Development of complex Mechatronic Systems - Computer aided Conceptual Design

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Agenda

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- Motivation
- Approach
- Summary and Outlook

agenda

- motivation
- approach
- summary and outlook

SFB588 – Humanoid Robots in Karlsruhe

- **Objective of SFB588: Development of concepts, methods and concrete mechatronic components for a humanoid robot that can share its working space with humans**

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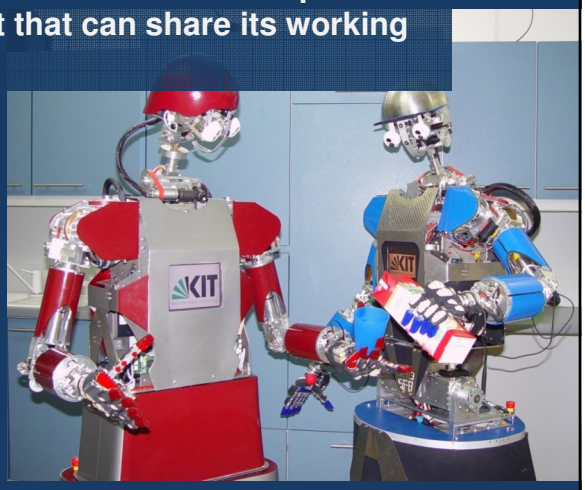

SFB588 – Humanoid Robots

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- **Objective of SFB588: Concepts, methods and mechatronic components for a humanoid robot that shares its working space with humans**

Example

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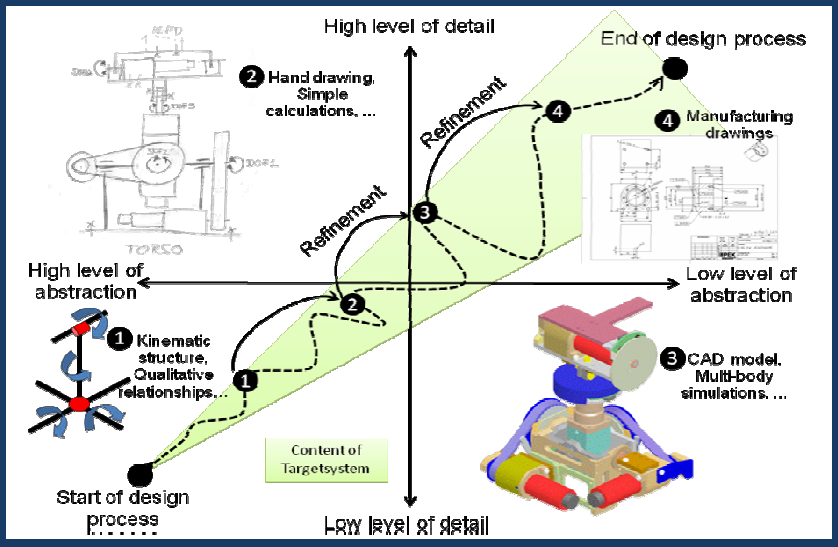
- Development of ARMAR IV-V
- no evolution but revolution (e.g. elbow)
- Application of approved components
- Multidomain development
  → high complexity
- How do we determine an “optimal” configuration?
- Additional Challenge:
  → fast determination of new optimal configurations after changed boundary conditions

Motivation: Typical Development-Process

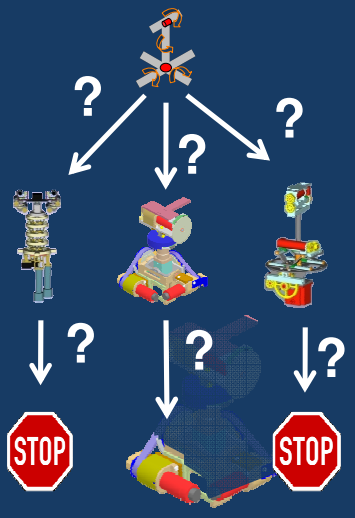


Motivation 2: Many possible Solutions

Development processes often include divergencies and iterations (fluctuating BCs)

Aims:

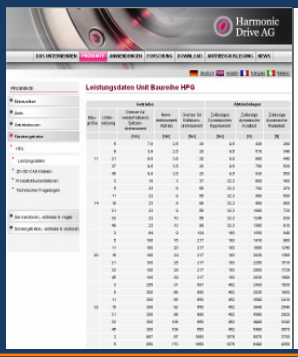
- (semi-) automatic configuration and weighting of (sub-) systems
- computer-aided optimization of generated configurations

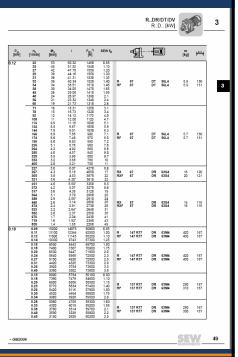


Motivation 3: Find suitable Components

- **Challenge:**
  - big number of catalogues with diverse structures
  - selection of suitable and foremost compatible components difficult
  - → diversity of solution hard to oversee
  - → Which one is the “optimal” configuration?

The Idea:
Computer-aided finding components and generation of suitable and compatible subsystems.





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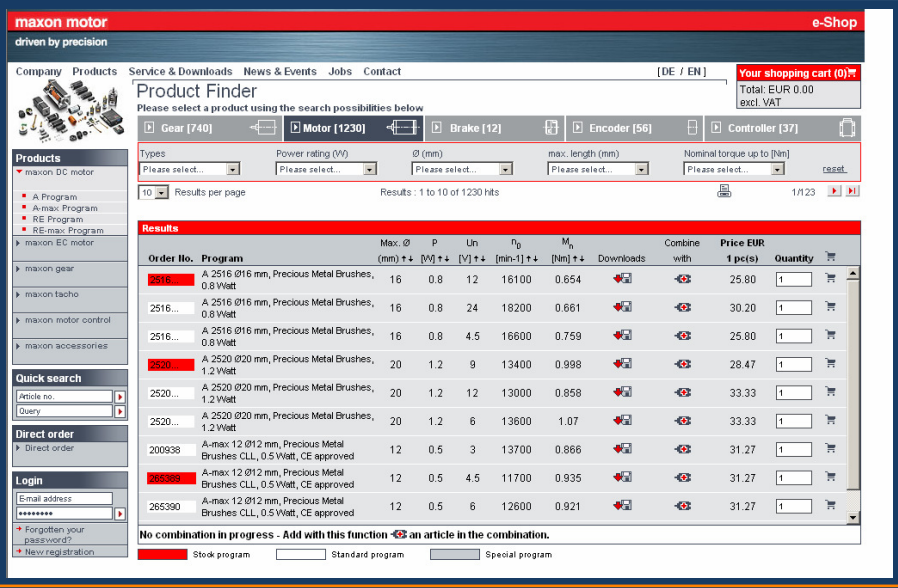
State of Technology



Conceptional Verification

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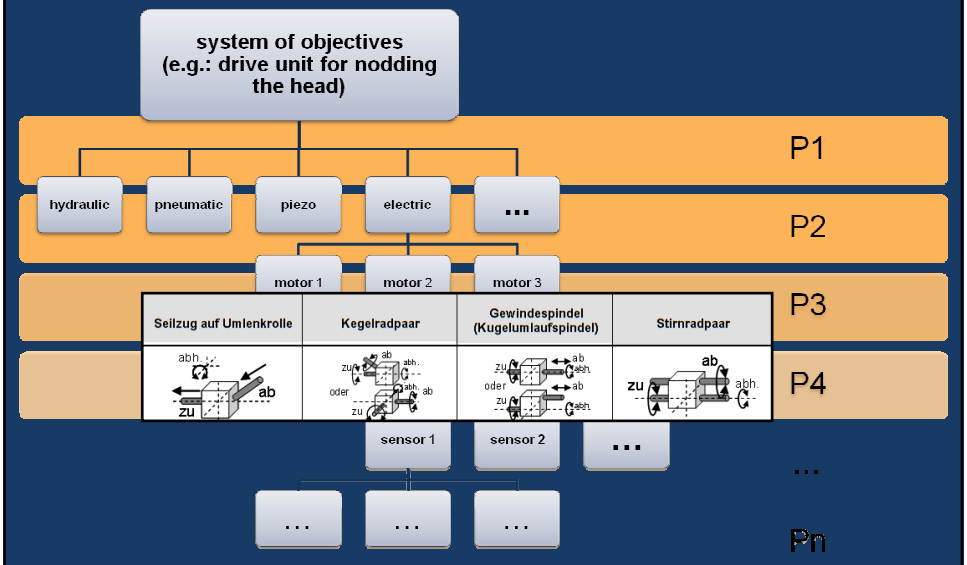
- Are there any existing configurations for subsystems, with which the requirements can be fulfilled?
- Are there configurations of subsystems, that are compatible to each other?
- **precondition:**
  All component parameters must be stored in a proper classification.

Approach

Two-stage method:

- **phase 1 – configuration phase**
  computer-aided selection of suitable configurations (not only components!) using standardized component libraries
- **phase 2 – optimization phase**
  computer-aided determination of free parameters (search of optimal configuration, placement of configurations within design space, …)

Phase 1: Configuration



configuration phase – library

- **precondition :**
  All component parameters must be stored in a proper classification: Excel-Sheet → XML

manufacturer	product id	torque	efficiency factor	dimension x	dimension y	dimension z	diameter	voltage
SEW	S/00102	10	0.91	45	90	177	4	24
SEW	S/00103	15	0.91	35	85	185	6	12
SEW	S/00104	20	0.89	34	93	105	6	12
SEW	S/00105	25	0.90	33	81	100	11	12
SEW	S/00106	30	0.85	31	99	193	12	24
SEW	S/00107	35	0.92	31	100	184	5	12
SEW	S/00108	40	0.93	35	84	106	6	12
Maxon	m-33541	35	0.82	31	85	178	10	24
Maxon	m-33542	20	0.86	45	88	137	8	12
Maxon	m-33543	15	0.85	32	100	150	2	12
Maxon	m-33544	10	0.87	38	94	181	10	24
Faulhaber	F14235	20	0.83	30	86	194	4	12
Faulhaber	F14236	23	0.79	32	94	137	9	12
Faulhaber	F14237	27	0.81	42	99	192	5	12
Faulhaber	F14238	32	0.81	31	95	175	7	12
Parker	512p	15	0.81	40	100	187	7	12
Parker	513p	12	0.76	43	87	196	5	12

Configuration Phase – Library

- **Precondition :**
  All component parameters must be stored in a proper classification: Excel-Sheet → XML

```
<root>
        <title> manufacturer</title>
        <parameter>
            <label> torque [Nm]</label>
            <value> 10 </value>
        </parameter >
        < parameter >
            <label> voltage [V]</label>
            <value> 24 </value>
        </ parameter >

    …
    </root>
```

Example: Elbow Joint

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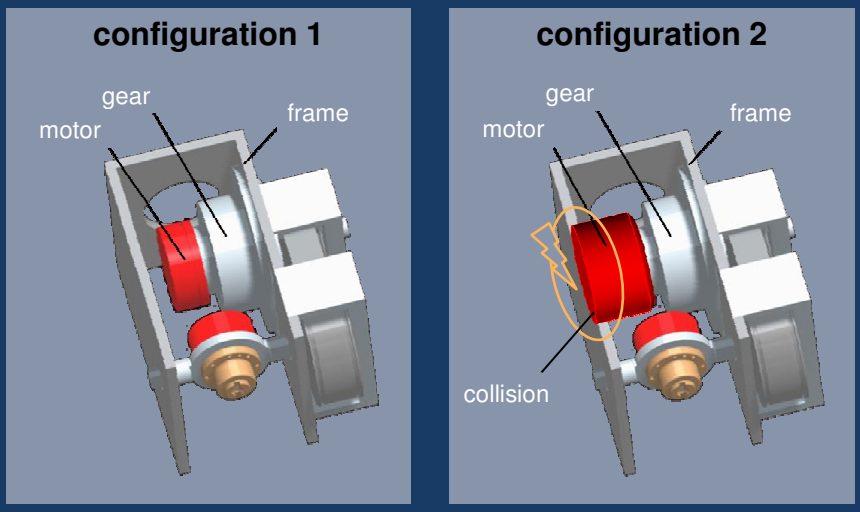

Phase 2: Optimization

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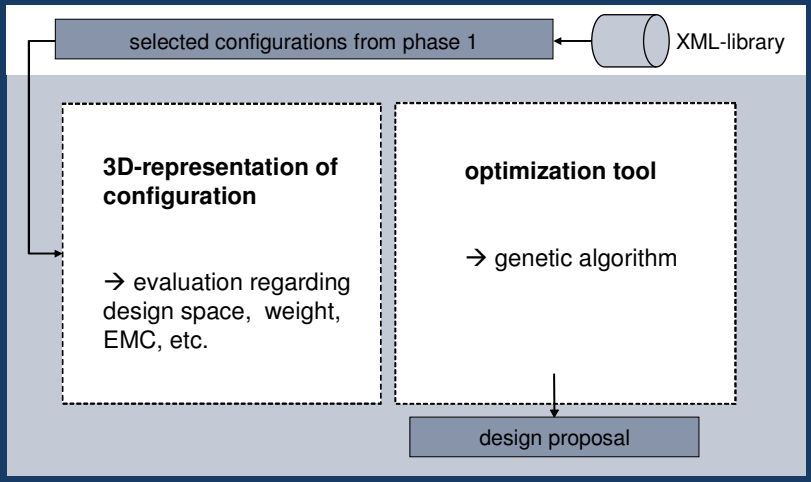
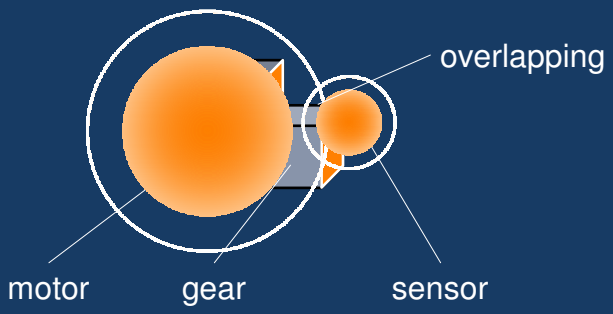
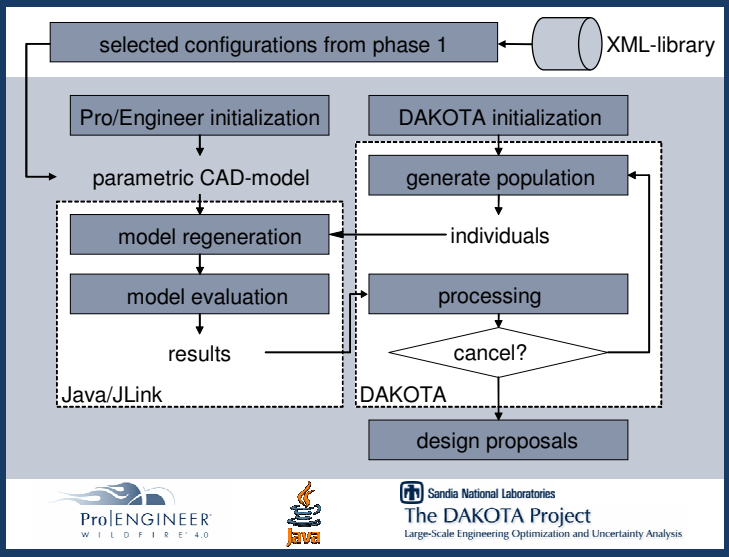


configuration phase / optimization phase

- **example: electromagnetic compatibility**
  - based on CAD-models including information regarding mechanical interfaces
  - automatic checking of diverse constraints
    → evaluation of configurations resp. concept



Implementation



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Summary and Outlook

- **Summary:**
  - Support configuration process using computer-aided methods
  - Reduce risk to forget possible solutions
  - Make sure to find optimal configurations
  - - Implementation still under progress!
- **Outlook:**
  - Integration of other software tools like Matlab/Simulink:
    - simulation and evaluation of dynamic behavior of entire system
    - exchange of CAD-Data between ProE Simulink via XML
  - Implementation as a completely automated process
  - Refeeding of already know solutions - integration in PDM-System