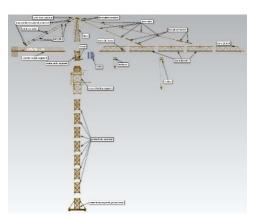# Design and Simulation of Tower Crane 3D Lift Task Integrated with Reinforcement Learning

Description

Tower cranes are essential transportation devices on construction sites, performing heavy lifting and material handling tasks. They typically feature five degrees of freedom (DoF), with three actuated (powered by motors) and two unactuated (radial and tangential swings caused by load dynamics). A key requirement of this task is to ensure that the tower crane precisely tracks the planned paths and positions the payload at the specified target location [1].

In this project, we aim to develop a reinforcement learning (RL)-based method [2,3] that incorporates the actuator system of a tower crane into spatio-temporal lift planning in three-dimensional virtual environments, where various strategies of algorithm types and learning rules will be tested. The proposed approach should be promising for planning feasible lifting paths and estimating reasonable lifting times, which help generate and review lifting plans given the site conditions.

For the project work, a realistic 3D simulation environment should be developed that incorporates the physics (kinematics/dynamics) of a sample tower crane (available in URDF). The simulation should produce parallel environments to train RL agents based on various state representations to achieve a set of lift-task requirements. Baseline model-based controllers as well as basic motion planners should be developed for the tower crane.

Tasks

- Defining the crane and task requirements, including payload capacity, joint speed, and component weight.
- Simulating complete crane functionalities in the Isaac Sim / Unity simulator.
- Developing an interface to the simulator appropriate for Gymnasium environments to deploy de facto RL frameworks.
- Implementing several model-based control methods for basic tower crane operations.
- Testing SOTA RL methods for various transportation tasks of the tower crane.

References

[1] Burkhardt, M., Gienger, A., et al. (2023). Data-based error compensation for georeferenced payload path tracking of automated tower cranes. *Mechatronics*, 94, 103028.

[2] Cho, S. & Han, S. (2022). Reinforcement learning-based simulation and automation for tower crane 3D lift planning. *Automation in Construction*, 144, 104620.

[3] Sutton, R. S., & Barto, A. G. (2018). Reinforcement Learning: An Introduction. A Bradford Book.