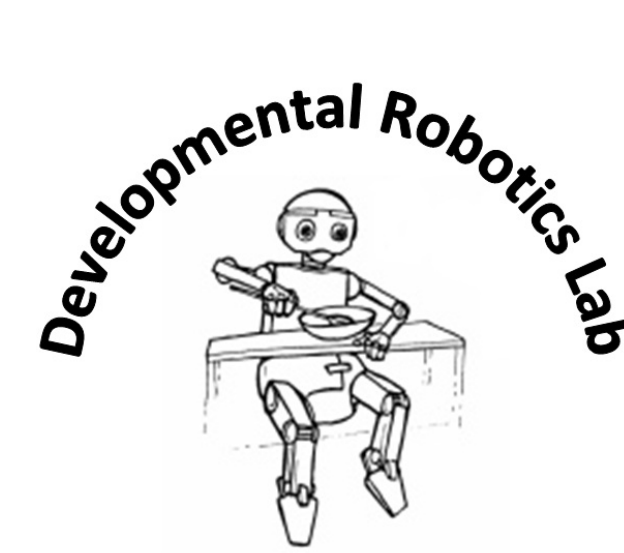




# Learning to Detect Spatial Regions with Constraints



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## 1. Introduction

### Research Question

How can the robot learn to move in a constrained space?

### Related Questions

- How does the robot identify that its movements are constrained or unconstrained in specific directions?
- What are the sensorimotor patterns associated with these constraints?



## 2. Related Work and References

Other robots can insert objects, but do not gain knowledge of the task or their environment.



(Koonce et al., 2010)



(Meeussen et al., 2010)

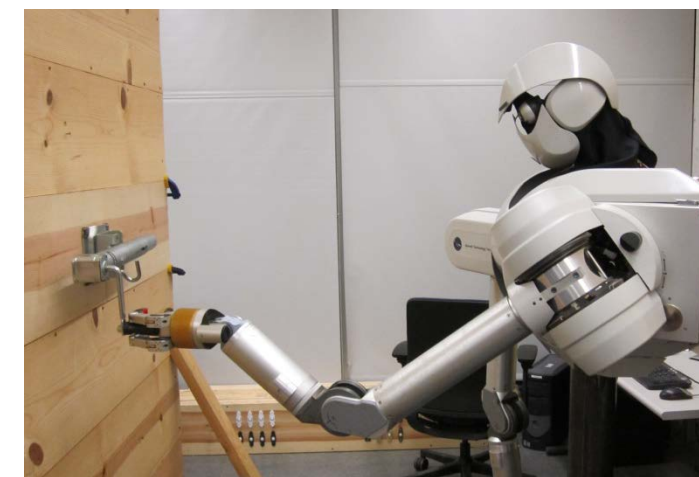


(Mayton et al., 2010)

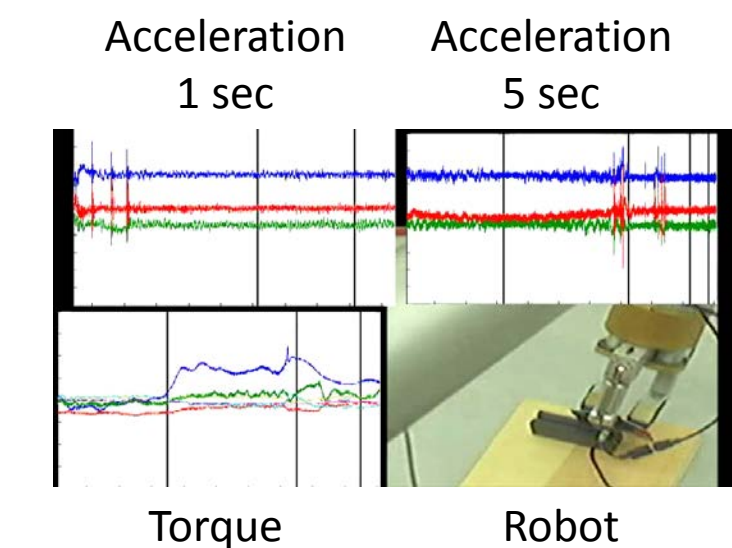
## 3. Experimental Setup

### Upper-torso robot

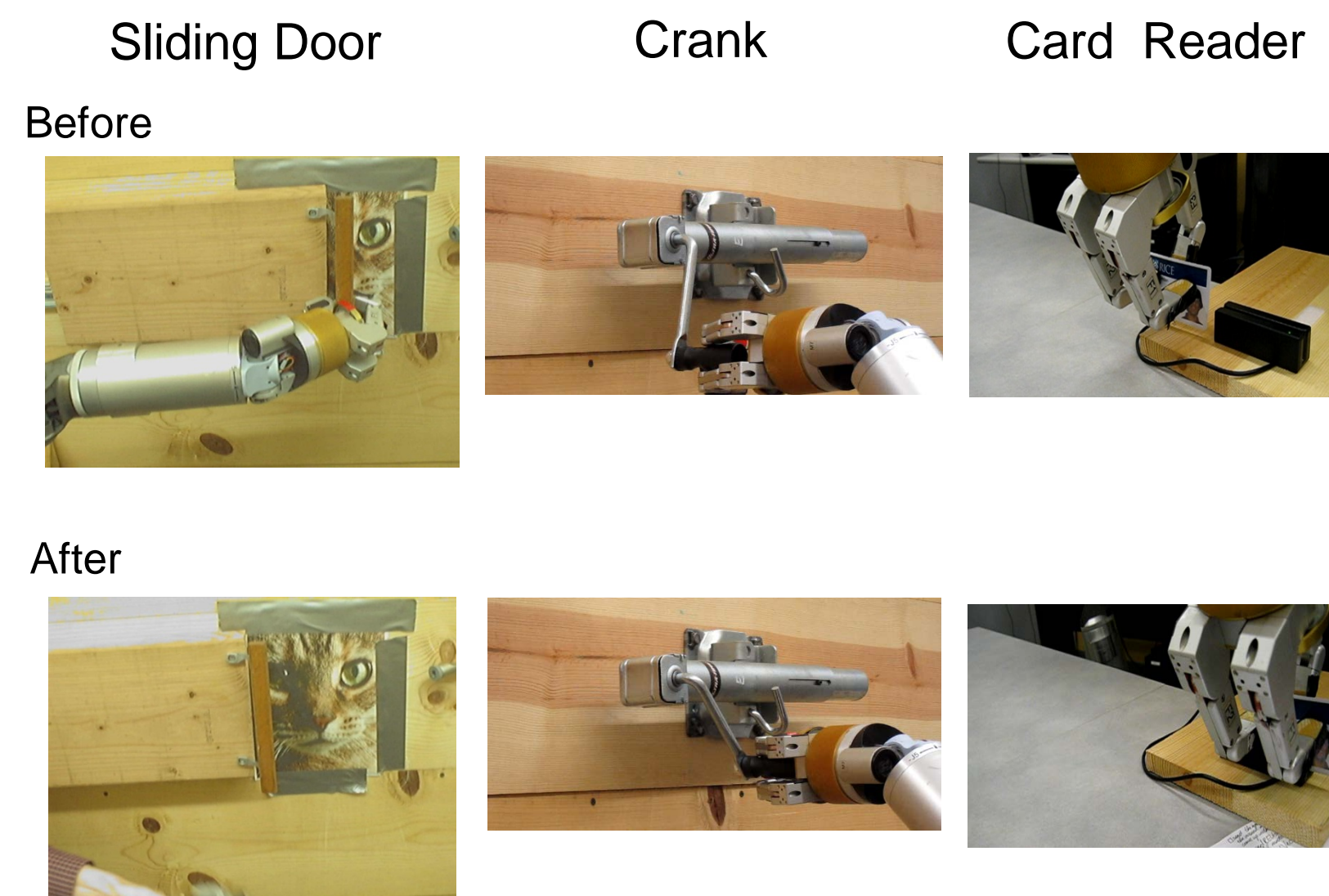
Two Barrett WAMs



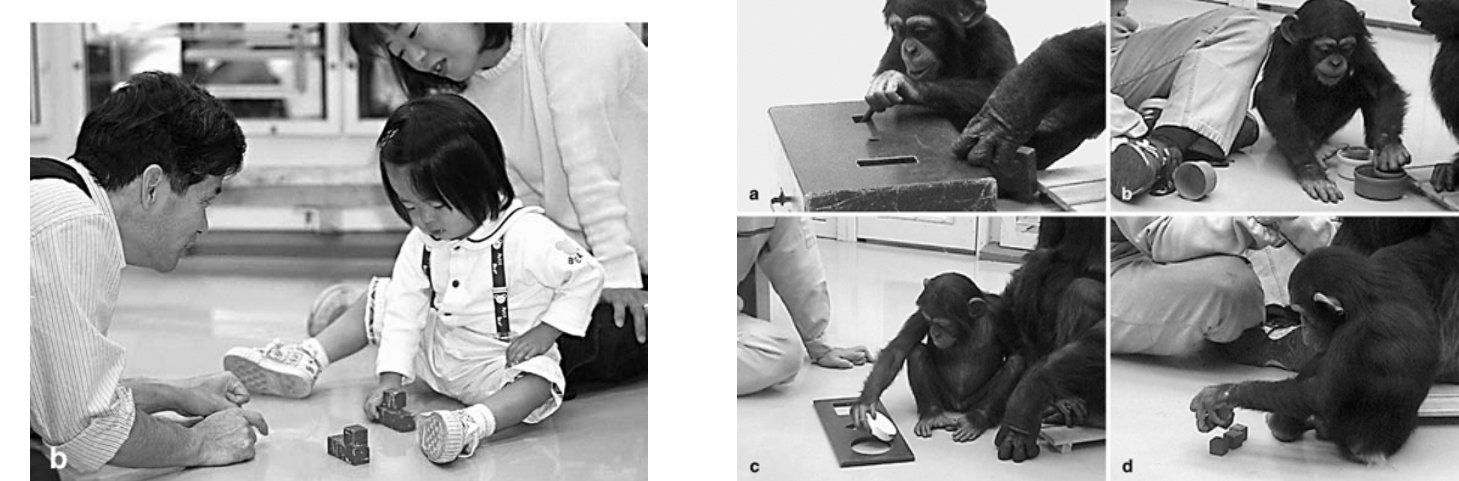
Video and Proprioception



### Tools and Spaces for Exploration



Work has been done to show how human and chimpanzee babies learn developmentally through exploration.

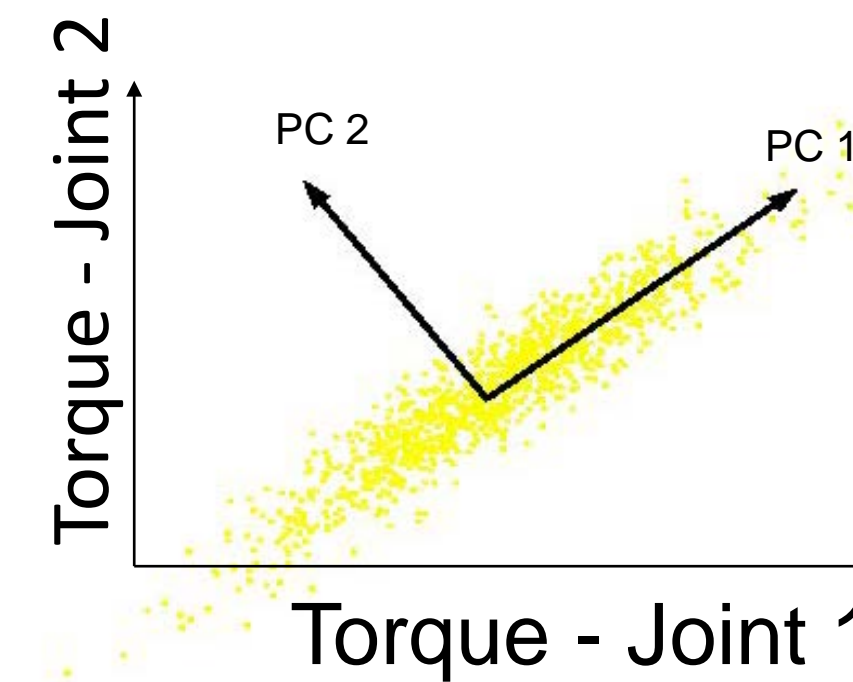


(Hayashi and Matsuzawa, 2003)

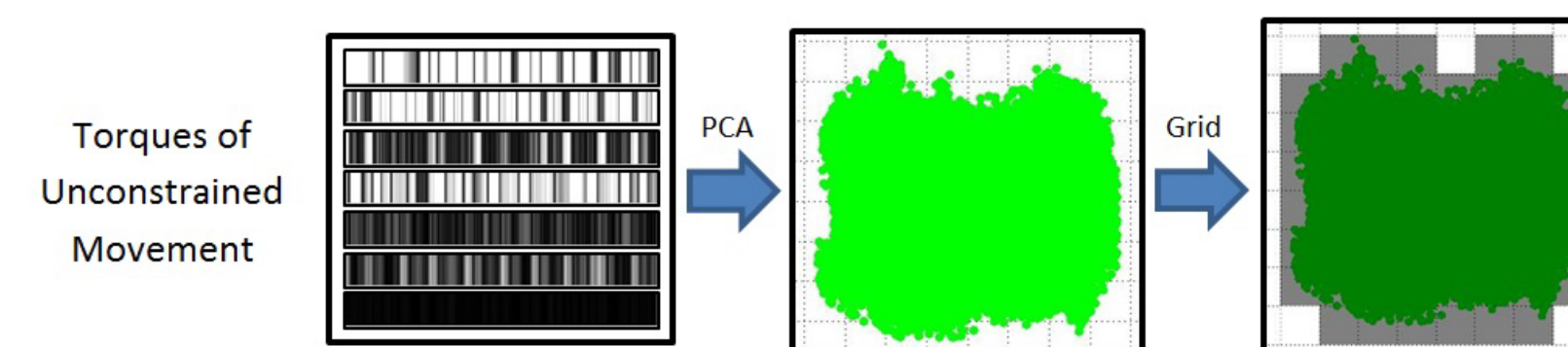
We want our robot to learn about constrained motion in the same way as infants and chimpanzees.

## 4. Methodology

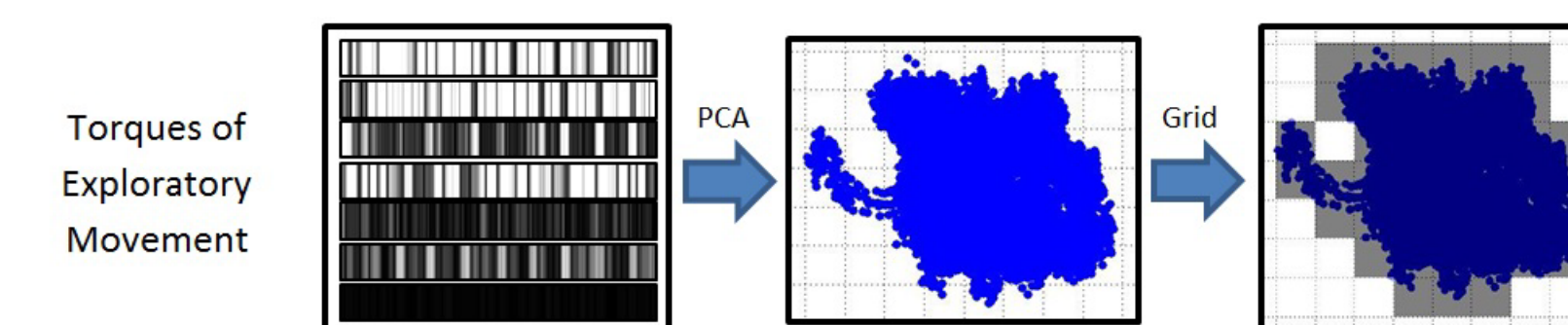
- Explore unconstrained space with a Barrett WAM.
- Torque readings are collected from all the joints.
- Principle Component Analysis is used to create a 2-dimensional representation, or profile, of these torques.



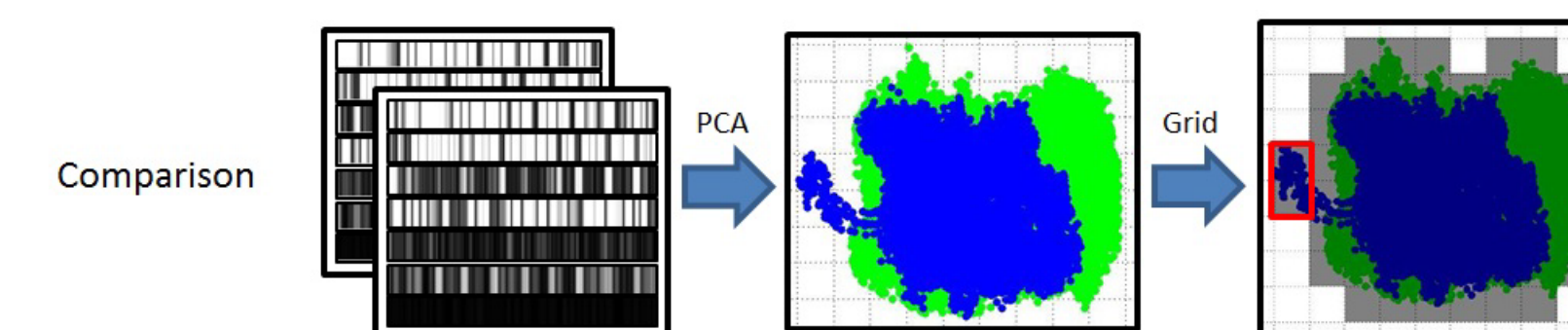
- The profile is discretized into a grid.



- The robot explores a new space containing novel objects.



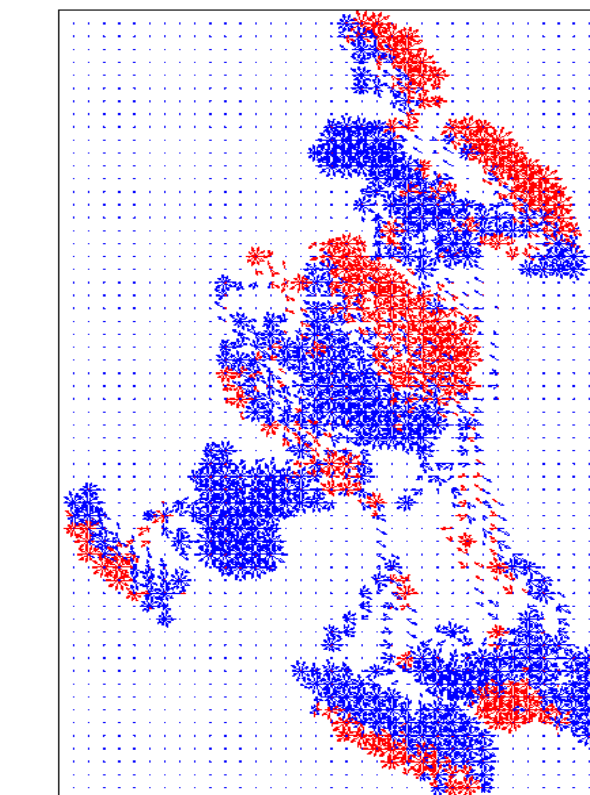
- It then compares proprioceptive data for the current trial to the stored profile.



- Proprioceptive data that lies outside the profile (highlighted by a red box) indicates that the robot is being constrained.

## 5. Cont. Methodology and Results

1. The robot attempted to create a map of the constraints in proprioceptive space.

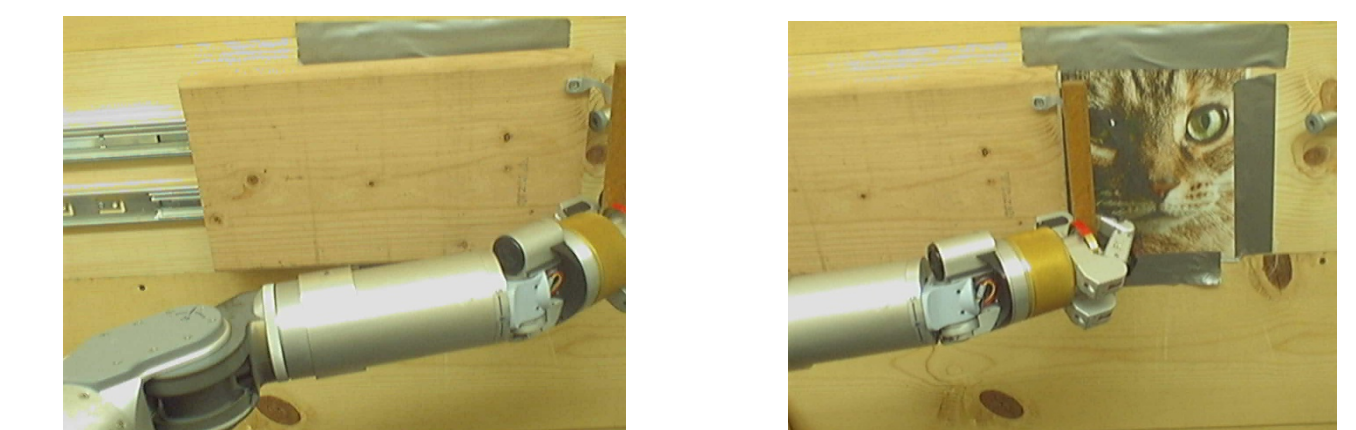


### Map of Constraints

Blue shows directions in which movements are unconstrained

Red shows directions in which movements are constrained

- Constraints caused inaccuracies in the arm's positioning system, corrupting the map.
2. Next, the robot found unconstrained directions and explored those directions until it became constrained.



## 6. Conclusion and Future Work

- The robot can detect constraints using proprioceptive data.
- The robot can manipulate objects by randomly applying force and finding unconstrained space.
- Future research would develop methods to minimize inaccuracies in proprioceptive data during exploration of constrained regions.