Coaction of Semantic Technology and Virtual Reality in an Integrated Engineering Environment

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Introduction

- SEVENPRO aims to develop technologies supporting mining of product engineering knowledge from multimedia repositories and semantically enhanced 3D interaction in integrated engineering environments
- Semantic Annotation of Knowledge enables

  Information Searching and Organisation

- Data Mining of Engineering Design enables

  Discovery of implicit Design Patterns

- VR Interaction with Knowledge enables

  Visualizing and sharing the knowledge

Introduction

- Item concept:

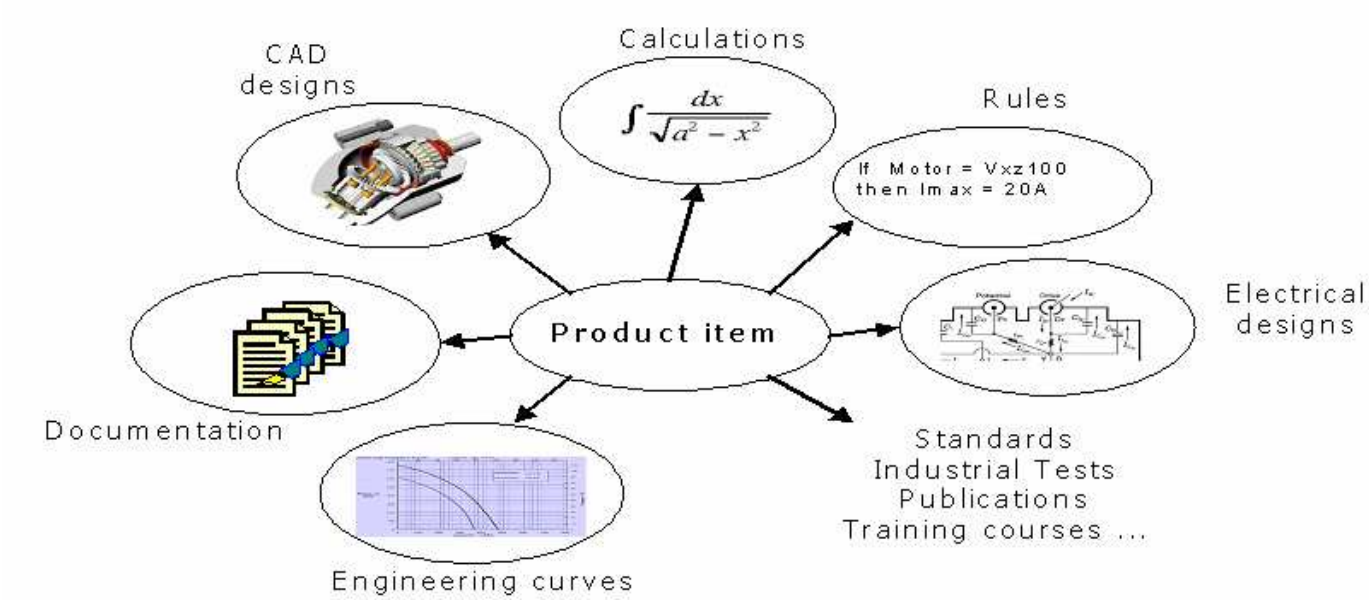


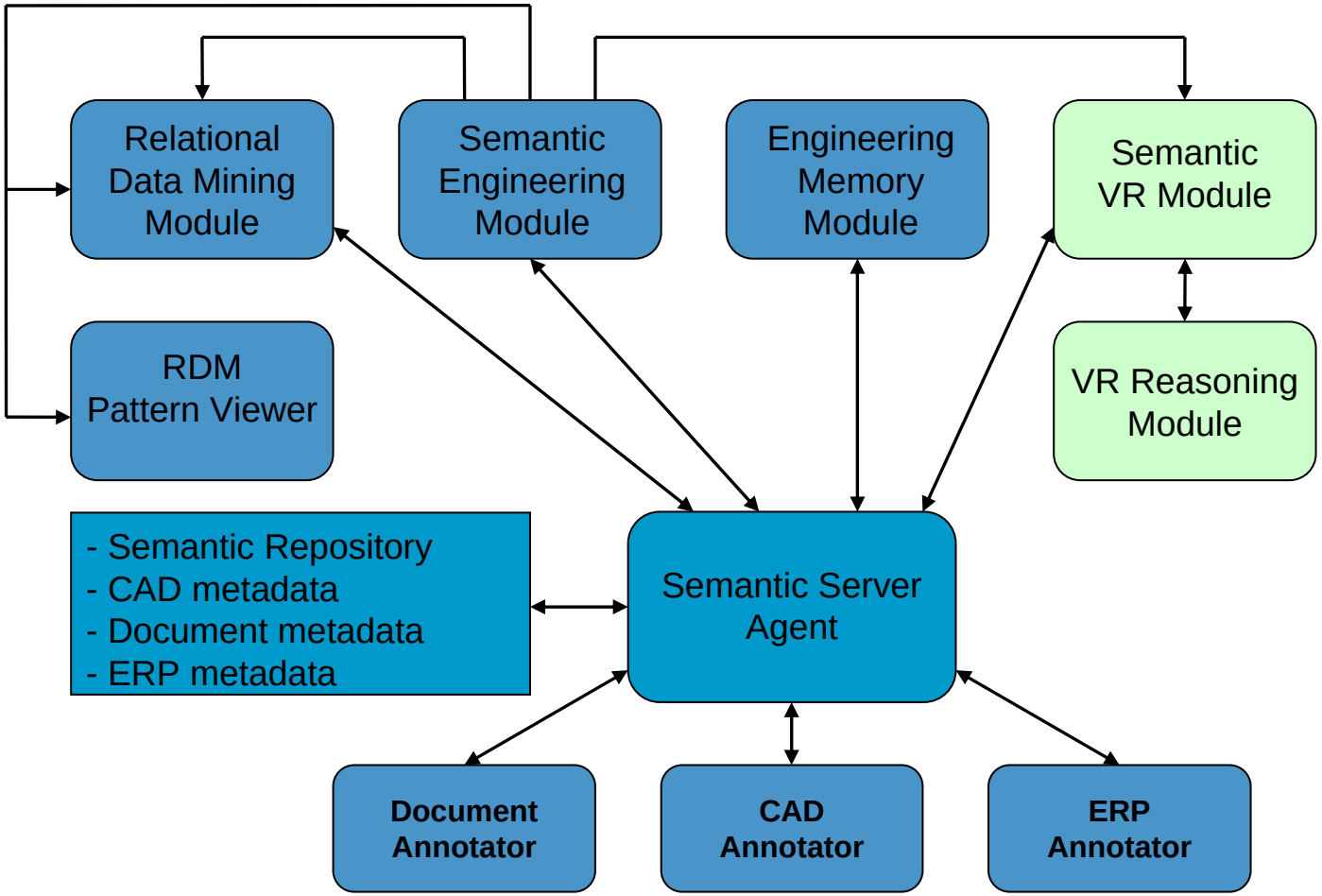
Figure. Product/Service related knowledge

- Product definition specific for each company: ontologies
- Important knowledge ”hidden” in proprietary format files

Outline

- Semantic Virtual Engineering Environment
- Introduction to Virtual Reality (VR)
- Semantically Enhanced VR interaction
- VR Reasoning
- Results and conclusion

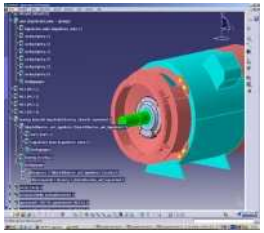
Semantic Virtual Engineering Environment

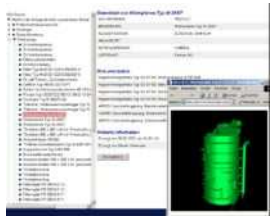


Introduction to Virtual Reality

Design Review
- Engineering
- Manufacturing/ assembly
- Maintenance

Functional Test
- Mechanics
- Electronics
- Control

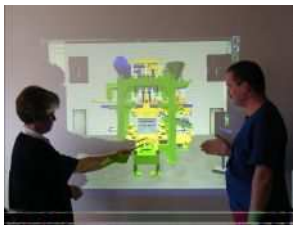




Technical Documentation
- Visual-interactive catalogs
- Electronic manuals

Maintenance
- Assistant systems
- Visual-interactive repair instructions

Virtual knowledge base

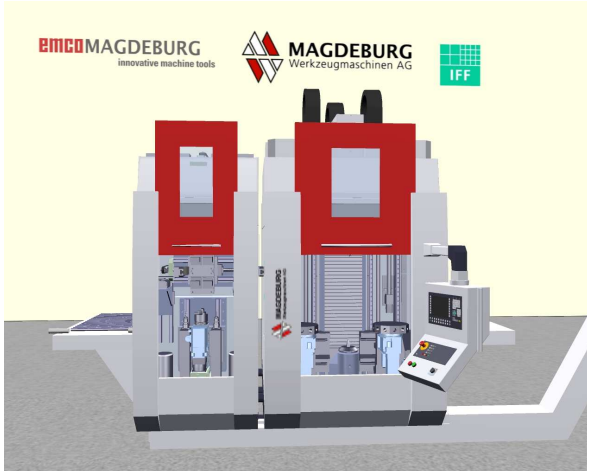


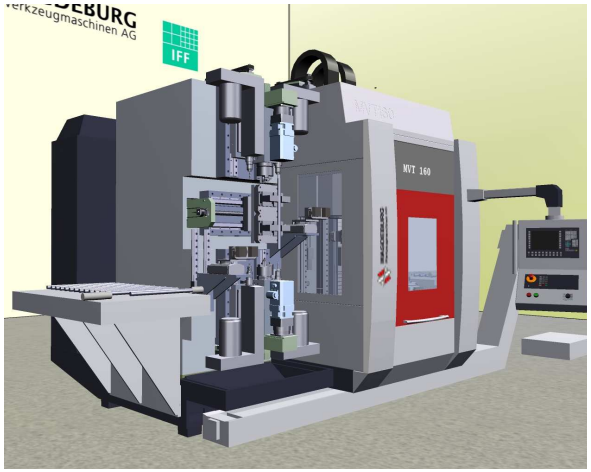
Education and Training
- Technical staff
- Operation service
- Assembly service

Factory Planning
- Layout planning
- Process planning

Job Preparation
- Work scheduling
- Resource optimization
- Logistics functions

Introduction to Virtual Reality



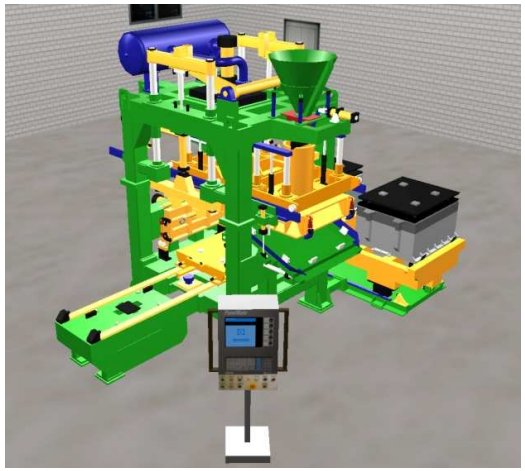


- **Options of a module building set for complete machining of undulated parts**
  - Platform with max. 4 supports
  - Possibility of process combinations and simultaneous machining – throwing, milling, drilling, grinding and finishing
  - Variable process strategy through random chaining of several machining modules
- **Example**
  - Interactive 3D-Visualisation of machining tools including of machining sequence
  - Support of the sales department through visualisation of different machining tool configurations and detailed presentation of operating modes

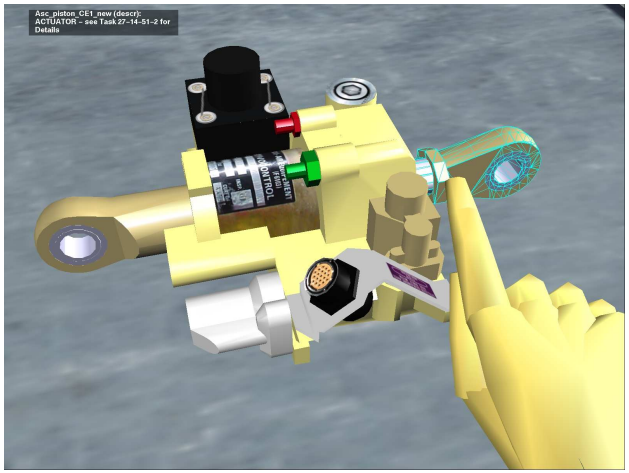
Introduction to Virtual Reality

Training with Virtual Reality

- Less dangerous
- Independent from the availability of the machine
- Individual and focussed training
- Training for maintenance, assembly and disassembly of machines
- Sample training scenarios:



Core Shooter



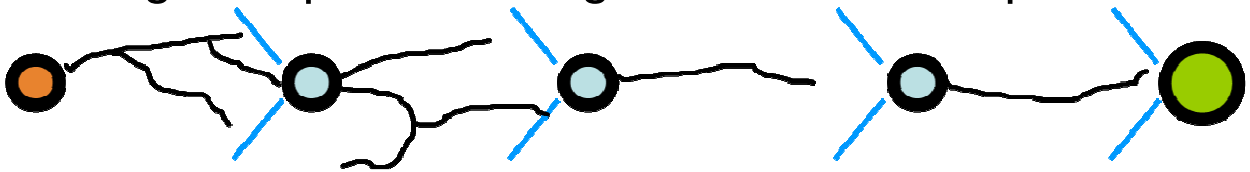
Aileron Servo Control

Introduction to Virtual Reality

Organization of a virtual Training

- **Presentation mode**
  - Navigation through procedure steps; sequence of steps

- **Guided Mode**
  - Solving a step task through interaction; sequence of steps



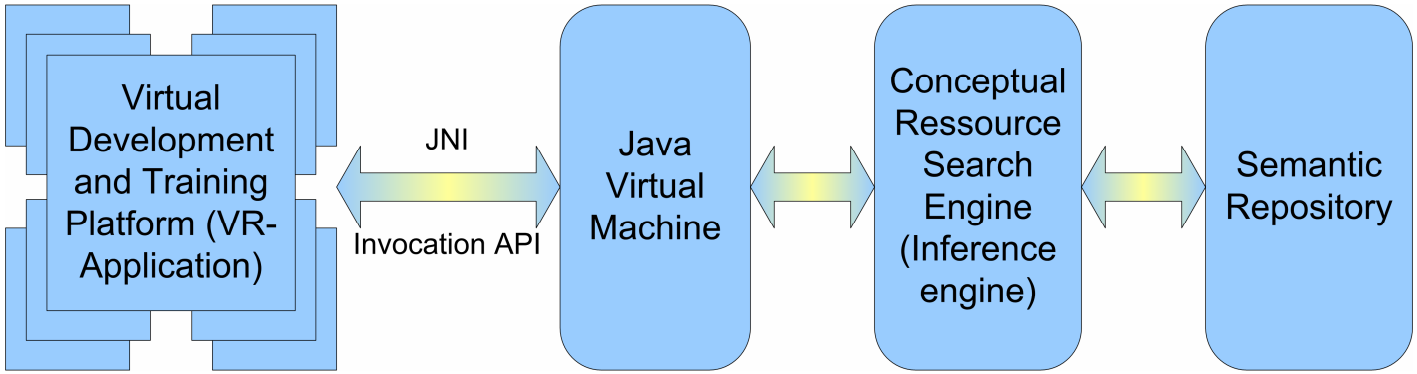
- **Free Mode**
  - Solving a task as a whole without a given step order

Introduction to Virtual Reality

- **Concentrate on raw geometry data**
  - Visualization of 3-D scene
  - Knowledge representation for structure and procedure
  - Preliminary relation between VR-scene and related documents
  - No relation to a knowledge base
- **New challenge within the project**
  - Access to knowledge base (intuitive, contextual, scalable,…)
  - Visualization of data retrieved from knowledge base
  - Methods to enrich the VR Scenarios by means of a semantic engine.
  - Combine raw geometrical information with product related meta-information

Semantically Enhanced VR interaction

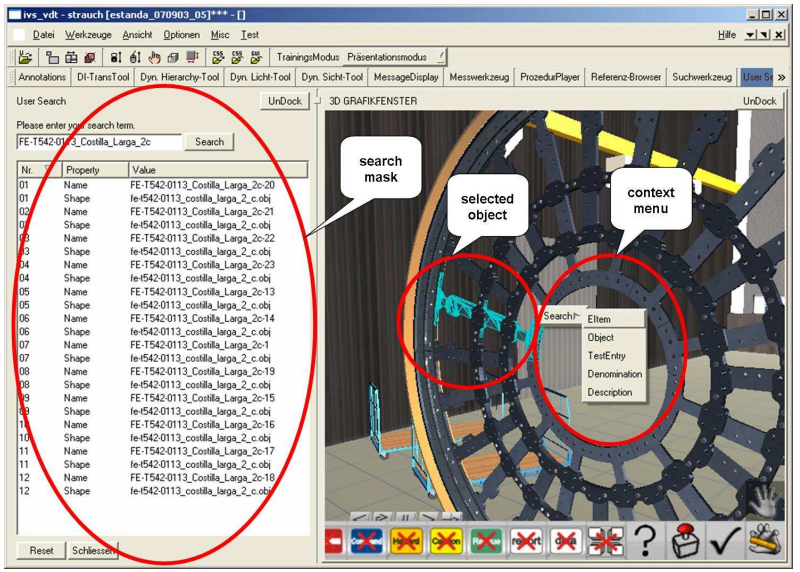
- Literature is devoid of any examples of combined semantic technology and virtual reality
- Embedded inference engine into the VRM for rule-based access to the semantic repository

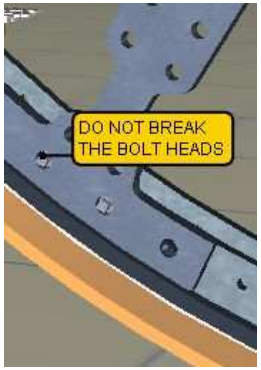


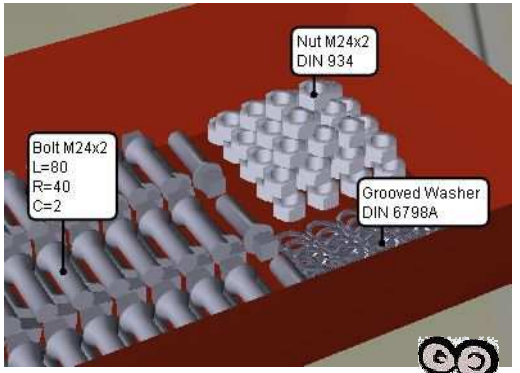
- Query service translates user requests into a semantic query expressed in SPARQL
- Several query templates executable in different VR scenario states

Semantically Enhanced VR interaction

- Interactive search within a VR scene by means of context menu and search mask like
  - Retrieve all EItems whose code is ”PG” and creation date was between 01/01/06 and 05/31/06
- Using 3D text elements - Labels - Another way to intuitively search and displaying of EItem-related information covered in the knowledge base directly on VR objects







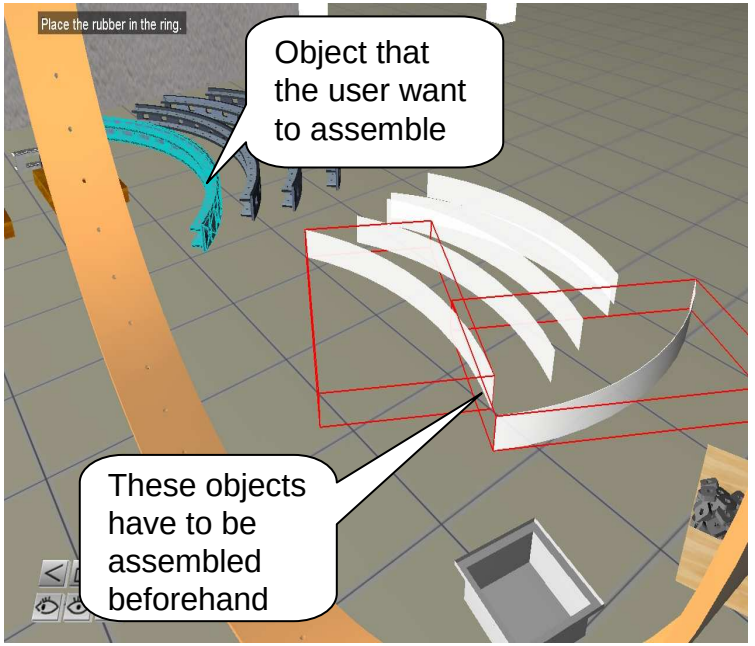
Semantically Enhanced VR interaction

- Inference engine behind the VR scenario take care of rules and constrains for assembly and disassembly procedures
- Governing of object behaviour by mean of VR reasoning
- **Example**

  Obtain a decision about the mountability of a part
  - User intents to assemble the first part of the base

    ⇒ it is not possible in current scenario situation
  - VR reasoning module returns a list of the objects, that have to be assembled beforehand

    ⇒ highlighting of objects in VR scene



Introduction to Reasoning

- **Reasoning objectives**
  - enrich knowledge base (ontologies/instances) contents
  - enhance query retrieval capabilities
- **Two approaches used for VR**
- **Information retrieval-based reasoning**
  - increase user-awareness of VR scene
  - using *SPARQL queries*
- **Inference rule-based reasoning**
  - add property to resource
  - classify resource
  - using *RDF/OWL Rules*

VR reasoning examples

Information retrieval-based reasoning

E.g.: complete VR scene with knowledge queries (SPARQL)

Which screw parts are not yet assembled?

```
SELECT * WHERE {
       ?x rdf:type c:Screw
       ?x c:isMember c:Door
       OPTIONAL {
              ?x c:isAssembled ?nut
       }
       FILTER (! bound(?nut))
}
```

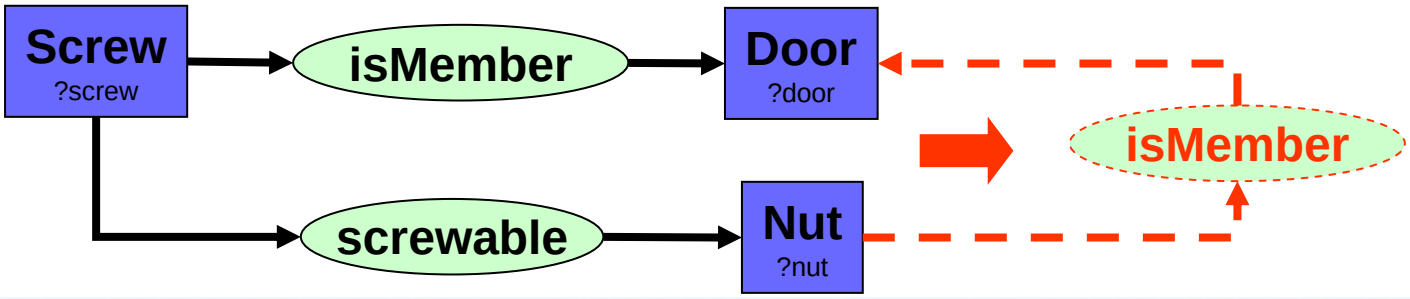
VR reasoning examples

Inference rule-based reasoning (1/2)

E.g.: add property to resource (i.e. object)

IF screw with right thread is member of door and screwable to nut, THEN nut is member of the door

```
?screw c:isMember ?door
?screw c:screwable ?nut
→
?nut c:isMember ?door
```

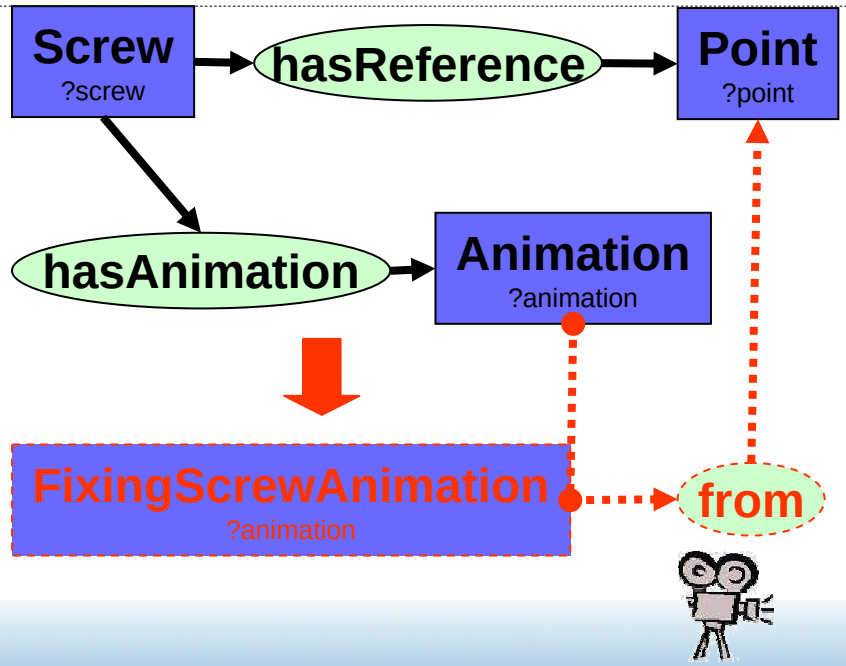


Inference rule-based reasoning (2/2)

E.g: classify resource (i.e. an animation)

IF screw has reference point and is animated, THEN a fixing screw animation is triggered

```
?screw c:hasReference ?point
?screw c:hasAnimation ?animation
→
?animation rdf:type
      c:FixingScrewAnimation
?animation c:from ?point
filter(
  triggerAnim(?screw, ?point))
```



Results and Conclusion

- Use of generic product engineering ontologies to integrate information from heterogeneous engineering repositories
- Access information through Virtual Reality
- Retrieval of semantic data from virtual reality scenarios is based on a query mechanism for ontological data (SPARQL)
- Reasoning approach for the transfer of implicit knowledge
- User tests for evaluation of reasoning technology and improvements

