ME5402/EE5106R ADVANCED ROBOTICS

Supplementary Material for Project 1-2

Configuration Space

Definition The *configuration* of a robot system is a complete specification of the position of every point of that system. The *configuration space*, or *C-space*, of the robot system is the space of all possible configurations of the system.

Remark

1) A configuration is simply a point in the abstract configuration space.
2) The number of degrees of freedom of a robot system is the dimension of the configuration space, or the minimum number of parameters needed to specify the configuration.

Examples

1) A circular mobile robot that can translate without rotating in the plane.

Define the configuration as $q=(x,y)$, the set of points $R(x,y)$ occupied by the robot can be represented as $R(x,y)=\{(x',y')\,|\,(x-x')^2+(y-y')^2\le r^2\}$, and we see that these two parameters x and y are sufficient to completely determine the configuration of the circular robot. Therefore, for the circular mobile robot, we can represent the configuration space by $\mathbb{R}^2$ once we have chosen a coordinate frame in the plane.

2) Two-joint planar robot arm as shown in the following figure.

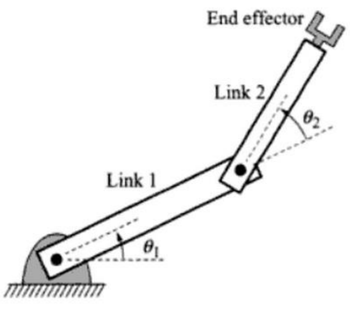

Fig.1 The angles θ_1 and θ_2 specify the configuration of the two-joint robot

If we specify the parameters θ_1 and θ_2, we have specified the configuration of the arm. Each joint angle θ_i corresponds to a point on the unit circle S^1, and the configuration space is $S^1\times S^1=T^2$, the two-dimensional torus.

Motion-planning problem

The motion-planning problem is to determine a continuous mapping $c:[0,1]\to\mathcal{Q}$, such that no configuration in the path causes a collision between the robot and an obstacle. We define a *configuration space obstacle* $\mathcal{QO}_i$ to be the set of configurations at which the robot intersects an obstacle $\mathcal{WO}_i$ in the workspace, i.e.,

$$\mathcal{QO}_i = \{q \in \mathcal{Q} \mid R(q) \bigcap \mathcal{WO}_i \neq \varnothing\}$$

The *free space* or *free configuration space* is the set of configurations at which the robot does not intersect any obstacle, i.e.,

$$\mathcal{Q}_{\text{free}} = \mathcal{Q} \setminus (\bigcup_i \mathcal{QO}_i) .$$

For detailed discussion, please refer to the following references:

References

[1] Choset, Howie M. *Principles of robot motion: theory, algorithms, and implementation*. MIT press, 2005.

[2] LaValle, Steven M. *Planning algorithms*. Cambridge university press, 2006.