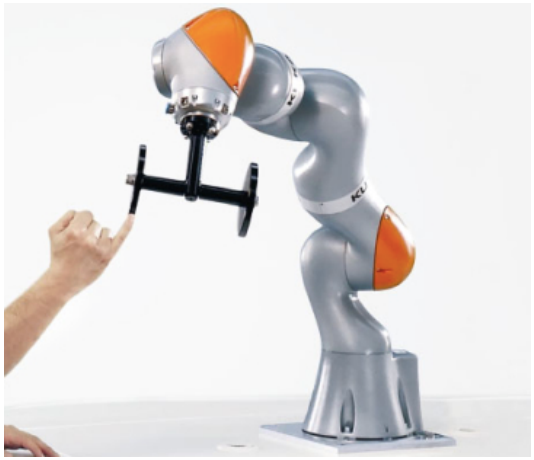
New Trends in Robotics

- **Collaborative robots (Co-bots)**
  - Safe human-robot-interaction (HRI)
  - Light-weight robots (force controlled)
  - Examples are WAM, KUKA iiwa, Franka, and many more

https://cobotsguide.com/cobots/



Robots are going to be everywhere!

- **Self-Driving Cars**
  - **ELA, Edmonton's electric autonomous vehicle**
    - Old Strathcona from October 22 to November 4
  - **Autonomous trucks**
  - **Autonomous mining trucks**
  - **UAVs, military UAVs**

Cat 793F autonomous truck at Navajo Mine trial. Truck image: Caterpillar

Search and Rescue Robots
DARPA Robotics Challenge 2015

Goal: develop **semi-autonomous** ground robots that could do **”complex tasks in dangerous, degraded, human-engineered environments”**.

https://www.youtube.com/watch?v=FRkYOFR7yPA

A Compilation of Robots Falling Down at the DARPA Robotics Challenge

Medical Robotics

- Robotic Hair Restoration can improve millions of Lives

video

Assistive Robotics

- Assistive Arm and Hand Manipulation: How does current research intersect with actual healthcare needs?

video

http://handbookofrobotics.org/view-chapter/videodetails/64

Learning from Demonstrations (LfD)

- Teaching a Robot to Roll Pizza Dough: A Learning from Demonstration Approach

Reinforcement Learning Based Control

- Policy refinement after demonstration with RL

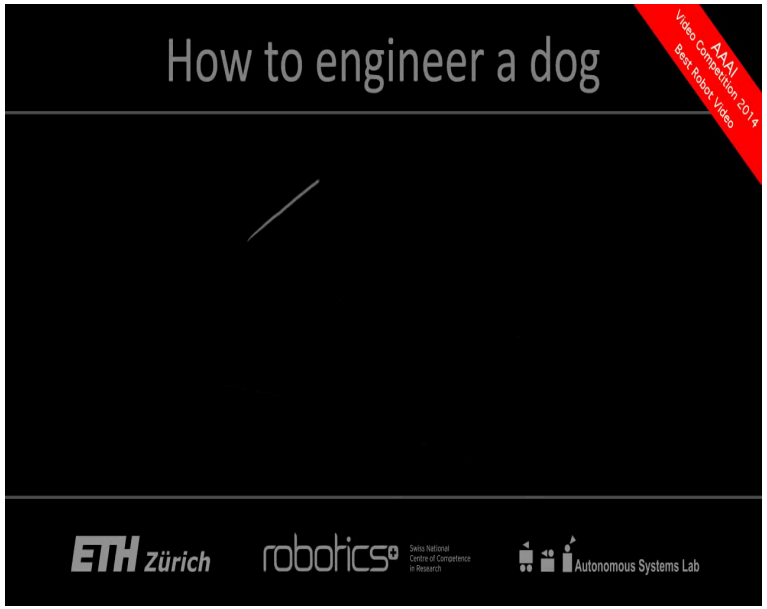
Deep Reinforcement Learning

- **AI-driven robot hand spent a hundred years teaching itself to rotate a cube**

Service & Social Robotics

Soft Actuators

- Even if you have active torque control (closed-loop), we have to handle impact (open-loop)
- Variable Stiffness Actuators (VSA) ->
- Inherent (passive) compliance -> optimal control



Compliance Control

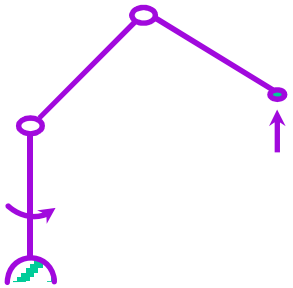
Compliance Control

Compliance

$$I\ \ddot{x} = F'$$

$$F' = -\begin{pmatrix} k'_{p_x} & 0 & 0 \\ 0 & k'_{p_y} & 0 \\ 0 & 0 & k'_{p_z} \end{pmatrix}(x - x_d) - k'_v \dot{x}$$

set to zero



$$\ddot{x} + k'_v \dot{x} + k'_{px}(x - x_d) = 0$$

$$\ddot{y} + k'_v \dot{y} + k'_{py}(y - y_d) = 0$$

$$\ddot{z} + k'_v \dot{z} = 0$$

Compliance along Z

Stiffness

$$\ddot{z} + k'_v \dot{z} + k'_{p_z} (z - z_d) = 0$$

determines stiffness along z

Closed-Loop Stiffness: $\hat{M}_x k'_p = k_p$

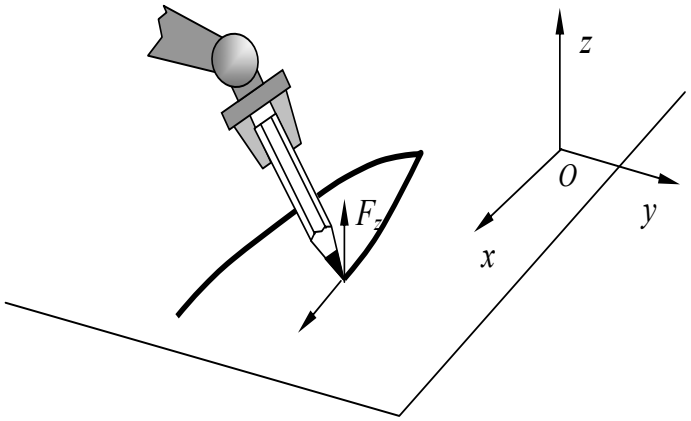
$$F = K_x (x - x_d)$$

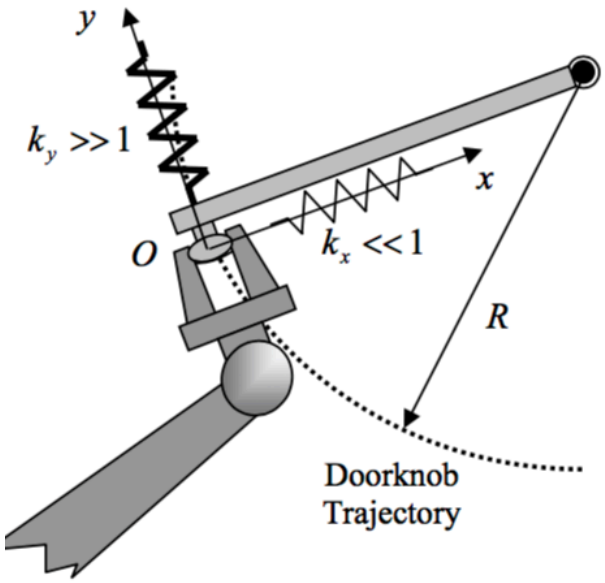
$$\tau = J^T F = J^T K_x \Delta x = (J^T K_x J) \Delta\theta = K_\theta \Delta\theta$$

$$\boxed{K_\theta = J^T(\theta) K_x J(\theta)}$$

Applications

- Contact with environment





IROS demo