Robot Autonomy Lecture Note 3.6

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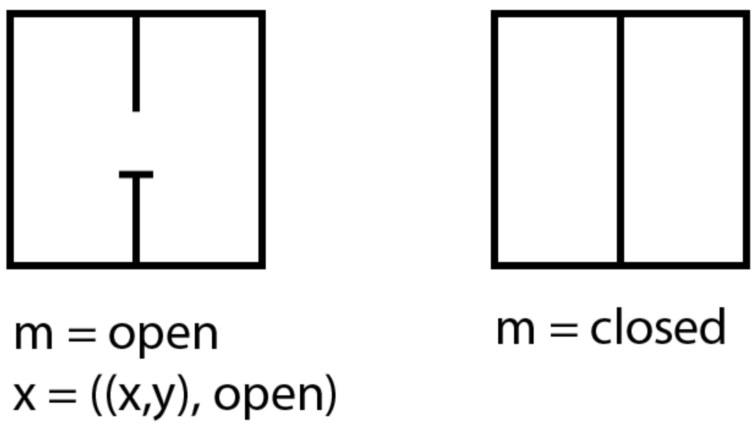
1 Hybrid-System

Hybrid system is a mixture of discrete and continuous variable.

1.World $W = R^2$ or R^3

2.Model Space M with modes m



3.An obstacle region $O(m) \subset W$

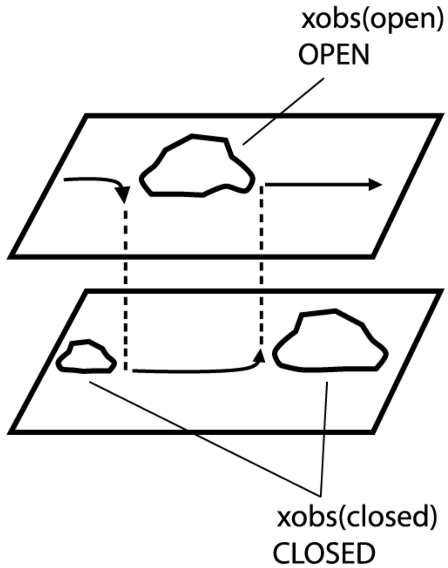
4.A robot $A(m)$ for each mode m

5.State Space $X = C \times A$
$x = (q, m)$ e.g. $x = ((x, y), OPEN)$
$X_{obs} = \{(q, m) \in X | A(q, m) \cap O(m) \neq \phi\}$

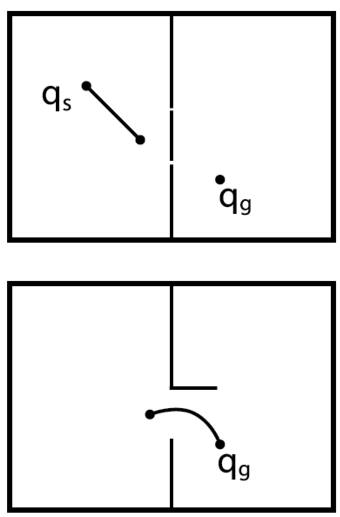
6.For each state x, define a finite action space $U(x)$
Example: Open Door/ Close Door

7.Mode transition function
$f_m((q, \underset{\text{mode}}{\underline{OPEN}}), \underset{\text{action}}{\underline{CloseDoor}}) = \underset{\text{mode}}{\underline{Closed}}$

8.State transition function



$f(x,u) = (q, f_m(x,u))$
Example:$f((q, OPEN), CloseDoor) = (q, Close)$

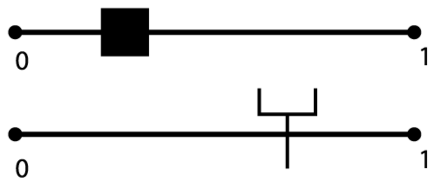


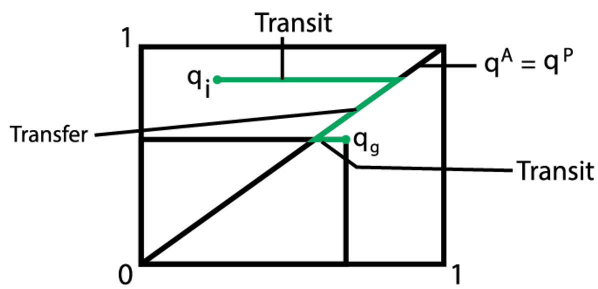
2 Bead on Wire

Case 1:

Actions:{grasp,ungrasp}
modes:{Transfer,Transit}

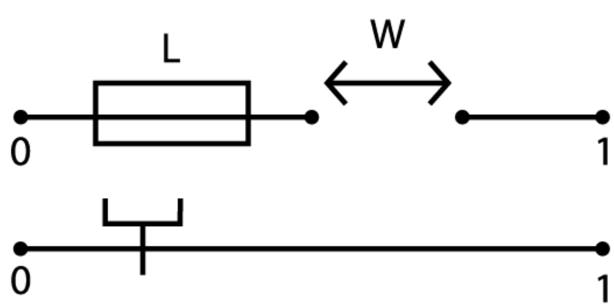
Transfer→Robot moving bead
Transit→Robot moving on its own



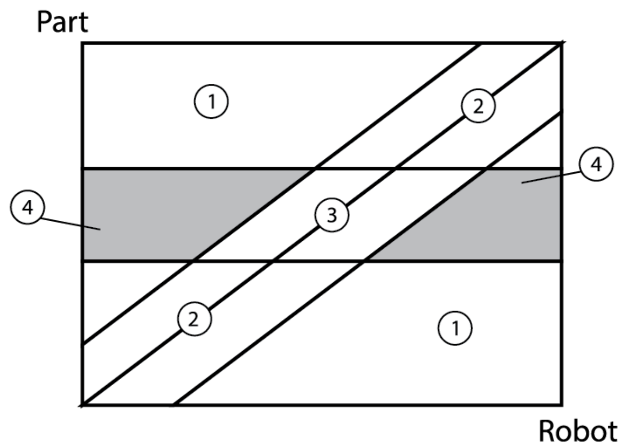


Transfer Space:$q^A = q^P$
Transit Space:Copies of R^1 stacked on each other to form R^2(Foliation)

Case 2:

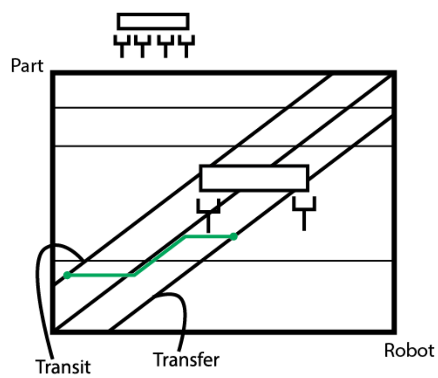


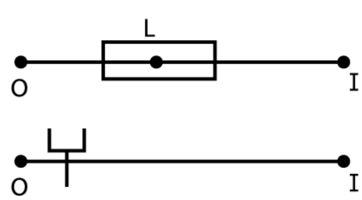
Both Transfer and Transit *Cspace* are foliated



1.Transit only
2.Transit + Transfer
3.Transfer only
4.Forbidden

Case 3:
Rod L can cross gap W if being held by the robot while crossing





Consider if the rod had an encasing tub instead of the gap → TRANSFER OBSTACLE

3 Manipulation Cspace

1. World $W = R^2$ or R^3
2. Obstacle $O \subset W$
3. Robot A, $q^A \in C^A$
4. Part p, $q^p \in SE(2)$ or $SE(3)$

$C = C^A \times C^p$
$C^A_{obs} = \{(q^A, q^p) \in C | A(q^a) \cap O \neq \phi\}$ Robot-Obstacle
$C^p_{obs} = \{(q^A, q^p) \in C | p(q^p) \cap O \neq \phi\}$ Part-Obstacle
$C_{adm} = C \setminus C^A_{obs} \setminus C^p_{obs} \setminus C^{Ap}_{obs}$
$C^{Ap}_{obs} \rightarrow$ Robot penetrate object

C^{stable}: set of all stable configuration.
C^{grasp}: set of all configuration where robot is grasping the part
$C^{transition} = C^{grasp} \cap C^{stable}$ (only places the robot can pick up and put down the part)