Geometric Optimization of Network Controlled Parallel Manipulator

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This project presents geometric optimization and compliant control of a 3T1R network controlled parallel manipulator called Ragnar. It is designed for handling high-speed pick-and-place tasks of delicate objects. Previous work on the robot concluded that specific motor configurations resulted in multiple end-effector poses. This means that in the current state the kinematic Jacobian is ill-conditioned. The suggested solution was to modify the current mechanical construction of Ragnar. This was done by using the condition number of the Jacobian as the target function in a multi-objective optimization algorithm, that yields the optimal actuator mounting points for the pick-up and hand-off poses. This results in a significantly lower condition number of 50 compared to the previous condition number in the magnitude of 10^{18} which is considered singular for any practical purposes.

Compliant control of a robot is a way of implementing its interaction with an environment. With Ragnar in a poultry production line, compliance similar to a hand is desired to prevent damage of the product. Our compliant control system is designed as a full-order observer with state feedback, with the system modelled as a mass-spring-damper system.

The controller is tested on a simulated CAN-bus network. Furthermore, a simulation is performed in task space, showing how the system behaves with and without the influence of CAN-bus and the impact of packet loss on the network. The system frequency was found to be able to run at speeds up to 375 Hz, by experimentally measuring task execution times on a microcontroller and calculating transmission times of messages on the CAN-bus network. It was found that due to the high speed of the network, the impact of the network on the system was negligible. During packet loss it was found that the system achieved resilience towards packet loss with the addition of the observer.

The improvement of the mechanical construction proved to remove the singularity. Simulations show that control is achievable in the hand-off pose, using CAN-bus. As a result, it should be possible to derive the forward kinematics and thus develop a controller to achieve control of the end-effector in before uncontrollable poses.