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An Ontological Analysis of Reference in Health Record Statements

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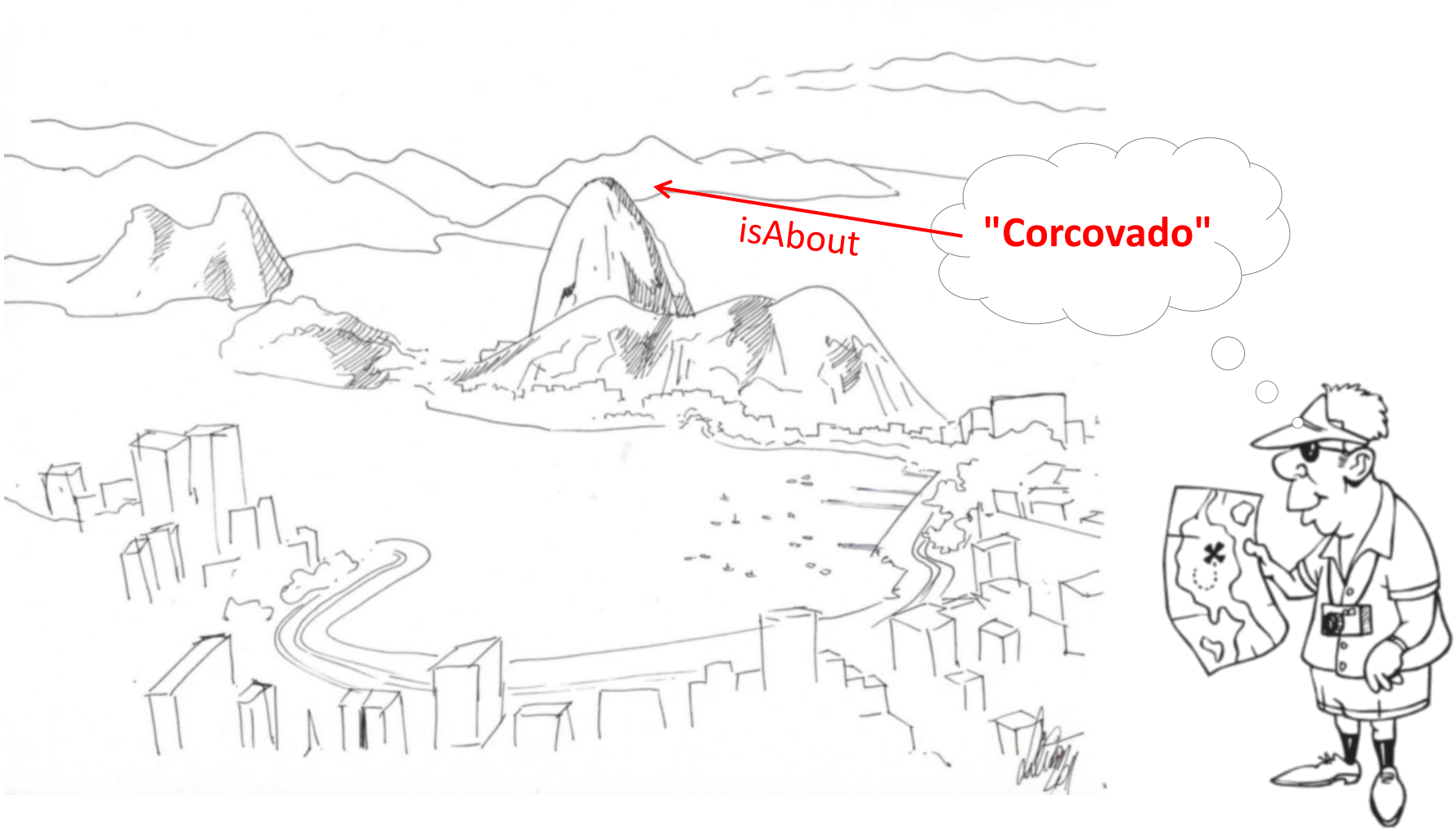
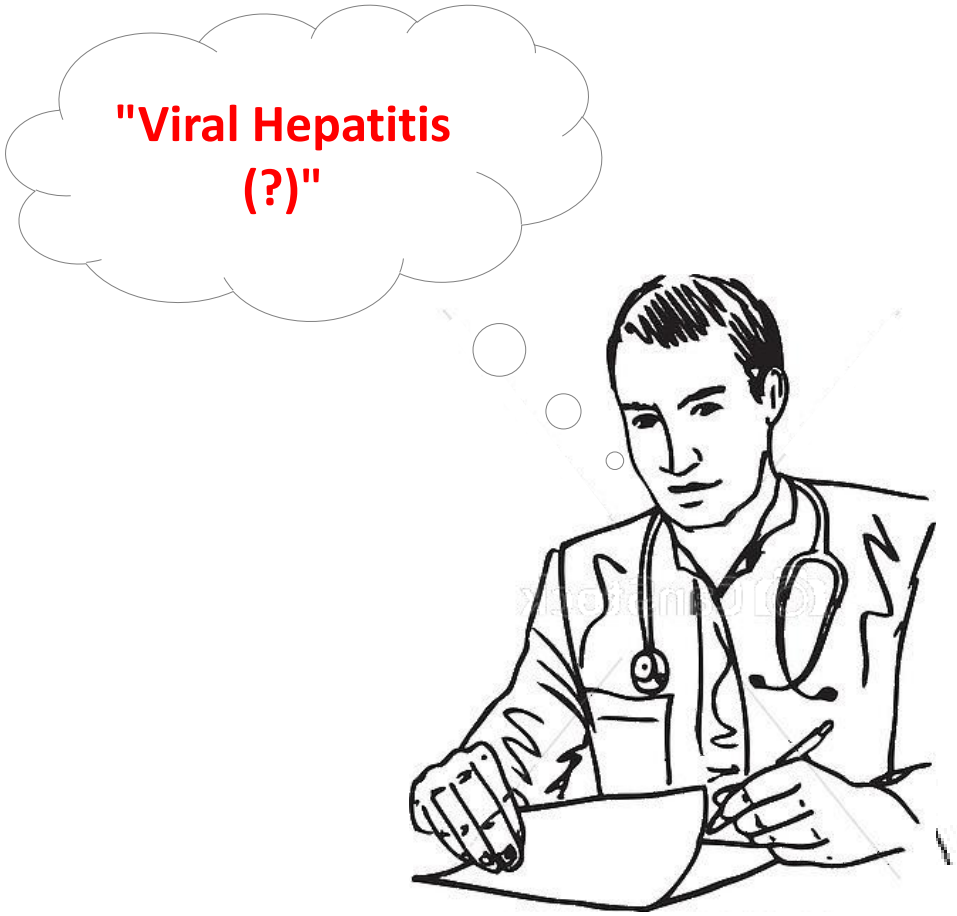
Correct reference?



Correct reference?

Alcoholic Hepatitis



"patient with **possible viral hepatitis**"
(has alcoholic hepatitis)

"patient scheduled for **heart transplant**"
(dies before operation)

"**planned pregnancy**"
(unfortunately never gets pregnant)

"omeprazol given to prevent **gastric ulcer**"
(works, therefore patient won't get an ulcer)

"patient **drinks socially**"
(in fact a heavy drinker)

"patient reports **severe back pain**"
(patient simulates)

"patient denied **hemodialysis**"
(survives without hemodialysis)

"father **died from myocardial infarction**"
(died from ruptured aneurysm, son did not remember)

Non-referring expressions in health records

Adjectival modifiers in diagnostic statements

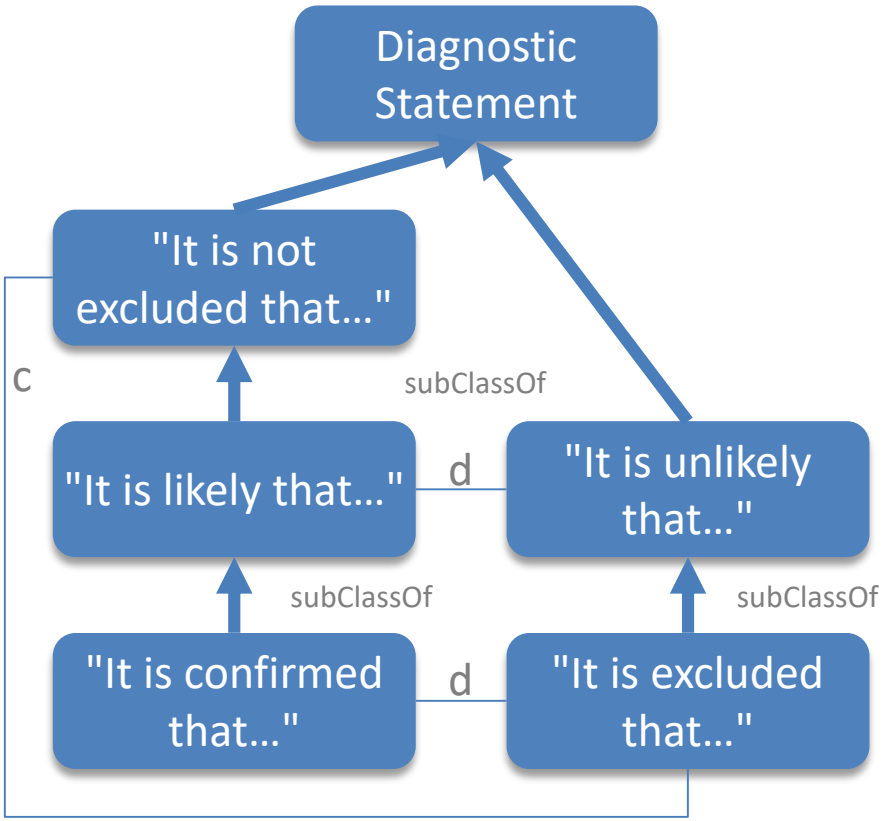
- "It is unlikely that the patient has hepatitis B"
- "It is confirmed that the patient has hepatitis B"
- "It is excluded that the patient has hepatitis B"

Goal

- Develop appropriate OWL-DL patterns that allow for expressing reference with different (qualitative) gradings of certainty
- Create a gold standard of examples of commonly agreed plausible inferences
- Validate the ontology patterns by comparing machine inferences to gold standard using DL reasoner (HermiT)

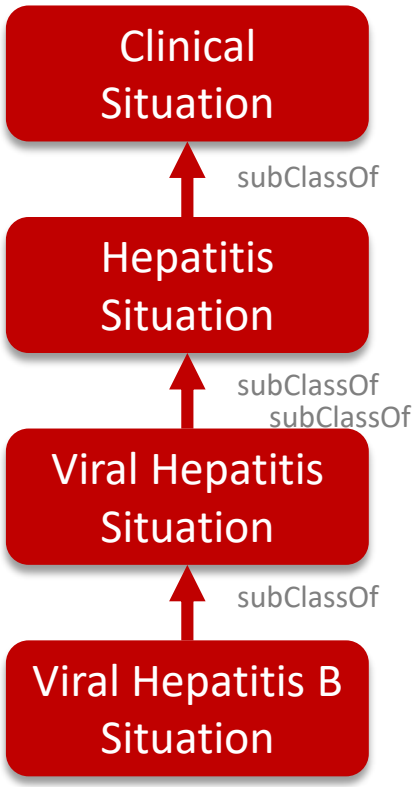
Example

Diagnostic statement: “The diagnosis of the condition X is confirmed / likely / not excluded / unlikely / excluded.”



duality (d) , complement (c)

is about situation



situation X ≡ episode with X

Plausible inferences

		Being said to have hepatitis (H) / viral hepatitis (vH) / viral hepatitis B (vHB) is…														
Precondition:		confirmed			likely			not excluded			unlikely			excluded		
Entailment:		H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB
confirmed	H	x	x	x												
	vH		x	x												
	vHB			x												
likely	H	x	x	x	x	x	x									
	vH		x	x		x	x									
	vHB			x			x									
not excluded	H	x	x	x	x	x	x	x	x	x						
	vH		x	x		x	x		x	x						
	vHB			x			x			x						
unlikely	H										x			x		
	vH										x	x		x	x	
	vHB										x	x	x	x	x	x
excluded	H													x		
	vH													x	x	
	vHB													x	x	x

Five OWL patterns

- *"Existential"* (using OWL existential restrictions)
- *"Universal"* (using OWL universal restrictions)
- *"Punning"* (using the same OWL entities as classes and individuals)
- *"Two-Level"* (introducing universals as A-Box inhabitants)
- *"Query"* (expressing reference as SPARQL queries on OWL models)

Five OWL patterns

- *"Existential"* (using OWL existential restrictions)
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OWL pattern "Existential"

BeingSaidToHaveXisConfirmed equivalentTo
DiagnosticStatement and (**hasCertainty** only *isConfirmed*)
and (**isAboutSituation** some *Xsituation*)

BeingSaidToHaveXisLikely equivalentTo
DiagnosticStatement and (**hasCertainty** only *isLikely*)
and (**isAboutSituation** some *Xsituation*)

BeingSaidToHaveXisNotExcluded equivalentTo
DiagnosticStatement and (**hasCertainty** only *IsNotExcluded*)
and (**isAboutSituation** some *Xsituation*)

BeingSaidToHaveXisUnlikely equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isLikely*) and
(**isAboutSituation** some (*ClinicalSituation* and not *Xsituation*))

BeingSaidToHaveXisExcluded equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isConfirmed*) and
(**isAboutSituation** some (*ClinicalSituation* and not *Xsituation*))

Entailments of "Existential"

		Being said to have hepatitis (H) / viral hepatitis (vH) / viral hepatitis B (vHB) is…														
Precondition:		confirmed			likely			not excluded			unlikely			excluded		
Entailment:		H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB
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	vH		x	x												
	vHB			x												
likely	H	x	x	x	x	x	x									
	vH		x	x		x	x									
	vHB			x			x									
not excluded	H	x	x	x	x	x	x	x	x	x						
	vH		x	x		x	x		x	x						
	vHB			x			x			x						
unlikely	H										x			x		
	vH										x	x		x	x	
	vHB										x	x	x	x	x	x
excluded	H													x		
	vH													x	x	
	vHB													x	x	x

Problem with "Existential" pattern

- Existential import: for each statement about X there is
  - some instance of *XSituation* , or
  - some instance of '*Clinical Situation* and not *XSituation*'
- Conflicting statements would produce logical contradictions
- Solution: universal quantifier ("only") instead of existential quantifier ("some")
- "**isAboutSituation** only *SituationX"* → in case there a reference exists, then it is of the type *SituationX*

OWL pattern "Universal"

BeingSaidToHaveXisConfirmed equivalentTo
DiagnosticStatement and (**hasCertainty** only *isConfirmed*)
and (**isAboutSituation** only *Xsituation*)

BeingSaidToHaveXisLikely equivalentTo
DiagnosticStatement and (**hasCertainty** only *isLikely*)
and (**isAboutSituation** only *Xsituation*)

BeingSaidToHaveXisNotExcluded equivalentTo
DiagnosticStatement and (**hasCertainty** only *IsNotExcluded*)
and (**isAboutSituation** only *Xsituation*)

BeingSaidToHaveXisUnlikely equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isLikely*) and
(**isAboutSituation** only (*ClinicalSituation* and not *Xsituation*))

BeingSaidToHaveXisExcluded equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isConfirmed*) and
(**isAboutSituation** only (*ClinicalSituation* and not *Xsituation*))

Entailments of "Universal"

		Being said to have hepatitis (H) / viral hepatitis (vH) / viral hepatitis B (vHB) is…														
Precondition:		confirmed			likely			not excluded			unlikely			excluded		
Entailment:		H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB
confirmed	H	x	x	x												
	vH		x	x												
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	vH		x	x		x	x									
	vHB			x			x									
not excluded	H	x	x	x	x	x	x	x	x	x						
	vH		x	x		x	x		x	x						
	vHB			x			x			x						
unlikely	H										x			x		
	vH										x	x		x	x	
	vHB										x	x	x	x	x	x
excluded	H													x		
	vH													x	x	
	vHB													x	x	x

Problem with "Universal" pattern

"**isAboutSituation** only *SituationX*" ≡
not (**isAboutSituation** some (not *SituationX*)

- contradicts ground axiom of IAO
- Known issues with this kind of statements in DL → unexpected entailments (probably not relevant here (due to strict range restriction of the **isAboutSituation** relation), but doubts persist
- Expression is still "about" something, viz. the type SituationXType

OWL pattern "Two level"

Type subClassOf *owl:Thing*

Particular subClassOf *owl:Thing*

Type subClassOf **hasInstance** some *Particular*

X EquivalentTo **isInstanceOf** value **x_Type**

x_Type type Type and **hasInstance** only X

X subclassOf **isInstanceOf** value **x_Type**

every member of the class *X* is an instance of the type **x_Type**. The type **x_Type** has only instances that are members of the class *X*

isAboutSituation o **isSubtypeOf** subPropertyOf **isAboutSituation**

OWL pattern "Two Level"

BeingSaidToHaveXisConfirmed equivalentTo
DiagnosticStatement and (**hasCertainty** only *isConfirmed*)
and (**isAboutSituation** value *XsituationType*)

BeingSaidToHaveXisLikely equivalentTo
DiagnosticStatement and (**hasCertainty** only *isLikely*)
and (**isAboutSituation** value *XsituationType*)

BeingSaidToHaveXisNotExcluded equivalentTo
DiagnosticStatement and (**hasCertainty** only *IsNotExcluded*)
and (**isAboutSituation** value *XsituationType*)

BeingSaidToHaveXisUnlikely equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isUnlikely*) and
(**isAboutSituation** value *XsituationType*)

BeingSaidToHaveXisExcluded equivalentTo
DiagnosticStatement and
(**hasCertainty** only *isExcluded*) and
(**isAboutSituation** value *XsituationType*)

Entailments of "Two Level"

		Being said to have hepatitis (H) / viral hepatitis (vH) / viral hepatitis B (vHB) is…														
Precondition:		confirmed			likely			not excluded			unlikely			excluded		
Entailment:		H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB	H	vH	vHB
confirmed	H	x	x	x												
	vH		x	x												
	vHB			x												
likely	H	x	x	x	x	x	x									
	vH		x	x		x	x									
	vHB			x			x									
not excluded	H	x	x	x	x	x	x	x	x	x						
	vH		x	x		x	x		x	x						
	vHB			x			x			x						
unlikely	H										x	x	x	x	x	x
	vH											x	x		x	x
	vHB												x			x
excluded	H													x	x	x
	vH														x	x
	vHB															x

Problem with "Two Level" pattern

- No inversions with negative statements
- The sentence "Hepatitis B excluded" is still a statement about the type Hepatitis, whereas it does not claim the existence of an instance of the type hepatitis
- Possible solution: combine "Universal" with "Two Level", but removing the axiom

isAboutSituation o **isSubtypeOf** subPropertyOf **isAboutSituation**

- Is there any practical usefulness of maintaining parallel, isomorphic hierarchies of OWL classes in the T-box and OWL types in the A-box ?

Open issues / Outlook

- Related work from philosophy, e.g. dummy entities like "subfactuals" (Meinong)
- Relax assumptions of ontological realism
- Relation to alternative approaches of representing the content of health records, e.g. Referent tracking (Ceusters)
- Relation to other logics (higher-order, modal logics)
- Relation to models of probability
- Empirical assessment of computational behaviour (theoretically, OWL DL is NExpTime-complete)

Thank you

Download sample ontologies from https://biotop.googlecode.com/svn/trunk/apps/FOIS2014/