Ontologies and Reasoning to Capture Product Complexity in Automation Industry

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Motivation

Basic Components (thousands) → Drive Trains (millions) → Complex Cartesian Systems (billions)
Motivation

Geometrical + electrical compatible components

Drive trains combinations filtered according to product manager input

Basic Components
(thousands)

Drive Train
(millions)

Complex Cartesian Systems
(billions)
Motivation: RDBMS based Solution

Product Management Constraints (pptx, xls, ...)

scripted

Axis
Motor
Controller
Mounting Kit
Basic Components (thousands)
Drive Train (millions)
Complex Cartesian Systems (billions)
Capturing Automation Systems with Ontologies

Basic Components

- Axis
- Mounting Kit
- Motor
- Controller
- Gear
- Housing
- Coupling
- Flange

Arrows indicate:
- explicit compatibility
- transitive compatibility
- part-of
Capturing Automation Systems with Ontologies

Complex Cartesian System

Gear

Axis

Mounting Kit

Motor

Electric Drive Train

Housing

Coupling

Flange

SWRL Rules & OWL RL Axioms

Product Management Constraints (pptx, xls, …)

has drive train
Ontology Status and Tools

- DL Expressivity: horn-SROIF(D)
- Axioms: \( \approx 200,000 \)
- Classes: \( \approx 550 \)
- Object Properties: \( \approx 64 \)
- Data Properties: \( \approx 230 \)
- Individual Count: \( \approx 9,000 \)

- Protégé
- Technology: JDBC, SQL, OWL API, SPARQL
- Evaluation: OWL 2 RL engines (performance gain: 1000x)
- Application & services: Java, Rest API, JSON, HTML5, JavaScript
Drive Train Demo Configurator
Exploring the Festo Electric Drives with SemSpect
Conclusion & Outlook

Benefit
• Significant improvement in data quality
• Increase in speed for data preparation and querying
• Better data comprehensibility
• Significant less maintenance effort
• Higher deployment flexibility

Lesson Learned
• Ontology modeling is not for free – but pays of in the end

Next
• App for maintaining interfaces & system configuration
• Pneumatic components and systems
• Configurator able to understand abstract descriptions
Thank You

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BACKUP
Architecture Overview

Ontology Modeling, Configuration Services and Demo UI

Source DBs

Exporter: JDBC
OWL-API

Schema

Protégé

Ontology Engineer

Schema + Instances

Server: SPARQL
Restlet

UI: HTML5
JavaScript

Ontology Verifier: SPARQL

RDFox

JSON

JNI

• EA Expert
• Product Manager
(PPT/XSL)
• Product Documentation

Source DBs

SQL
SPARQL Query: Computation of Valid Drive Trains

```
WHERE {
  {
    WHERE {
      UNION
      { ?anbausatz fe:direkt-kompatibel-Bausatz-Getriebe ?gear
      }{
      }
      UNION
      { ?axis fe:achse-mit-fuehrung-simulations-id ?simaxis. }
    }
  }
}
```
SWRL to Address Product Management Constraints

EHMX-Antriebsstrang(?strang-x),
besteht-aus-motor(?strang-x,?motor-x),
SingleTurnEncoder(?motor-x),
Servomotor(?motor-x),
strang-nachbar(?strang-x,?strang-y),
EHMY-Antriebsstrang(?strang-y),
besteht-aus-motor(?strang-y,?motor-y),
SingleTurnEncoder(?motor-y),Servomotor(?motor-y)
->
strang-via-motor-kombinierbar-mit(?strang-x, ?strang-y)
Festo  At the forefront of industrial automation.

- Automation and Didactic
- Factory and process automation
- 300,000 customers
- 18,800 employees

- Sustainable education and training
- Turnover (Group): EUR 2.74 billion (2013)
- R&D budget: around 8 % of sales

Inspired by Nature

Innovations worldwide – patented

Quality worldwide – certified

Over 30,000 products worldwide – documented