1. Define the configuration space of the problem

Without grippers, the C-Sapce for this problem is R2 x Sj, where R2 denotes the position of the base of the robot arm, which is usually expressed using two-dimensional planar coordinates (x, y). Sj denotes the angle of the joints and j denotes the number of joints. The angle of each joint is limited to [-150°; 150°].

If with a gripper, the C-Sapce of the problem is R2 x Sj x R4, and R4 denotes the length of each part of the gripper. The length of each part is constrained to [0.3,0.7]

Each configuration in the configuration space represents a specific state of the robot arm in the space, which can be uniquely determined by the values of these components.

2. Motion planning method:

I have chosen Probabilistic Roadmap as the motion planning method to solve the path planning problem of wheelchair robot arm:

The PRM is a probabilistic-based path planning method that creates a routing graph by randomly sampling a large number of configurations in the configuration space. This graph contains connections (edges) between configurations, and a search algorithm (e.g., A*) can then be used to find paths on the graph from a starting configuration to a destination configuration. The main steps of PRM include sampling, connecting, and searching.

Design Choice Rationale:

- PRM is suitable for path planning problems for multi-degree-of-freedom robot arms because it can handle high-dimensional configuration spaces.
- PRM is based on probabilistic sampling, which can better handle complex environments and obstacle situations.
- PRM allows pre-computation of connections so that paths can be found faster during actual queries.

3. empirical analysis

4.Program failure condition:

- When there are impassable obstacles or constraints in the configuration space, the PRM may fail to find a path.
- If the configuration space is very high dimensional and the number of sampling points is not sufficient to cover the possible paths, the PRM may fail to find the path.
- Path planning will fail when the start configuration or target configuration is in an unreachable area.
- Path planning may also fail if the robot arm's joint angle or gripper length varies beyond the PRM's preset sampling range.