Where we are:

Chap 2  Configuration Space
        2.1 DOF of a Rigid Body
        2.2 DOF of a Robot
        2.3 C-space: Topology and Representation

Chap 3  Rigid-Body Motions
Chap 4  Forward Kinematics
Chap 5  Velocity Kinematics and Statics
Chap 6  Inverse Kinematics
Chap 8  Dynamics of Open Chains
Chap 9  Trajectory Generation
Chap 11 Robot Control
Chap 13 Wheeled Mobile Robots
Important concepts, symbols, and equations

• Two C-spaces may have the same dof but differ in other ways. The topology ("shape") of a space is independent of how we represent it.

• Two spaces are topologically equivalent if one can be continuously deformed to the other without cutting or pasting.

• Some spaces are Cartesian products of spaces of lower dimension, e.g.,

\[(1d) \mathbb{E}, S = T \quad (2d) \mathbb{E} \times \mathbb{E} = \mathbb{E}^2, S \times S = T^2, S^2, \mathbb{E} \times S \quad (\text{higher}) \mathbb{E}^k \times S^m \times T^n\]

• Represent Euclidean ("flat") spaces \(\mathbb{E}^n\) as \(\mathbb{R}^n\). For curved spaces, choose
  • minimum-parameter explicit parameterizations (choose between singularities or an atlas of coordinate charts), OR
  • implicit representation (use more numbers subject to constraints).
<table>
<thead>
<tr>
<th>System</th>
<th>Topology</th>
<th>Sample Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point on a plane</td>
<td>$\mathbb{R}^2$</td>
<td>$(x, y)$</td>
</tr>
<tr>
<td>Spherical pendulum</td>
<td>$S^2$</td>
<td>$[-180^\circ, 180^\circ] \times [-90^\circ, 90^\circ]$</td>
</tr>
<tr>
<td>2R robot arm</td>
<td>$T^2 = S^1 \times S^1$</td>
<td>$[0, 2\pi] \times [0, 2\pi]$</td>
</tr>
<tr>
<td>Rotating sliding knob</td>
<td>$\mathbb{E}^1 \times S^1$</td>
<td>$\mathbb{R}^1 \times [0, 2\pi]$</td>
</tr>
</tbody>
</table>

Any value in an atlas of coordinate charts? An implicit representation?

Any value in an atlas of coordinate charts? An implicit representation?

Any value in an atlas of coordinate charts? An implicit representation?
C-space topology, with and without arm joint limits, rotor angles? Implicit/explicit representations? Grübler’s formula?

hexrotor with two 5-DOF arms

https://www.prodrone.com/archives/1420/
KUKA youBot
mecanum-wheel omnidirectional base
moving on flat ground
plus 5-DOF robot arm + gripper

C-space topology and representation?
Include gripper, wheel angles?