

Ontology integration and non-monotonic reasoning

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Interoperability of Biomedical Ontologies, 2007

Bio-Ontology Research Group Leipzig



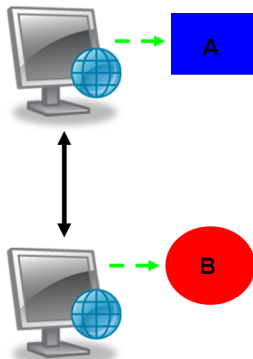
- ▶ Application of formal ontological methods
- ▶ General Formal Ontology (GFO)
- ▶ Bioinformatics applications



Interoperability

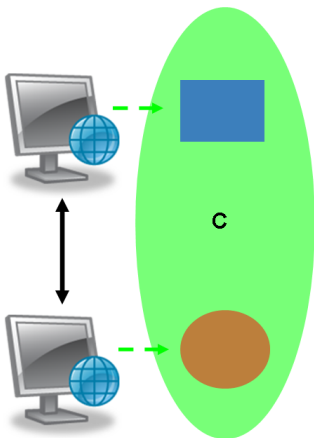
Interoperability: “the ability of two or more systems or components to exchange information and to use the information that has been exchanged” [IEEE, 1990]

Interoperability



Inter-operability and Integration

Interoperability



FMA: canonical anatomy

Foundational Model of Anatomy:

Body has-part Appendix (1)

Appendix part-of Body (2)

- ▶ Consequence of frame-representation
- ▶ (1) and (2) are not inverse

OBO anatomy: the mouse example

Tail part-of Mouse (3)

Mouse has-part Tail (4)

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- ▶ But *people* may derive (4) from (3).

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- ▶ (3) is included in MA, (4) is not.
- ▶ Formally, MA contains *no* constraints about “Mouse”.
- ▶ But *people* may derive (4) from (3).
- ▶ *Normally*, (4) is true.

Pathology ontologies

What do tail-less mice instantiate?

- ▶ adult mouse [MA:0002405]



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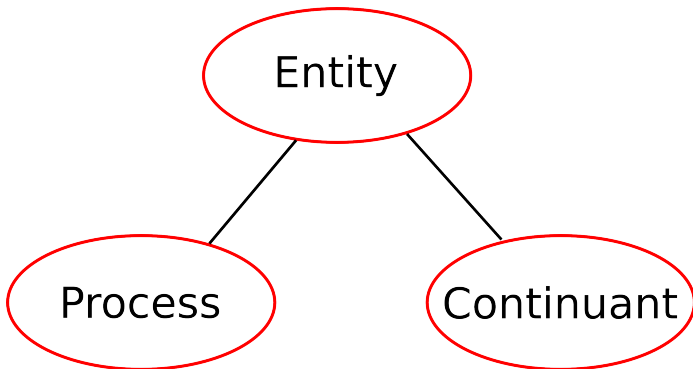
- ▶ Inclusion of *Mouse has-part Tail* in MA would lead to inconsistency (with “absent tail”).



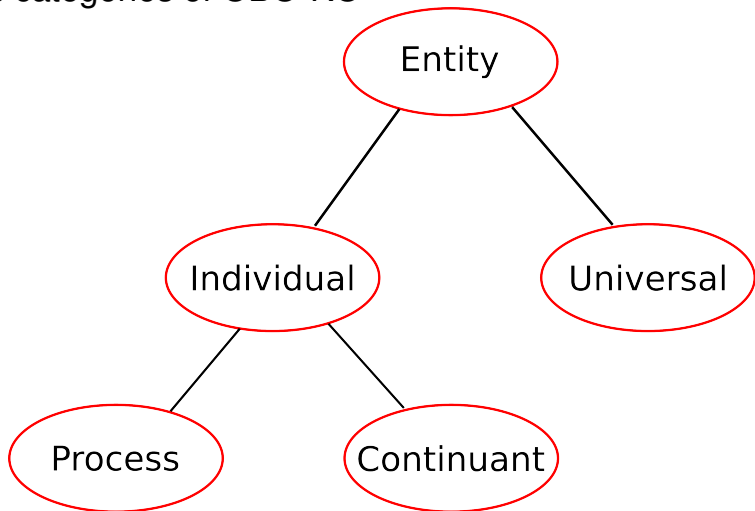
Integration

- ▶ Problem: integrate canonical and pathology ontologies
- ▶ avoid inconsistencies
- ▶ preserve intuition (mice have tails)
- ▶ re-use current implementations

Basic categories of OBO-RO



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Classes of relations

Types of relations

- ▶ Individual–Individual: *part-of, develops-from*
- ▶ Universal–Universal: *part-of, develops-from*
- ▶ Individual–Universal: *instance-of, lacks, part-of*

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Definition

Individual p **lacks** universal U with respect to relation \mathbf{R} if and only if there is not an x such that: $p\mathbf{R}x$ and x is an instance of U . [Ceusters et al., 2006]



lacks in DL

- ▶ Define: $Mouse \sqcap Absent_Tail(jerry)$



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- ▶ $Mouse \sqcap \neg \exists hasPart. Tail(jerry)$
- ▶ $Mouse \sqcap \exists lacksHasPart. \{ Tail \}(jerry);$
- ▶ $instanceOf(jerry, Mouse), lacksHasPart(jerry, Tail), Individual(jerry), Universal(Mouse), Universal(Tail)$

Defaults

- ▶ Goal: $Mouse \sqsubseteq \exists hasPart.Tail$ as true by default
- ▶ treat $lacksHasPart(x, Tail)$ as exception

We introduce *normally-R* as a universal–universal relation:

Definition

U_1 normally- R $U_2 \Rightarrow$ for all $x: x :: U_1$ and **it is consistent to assume that** there exists a $y: y :: U_2$ such that $R(x, y)$, then there exists a $y: y :: U_2$ such that $R(x, y)$.

Formalizing defaults

- ▶ Circumscription (Ab): $Mouse \sqcap \neg Ab \sqsubseteq \exists hasPart.Tail$
- ▶ Autoepistemic logic (ALCK):
 $Mouse \sqcap \neg K \neg \exists hasPart.Tail \sqsubseteq \exists hasPart.Tail$
- ▶ Default logic: $\frac{Mouse(x) : \exists y (y :: Tail \wedge hasPart(x,y))}{\exists y (y :: Tail \wedge hasPart(x,y))}$

Implementation using HEX-programs

New individual–universal relation:

$$IU-R(p,U) \iff \exists x(x :: U \wedge R(p,x)).$$

```
IU-R(X,Y) :- ind(X), universal(Y), inst(X,Z),
normally-R(Z,Y), not lacks-R(X,Y), universal(Z).
lacks-R(X,Y) :- ind(X), universal(Y), - IU-R(X,Y).
```

Proposed additions

For each relationship R between individuals, eight relations can be defined:

- ▶ $II-R$
- ▶ $UU-R$
- ▶ $IU-R$
- ▶ $II-lacks-R$
- ▶ $UU-lacks-R$
- ▶ $IU-lacks-R$

Relations between universals can be declared “default”:
 $UU-normally-R$ and $UU-normally-lacks-R$, and axioms generated.

Proposed additions 2

- ▶ Separate default and non-default relations within canonical ontologies (e.g. the FMA).
- ▶ Include defaults in anatomical ontologies (e.g. MA).
- ▶ Include a *Universal*-concept in upper ontologies
- ▶ Analyze “absent-*X*” concepts using *lacks* (cf. Ceusters et al.)

Conclusion

- ▶ Integration of biomedical ontologies requires non-monotonic logic
- ▶ Re-interpretation of *canonical* ontologies required
- ▶ Upper ontologies must provide the possibility for *default* reasoning if they are to be successful in integrating ontologies
- ▶ Implemented in GFO-Bio

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Thank you

Thank you!

Discussion

- ▶ Is there an implied inverse to “Tail part-of Mouse”? What is it?
- ▶ Should defaults be represented in ontologies? Or somewhere else? And what about the FMA?