Design Repositories on the Semantic Web with Description-Logic Enabled Services

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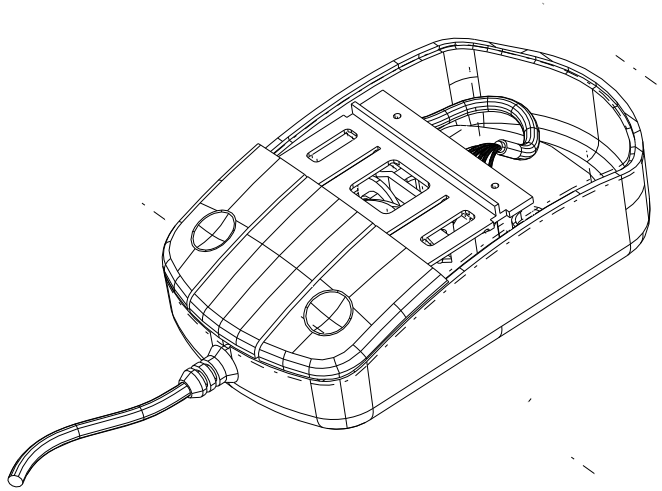
Collections of Engineering Designs

Engineering firms maintain large collections of complex design knowledge

- **Part/Design Libraries**
  - **Used in: assembly design, variant design, process/analysis re-use**
- **Design Databases**
  - **Used in: collaborative design, life-cycle management (e.g. maintenance, disassembly)**
- **Legacy Data**
  - **Weakly organized (if at all)**



Current systems provide only inadequate services

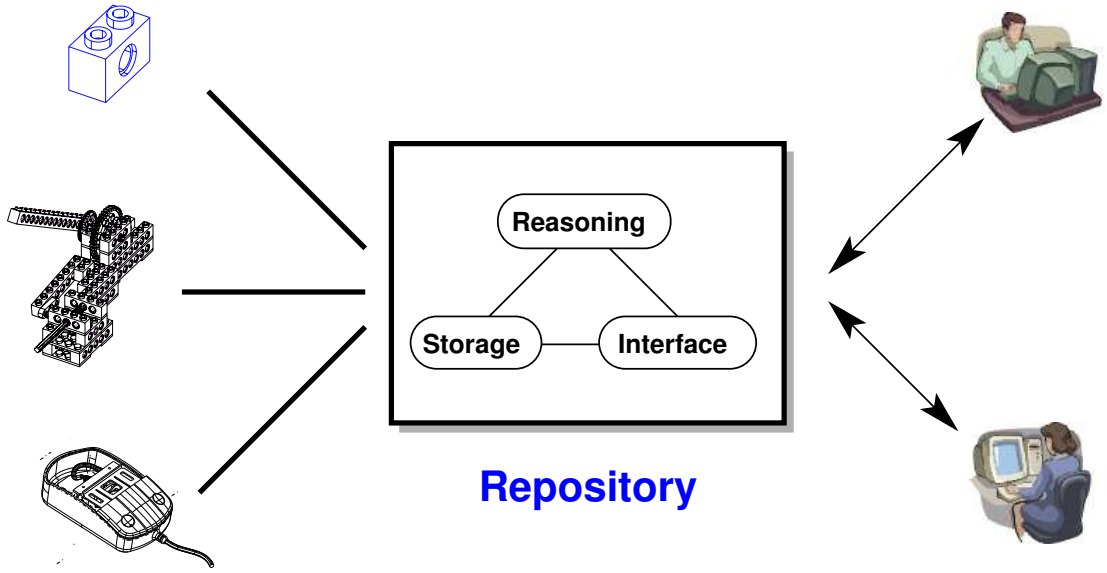
- **Search limited to filenames, keywords in documentation**
- **Classification manual and limited**
- **Categorization non-existant**

(figure © SDRC)

Design Repositories

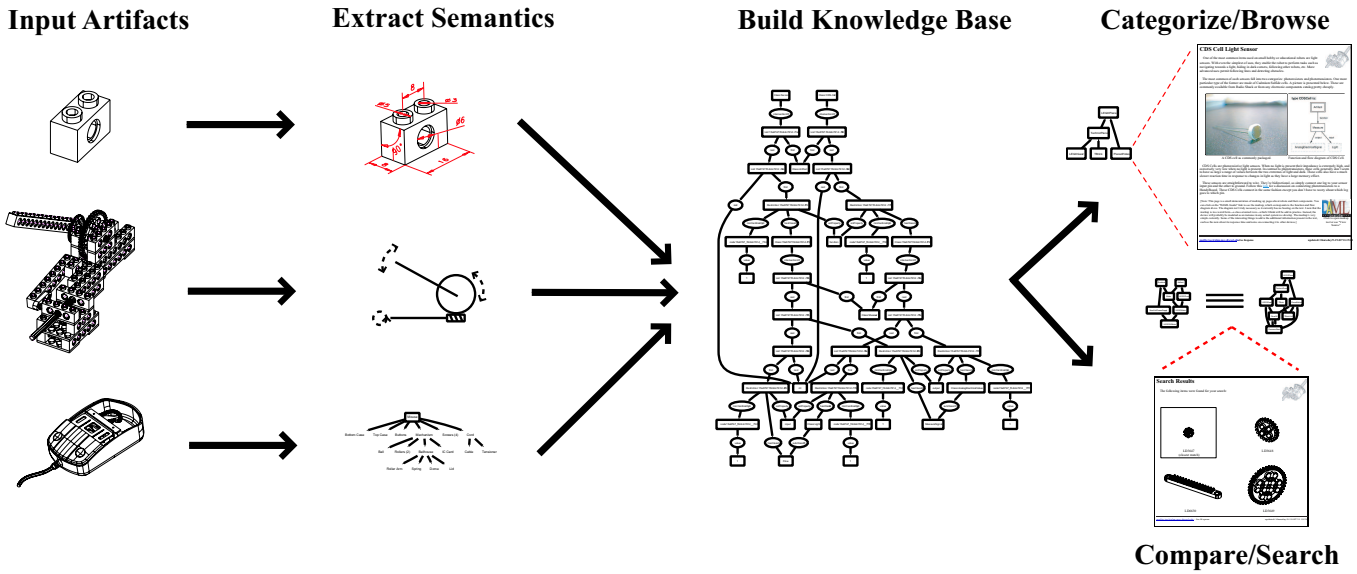
Design repositories—an evolution of traditional design databases

- **Capture** and **utilize** more design knowledge
  - Function, behavior, structure, rationale
- Enable enhanced **services**
  - Sophisticated search, browsing, interfaces
- Provide **storage** for and **effective access** to heterogenous information
  - CAD data, documentation, simulations, animations, analyses



Repository Operations

Knowledge-based repository overview:



Major services of interest that a repository may provide:

- **Search**: Finding designs that meet criteria
- **Classification**: Placing designs into a hierarchy
- **Categorization**: Inducing a hierarchy automatically

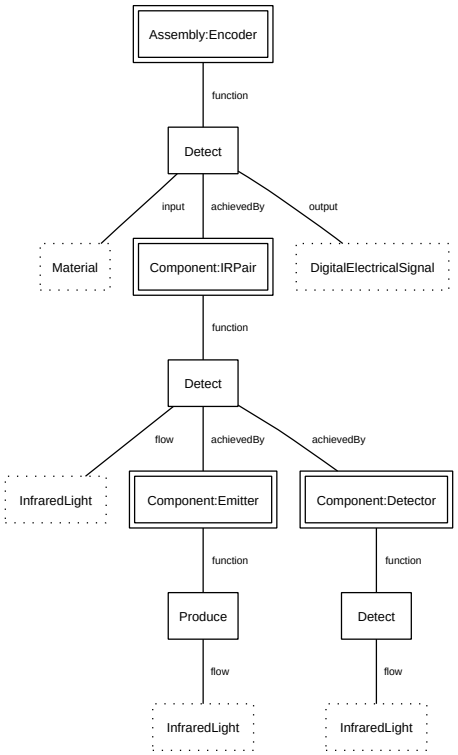
Representation

Function and flow signatures: DL-oriented function modeling approach

Simple DL core ontology (~13 statements)
- **Function, flow, and artifact classes**
- **Relations between them**

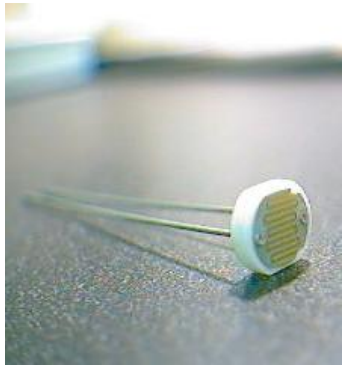
Non-conservative descriptive extensions
- **~75 functions, ~50 flows**
- **Based on Functional Basis/NIST SBF**
- **Conservatively domain extensible**

Break-Beam Encoder

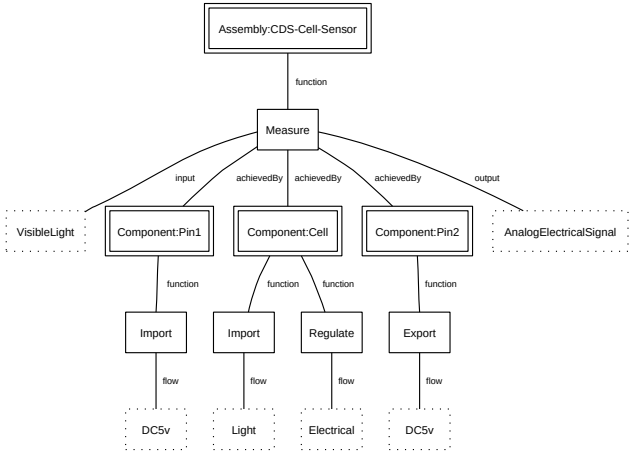


F & F Signature

Signature Formalization in Description Logic



CDS Cell



Function and flow signature

$$CDS\text{-}Cell\text{-}Sensor \equiv Assembly \sqcap \exists function.[Measure \sqcap \exists input.VisibleLight \sqcap \exists achievedBy.[Component \sqcap \exists function.[Import \sqcap \exists flow.DC5v]] \sqcap \exists achievedBy.[Component \sqcap \exists function.[Import \sqcap \exists flow.Light] \sqcap \exists function.[Regulate \sqcap \exists flow.Electrical]] \sqcap \exists achievedBy.[Component \sqcap \exists function.[Export \sqcap \exists flow.DC5v]] \sqcap \exists output.AnalogElectricalSignal].$$

Function and flow signature as class description

Repository Operations Revisited

Standard capabilities provided by description logic formalization:

- **Search: Query is defined using a class description**
  - — **DL classification**
- **Classification: Hierarchy is defined *a priori* through class descriptions**
  - — **DL classification**

Novel capabilities provided by description logic formalization:

- **Search: Browse relationships between query and hierarchy**
  - — ***DL subsumption***
- **Classification: Knowledge discovery**
  - — **DL classification/subsumption**
- **Classification: Provide for loose construction of hierarchy**
  - — **DL subsumption**
- **Categorization: Induce hierarchy from given designs**
  - — ***DL least common subsumer***

Repositories on the Semantic Web

Can embed representation into web content

- Enable repository engine to operate across the Semantic Web

```
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  xmlns:eng  = "&eng;#" xmlns:func = "&func;#" xmlns:flow = "&flow;#"
  xmlns =
 "http://edge.mcs.drexel.edu/assemblies/tests/iaai03/cds-cell.daml#">

<daml:Ontology rdf:about="#" >
  <daml:imports rdf:resource="&eng;" />
  <daml:imports rdf:resource="&func;" />
  <daml:imports rdf:resource="&flow;" />
</daml:Ontology>

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  <eng:function><func:Measure>
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          </func:Import></eng:function>
      </eng:Component></eng:achievedBy>

      <eng:achievedBy><eng:Component rdf:about="#Cell">
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            <eng:flow><flow:Light /></eng:flow>
          </func:Import></eng:function>

          <eng:function><func:Regulate>
              <eng:flow><flow:Electrical /></eng:flow>
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      </eng:Component></eng:achievedBy>

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          </func:Export></eng:function>
      </eng:Component></eng:achievedBy>

      <eng:output><flow:AnalogElectricalSignal /></eng:output>
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</eng:Assembly>
</rdf:RDF>
```
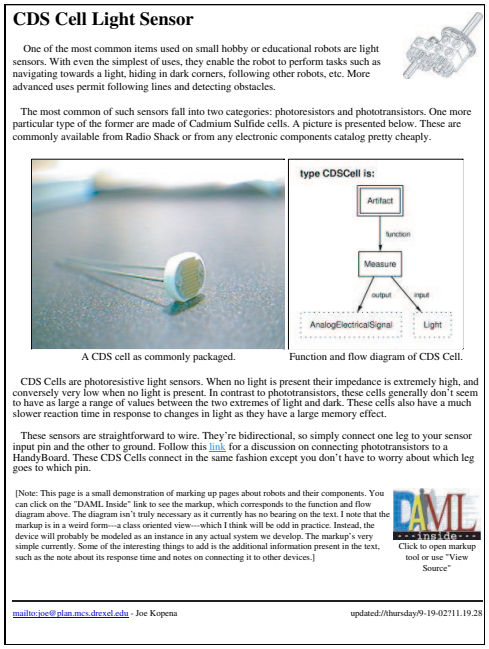

RDF/DAML source for CDS Cell signature



CDS Cell Light Sensor

One of the most common items used on small hobby or educational robots are light sensors. With even the simplest of uses, they enable the robot to perform tasks such as navigating towards a light, hiding in dark corners, following other robots, etc. More advanced uses permit following lines and detecting obstacles.

The most common of such sensors fall into two categories: photoresistors and phototransistors. One more particular type of the former are made of Cadmium Sulfide cells. A picture is presented below. These are commonly available from Radio Shack or from any electronic components catalog pretty cheaply.

A CDS cell as commonly packaged. Function and flow diagram of CDS Cell.

CDS Cells are photoresistive light sensors. When no light is present their impedance is extremely high, and conversely very low when no light is present. In contrast to phototransistors, these cells generally don't seem to have as large a range of values between the two extremes of light and dark. These cells also have a much slower reaction time in response to changes in light as they have a large memory effect.

These sensors are straightforward to wire. They're bidirectional, so simply connect one leg to your sensor input pin and the other to ground. Follow this link for a discussion on connecting phototransistors to a HandyBoard. These CDS Cells connect in the same fashion except you don't have to worry about which leg goes to which pin.

[Note: This page is a small demonstration of marking up pages about robots and their components. You can click on the "DAML Inside" link to see the markup, which corresponds to the function and flow diagram above. The diagram isn't truly necessary as it currently has no bearing on the text. I note that the markup is in a weird form—a class oriented view—which I think will be odd in practice. Instead, the device will probably be modeled as an instance in any actual system we develop. The markup's very simple currently. Some of the interesting things to add is the additional information present in the text, such as the note about its response time and notes on connecting it to other devices.]

Click to open markup tool or use "View Source"

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updated://thursday/9-19-02?11.19.28

Webpage with embedded signature

Summary

There's a real need for managing engineering knowledge

- Has applications in design, world at large

Our approach: DL-based function and flow signatures

- *Informal* in the sense of (not) truly capturing design semantics
- *Formal* in the sense of having a representation semantics
  $\longrightarrow$ well-defined inferences $\longrightarrow$ automated reasoning

This representation seems to offer

- Novel reasoning capabilities for design repositories
- Management/utilization of design data on the Web

In Closing...

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More information:

- **Project homepage:** http://edge.cs.drexel.edu/assemblies/
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Questions?