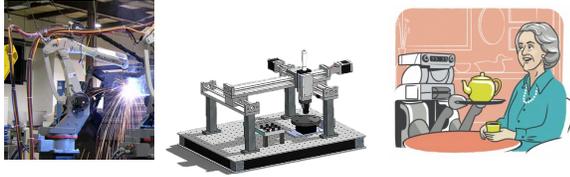


Manipulation Overview, Concepts, Types



Many slides adapted from:
S. N. Kale, Assistant Professor, PVPIT, Budhgaon
www.amci.com/tutorials/tutorials-stepper-vs-servo.asp
www.modmypi.com/blog/whats-the-difference-between-dc-servo-stepper-motors
en.wikipedia.org

Bookkeeping

2

- ◆ Homework 2 due evening of March 14
 - ◆ Trouble? See Nikhil!
- ◆ Project milestone 1 due right after spring break
 - ◆ It's easier than if you choose your own project.
- ◆ Make sure you make arrangements with your group for spring break!
- ◆ A little tiny bit of stern stuff:
 - ◆ Do not let 1-2 people do all the building.
 - ◆ Do not do anything to mess up your group.

BattleBots!

3

- ◆ The UMBC BattleBots tournament is on **April 14!**
- ◆ Details
 - ◆ Goal: design a robot that will push the competitor out of the ring or disable them (yikes!) so they can't continue
 - ◆ Teams have a month to build their robot
 - ◆ Groups of **2 to 5** students create a fighting robot
- ◆ Each team will be provided all materials

Competition Signup: tinyurl.com/UMBCBB

Project sneak peek

4



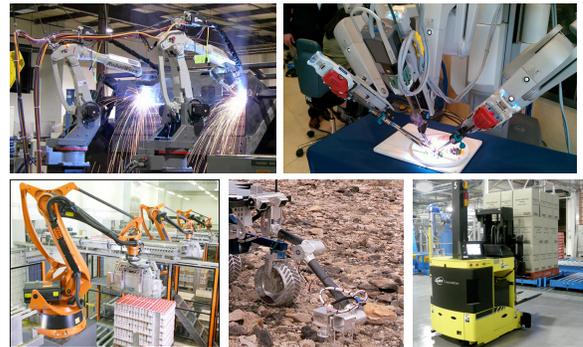
Project sneak peek

5

1. Build!
 - ◆ No soldering, plenty of instructions
 - ◆ Everyone should participate!
2. Get working under ROS
3. Line following
4. Maze exploration (this is the fun part)
 - ◆ Localization, data tracking, planning, sensors, ...
5. Tournament/demos
6. Unbuild ☹️

Manipulators

6



Manipulators



7



Manipulators



8



Manipulators



9



Manipulation



10

- ◆ What is a manipulator?
 - ◆ Manipulates something in the world
 - ◆ Physically alter the world through contact
 - ◆ As a primary goal
 - ◆ But not its own position
 - ◆ Directly or indirectly
- ◆ When is this desirable?
 - ◆ Dangerous workspaces
 - ◆ Space; foundries; underwater; factories
 - ◆ Human-intractable workspaces
 - ◆ Too small; too big; too much precision needed
 - ◆ Boring, repetitive, unpleasant work



Uses



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<ul style="list-style-type: none"> ◆ Current <ul style="list-style-type: none"> ◆ Industrial <ul style="list-style-type: none"> ◆ Welding ◆ Drilling ◆ Attaching (screws, rivets) ◆ Painting ◆ Loading/unloading ◆ Surgery ◆ Space exploration ◆ Chores ◆ Patient care ◆ Delivery 	<ul style="list-style-type: none"> ◆ Future <ul style="list-style-type: none"> ◆ Elder care ◆ Entertainment ◆ Environment sampling ◆ Compliant-material interactions (sewing) ◆ Police work ◆ Plus: more chores, more patient care, more surgery, more space, &c. (but better)
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Pick-and-Place



12

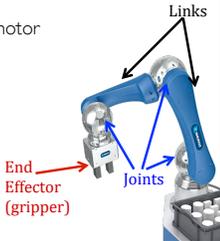


Terminology



13

- ◆ What is a manipulator?
 - ◆ Device to physically alter the world through contact
 - ◆ Modeled as a chain of *rigid links* connected by *joints*
- ◆ Actuator
 - ◆ Generates motion or force; usually a motor
- ◆ End Effector
 - ◆ Device at the end of an arm; interacts with environment
 - ◆ Grippers, tools
- ◆ Actuation
 - ◆ How are parts made to move?



Terminology



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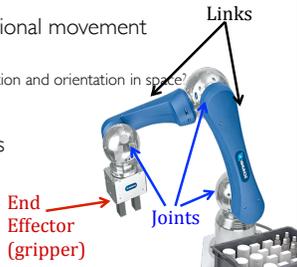
- ◆ Actuator
 - ◆ Generates motion or force; usually a motor
 - ◆ "Drive type"
- ◆ End Effector
 - ◆ Device at the end of an arm; interacts with environment
- ◆ DoFs
- ◆ Gripper
 - ◆ What it sounds like; a type of manipulator
- ◆ Actuation
 - ◆ How are the individual parts made to move?

Manipulator Robot



15

- ◆ Modeled as a chain of *rigid links* connected by *joints*
- ◆ Links: unjointed length of robot
- ◆ Joints: translational or rotational movement
 - ◆ Joints have DoFs
 - ◆ How many to describe its position and orientation in space?
 - ◆ Sliding or jointed
- ◆ Manipulator / End Effectors
 - ◆ Grippers / Tools
 - ◆ Sensors



Characterization



16

- ◆ Types
 - ◆ By drive
 - ◆ Tendons
 - ◆ Direct servoing
 - ◆ Underactuation
 - ◆ By motion
 - ◆ Prismatic (linear)
 - ◆ Revolute (rotational)
 - ◆ By Characteristics
 - ◆ Payload
 - ◆ Working area/radius



Joints



17

- ◆ Prismatic: sliding / translational



- ◆ Revolute: rotational



Actuators



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Hydraulic Motor



Pneumatic Cylinder



Stepper Motor



Pneumatic Motor



DC Motor



Servo Motor

When Do We Use...

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- ◆ Hydraulic/pneumatic
 - ◆ Heavy loads, high speeds
 - ◆ Sometimes hard to control (esp. pneumatic)
 - ◆ Doesn't produce sparks



Pneumatic Motor



Pneumatic Cylinder



Hydraulic Motor

When Do We Use...

20

- ◆ Most common robotic actuators utilize combinations of different electro-mechanical devices
 - ◆ Stepper motor
 - ◆ Subdivides a rotation into 4-10 increments
 - ◆ Open Loop
 - ◆ Servo Motor
 - ◆ Subdivides a rotation arbitrarily
 - ◆ Closed Loop
 - ◆ AC servo motor
 - ◆ Brushless DC servo motor
 - ◆ Brushed DC servo motor
- ◆ But usually *motors*.



Characterizing Manipulators

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- ◆ Power source (drive type: pneumatic, electric, ...
 - ◆ Servoing and non-servoing / open-loop and closed loop
- ◆ Type of actuation: tendons, direct
- ◆ Configuration
 - ◆ Aka geometry, kinematic structure
 - ◆ Combinations of
 - ◆ Prismatic (linear)
 - ◆ Revolute (rotational)
- ◆ Characteristics
 - ◆ Payload
 - ◆ Working area/radius
 - ◆ Application area
 - ◆ Method of control

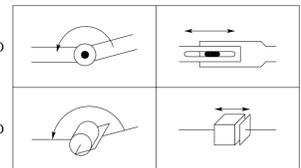


www.neobotix-robots.com/mobile-manipulator-mm-500.html

P(rismatic) & R(evolute)

22

- ◆ A kinematic chain of rigid links connected by joints
 - ◆ *"Kinematics is the branch of classical mechanics which describes the motion of objects and groups of objects."*
- ◆ Prismatic (denoted P)
 - ◆ Sliding / translational / linear; allows a linear relative motion between 2 links
- ◆ Revolute (denoted R)
 - ◆ Rotational; allows relative rotation between two links



Spong, Hutchinson, Vidyasagar. Robot Modeling and Control. 2006.

Joints: Denotation

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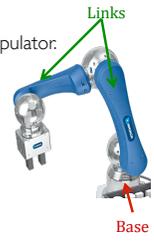
- ◆ A joint represents a connection between two links
- ◆ Denotation of relative displacement between links
 - ◆ θ for revolute joint
 - ◆ d for prismatic joint
- ◆ Denotation of axis of motion
 - ◆ z_i between link i and link $i+1$
 - ◆ Axis of rotation of a revolute joint
 - ◆ Axis of translation of a prismatic joint

Spong, Hutchinson, Vidyasagar. Robot Modeling and Control. 2006.

Configuration Space

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- ◆ Configuration
 - ◆ Specification of location of every point on manipulator.
- ◆ How can we specify?
 - ◆ Links are rigid
 - ◆ Base is (assumed to be) fixed
 - ◆ So if we know values for the joint variables
 - ◆ Angle for R joints (θ), offset for P joints (d)
 - ◆ We know everything!
- ◆ Manip. configuration \equiv a set of values for joint variables
- ◆ Set of all possible configurations is the *configuration space*.



Spong, Hutchinson, Vidyasagar. Robot Modeling and Control. 2006.