Robotics for Educational Purposes

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Overview

- Motivation and task setting
- Project objectives
- Implementation of the Solution: Hardware and Software
- Demonstration
- Summary

Motivation and task setting

- Lightweight robots like KUKA’ s iiwa play an increasing role in human-machine collaboration.
- Excellent kinematic features by means of 5 (7) joint servo drives facilitate filigree assembly applications.
- Security features with a high integrity level enables a parallel work flow between men and machine.

Project objectives

Toy model

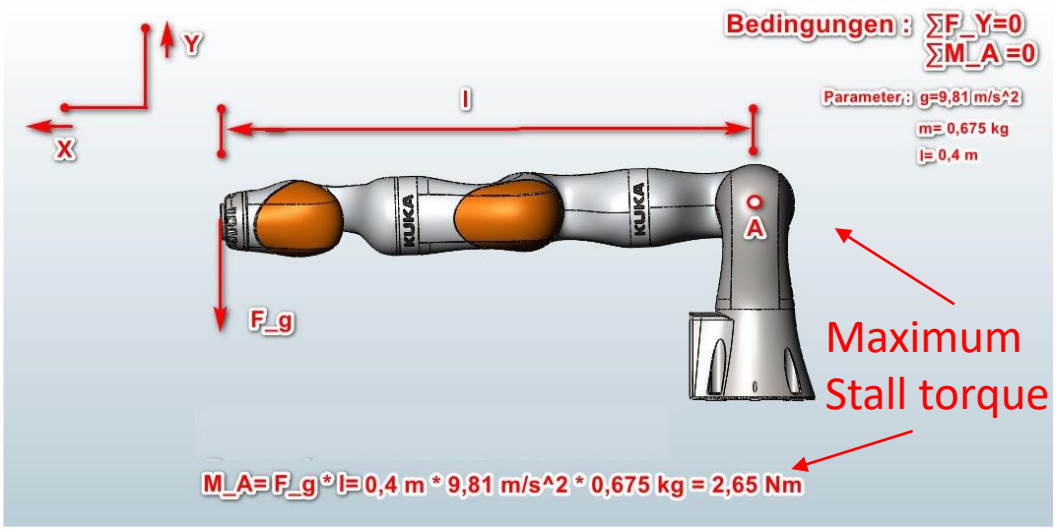
Robotic model for educational purposes

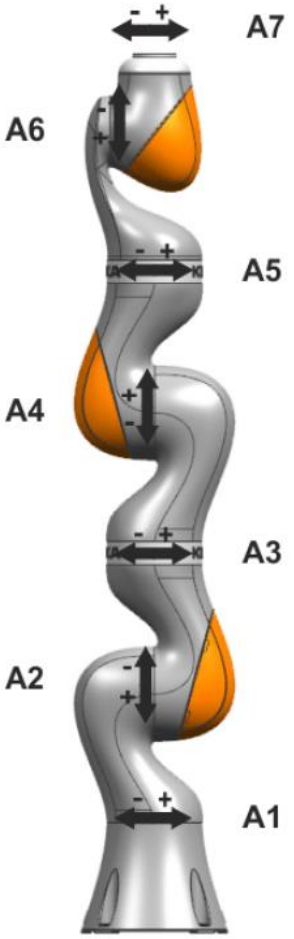
Original

- For teaching and demonstration purposes a downsized model is necessary with which fulfills certain requirements:
  - **Transportable**
  - **Reproducable** within the facilities of Kiel University of Applied Sciences
  - **Cheap** (less than 800€)
  - **Digitally controlled joint drives** with **identical kinematics** of the original
  - **Torque** and **security features** were neglected

Implementation of the solution

Downsizing model with a scale of 4:1



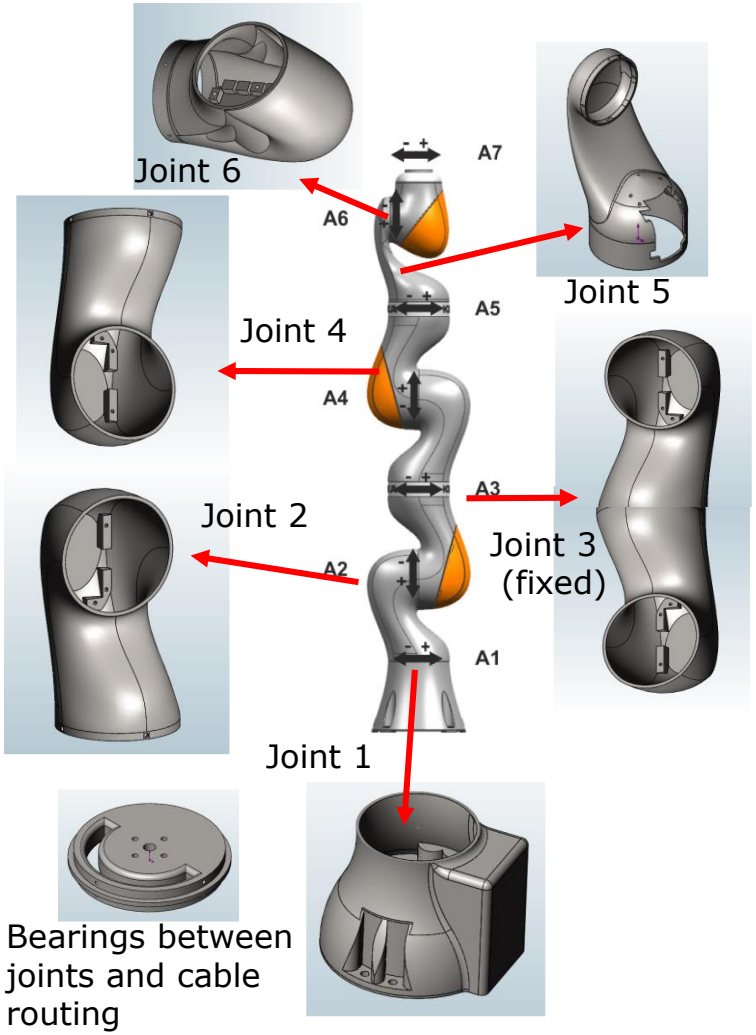


- Challenges:
  1) Plastic filament with minimum weight and maximum stiffness of body parts
  2) Integration of 5 (7) joints with electrical servo drives
  3) Digital position control of joint drives by means of a central computer

Implementation of the solution

Production: 3D-Printer

Material: Plastic filament

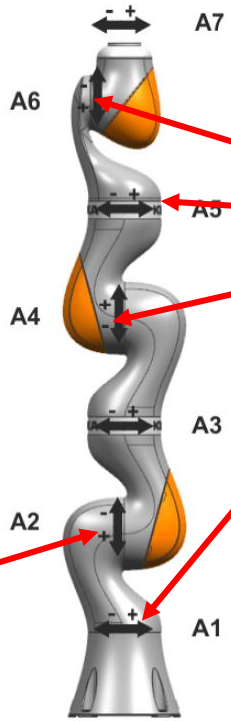


Bearings between joints and cable routing

Implementation of the solution

Usage of stepper motors with integrated hardware and one wire interface
(for daisy chain connection)

Supply voltage	10V - 14,8V
Torque	2,3Nm @ 11,1V 2,5Nm @ 12V 3,1Nm @ 14,8V
Size	35,6x50,6x35,5mm
Weight	72g
Resolution	0,088°
Speed	50min-1 @ 11,1V 55min-1 @ 12V 67min-1 @ 14,8V
Working angle	0° - 360°
Feedback	Position of the shaft, Temperature



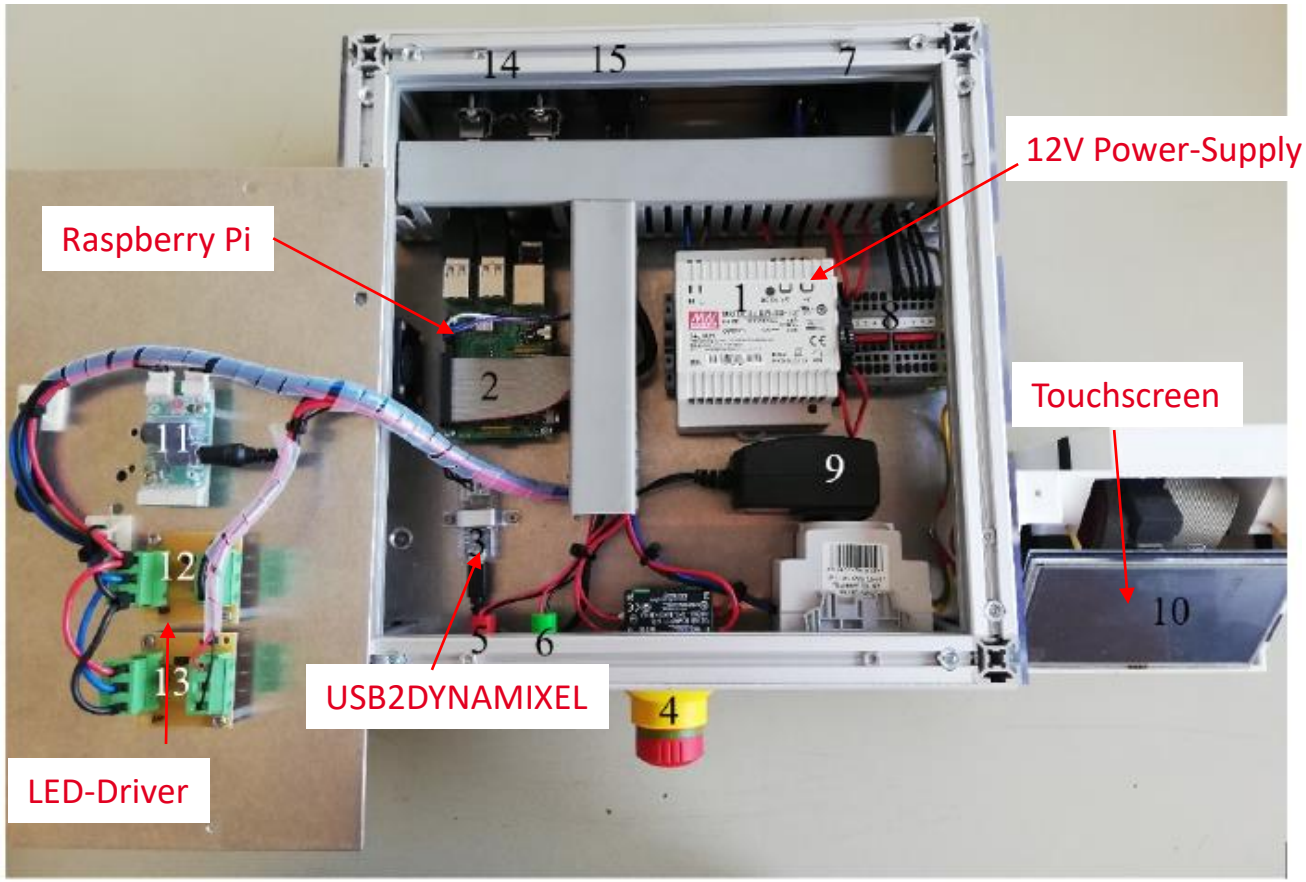
Dynamixel AX-15A

Dynamixel MX-28AT

Supply voltage	9V - 12V
Torque	1,52Nm @ 12V
Size	32x50x40mm
Weight	54,6g
Resolution	0,29°
Speed	59min-1
Working angle	0° - 300°
Material:	Plastic
Feedback	Position of the shaft, Temperature

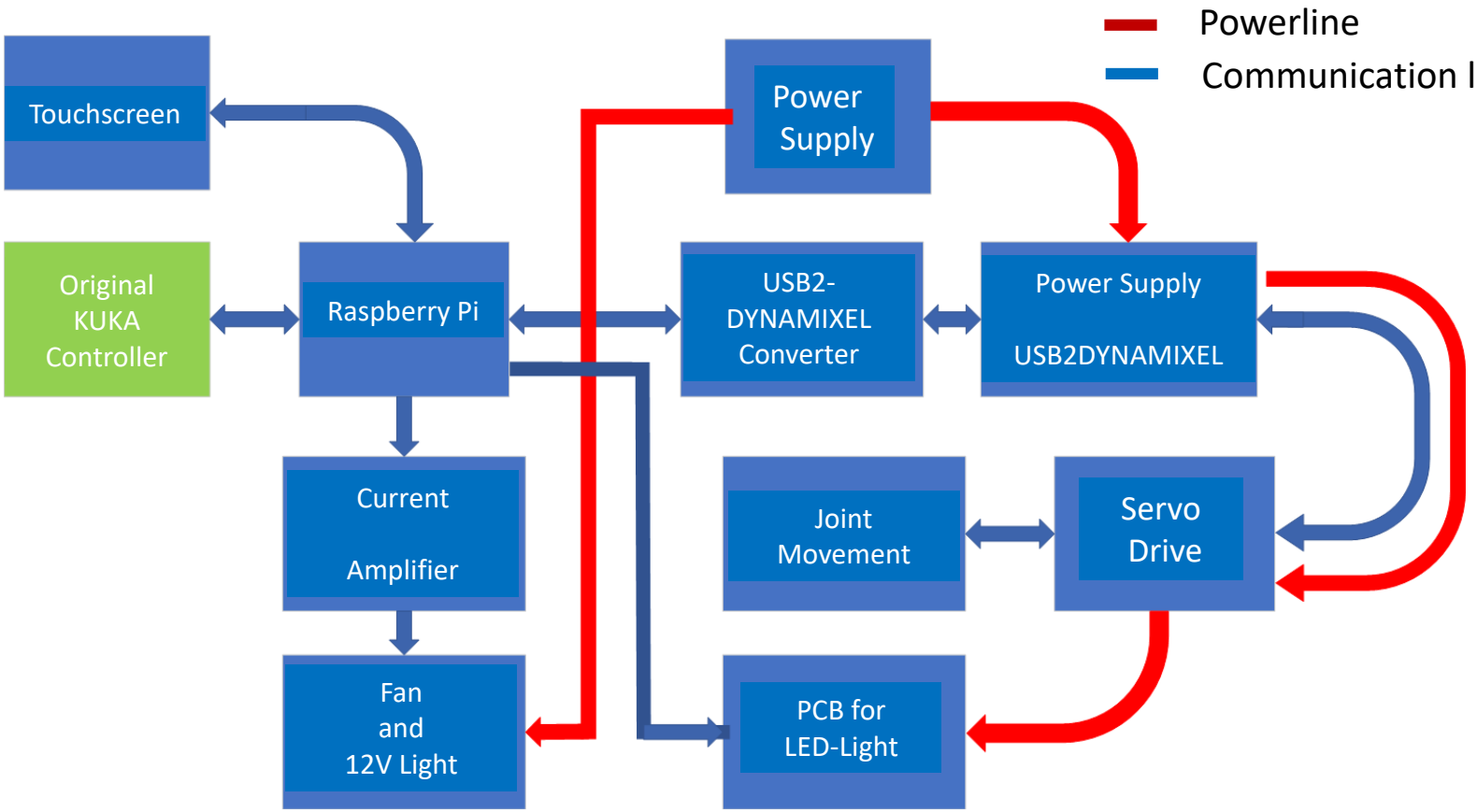
Implementation of the solution

Electric Setup (Power Supply, Computer unit, Touchscreen)



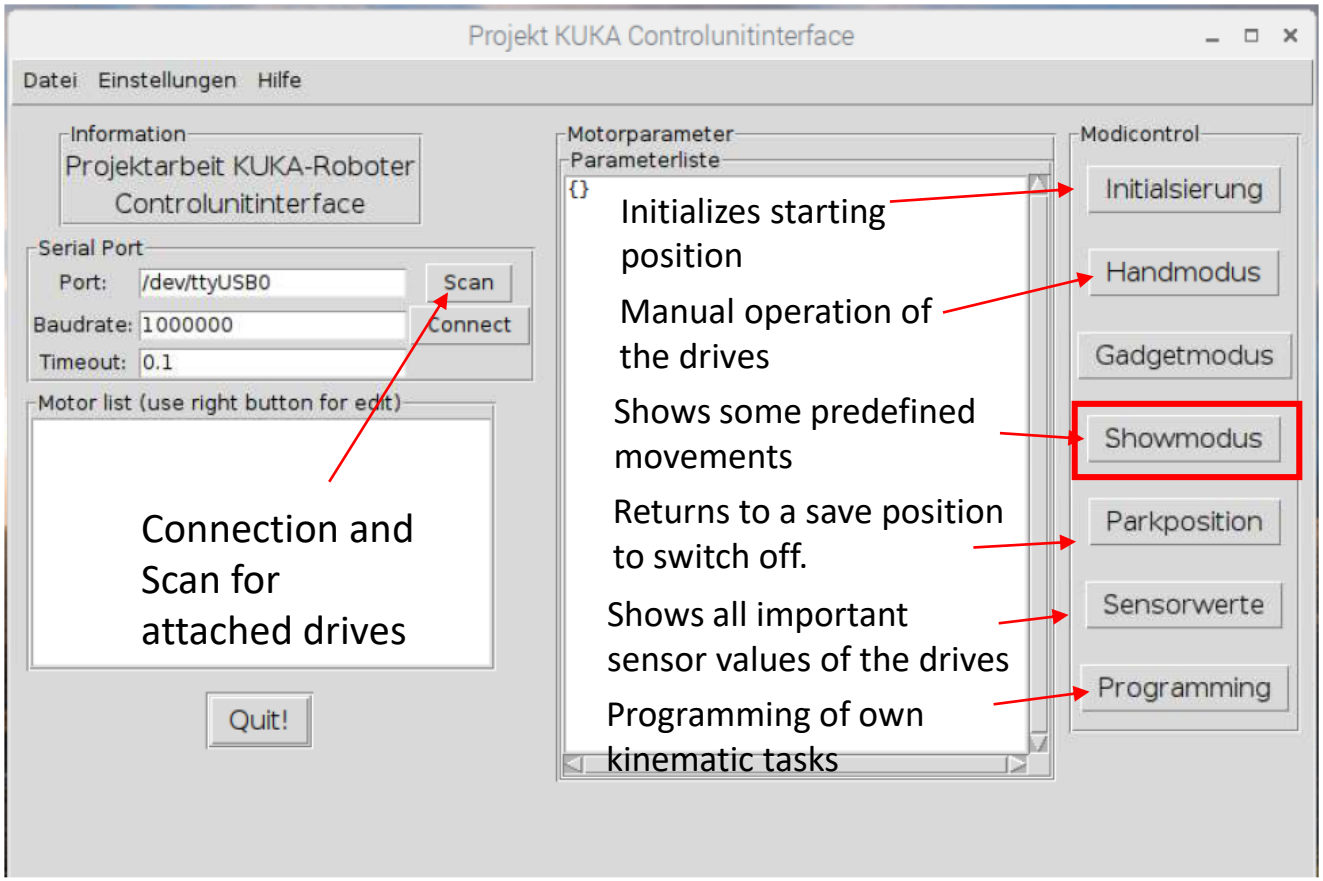
Implementation of the solution

Component Setup



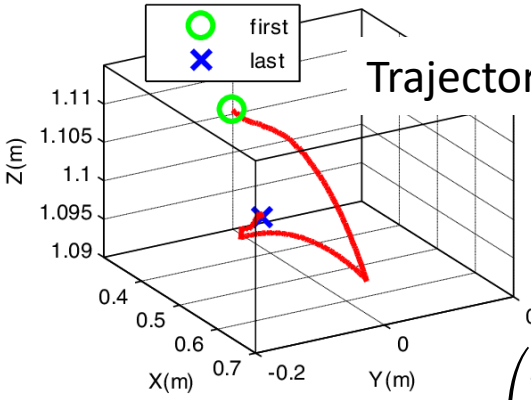
Implementation of the solution

GUI-with python 2.7



Implementation of the solution

Usage with the original KUKA Robot Controller

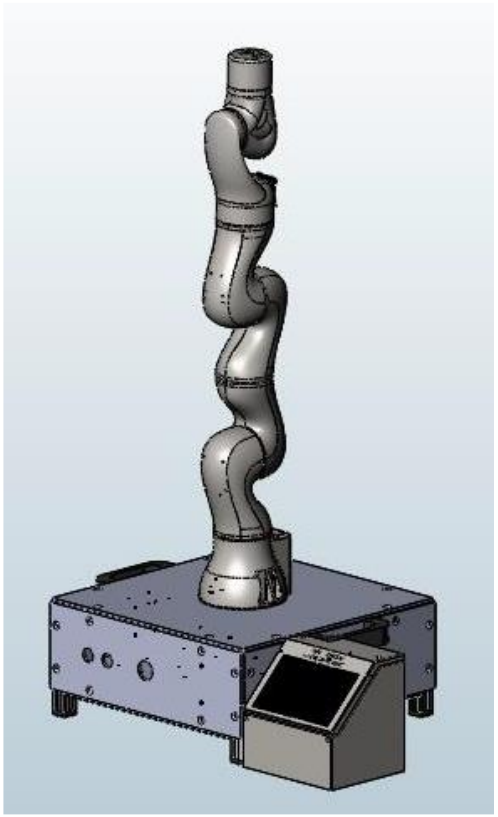


Trajectory plan

$$\begin{pmatrix} x(t_k) \\ y(t_k) \\ z(t_k) \end{pmatrix} \xrightarrow{Inverse\ Kinematics} \begin{pmatrix} \varphi_{Joint1}(t_k) \\ \varphi_{Joint2}(t_k) \\ \varphi_{Joint3}(t_k) \\ \varphi_{Joint4}(t_k) \\ \varphi_{Joint5}(t_k) \end{pmatrix}$$

KUKA Robot Controller

KUKA-Robot-Controller calculates The desired angles for each joint



Results

The Robot fulfills the most important requirements:

- Weight
- Kinematics
- Price
- Transportability
- Reproducibility
- Digital interface and control

Comparison real robot and model

Vergleich Original - Modell		
Werte	Original	Modell
Grunddaten:		
Size	1266x206x216mm	595x100x100mm
Weight	23,9kg	0,677kg
Axes - total - mobile - fixed	 7 7 0	 7 5 2
Rated load	7kg	0kg
Maximum range	800mm	450mm
Axis data		
Joint1	±170°	±150°
Joint2	±120°	±130°
Joint3	±170°	0°
Joint4	±170°	±150°
Joint5	±170°	±150°
Joint6	±120°	±130°
Joint7	±175°	0°
Costs		
Preis	100.000€	<1000€