



Logic: A Motivation

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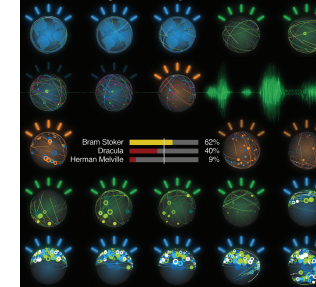
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IBM Watson example

<https://www.youtube.com/watch?v=Dyw04zksfXw>

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IBM Journal of Research
 and Development
 Including IBM Systems Journal

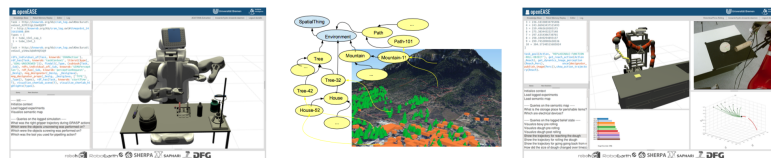


This Is Watson



Knowrob: Why is knowledge so important?

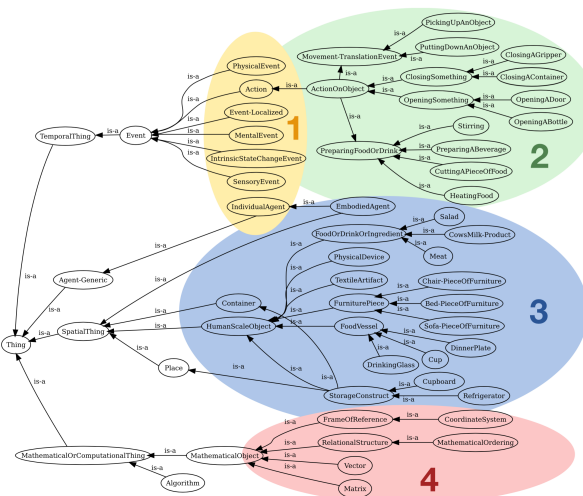
- if the robot does not know about the task, the environment, or the robot, then the programmer has to hardcode **everything**



- programming/instructing at an abstract/semantic level
 - put the bolt into the nut and fasten it
 - pour water into the glass
 - ...



Knowrob: Ontology (knowrob.owl)



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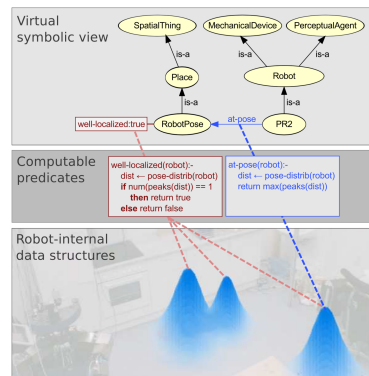


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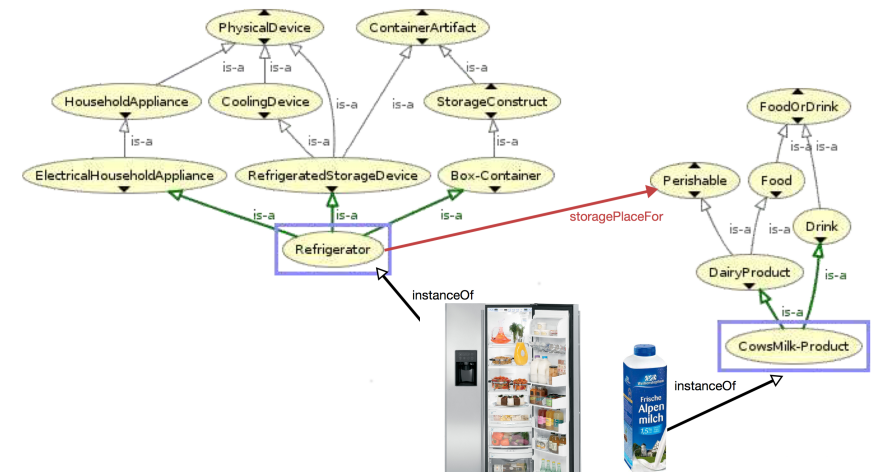


Knowrob: Procedural attachments

- Compute symbolic knowledge **on demand** from data structures that already exist on the robot by attaching procedures to semantic classes and properties
- Re-use existing information and make sure abstract knowledge is grounded



Knowrob: Inferring storage location



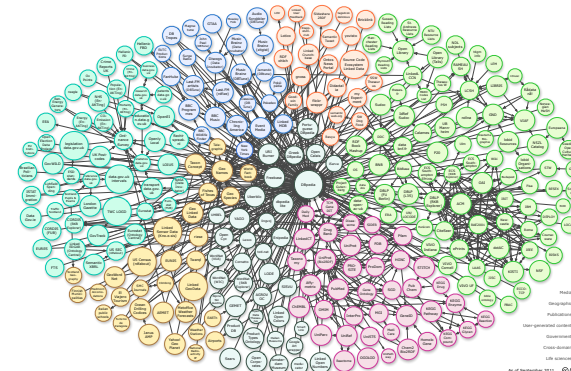
Knowrob: Summary

- declarative knowledge: ontologies
- procedural attachment
- logical inference
- multi-modal representation

Video (13 mins):

<https://www.youtube.com/watch?v=4usoE981e7I>

Semantic Web



Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. <http://lod-cloud.net/>



Semantic Web

Lots of hype. Lots of acronyms. But some are important!

- URI – Uniform Resource Identifier
- RDF – Resource Description Framework
- RIF – Rule Interchange Format
- SPARQL – SPARQL Protocol and RDF Query Language
- OWL – Web Ontology Language

Open World Assumption!



SPARQL

W3C Recommendation

Queries:

- SELECT (returns a table)
- CONSTRUCT (returns RDF)
- ASK (returns a boolean)
- DESCRIBE (freedom)

Example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?name ?email
WHERE {
    ?person a foaf:Person.
    ?person foaf:name ?name.
    ?person foaf:mbox ?email.
}
```



A SPARQL query

What are all the country capitals in Africa?

```
PREFIX abc: <http://example.com/exampleOntology#>
SELECT ?capital ?country
WHERE {
    ?x abc:cityname ?capital ;
        abc:isCapitalOf ?y .
    ?y abc:countryname ?country ;
        abc:isInContinent abc:Africa .
}
```



A real SPARQL query

<http://wiki.dbpedia.org/OnlineAccess>

```
PREFIX rosetta: <http://kif.cs.lth.se/ontologies/rosetta.owl#>
select ?s where {
    ?s a rosetta:Device.}

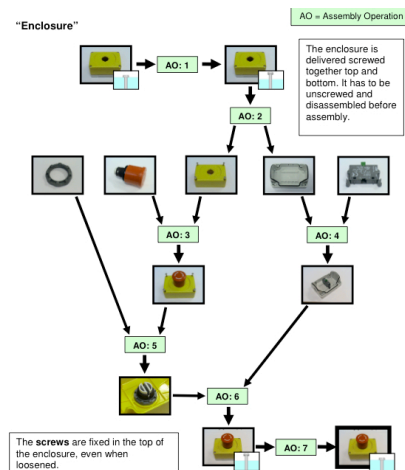
select ?s where {
    ?s a rosetta:ManipulationAndHandlingDevice.}

select ?s ?k where {
    ?s a rosetta:ManipulationAndHandlingDevice.
    ?s rosetta:hasSkill ?k.}

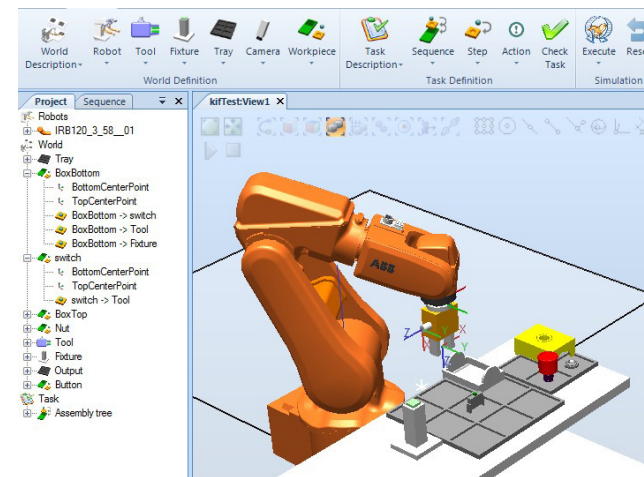
select ?s ?k where {
    ?s a rosetta:ManipulationAndHandlingDevice.
    ?s rosetta:hasSkill rosetta:VacuumGrip.}
```



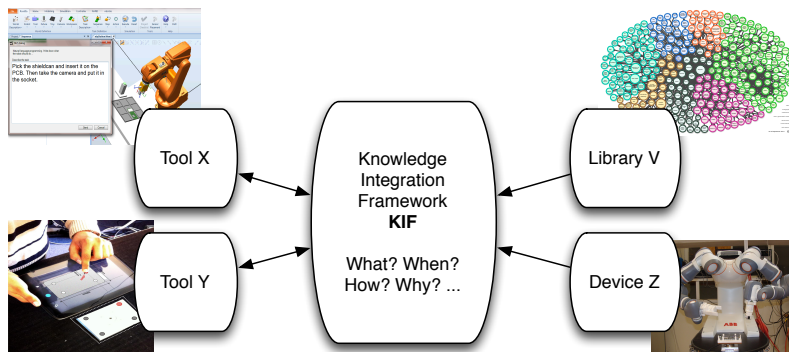

A real case



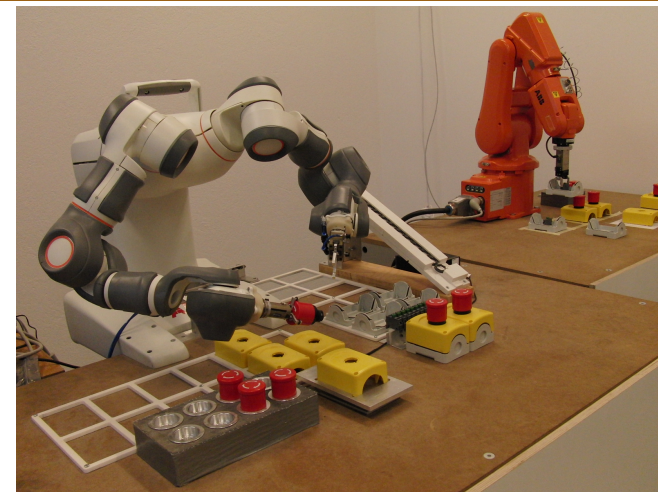
A real case



A real case

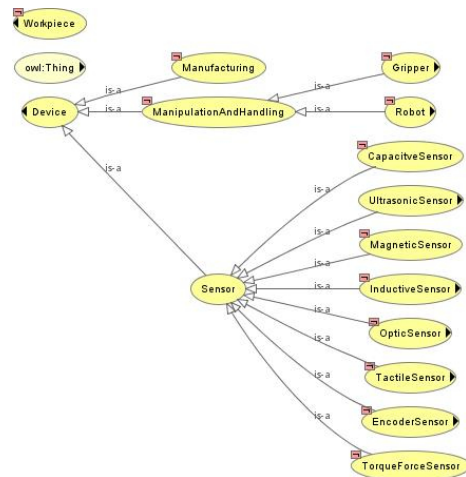


A real case





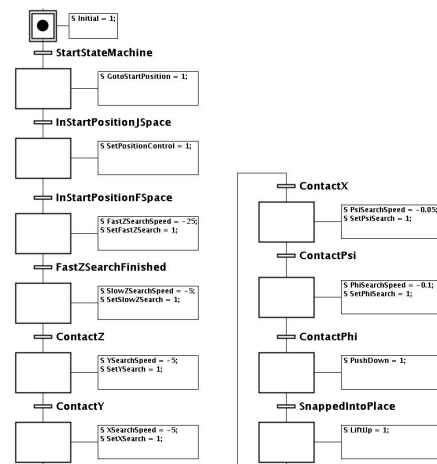
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A real case



A real case



A real case

