Project 6 – Task and Motion Planning (TAMP)

Description: The purpose of this project is to introduce the concept of **Task and Motion Planning (TAMP)** in robotic manipulation. Three colored cubes (red, green, blue) are initially stacked on a blue platform in the order **red (bottom)**, **green (middle)**, **blue (top)**. The goal is to transfer these cubes to a red target surface and re-stack them in a new, user-defined order.

Target stacking constraints are provided using abstract relations of the form:

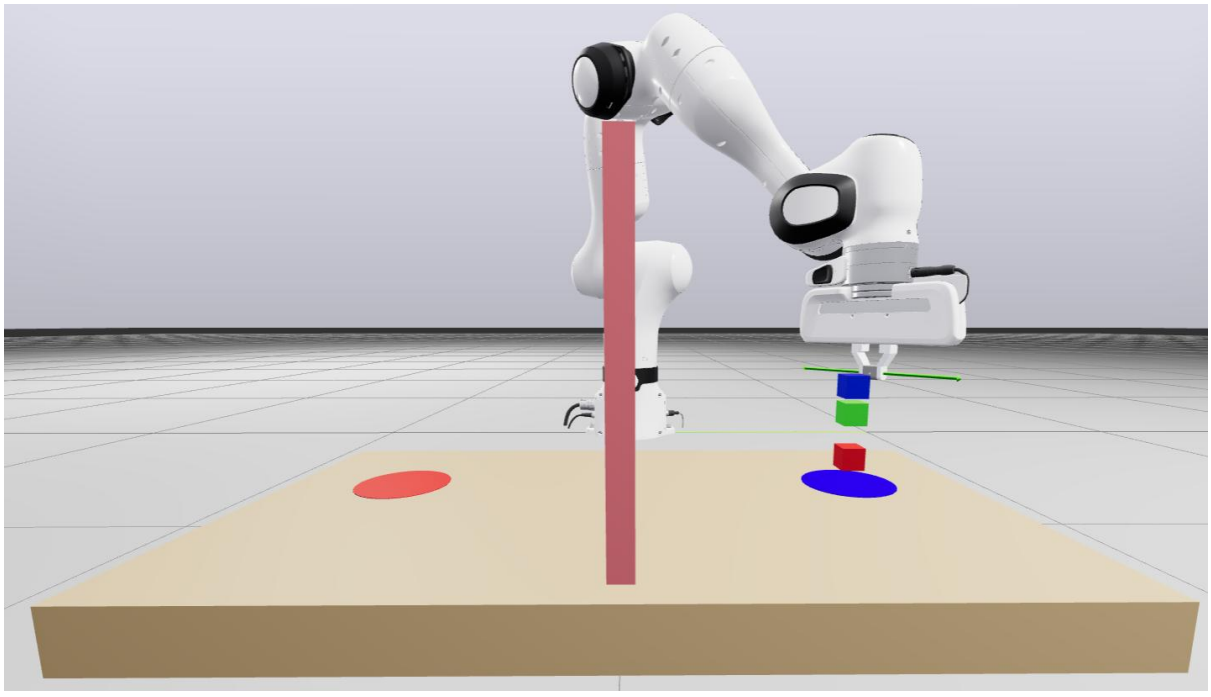
- On ?(A) ?(B) meaning *cube A must be placed on top of cube B*.

For example:

- On ?(red cube) ?(green cube)
- On ?(blue cube) ?(red cube)

would require a final stack (from bottom to top): **green → red → blue**.

Achieving such target configurations typically requires **intermediate placements** because some cubes may be blocked by others. Therefore, the robot must temporarily relocate obstructing objects to make them accessible, illustrating the fundamental principles of task-level reasoning combined with motion-level control.



Objective: Design a control framework capable of:

- Computing a **logical task plan** to satisfy given On ?(A) ?(B) relations.
- Executing corresponding **motion plans** with the robot to realize the task physically.
- Managing intermediate placements when necessary.
- Remaining robust to variations in the cubes' initial positions, and abstract target relationships.

Provided material: an SDF containing: 1) A Franka Panda robotic manipulator, 2) A red cube, a green cube, and a blue cube, 3) Initial and target markers, 4) A wall and a table.

Expected Implementation

1. Load and visualize the provided SDF world using **Drake**.

- Implement a **task-level reasoning** component that: 1) Interprets desired On ?(A) ?(B) constraints, 2) Generates a feasible sequence of operations (pick, place, unstack, restack, etc.), 3) Accounts for obstructions and necessary intermediate placements.

2. Integrate task planning with motion-level execution to physically rearrange the cubes on the red target surface.

Requirement: solution should be conceptually extensible to more than three objects and should handle different feasible stacking combinations.

Notes

- **Do not** modify the base pose of the robot or fixed workspace geometry.
- Define a logical planner that can determine a valid sequence of steps for object placement. You may find **PDDLStream** or **PDDL** frameworks helpful for conceptual guidance.
- Begin experimenting with **two objects** to simplify the logic, then extend to three.
- Minor execution imperfections (e.g., accidental cube drops) are acceptable; the focus is on demonstrating **the reasoning process** and **planning architecture**, not perfect motion control.

Contact person: Mehran.raisi.hatmabadi@vub.be