View-Based Teaching/Playback for Grasp and Graspless Manipulation

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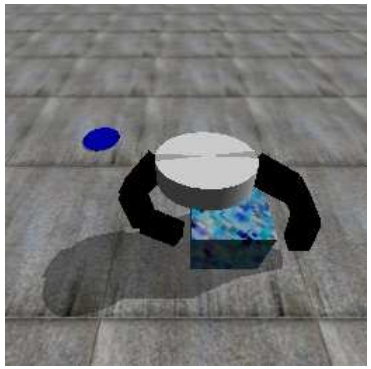
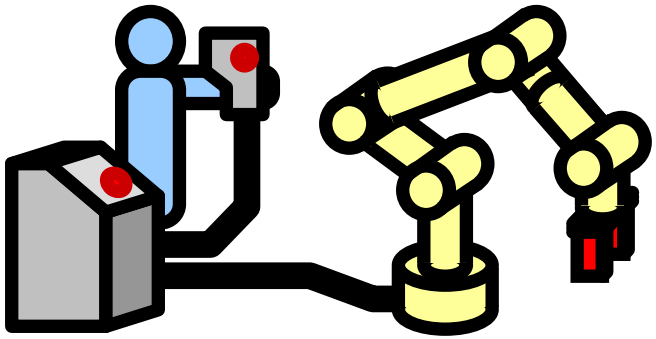


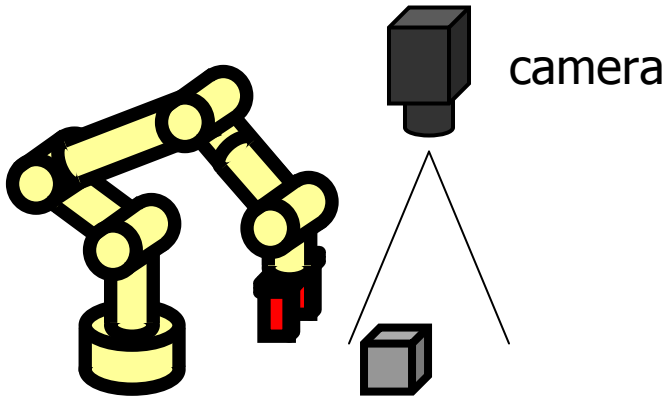
Background

- Conventional Teaching/Playback
  - still widely used
  - versatile
  - for constant task conditions
    - e.g.) initial pose of object does not change



If the initial object pose is not constant…

- Object localization with cameras
  - Model-based image processing
    - Feature extraction: edge, vertex, …
    - Pattern matching
  - Object-specific: versatility is limited



Motivation

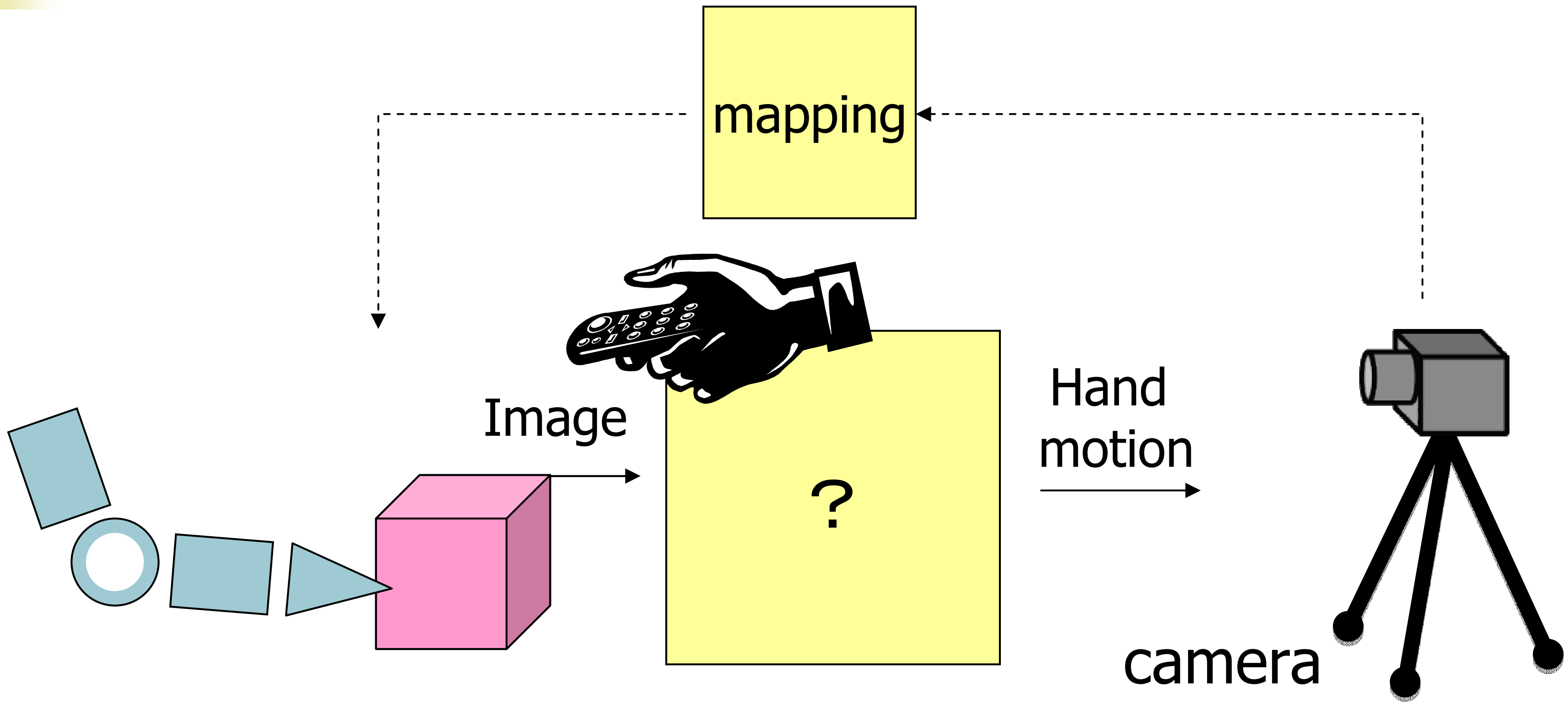
- To develop a **versatile** robot programming method that can deal with change of task conditions

View-based teaching/playback: robot programming with view-based image processing

Model-based vs. View-based

- Model-based approach
  - with object-specific models
  - accurate
- View-based (Appearance-based) approach
  - without object-specific models
  - versatile

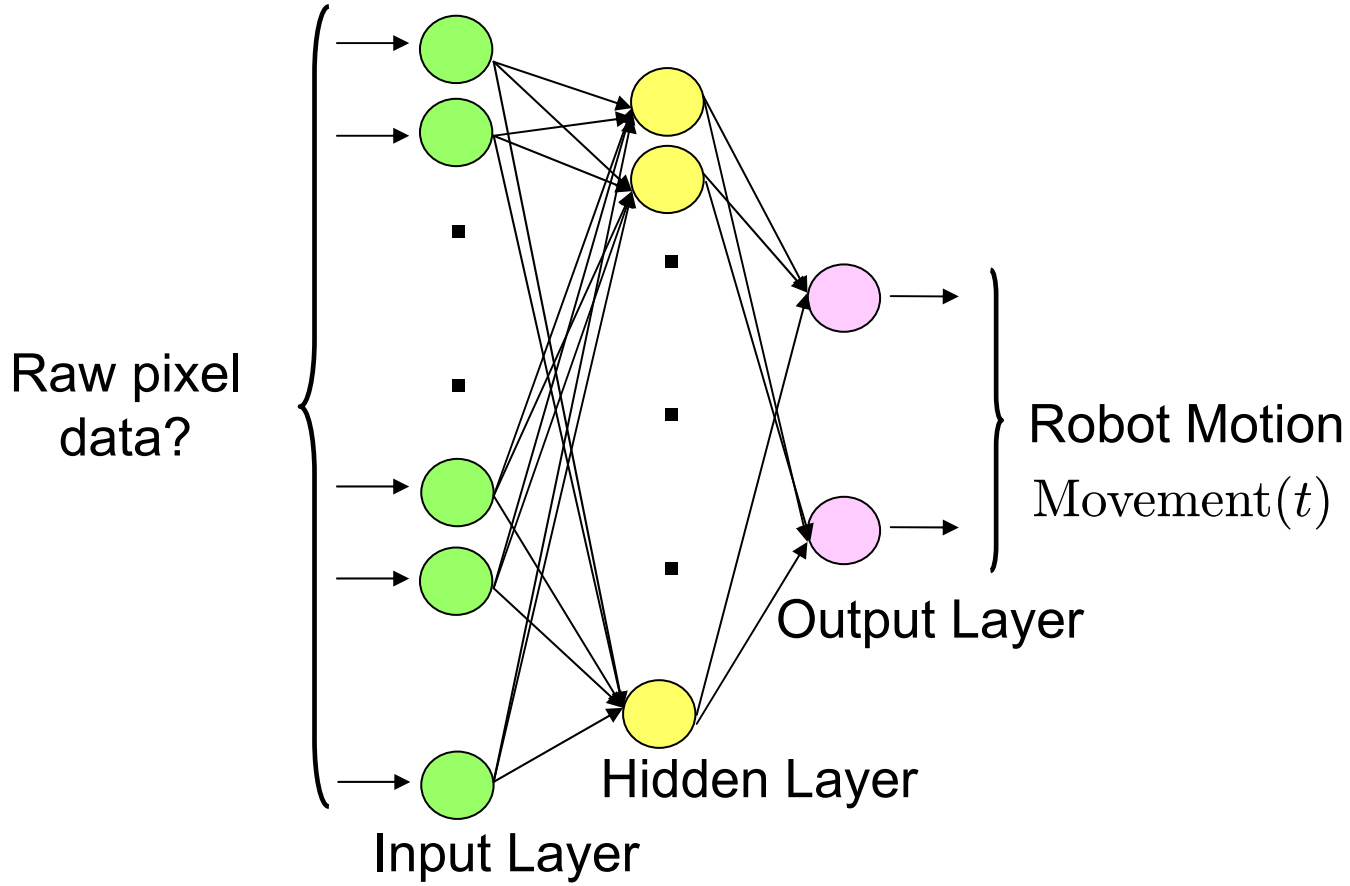
Overview of view-based teaching/playback



1. Human demonstrator commands a robot to perform a manipulation task
2. Obtain the mapping from image to motion
3. Playback: Robot generates motion according to the mapping

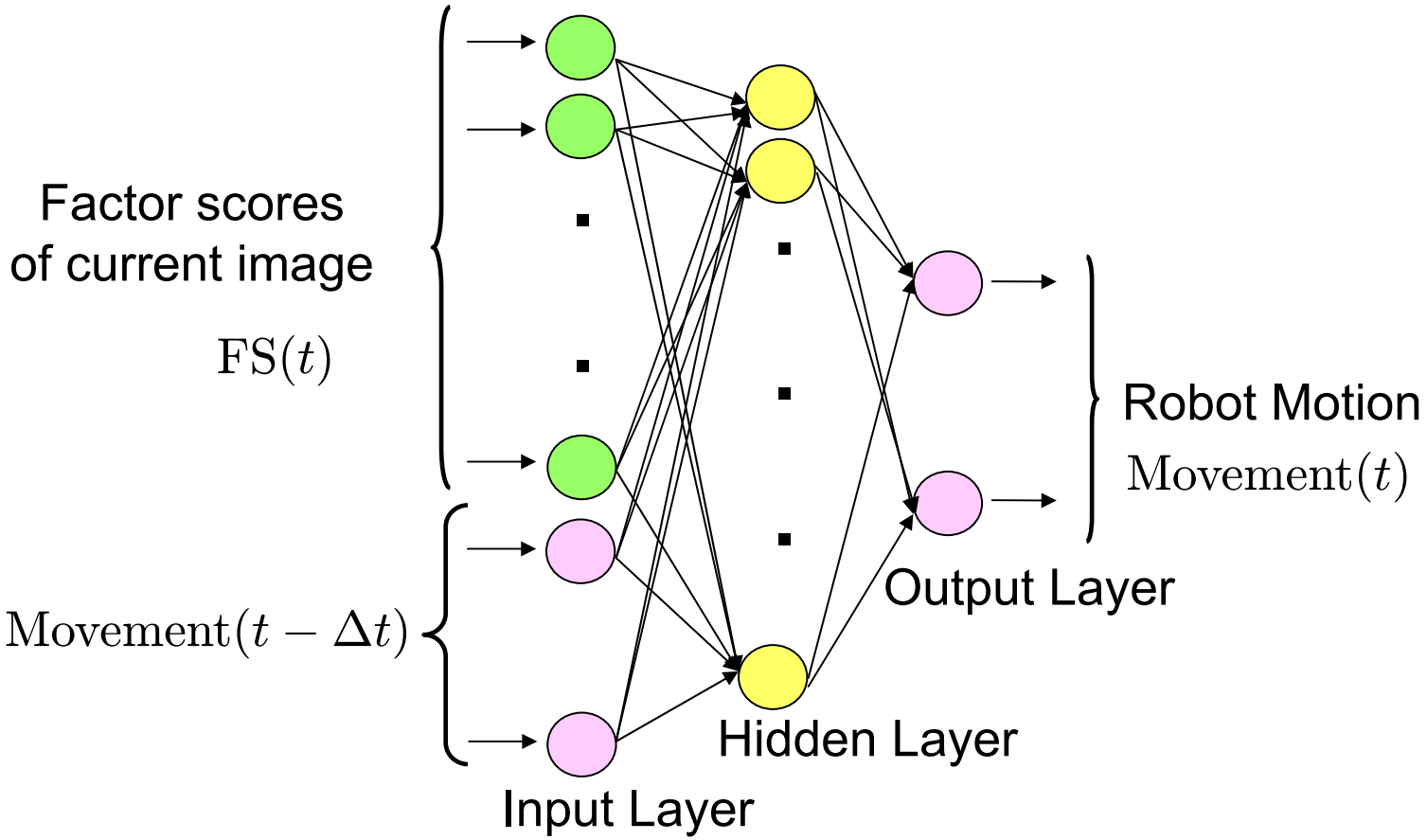
Mapping from image to motion (1)

- Neural network



Mapping from image to motion (2)

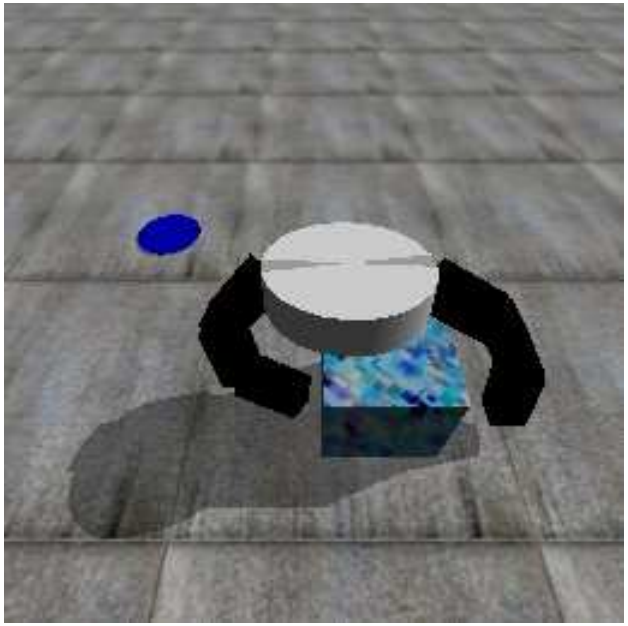
- PCA (Principal Component Analysis)



View-based teaching/playback

- View-based image processing using PCA
  - not object-specific
  - no need for camera calibration
- Adaptability to change of the initial pose of the object using the generalization ability of neural networks
  - generalization from multiple demonstrations

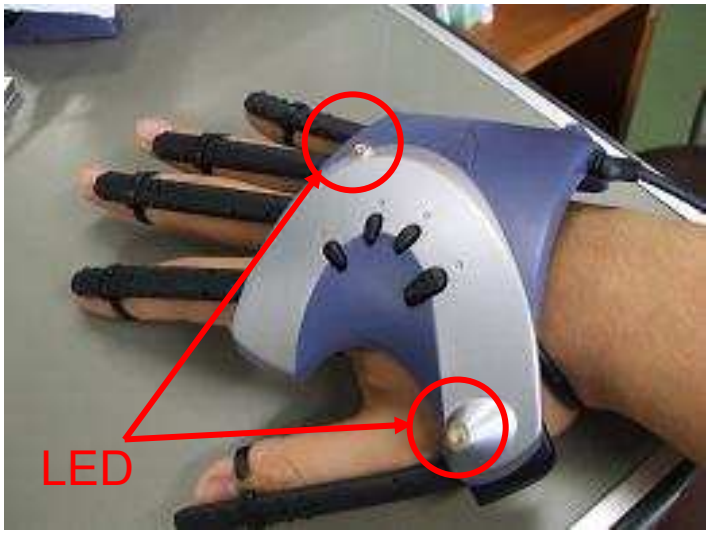
Virtual Manipulation Environment for Proof of Concept



PC + Data glove + Dynamics Simulator

Data Glove for Teaching

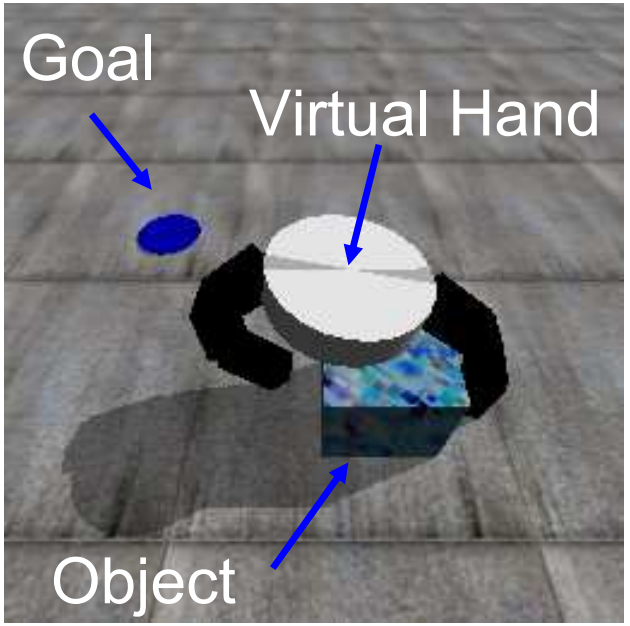
- P5 Glove (for games)



6 DOF for palm and 1 DOF for each finger (bending)

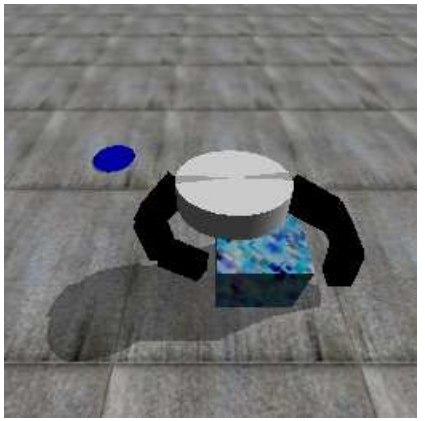
Virtual Hand

- PD-controlled according to glove input in ODE (Open Dynamics Engine)
- 8 DOF
  - 6 DOF for palm
  - 1 DOF for thumb
  - 1 DOF for index finger

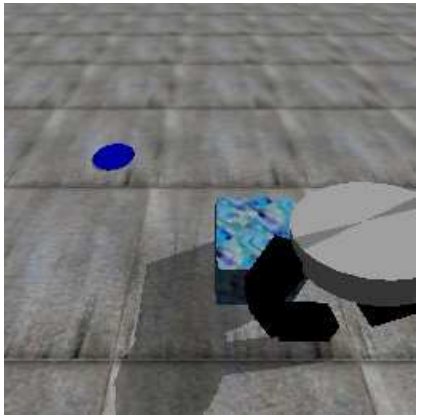


Target Manipulation

- Grasp Manipulation (pick-and-place)

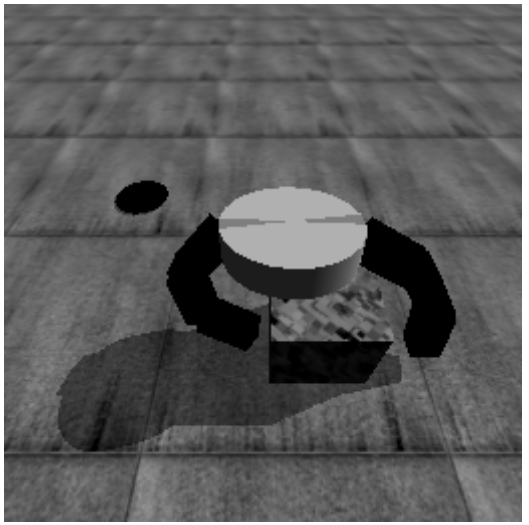


- Graspless Manipulation (pushing)



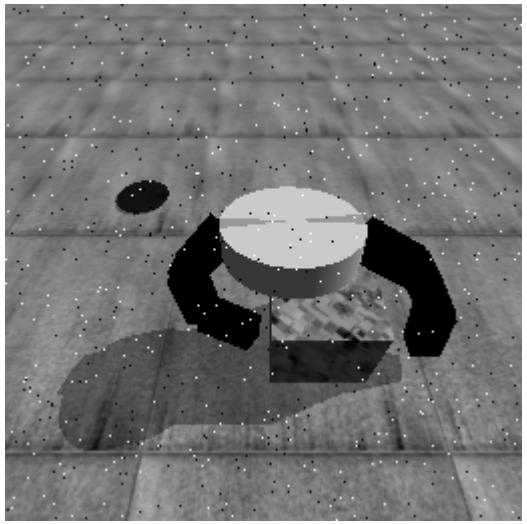
Camera images in virtual environment

- Simulate actual camera images
  - Grayscale
  - Change of lighting conditions
  - Salt-and-pepper noise

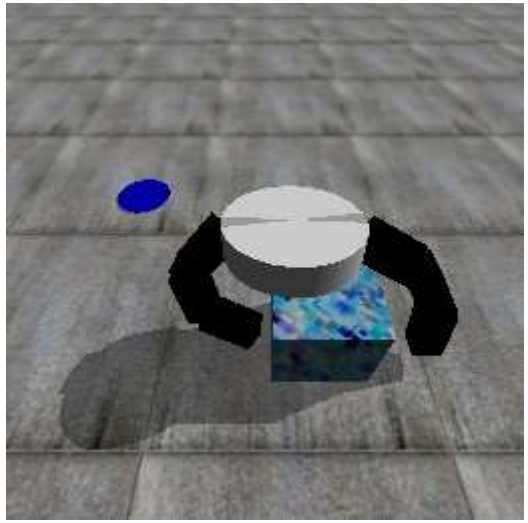


Coping with noise and change of lighting conditions

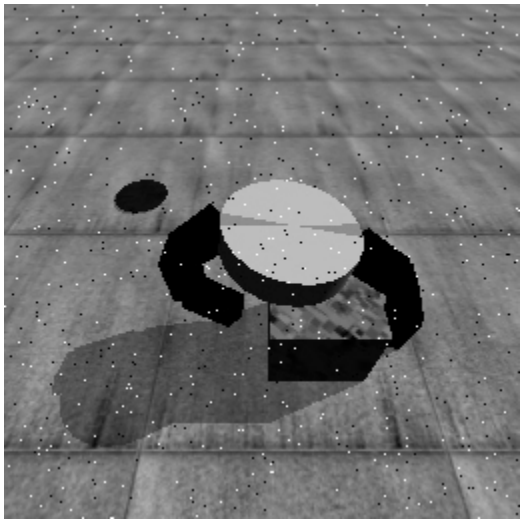
- Median filtering
- Histogram normalization
  - By gamma correction



Teaching and Playback of Grasp Manipulation



Teaching



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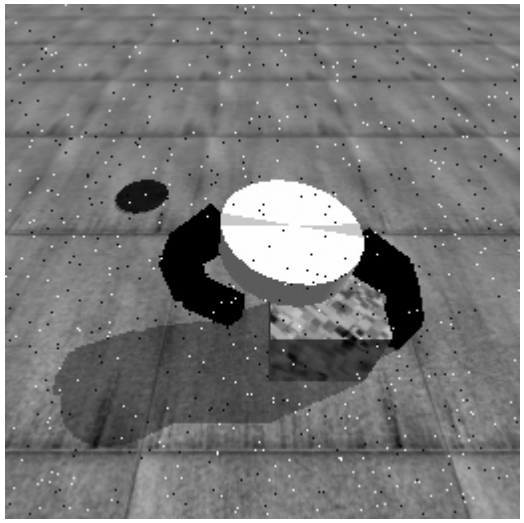

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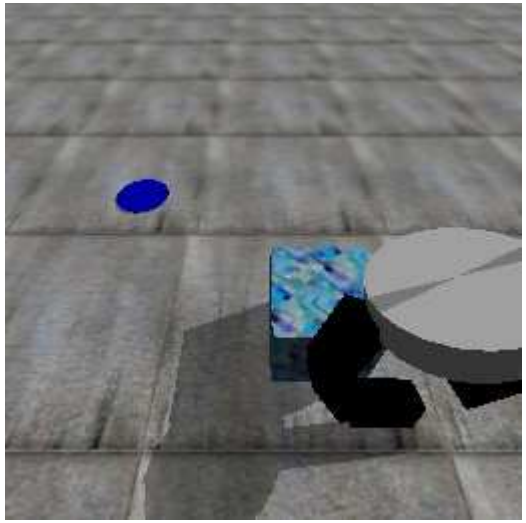
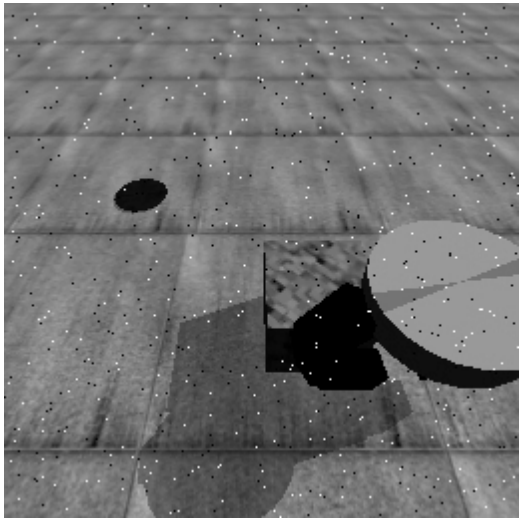
Playback

Teaching and Playback of Graspless Manipulation



Teaching



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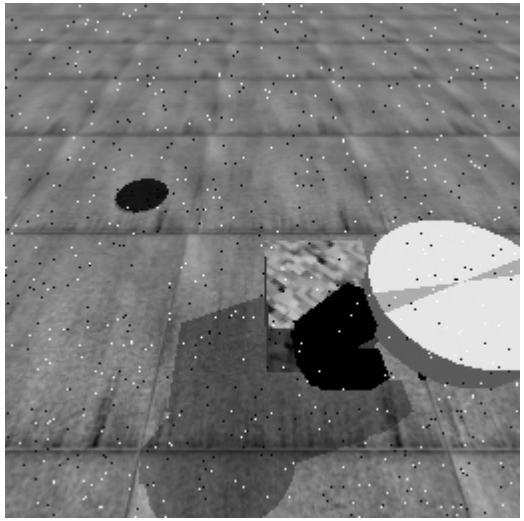

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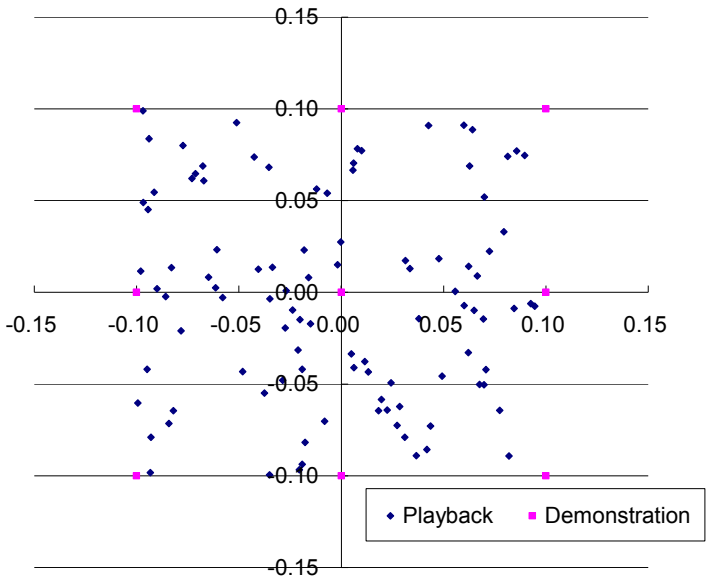
Playback

Dealing with fluctuation of initial object positions

- Demonstrations from 9 different initial positions
- 100 Playbacks from random initial positions

	Dar
1% Noise	
5% Noise	



Conclusion

- View-based teaching/playback is proposed and implemented on a virtual environment.
- It can adapt to the change of initial pose of the object in grasp and graspless manipulation tasks.

Future Work

- Application to actual industrial robots
- Reinforcement learning