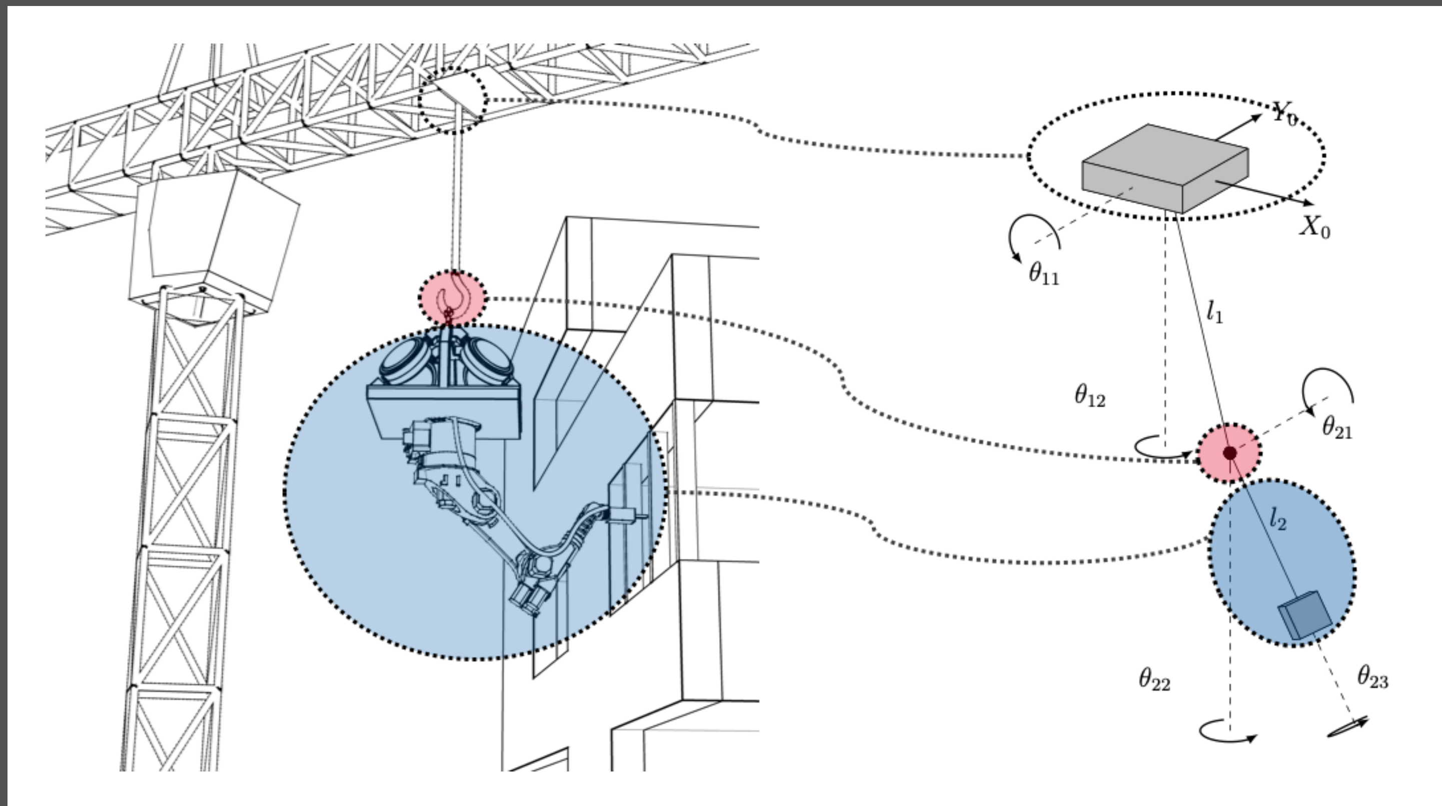

The digitalization of the construction industries planning and execution phases, coupled with advances in automation technology has led to a renaissance for construction robotics. Current efforts to provide robots for the execution of digital construction plans revolve around either the adaptation of industrial robots for the construction site, highly specialized custom robots or the digitalization of existing construction equipment. However, there is currently no robotics approach that addresses the very large work envelope that constitutes a construction site.

This work therefore evaluates the feasibility of operating robots and other kinematic systems hanging from a regular crane. A crane's hook is not a stable base for a robot. Movements of the robot as well as external forces would lead to motions and oscillations. The robot would therefore not be able to execute accurate movements.

Stabilizing a platform at the hook to create a useable base for robots requires adding further means of control to said platform. Three approaches are known: additional ropes, propulsive devices and momentum control devices. This work studies the use of a specific type of momentum control device, so called control moment gyroscopes. These are an established technology for the stabilization of ships and also the reorientation of spacecraft. By gimbaling a fast spinning rotor orthogonal to its axis of rotation, CMGs are able to generate torque through the principle of gyroscopic reaction. They are thereby able to generate torque in mid-air and unlike additional ropes or propulsive devices do not interfere with their environment.

The following work develops equations of motion and a model for the crane-CMG-robot system. A general control strategy is laid out and a simple PD-based controller is designed. The model is validated through a variety of simulations and used to understand the critical interactions between the three systems. The ability of a CMG platform to predictively compensate the torques produced by a robot and thereby improve its path accuracy is shown through simulation. It is also shown how such a platform can help dampen hook and load oscillations. The simulations not only show the potential of the approach, but also allow the work to develop sizing guidelines and identify critical areas for future research. The work therefore closes by laying out the critical path to bringing this approach to the construction site.

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Momentum Control for Crane Load Stabilization

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