Learning about Objects by Experiment

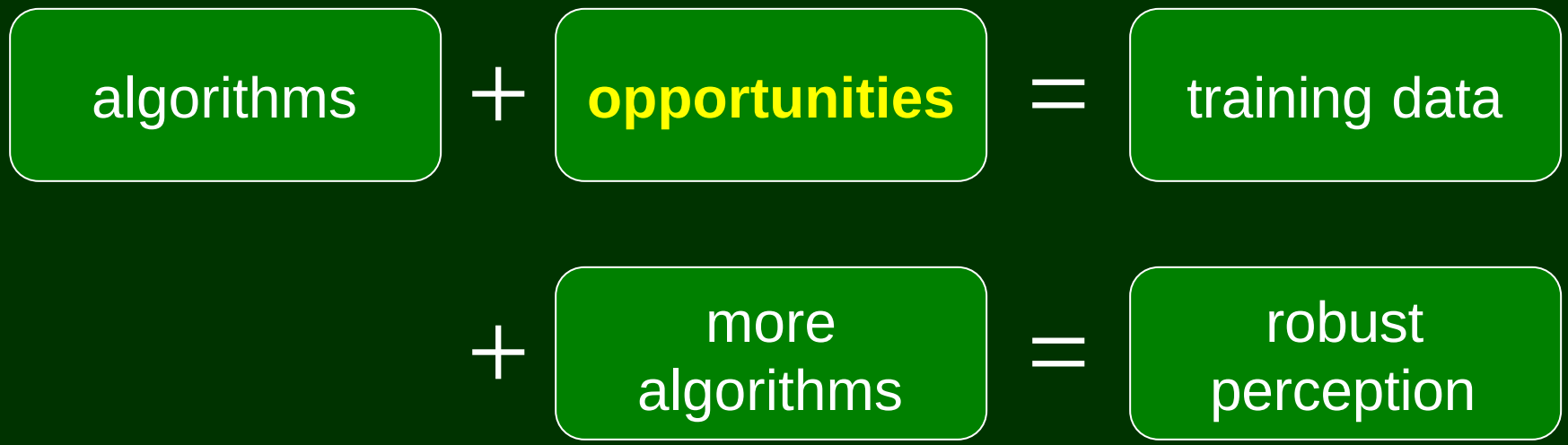
– Paul Fitzpatrick –

MIT Artificial Intelligence Laboratory

machine perception

algorithms + **training data** = robust perception

self-training perceptual system



making opportunities

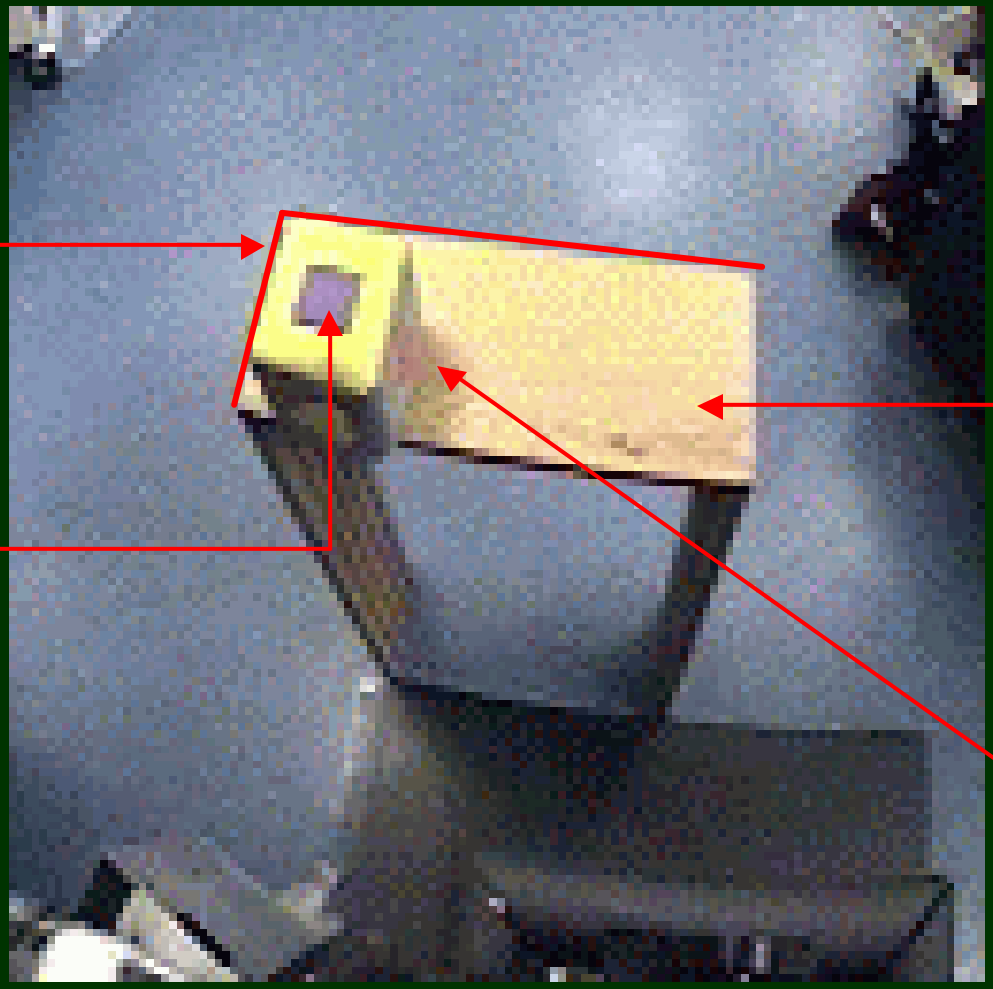
In robotics, vision is often used to guide manipulation

But manipulation can also guide vision

Important for…

- Experimentation progressing when perception is ambiguous
- Correction recovering when perception is misleading
- Development bootstrapping when perception is primitive

a simple scene?



Edges of table and cube overlap

Cube has misleading surface pattern

Color of cube and table are poorly separated

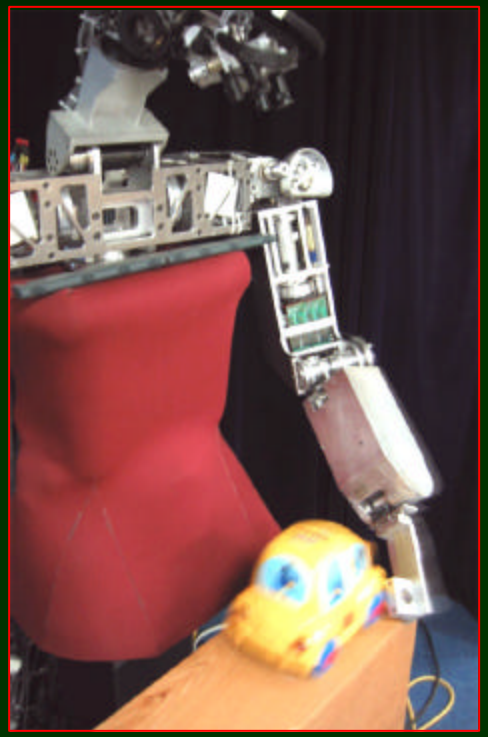
Maybe some cruel grad-student faked the cube with paper, or glued it to the table

active segmentation

- Object boundaries are not always easy to detect visually

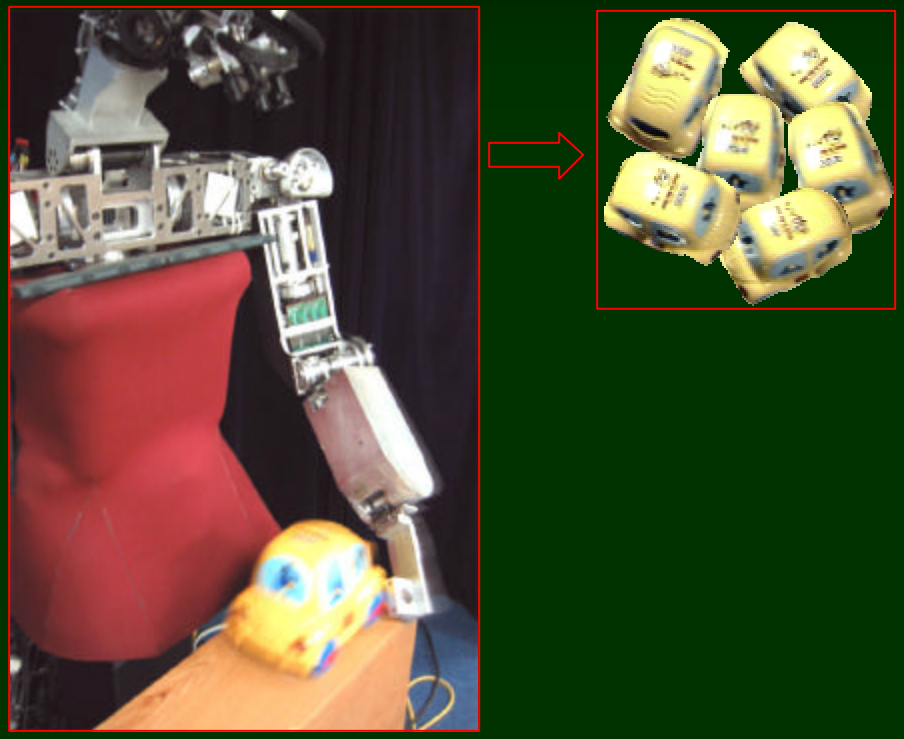
active segmentation

- Object boundaries are not always easy to detect visually
- Solution: *Cog* sweeps through ambiguous area



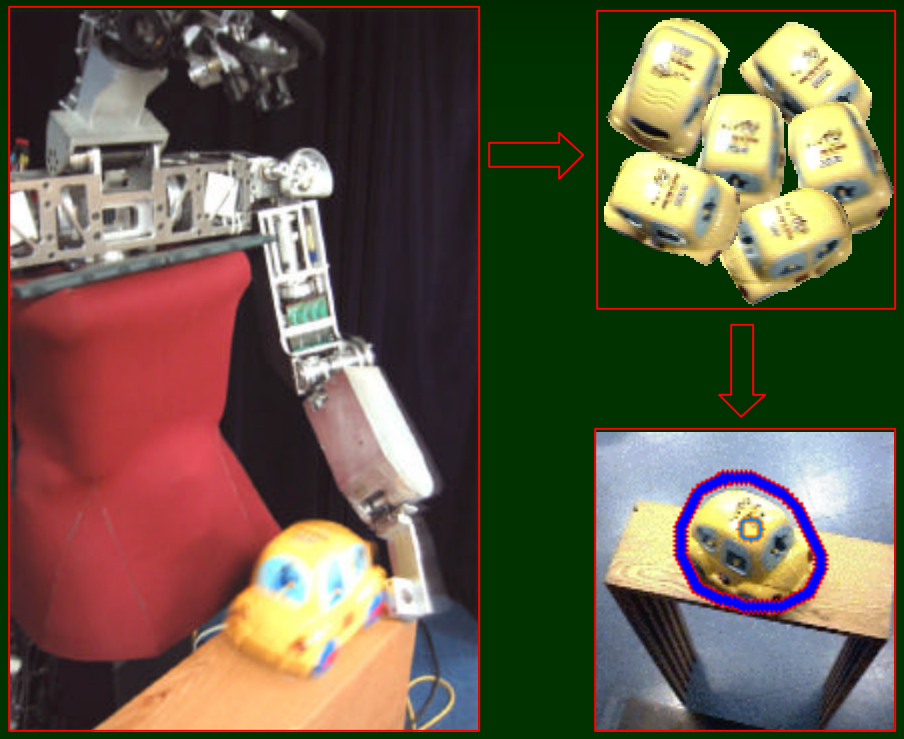
active segmentation

- Object boundaries are not always easy to detect visually
- Solution: *Cog* sweeps through ambiguous area
- Resulting object motion helps segmentation



active segmentation

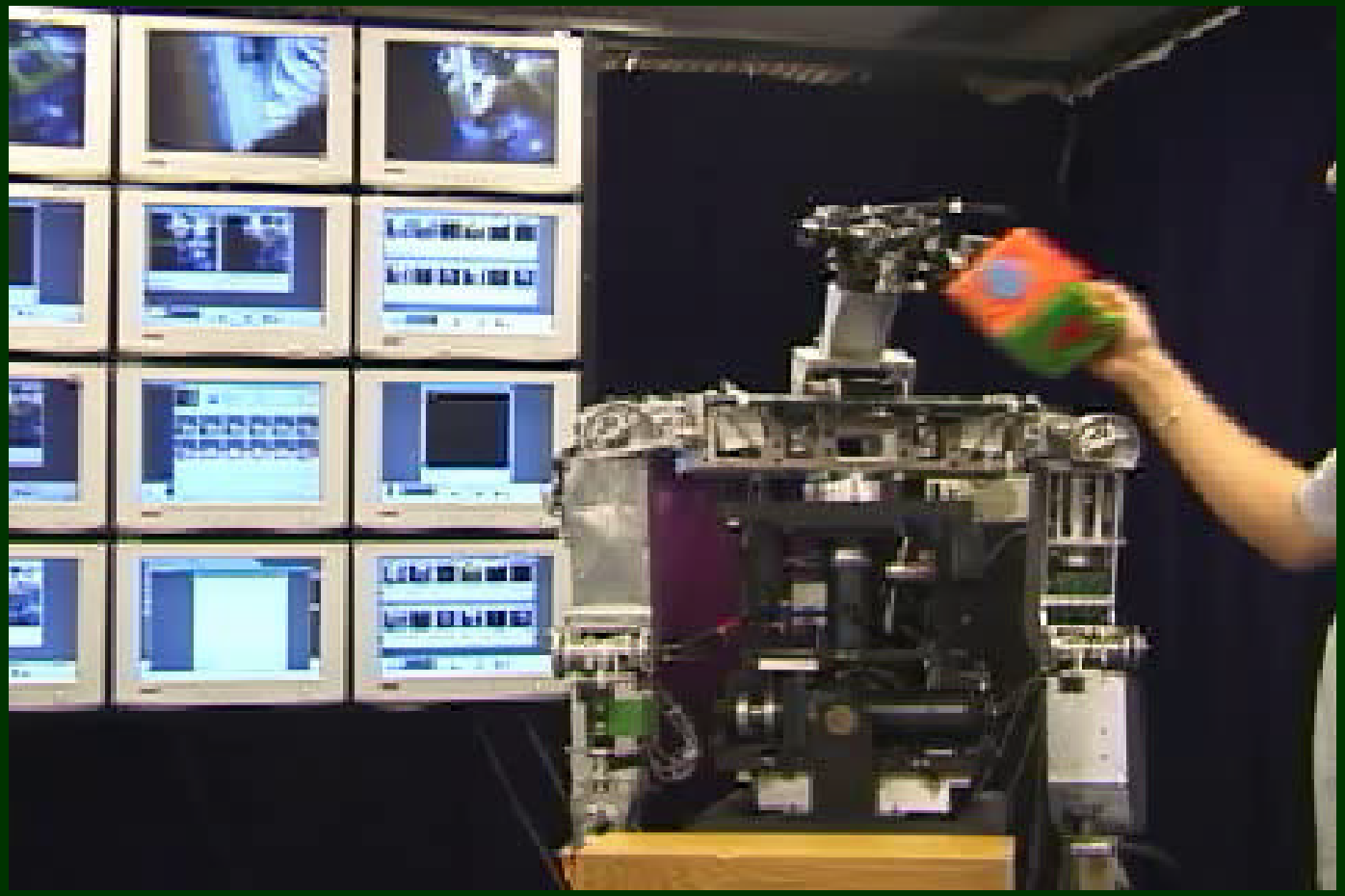
- Object boundaries are not always easy to detect visually
- Solution: *Cog* sweeps through ambiguous area
- Resulting object motion helps segmentation
- Robot can learn to recognize and segment object without further contact



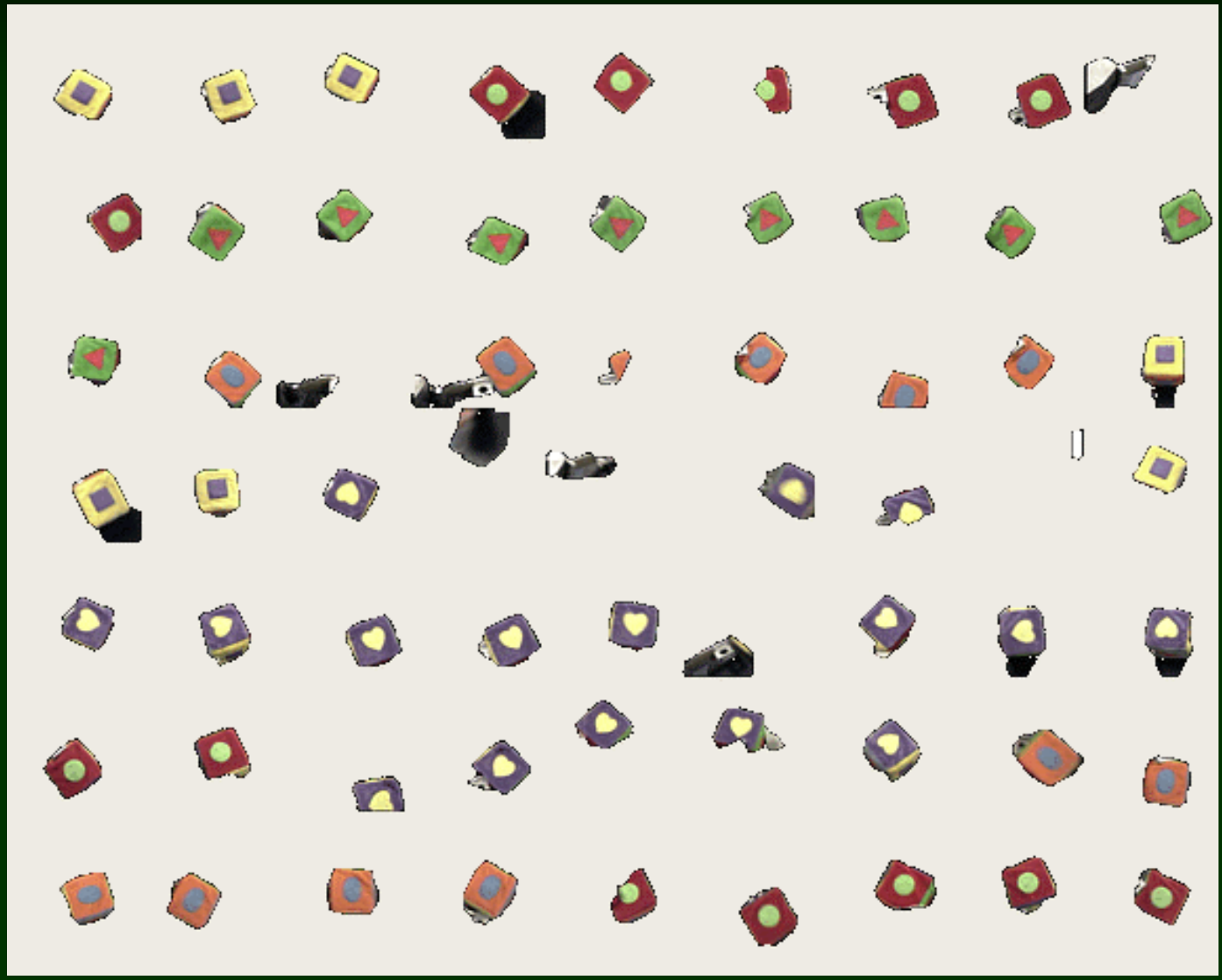
active segmentation

active segmentation

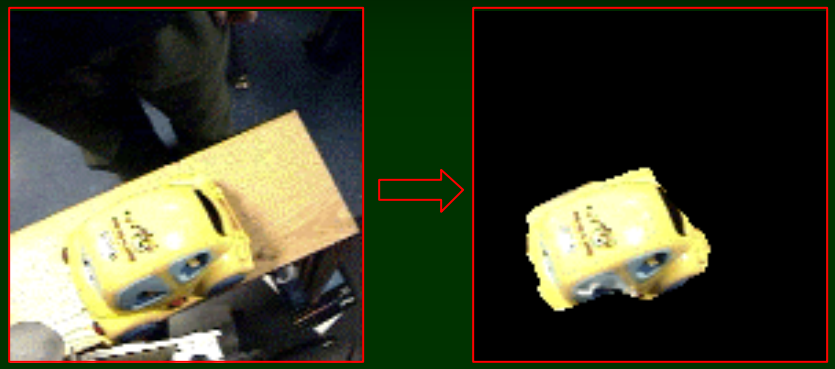
integrated behavior

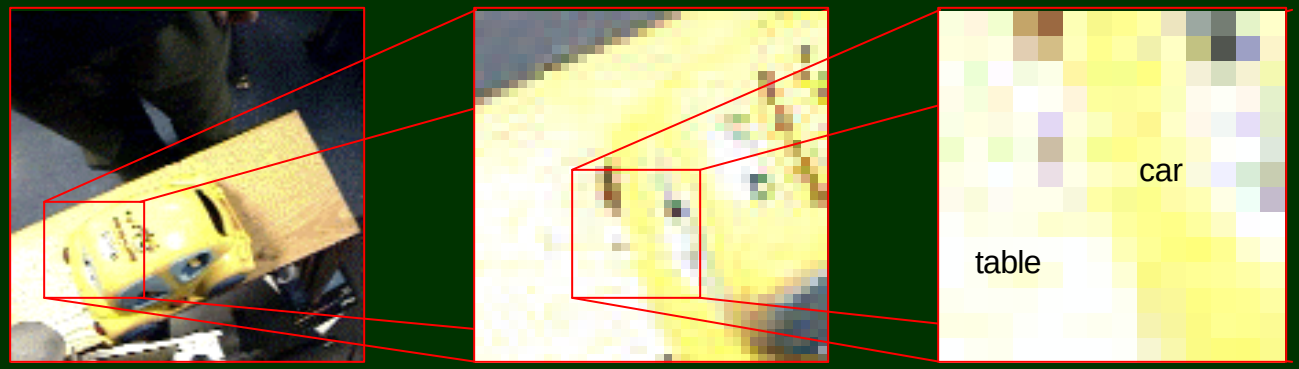


segmentation examples

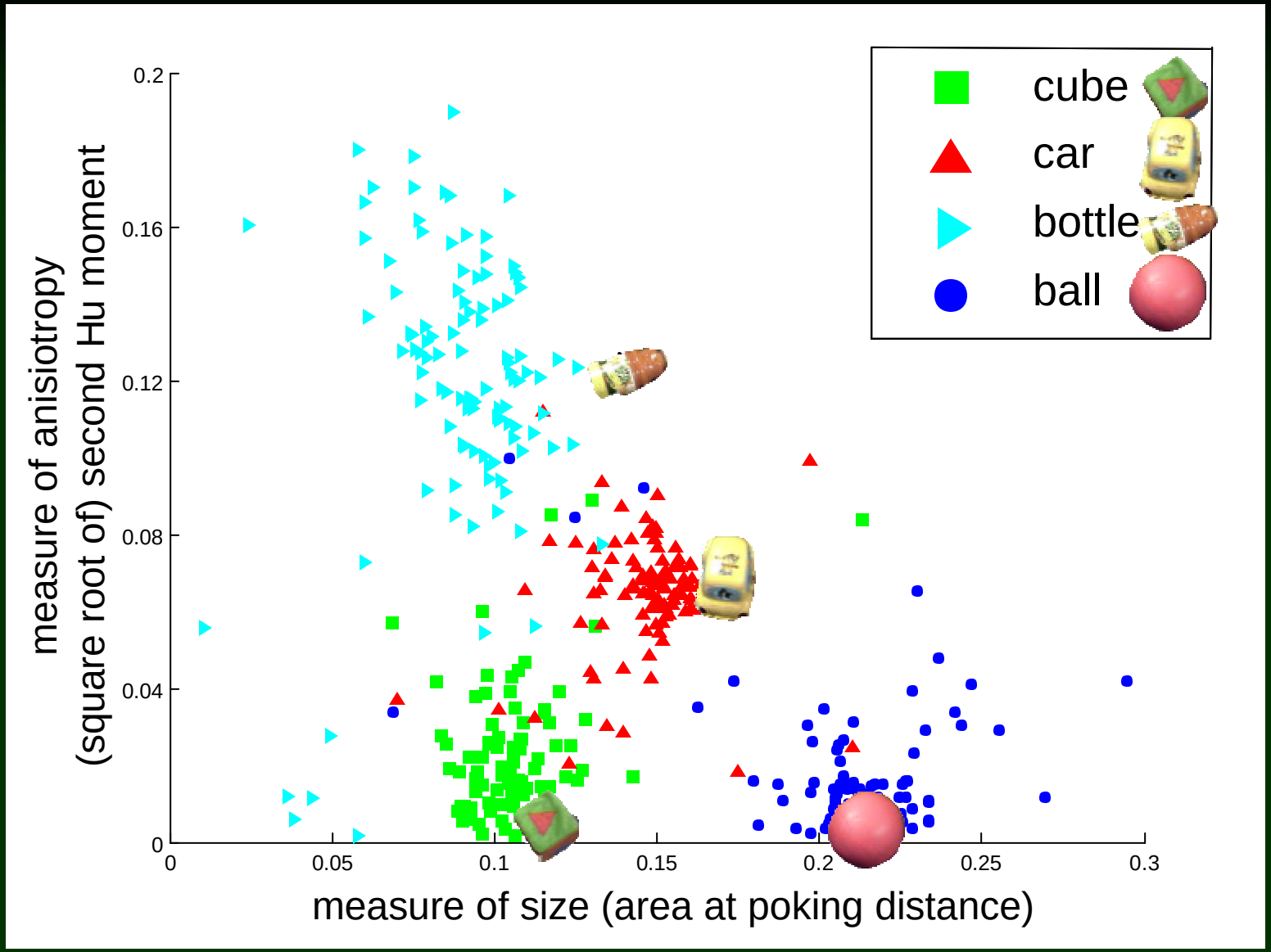


segmentation examples





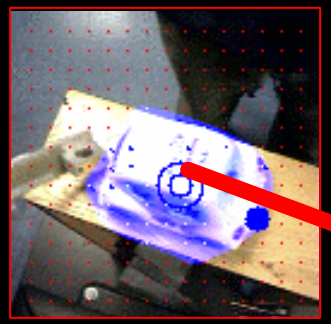
boundary fidelity



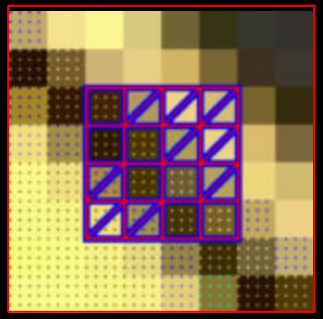
poking

object segmentation

affordance exploitation
(rolling)



edge catalog

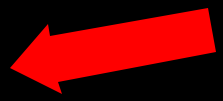


object detection
(recognition, localization,
contact-free segmentation)

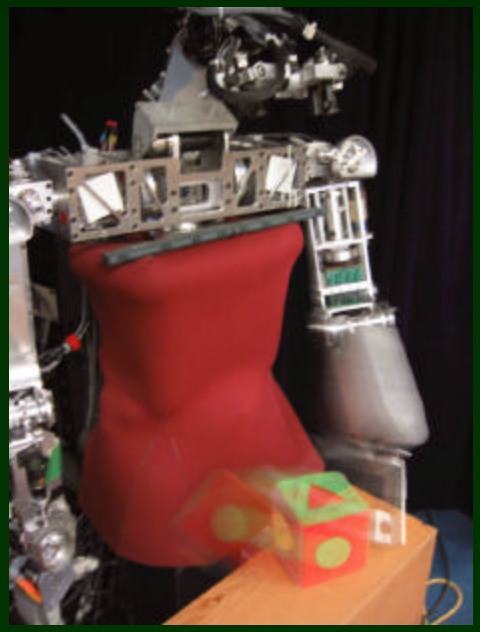
manipulator detection
(robot, human)

poking

object segmentation



opportunities for segmentation

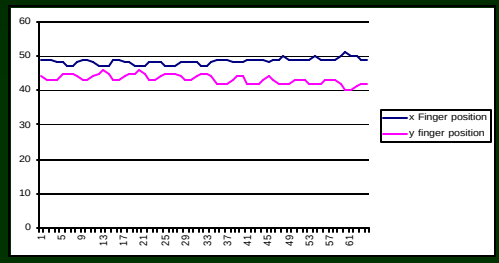


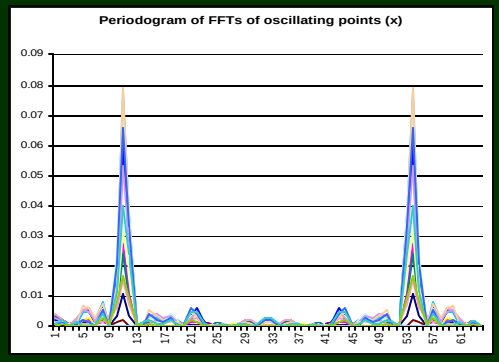
robot, poking

(Paul Fitzpatrick, Giorgio Metta)

wearable, illumination

(Charlie Kemp)

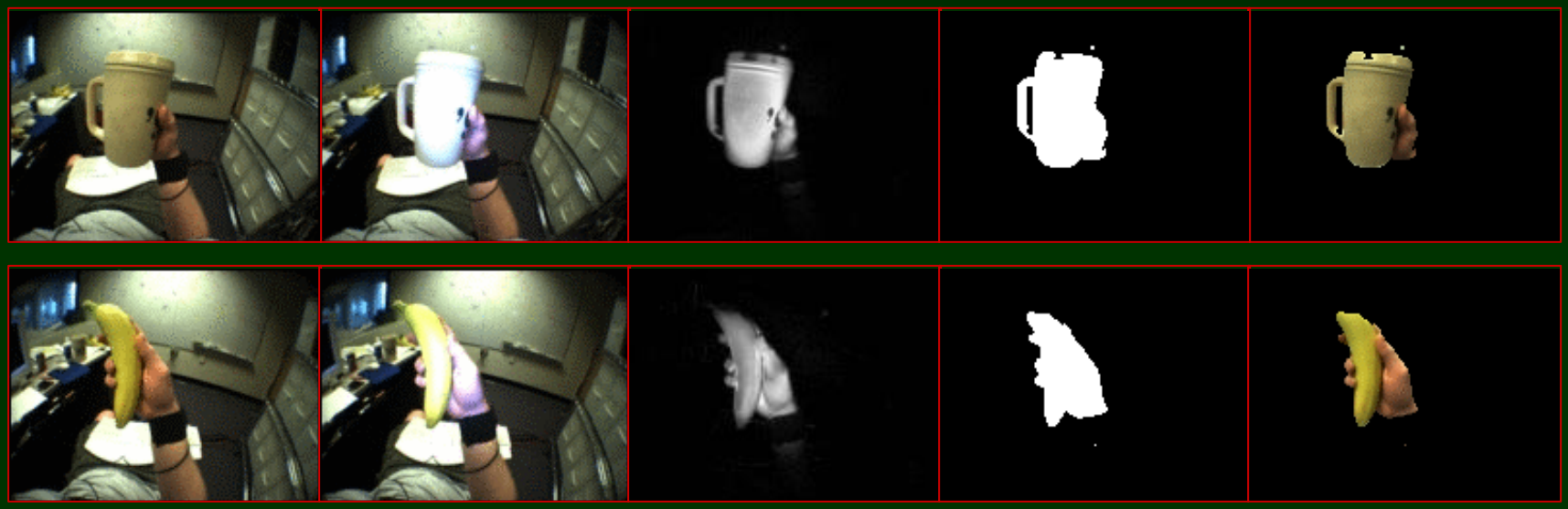




camera, periodicity

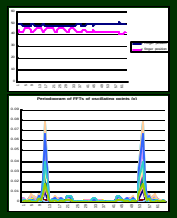
(Artur Arsenio)

segmentation on a wearable



System detects when wearer reaches for an object, requests wearer to hold it up, then illuminates it

segmentation by watching a human

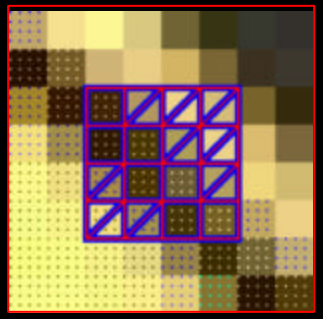


System detects periodic motion – waving, tapping, etc. – and extracts seed points for segmentation

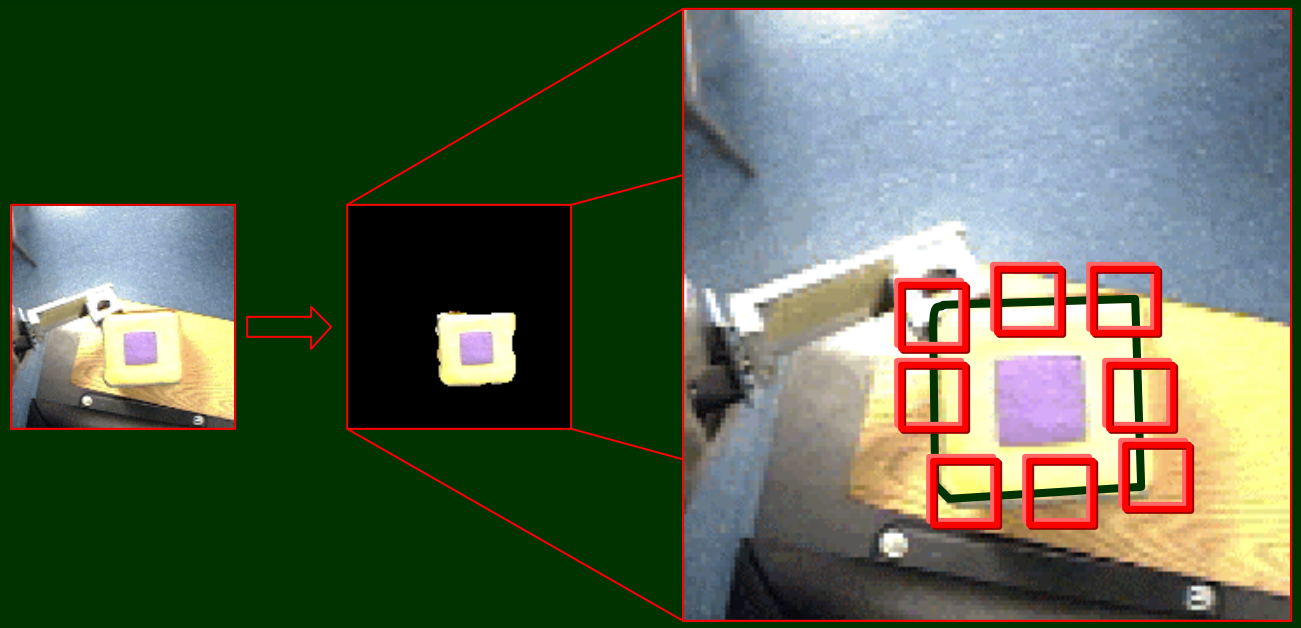
poking

object segmentation

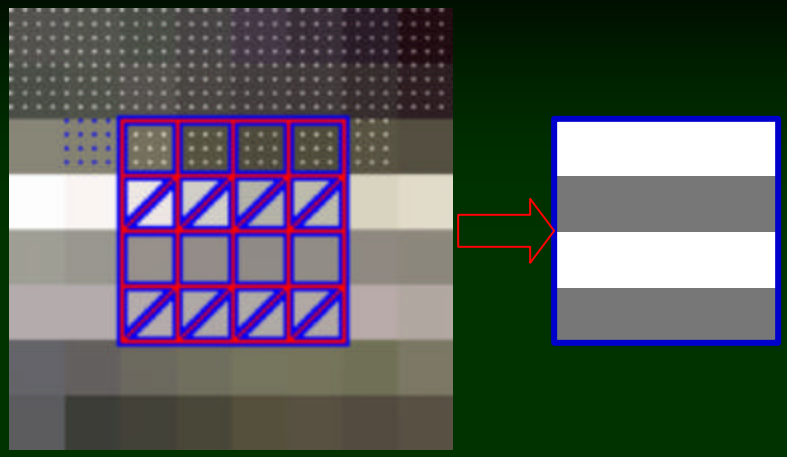
edge catalog

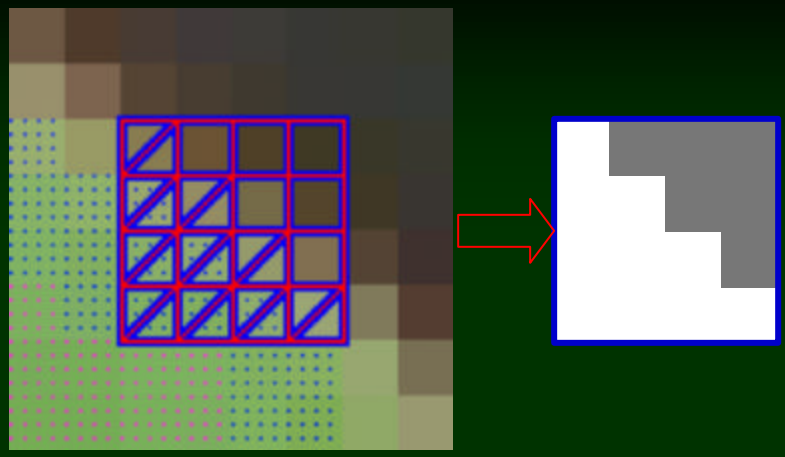


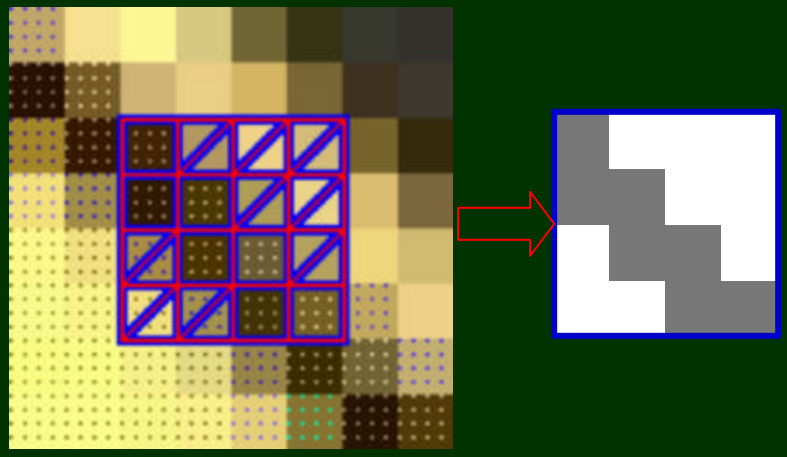
sampling oriented regions

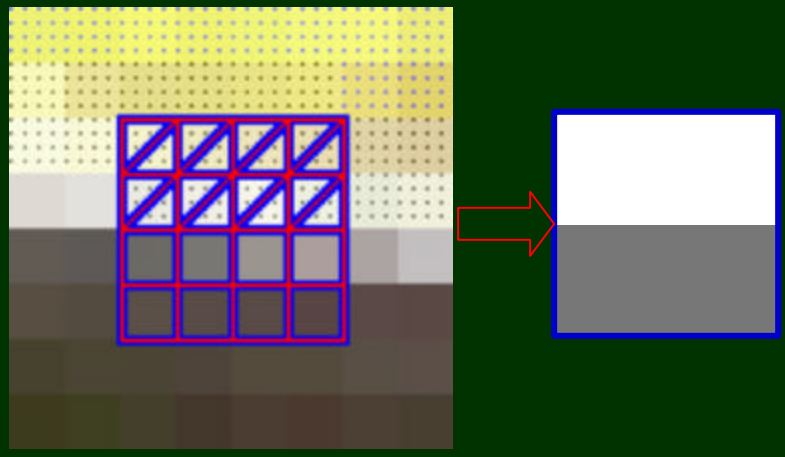


sample samples

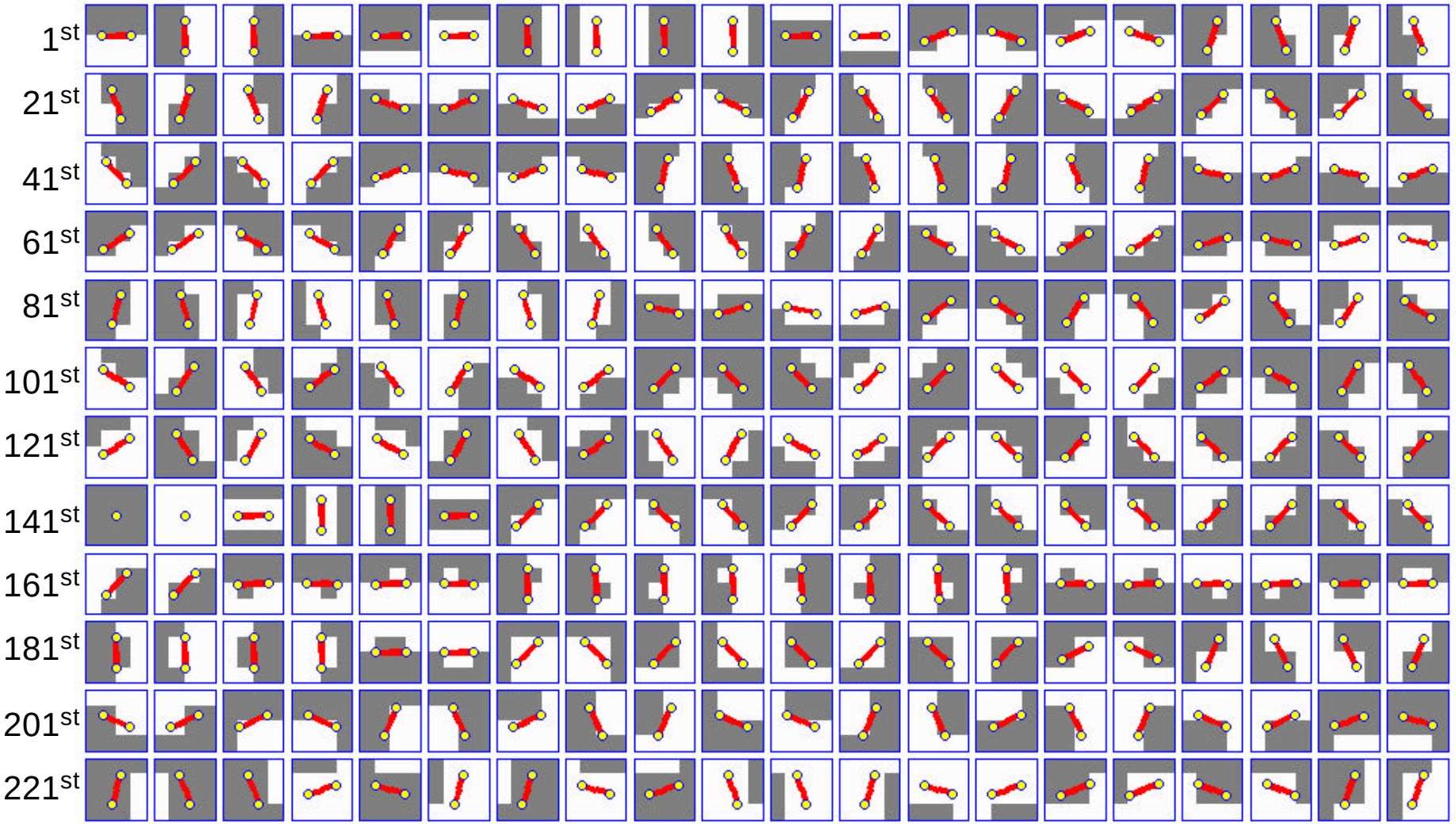




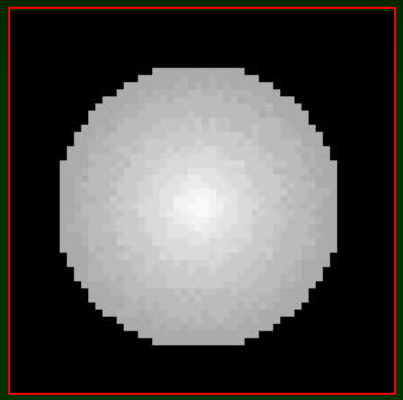
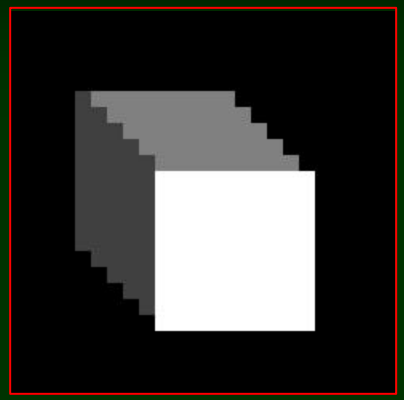
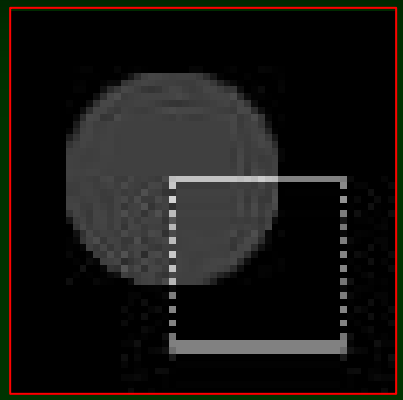
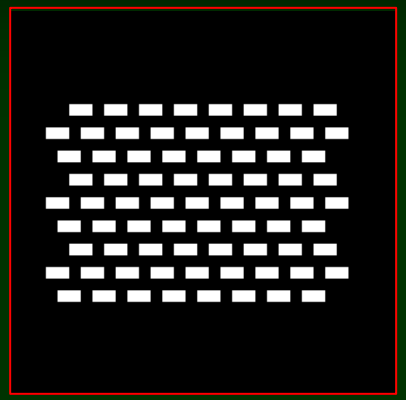
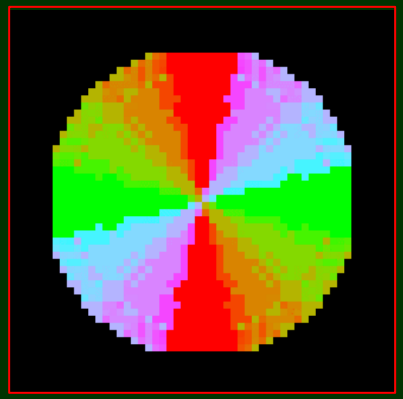


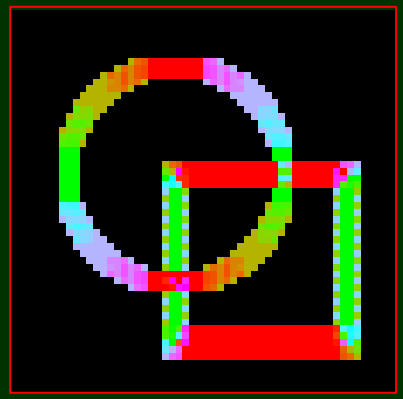
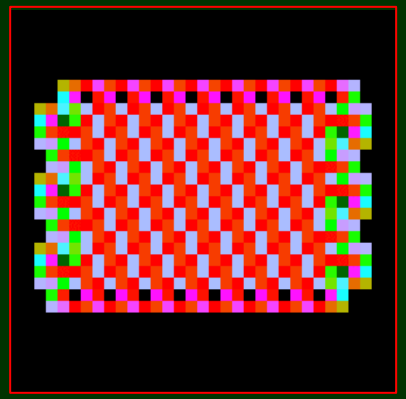


most frequent samples



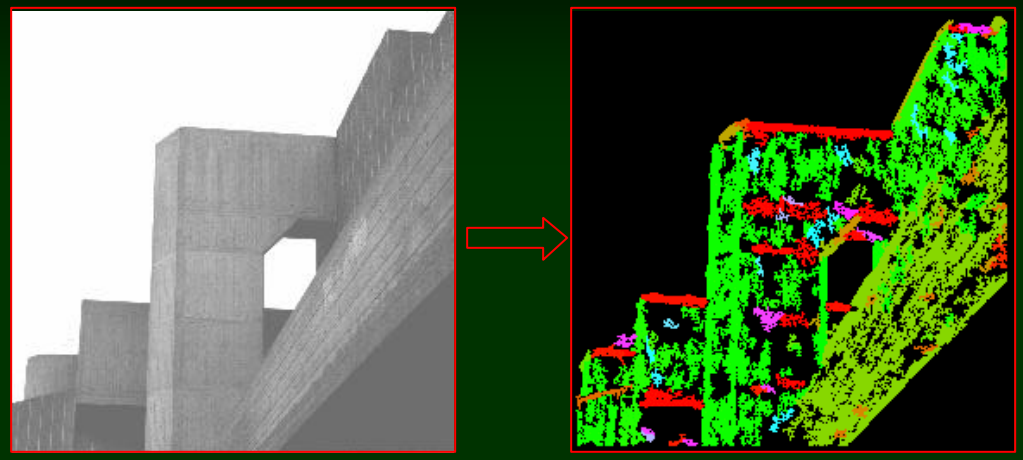
some tests

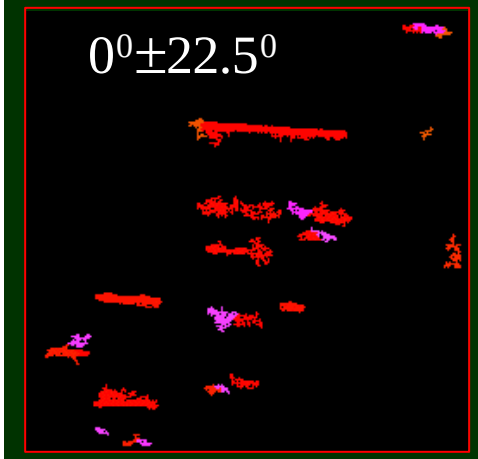






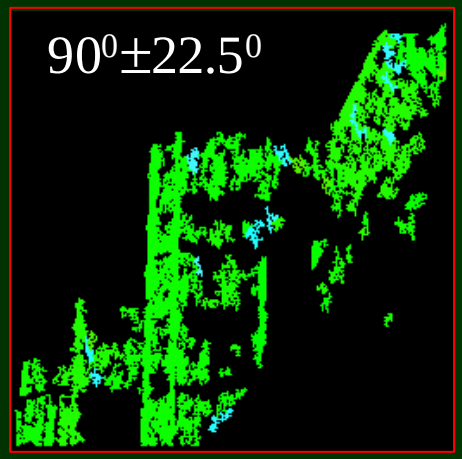



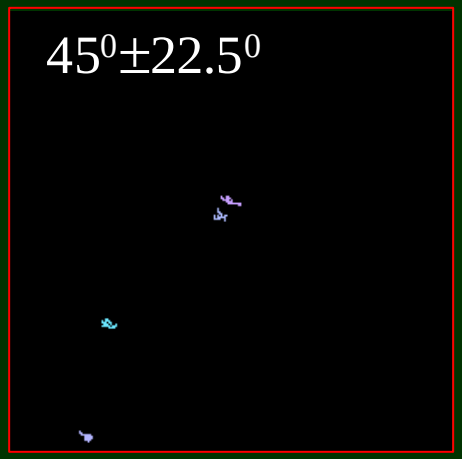
Red = horizontal Green = vertical

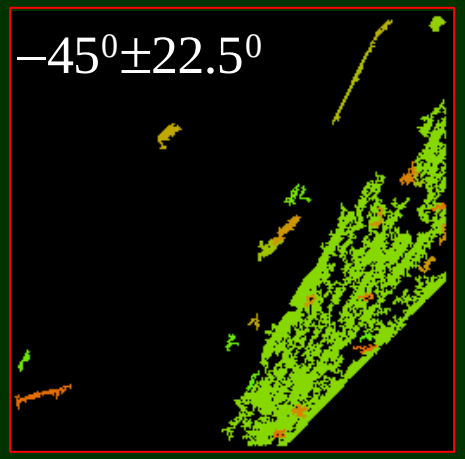
natural images







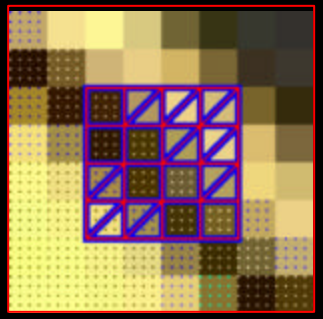




poking

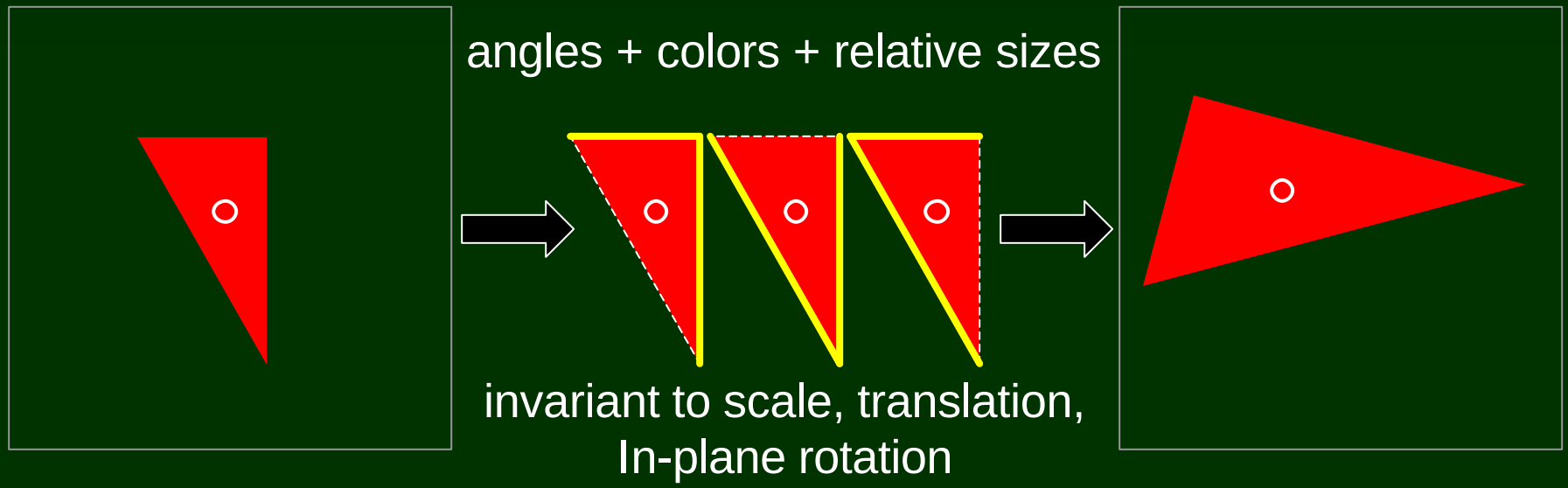
object segmentation

edge catalog



object detection
(recognition, localization,
contact-free segmentation)

geometry+appearance

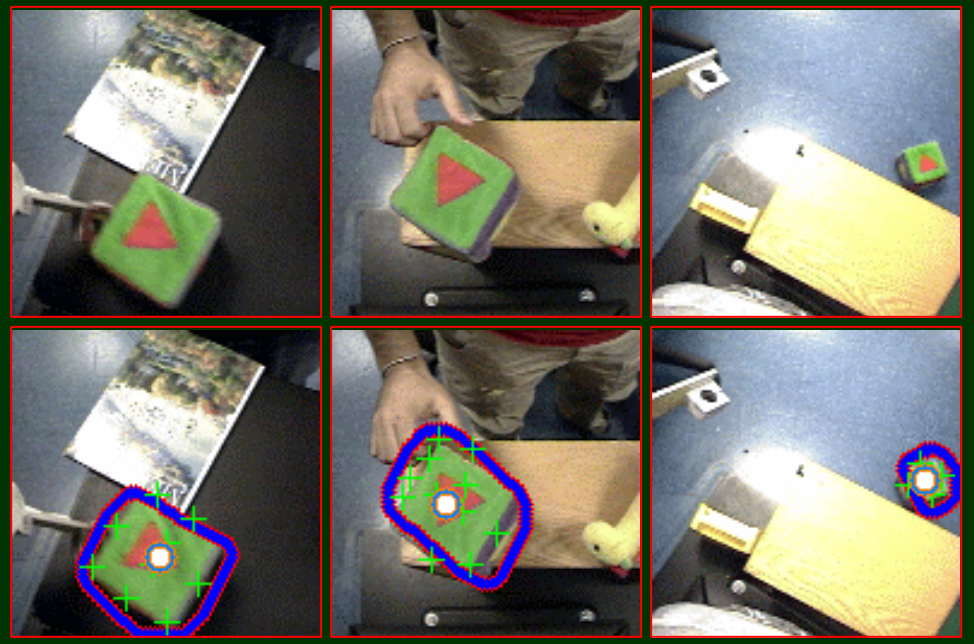


Advantages: more selective; fast

Disadvantages: edges can be occluded; 2D method

Property: no need for offline training

in operation

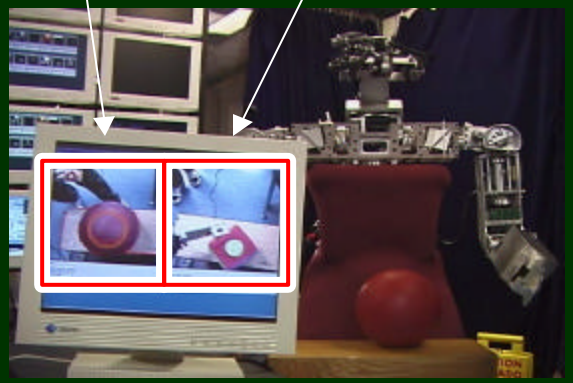


yellow on yellow

open object recognition

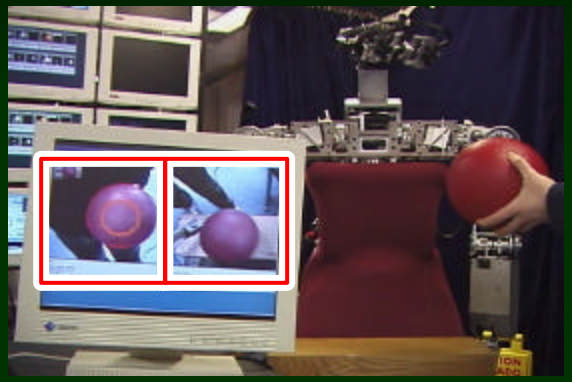
robot's current view

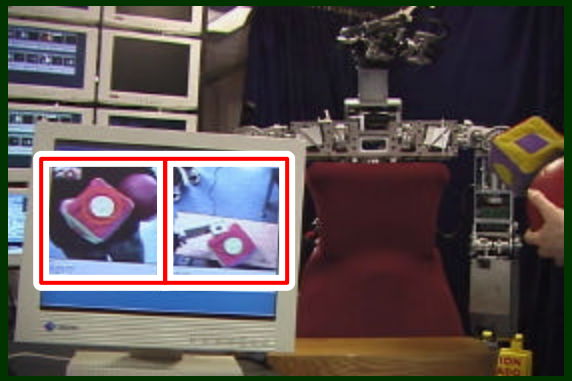
recognized object (as seen during poking)



sees ball, "thinks" it is cube

pokes, segments ball





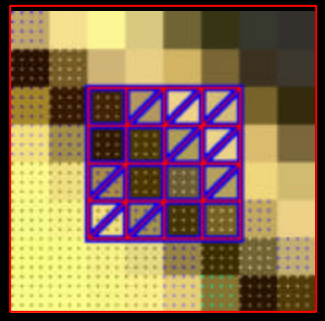
correctly differentiates ball and cube

open object recognition

poking

object segmentation

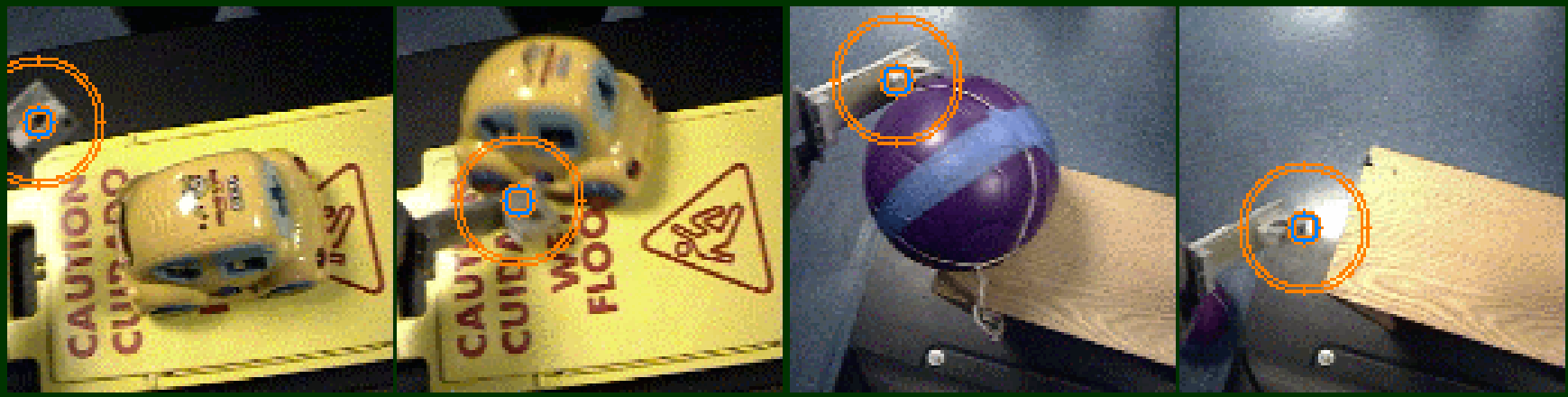
edge catalog



object detection
(recognition, localization,
contact-free segmentation)

manipulator detection
(robot, human)

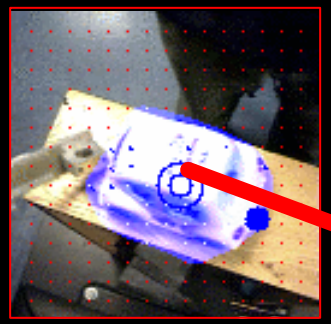
manipulator recognition



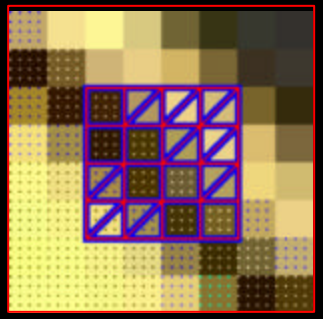
poking

object segmentation

affordance exploitation
(rolling)



edge catalog



object detection
(recognition, localization,
contact-free segmentation)

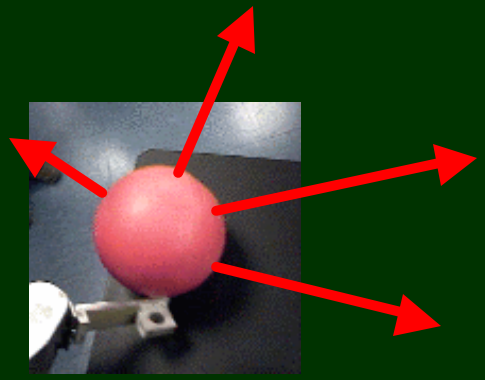
manipulator detection
(robot, human)

objects roll in different ways

a bottle
it rolls along its side

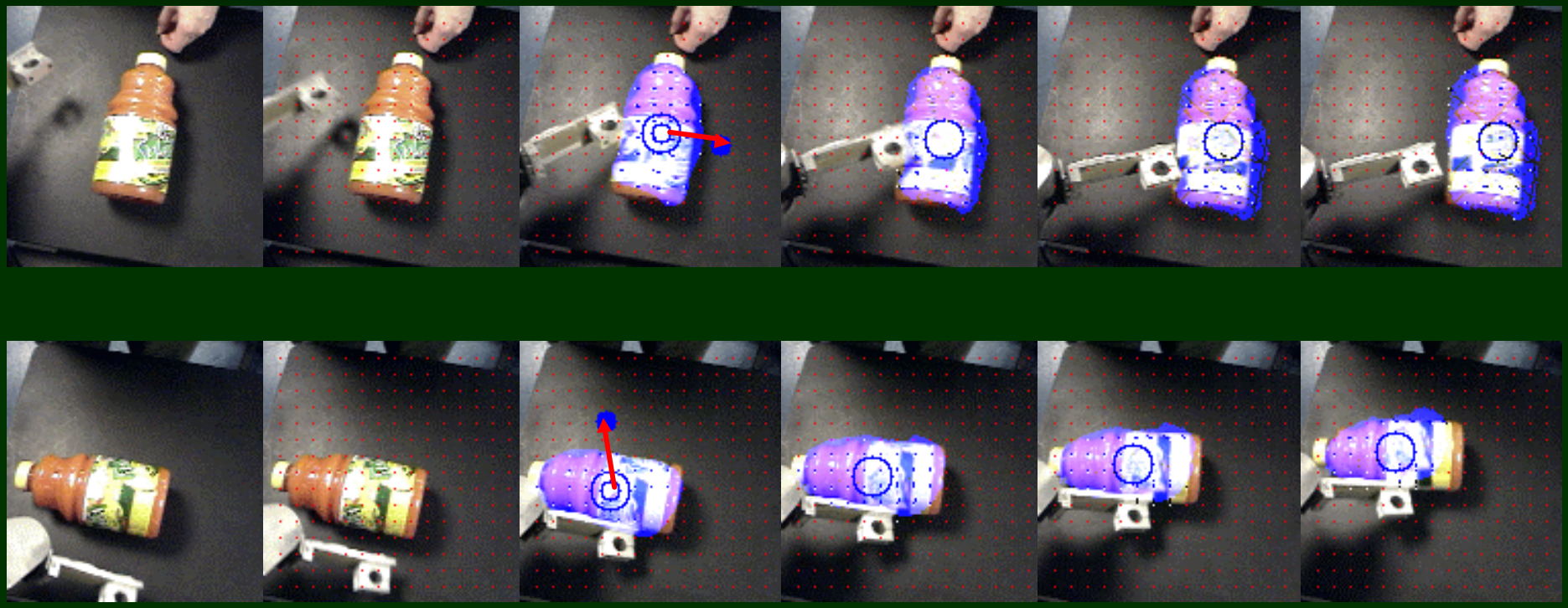
a toy car
it rolls forward

a toy cube
it doesn’t roll easily

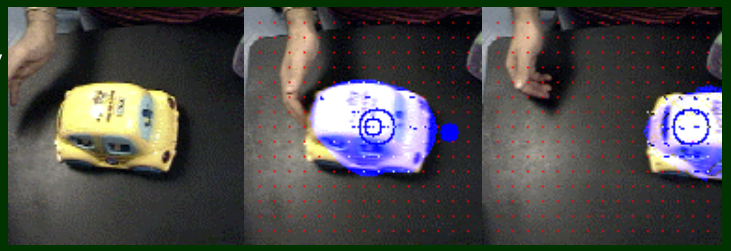
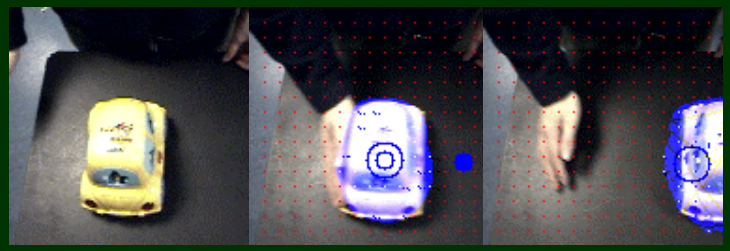
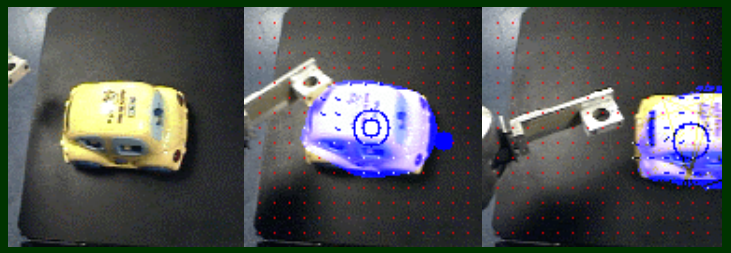
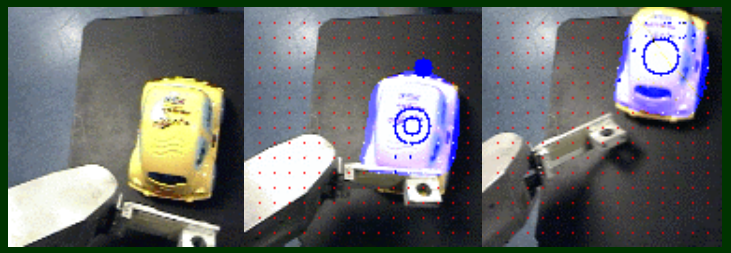
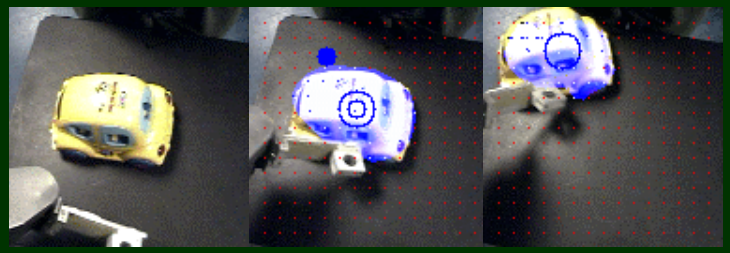


a ball
it rolls in
any direction

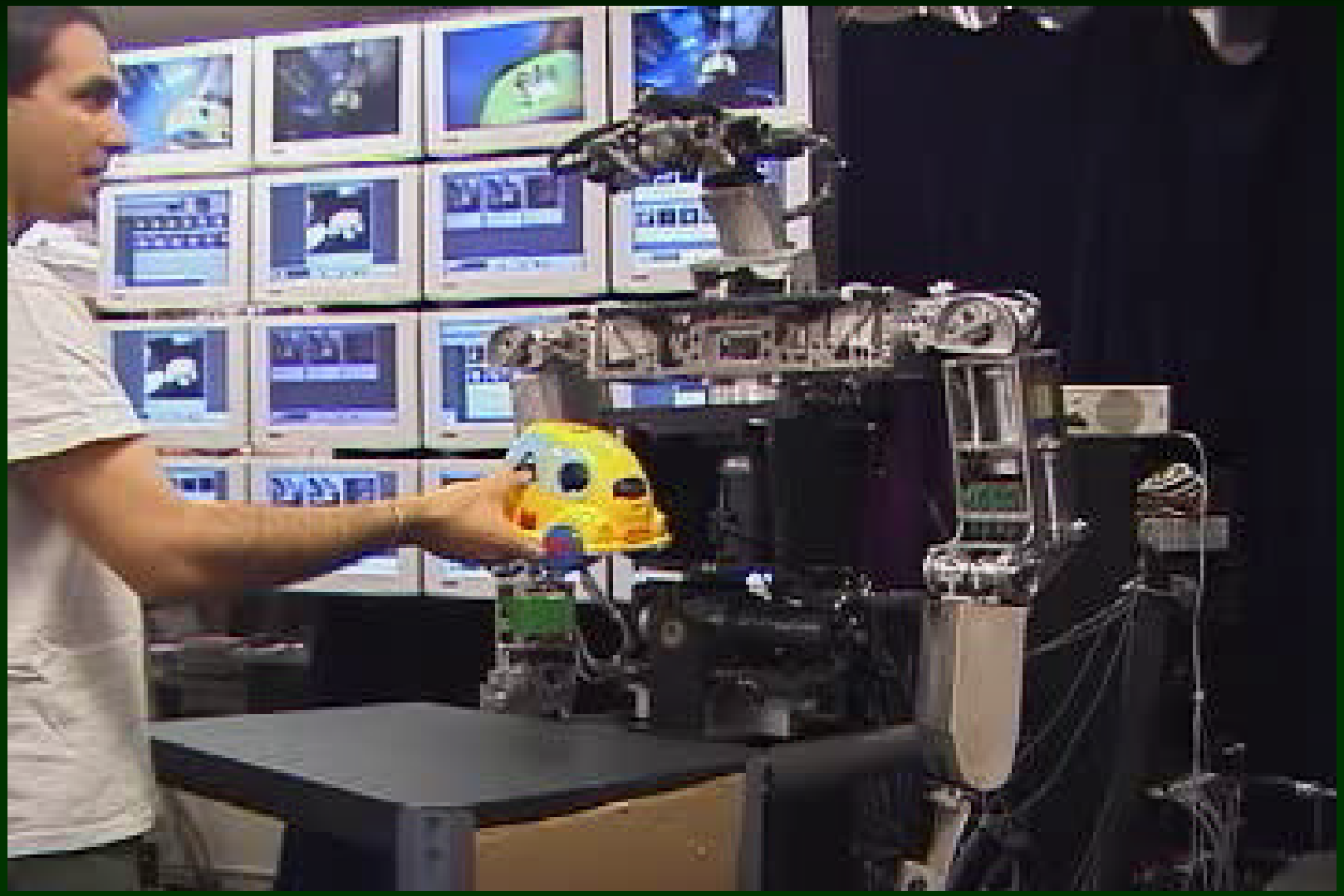
affordance exploitation



mimicry test

	Invoking the object's natural rolling affordance	Going against the object's natural rolling affordance
Demonstration by human		
Mimicry in similar situation		
Mimicry when object is rotated		

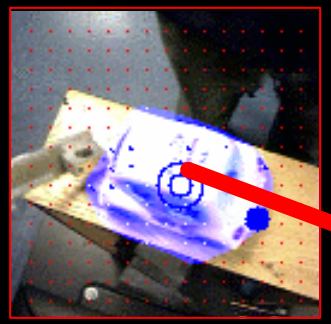
mimicry test



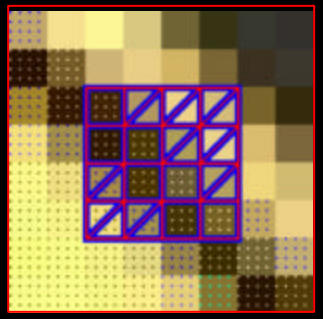
poking

object segmentation

affordance exploitation
(rolling)



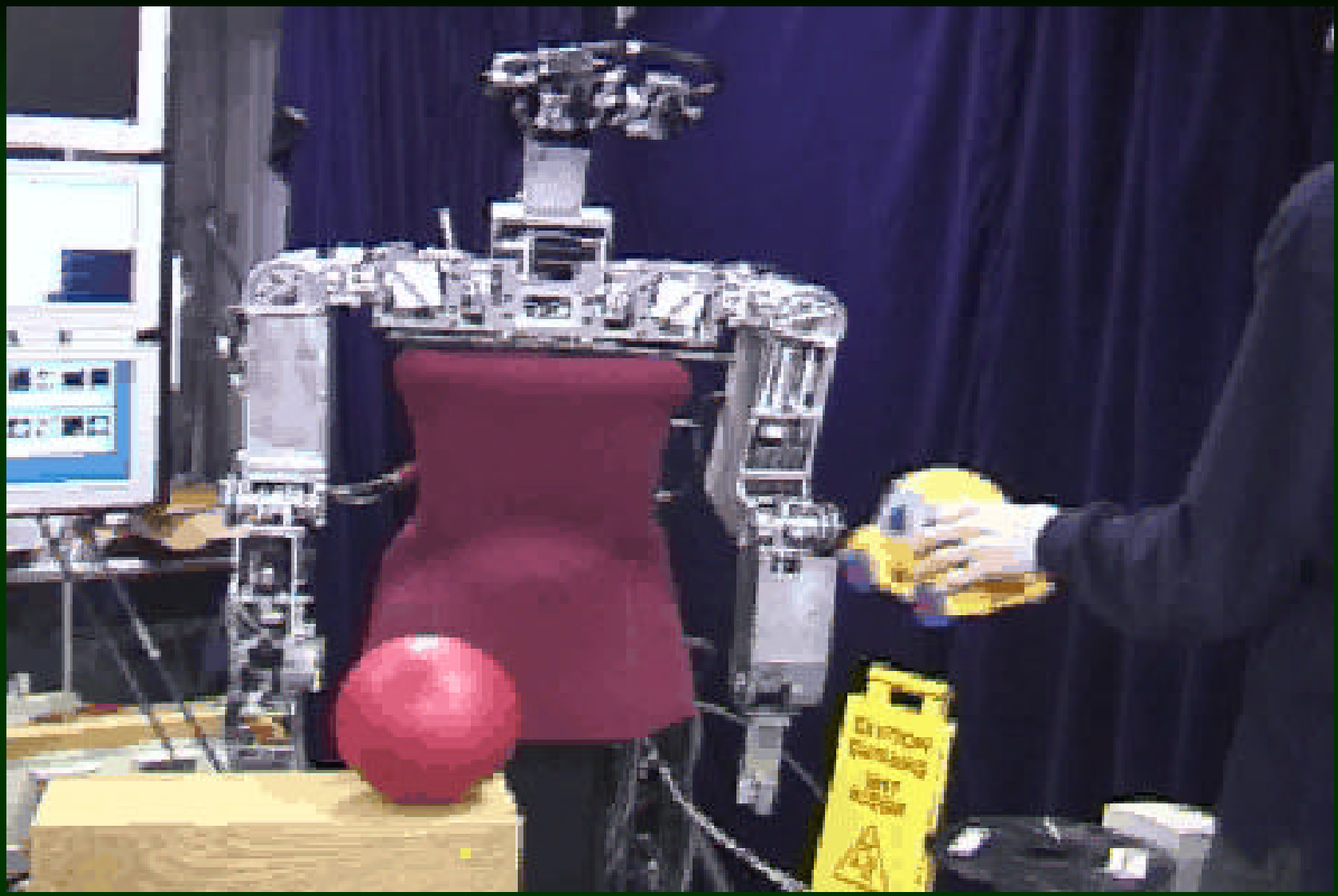
edge catalog



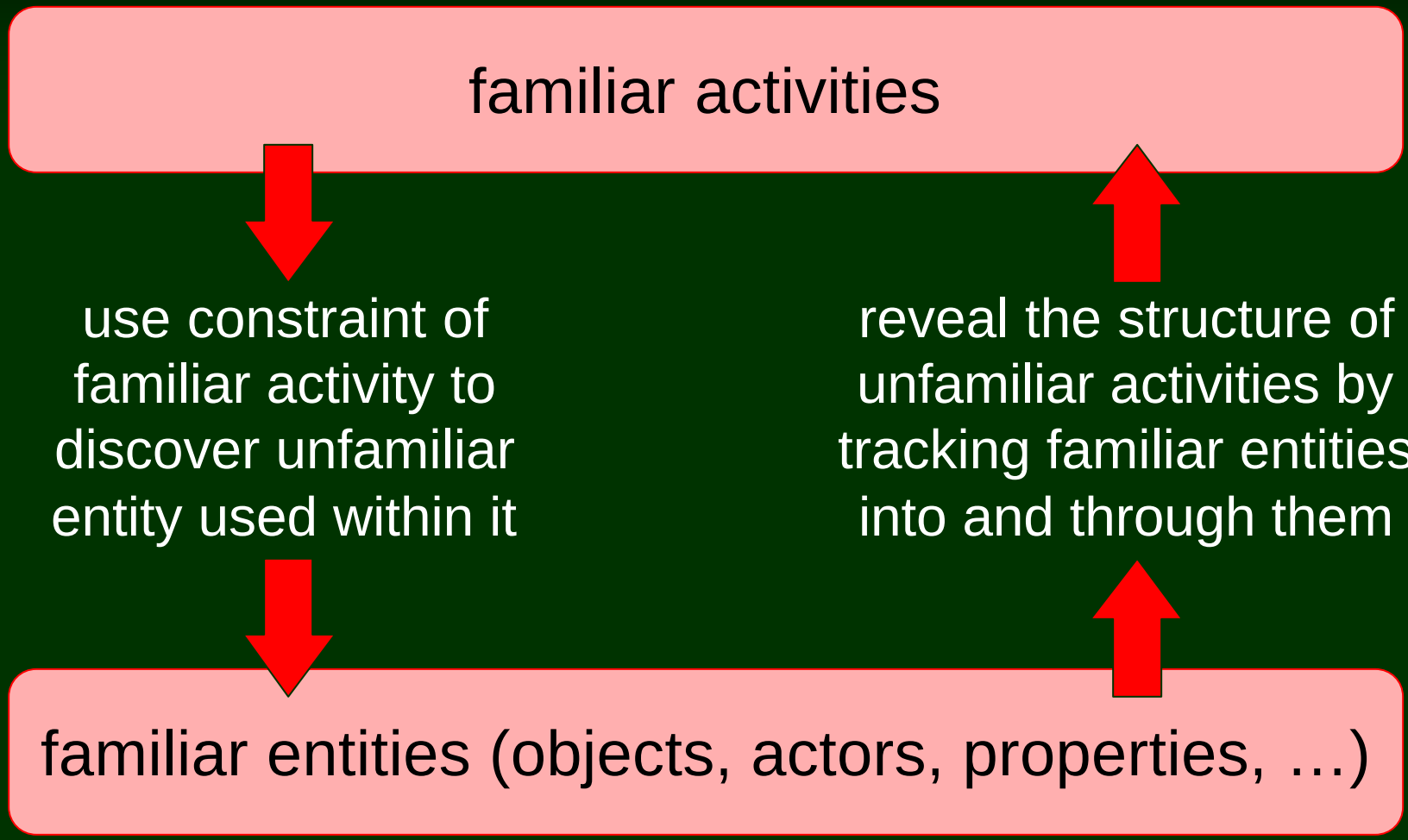
object detection
(recognition, localization,
contact-free segmentation)

manipulator detection
(robot, human)

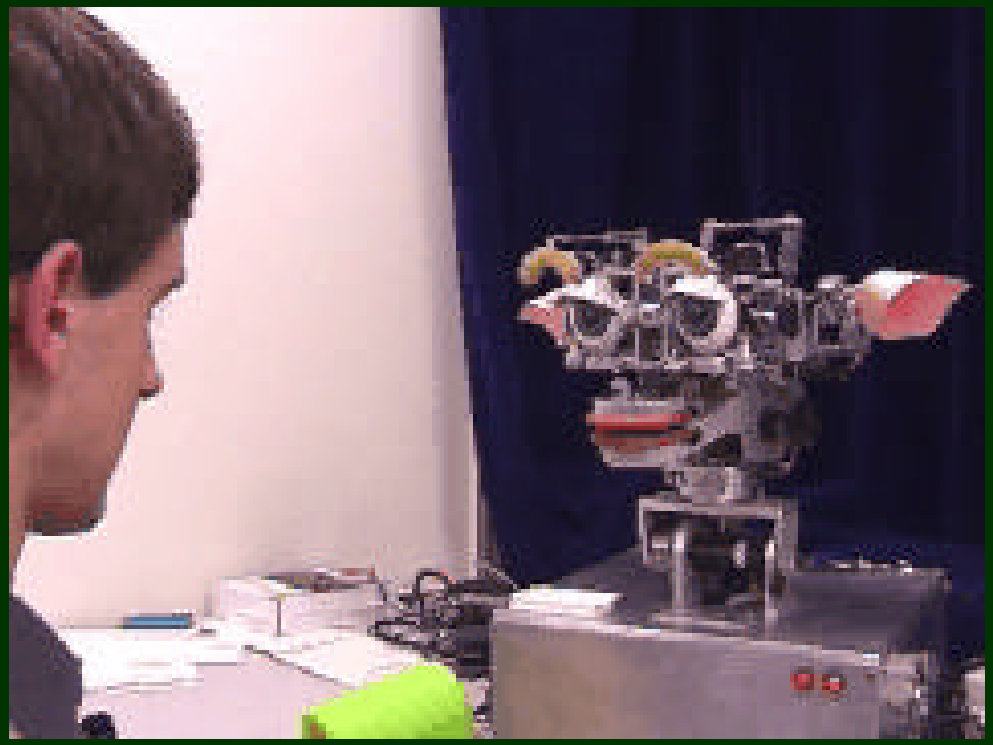
referring to objects

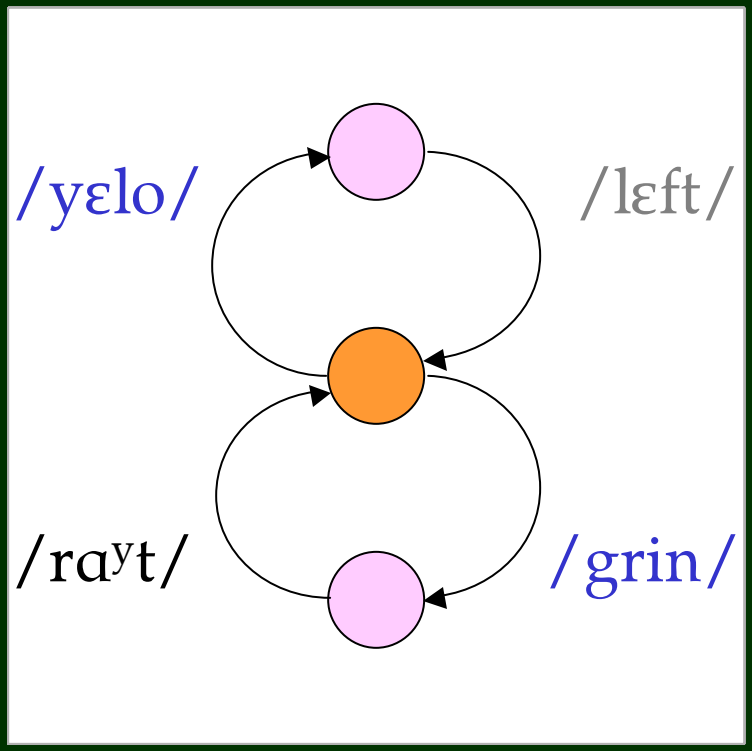


beyond objects



learning activity structure





conclusions

active segmentation	(through contact)
appearance catalog	(for oriented features)
open object recognition	for correction, enrollment
affordance recognition	(for rolling)
open speech recognition	(for isolated words)
virtuous circle of development	learning about and through activity