LINK-SIC — Industrial Robotics

Ongoing master thesis projects at ABB Robotics

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AutoTune

Project goal: Investigation of how to tune the flexible model parameters for each joint in order to increase the precision of the tool.

Problems:

- Objective function
- Optimization
- Experiment design

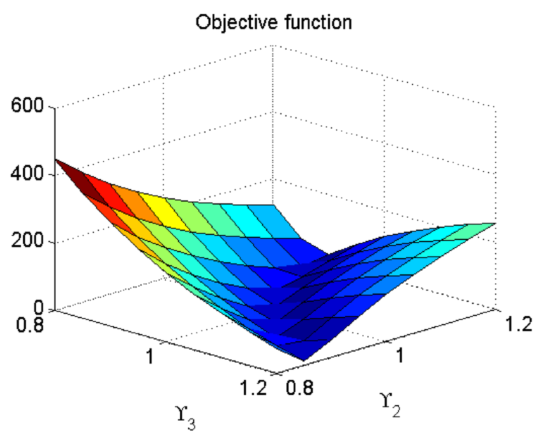
Approach: Investigate the dependency between joint two and three. First in simulations and then on a robot.

Objective function

The objective function is evaluated as

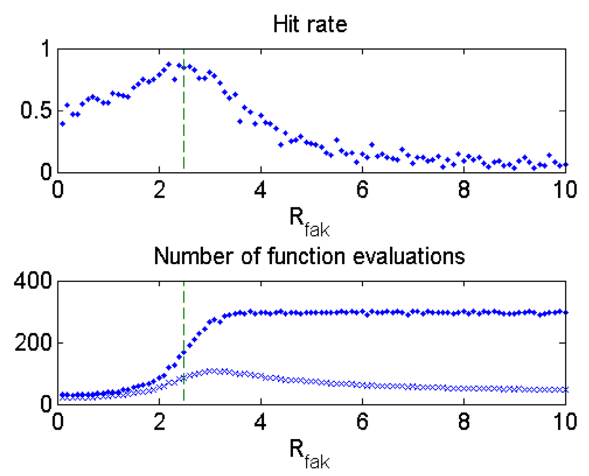
$$\frac{1}{N}\sum_{i=1}^{N}\sqrt{\sum|F(\tau_i(\Upsilon))|^2},$$

where N is the number of joints, $F(\cdot)$ is a low pass filter, τ is a sequence from the measured torque and $\Upsilon = [\Upsilon_1 \dots \Upsilon_N]$ are the tune parameters. The global optimum lies in a valley surrounded by several local optima which are easy to fall into.



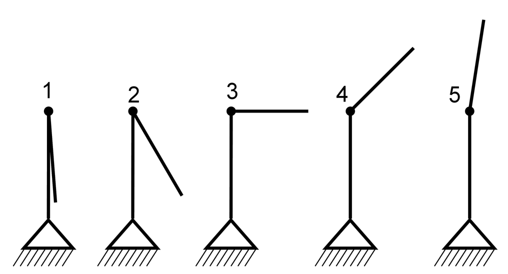
Optimization

A discrete optimization algorithm called Complex-RFD is used because it works well for objective functions based on noisy measurements. The algorithm is tuned so that it has a high hit rate and low number of function evaluations.



Experiment design

Five start positions have been tested and the main difference between these are the coupled inertia between the two links. The objective function varied between different start positions, movement lengths and directions of the movement.



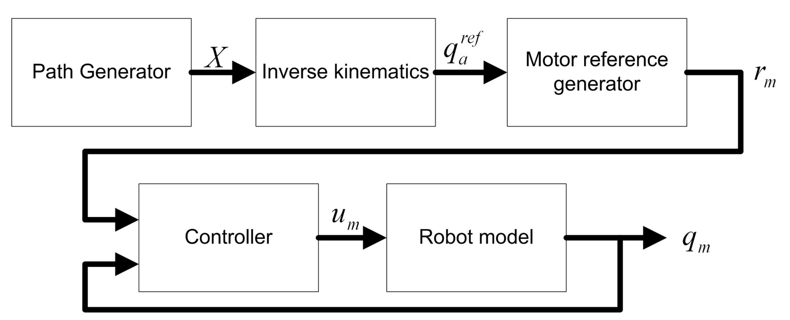
Project introduction

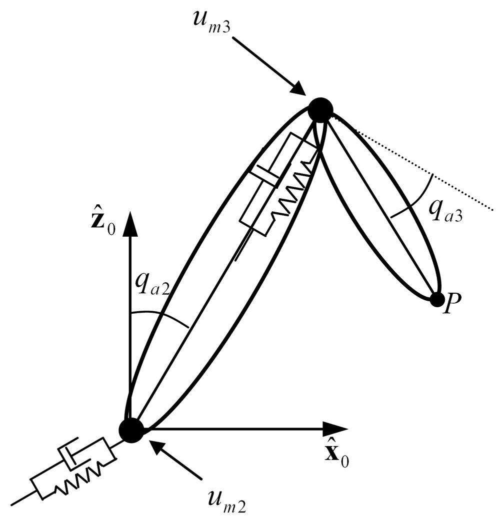
It is important to handle problems derived from model uncertainties and flexibilities in order to increase accuracy and performance. Two different approaches are being evaluated, both with the same goal to increase the performance of the next generation of industrial robots.

- **Autotune** is one approach which tunes several model parameters of an active deployed robot, to achieve better performance.
- **Sensor Fusion** is an observer-based approach which estimates the arm angles and tool position of the robot in order to increase accuracy and robustness against model errors and disturbances for various applications.

Simulation model

At first, both **Autotune** and **Sensor Fusion** have been evaluated in simulations using a two-axis flexible-joint (FJ) robot model with nonlinear flexibilities and friction. The model has been simulated in Simulink and the two approaches have been evaluated and developed based on the performance in simulations. At a later stage the simulation results will be verified on real data and measurements from an industrial robot.





Validation

A high-precision Leica laser system is used to validate the results. A laserbeam follows a crystal attached to the robot tool and the system measures the tool position in cartesian coordinates. These measurements are then compared to the results achieved by the two approaches **Autotune** and **Sensor Fusion**.

Sensor Fusion

Project goal: Achieve high accuracy and robust estimates of arm angles and tool position for a flexible-joint industrial robot

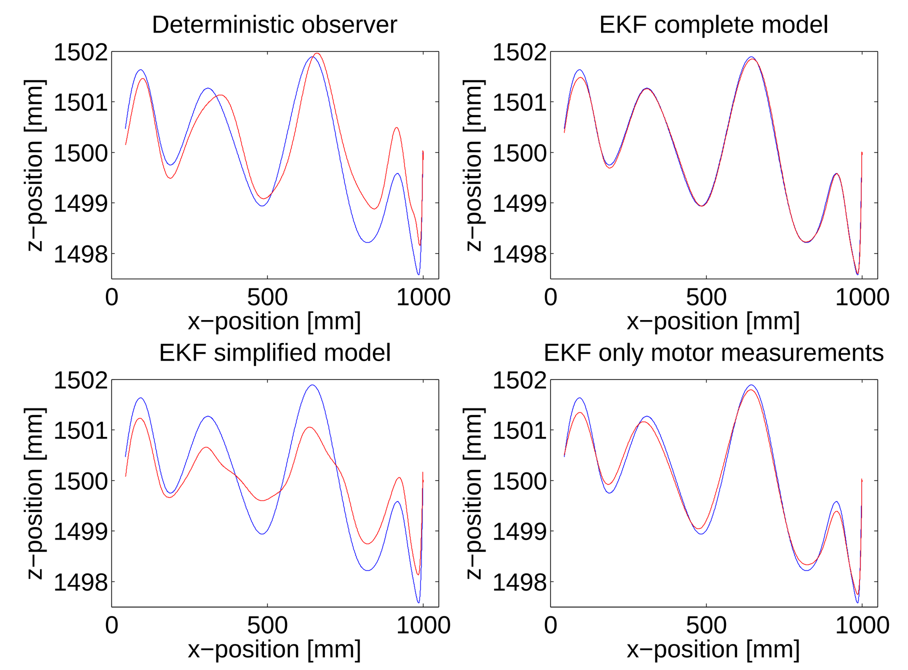
Problems:

- Disturbances and model errors
- External forces

Approach: Develop state observers which uses measured motor angles and the TCP acceleration measured by an accelerometer

Disturbances and model errors

Two different observer approaches have been developed. One deterministic approach which is very fast and with moderate accuracy, and one based on an EKF which delivers highly accurate estimates, but with a large calculation burden. The path-tracking performance of these approaches are shown in the figure to the right, including two additional EKF observers.



External forces

One important case is when an external force is applied to the robot. The figure to the right shows path tracking for the observers when a step force of $500N$ is applied to the TCP during 0.2 s.