Laboratory for Applied Ontology

Institute of Cognitive Science and Technology
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Ontological Analysis

5 - OntoClean

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Defining unity

- A tentative formulation: *x* ***is a whole*** under a unifying relation U iff U is an *equivalence relation* that binds together all the parts of *x*, such that, ***necessarily***,

$$P(y,x) \rightarrow (P(z,x) \leftrightarrow U(y,z))$$

but not

$$U(y,z) \leftrightarrow \exists x(P(y,x) \wedge P(z,x))$$

- P is the ***part-of*** relation
- U can be seen as a ***generalized indirect connection***

Unity Refined

$\delta_U(x) =_{df} U(x, x)$ (*x belongs to the domain of U*)

$\mathsf{U}_U(x) =_{df} \Sigma_{\delta_U}(x) \wedge \forall y,z((\delta_U(y) \wedge \delta_U(z) \wedge P(y, x) \wedge P(z, x)) \rightarrow U(y, z))$

(*x is unified by U*)

$\mathsf{W}_U(x) =_{df} Max_{\mathsf{U}_U}(x)$ (*x is a whole under U*)

$\Sigma_\phi(x) =_{df} \forall y(P(y, x) \rightarrow \exists z(\phi(z) \wedge P(z, x) \wedge O(z, y)))$ (*sum of* ϕ*s*)

Kinds of Whole

- Depending on the **nature of the *unifying relation***, we can distinguish:
  - ***Topological wholes*** (a piece of coal, a heap of coal)
  - ***Morphological wholes*** (a constellation)
  - ***Functional wholes*** (a hammer, a bikini)
  - ***Social wholes*** (a population)

* a whole can have ***parts that are themselves wholes*** (with a different unifying relation)

Unity and Plurality

- *Ordinary objects:* ***wholes or sums of wholes***
  - *Singular*: ***no wholes as proper parts***
  - *Plural*: ***sums of wholes***
    - *Plural wholes* (the sum is ***also a whole***)
    - *Collections* (the sum is not a whole)

Unity Disjointness Constraint

Classes with incompatible UCs are ***disjoint***

Example: Object and Matter

Identity criteria

- *Classic formulation:*

$$\phi(x) \wedge \phi(y) \rightarrow (\rho(x,y) \leftrightarrow x = y)$$

(ϕ carries the identity criterion ρ)

- *Generalization:*

$$\phi(x,t) \wedge \phi(y,t') \rightarrow (\Gamma(x,y,t,t') \leftrightarrow x = y)$$

(synchronic: $t = t'$; diachronic: $t \neq t'$)

- In most cases, Γ is based on the ***sameness*** of certain ***characteristic features***:

$$\Gamma(x,y,t,t') = \forall z\,(\chi(x,z,t) \wedge \chi(y,z,t'))$$

- **Non-triviality condition:**
  - $\Gamma(x,y,t,t')$ must not contain an identity statement between x and y!

Carrying vs. Supplying Identity

- ***Supplying*** (global) identity (**+O**)
  - Carrying an IC (or relevant essential property) that doesn't hold for *all* directly subsuming properties
- ***Carrying*** identity (**+I**)
  - Not supplying identity, while being subsumed by a property that does.
- ***Common sortal principle***: x=y -> there is a common sortal supplying their identity

- Theorem: only rigid properties supply identity

Heuristics for Identity

- Finding necessary *and* sufficient ICs for a given property may be ***very hard***.

- Heuristic 1: ***at least a sufficient IC***.
- Heuristic 2: ***some essential parts or qualities***
- Heuristic 3: ***some essential (non-rigid) properties***

Sortals and other properties

- **Sortals** (*horse, triangle, amount of matter, person, student...)*
  - Carry (non-trivial) identity conditions
  - Usually correspond to ***nouns***
  - High organizational utility
- **Non-sortals** *(red, big, old, decomposable, dependent...)*
  - No identity
  - Usually correspond to ***adjectives***
  - Span across different sortals
  - Limited organizational utility (but high semantic value)

Identity Disjointness Constraint

ICs impose ***constraints*** on sortals, making their ontological nature explicit:

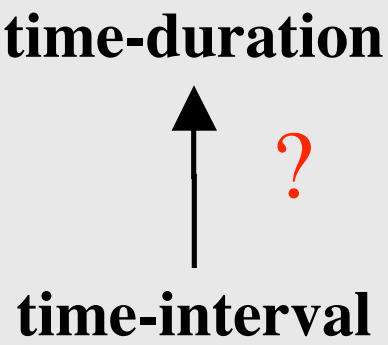
> Properties with incompatible ICs are ***disjoint***

Examples:

- sets vs. ordered sets
- persons and passengers
- amounts of matter vs. assemblies

Example - Identity

- Is *time-interval* a subclass of *time-duration*?
  - Initial answer: yes
- IC for *time-duration*
  - Same-length
- IC for *time-interval*
  - Same start & end



Why bother with this?

- ***Formal ontological analysis*** requires analyzing all properties according to their meta-properties – This is a ***lot*** of work!
- Why perform this analysis?
  - Makes ***modeling assumptions*** clear, which:
    - Helps resolving known conflicts
    - Helps recognizing unkown conflicts
  - Imposes ***constraints*** on standard modeling primitives (*generalization, aggregation, association*)
  - Elicits ***natural distinctions***
  - …results in more ***reusable ontologies***

Taxonomic Constraints

- $+R \not\subset \sim R$
- $-I \not\subset +I$
- $-U \not\subset +U$
- $+U \not\subset \sim U$

- Incompatible IC's are disjoint
- Incompatible UC's are disjoint

Resolving Ontological Conflicts

- Two well-known linguistic ontologies define:
  - ***Physical Object is-a Amount of Matter*** (WordNet)
  - ***Amount of Matter is-a Physical Object*** (Pangloss)

- Amount of Matter
  - unstructured /scattered “stuff”
  - Identity: mereologically extensional
  - Unity: intrinsically none (anti-unity)

- Physical Object
  - Isolated material body
  - Identity - three options:
    - None
    - Non-extensional
    - Extensional
  - Unity: Topological

Conclusion: the two concepts are ***disjoint***. Physical objects are ***constituted*** by amounts of matter