Abstract Sensing Models

Configuration spaces
\[ \mathbb{R}^2 \times S^1 \cong SE(2) \]

State space concepts
Define some sensors

Time
History-based sensors
Observation histories

Configuration spaces
1. Rigid body, 2D
2. Multiple moving bodies
3. Discrete
4. 3D
5. Obstructions
6. Attached bodies
4) Obstructions (Obstacles)

Return to a point in $\mathbb{R}^2$

Consider rigid body, $A$

$A(x, y)$

Which configurations are prohibited?
- Avoid configurations that cause collision
- If \( C = \mathbb{R}^2 \times S' \), then with obstacles, we restrict to some \( F \subset \mathbb{R}^2 \times S' \)
- How to determine \( F \)? See, LaValle, 4.3
- Basis of motion planning \( \rightarrow \) LaValle, Ch. 5, 6, 7
  (Piano maver's problem)
S) Attached bodies

\[ C = S' \times S' \]

(Lavalle, 3.3)

\[ (\mathbb{R}^2 \times S') \times (\mathbb{R}^2 \times S') = \mathbb{R}^4 \times S' \times S' \]

Suppose the lower body is not attached

\[ C = \mathbb{R}^2 \times S' \times S' \]

Sweden 2
Finland 1
For everything so far, the state becomes the configuration space: \( X = \mathbb{C} \)

\[ h: X \rightarrow Y \]

However, for many problems, this is insufficient.

Additional information/complications:

1) Unknown environments
2) Keep track of velocities
3) Additional fields
4) Discrete modes
1) **Unknown environments (2D)**

Suppose we are in a bounded, polygonal environment.

Let $e_i$ be an exact description of the set of available points in $\mathbb{R}^2$.

Let $E$ be the set of possible environments, called the environment space.

Note: $E$ may be infinite.

Each $E_i$ is called an environment.
Ex. Let $E$ be the set of all bounded, simply connected, polygonal subsets of $\mathbb{R}^2$.

Note: $E$ is HUGE! → no problem

The state space becomes $X = C \times E$.

$C$ = whatever configuration space

$E$ = set of environments

$X = (\cdot, \cdot, \cdot, \cdot, e)$

$h: X \rightarrow Y$

$y = h(q, e)$

Conf.
2. Velocities

Sensor readings may depend on velocity (linear or angular).

Translation only cases in $\mathbb{R}^2$

\[ \dot{x} = \dot{\theta} \]
\[ \dot{y} \]

State space: $X = (x, y, \dot{x}, \dot{y})$

Phase space - in physics

State space - in control theory

$C = \mathbb{R}^2$

$(x, y) \in C$

$\dot{x} \rightarrow y$
3) Fields

At each point in the environment, associate a vector (or scalar)

\[ \text{Ex: Electromagnetic field } \quad E = \mathbb{R}^2 \]

\[ \text{Ex: Signal intensity } \quad (x, y, z, \theta) \]

State: \((x, y, v_1, v_2)\) in which \(\vec{v}=(v_1, v_2)\) is the field vector

State space: \(X = \mathbb{R}^4\)

\[ h: X \rightarrow Y \]