CPS: Small: Syntax-Guided Synthesis for Cyber-Physical Systems

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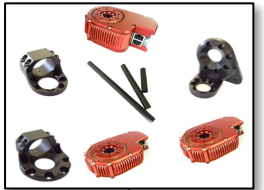
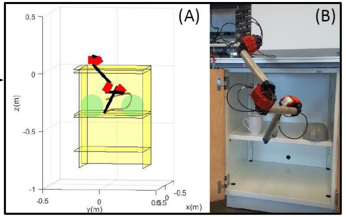
This project focus on correct-by-construction synthesis of both structure and controls of CPS from high-level specifications. Given a task specification, our approach synthesizes a robotic manipulator able to perform the task, and the control commands to achieve the task, or provides feedback to the users in case a solution was not found.



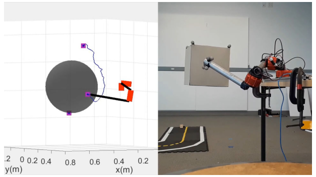
High-level task definition → Automated synthesis of structure and controls →



Scientific challenges: How can we create frameworks for correct-by-construction synthesis of CPS that generalize to different CPS domains? How can we handle uncertainties in the environment in terms of the synthesis problem (malfunctioning modules)? How can we provide feedback to the user in terms of the task feasibility?

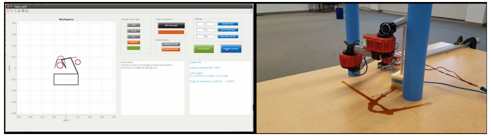
Solution: We encode the task specification as a set of constraints in the manipulator's kinematics and/or dynamics. Depending on the task, we create either a serial manipulator or a hybrid serial-parallel structure.

Task type 1: Tasks are defined as a set of points in space and obstacles to avoid. In our approach we used the Sketch synthesis system to solve the constraints on the design and controls, allowing for partially infeasible tasks and generation of more than one configuration if the task cannot be solved by a single one.



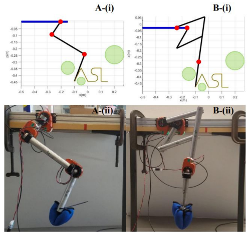
Campos T.*, Inala J.P.*, Solar-Lezama A., Kress-Gazit H.,"Task-Based Design of Ad-hoc Modular Manipulators" in 2019 IEEE International Conference in Robotics and Automation, Montreal, Canada, 2019.

Task type 2: Tasks are defined as trajectories composed of basic shape primitives. In our framework, we avoid discretizing the trajectory, as other approaches in the literature do. By solving for the continuous trajectory, we ensure that the original task is satisfied.



Campos T., Marri S., Kress-Gazit H.,"Automated Synthesis of Modular Manipulators' Structure and Control for Continuous Tasks around Obstacles" in Robotics: Science and Systems 2020.

Task type 3: Tasks are defined as trajectories with position accuracy requirements even under heavy loads. For this type of tasks, hybrid manipulators, mixing parallel and serial structures, are better suited due to the improved structural stiffness and load distribution.



Campos T., Kress-Gazit H.,"Automated Task-Based Approach to Modular Manipulator Design: Position Accuracy and Heavy Payload Capacity Requirements" *in Preparation*.

VERIFIABLE ROBOTICS RESEARCH GROUP

Award ID# 1837506 10/1/2018