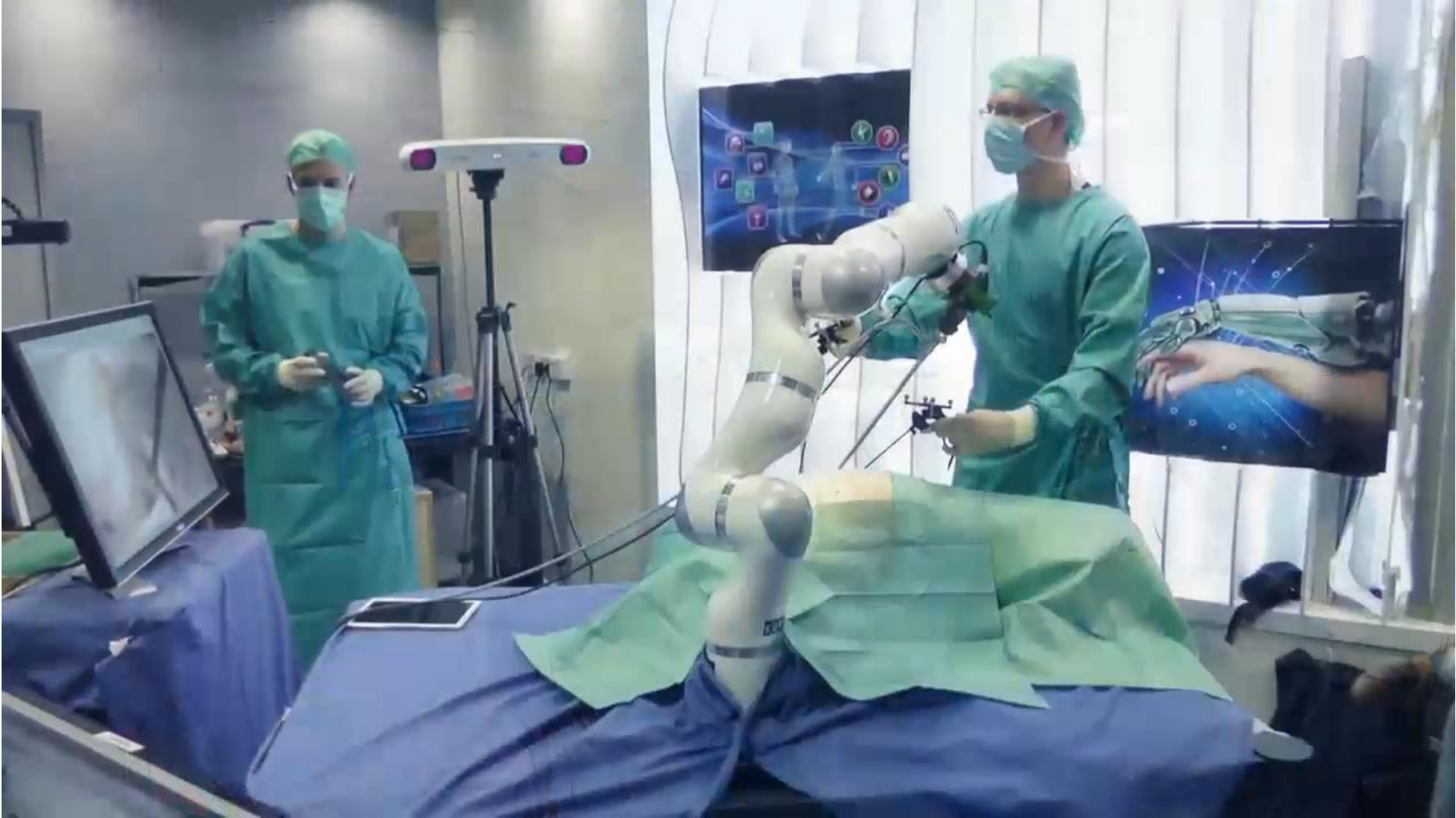


TOWARDS COGNITIVE COMPUTER AIDED ENGINEERING

Stefan Suwelack¹, Markus Stoll², Annika Meyer¹, Steffen Slavetinsky¹,
Manuel Serf¹, Nikola Bursac¹, Albert Albers¹, Rolf Bendl², Rüdiger
Dillmann¹ and Stefanie Speidel¹

¹Karlsruhe Institute of Technology

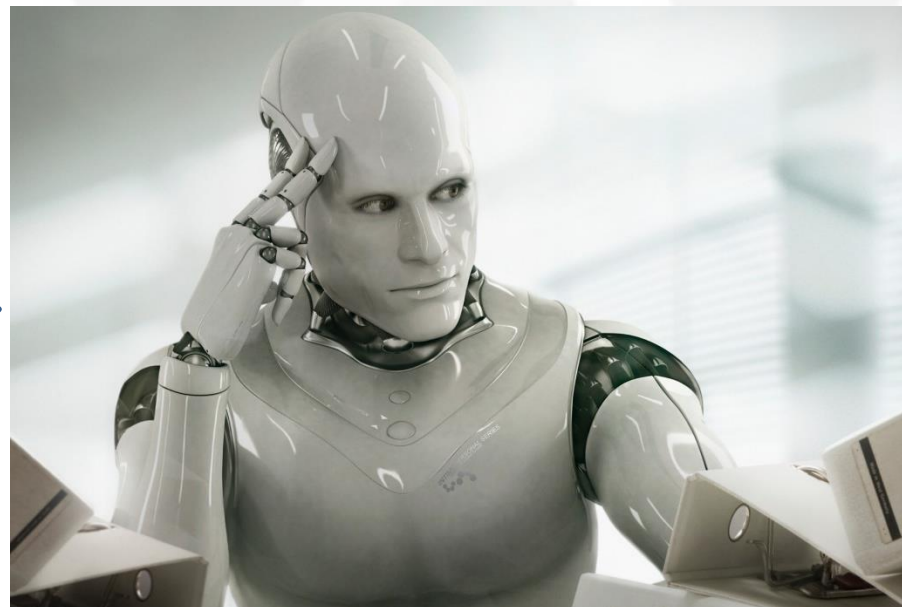
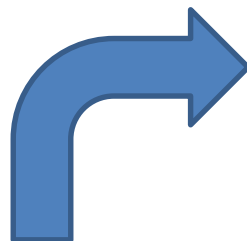
²German Cancer Research Center



Cognition-Guided
Surgery



Surgeon

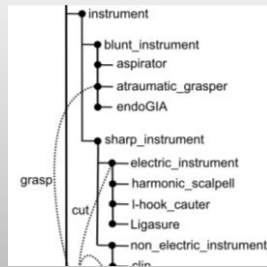


Cognitive
Surgical
Assistant

Knowledge Base

Factual Knowledge

Semantics



Type	User Factor	Possible observation values
Stent	Number of Stents	
	Material of Stent	Metal, Plastic, Others
	Date of Stent Implantation	
BD		
PTCD	Number of left side PTCDs	
	Number of right side PTCDs	
	Date of PTCD	
PVD	Type	PVE, PVE
	Location	Right, Left, Tri-sector
	Duration	Minutes, greater 3
Antibiotics	Complications	arterial embolization
	Antibiotics	
	Chemotherapy	Yes, No
	Radiotherapy	Yes, No
Neoadjuvant	Chemoradiotherapy	Yes, No
	TACE	Yes, No

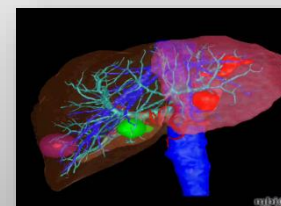
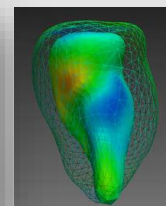
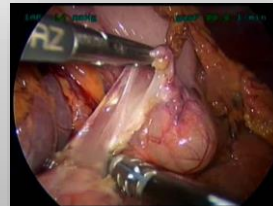
	resection_cystic_artery	mobilisation	start	dissection	closure	drain	resection_cystic_duct	port_placement	resection_gallbladder
resection_cystic_artery	X						X	X	
mobilisation		X							
start	X	X	X				X	X	
dissection	X			X					
closure					X	X			
drain						X			
resection_cystic_duct	X						X	X	
port_placement		X						X	
resection_gallbladder			X					X	



describes

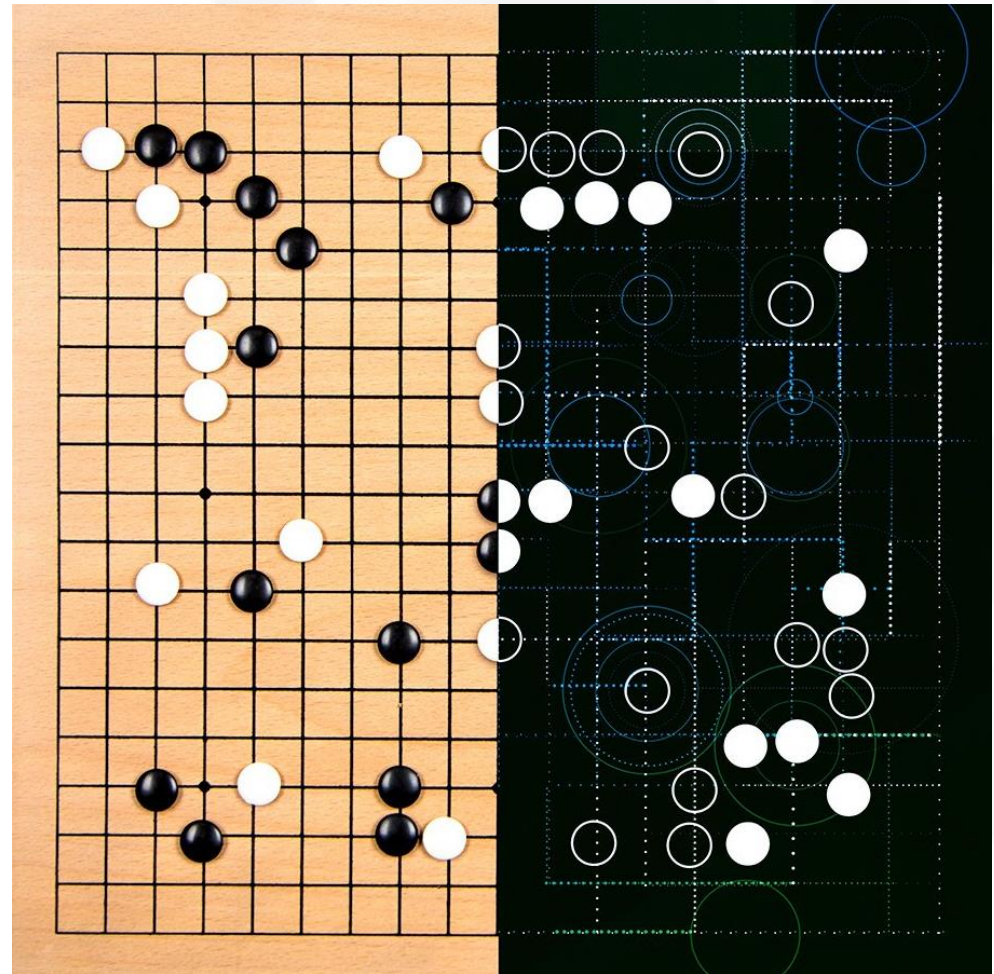
Experience

Data



Cognitive Computing

- Deep Blue 1997
- DARPA Grand Challenge 2007
- Watson 2011
- AlphaGo 2016

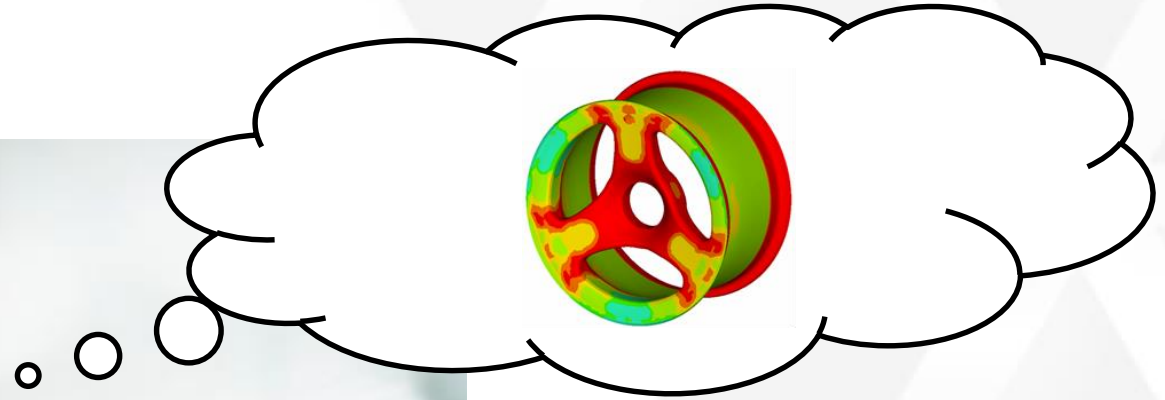
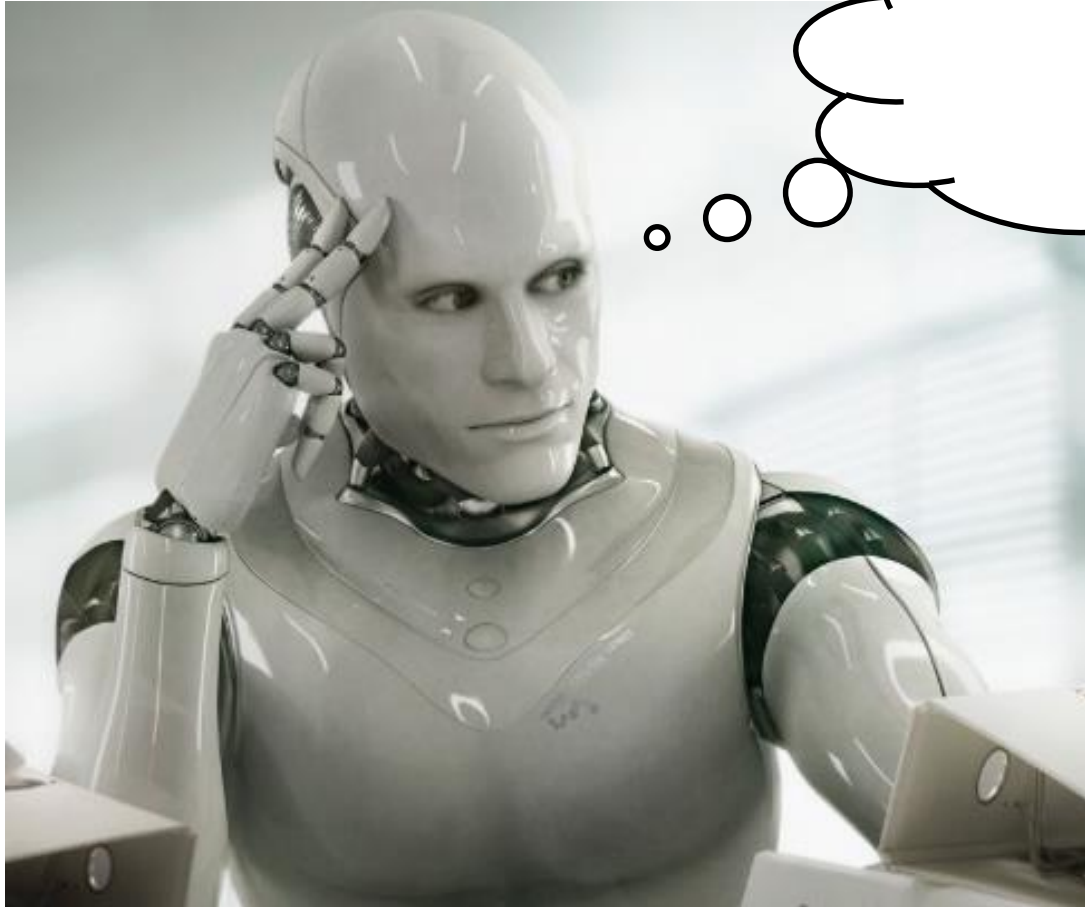


Cognitive Computing: Deep Learning



“Two pizzas sitting on top of a stove top oven”

Vision: Cognitive Simulation Assistant



Challenges in CAE

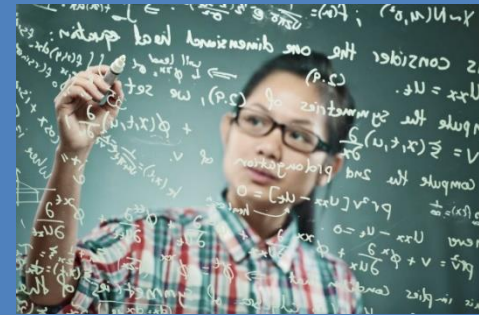
License Cost



Hardware Cost



CAE-Experience



SaaS



CAE AAS

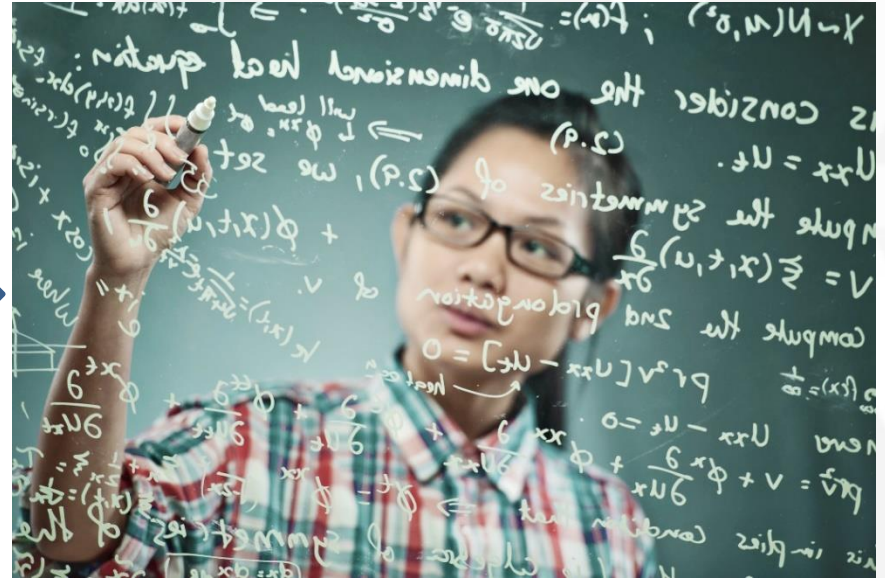
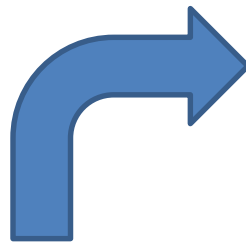


NUBERISIM

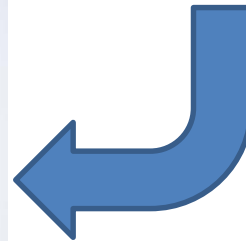
Cognitive Computing

CAD und CAE Today

Design-engineer



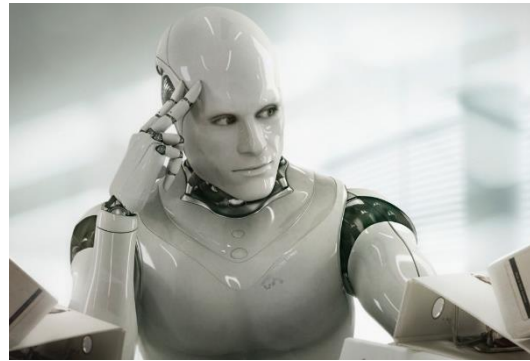
Numerical analyst



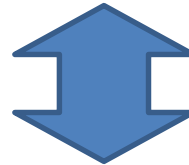
Cognitive CAE



Numerical analyst



Cognitive Simulation Assistant



Design-engineer

Simulation Apps I

The screenshot shows a web browser window displaying the Comet Spring Calculator. The browser address bar shows the URL: <http://webapps.cometsolutions.com/jsp-rasa/prefloc-rasap/option/redirect?uid=TEJ3FA83>. The page title is "Spring Calculator".

The interface is divided into several sections:

- Comet Logo:** "The performance engineering workspace".
- Spring Calculator:** A sub-header for the application.
- Design Specifications:** A section containing two sub-sections:
 - Specifications:** Fields for Target Price per Spring (\$), Coil Inner Diameter (ID), Ride Height Ratio, Spring Free Length (SL), Sump Pivot Pt to Lower Shock Mount (H1), Sump Pivot Pt to Wheel Center (H2), Angle of Shock Axis (alpha), and Corner Spring Weight.
 - Design and Production Parameters:** Fields for Spring Design Type, Material, Wire Diameter (Dw), Number of Active Coils (Nc), Hourglass Radius, Manufacturing Location, Production Number of Batches, Production Batch Size, and Post-Production Coating.
- Diagram:** A 3D rendering of a coil spring with labels: "Coil Inner Diameter (ID)", "Wire Diameter (Dw)", "Spring Free Length (SL)", "Hourglass Radius", and "Number of Active Coils (Nc)".
- Buttons:** "Calculate" and "Exit" buttons are located at the bottom of the design specifications section.
- Footer:** A zoom level indicator showing "100%".


Simulation Apps II

Geometrical Dimensions

Prong length: mm

Prong radius: mm

Base radius: mm


 Show Geometry

Find

Find prong length:

Target frequency: Hz


Computation

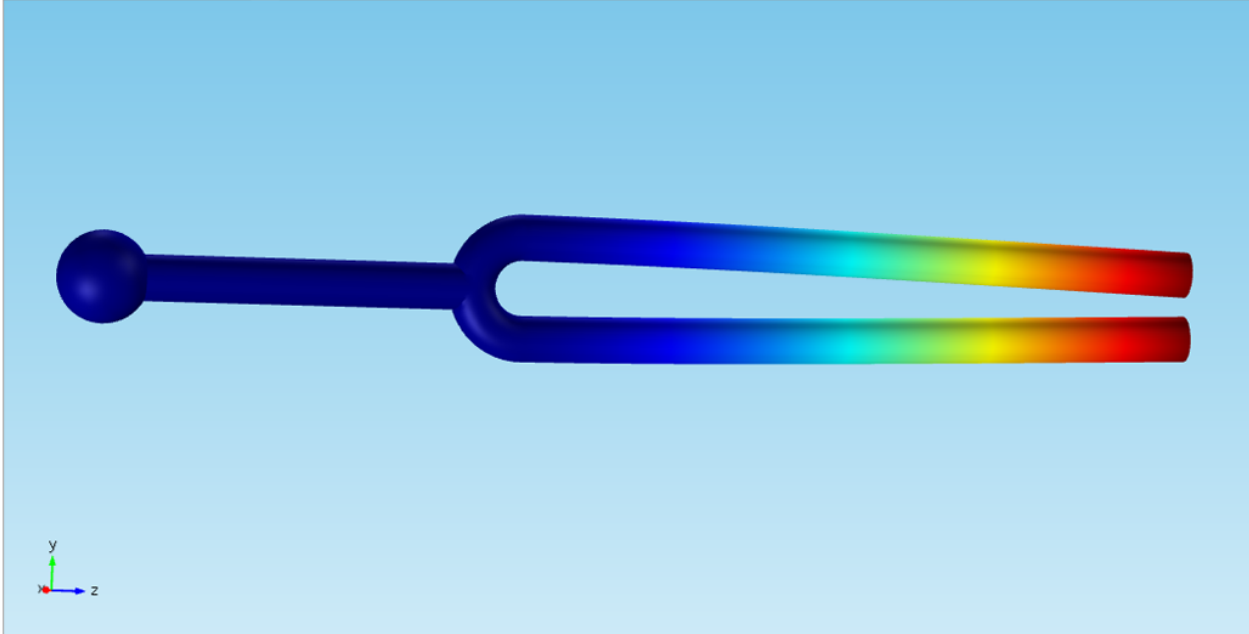
 Compute

Sound

Computed fundamental frequency: 509.9 Hz

Sound duration: s

 Play Sound



[About](#)


Generalized Cognitive Simulation App

Geometrical Dimensions

Prong length: mm

Prong radius: mm

Base radius: mm


 Show Geometry

Find

Find prong length:

Target frequency: Hz


Computation

 Compute

Sound

Computed fundamental frequency: Hz

Sound duration: s

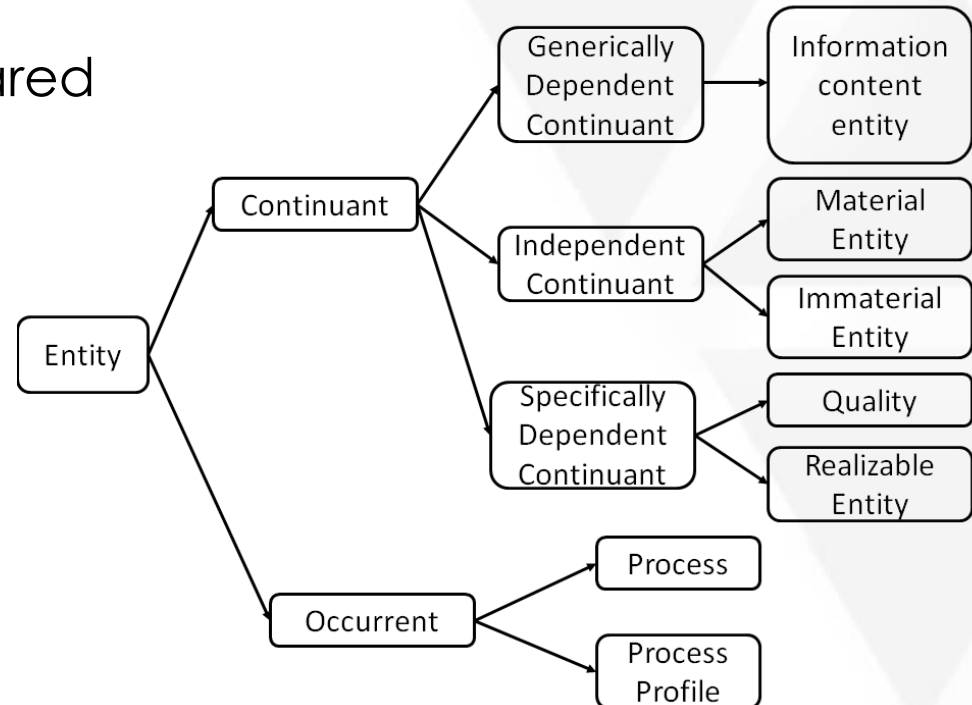
 Play Sound

Drop CAD file

[About](#)

Model Factual CAE Knowledge

- Philosophie: Study basic categories of being
- Computer science: Knowledge representation
- Compatibility through shared *Upper Ontologies*
- Well suited for data integration



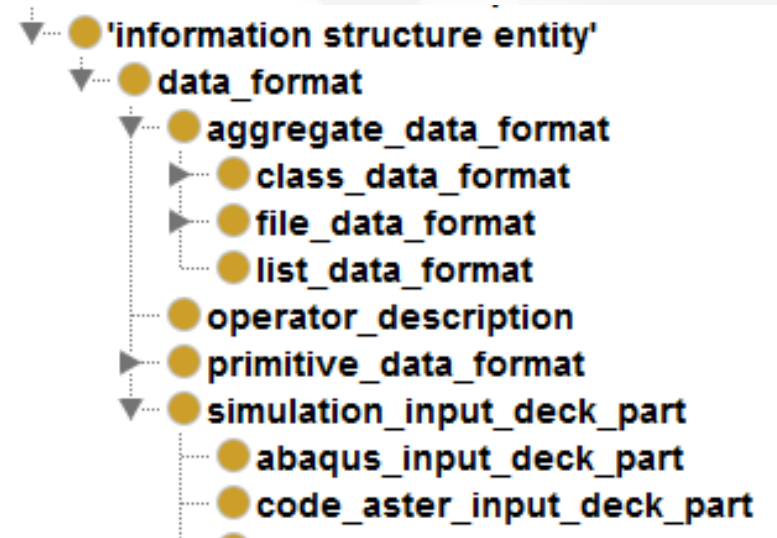
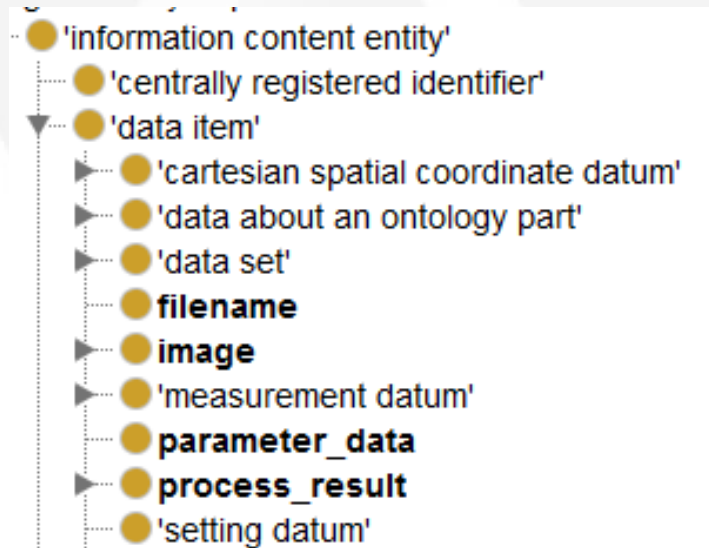
Data ontology

What is represented by the data?

- Information content entity

How is the data represented?

- Information structure entity



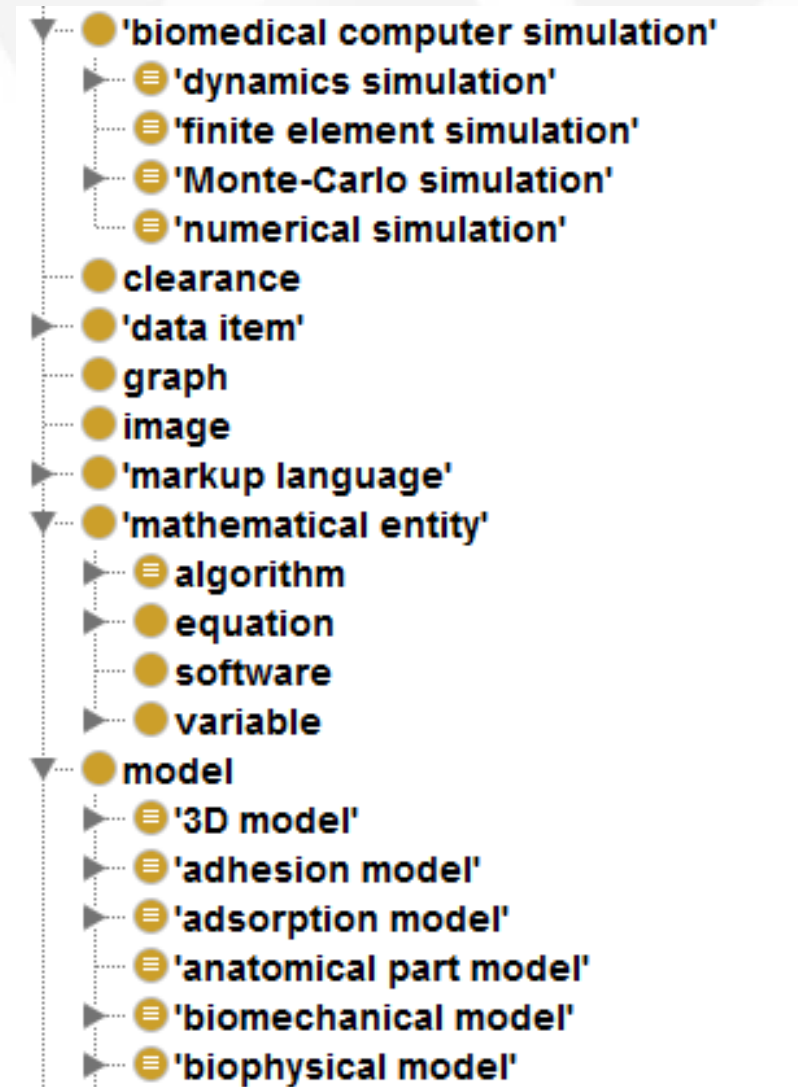
Algorithm ontology

- Draws on existing standards, e.g. OpenAPI model
- Based on data ontology
- Integrates different software modules and services
- Alternative representation by YAML/JSON

```
#version number of the specification file
caeml: "1.0"
#software module
module:
  name: TetgenVolumeMesher
  version: 1.0.0
  description: This module contains the i
  keywords: volume meshing, tetrahedral m
  contributors: Stefan Suwelack, Markus S
  #this is the software interface specifi
  api:
    type: PythonModule
    namespace: msml.ext.tetgen
    #option terms of service for web apis
    termsOfService:
  contact:
    name: Stefan Suwelack
    email: suwelack@kit.edu
    url:
  license:
    name: AGPLv3
    url: http://www.gnu.org/licenses/agpl
  externalDocs:
    description: Find more information he
    url: www.msml.org
  # here is the list of operators (i.e. alg
```

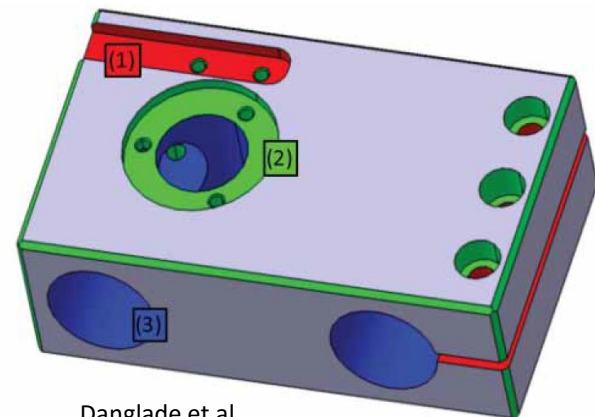
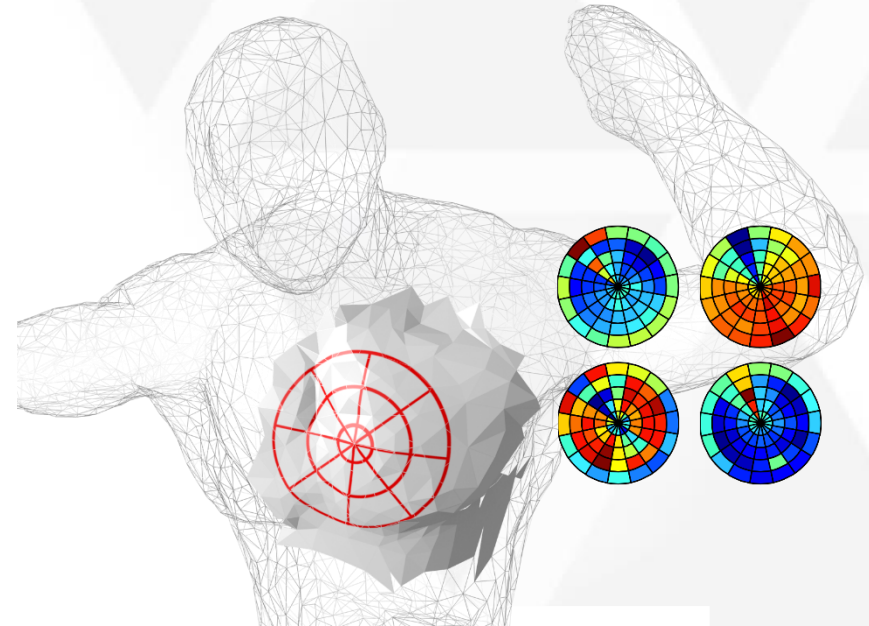

Simulation ontology

- Representation of simulation knowledge
- Models, boundary conditions, solvers...
- Based on existing work, e.g. HuPSON ontology, Step AP 209
- Workflow representation and simulation automatization



Current work: Learn from experience

- Semantic database of simulation data
- Use machine learning to extract knowledge
- Deep learning for shape understanding
- Enables: BC transfer, automate defeaturing, meshing etc.



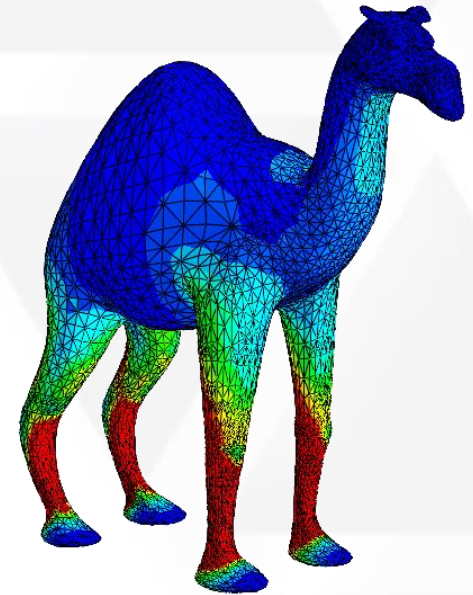
Danglade et al.



**Life is cheap.
It's the accessories that kill you!**

Computer Aided Engineering modeling language

- Semantics-based CAE middleware
- Interfaces, converters and runtime for CAE modules
- Simulation data management
- Open source license (autumn 2016)
- Vision: Help to create OSS stack for CAE



CAEML



openstack™

ROS



Open Source Robotics Foundation

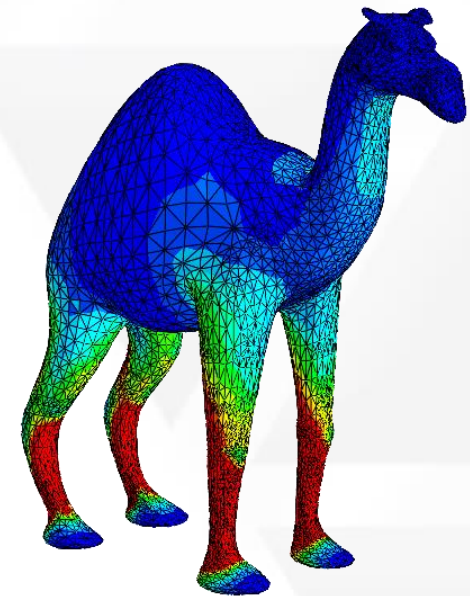
Computer Aided Engineering Modeling Language

CAEML Runtime Python API

YAML

Python Data API

Simulation Ontology



CAEML

CAEML core features

- Framework for data conversion
 - Data is represented as acyclic directed graph
 - Format conversion is graph matching
 - Easy creation of new convertes
- Definition of simulation workflows
- Runtime for simulation workflows
- Simulation data management

Applications

- Intuitive visual programming of simulation workflows
- Cloud-based simulation services
- Cognitive Computer Aided Engineering

Towards Cognitive CAE

Cognitive
Simulation Apps



Lifelong
learning,
data analytics

CAEML
middleware

Cognition-Guided
Surgery

