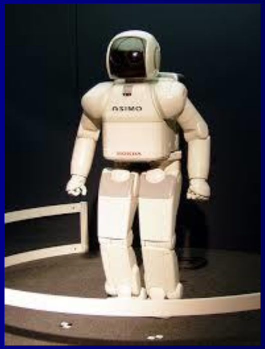
Lets Learn of Robot Technology



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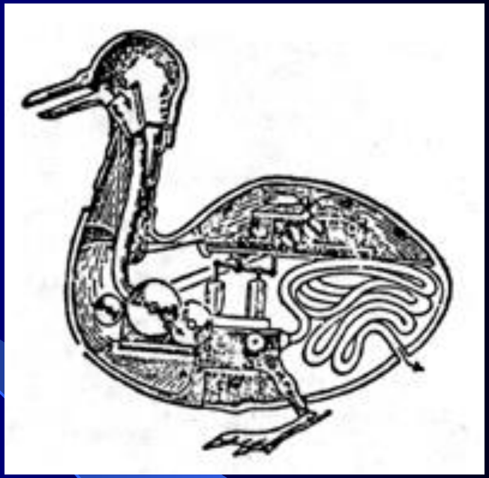
The Origins of Robots

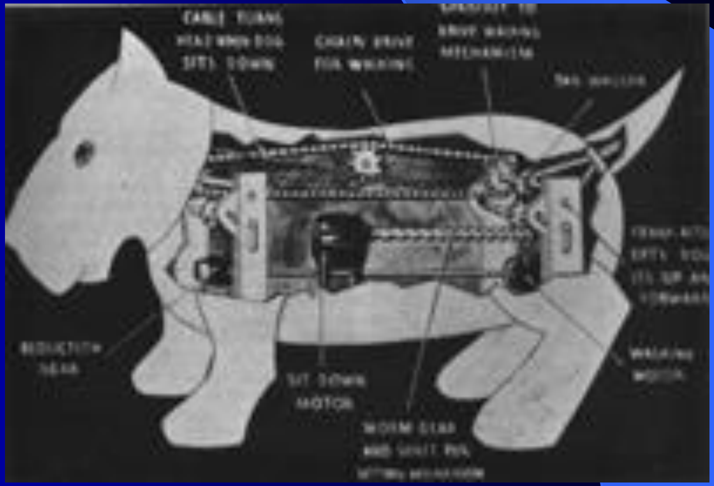
1738 — Jacques de Vaucanson builds a mechanical duck made of more that 4,000 parts. The duck could quack, bathe, drink water, eat grain, digest it and void it. Whereabouts of the duck are unknown today.



1805 — Doll, made by Maillardet, that wrote in either French or English and could draw landscapes.

1923 Karel Capek coins the term *robot* in his play *Rossum's Universal Robots (R.U.R).* *Robot* comes from the Czech word *robota*, which means "servitude, forced labor."

1940 Sparko, the Westinghouse dog, uses both mechanical and electrical components.



1950's -1960's

Computer technology advances and control machinery is developed. Questions Arise: Is the computer an immobile robot?

Industrial Robots created. Robotic Industries Association states that an "industrial robot is a re-programmable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions to perform a variety of tasks.

- **Unimation (61):** built first robot in a GM plant. The machine is programmable.
- Robots were then improved with sensing: force sensing, rudimentary vision.
- Two famous robots:
  - **Puma**. (Programmable Universal Machine for Assembly). ‘78.
  - **SCARA.** (Selective Compliant Articulated Robot Assembly). ‘79.

Robot Examples

The Three Laws of Robotics

- A robot may not injure humanity, or, through inaction, allow humanity to come to harm
- A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Robot Applications

Traditionally, robots are applied anywhere one or more of the 3Ds exist: in any job which is too: *Dirty*, *Dangerous*, and/or *Dull* for a human to perform.

Industry
Manufacturing, assembly, part handling, palletizing, maintenance, inspection, welding, spray painting, deburring, machining.

Remote operations
Undersea, nuclear environment, bomb disposal, law enforcement, outer space, other hazardous environments.

Service
Hospital helpmates, handicapped assistance, retail, household servants, lawnmowers, security guards.

Robotics Field is a Combination of:

Mechanical Engineering

↓

Electrical Engineering

↓

Computer Science

Combining these fields we can create a system that can:

SENSE

↓

PLAN

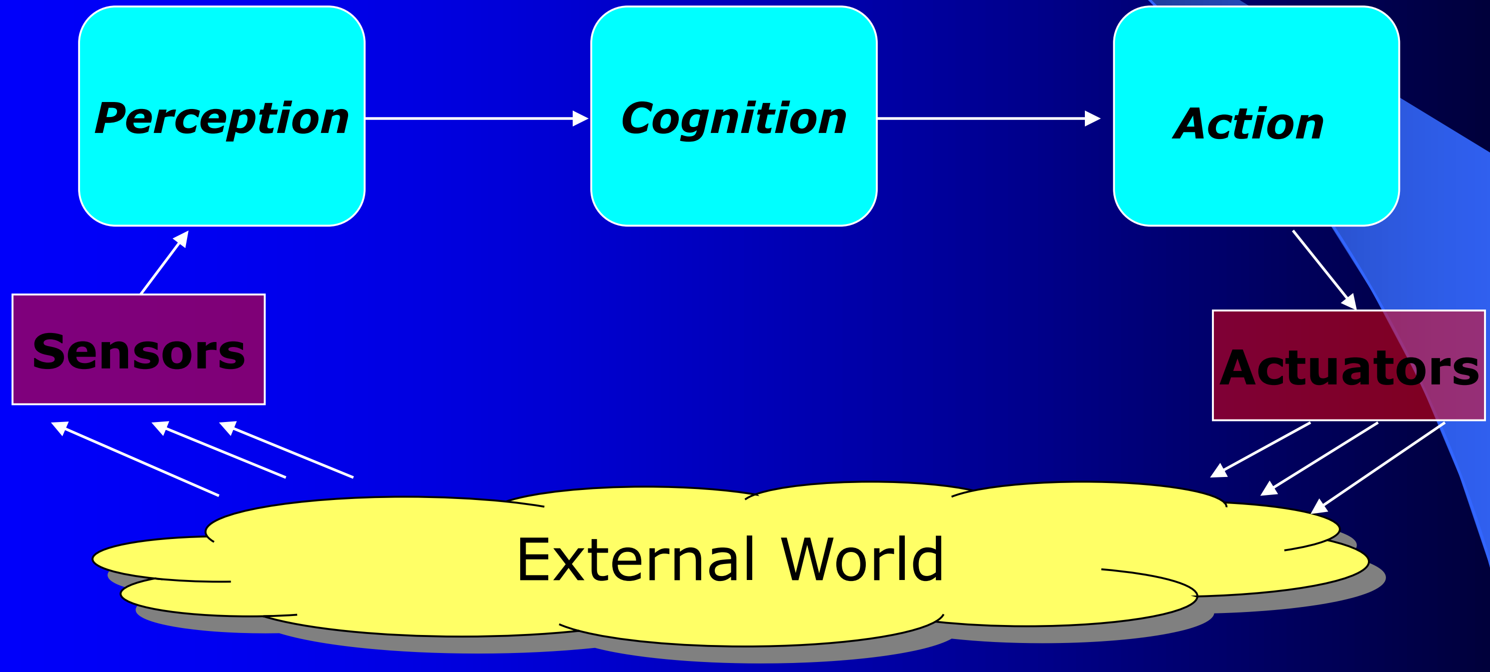
↓

ACT

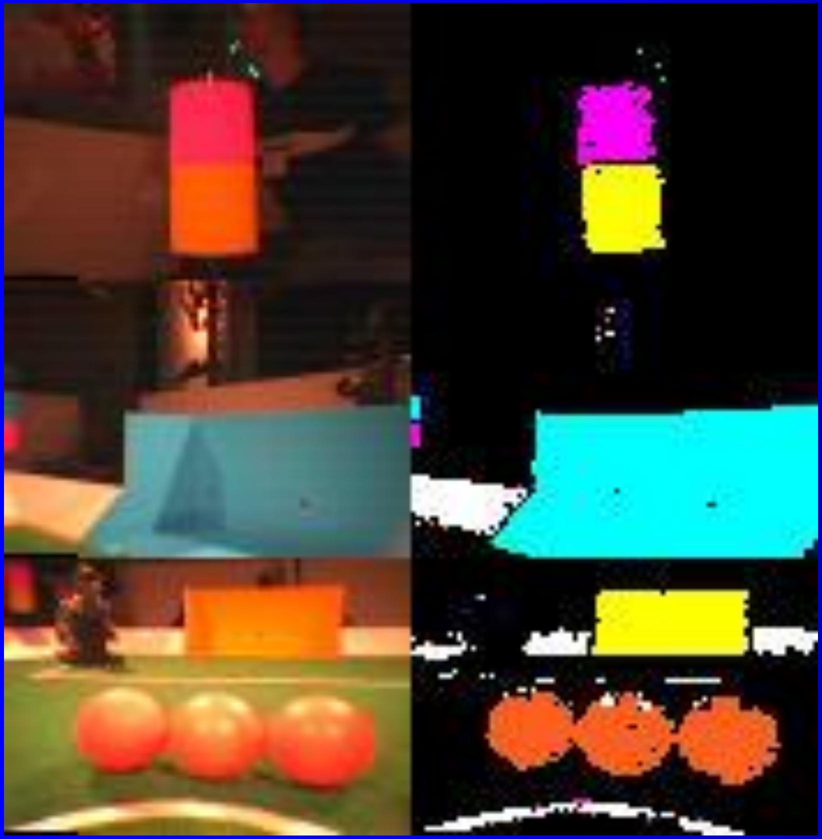
Autonomy

- Perception
  - sensing, modeling of the world
- Cognition
  - behaviors, action selection, planning, learning
  - multi-robot coordination, teamwork
  - response to opponent, multi-agent learning
- Action
  - motion, navigation, obstacle avoidance

Intelligent Complete Robot

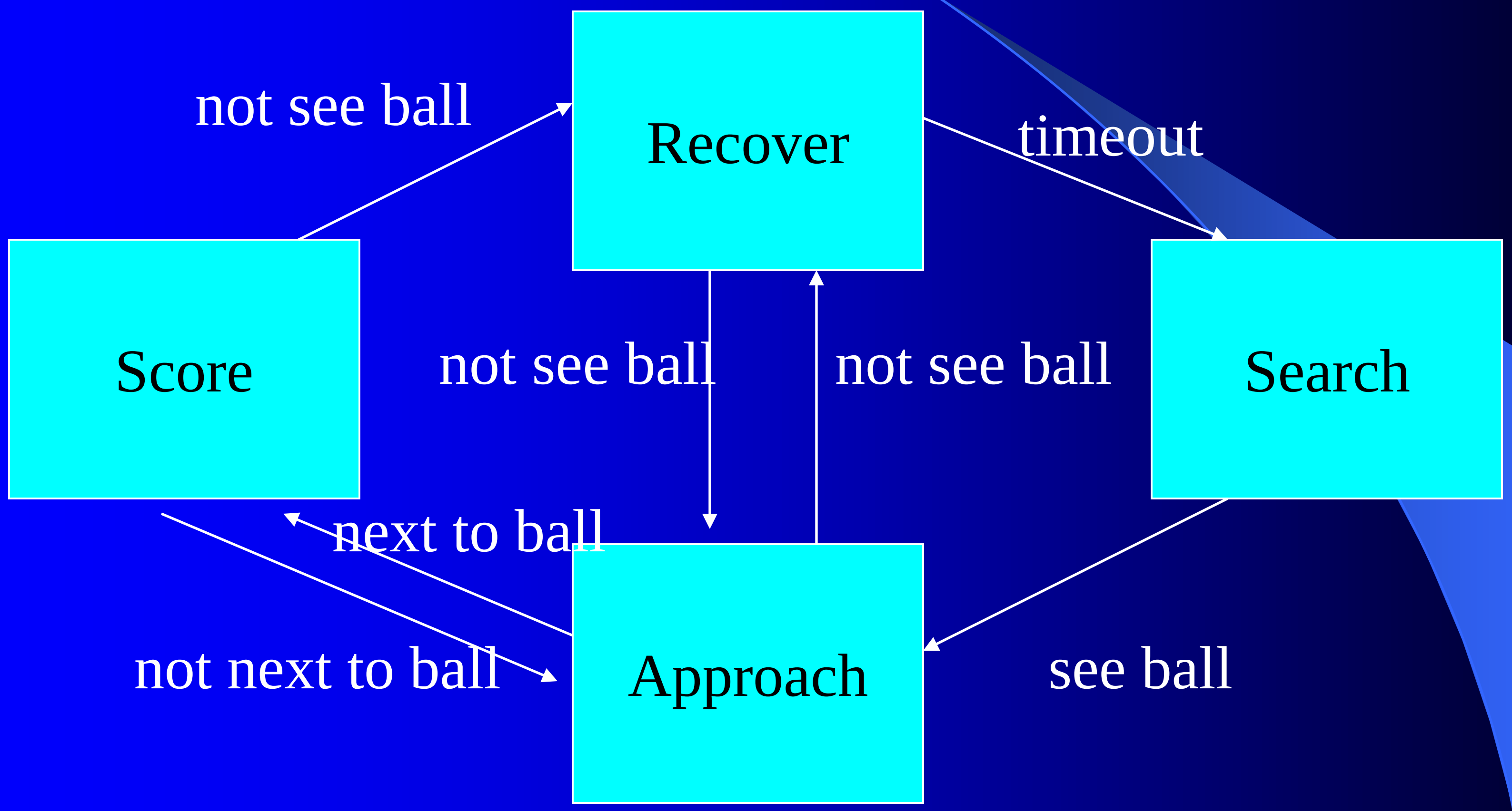


Perception: Vision



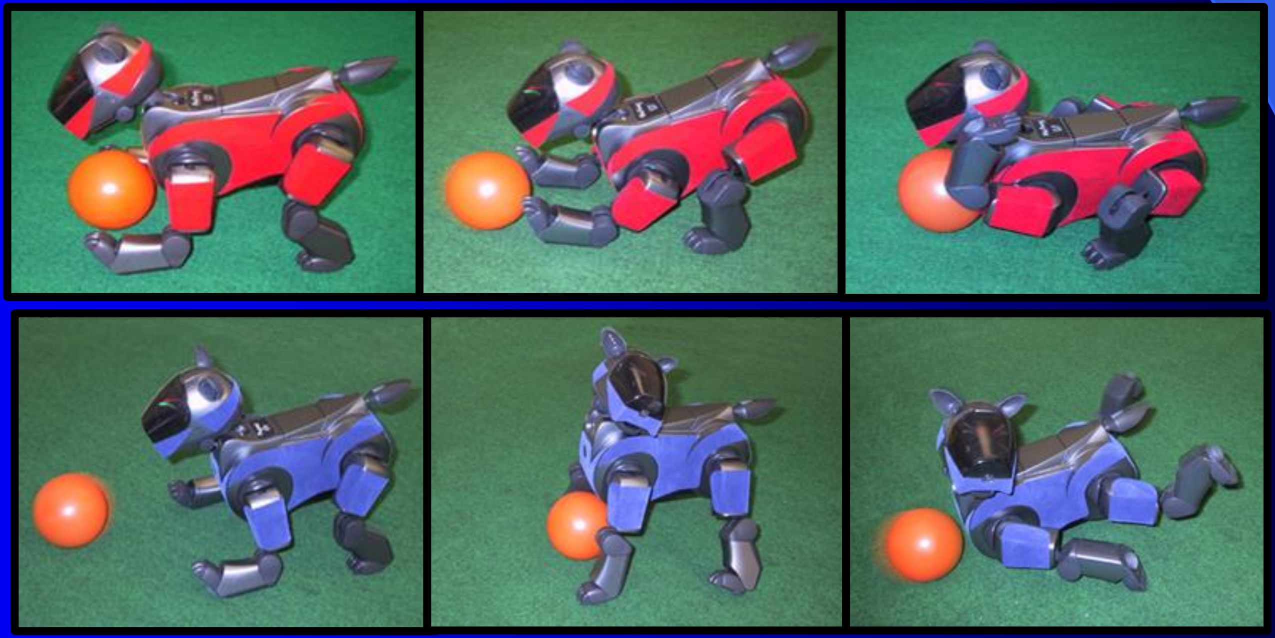
- Real-time and robust
- Effective calibration
- Colored blobs identified as objects
- Confidence computed

Cognition: Behaviors



Action: Motion

- Four-legged walking
- Head motion
- Turning, kicking



Current Areas of Interest in Robot Technology

- Industrial Robots
- Mini Robots
- Micro Robots
- Nano Robots
- Neuro Robots
- Bio Robots

Industrial Robot Classification

Industrial robots: robotic arms or *manipulators*

Manipulators are *anthropomorphic* in the sense that they are patterned after the human arm.

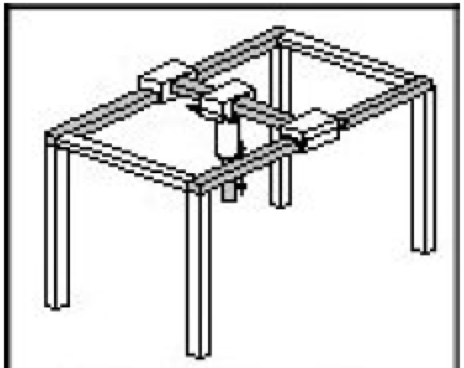
Robotic manipulator: a collection of **links** inter-connected by joints.At the end there is a tool or **end-effector.**

Classification Of Industrial Robots:

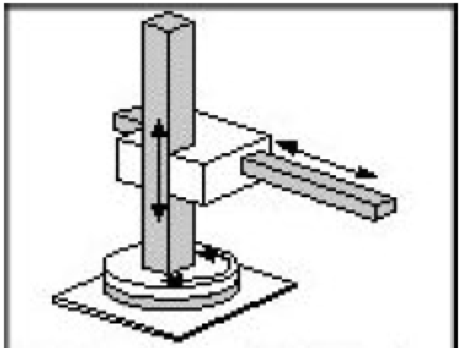
- **Drive Technology.** Which source of power drives the joints of the robot.
- **Work-envelope geometries.** Points in space which can be reached by the end-effector.
- **Motion control method.** Either point-to-point or continuous path

Cartesian

Robots which have three linear (P, as opposed to rotational R joints) axes of movement (X, Y, Z). Used for pick and place tasks and to move heavy loads. They can trace out rectangular volumes in 3D space.



Cartesian Robot



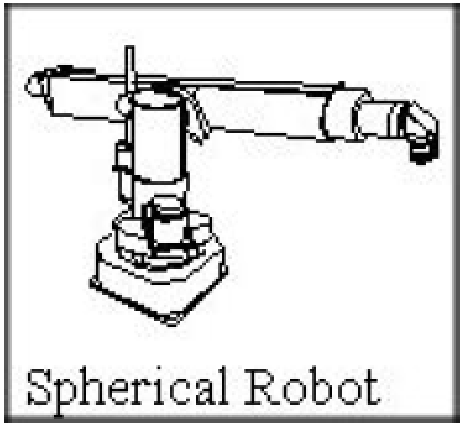
Cylindrical Robot

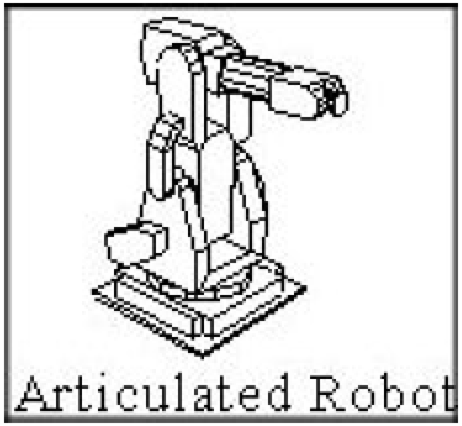
Cylindrical

The positions of these robots are controlled by a radius, a height and an angle (that is, two P joints and one R joint). These robots are commonly used in assembly tasks and can trace out concentric cylinders in 3D space.

Spherical

Spherical robots have two rotational R axes and one translational P (radius) axis. The robots' end-effectors can trace out concentric spheres in 3D space.



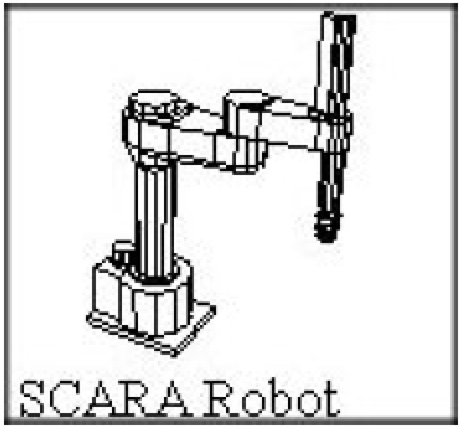


Articulated

The positions of articulated robots are controlled by three angles, via R joints. These robots resemble the human arm (anthropomorphic). They are the most versatile robots, but also the most difficult to program.

SCARA (Selective Compliance Articulated Robot Arm)

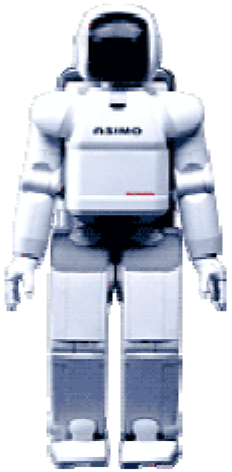
SCARA robots are a blend of the articulated and cylindrical robots, providing the benefits of each. The robot arm unit can move up and down, and at an angle around the axis of the cylinder just as in a cylindrical robot, but the arm itself is jointed like a revolute coordinate robot to allow precise and rapid positioning. The robot consists of three R and one P joints; an example is shown below.



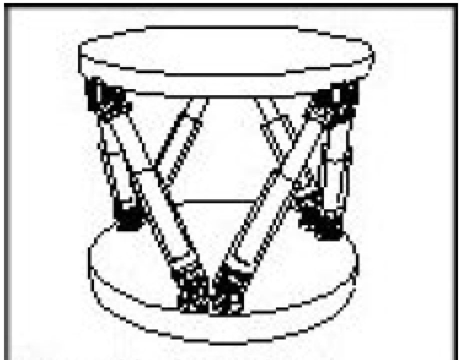
OU RoboCup Player

Mobile robots

Mobile robots have wheels, legs, or other means to navigate around the workspace under control. Mobile robots are applied as hospital helpmates and lawn mowers, among other possibilities. These robots require good sensors to "see" the workspace, avoid collisions, and get the job done. The following six images show Ohio University's involvement



Honda Humanoid Robot



Parallel Robot

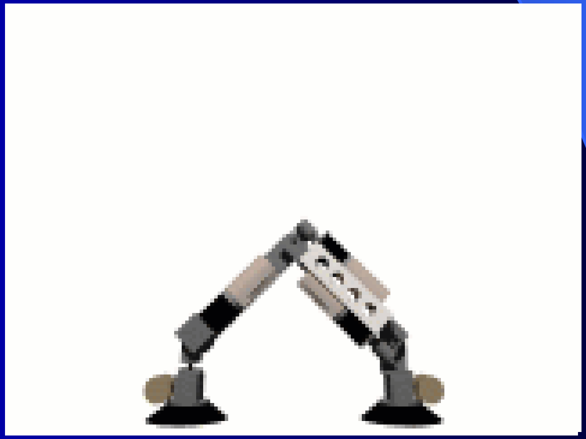
Parallel robots

Most of the robots discussed so far are serial robots, where joints and links are constructed in a serial fashion from the base, with one path leading out to the end-effector. In contrast, parallel robots have many "legs" with active and passive joints and links, supporting the load in parallel. Parallel robots can handle higher loads with greater accuracy, higher speeds, and lighter robot weight; however, a major drawback is that the workspace of parallel robots is severely restricted compared to equivalent serial robots. Parallel robots are used in expensive flight simulators, as machining tools, and can be used for high-accuracy, high-repeatability, high-precision robotic surgery.

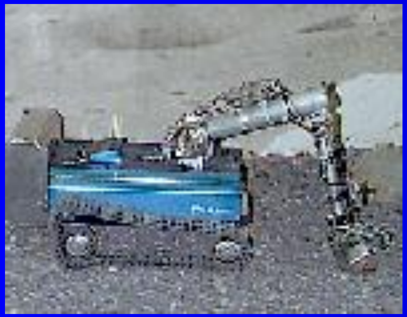
MINI- Robots

So now lets walk up walls and walk on Mars and fly too!!

Flipper; is able to flip
Over and the suction cups
allow it to literally walk up
Walls.



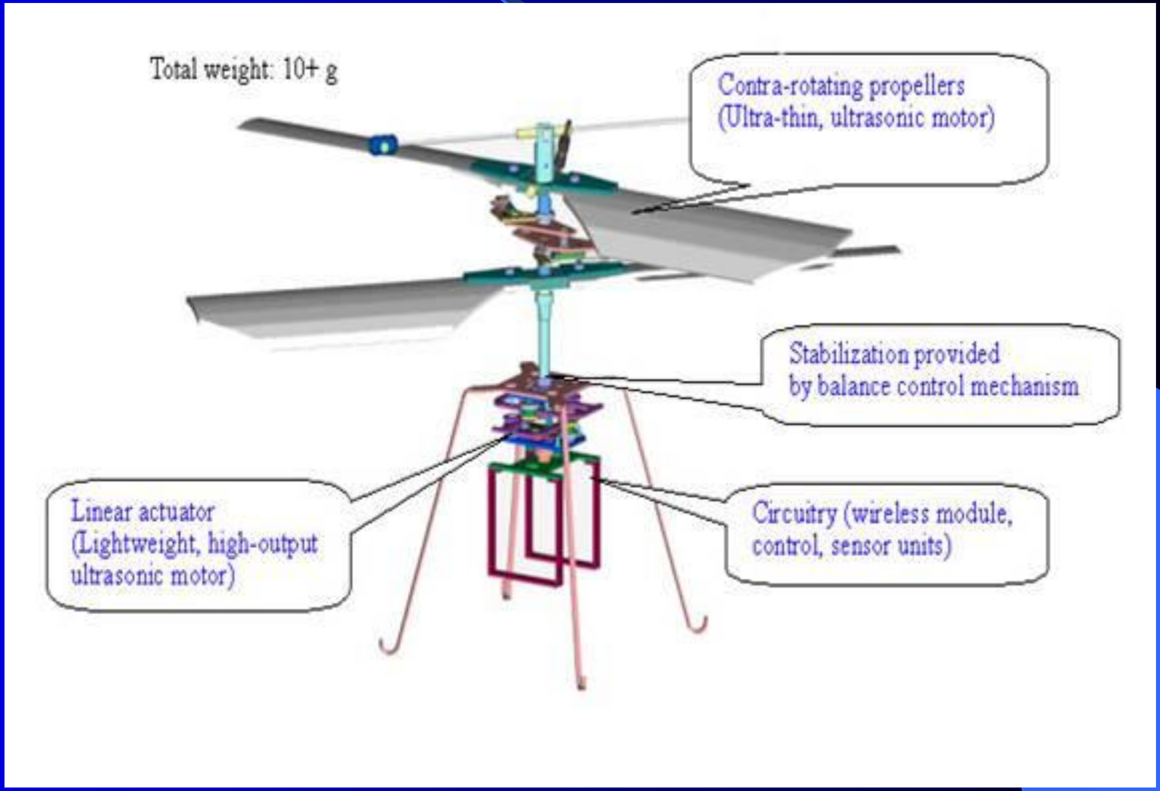
Mars Rovers



- Work sponsored by NASA JPL (from around 1998).

- Pebbles is a vision-based mobile robot that uses a single camera for obstacle avoidance in rough unstructured environments.
- Goal of Rockettes project is to build small, 10 gram mobile robots for planetary exploration. Can send many microrobots instead of a single larger one.

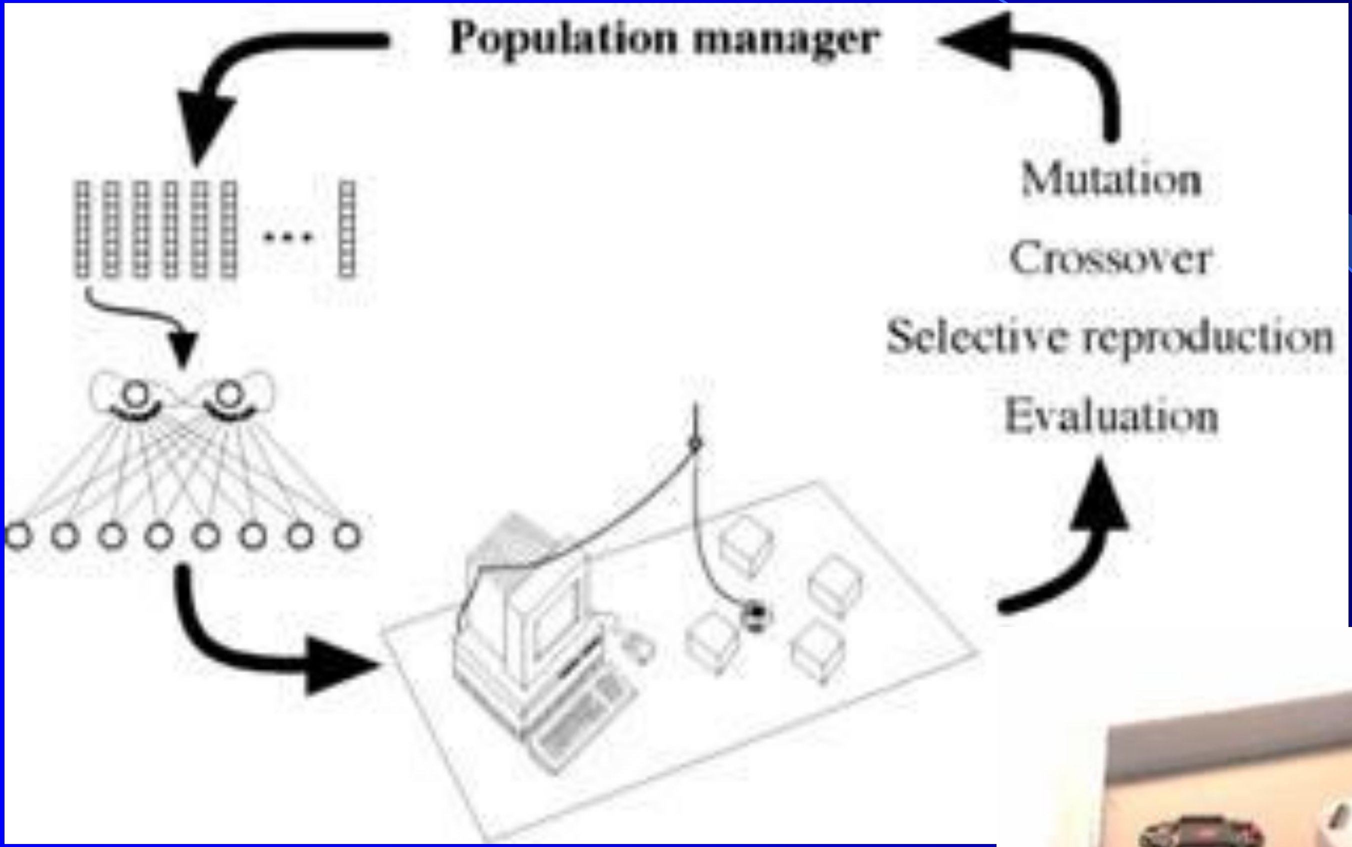
More flying machines worlds smallest flying beastie:



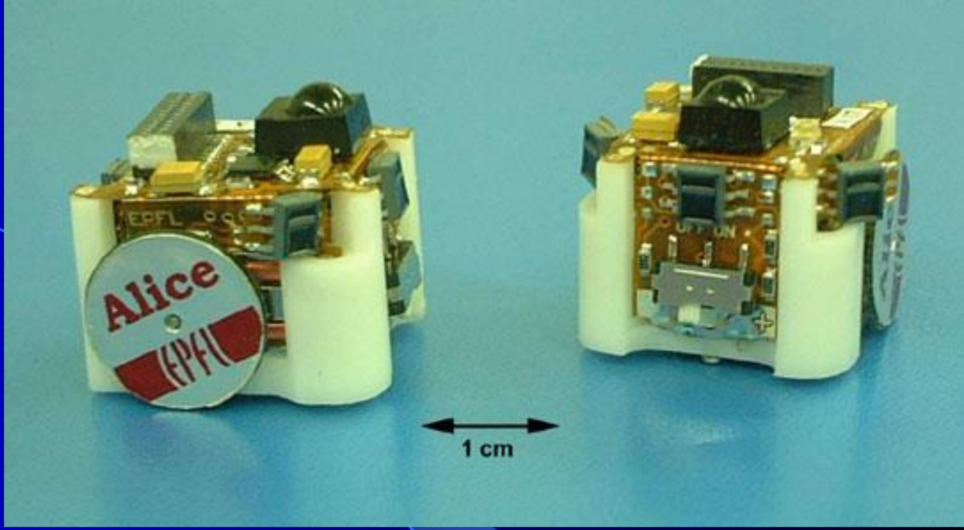
Really tiny robots

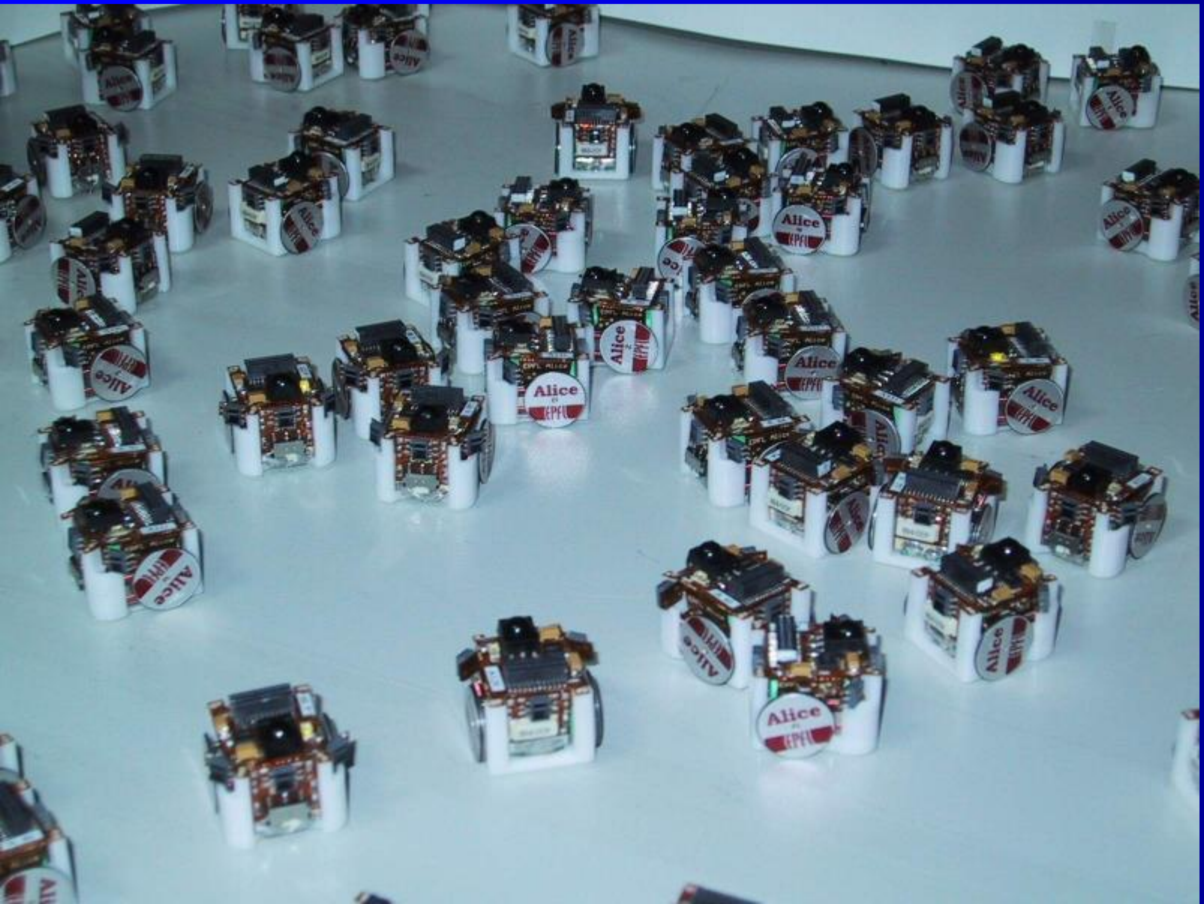
Japanese Robot 1999 measure 1cm long.
US gov engineers are also working on
Robots that can hover around a room.

Evolutionary robotics

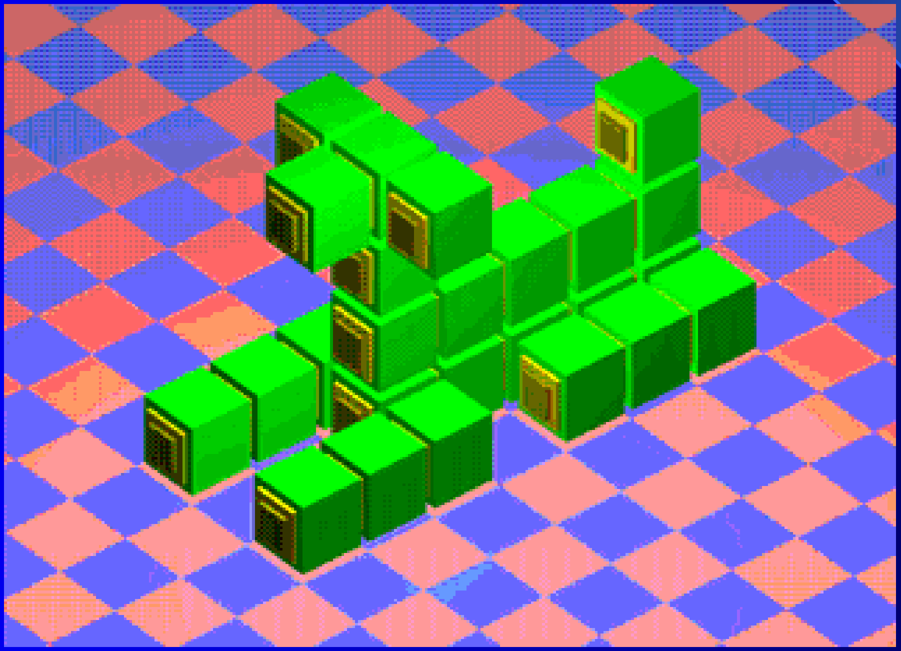


Collective behaviors



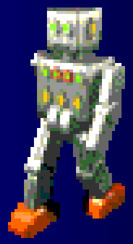


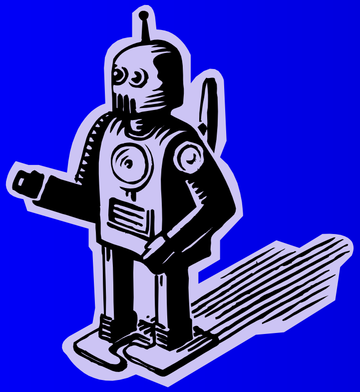
Modular Robot - Little mini robots that change shape.

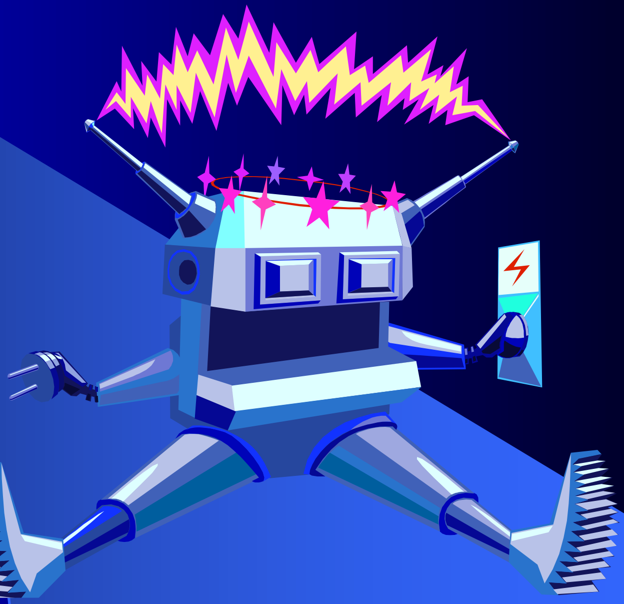


Dog changes into a couch!

Micro Robotics





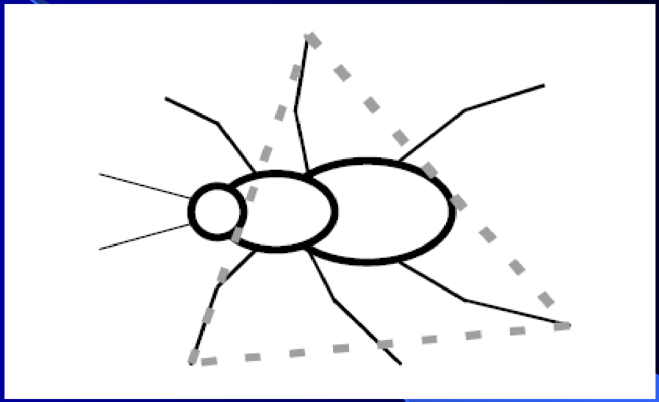


Specific Application Of Micro-Robots

- Micro robots for use in nuclear plants- crawl into small spaces that are otherwise inaccessible.
- Flying robots for use in surveillance and planetary exploration (Mars- NASA).
- Swimming robots- small enough to enter the body for highly localized drug delivery and screening for diseases
- Control of a micro organism as a prototype micro-robot.

Micro Robot- Insect Form

- Mimic the way six legged insects walk
- Leg design has two degrees-of-freedom motion, with three legs arranged in a tripod
- Able to transport objects across their bellies while lying on their backs
- Can transport a piece of plastic film in a single direction



Microrobot Leg Design

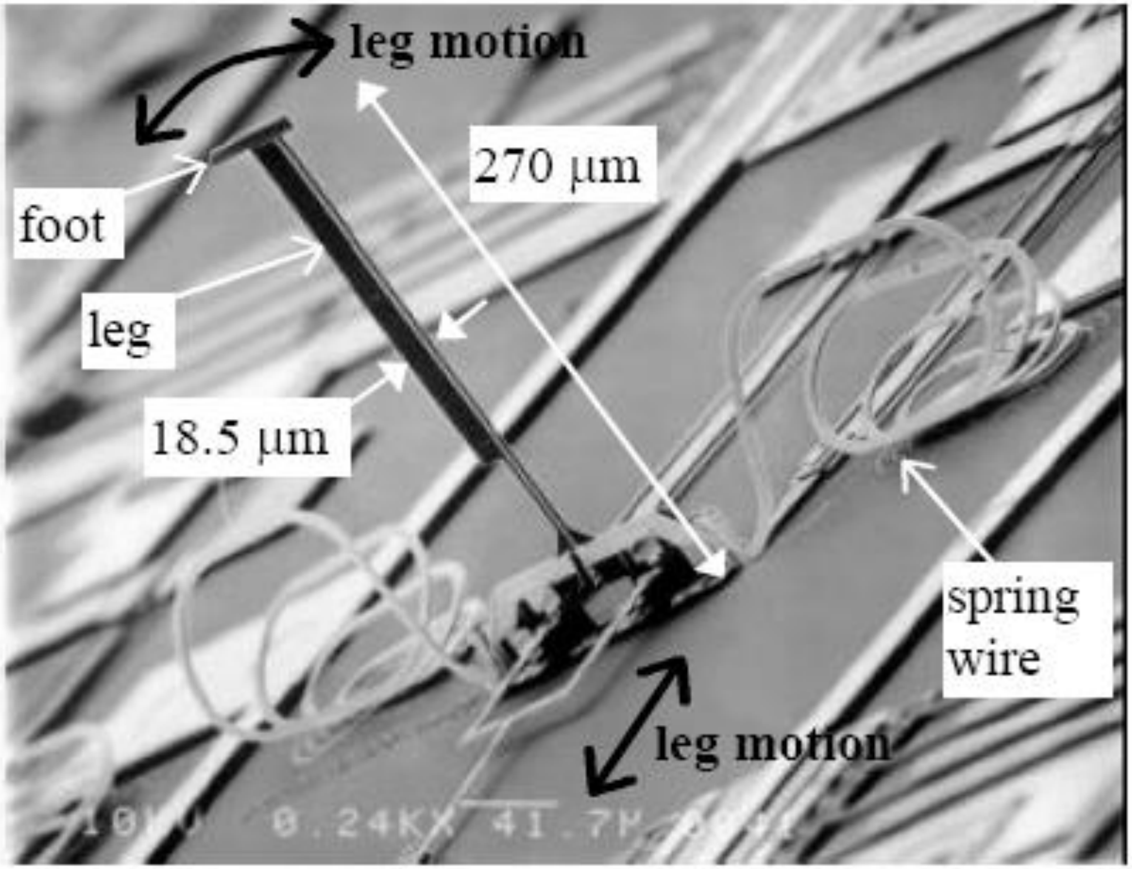
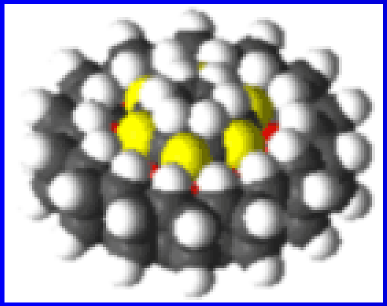
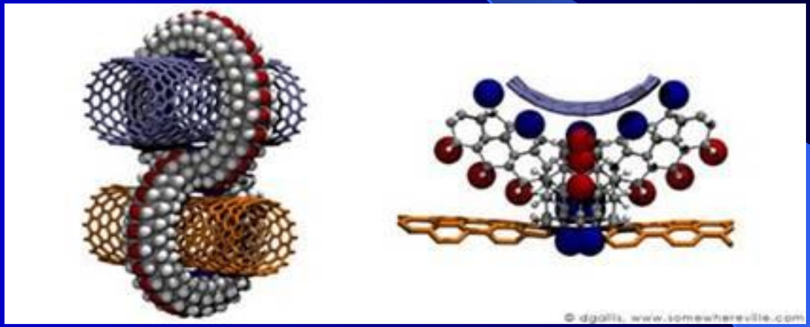
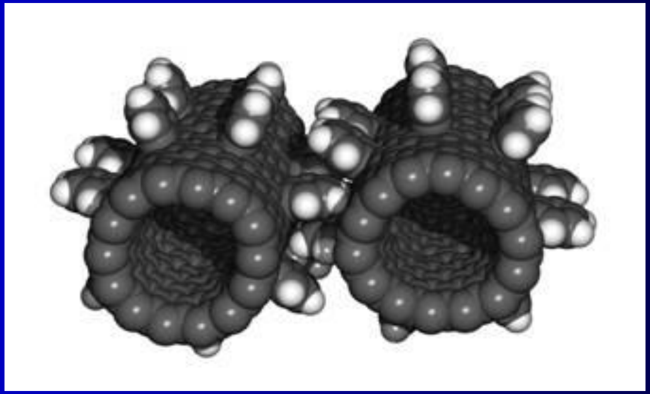


Figure 4: SEM of an assembled microrobot leg with two degrees-of-freedom motion.

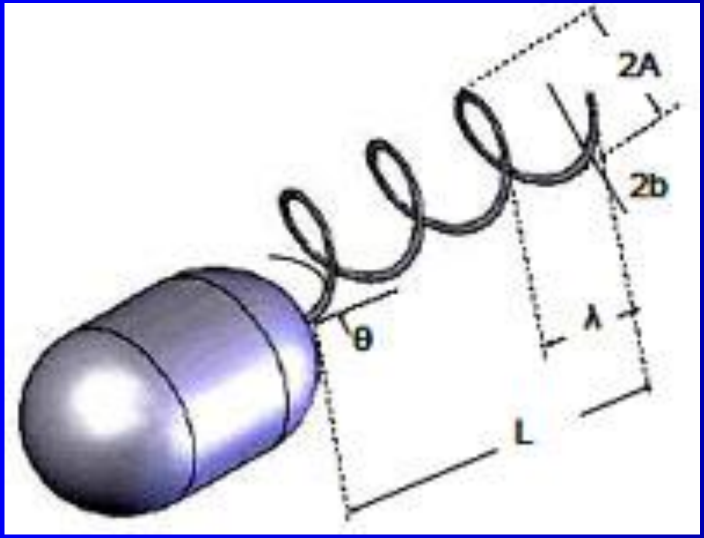
Nano Robots







Swimming robotics bugs



Remember high viscosity at
Small scales makes a corkscrew
Motion of propulsion far more
Effective.

Information Society Technologies

Future and Emerging Technologies

Sixth Framework Programme

NEUROBOTICS

The fusion of NEUROscience and RoBOTICS for augmenting human capabilities

Objectives:

- To investigate new frontiers of knowledge on the human brain, by developing 3 hybrid bionic systems:
  1. “Beyond Tele-operation”: robotic aliases for explorations in hostile environments
  2. “Beyond Ortheses”: a smart exoskeleton for improving accuracy, endurance and strength of human arm and hand movements
  3. “Beyond Prostheses”: a novel highly anthropomorphic arm/hand system, for limb substitution or for adoption of additional limbs

Neuro-Robotics: using robots to investigate the brain

Retina-like
Vision system:
2 cameras

Validating a step-wise learning theory for grasping and manipulation

Five "*primitive learning steps*" related to "*five types of cortical connections*" of the multi-network architecture forming "fi*ve learning modules*"

learning of the sensory effects of motor commands (S1,M1)

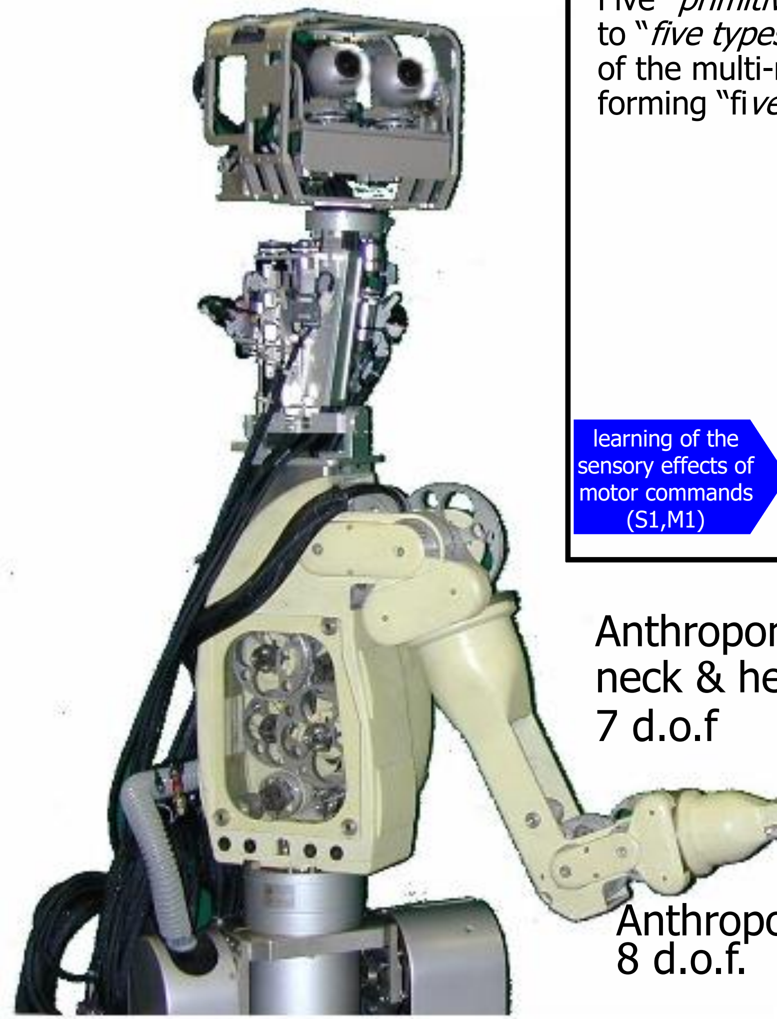
learning of a multimodal representation of hand movement (PP)

learning of goal directed sequences (PT)

learning of reach, grasp and manipulation for simple objects (PMd)

learning of reach and grasp of various objects with subsequent manipulation (PMv)

Age



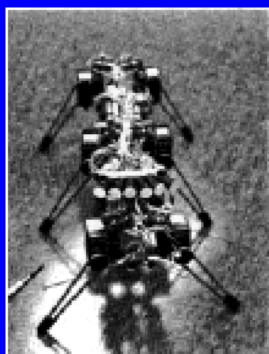
Anthropomorphic
neck & head:
7 d.o.f

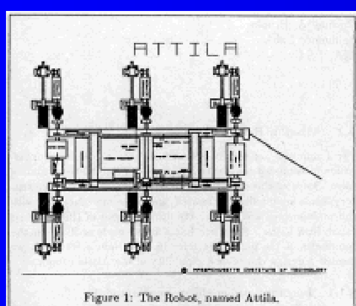
Anthropomorphic robot arm:
8 d.o.f.

Examples: Herbert

- 24 8-bit processors, loosely coupled via slow interfaces.
- 30 IR sensors for obstacle avoidance.
- Manipulator with grasping hand.
- Laser striping system: 3D depth data.
- Wanders office, follows walls.
- Finds table, triggering can finder, which robot centers on.
- Robot stationary: drives arm forward.
- Hand grasps when IR beam broken.

Examples: Genghis & Attila

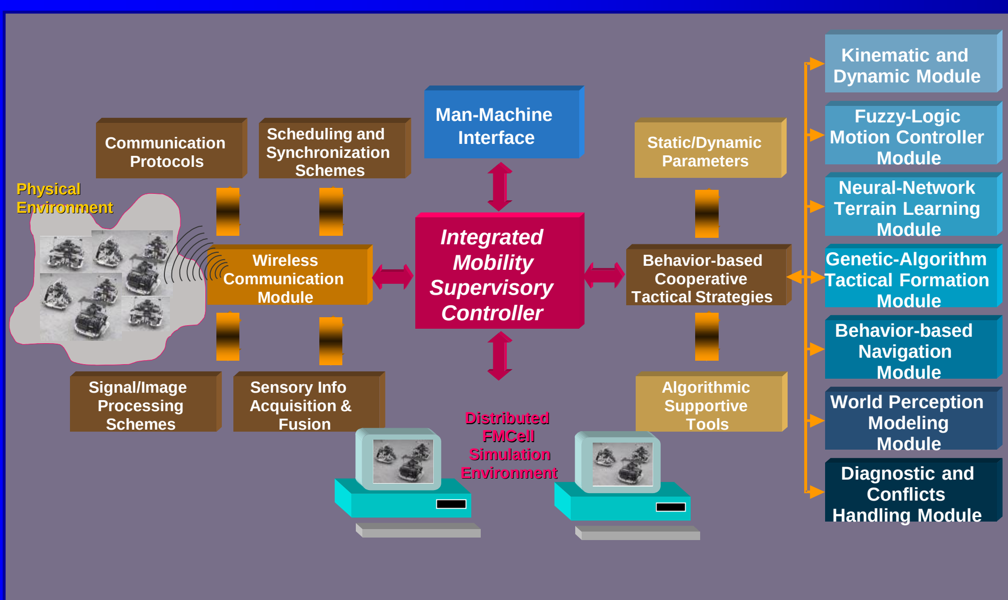


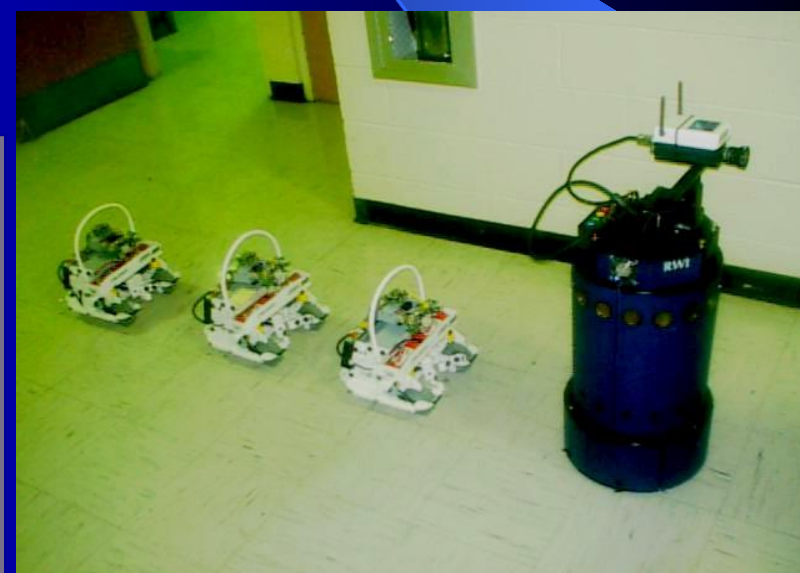


- Walk under subsumption control over varied terrain.
- Each leg “knows” what to do.
- Leg lifting sequence centrally controlled.
- Additional layers suppress original layers when triggered.
- Highest layer suppresses walking until person in field. Then Attacks.
- Attila stronger and faster. Periodic recharging of batteries.

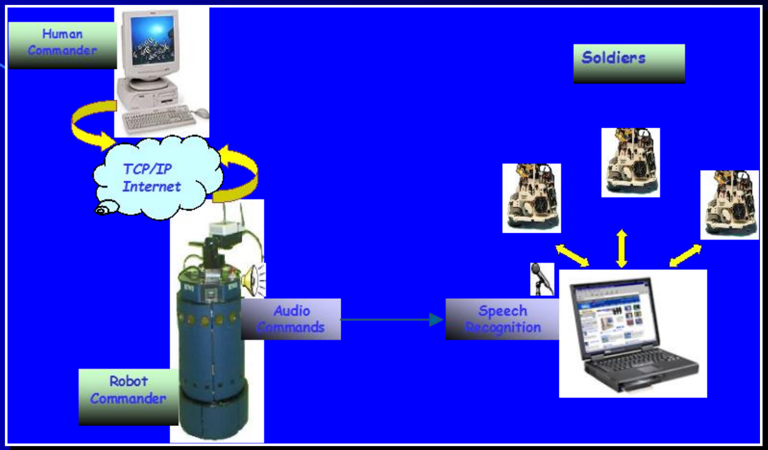
Autonomous Surveillance Perspective

ROBOTIC COMMUNICATION





Combat Terrorism: Chemical Biological Warning Network



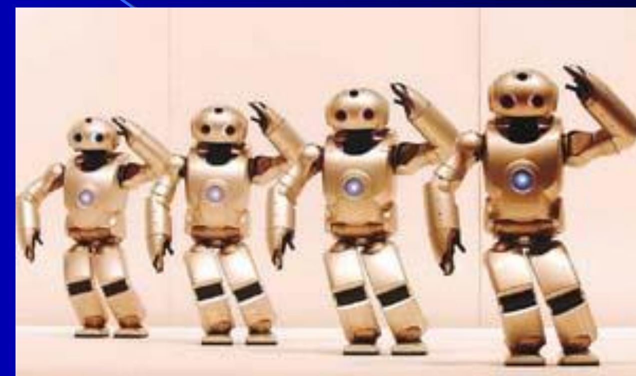
<u>Operational Capability</u>:

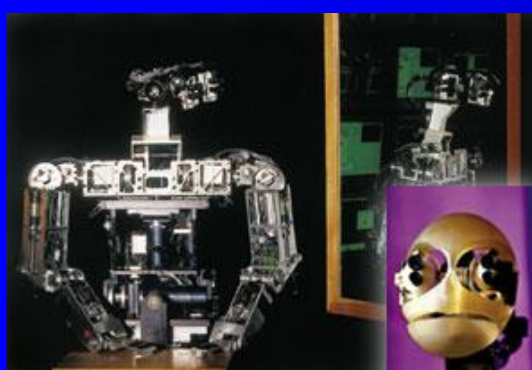
Cooperative robots will collect and transmit the following information in real time via wireless network to the operator and/or the Internet:

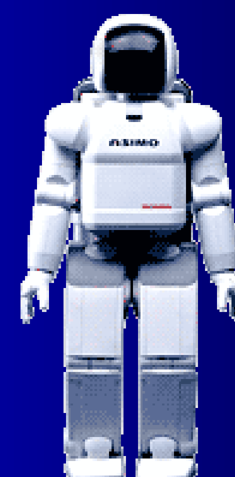
- **Building interior layout/map**
- **Live and still images of casualties and incidents locations**
- **Sensor data, including smoke, chemical/biological sensor, etc.**

Developing humanoid robots

- Objectives
- Robustness
- Embodiment
- Grounding problem
- Decision Making
- Action







Issues more critical in complex robots:

- Issues more critical in complex
- robots:
  - Bodily form
  - Motivation
  - Coherence
  - Self-adaptation
  - Development
  - Historical contingencies
  - Inspiration from the brain

Biorobotics

- Biological Robots

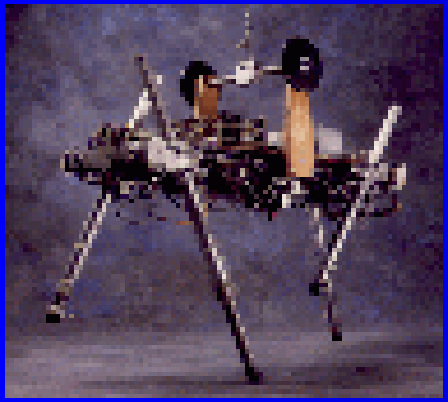
- *“Goal of the newly emerging area of bio-robotics is to seek inspiration from biological systems to build robots with a full range of adaptable behaviors in any given environmental niche“.*

The Robot Alligator

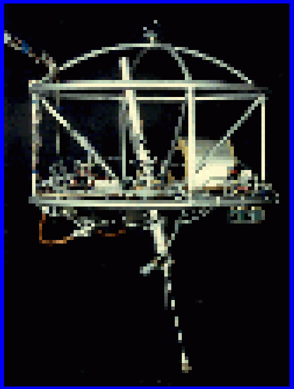
Attributes

- autonomous
- design
- power
- propulsion
- sensors

Robots that fly, walk and hop.



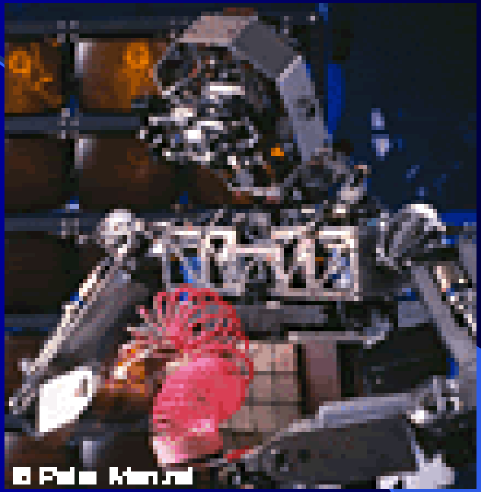
Robots Developed in MIT:



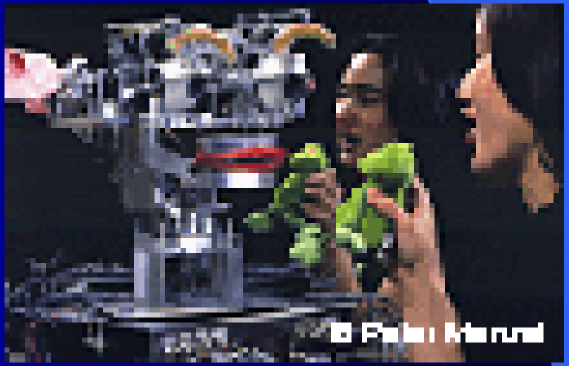
3D hopper, actively
Balanced dynamic
locomotion

Coco

Flamingo; uses
-feet and ankles



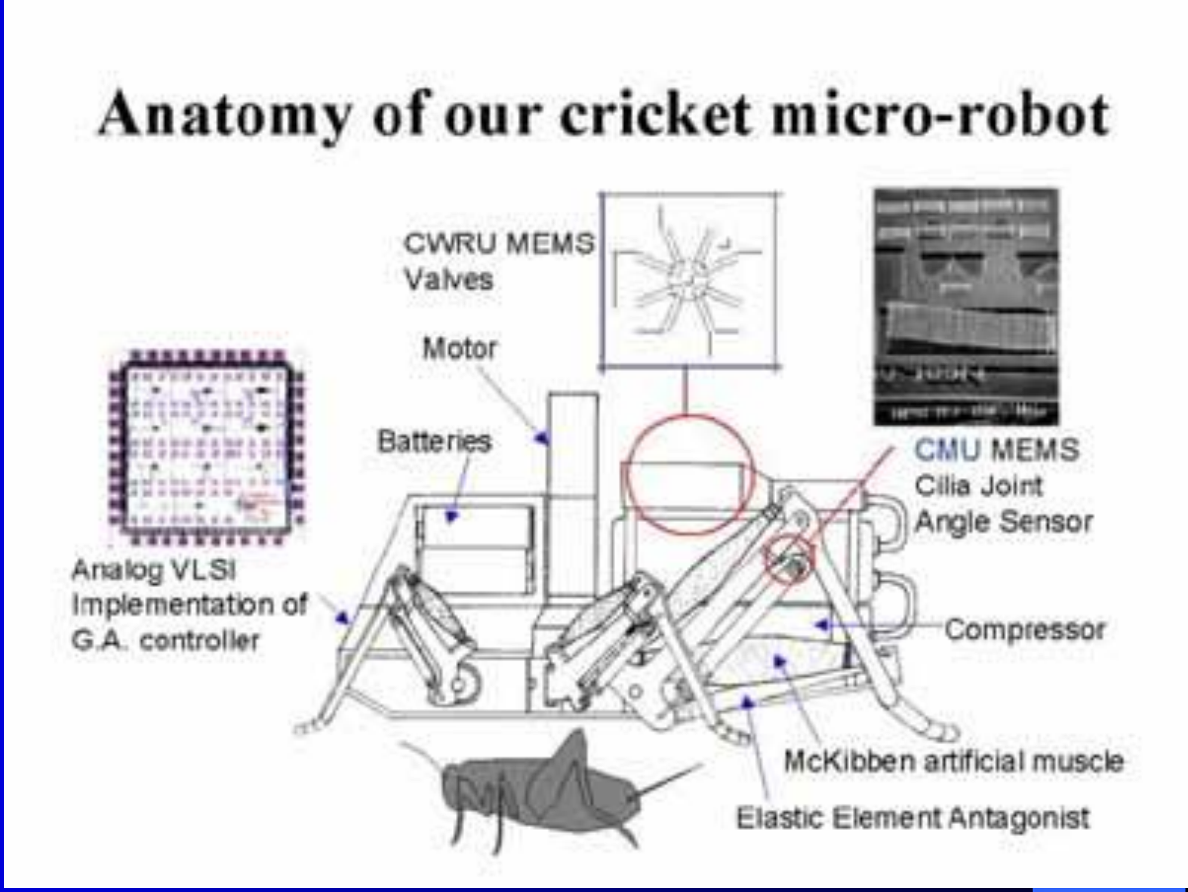
Cog



Kismet

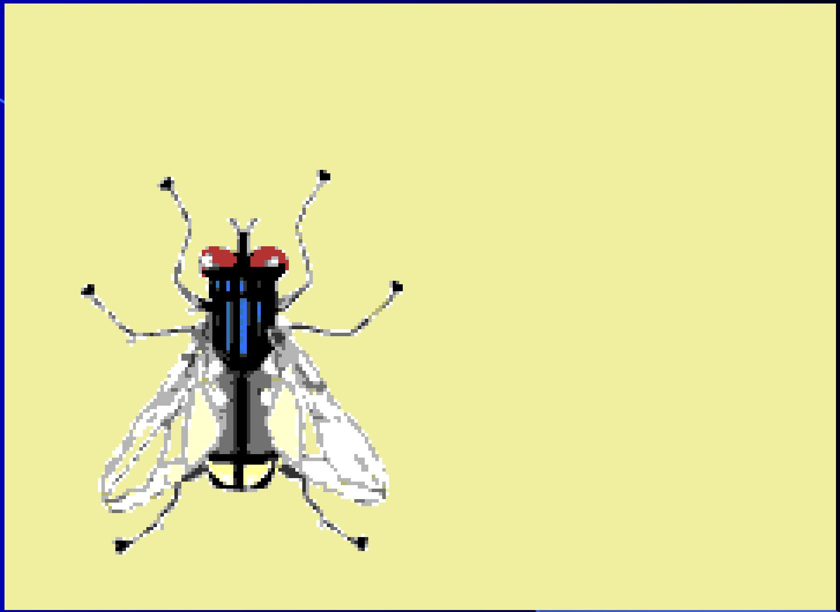
Bug robotics

Micro-Cricket Series of Robots



Plenty more BUGS !!

Millipede

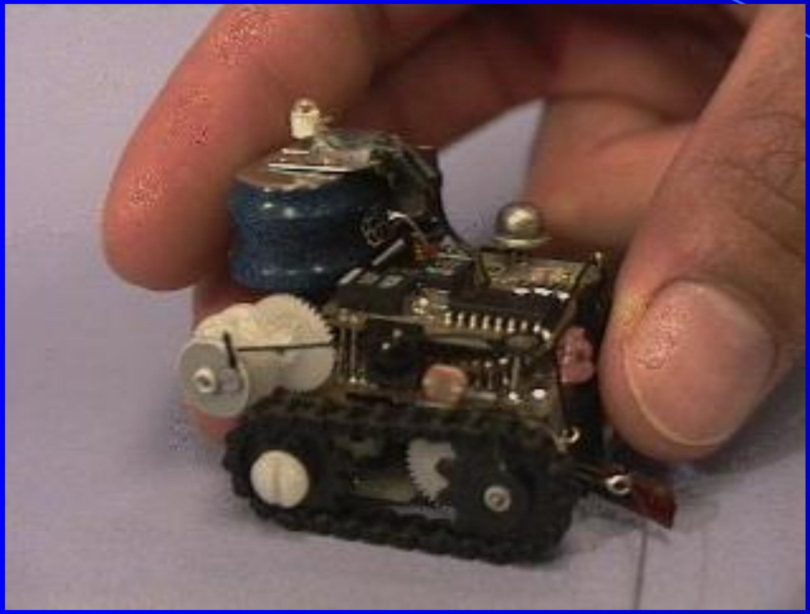


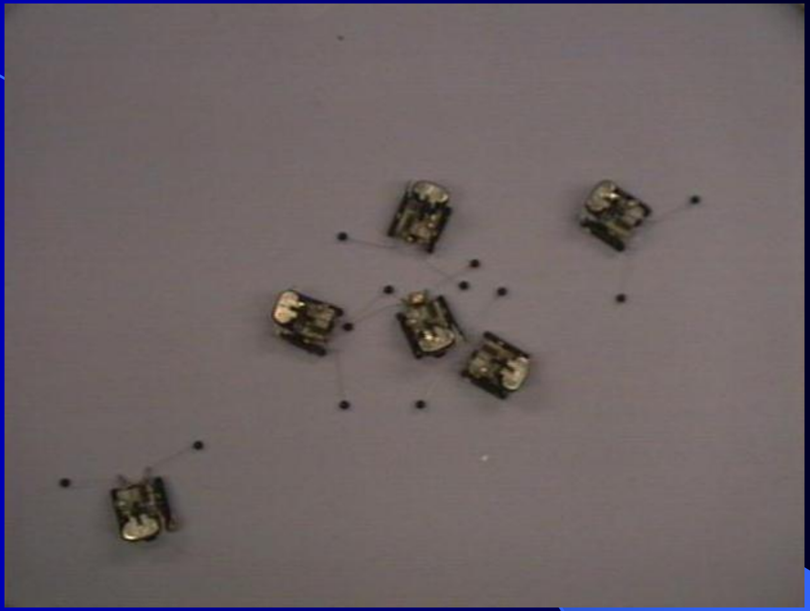
Frog-Robot-1

Frog-Robot-2

and bugs that walk on water!!

Swarm Robots





- **Collective task completion**
- **No need for overly complex algorithms**
- **Adaptable to changing environment**

The Future?

Miniaturization

Telecommunications

Pipe Inspection

Cleaning Ship Hulls

Medical

Self-Assembling Robots

Satellite Maintenance

Engine Maintenance

Job Scheduling

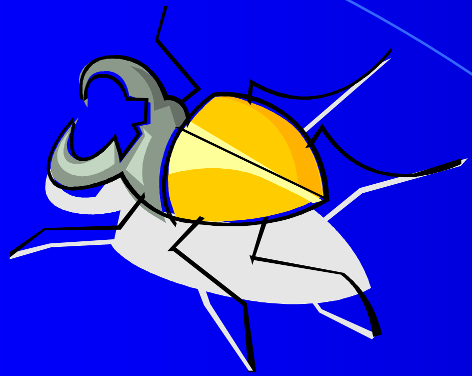
Pest Eradication

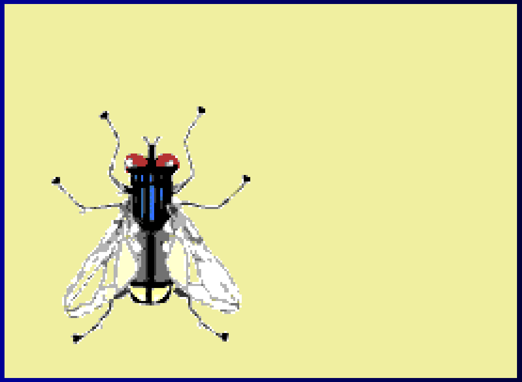
Combinatorial Optimization

Vehicle Routing

Optimal Resource Allocation

THE END





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