18. Visuomotor Polices (via behavior cloning)

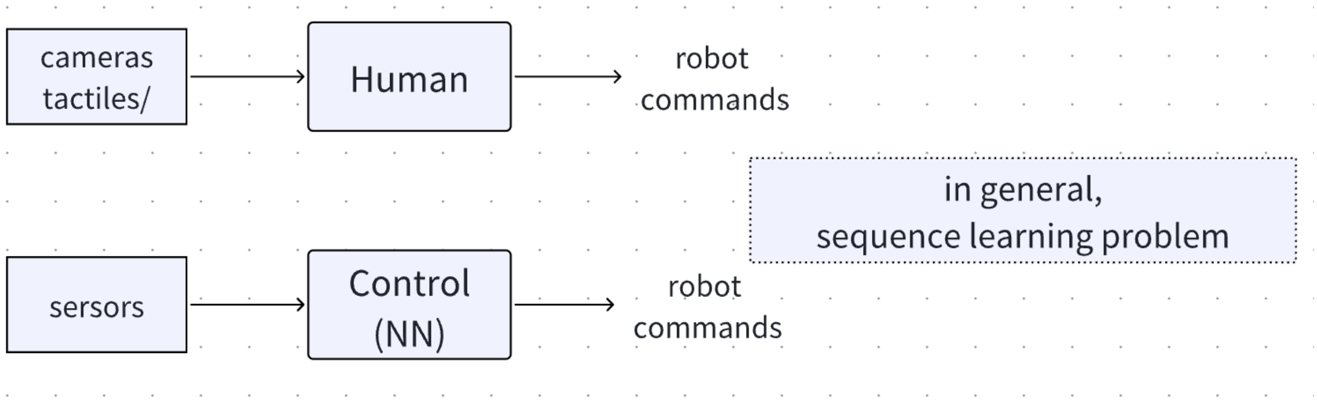
Last Lecture outline

- Manipulator Control
  - mutibody dynamic equation
    $$M(q)\ddot{q} + C(q, \dot{q})\dot{q} = \tau_g(q) + u + \sum J_i(q) f_i$$
  - trajectory tracking
  - Force Control (direct / indirect)
  - all of above are controlling the DOF of robot, but the big control problem:
  - $q = [q_{robot}, q_{environment}]'$
    $$M(q)\ddot{q} + C(q, \dot{q})\dot{q} = \tau_g(q) + Bu + \sum J_i(q) f_i$$

  which becomes an optimal control problem
- Perception with deep learning
  - perception also gets harder, estimate q
  - Sometimes we have to use probabilities
- We are going to control the robot & environment using
  - imitation learning
  - Reinforcement learning
  - Model-based Reinforcement Learning

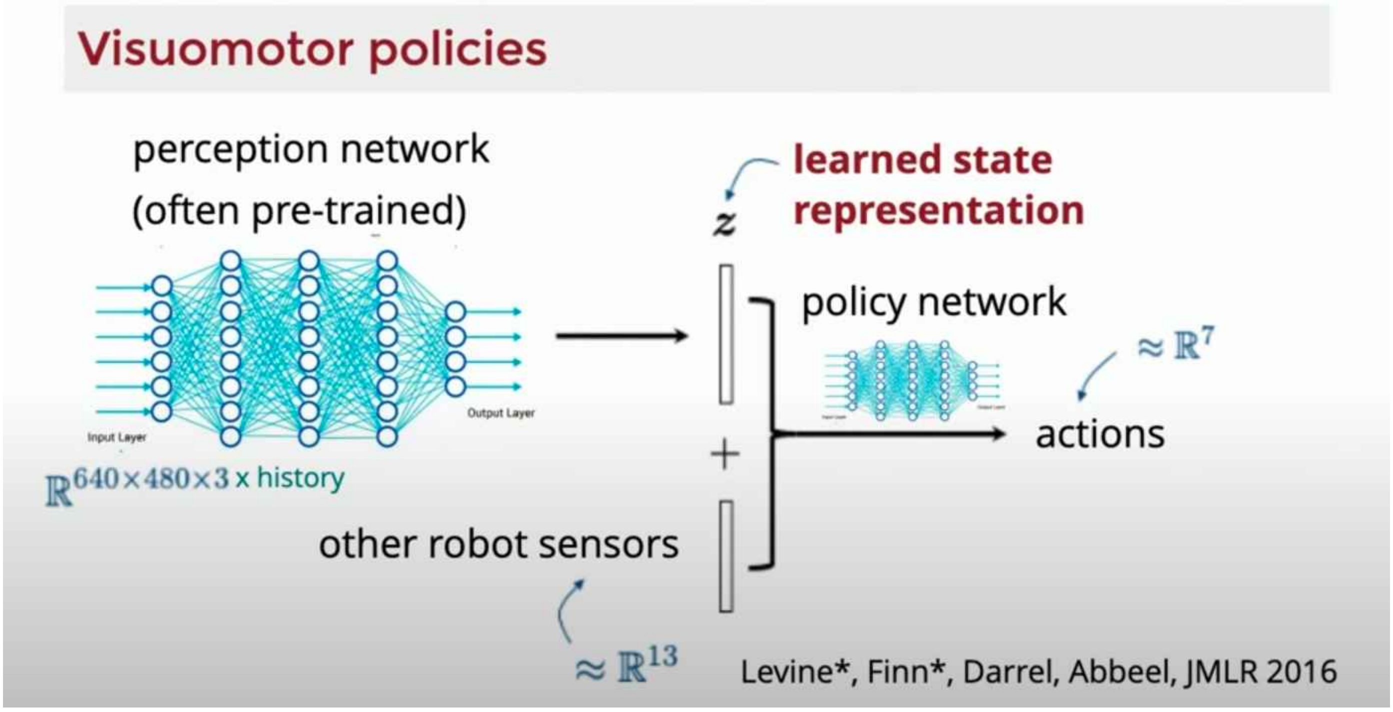
Today's Topic outline

- policy extension
  - control "policy": $u = \pi(q, \dot{q})$, q = q(robot)
  - try to extend to: $u = \pi(q, \dot{q})$, q = q(robot + environment)
  - why not $u = \pi(camera, tactile, etc)$
  - write a single controller that works for an entire class of objects

- Try to do the controller more locally, in an easier way
    - Deep Imitation Learning for Complex Manipulation Tasks from Virtual Reality Teleoperation.pdf
    - Control becomes a supervised learning problem
    - 

    - Imitation Learning
        - Behavior cloning (mimic input/output from human)
        - Inverse Optimal Control / Inverse Reinforcement Learning (just learn the reward, then do RL)

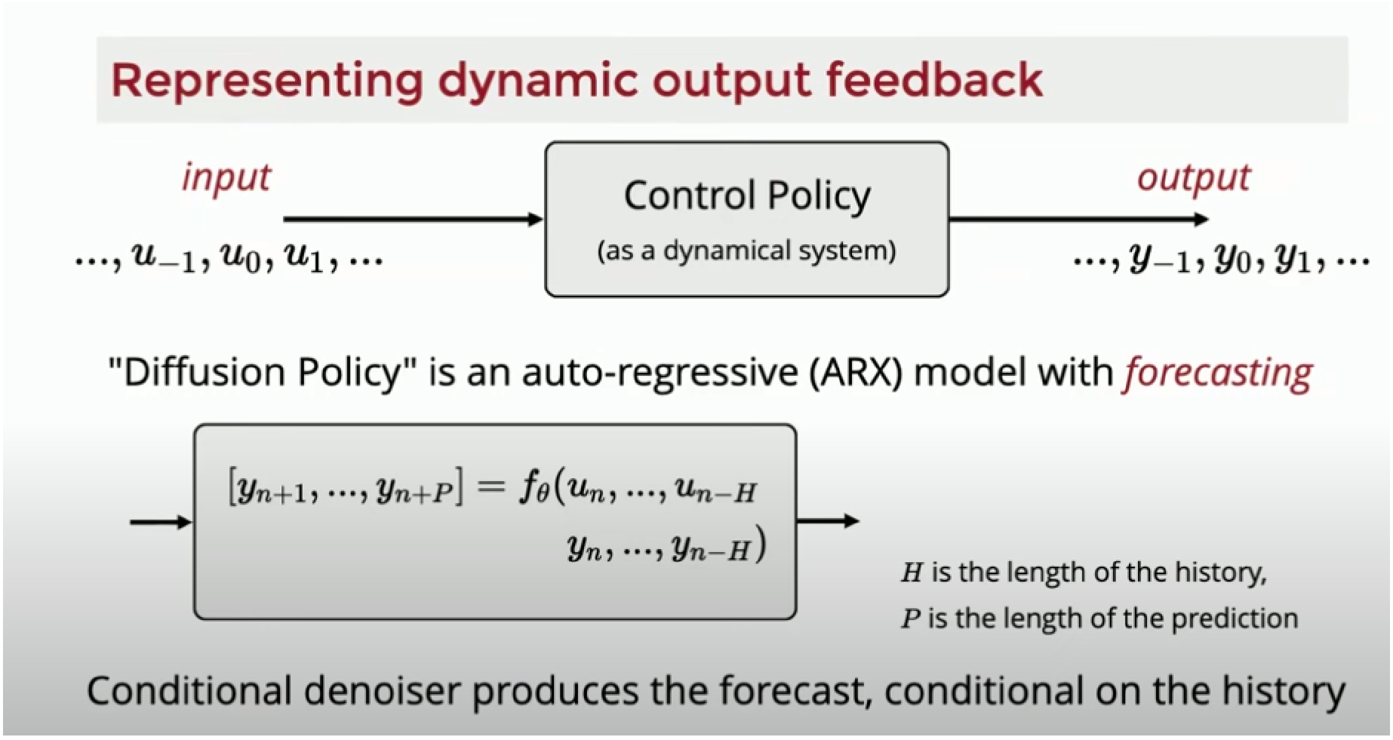
- Visuomotor policies
    - Pre-train on Image-net, we dont care about elephants/dogs etc, drop off the last layer, and add a layer do emphasis dishes and mug, fine tuning.
    - **Close a loop on the RGB sensors directly, Closing the loop on cameras!! So valueable**



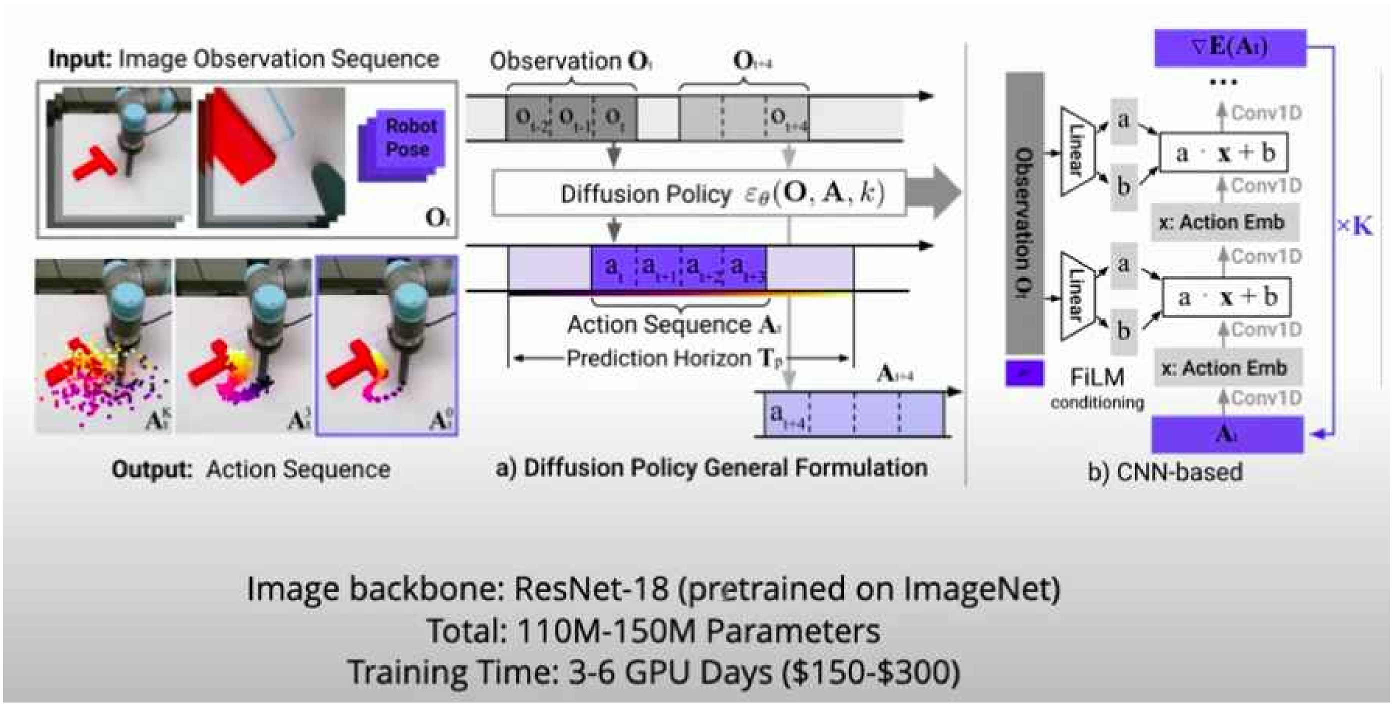
End-to-End Training of Deep Visuomotor Policies.pdf

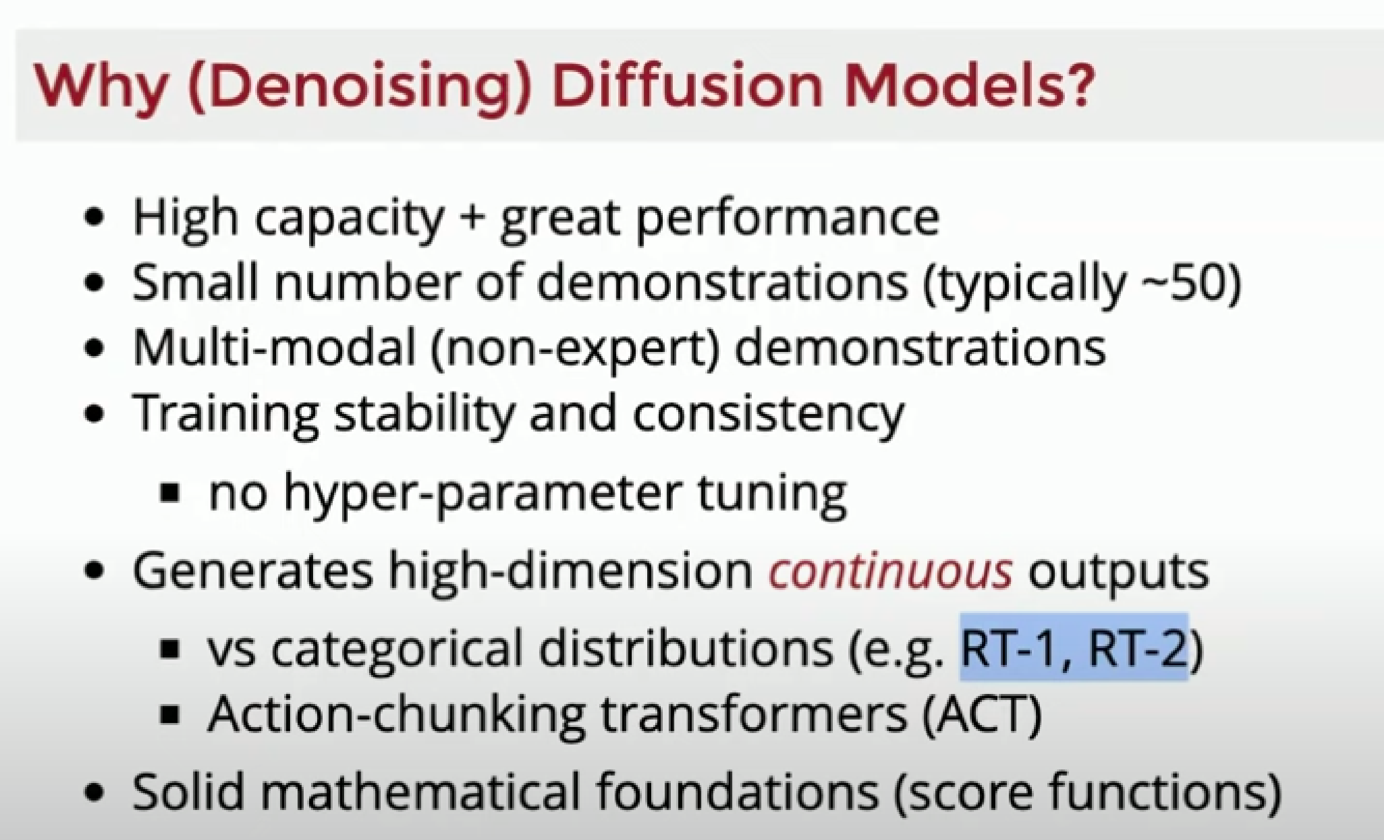
- a lot of people use Transformers, google RT1, RT2 , decision transformers
- Dense Descriptors

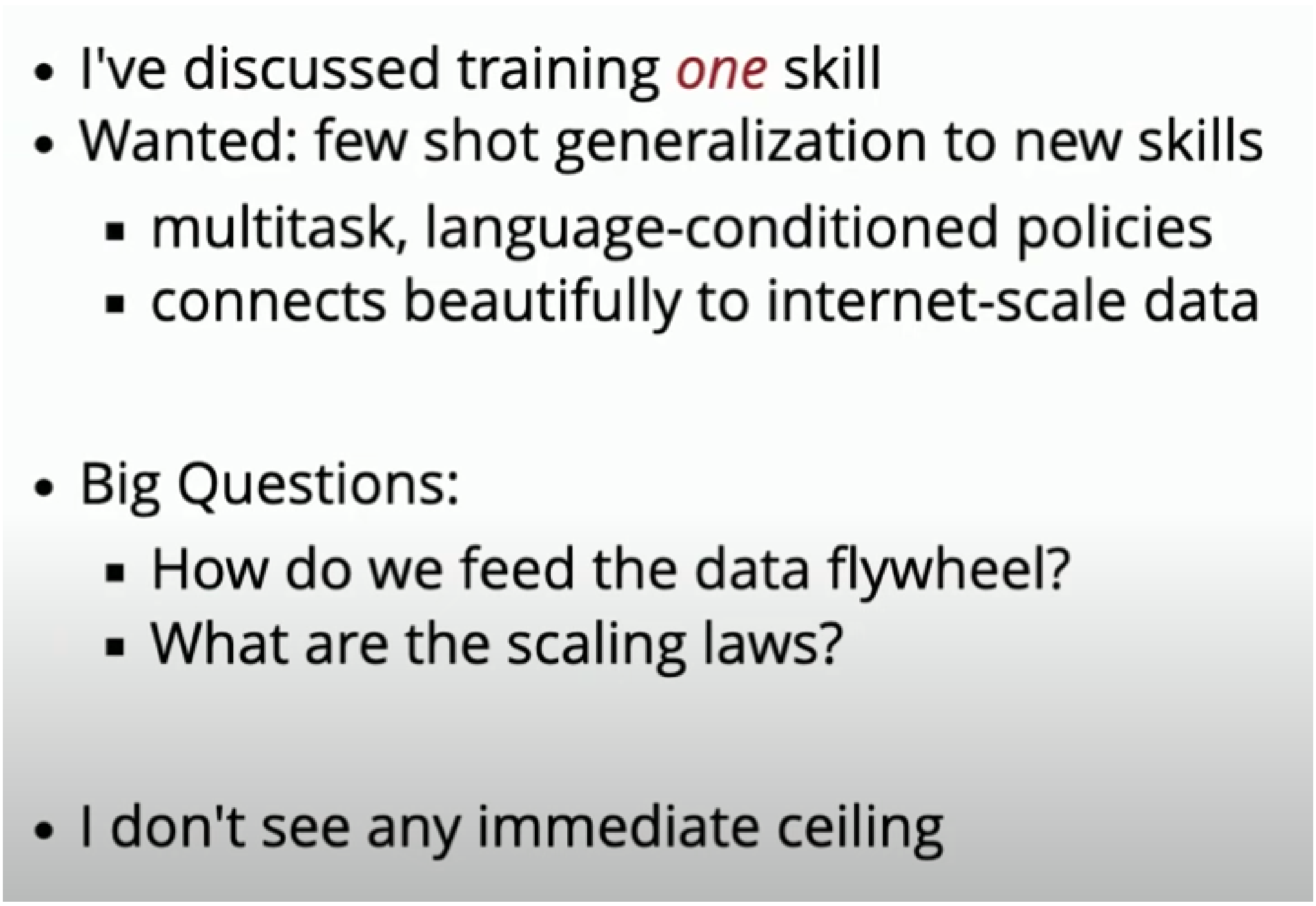
1. ## Start on tasks that can not be simulated, food, deformable object
   - Diffusion Policy, Visuomotor Policy Learning via Action Diffusion
   - Does the task, humans need the force feedback to get it done?
2. ## Diffusion, another self supervised learning
   - take any image in your data set and add noise, random gaussian
   - train the backwards process



- auto-regressive model ; predicte a sequency of actions







Maybe control becomes like Vision or NLP. I won't stop trying to understand things

I think there is a handful of fruits of controls theory, but sometimes you can see better with models GCS. try to understand both and push, to get a much deeper way looking through