

# Safety verification of industrial robots using hybrid systems



Technische Universität München



Fakultät für Informatik

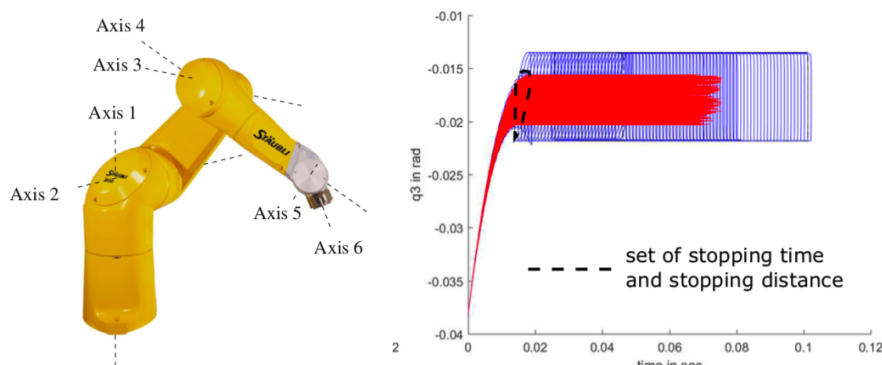
Lehrstuhl für Echtzeitsysteme und Robotik

## Background

This project is concerned with robust and conservative prediction of robot trajectories, when mechanical brakes are applied for the stopping of the robot. Since parameters such as brake torques are uncertain and inconstant, and state measurement is subject to error, we use reachability analysis, a set-based method which allows prediction with a range of parameter values. The system under consideration —the braking robot —is a hybrid system. We explore the methodology of reachability analysis for hybrid systems to see which methods apply to our problem and where methods need to be further developed for our application.

## Description

This thesis aims to find a valid model of a robot manipulator executing emergency braking maneuvers, through conformance testing. This thesis involves finding an efficient testing procedure, setting up a real industrial robot, and conducting the tests under varying conditions.



Left: Staubli TX90 robot, Right: Conformance test; Trajectories obtained from experimental testing vs. Reachability prediction through a hybrid system model

## Recommended prerequisites

- Programming language: C, (MATLAB)
- Experience in robot programming (e.g., from 'Industrieroboterpraktikum') is highly beneficial
- Experience in real-time communication is beneficial
- Having attended one of the following lectures is beneficial: Robotics, Robot Dynamics, Cyber-Physical Systems

### Supervisor:

Prof. Dr.-Ing. Matthias Althoff

### Advisor:

Stefan Liu, M.Sc.

### Research project:

-

### Type:

MA

### Research area:

Robotics, modelling and identification, experimental

### Programming language:

C, MATLAB

### Required skills:

-

### Language:

English

### Date of submission:

10. Oktober 2019

### For more information please contact us:

Phone: +49.89.289.18144

E-Mail: [stefan.liu@tum.de](mailto:stefan.liu@tum.de)

Internet: [www6.in.tum.de](http://www6.in.tum.de)