# Mobile Manipulation for the KUKU youBot

**Software:**

- ❖ Milestone1, *NextState* function:
    - ➢ Given A 12-vector representing the current configuration of the robot, a 9-vector of controls indicating the arm and wheel twist, a timestep Δt and a speed limit, find a 12-vector representing the configuration of the robot at a time step later.
- ❖ milestone2, *TrajectoryGenerator* function:
    - ➢ Given the configuration of initial ee position, initial standoff position, initial grasping position, final standoff position and final grasping position can be computed from the given initial configuration of the end effector, cude's initial configuration and cube's final configuration. Find the total trajectory of the end-effector frame will be divided by eight segments: 1. From initial ee position to initial standoff position; 2. From initial standoff position to grasping position; 3. Stay at grasping position, close gripper; 4. From grasp position to initial standoff position; 5. From initial standoff position to final standoff position; 6. From final standoff position to final grasping position; 7. Stay at final grasping position, open gripper; 8. From final grasping position to final standoff position.
    - ➢ Use the ScrewTrajectory function from the modern_robotics library, given these computed configurations and gripper state, to generate a trajectory for each segment. We can also specify the moving time, number of points, time-scaling method for each trajectory. Therefore, we can develop a function called TrajectoryGenerator to return the final trajectory integrating these eight segments. The function will store a csv file including 12 elements for transformation matrix and gripper state in each transient configuration.
- ❖ Milestone3, *FeedbackControl* function:
    - ➢ Given the current actual end-effector configuration, the current end-effector reference configuration, the end-effector reference configuration at the next time step, the PI gain matrices Kp and Ki and the timestep Δt between reference trajectory configurations, calculate the commanded end-effector twist expressed in the end-effector frame {e}.
- ❖ Run the simulation:
    - ➢ In the /code directory, run scripts for separate cases. Each script imports needed functions from milestones, and has a main function *Simulate* to call milestone functions and return all useful files in the same directory.

**Results:**

- ★ Best response:
    - ○ With kp =8 , ki =0.5 , the response time is super fast (within 0.5 s), and almost no overshoot.

- Overshoot:
  - With kp =2 , ki =3 , the response time is super fast (within 0.5 s) but with overshoot (around 0.2 m or rad), however, this controller gives less steady state errors in the end.
- New Task:
  - With new initial block configuration is (x, y, theta) = (1m, 0.5m, 0 rad), final block configuration is (x, y, theta) = (0.5, -1.5, -pi/2 rad), kp =6, ki =0.2, the response time is super fast (within 0.5 s), and almost no overshoot.