PMD Ontology Series

Ontology Development Guide - Part 1: Domain Experts' Structured Knowledge Collection

Innovations-Plattform MaterialDigital

Die Plattform für die Digitalisierung der Materialien

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

Ein Verbundprojekt von: Fraunhofer IWM, KIT Karlsruher Institut für Technologie, Max-Planck-Institut für Eisenforschung, BAM Bundesanstalt für Materialforschung und -prüfung, IWT Leibniz-Institut für Werkstofforientierte Technologien

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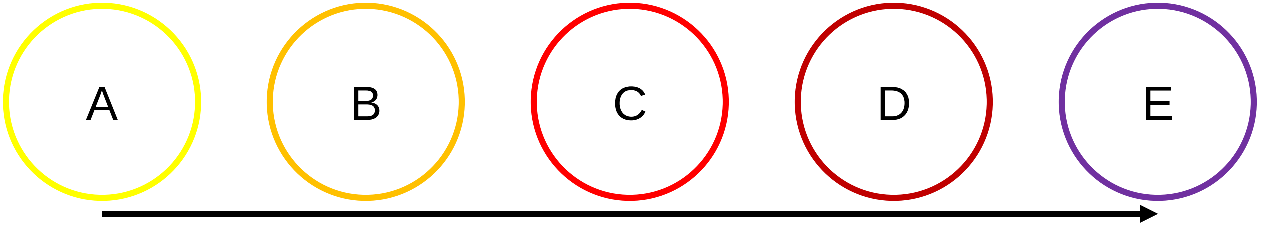
1. Visualization and sketching

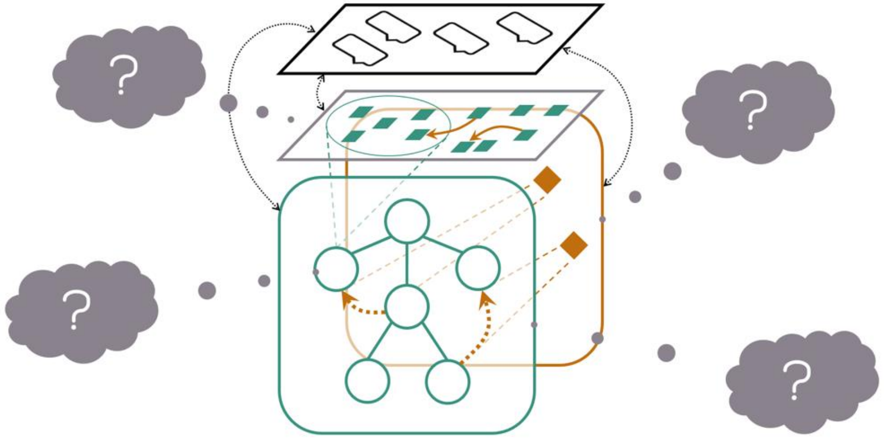
- Get an overview by visualizing your process chain to be represented:
  - The methods, machines, recipes involved, …

- Use creative tools to facilitate your work:
  - Pen and paper
  - Mind map
  - Powerpoint
  - Kanban



2. Questioning the purpose

- What do I want to represent in the end?
- What demands do I have on my ontology?
- Is it only about data management and data searching strategies via SPARQL?
- Competency questions?
- Should knowledge also be represented/extracted?



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3. Information extraction

Sources of information:

- Standards
- Manuals
- Scientific literature
- Existing ontologies
- Interviews of domain experts

Collect all relevant information sources

4. Identify common vocabulary

Identify and select information relevant to your domain:

- Standards
  - Is this always used for your process?
- Manuals
  - Are there some missing terms that are common knowledge?
  - Is it also understandable for non-expert persons?
- Scientific literature
  - Where is it not useful for your case anymore? – Maybe to many details?
- Existing ontologies (Re-use) (Link: e.g., MatPortal, PMD-co, PMD-ao)
  - What could be reused?
  - Where are vocabularies missing?
- Interviews of domain experts, e.g., technicians, engineers, scientists

Identify the relevant vocabularies …

5. Agreement about meaning

Define rough meaning / definition of terms:

- Are the vocabularies' meaning of the different sources fitting together?
  - Used in a different context – different meaning?

- Some examples – the meaning is important!:
  - grain size ≠ grain size
    - can be measured differently (different 2D methods / 3D methods)
    - is different for different material classes (polymer vs. glass or metals)

  - ...there are many more examples in MSE where meaning is not unique

Agree on meanings of the vocabularies …

6. Hierarchically ordered collection

Structuring / Categorization:

- Get the vocabularies connected
  - Classes and subclasses
  - Connections between concepts
- Best practice suggestion: Be visual!
  - Use mind-maps (paper or digital tools)
  - Make yourself familiar with the different possible connections
  - Use discussions to check your order

Structure the vocabularies …

7. Structured formalized knowledge

- Provide a document with structured knowledge – vocabularies with e.g.:
  - **Definition**
  - Denotation / commonly used symbols
  - **Relation to other vocabularies**
  - Additional information, e.g., notes for a better understanding of the meaning
  - Unit(s): commonly agreed ones
  - Formulas
  - Source (of knowledge / definition): links are desired if available

- Best practice suggestion:
  - Start with some easy terms and check out the following examples
  - Use the tables where you agreed on the meanings AND the visualization for writing

Write a first draft of your structured knowledge collection…

8. Examples

- PMD-ao: Tensile Test Application Ontology
- PMD-co: (Mid-Level) Ontology
- Additional Information

Tensile Test ontology

Underlined font: underlined terms are defined within the respective, regarded section

Original Gauge Length (mm) : length between *gauge length* marks on the *test piece* measured at room *temperature* before the test : denotation L_{o} : is a *metadata* : has object characteristics : Note: Choice of the original gauge length For proportional *test pieces*, if the *original gauge length* is not equivalent to $5.65 \sqrt{S_{o}}$, where S_{o} is the original cross-sectional area of the *parallel length*, the symbol A should be supplemented by a subscript indicating the coefficient of proportionality used, e.g. $A_{11.3}$ indicates a *percentage elongation* of the *gauge length*, L_{o}, according to: : $L_{o} = 11.3 \sqrt{S_{o}}$ (L_o=11.3 √(S_o)) : Note: equation: $5.65 \sqrt{S_{o}} = 5 \sqrt{\frac{4 S_{o}}{\pi}}$. : Note: For non-proportional *test pieces*, the symbol A should be supplemented by a subscript indicating the *original gauge length* used, expressed in millimetres, e.g. $A_{80 mm}$ indicates a *percentage elongation* of a *gauge length*, L_{o}, of 80 mm. : Source: DIN EN ISO 6892-1 in chapter 3.1.1

PMD-ao: Tensile Test Application Ontology

Tensile Test ontology

> *Italic font*: terms given in italic represent terms that are defined within the thesaurus as well

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MATERIALD1G1TAL

Tensile Test ontology

unit(s)

definition

classification / relation with respect to higher / other level ontological aspects

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denotation / symbol

formula

notes / human readable additional information (closely connected to definition)

source (of knowledge / definition) ; links are desired if available

PMD-ao: Tensile Test Application Ontology

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Yield Strength (MPa) : is *output* of *tensile test* : is equivalent to *yield stress* : when the metallic material exhibits a *yield* phenomenon, *stress* corresponding to the point reached during the *tensile test* at which plastic deformation occurs without any increase in the force which is typically marked by the end of the first straight line in the stress-strain curve : is *secondary data* : has object characteristics : Source: DIN EN ISO 6892-1 in chapter 3.10.2

classification / relation with respect to higher / other level ontological aspects

formula

unit(s)

Modulus Of Elasticity (GPa) : quotient of change of *stress* δR and change of percentage *extension* δe in the range of evaluation, multiplied by 100 % : is *secondary data* : has object characteristics for *material property* of *modulus of elasticity* : is *output* of *tensile test* : synonyms: *Young's modulus*, *elastic modulus* : equation: $E = \frac{\delta R}{\delta e} * 100%$ (E=ΔR/Δe·100%) : denotation E : Note: It is recommended to report the value in GPa rounded to the nearest 0.1 GPa and according to ISO 80000-1. : Source: DIN EN ISO 6892-1 in chapter 3.13

notes / human readable additional information (closely connected to definition)

source (of knowledge / definition) ; links are desired if available

MATERIALD1G1TAL

Processes

definition

Process: A series of actions or operations conducing to an end : In PMD, a *process* is conducted via *process nodes* and has a discernable duration as part of a *workflow*. *A* process *consumes* objects *and* parameters*.* A *process* potentially generates new *objects* and *measurements*. A *process* is either a *transformative process* or a *non-transformative process* with respect to *objects* processed via a *process node*. There are primarily two types of distinguishable *processes*: *manufacture process, analysis process*. A *process* is a series of operations that are linked subordinate *processes*.

Cutting: A *manufacture process* of extracting the final *test piece* according to the *nominal test piece geometry* from the *object* : Machining process in which a moving cutting tool is inserted into the *object* using a distinct *cutting speed* to extract a *test piece*. *: subprocess to test piece preparation of tensile test and metallography.*

classification / relation with respect to higher / other level ontological aspects

MATERIALD1G1TAL

Process Nodes

definition

Process Node: A constituent that consumes and creates the *objects* in a *process*. The enabler of *manufacture process* steps, *analysis process* steps or *simulation process* steps. : A *process node* realizes *transformative processes* and/or *non-transformative processes*.

Process Node Characteristics: A sufficiently detailed description of a *process node* : *Process node characteristics* include *information* about: name, age, vendor, type, model, specifications, etc. *At the time of an* object *passing through a* process *the* process node characteristics *define the* system condition *as* context parameters.

Oven Manufacturer: The manufacturer of the *oven* used for the *heat treatment*.

classification / relation with respect to higher / other level ontological aspects

Material properties

definition

denotation / symbol

formula

<u>Shear Modulus:</u> Ratio of *shear stress* to the shear strain : Denotation: G : Equation $\displaystyle G\ {\stackrel {\mathrm {def} }{=}}\ {\frac {\tau_{xy}}{\gamma_{xy}}}$: $\tau_{xy} =$ *shear stress* : $\gamma_{xy} =$ *shear strain* : is a *material property* at the *continuum level* : is influenced by *shear stress, shear strain* : has unit Pa :
Source: https://www.wikidata.org/wiki/Q461466

source (of knowledge / definition) ;
links are desired if available

classification / relation with respect to higher / other level ontological aspects

unit(s)

notes / human readable additional information (closely connected to definition)

Additional Information

Some common rules:

Language: US English

Definition:
Denotation / symbol: Common used ones – if more than one also provide others
Classification / relation with respect to higher / other level ontological aspects:
Notes / human readable additional information (closely connected to definition)
Unit(s): Common used ones – in PMD we link to units that are available in Wikidata
Formula: LaTeX interpretable format
Source (of knowledge / definition): links are desired if available

THANK YOU

More information
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