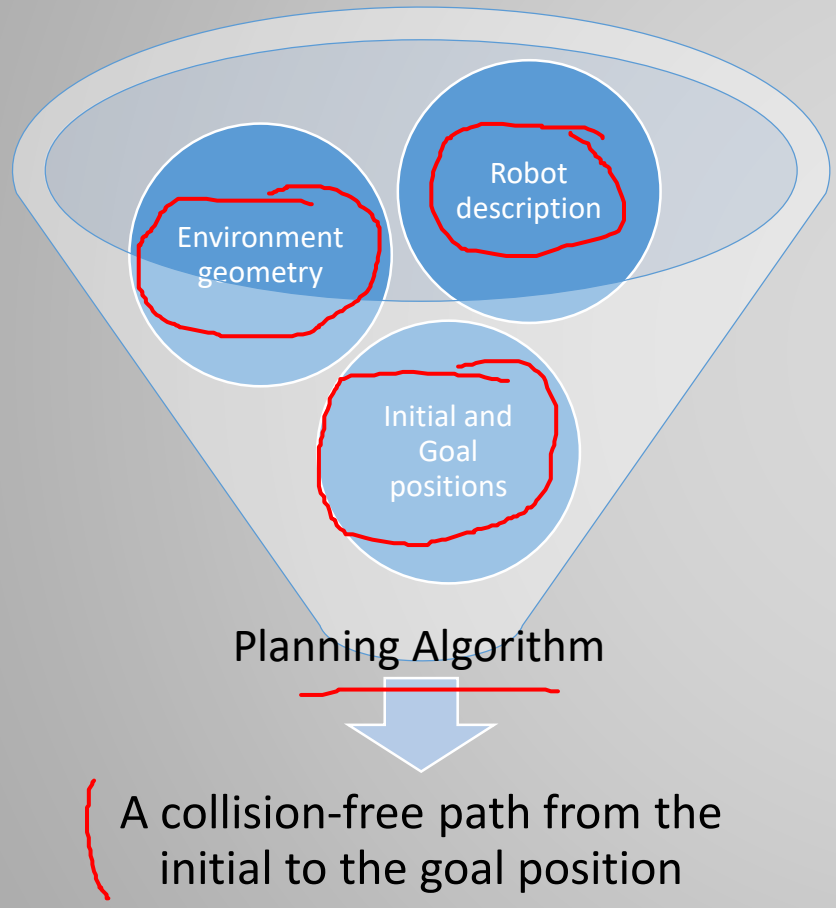
Part 1
-
Motion Planning

THE PIANO MOVERS' PROBLEM

GIVEN AN ENVIRONMENT WITH OBSTACLES AND A PIANO, IS IT POSSIBLE TO MOVE THE PIANO FROM ONE POSITION AND ORIENTATION, CALLED ITS CONFIGURATION Q, TO ANOTHER WITHOUT COLLIDING WITH THE WALLS OR THE OBSTACLES IN A REAL GEOMETRIC SPACE OR WORKSPACE W?

SCHWARTZ J. T., SHARIR M. "On the piano movers' problem II, general techniques for computing topological properties of real algebraic manifolds." *Advances of Applied Maths 4 (1983), 298–351.*

PROBLEM DEFINITION



PROBLEM EXTENSIONS:

- Moving obstacles
- Multiple robots
- Movable objects
- Deformable robots
- No or partial prior knowledge of environment
- Dynamic constraints
- Optimal planning

ROBOT CONFIGURATION

A ROBOT CONFIGURATION IS A SPECIFICATION OF THE POSITIONS OF ALL ROBOT POINTS RELATIVE TO A FIXED COORDINATE SYSTEM

USUALLY A CONFIGURATION IS EXPRESSED AS A "VECTOR" OF PARAMETERS

$$\begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \\ q_5 \\ q_6 \end{bmatrix}$$

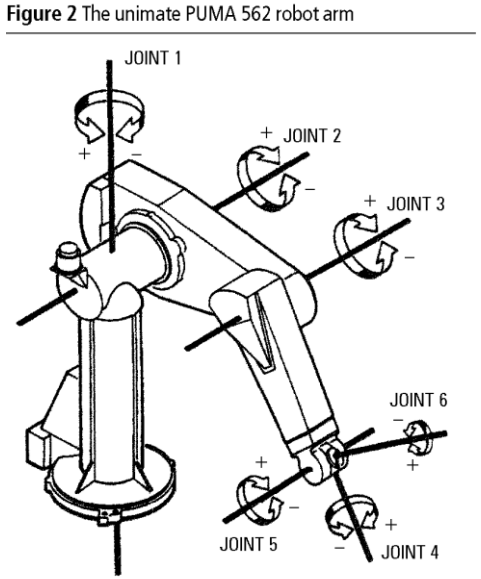


Figure 2 The unimate PUMA 562 robot arm

Lozano-Perez, T. (1990). Spatial planning: A configuration space approach. In *Autonomous robot v*
259-271). Springer, New York, NY.

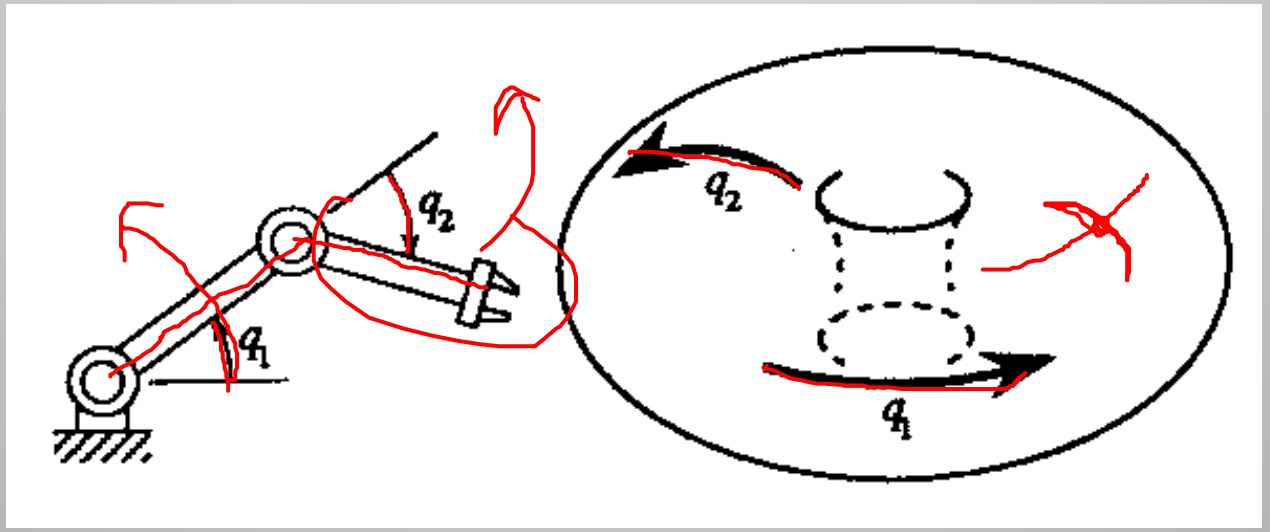
The configuration space C

Space of all its possible configurations

But the topology of this space is usually not that of a Cartesian space

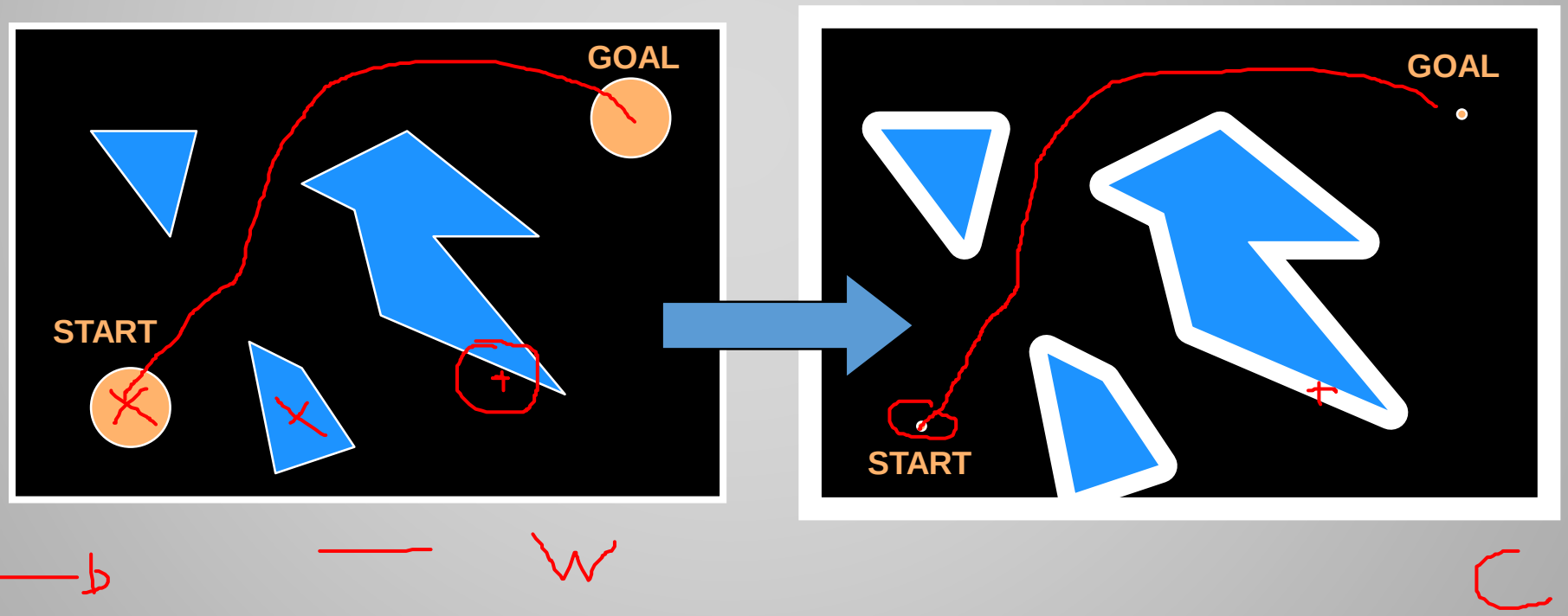
Path: continuous sequence of configuration

Trajectory: time parameterization of a path



THE FREE CONFIGURATION SPACE C_{FREE}

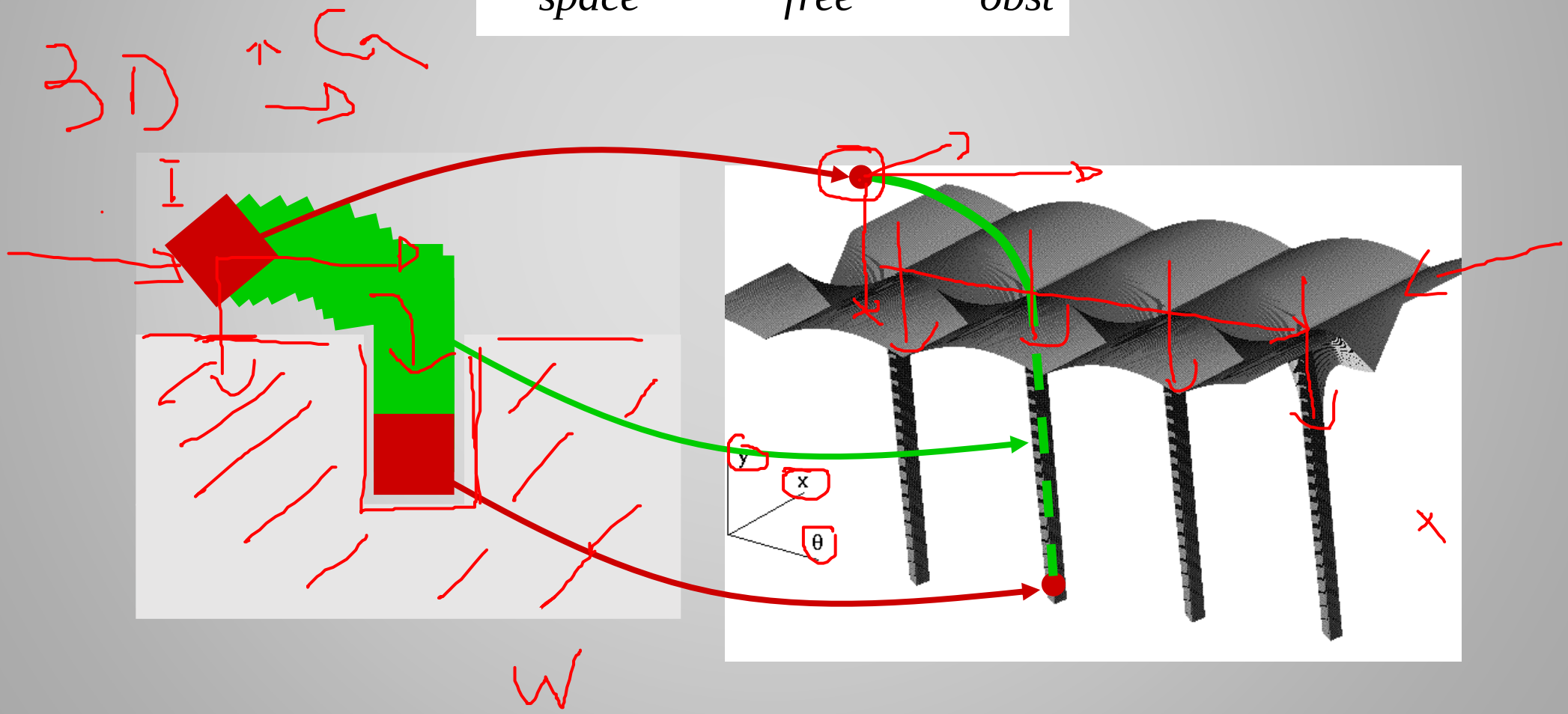
$$C_{space} = C_{free} + C_{obst}$$



Example: 2D navigation

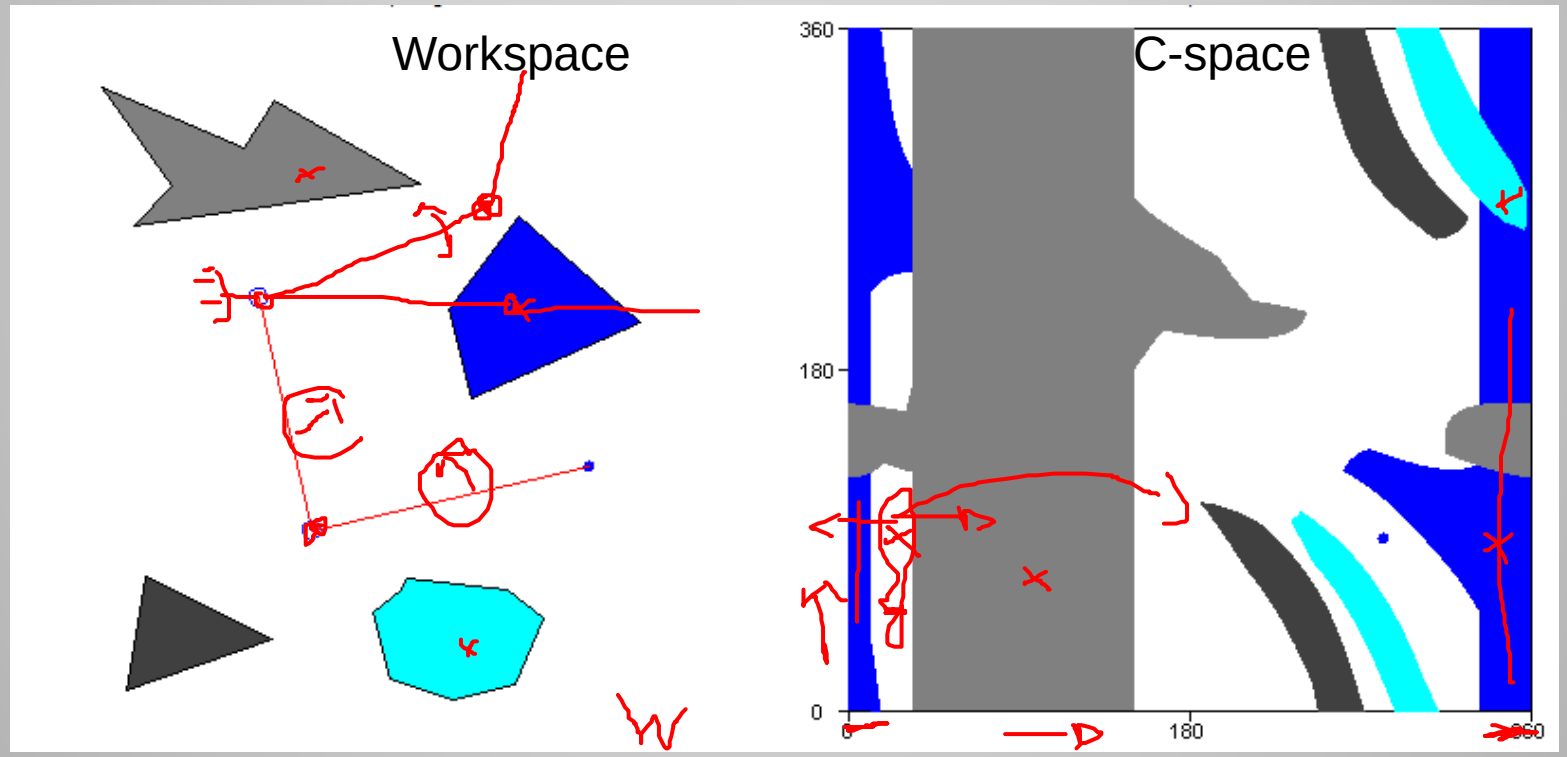
THE FREE CONFIGURATION SPACE

$$C_{space} = C_{free} + C_{obst}$$



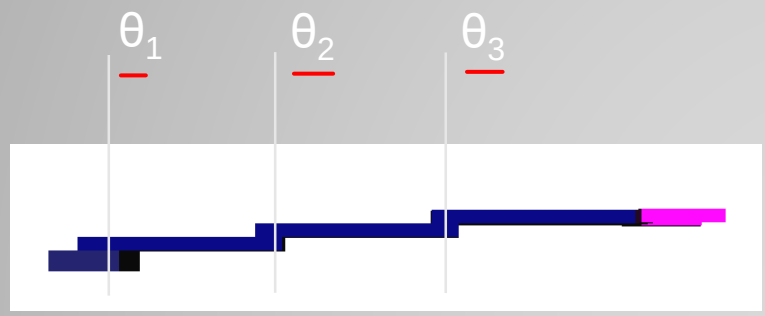
THE FREE CONFIGURATION SPACE

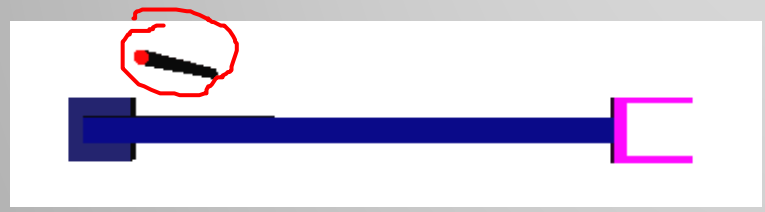
$$C_{space} = C_{free} + C_{obst}$$



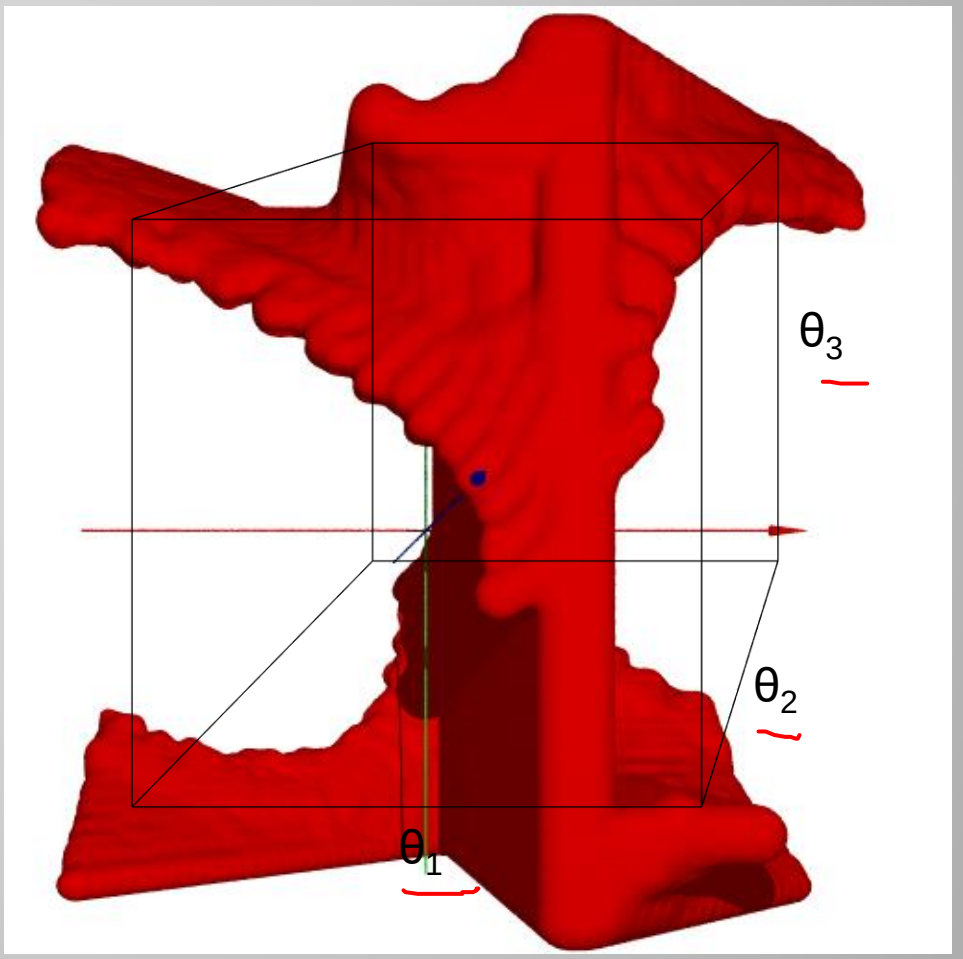
Images created by C-space Java applet : http://ford.ieor.berkeley.edu/cspace/

THE FREE CONFIGURATION SPACE





Vue de dessus



Conclusion

- In the case of poly-articulated robots, with *n* degrees of freedom, the configuration of the robot is defined by the *n* parameter values of each joint.
- The configuration space is *n*-dimensionnal, and each point of this space corresponds to a robot position in the workspace
- A motion planning problem can be reduced to the one of computing a path for a point in the configuration space