Towards intelligent machines

Thanks to CSCI561, we now know how to...

- Search (and play games)
- Build a knowledge base using FOL
- Use FOL inference to ask questions to the KB
- Plan

Are we ready to build the next generation of super-intelligent robots?

Some problems remain…

- Vision
- Audition / speech processing
- Natural language processing
- Touch, smell, balance and other senses
- Motor control

Computer Perception

- Perception: provides an agent information about its environment. Generates feedback. Usually proceeds in the following steps.

1. Sensors: hardware that provides raw measurements of properties of the environment
    1. Ultrasonic Sensor/Sonar: provides distance data
    2. Light detectors: provide data about intensity of light
    3. Camera: generates a picture of the environment
2. Signal processing: to process the raw sensor data in order to extract certain features, e.g., color, shape, distance, velocity, etc.
3. Object recognition: Combines features to form a model of an object
4. And so on to higher abstraction levels

Perception for what?

- **Interaction** with the environment, e.g., manipulation, navigation
- **Process control**, e.g., temperature control
- **Quality control**, e.g., electronics inspection, mechanical parts
- **Diagnosis**, e.g., diabetes
- **Restoration**, of e.g., buildings
- **Modeling,** of e.g., parts, buildings, etc.
- **Surveillance**, banks, parking lots, etc.
- ...
- And much, much more

Image analysis/Computer vision

1. Grab an image of the object (digitize analog signal)

2. Process the image (looking for certain features)
   1. Edge detection
   2. Region segmentation
   3. Color analysis
   4. Etc.

3. Measure properties of features or collection of features (e.g., length, angle, area, etc.)

4. Use some model for detection, classification etc.

Image Formation and Vision Problem

- **Image:** is a 2D projection of a 3D scene.
  Mapping from 3D to 2D, i.e., some information is getting lost.

- **Computer vision problem:** recover (some or all of) that information. The lost dimension 2D → 3D
  (Inverse problem of VR or Graphics)
  Challenges: noise, quantization, ambiguities, illumination, etc.

- Paradigms:
  - **Reconstructive vision**: recover a model of the 3D scene from 2D image(s) (e.g., shape from shading, structure from motion)
    More general
  - **Purposive vision:** recover only information necessary to accomplish task (e.g., detect obstacle, find doorway, find wall).
    More efficient

How can we see?

- Marr (1982): 2.5D primal sketch

1) pixel-based (light intensity)

2) primal sketch (discontinuities in intensity)

3) 2 ½ D sketch (oriented surfaces, relative depth between surfaces)

4) 3D model (shapes, spatial relationships, volumes)

State of the art

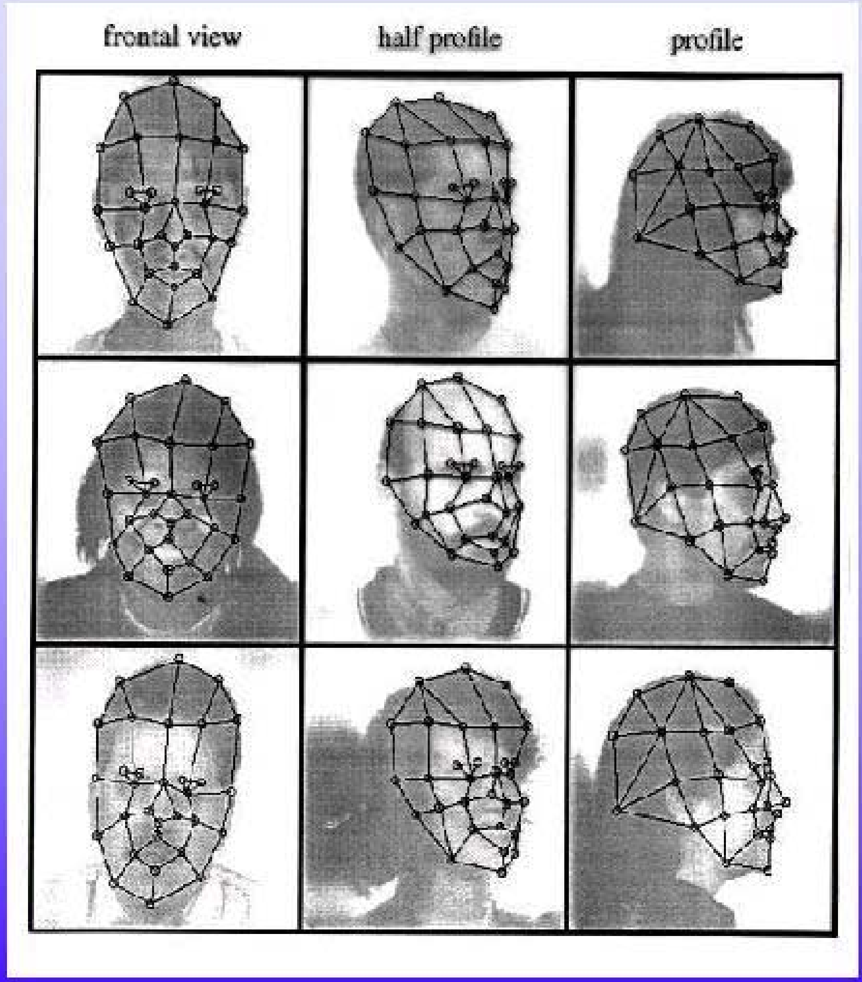
- Can recognize faces?
- Can find salient targets?
- Can recognize people?
- Can track people and analyze their activity?
- Can understand complex scenes?

State of the art

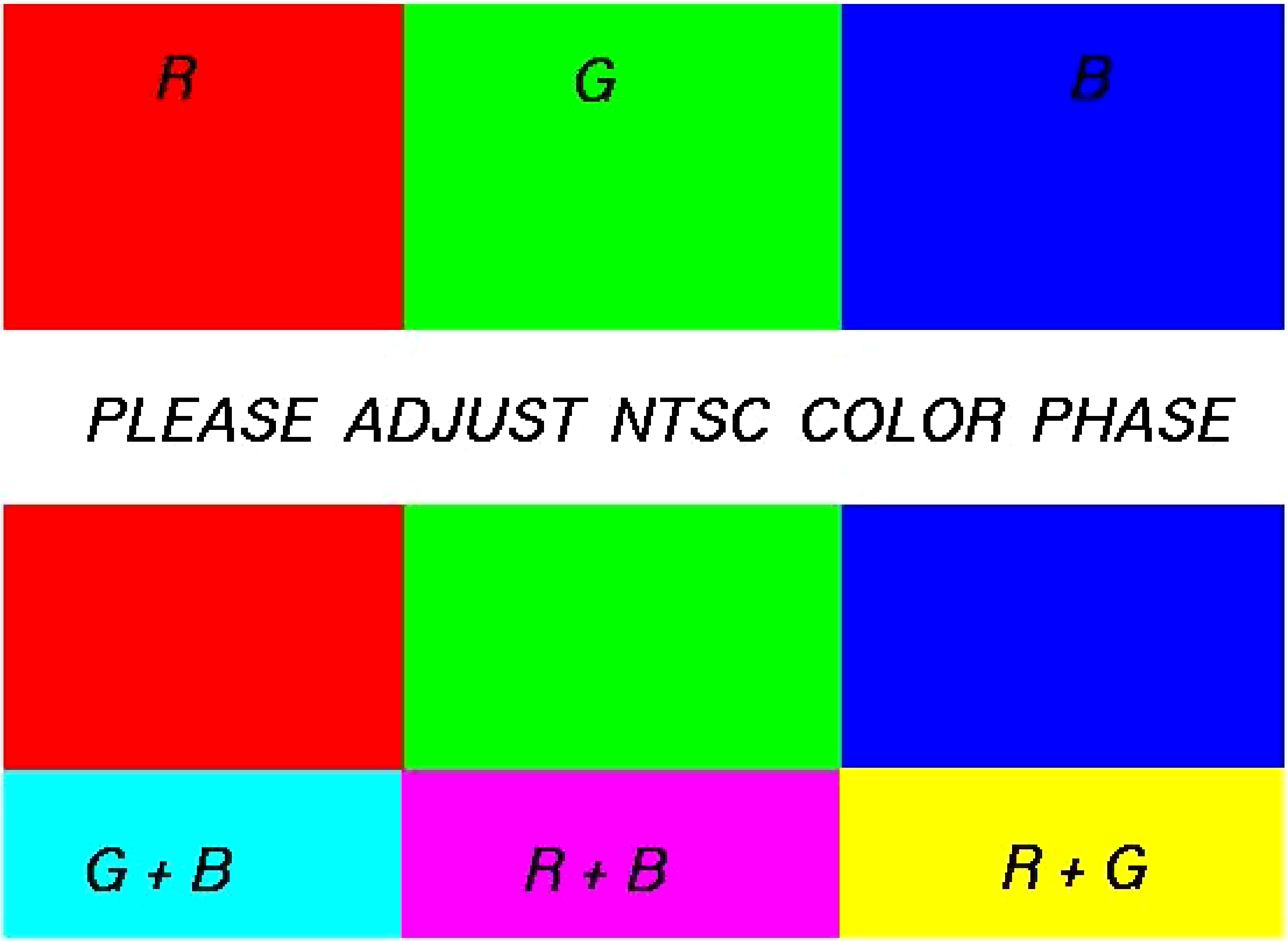
- Can recognize faces? – yes, e.g., von der Malsburg (USC)
- Can find salient targets? – sure, e.g., Itti (USC) or Tsotsos (York U)
- Can recognize people? – no problem, e.g., Poggio (MIT)
- Can track people and analyze their activity? – yep, we saw that (Nevatia, USC)
- Can understand complex scenes? – not quite but in progress

Face recognition case study

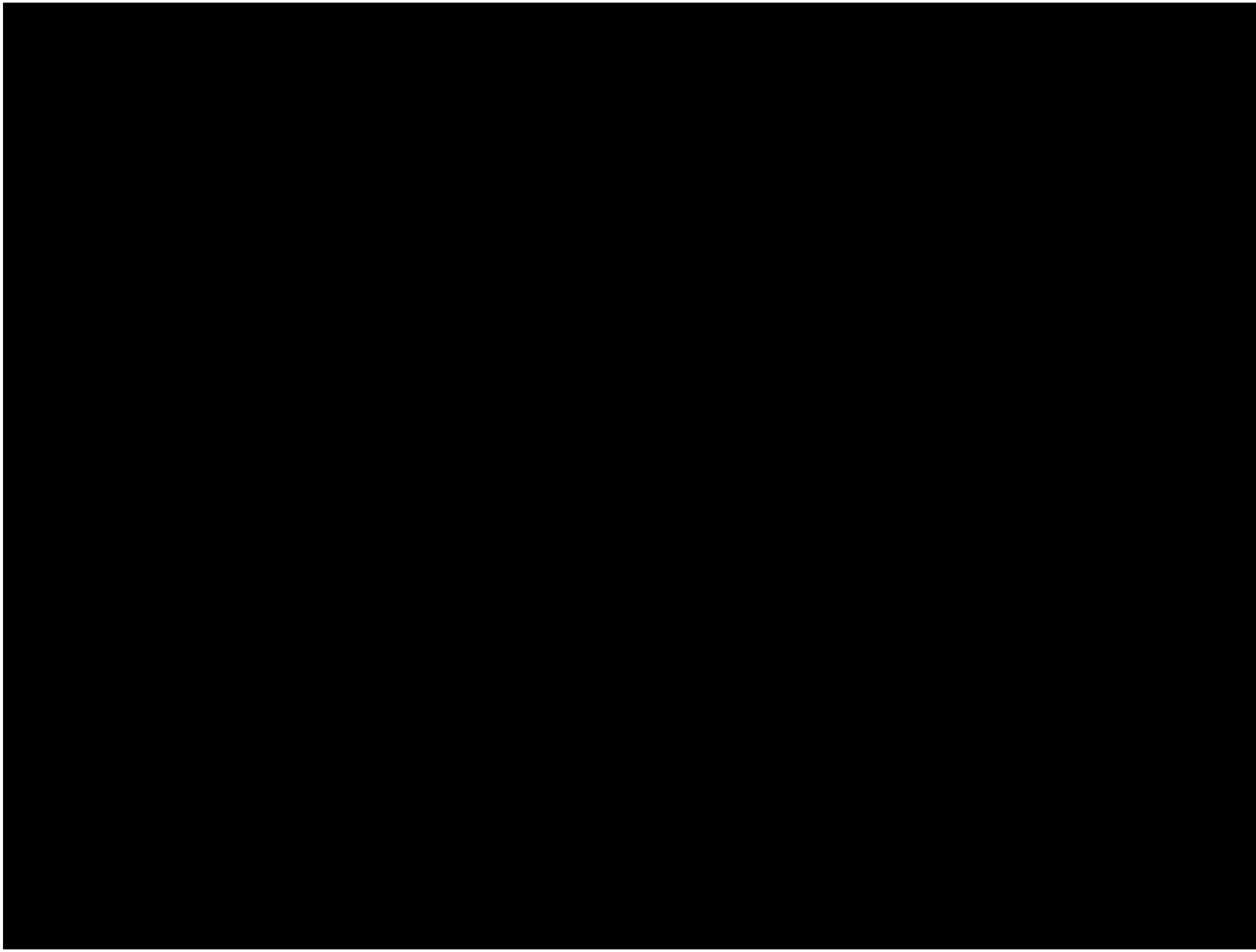
- C. von der Malsburg's lab at USC



Finding "interesting" regions in a scene



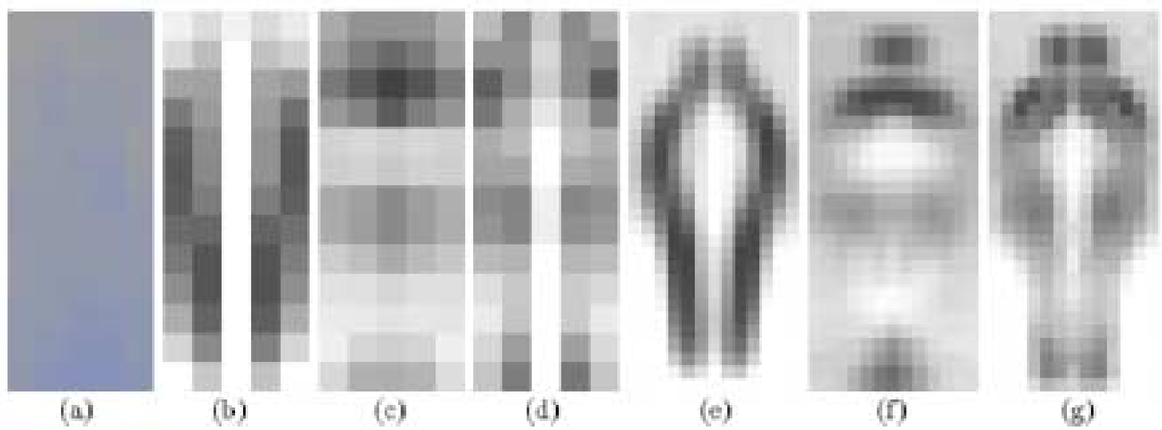
Visual attention



Visual Attention

Pedestrian recognition

- C. Papageorgiou & T. Poggio, MIT



How about other senses?

- Speech recognition -- can achieve user-undependent recognition for small vocabularies and isolated words
- Other senses -- overall excellent performance (e.g., using gyroscopes for sense of balance, or MEMS sensors for touch) except for olfaction and taste, which are very poorly understood in biological systems also.

How about actuation

- Robots have been used for a long time in restricted settings (e.g., factories) and, mechanically speaking, work very well.

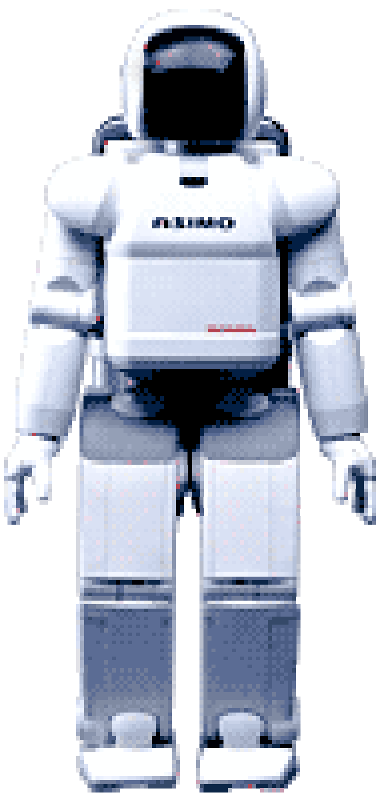
- For operation in unconstrained environments, **Biorobotics** has proven a particularly fruitful line of research:

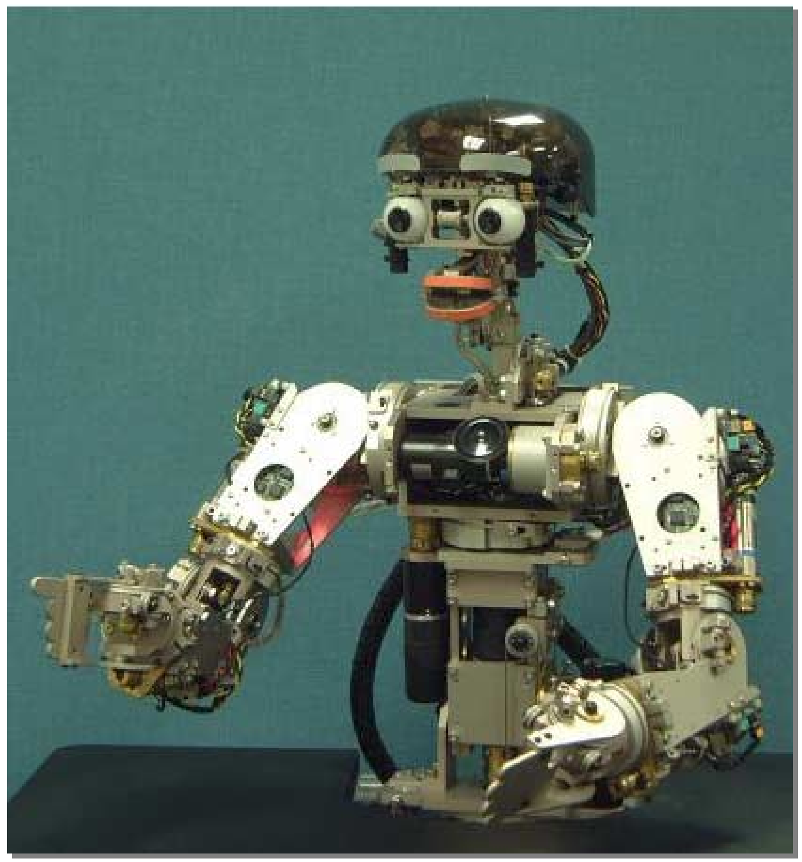
Motivation: since animals are so good at navigating through their natural environment, let's try to build robots that share some structural similarity with biological systems.

Robot examples: constrained environments

Robot examples: towards unconstrained environments

See Dr. Schaal's lab at http://www-clmc.usc.edu

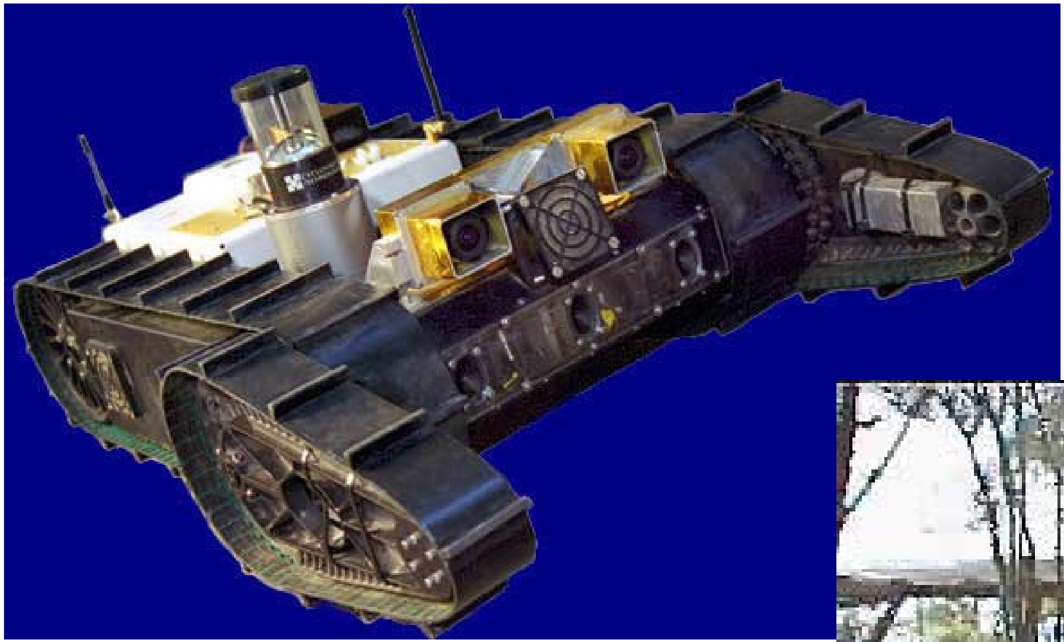




More robot examples

Rhex, U. Michigan

More robots



Urbie @ JPL and
robots from iRobots, Inc.

Outlook

- It is a particularly exciting time for AI because...

  - CPU power is not a problem anymore
  - Many physically-capable robots are available
  - Some vision and other senses are partially available
  - Many AI algorithms for constrained environment are available

So for the first time YOU have all the components required to build smart robots that interact with the real world.

Hurry, you are not alone…

Robot mowers and vacuum-cleaners are here already...

http://www.shopping-emporium-uk.com/mower/

http://www.roombavac.com/