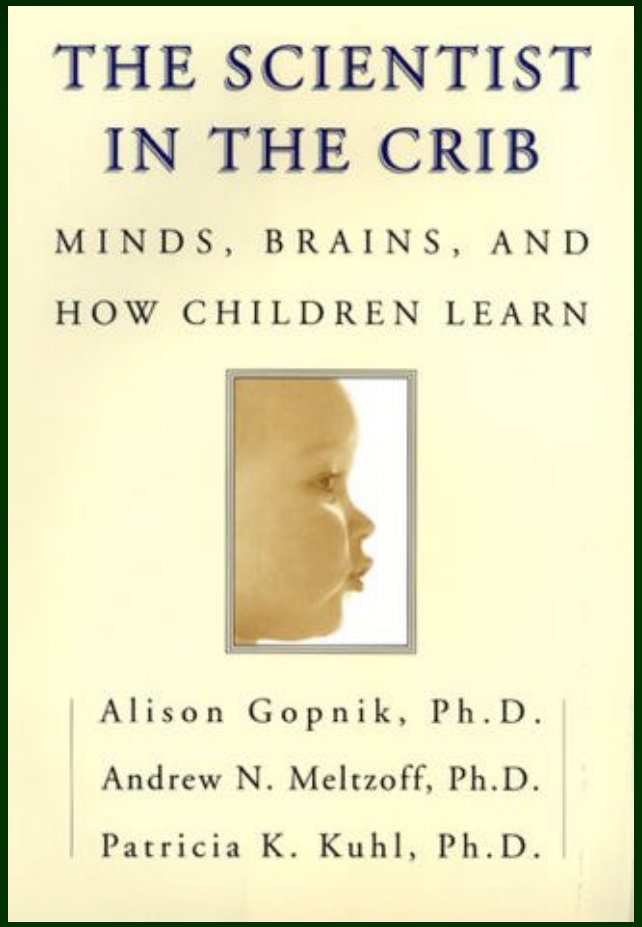
The Whole World in Your Hand:
Active and Interactive Segmentation

– Artur Arsenio, Paul Fitzpatrick, Charlie Kemp, Giorgio Metta –

3 × MIT-CSAIL + 1 × LIRA-LAB

the scientist in the crib

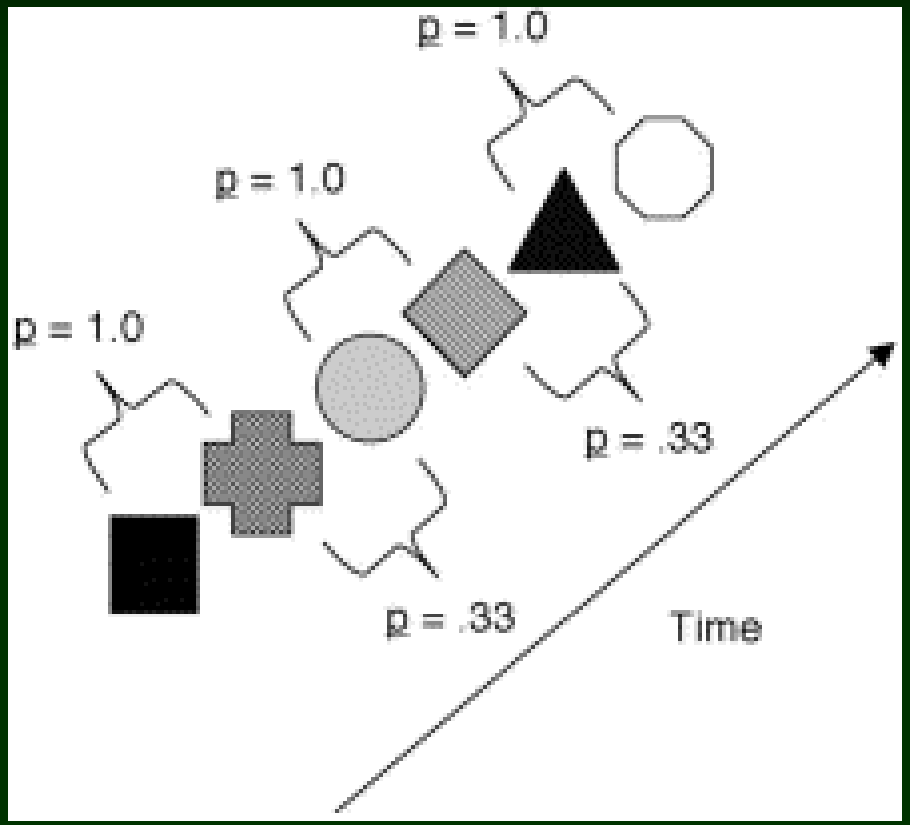


"Walk upstairs, open the door gently, and look in the crib. What do you see? Most of us see a picture of innocence and helplessness, a clean slate. But, in fact, what we see in the crib is the greatest mind that has ever existed, the most powerful learning machine in the universe."

watch and learn

(http://www.acuitydesign.com/baby/photoalbum.htm)

passive ‘domain general’ learning



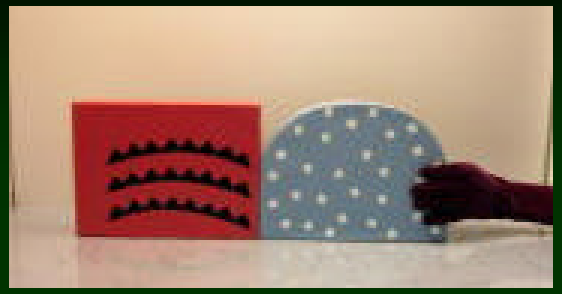
(Kirkham et al, Cornell)

learning about object boundaries

Prior visual experience facilitates an infant's perception of object boundaries

Experience = seeing individual object before seeing object pairing

Needham et al (Duke University)



act and learn

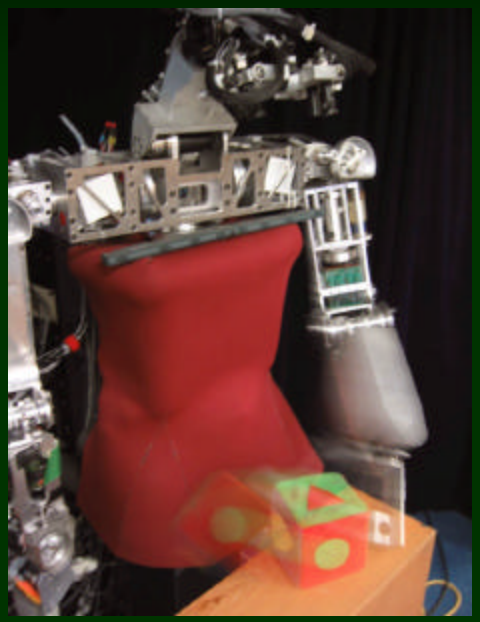
learning about object boundaries

Object exploration enhances knowledge of object boundaries compared with age-matched controls

Velcro mittens allow early start to active object exploration

Needham et al (Duke University)

perception of object manipulation



robot ‘manipulation’,
first person perspective

(Paul Fitzpatrick,
Giorgio Metta)

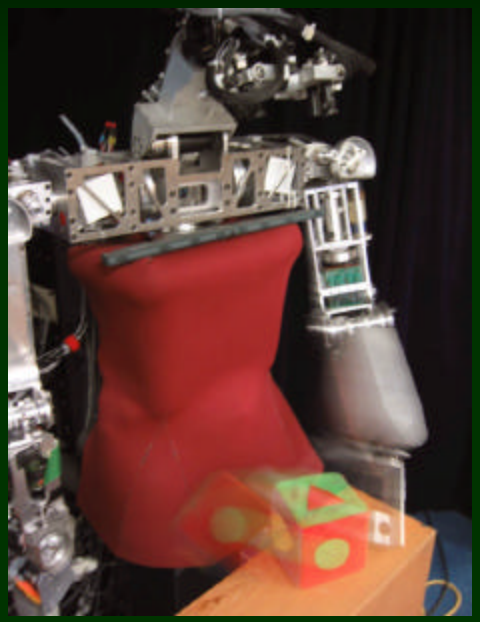
human manipulation,
external perspective

(Artur Arsenio)

human manipulation,
first person perspective

(Charlie Kemp)

perception of object manipulation



robot ‘manipulation’,
first person perspective

(Paul Fitzpatrick,
Giorgio Metta)

experimentation helps perception

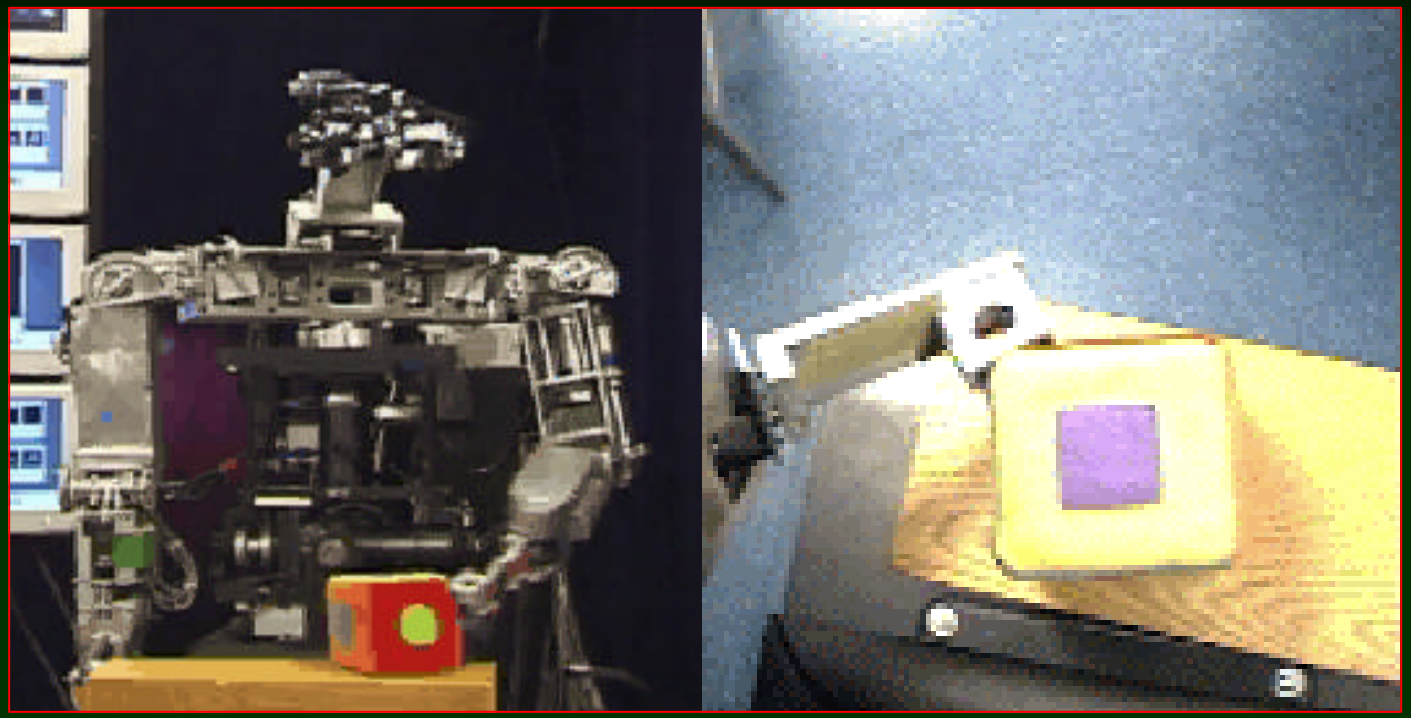
Rachel: We have got to find out if [ugly naked guy]'s alive.

Monica: How are we going to do that? There's no way.

Joey: Well there is one way. His window's open – I say, we poke him.

(brandishes the Giant Poking Device)

robots can experiment



Robot: We have got to find out where this object's boundary is.

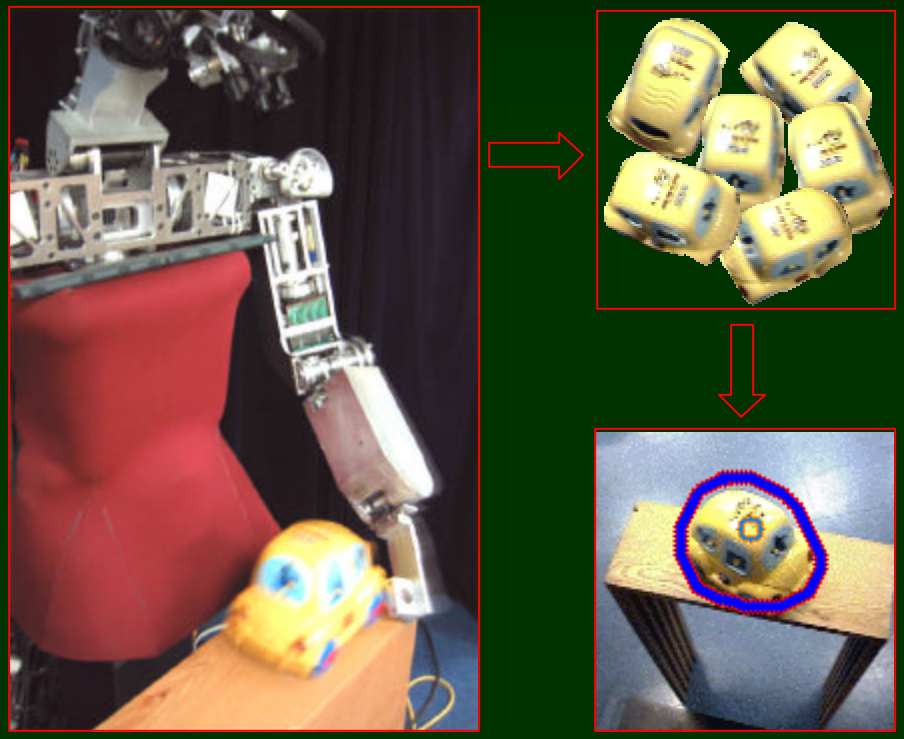
Camera: How are we going to do that? There's no way.

Robot: Well there is one way. Looks reachable – I say, let's poke it.

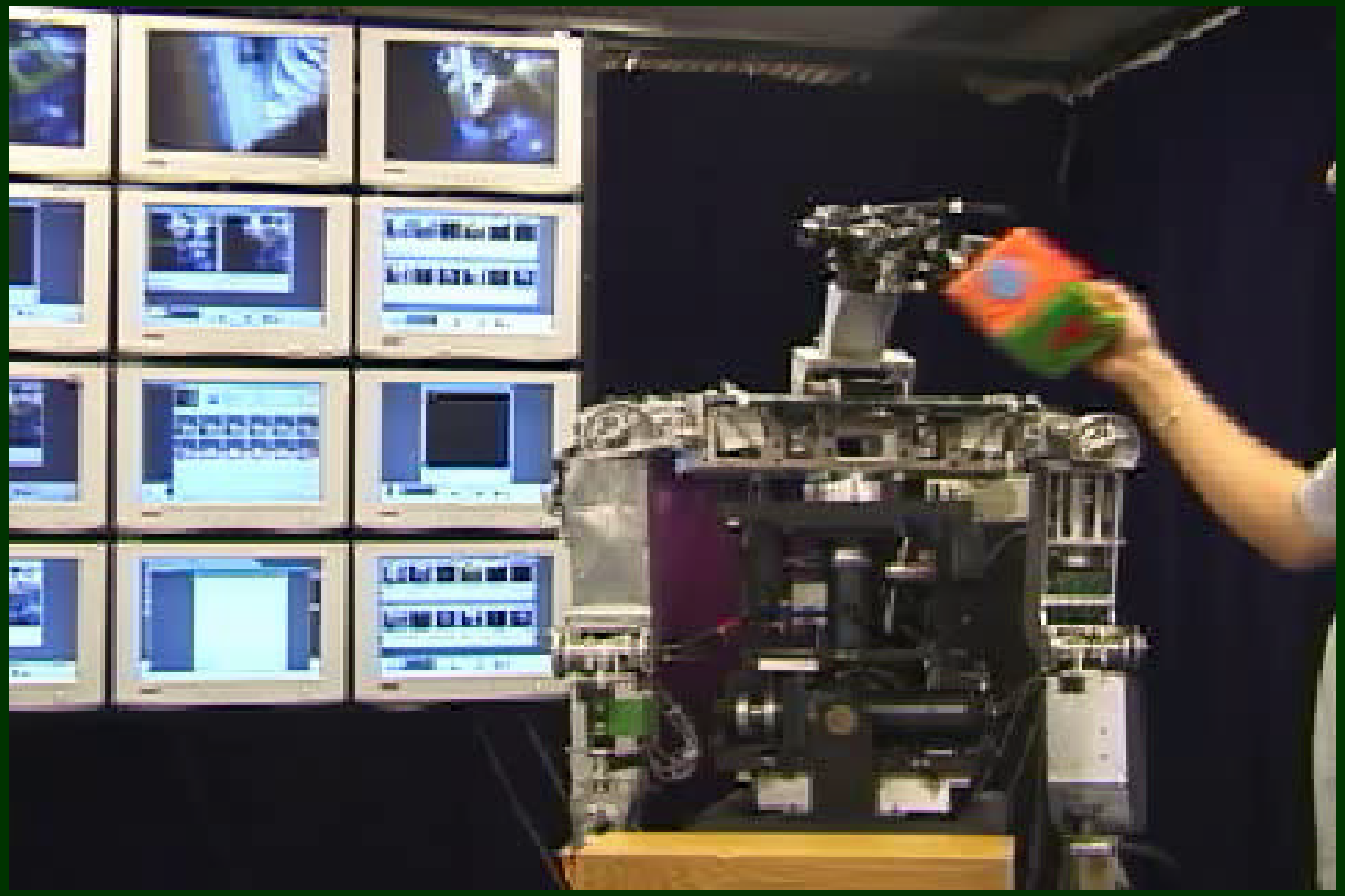
(brandishes the Giant Poking Limb)

active segmentation

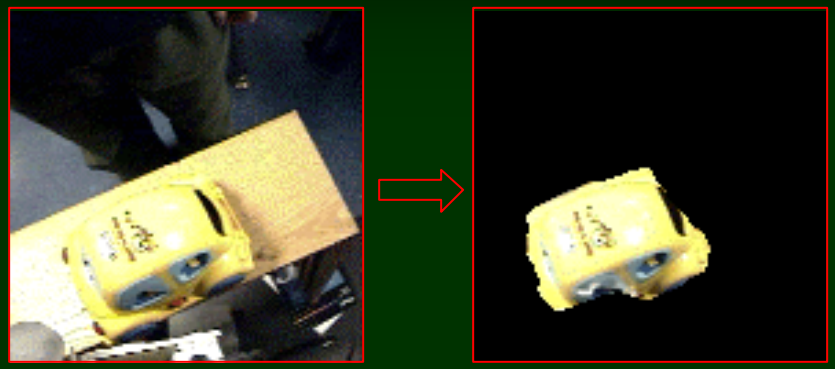
- Object boundaries are not always easy to detect visually
- Solution: *Cog* sweeps through ambiguous area
- Resulting object motion helps segmentation
- Robot can learn to recognize and segment object without further contact

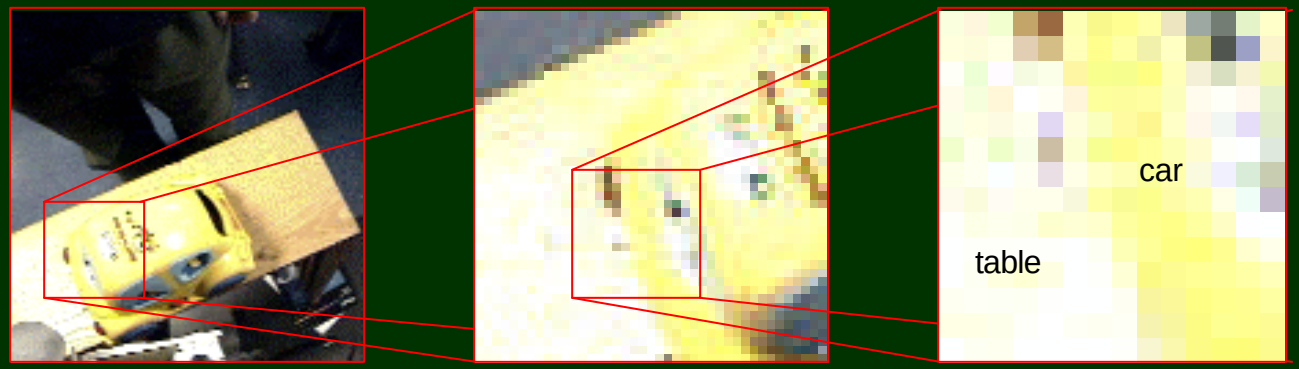


integrated behavior



segmentation examples





head segmentation – the hard way!

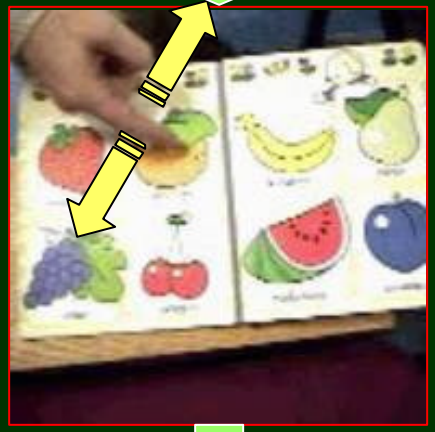
perception of object manipulation

human manipulation,
external perspective

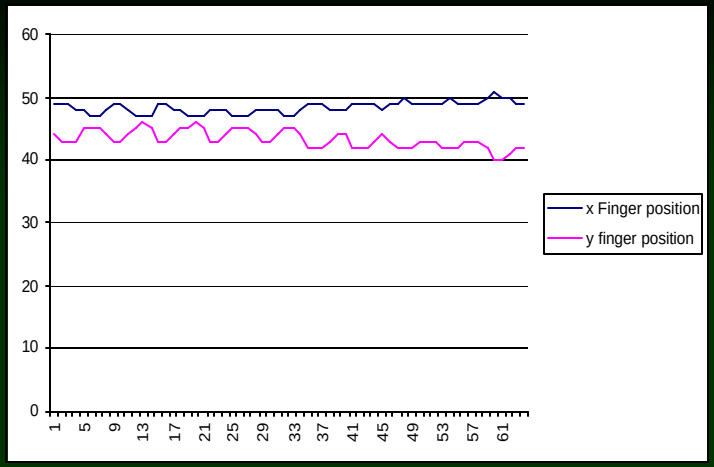
(Artur Arsenio)

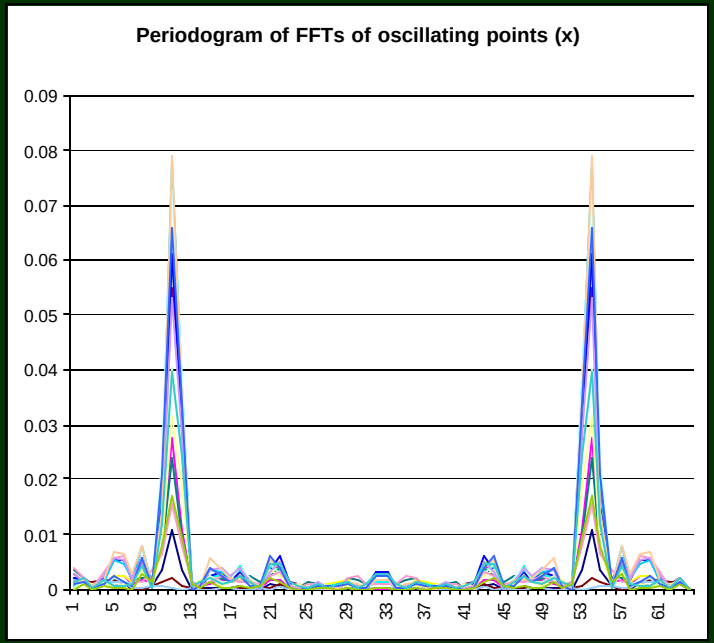
interactive segmentation

Event Detection
Tracking
Multi-scale periodicity detection

manipulator motion and no object motion	object motion and no manipulator motion	object motion and manipulator motion
		
human is waving to introduce a stationary object to the robot	human triggered a bouncy/wobbling object	human is showing an object by waving it

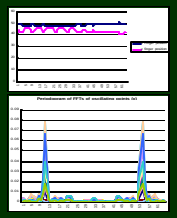
example: child's book





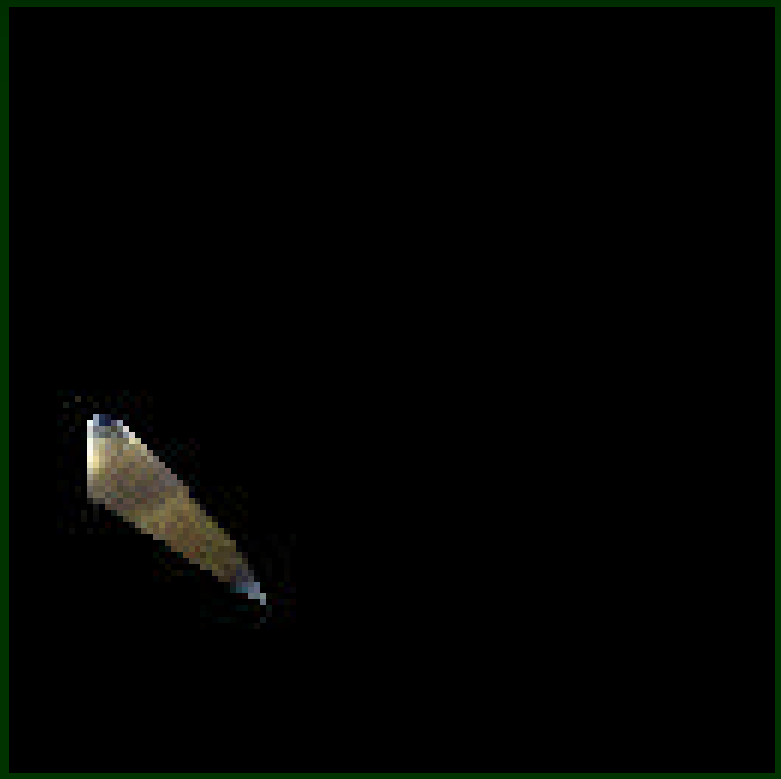
example: child's book

example: waving a toy



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

example: sweeping brush

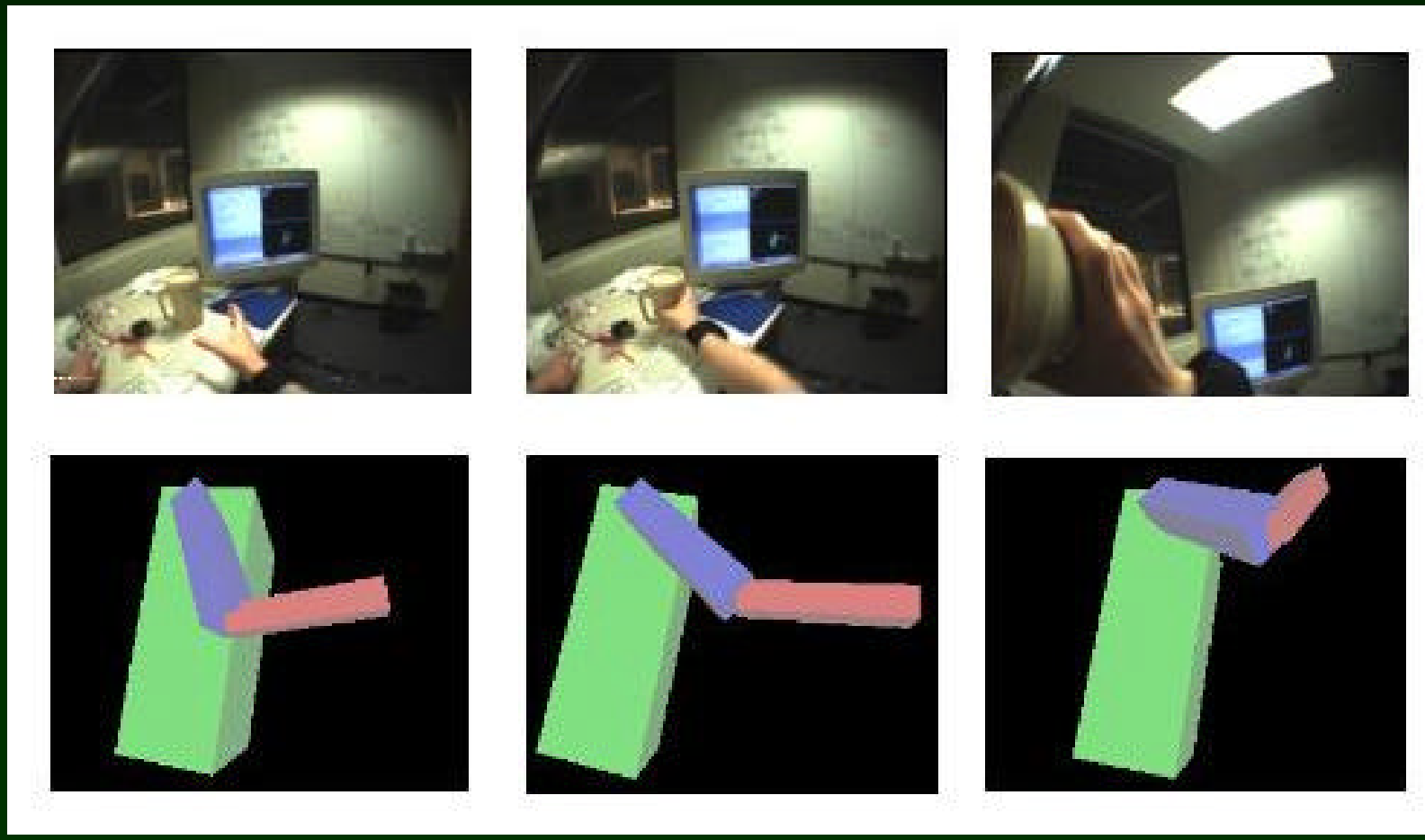


perception of object manipulation

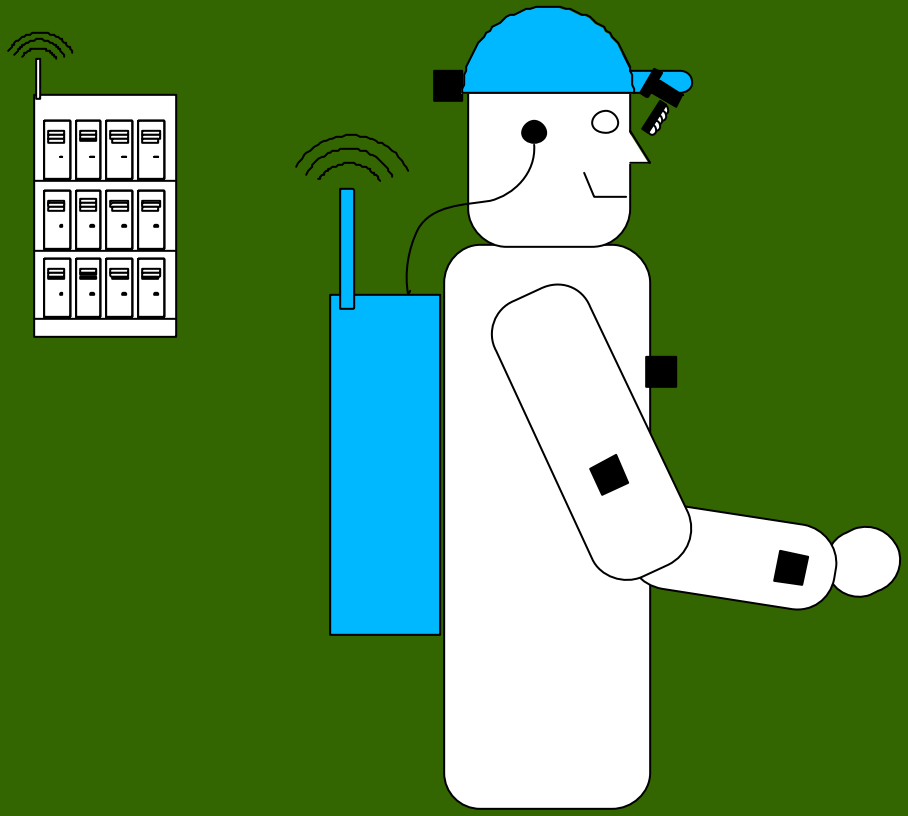
human manipulation,
first person perspective

(Charlie Kemp)

human action, machine perception



the “Duo” system



Intersense Cube, which measures absolute orientation

Backpack with wireless communication to the cluster

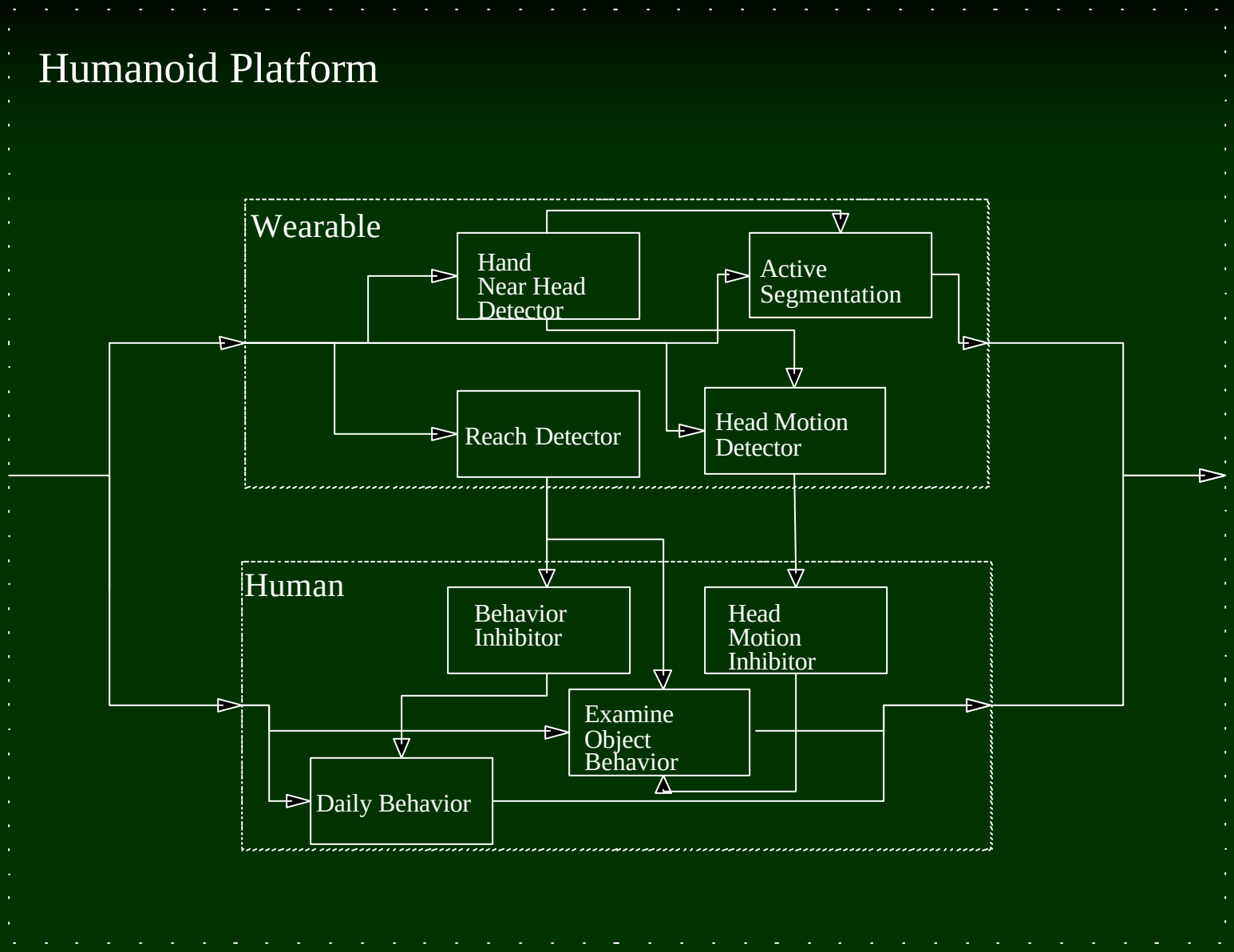
Headphones that give spoken requests from the wearable creature to the human

Wide angle camera focused on the workspace of the hand

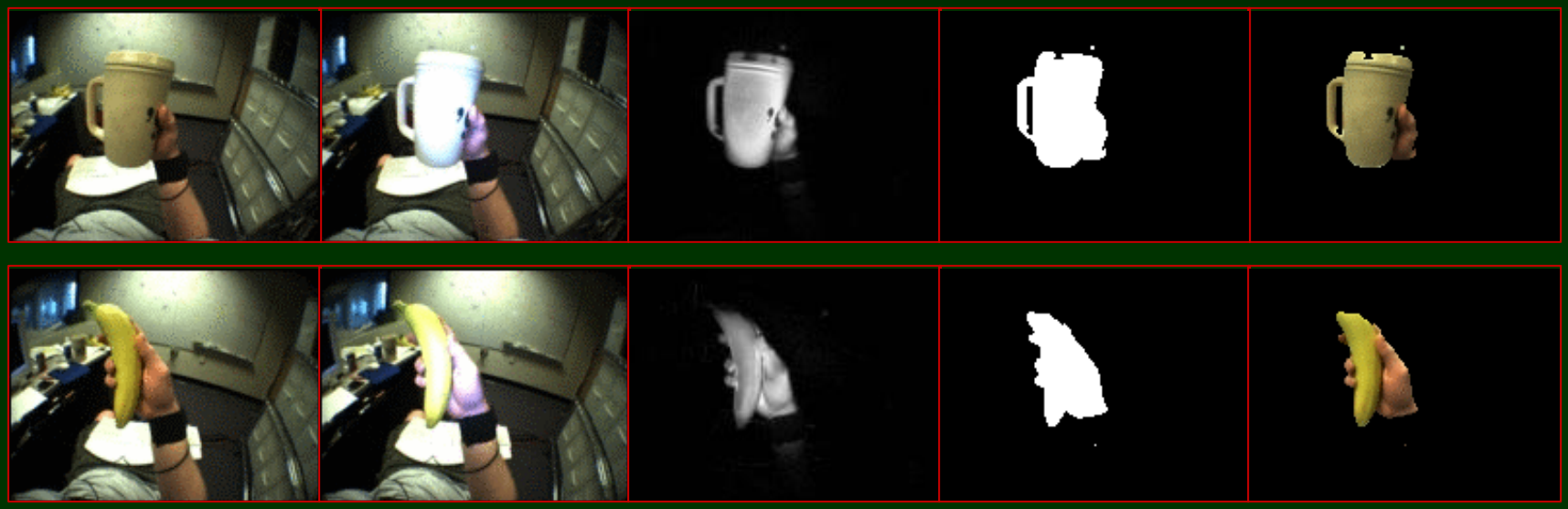
LED array, for creature controlled lighting for object segmentation

Computer cluster for real-time perceptual processing and control through wireless communication

the “Duo” system

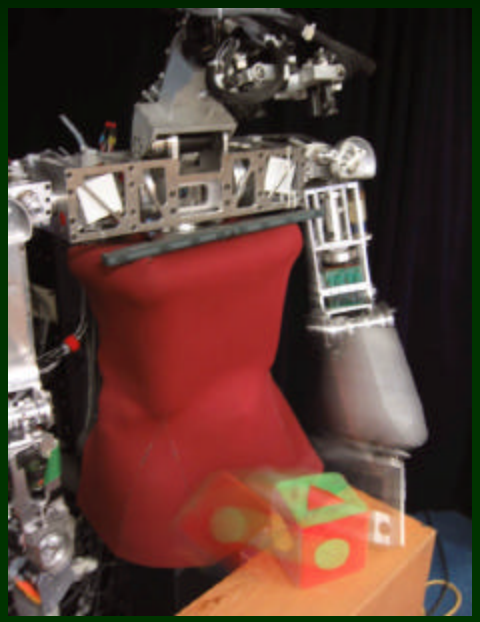


say cheese…



System requests wearer to reach for object, and when it is held up to view it is illuminated

perception of object manipulation



robot ‘manipulation’,
first person perspective

(Paul Fitzpatrick,
Giorgio Metta)

human manipulation,
external perspective

(Artur Arsenio)

human manipulation,
first person perspective

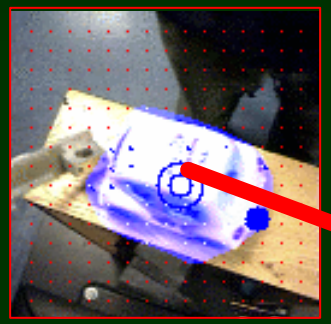
(Charlie Kemp)

using segmentation

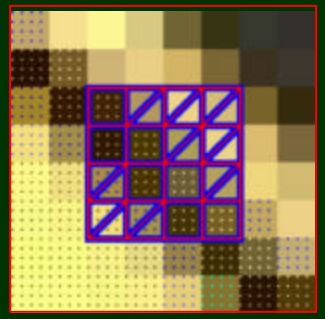
constraint

object segmentation

affordance exploitation
(rolling)



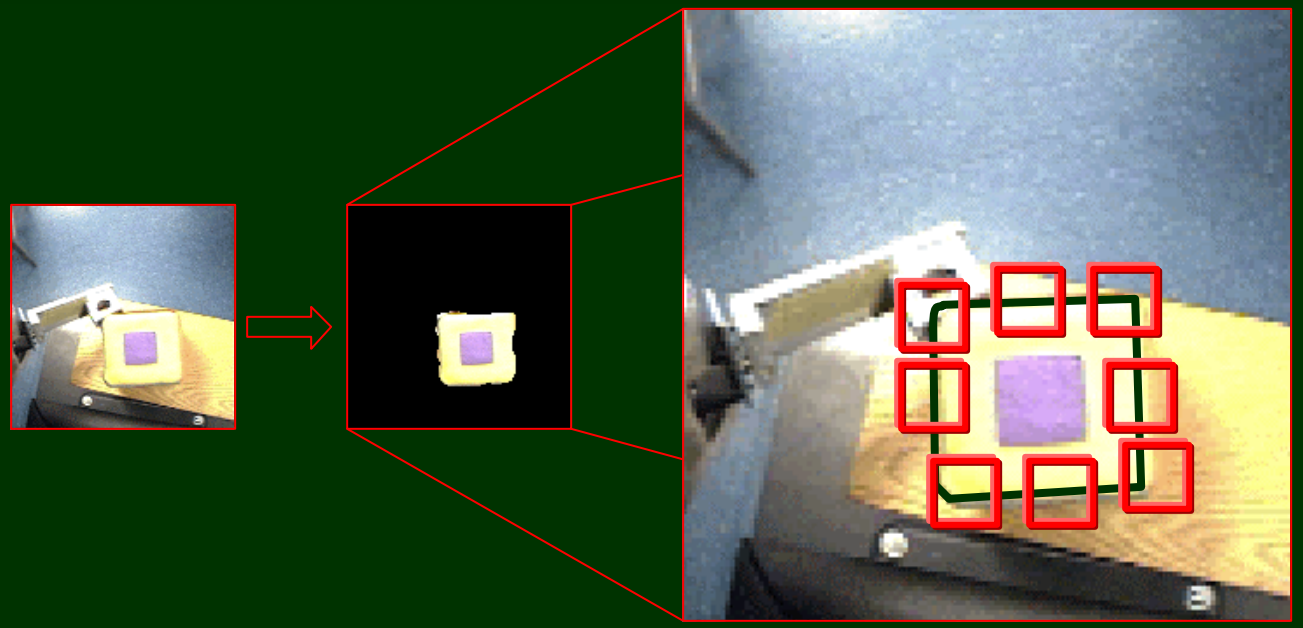
edge catalog



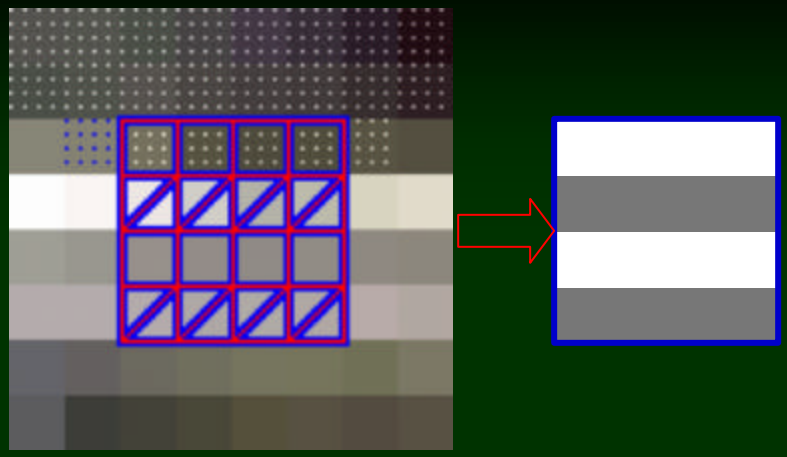
object detection
(recognition, localization,
contact-free segmentation)

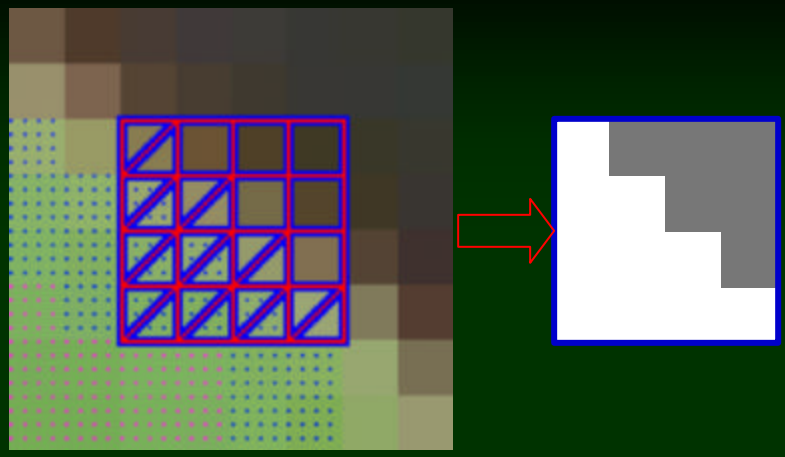
manipulator detection
(robot, human)

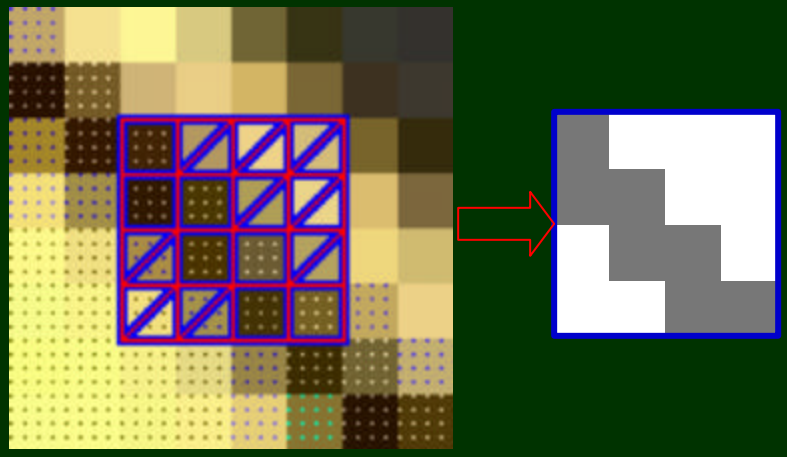
learning about edges

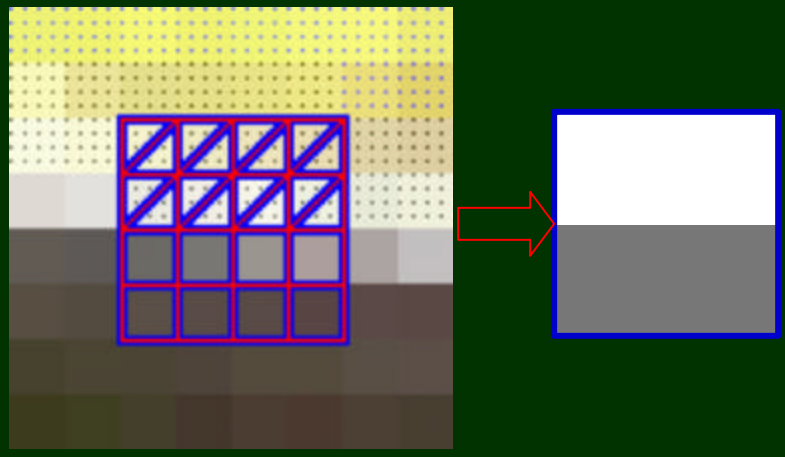


sample samples

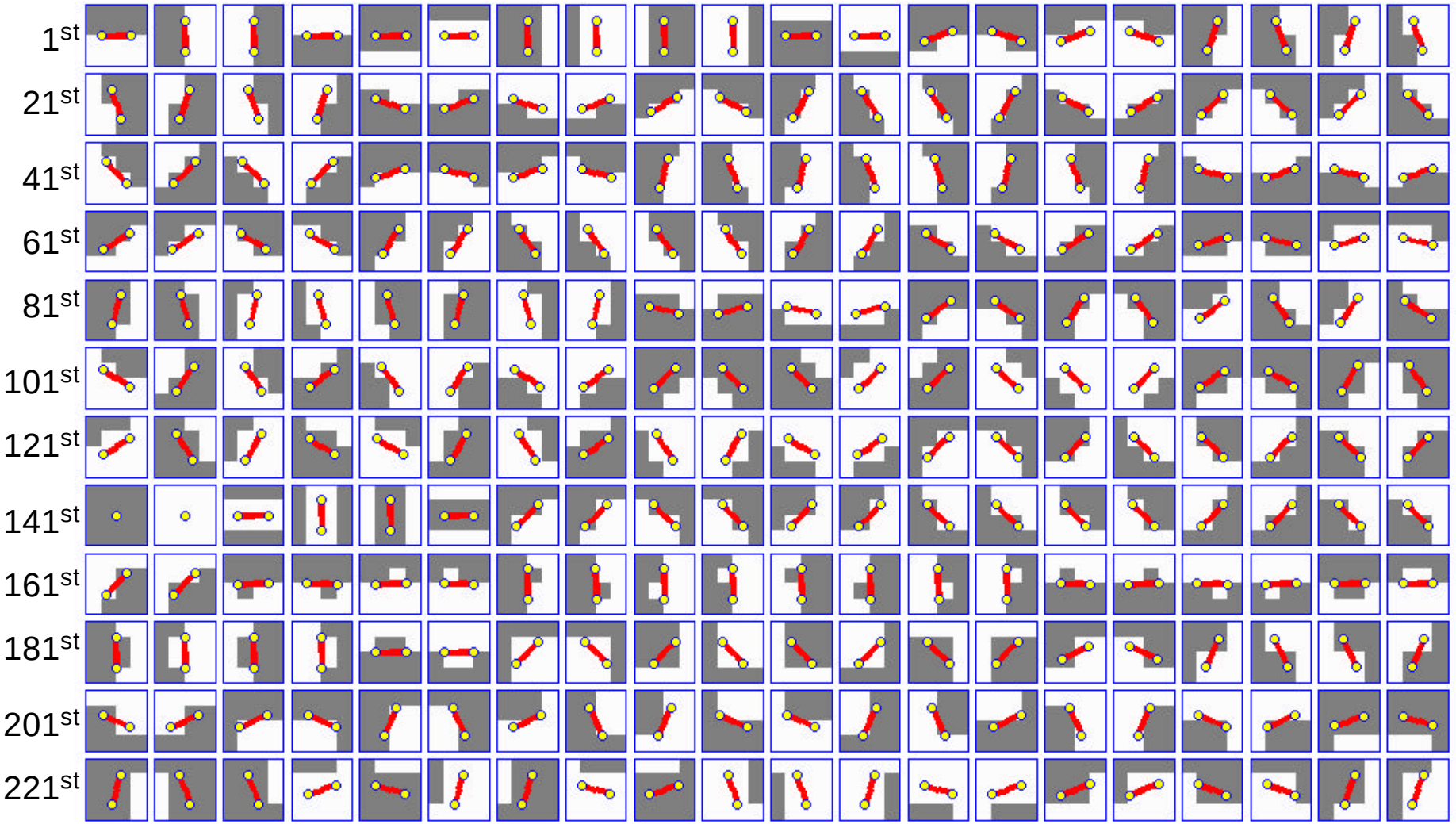




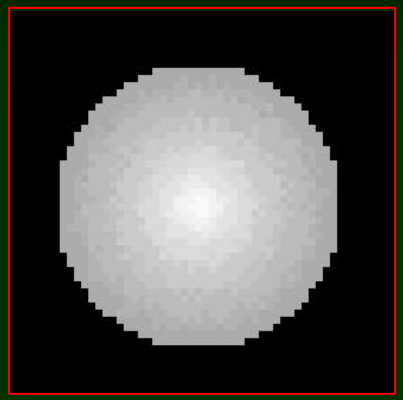
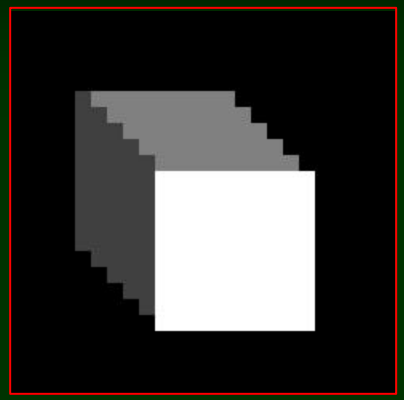
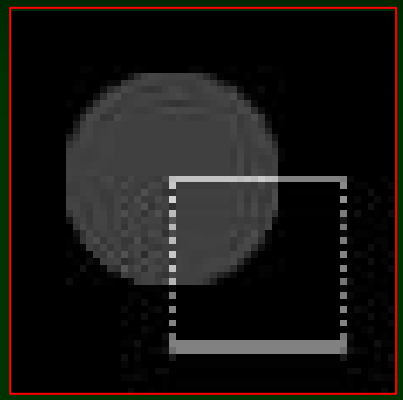
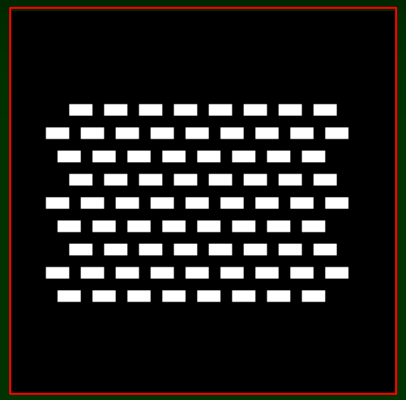
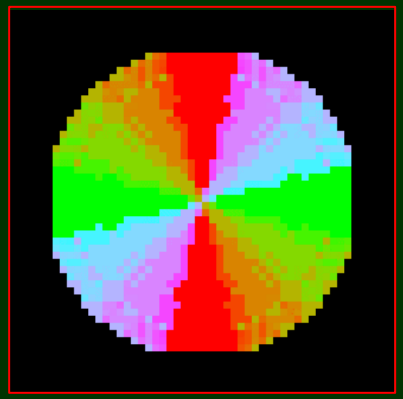


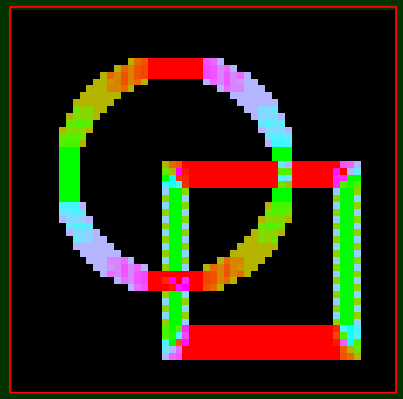
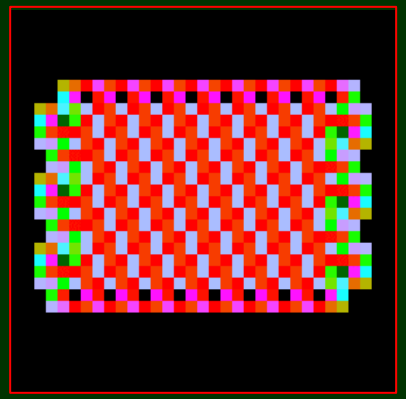


most frequent samples



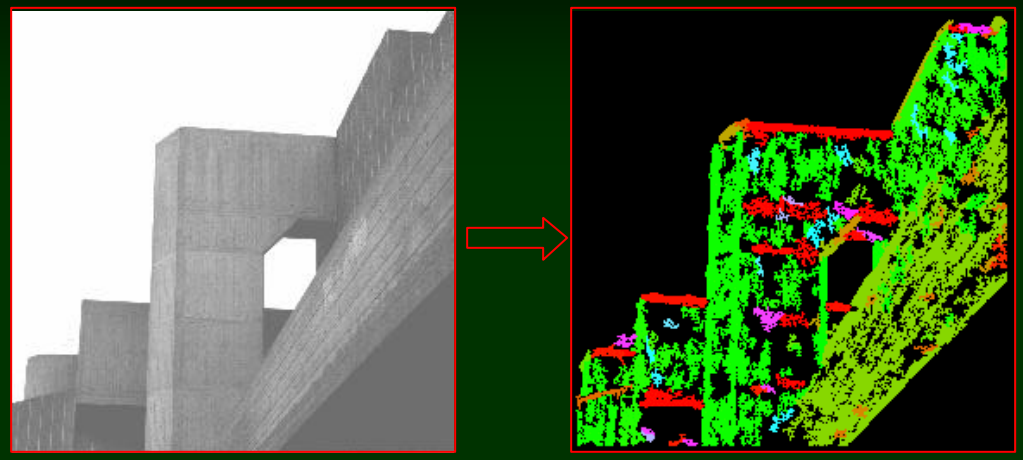
some tests

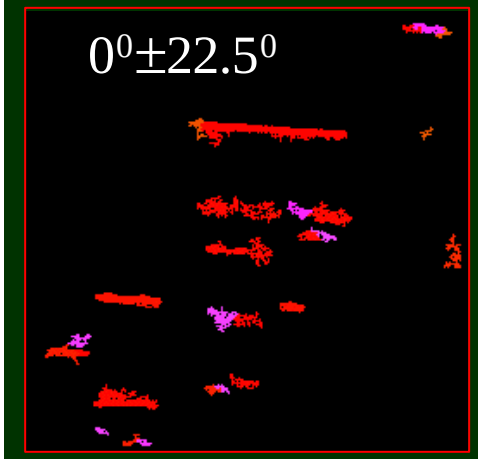






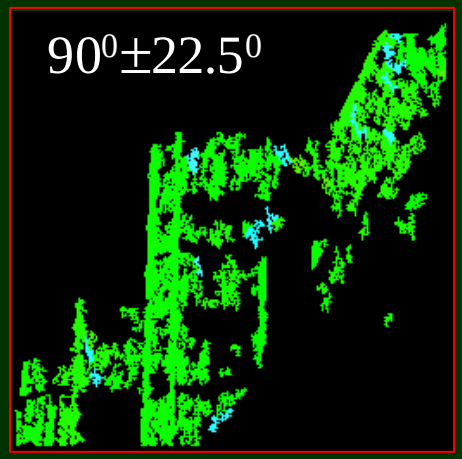



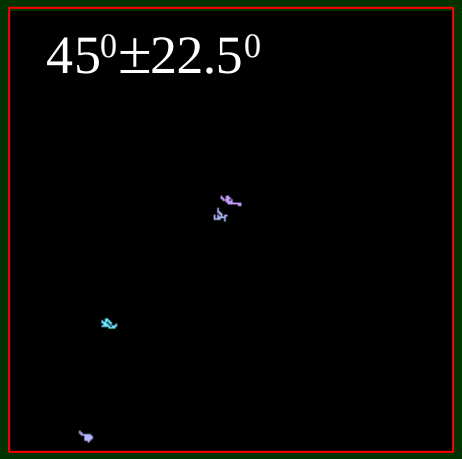
Red = horizontal Green = vertical

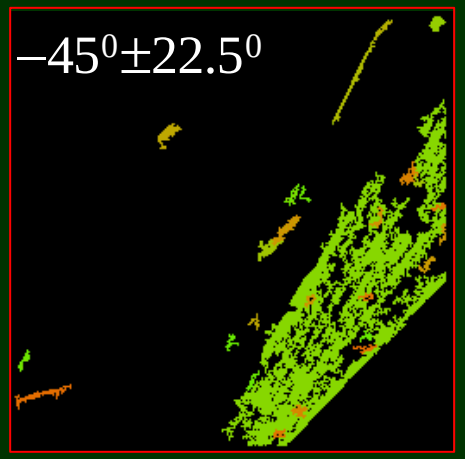
natural images



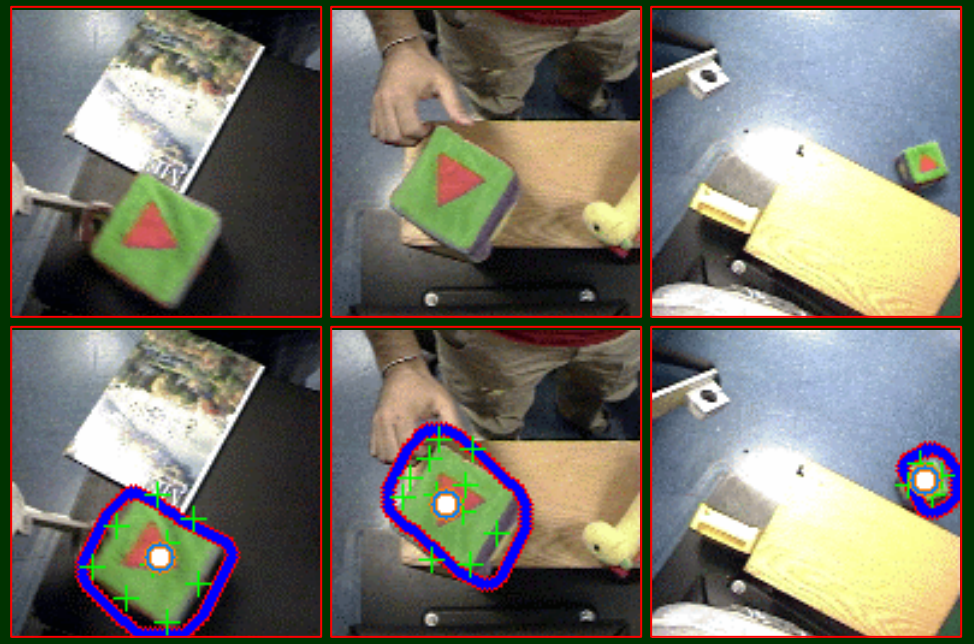








object recognition

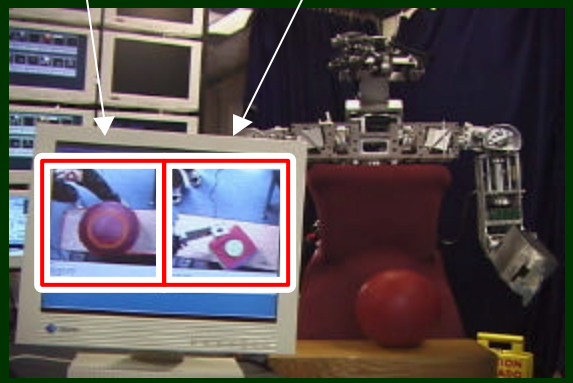


yellow on yellow

open object recognition

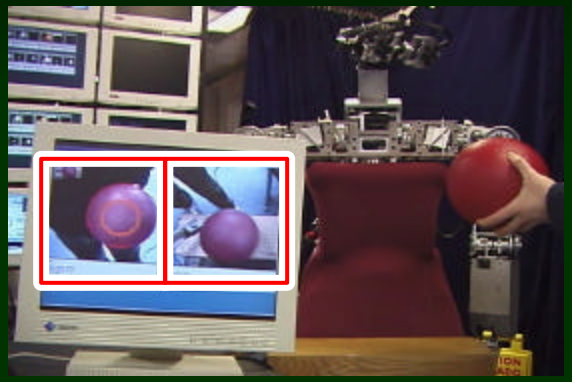
robot's current view

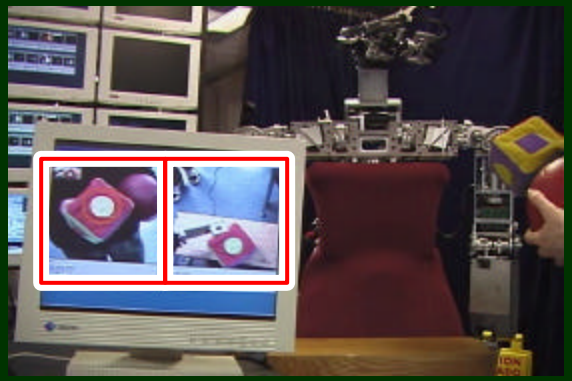
recognized object (as seen during poking)



sees ball, "thinks" it is cube

pokes, segments ball





correctly differentiates ball and cube

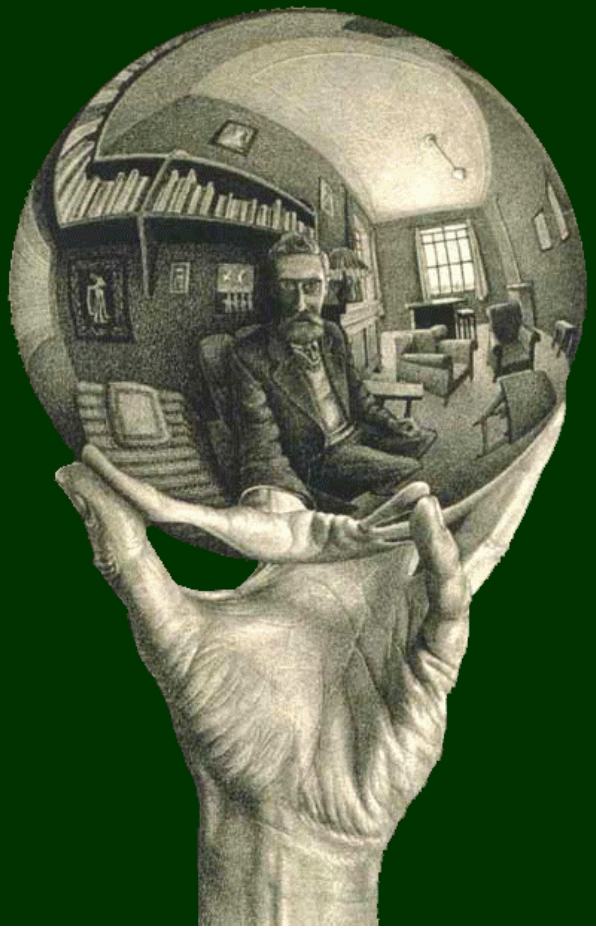
open object recognition

conclusions

Find the hand, and you may find manipulable objects

The constraint of manipulation simplifies object segmentation

Offers an opportunity to gather visual experience, and extend the range of situations within which segmentation is possible…



conclusions

The hand is a good starting point!