dimension

"A represented dimension where the attributes of the mark are about measurements, decisions, aggregates, or calculations related to measured behavior." http://purl.obolibrary.org/obo/psdo#psdo_0000037

performance gap

A relational quality of the perceived distance between marks. http://purl.obolibrary.org/obo/psdo#psdo_0000029

performance measure dimension

A represented dimension where the attributes of the mark are about the methods of measuring behavior.http://purl.obolibrary.org/obo/psdo#psdo_0000035

performance report

A report designed for the purpose of providing performance summary information to a recipient of an intervention.http://purl.obolibrary.org/obo/psdo#psdo_0000031

performance summary display template

An information content entity that is the collection of specification and metadata associated with a generalized potential information display. http://purl.obolibrary.org/obo/psdo#psdo_0000002

performance summary display

"A relational information display whose display components bear some combination of dimension roles: ascribee dimension, performance measure dimension, performance dimension, or time dimension."http://purl.obolibrary.org/obo/psdo#psdo_0000003

performance trend

"A relational quality of the perceived general movement of a mark, or set of marks that is integrated over a time dimension." http://purl.obolibrary.org/obo/psdo#psdo_0000028

position

An attribute of relation in which a thing stands with respect to another or others.http://purl.obolibrary.org/obo/psdo#psdo_0000056

ratio scale

"A scale type with four formal properties that (1) the instances can be distinguished from each other and (2) that one instance on a scale can be judged greater than, less than, or equal to another instance on the same scale, that (3) the magnitude of an instance represented by a unit on the scale is the same regardless of where on the scale the unit falls and (4) an absolute zero value can indicate that nothing at all of the property being represented exists."http://purl.obolibrary.org/obo/psdo#psdo_0000024

recipient element

A focal element that conveys information about identity to the recipient of the performance summary report.http://purl.obolibrary.org/obo/psdo#psdo_0000041

relational information display component

An information content entity that is a proper part of a relational information display and is concretized by a mark.http://purl.obolibrary.org/obo/psdo#psdo_0000008

relational information display

An information content entity that displays relations between dimensions in a concretized collection of display components.
http://purl.obolibrary.org/obo/psdo#psdo_0000001

represented dimension

A role inhering in the set of attributes of a mark that share a scale type and that convey information about something in a relational information display.
http://purl.obolibrary.org/obo/psdo#psdo_0000006

scale type

A quality that is the abstract measurement property of a concretized display component.http://purl.obolibrary.org/obo/psdo#psdo_0000020

shape

An attribute of external form or contour.
http://purl.obolibrary.org/obo/psdo#psdo_0000054

social comparator

A comparative element that conveys information about an entity that has an attributed performance value.http://purl.obolibrary.org/obo/psdo#psdo_0000045

standard comparator

A comparative element that conveys information about a predetermined performance value.http://purl.obolibrary.org/obo/psdo#psdo_0000047

texture

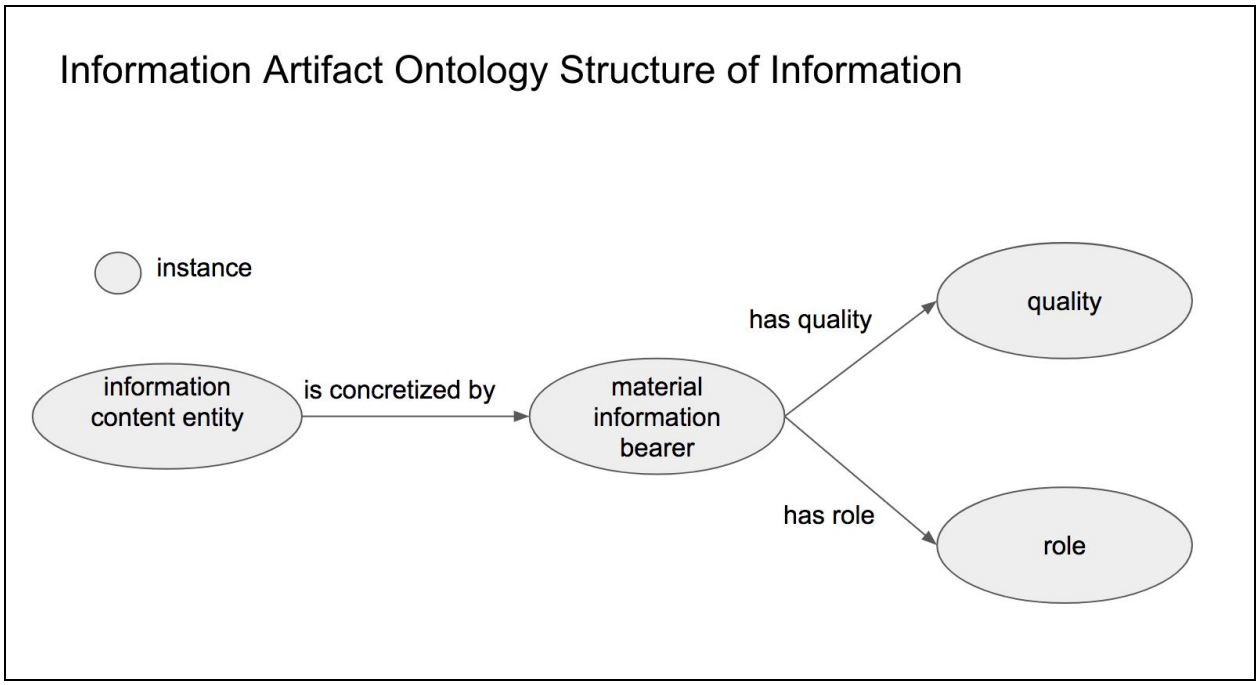
"An attribute of constitution, structure, or substance of anything with regard to its constituents or formative element."http://purl.obolibrary.org/obo/psdo#psdo_0000059

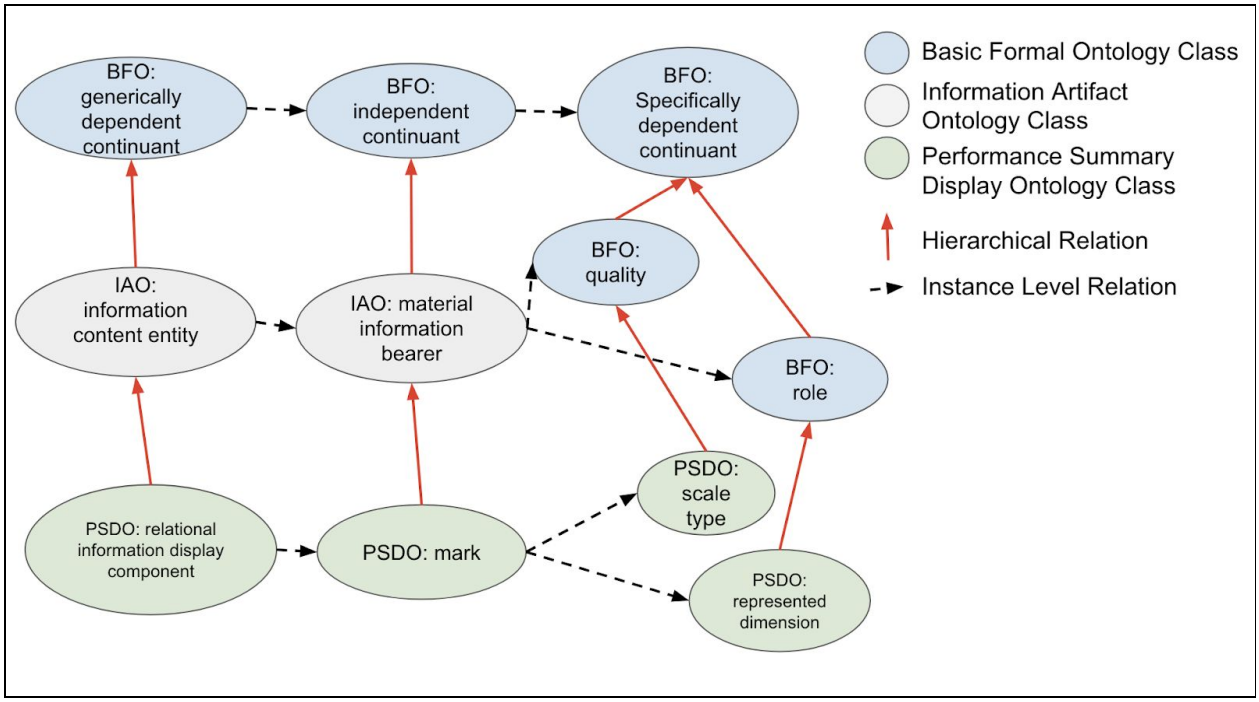
time dimension

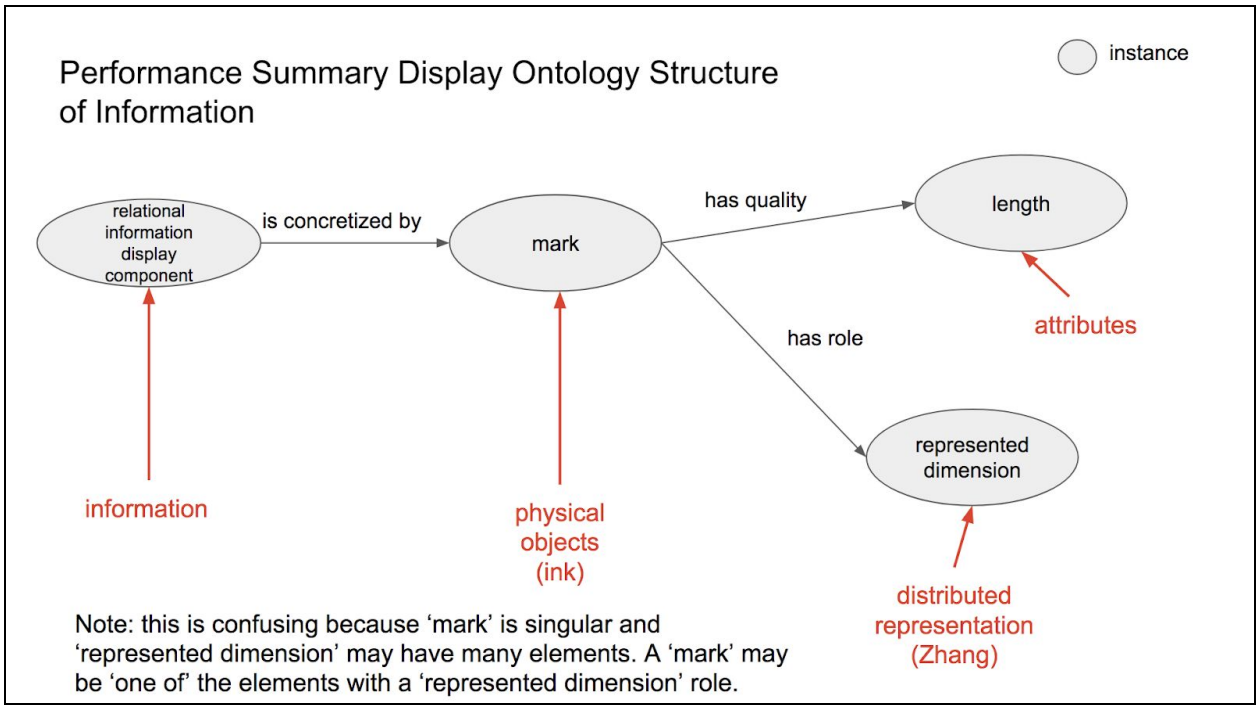
A represented dimension where the attributes of the mark are about time.http://purl.obolibrary.org/obo/psdo#psdo_0000036

5. Diagrams

The diagrams below are meant only to demonstrate high-level structure of PSDO. This work is not peer-reviewed, and makes some simplifications of the IAO structure of information. Much more detailed information can be found on the Information Artifact Ontology Wiki.

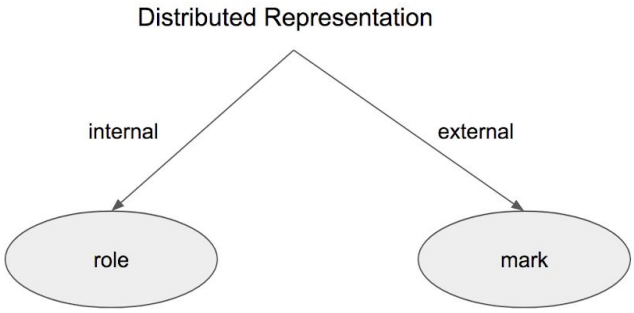



BFO: generically dependent continuant
BFO: independent continuant
BFO: Specifically dependent continuant
BFO: quality
IAO: information content entity
IAO: material information bearer
BFO: role
PSDO: scale type
PSDO: relational information display component
PSDO: mark
PSDO: represented dimension
Basic Formal Ontology Class
Information Artifact Ontology Class
Performance Summary Display Ontology Class
Hierarchical Relation
Instance Level Relation


Performance Summary Display Ontology Structure of Information
instance
relational information display component
is concretized by
mark
has quality
length
attributes
has role
represented dimension
information
physical objects (ink)
distributed representation (Zhang)
Note: this is confusing because 'mark' is singular and 'represented dimension' may have many elements. A 'mark' may be 'one of' the elements with a 'represented dimension' role.

Note on 'Distributed Representation'

instance



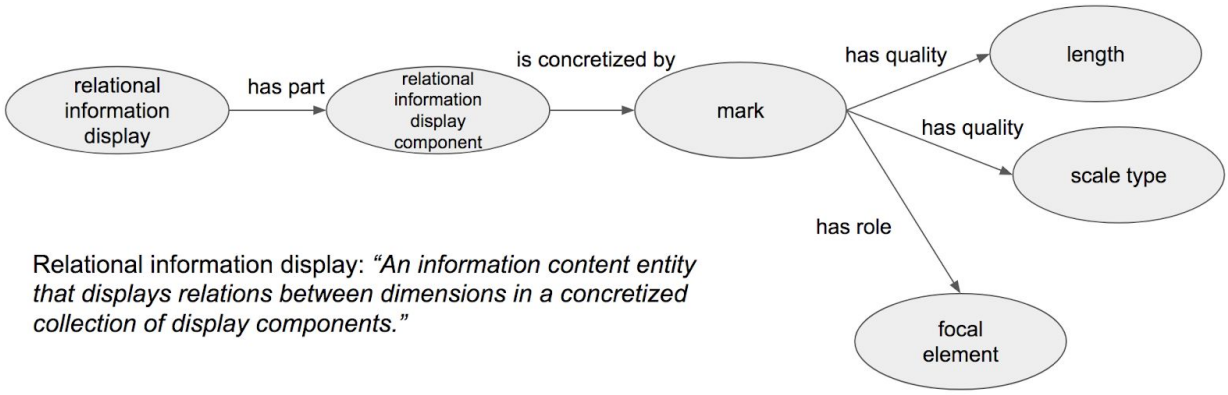
"The basic idea is that the representations of dimensions in RIDs are distributed representations with internal and external representations as two indispensable components."

Zhang J. A representational analysis of relational information displays. International Journal of Human-Computer Studies. 1996 Jul 1;45(1):59–74.

Relational Information Displays

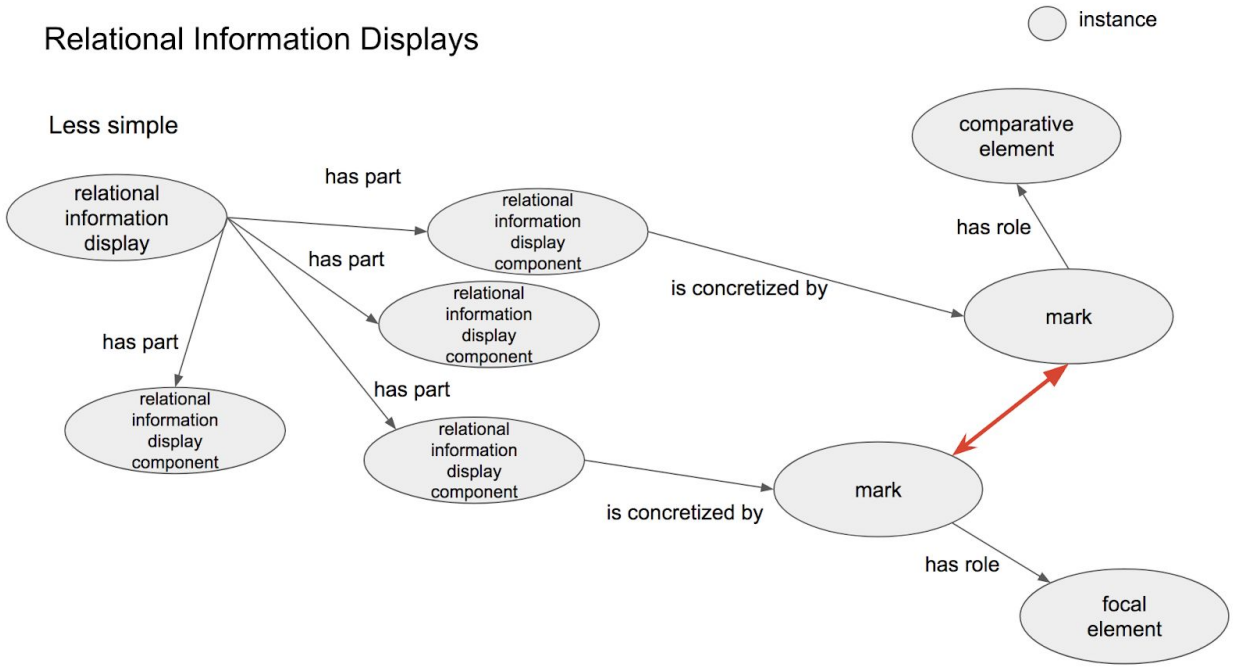
instance

Simple

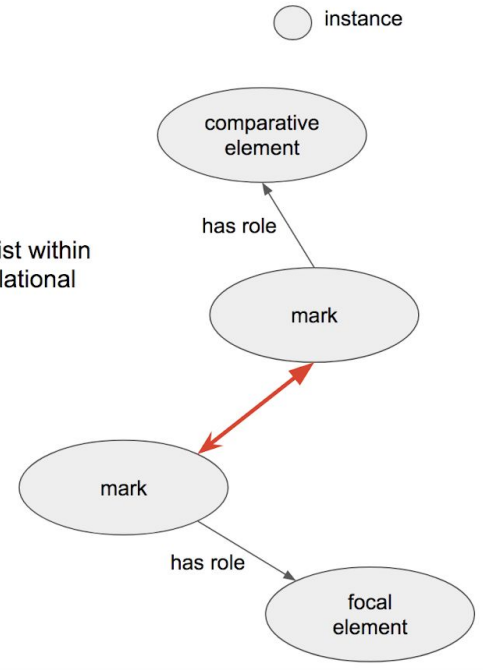


Relational information display: *"An information content entity that displays relations between dimensions in a concretized collection of display components."*

Relational Information Displays

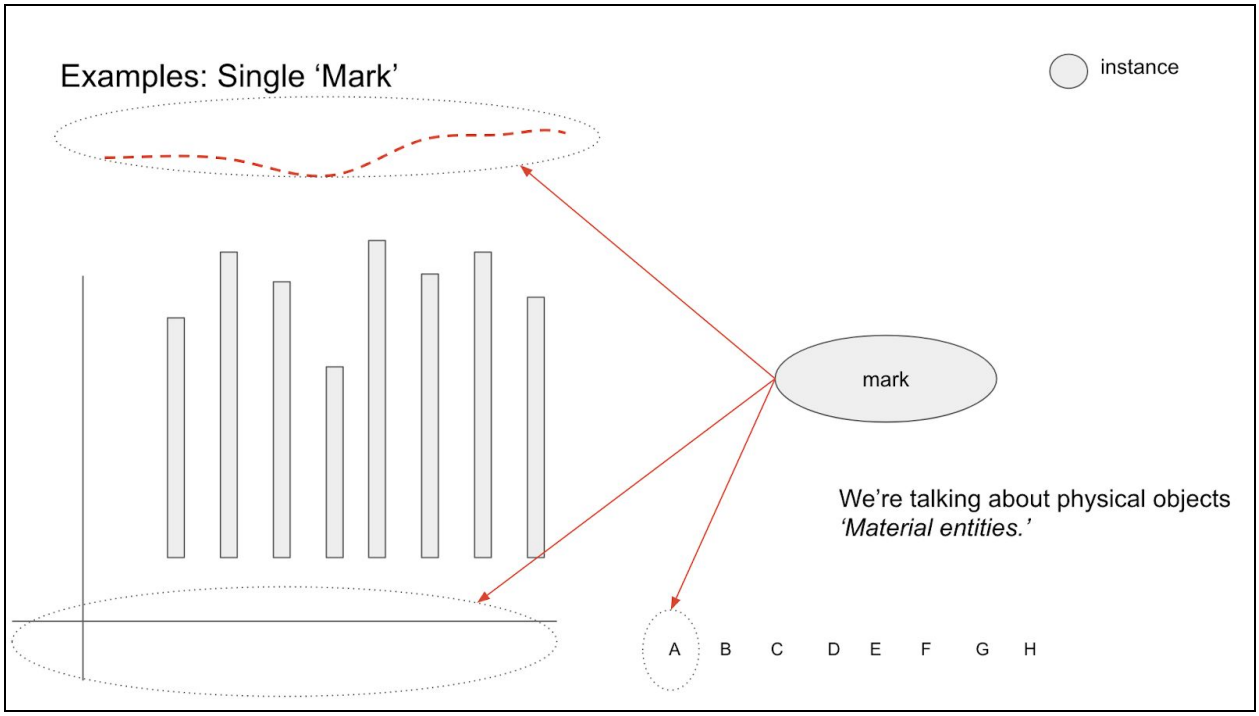


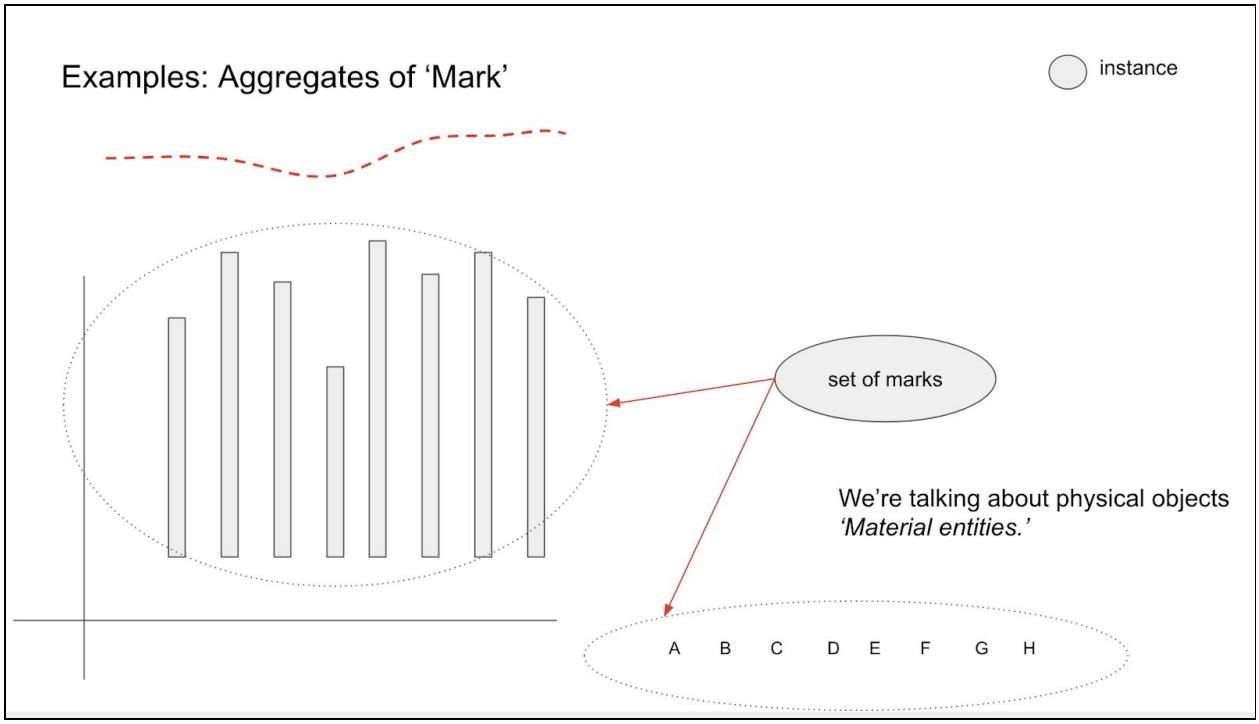
'Relations'



↔ is what Zhang calls a 'relation,' assuming the marks exist within some 'structure.' Here, we give the relation a name: 'relational quality.' In this case, it might be a 'performance gap.'

b is a relational quality = Def. for some independent continuants c, d and for some time t: b quality_of c at t & b quality_of d at t. (axiom label in BFO2 Reference: [057-001])





6. Selected References

1.

Amith M, He Z, Bian J, Lossio-Ventura JA, Tao C. Assessing the practice of biomedical ontology evaluation: Gaps and opportunities. Journal of Biomedical Informatics. 2018 Apr 1;80:1–13.

2.

Arp R, Smith B, Spear AD. Building Ontologies with Basic Formal Ontology. MIT Press; 2015. 245 p.

3.

Bandrowski A, Brush M, Grethe JS, Haendel MA, Kennedy DN, Hill S, et al. The Resource Identification Initiative: A cultural shift in publishing. F1000Res [Internet]. 2015 Nov 19 [cited 2018 Jul 12];4. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4648211/

4.

Bright TJ, Yoko Furuya E, Kuperman GJ, Cimino JJ, Bakken S. Development and evaluation of an ontology for guiding appropriate antibiotic prescribing. Journal of Biomedical Informatics. 2012 Feb 1;45(1):120–8.

5.

Brochhausen M, Spear AD, Cocos C, Weiler G, Martín L, Anguita A, et al. The ACGT Master Ontology and its applications – Towards an ontology-driven cancer research and management system. Journal of Biomedical Informatics. 2011 Feb 1;44(1):8–25.

6.

Conner WM. The dimension of a formal language. Information and Control. 1975 Sep 1;29(1):1–10.

7.

Franklin A, Gantela S, Shifarraw S, Johnson TR, Robinson DJ, King BR, et al. Dashboard visualizations: Supporting real-time throughput decision-making. Journal of Biomedical Informatics. 2017 Jul 1;71:211–21.

8.

Gomes PC e C, Moura AM de C, Cavalcanti MC. A multi-ontology approach to annotate scientific documents based on a modularization technique. Journal of Biomedical Informatics. 2015 Dec 1;58:208–19.

9.

Gurcan MN, Tomaszewski J, Overton JA, Doyle S, Ruttenberg A, Smith B. Developing the Quantitative Histopathology Image Ontology (QHIO): A case study using the hot spot detection problem. Journal of Biomedical Informatics. 2017 Feb 1;66:129–35.

10.

Heer J, Agrawala M. Software Design Patterns for Information Visualization. IEEE Transactions on Visualization and Computer Graphics. 2006 Sep;12(5):853–60.

11.

Hoxha J, Jiang G, Weng C. Automated learning of domain taxonomies from text using background knowledge. Journal of Biomedical Informatics. 2016 Oct 1;63:295–306.

12.

Huang H. Big data to knowledge – Harnessing semiotic relationships of data quality and skills in genome curation work. Journal of Information Science. 2018 Jan 11;0165551517748291.

13.

Karppinen P, Oinas-Kukkonen H, Alahäivälä T, Jokelainen T, Teeriniemi A-M, Salonurmi T, et al. Opportunities and challenges of behavior change support systems for enhancing habit formation: A qualitative study. Journal of Biomedical Informatics. 2018 Aug 1;84:82–92.

14.

Keet CM. Transforming semi-structured life science diagrams into meaningful domain ontologies with DiDOn. Journal of Biomedical Informatics. 2012 Jun 1;45(3):482–94.

15.

Larkin JH, Simon HA. Why a Diagram is (Sometimes) Worth Ten Thousand Words. Cognitive Science. 11(1):65–100.

16.

Munzner T. A Nested Model for Visualization Design and Validation. IEEE Transactions on Visualization and Computer Graphics. 2009 Nov;15(6):921–8.

17.

Munzner T. Visualization analysis and design. Boca Raton: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business; 2015. 404 p. (A.K. Peters visualization series).

18.

Neapolitan RE, Jiang X. Contemporary artificial intelligence. Second edition. Boca Raton, FL: CRC Press, Taylor & Francis Group; 2017. (Chapman & Hall/CRC artificial intelligence and robotics series ;v 2).

19.

Neururer SB, Lasierra N, Peiffer KP, Fensel D. Formalizing the Austrian Procedure Catalogue: A 4-step methodological analysis approach. Journal of Biomedical Informatics. 2016 Apr 1;60:1–13.

20.

Poli R, editor. Computer applications. Dordrecht: Springer; 2010. 576 p. (Theory and applications of ontology).

21.

Price R, Shanks G. A Semiotic Information Quality Framework: Development and Comparative Analysis. In: Enacting Research Methods in Information Systems [Internet]. Palgrave Macmillan, Cham; 2016 [cited 2018 Jul 20]. p. 219–50. Available from: https://link.springer.com/chapter/10.1007/978-3-319-29272-4_7

22.

Sen A, Sinha AP. An ontological model of the practice transformation process. Journal of Biomedical Informatics. 2016 Jun 1;61:298–318.

23.

Seppälä S, Ruttenberg A, Smith B. Guidelines for writing definitions in ontologies. 2017;16.

24.

Shneiderman B. The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. In: The Craft of Information Visualization [Internet]. San Francisco: Morgan Kaufmann; 2003 [cited 2018 Jun 25]. p. 364–71. (Interactive Technologies). Available from: https://www.sciencedirect.com/science/article/pii/B9781558609150500469

25.

Simon HA. On the Forms of Mental Representation. Minnesota Studies in the Philosophy of Science; Minneapolis. 1978 Jan 1;9:3.

26.

Sowa JF. Knowledge representation: logical, philosophical, and computational foundations. Pacific Grove: Brooks/Cole; 2000. 594 p.

27.

Spence R. Information visualization. New York: Springer; 2014.

28.

Tao C, Pathak J, Solbrig HR, Wei W-Q, Chute CG. Terminology representation guidelines for biomedical ontologies in the semantic web notations. Journal of Biomedical Informatics. 2013 Feb 1;46(1):128–38.

29.

Tory M, Moller T. Rethinking Visualization: A High-Level Taxonomy. In: IEEE Symposium on Information Visualization. 2004. p. 151–8.

30.

Ware C. Information Visualization: Perception for Design. Elsevier; 2012. 537 p.

31.

Zhang J. A representational analysis of relational information displays. International Journal of Human-Computer Studies. 1996 Jul 1;45(1):59–74.

32.

Zhang J. The Nature of External Representations in Problem Solving. Cognitive Science. 21(2):179–217.

33.

Zhang Y, Gou L, Zhou T, Lin D, Zheng J, Li Y, et al. An ontology-based approach to patient follow-up assessment for continuous and personalized chronic disease management. Journal of Biomedical Informatics. 2017 Aug 1;72:45–59.