

The collage consists of four overlapping screenshots:

- Top Left:** A grid of many small, pixelated images of human faces, creating a mosaic effect.
- Top Right:** A video player interface showing a presentation slide with the title "BIAS IN AI" in large, bold, black letters on a white background.
- Bottom Left:** A screenshot of a Forbes article titled "AI Bias Could Put Women's Lives At Risk - A Challenge For Regulators" by Carmen Nijthammer. The article is dated March 2, 2021.
- Bottom Right:** A video player interface showing a presentation slide with the title "This is the whole story?" in yellow text on a dark background.

MUSHROOMING OF "AI ETHICS INITIATIVES" ³

MUSHROOMING OF "AI ETHICS INITIATIVES" 4

WE Custom Live Streaming Service Recording

AI Ethics in practice

Research

- Fairness
- Explainability
- Interpretability
- Robustness
- Privacy
- Value alignment

AI companies

- Governance
- Internal processes
- Tools
- Risk assessment
- Training

Standard bodies

- IEEE P7000 series)
 - IEEE P7000-2021 - Standard Process for Addressing Ethical Considerations During System Design
 - IEEE P7000-1 - Transparency of Autonomous Systems
 - IEEE P7000-3 - Data Privacy Practice
 - IEEE P7000-4 - Algorithmic Bias Identification
 - IEEE P7000-5 - Standard on AI and Human Data Systems
 - IEEE P7000-6 - Standard on AI and Human Data Systems
 - IEEE P7000-7 - Ethical Design Standard for Privacy
 - IEEE P7000-8 - Standard for AI Ethics Policy Development
 - IEEE P7000-9 - Standard for AI Ethics Policy Development
 - IEEE P7000-10 - Standard for AI Ethics Policy Development
 - IEEE P7000-11 - Standard for AI Ethics Policy Development
 - IEEE P7000-12 - Standard for AI Ethics Policy Development
 - IEEE P7000-13 - Standard for AI Ethics Policy Development
 - IEEE P7000-14 - Standard for AI Ethics Policy Development
 - IEEE P7000-15 - Standard for AI Ethics Policy Development
 - IEEE P7000-16 - Standard for AI Ethics Policy Development
 - IEEE P7000-17 - Standard for AI Ethics Policy Development
 - IEEE P7000-18 - Standard for AI Ethics Policy Development
 - IEEE P7000-19 - Standard for AI Ethics Policy Development
 - IEEE P7000-20 - Standard for AI Ethics Policy Development

Educational institutions

1. Maastricht University (Maastricht)
2. KU Leuven (Leuven)
3. KU Leuven (Leuven)
4. KU Leuven (Leuven)
5. KU Leuven (Leuven)
6. KU Leuven (Leuven)
7. KU Leuven (Leuven)
8. KU Leuven (Leuven)
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16. KU Leuven (Leuven)
17. KU Leuven (Leuven)
18. KU Leuven (Leuven)
19. KU Leuven (Leuven)
20. KU Leuven (Leuven)

Governments

Example: EU AI Act

- Risk-based approach
- Four levels of risk
- Focus on AI systems
- Obligations for high risk applications, providers and users

ISSUE 2022

17. Social issues and Professional practice (UCT)

TECH

DISTRIBUTION OF AI ETHICS GUIDELINES

Figure 1- Geographic distribution of issuers of ethical AI guidelines by number of documents released



Figure 1: Geographic distribution of issuers of ethical AI guidelines by number of documents released. Most ethics guidelines are released in the United States (n=20) and within the European Union (19), followed by the United Kingdom (14) and Japan (4). Canada, Iceland, Norway, the United Arab Emirates, India, Singapore, South Korea, Australia are represented with 1 document each. Having endorsed a distinct G7 statement, member states of the G7 countries are highlighted separately. Map created using mapchart.net.

image: <https://www.nature.com/articles/d42256-019-0088-2>

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WHAT ABOUT ONTOLOGIES AND KNOWLEDGE GRAPHS?

- Semantics to the rescue (review) [ReyeroLobo22]
- Very little investigation into it
 - Data aggregation for the Dirty War index [Keet09]
 - Exploratory notes on knowledge graphs [Janowicz17]
 - Friend of a Friend vocabulary [Gomes20]
 - "Gaps" in clinical terminologies [Geller21]
 - surveillance example, OE processes [Paparidis21]
 - Exploration of cognitive bias [Keet21]

WHAT ABOUT ONTOLOGIES AND KNOWLEDGE GRAPHS?



Who controls the graph, then, is the one who controls the presentation and

images: screenshots from: <https://www.youtube.com/watch?v=mmQl6VGVX-c>

WHAT ABOUT ONTOLOGIES AND KNOWLEDGE GRAPHS?

- Google's Knowledge Graph¹
 - The person who builds and controls the ontology or knowledge graph, then, is the one who has the power to control presentation and access to information and possibly also the recording of information.
 - "to some degree contests the autonomy of the user" [Vang13]

¹ <https://blog.google/products/search/about-knowledge-graph-and-knowledge-panels/>
images: screengrabs from: <https://www.youtube.com/watch?v=mimQl6VGvXc>

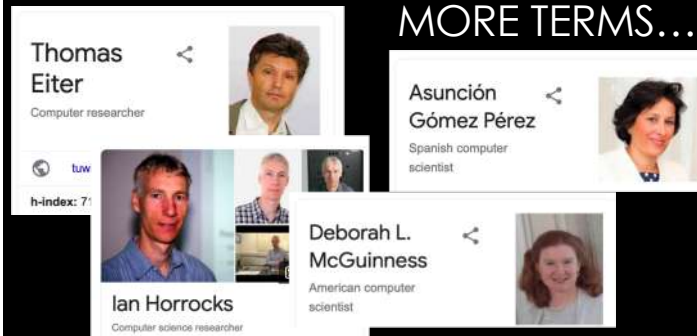
ANNOTATION AND RETRIEVAL – GOOGLE'S KNOWLEDGE GRAPH MESS

Brazilian computer scientists...



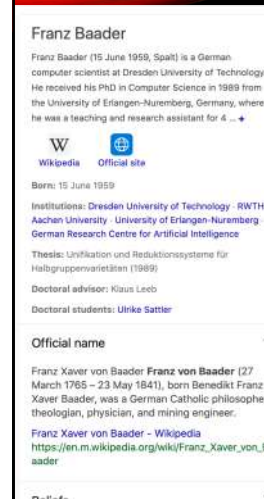
Fernanda Farinelli, Tiago Prince Sales, and Mara Abel have no info box, nor did most other organisers, nor the session chairs, as is the case with many other scientists not based in the Anglosphere or close to it ...

MORE TERMS...

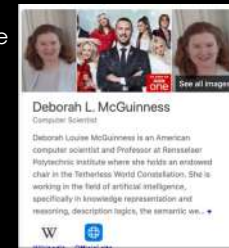


... For sure we won't all be easily *findable* with a simple query ... nor do we have the authority to fix this mess ... nor do we know all the terms to determine whether there is a bias in labeling

(BING'S GRAPH ISN'T WORKING MUCH BETTER)¹²



- It gets data off Wikipedia – no wiki page, no infobox
- It somehow infers different people to be the same, with
 - Franz to be dead and alive
 - Deborah to be a computer scientist and related to Bootleg Blondie



AIMS

- Contribute to systematising the sort of bias that may be present in ontologies and similar artefacts
- Provide a preliminary answer to what bias means for ontologies, what their sources are
- How that manifests itself in ontologies
- Assess it across a set of ontologies in the same domain
- Pointers to avenues for more research

Keet, C.M. An exploration into cognitive bias in ontologies. *Cognition And Ontologies (CAOS'21)*, part of JOWO'21, 13-16 Sept 2021, Bolzano, Italy. Santilippo, E.M. et al. (Eds.). CEUR-WS vol. 2969, 17p

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THIS TALK

- Identify and discuss sources of bias
- Cherry-picked examples and more substantive comparison with three COVID-19 ontologies
- Bias in the light of automated reasoning and applications

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PRINCIPAL SOURCES OF BIAS IN ONTOLOGIES

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PRELIMINARIES

- Defining cognitive bias... and differentiate from cognitive styles, alternate perspectives, image schemas, simple mistakes
- Inclusive definition for bias is adopted:
 - "a consequence of interference with honest attempts" [Oreg, 2009]
- Variants: narrow scope of *norm deviation* and *error*
- Implicit vs explicit
- Bias wrt effect, source, output vs process, antecedents vs effects of (cognitive) bias
- Types of bias
- (would benefit from a proper ontological investigation...)



image by [planetochun](#) is licensed under [CC BY-NC-ND 2.0](#)

PRELIMINARIES

- For IT and computing, grouped by dimension; e.g.,
 - by type of task for information visualisation [Dimara20]
 - by software engineering “knowledge area” [Mohanani20]

Bias	Antecedents	Knowledge area
Anchoring and Adjustment	Reusing previously written queries; difficult to identify referential points (anchors) [P2]	Construction
	Missing, weak and disuse of traceability knowledge [P17], [P18]	Design, Construction
	Recalling domain related information from past knowledge [P18]	Construction
	Not being able to adjust to the new environment [P20]	Requirements
	Development experience [P16]	Construction
	Uncertainty of future actions, lack of business / historical knowledge and inflexible clients [P63]	Management
	Confirmation and availability bias during design; [P17]	Design
Bias	Effects	Knowledge area
Anchoring and adjustment	Reusing SQL queries introduced errors in the new context [P2]	Construction
	Design errors and adding unnecessary functionality [P42]	Design
	Reduced long-term productivity [P51]	Management
	Ignorance change requests [P17]	Construction
	Inaccurate effort estimation [P64]	Design

SAMPLING OF COGNITIVE BIASES FROM DIMARA ET AL.'S LIST

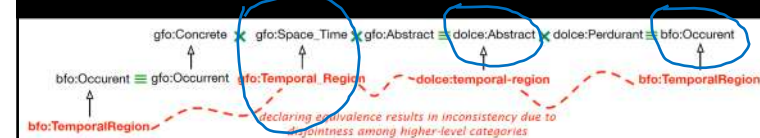
- 17 of the 154 seem potentially applicable to ontologies; among others:
 - Mere exposure/familiarity:** choice is influenced by exposure to it and thus familiarity with it.
 - Naive realism:** the belief that you experience objects in your world objectively.
 - False Consensus:** Overestimating that other people are and behave like you and agree with your opinion.
 - Distinction bias:** Choices affected by how many are the alternatives (?)
 - Barnum effect:** High accuracy ratings for vague and general statements. (?)

POSSIBLE BIASES, BY SOURCE

Type	Subtype	[im/ex]plicit bias
Philosophical	-	explicit
Purpose	-	explicit
Subject domain	Science	explicit
	Granularity	either
	Linguistic	either
	Socio-cultural	either
	Political or religious	either
	Economics	explicit

FOUNDATIONAL ONTOLOGY DIFFERENCES (PHILOSOPHICAL OR OTHERWISE)

- Realism vs idealism, concepts, universals etc.
- Some differences don't matter in praxis; some do
- Ways to find and resolve the (explicit!) conflict(s)
- Example: BFO's realism does not accept abstract entities



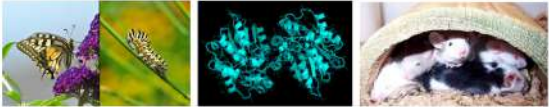
Khan, Z.C., Keet, C.M. Foundational ontology mediation in ROMULUS. *Knowledge Discovery, Knowledge Engineering and Knowledge Management: IC3K 2013 Selected Papers*, A. Fred et al. (Eds.), Springer CCIS vol. 454, pp. 132-152, 2015.

Keet, C.M., Grüter, R. Toward a systematic conflict resolution framework for ontologies. *Journal of Biomedical Semantics*, 2021, 12:15.

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PURPOSE: ENCODING BIAS, CF. A COGNITIVE BIAS

- (a) a class Transformation or (b) a relationship transformsInto?
- (a) Enzyme is a Protein or (b) Enzyme has bearer Protein?
- (a) Mouse hasColour Colour or (b) Mouse hasQuality Colour that hasQuale Physical Region?



<https://pxhere.com/en/photo/823275>
https://en.wikipedia.org/wiki/File:Enzyme_Polynuridine_Aldehyde_Esterase.png
https://commons.wikimedia.org/wiki/File:Fancy_mice.jpg

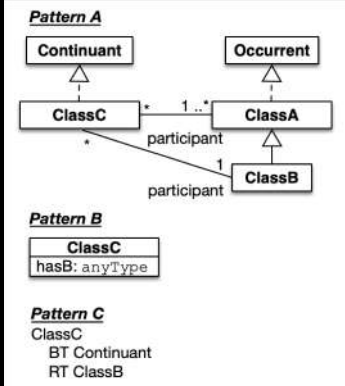
CM Keet, Encoding biases' influences on development and use of ontologies in the life sciences, Bio-ontologies 2022 keynote at ISMB22, Madison, Wisconsin, USA.

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PURPOSE: ENCODING BIAS, CF. A COGNITIVE BIAS

Three different patterns with a purpose bias:

- Pattern A: biased toward a scientific approach
- Pattern B: conceptual data modelling influence or purpose
- Pattern C: a thesaurus-like approach useful for document annotation



Pattern A

Continuant Occurrent

ClassC ClassA

participant participant

Pattern B

ClassC

hasB: anyType

Pattern C

ClassC

BT Continuant

RT ClassB

Filottirani, P.R., Keet, C.M., Dimensions Affecting Representation Styles in Ontologies. 1st Iberoamerican conference on Knowledge Graphs and Semantic Web (KGSWC'19), Springer CCIS vol. 1029, 186-200.

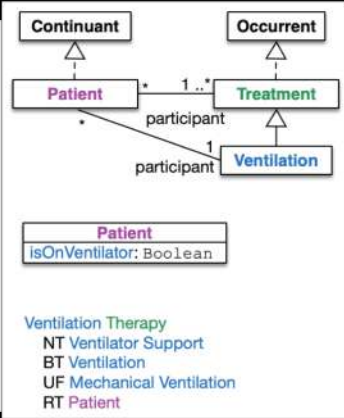
Filottirani, P.R., Keet, C.M. Patterns for Heterogeneous TBox Mappings to Bridge Different Modelling Decisions. Proc. of ESWC'17, Springer LNCS 10249, 371-386.

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Three different patterns with a purpose bias:

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Pattern A

Continuant Occurrent

Patient Treatment

participant participant

Pattern B

Patient

isOnVentilator: Boolean

Pattern C

Ventilation Therapy

NT Ventilator Support

BT Ventilation

UF Mechanical Ventilation

RT Patient

Filottirani, P.R., Keet, C.M., Dimensions Affecting Representation Styles in Ontologies. 1st Iberoamerican conference on Knowledge Graphs and Semantic Web (KGSWC'19), Springer CCIS vol. 1029, 186-200.

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ENCODING BIAS ISSUES

Different representation decisions in different ontologies impedes:

- ontology interoperability and alignment
- ontology reuse
- ontology development: in automation and, e.g., CQ translations
- deployment in ontology-driven information systems

CONFLICTING MODELING STYLES ILLUSTRATION

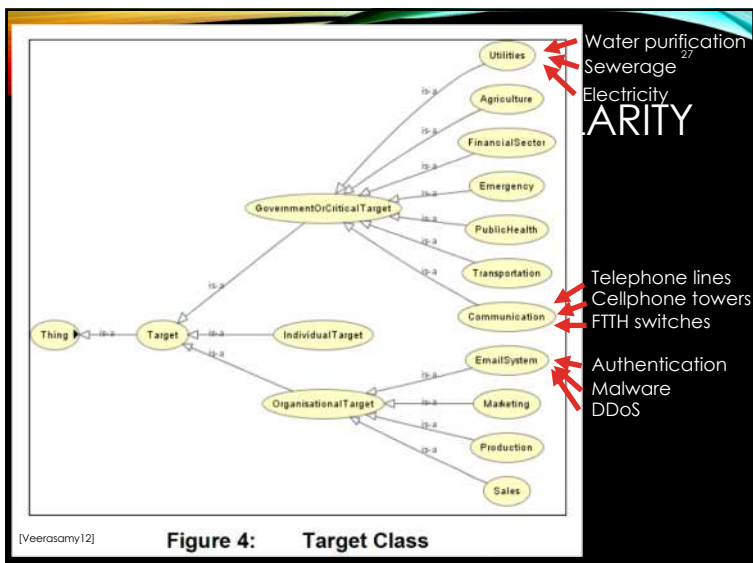
- **Requirement:** align/integrate/merge the COVID-19 ontologies
- CIDO ontology + CODO ontology
 - codo: 'laboratory testfinding' = {positive, pending, negative}
 - cido: 'COVID-19 diagnosis' as a class, with three subclasses [negative/positive/presumptive positive] COVID-19 diagnosis
- Issue: class vs. instance representations of the same idea
- Solution options:
 1. Change CODO
 2. Change CIDO
 3. Outside option (e.g.: approach with attribute+values)



Keet, C.M., Grütter, R. Toward a systematic conflict resolution framework for ontologies. *Journal of Biomedical Semantics*, 2021, 12:15.

GRANULARITY

- How detailed should it be? How many levels in the taxonomy? Unbalanced tree ok?
- Less details...
 - Act of omission
 - E.g.: aggregating ex-military persons with non-involved persons (civilians) as one group of 'Civilians'
 - Not needed
 - Ran out of time
- ... but may be very difficult to determine, unless stated
- Not needed and ran out of time may be explicit choices and prioritization (explicit bias), or honestly out of scope for v1 or ever



GRANULARITY

Category	Terminology	SNOMED CT	ICD-10	CPT	NCH	MedDRA
Healthcare Institution	Refusal of examination	No	No	No	No	10058840
	Denying referral to specialist	No	No	No	No	No
	Untreated chronic condition/Failed Examination	No	No	No	No	10016115
	Nutrition counseling declined	21701000175105	No	No	No	No
	Colorectal cancer screening not done	4471000175100	No	No	No	No
	Denied infertility therapy	No	No	No	No	No
	Follow-up after hospital stay for mental illness	No	No	No	No	No
	Non-adherence to medical treatment	No	Z91.19	No	No	10084084
	Refusal of vaccination	No	No	No	No	10082811
	Tampering with medication	No	No	No	No	10027092

[Geller21]

SOCIO-CULTURAL ISSUES IN ONTOLOGIES

- Relates to how society is organised, the assumptions that underlie it and history
 - organisational structures, who lives with whom, demographics, allocation of resources, or social geography
- Example: GoodRelations Ontology's payment methods and legal status of a Business [Hepp08]



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- Alcohol use and disorder across time and cultures
 - DSM-IV, DSM-V, and ICD-10 coding differences
 - modifications due to a combination of socio-cultural factors and some scientific disagreement [Wakefield15]



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POLITICAL MOTIVATIONS

- The easy one: Aggrieved group vs Terrorist organisation
- Concretely,
 - *terrorist* and *terroristgroup* in the terrorism ontology [Jindal20]
 - *ActorEntity* with various types of *Insiders* and *Protestors* in the Cyberterrorism ontology [Veerasamy12]



<https://www.cicopedia.org/viewboard/1/terrorism.html>
<https://www.wionews.com/world/mass-says-wasnt-labour-wuhan-job-leak-demands-10-billion-penalty-from-china-389376>

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- CIDO's "Wuhan virus"



<https://www.cicopedia.org/viewboard/1/terrorism.html>
<https://www.wionews.com/world/mass-says-wasnt-labour-wuhan-job-leak-demands-10-billion-penalty-from-china-389376>

DO THESE TYPES OF BIASES APPEAR IN ONTOLOGIES IN THE SAME DOMAIN?

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COVID-19 ONTOLOGIES

- 'same' topic on COVID-19, developed at same time by different groups
 - Coronavirus Infectious Disease Ontology (CIDO) [He20]
 - COVid-19 Ontology (CODO) [Dutta20]
 - Coronavirus Vocabulary (COVoc) [Pendlington20]
- Assess their documentation, characteristics, content
- Iteratively note observations of bias and check subset of cognitive bias list and consider wrt the ontologies

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BIAS BY COGNITIVE BIAS

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Bias (Cognitive biases from Dimara et al's list)	CIDO	CODO	COVoc
Mere exposure/familiarity (choice is influenced by exposure to it and thus familiarity with it)	+		+
Negative interpretation (judgement is affected more by negative information than positive)	+		
Optimism (more positive predictions for oneself than for others)	+		
Naive realism (the belief that you experience objects in your world objectively)	+		
False Consensus (Overestimating that other people are and behave like you and agree with your opinion)		+	
Illusory truth effect (a statement is considered to be true after repeated exposure to it)			+

PRESENCE

Bias (Source/type)	CIDO	CODO	COVoc
Philosophical	+	-	+
Purpose	-	+	+
Science	-	-	+
Granularity	±	+	±
Linguistic	+	-	-
Socio-cultural	+	+	+
Political or religious	+	+	+
Economics	-	-	±

- Exposure to COVID-19
 - Close contact
 - Gathering
 - InfectedCo-Passenger
 - InfectedCo-Worker
 - InfectedFamilyMember
 - InfectedSpouse
- experimental factor
 - anatomical entity
 - assay
 - biological sex
 - male
 - biological_process

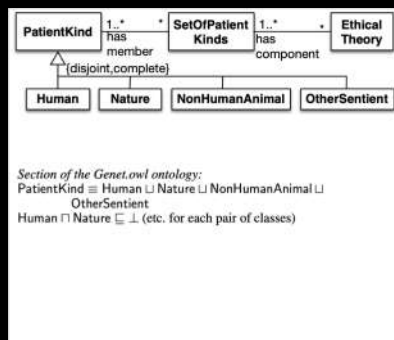
- organization
 - company
 - drive-thru COVID-19 testing entity
 - FDA EUA-authorized organization

AUTOMATED REASONING

ANY EFFECTS ON AUTOMATED REASONING?

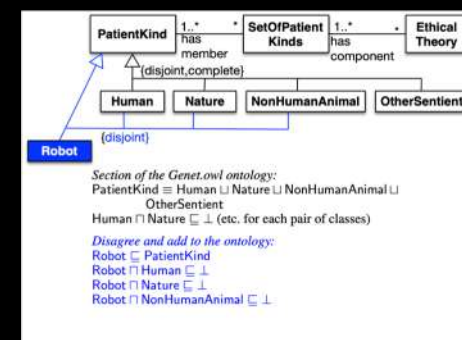
- 'Incoherence' (one or more unsatisfiable classes), inconsistencies, or undesirable deductions
- For TBox only: incoherence and undesirable deductions will be found at authoring time already, not during deployment
- For the knowledge base (Tbox + Abox [in owl or secondary storage]): inconsistencies or undesirable deductions either at authoring time or during deployment
 - Querying data
 - Annotating data (and subsequent retrieval)

DOMAIN ONTOLOGY EXAMPLE: DESIRABLE OR UNDESIRABLE DEDUCTION



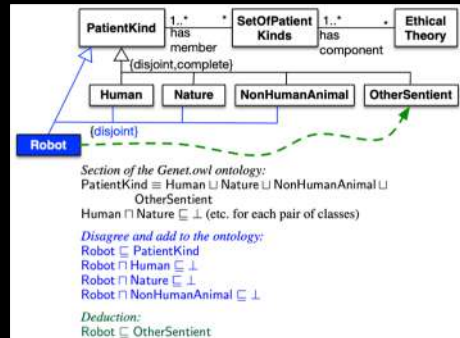
Rautenbach, J.G., Keet, C.M. Toward equipping Artificial Moral Agents with multiple ethical theories. *RobOntics: International Workshop on Ontologies for Autonomous Robotics*, co-located with BoSK'20, Bolzano, CEUR-WS vol. 2708, 5. Keet, C.M. Bias in ontologies – a preliminary assessment. Technical Report, Arxiv.org, January 20, 2021, 10p.

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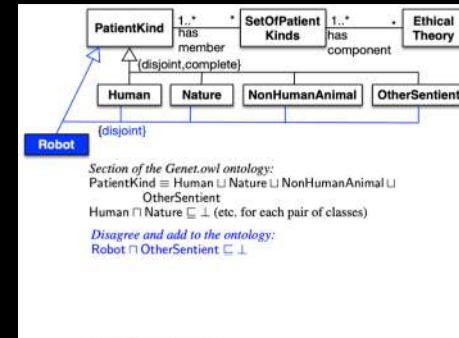
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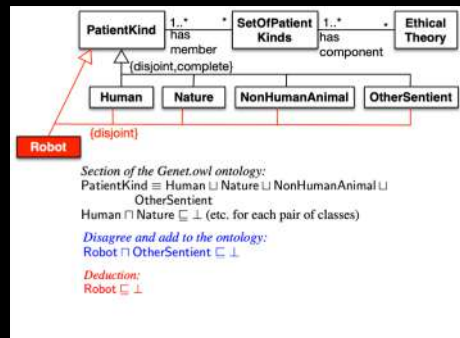
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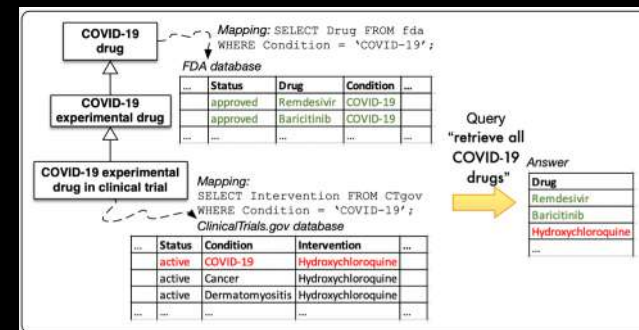
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EXAMPLE: OBDA DATA INTEGRATION EXAMPLE WITH THE CIDO



ENCODING BIAS EXAMPLE: QUERYING CELL TYPES IN THE CL ONTOLOGY

Description: Kupffer cell

Equivalent To

- 'tissue-resident macrophage'
- and ('located in' some 'hepatic sinusoid')
- and ('has plasma membrane part' some 'adhesion G protein-coupled receptor E1')
- and ('has plasma membrane part' some 'scavenger receptor cysteine-rich type 1 protein M130')
- and ('has plasma membrane part' some 'macrolin' with domain as bfo:Independent continuant
- and ('capable of' some 'erythrocyte clearance')
- and ('has low plasma membrane amount' some 'Inte... ..') and range as bfo:process

ENCODING BIAS EXAMPLE: QUERYING CELL TYPES IN THE CL ONTOLOGY

Annotations Usage

Usage: capable of

Show: ☒ this ☒ disjoints

Found 1540 uses of 'capable of'

▼ acid secreting cell (30)

- acid secreting cell SubClassOf 'capable of' some 'acid secretion'
- acid secreting cell EquivalentTo 'secretory cell' and ('capable of' some 'acid secretion')

Usage: capable of

Show: ☒ this ☒ disjoints

▼ Be1 Cell

- Be1 Cell SubClassOf 'capable of' some 'interleukin-2 production'
- Be1 Cell EquivalentTo 'Be cell' and ('capable of' some 'interferon-gamma production')
- Be1 Cell SubClassOf 'capable of' some 'positive regulation of T-helper 1 cell differentiation'
- Be1 Cell SubClassOf 'capable of' some 'interferon-gamma production'
- Be1 Cell SubClassOf 'capable of' some 'tumor necrosis factor production'

ENCODING BIAS EXAMPLE: QUERYING CELL TYPES IN THE CL ONTOLOGY

Comparing alternative encodings:

The "CL way"

$[an IC] \sqsubseteq \exists \text{capable of}.[a \text{ process}]$

versus

Kupffer cell $\sqsubseteq \exists \text{clears.erythrocyte}$

acid secreting cell $\sqsubseteq \exists \text{secretes.acid}$

Be1 cell $\sqsubseteq \exists \text{produces.interferon-gamma}$

type I NK T cell $\sqsubseteq \exists \text{binds.glycosphingolipid}$

vomer nasal organ $\sqsubseteq \exists \text{detects.pheromone}$

Example of an
"applied" way

ENCODING BIAS EXAMPLE: QUERYING CELL TYPES IN THE CL ONTOLOGY

- Cell Annotation Platform (Celltype.info) only allows search by celltype to find data sets: no effects
- Others that use CL also have mostly only simple term search
- But, if you were to want to search for, e.g.:
 - the function/role of a cell; or
 - all cells that perform a certain role
 - all datasets that are from experiments on erythrocyte clearance by macrophages
 - projects on capabilities of some cell type

then the 'capable of' version will be much easier cf. over very many possible names for relations: fewer names to remember, more structured, consistency in approach

DISCUSSION

- Ontological investigation of bias?
- Can an ontology ever be free of bias?
- That loose end on bias with "honest attempts" vs modelling mistake vs 'ran out of time':
 - Need a way to disambiguate
 - How can one be certain it is a bias when not involved in the development of that ontology? (but if one is, one may be blind to the bias)
- Consequences for automated reasoning

CONCLUSIONS

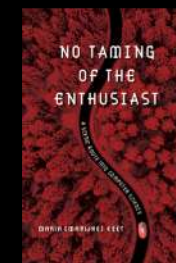
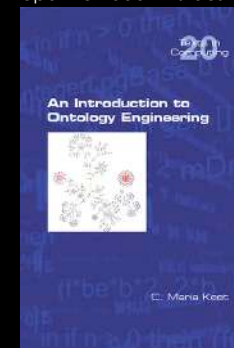
- Bias may be present in an ontology, a number of which can be categorised as cognitive biases
- Eight categories of sources of bias for ontologies: philosophical, purpose, science, granularity, linguistic, socio-cultural, political or religious, and economic motives
- Three COVID-19 ontologies each exhibited a different subset of the sources of bias and cognitive biases
- Preliminary work may contribute to further research into (cognitive) bias of ontologies, its methods, and definitions

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