Bookkeeping

- Team meetings status
- Assignment 2

Thursday:
- Quiz 3 (will be easier than 1 and 2)
  - Manipulation concepts, Grasping, Kinematics concepts
  - Closes 11:59pm Nov 4
- Homework 2 (homeworks are always easy)
  - Resolution, Kinematics & IK, Course Progress

Nov 5
- Assignment 3 (due Nov 13)
Bookkeeping

- Today:
  - General notes on project progress
    - Schedule wiki
    - Signout sheet
    - Meetings
  - A final note on mobile kinematics
  - Manipulator kinematics
  - Reading: CB 2.1 & 2.2–2.2.2
Project Progress

- Schedule wiki: [http://tiny.cc/robotics-team-schedules](http://tiny.cc/robotics-team-schedules)
  - Look for your team in left-hand nav column
- Milestones: How is *each component* going?
  - Contain:
    - Writeups – what am I seeing?
    - Demos, images, code, videos, …
- Is everyone fully involved?
Given this setup:

We can map \( \{X_I, Y_I\} \) (global) \( \leftrightarrow \) \( \{X_R, Y_R\} \) (robot)

- Use rotation matrices and velocity vector in \( x, y, \theta \)

Why do we care so much?
Goal: take robot from $A_I$ to $B_I$

- We know where we want it in the *global* setting
- What do we actually control? (In what frame of reference?)

Point: Convert from $A_I$ to $B_I$ by changing $\xi_R$

$$\xi_A = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}$$

$$\xi_B = \begin{bmatrix} x' \\ y' \\ \theta' \end{bmatrix}$$
Manipulator Kinematics

- Kinematics:
  - Geometrically possible motion of a body or system of bodies

- For manipulator robots
  - End effector position and orientation, wrt. an arbitrary initial frame

- A manipulator is moved by changing its...
  - Joints: revolute and prismatic
Manipulator State

- Configuration: where is every point on manipulator?
  - Instantaneous description of geometry of a manipulator

- State: a set of variables which describe
  - Change of configuration in time in response to joint forces
    - Control inputs
    - External influences
Position & Orientation
Position & Orientation
Forward Kinematics & IK
Mobile vs. Manipulator

- Description: how many terms...
  - ...to describe planar position & orientation?
  - ...to describe 3D position & orientation?

- AKA, how many
  - Degrees of freedom

\( \xi_I = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} \)
Kinematics Problem

- The **state space** is the set of all possible states
- The **state** of the manipulator is:
  - A set of variables which describe changes in **configuration** over time, in response to joint forces + external forces
- Where do joint forces come from?
  - Controllers!
- So, given some set of joints, what signals do we send?
- In joint space vs. Cartesian space

![Kinematics Problem Diagram](image-url)
Goal

- Goal: take robot end effector from $A_I$ to $B_I$
  - We know where we want it in the *global* setting
  - What do we actually control? (In what frame of reference?)

- Point: Convert from $A_I$ to $B_I$

- Now a $6 \leftrightarrow 6$ transformation
Mobile to Manipulator
Multiframe Kinematics

- How many frames of reference do we have?
  - We’ve been translating among frames based on possible motion

- How do they relate?
Kinematic Chaining

- Do you need to do every transformation?
- What do we really care about?