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

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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
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
Knowledge-based repository overview:

- **Input Artifacts**
- **Extract Semantics**
- **Build Knowledge Base**
- **Categorize/Browse**

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

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**Break-Beam Encoder**

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**F & F Signature**
Signature Formalization in Description Logic

\[ \text{CDS-Cell-Sensor} \equiv \text{Assembly} \sqcap \exists \text{function}.[\text{Measure} \sqcap \exists \text{input}.\text{VisibleLight}] \]

\[ \exists \text{achievedBy}.[\text{Component} \sqcap \exists \text{function}.[\text{Import} \sqcap \exists \text{flow}.\text{DC5v}]] \]

\[ \exists \text{achievedBy}.[\text{Component} \sqcap \exists \text{function}.[\text{Import} \sqcap \exists \text{flow}.\text{Light}]] \sqcap \exists \text{function}.[\text{Regulate} \sqcap \exists \text{flow}.\text{Electrical}] \]

\[ \exists \text{achievedBy}.[\text{Component} \sqcap \exists \text{function}.[\text{Export} \sqcap \exists \text{flow}.\text{DC5v}]] \]

\[ \exists \text{output}.\text{AnalogElectricalSignal}. \]

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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RDF/DAML source for CDS Cell signature

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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 a robot, etc. More advanced uses include following lines and detecting obstacles.

The most common of such sensors fall into two categories: phototransistors and photodiodes. One more particular type of the former are made of Cadmium Sulphide cells. A picture is presented below. These are commonly available for purchase. Block in front any electronic components catalog pretty cheaply.

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. A constant in photoreceptors, these cells generally don't have a large range of values between the two extremes of light and dark. These cells also have a slow 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.
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
  \[\rightarrow\] well-defined inferences \[\rightarrow\] 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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Questions?