

Foundations of Robotics

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Robotics: Iliad (7th-8th century BCE)— Homer

a great epic describing the Trojan war, a world of mythical automata, where men are instead controlled by the Gods.

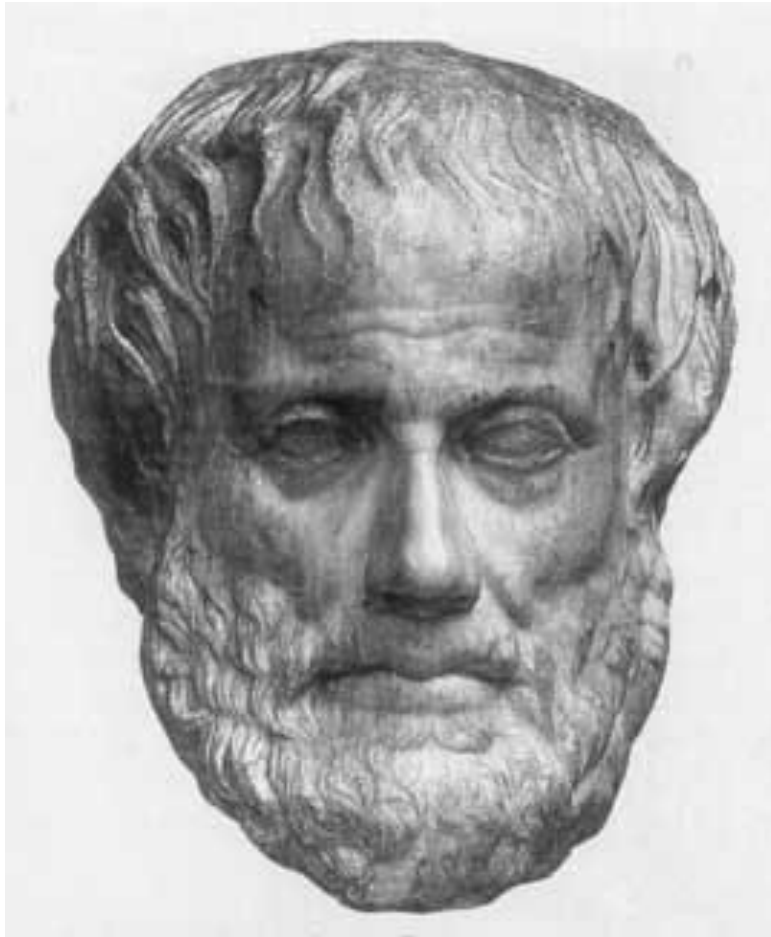
Talos, the bronze giant

Hephaestus, the god of mechanical arts and master of the forge

Daedalus (father of the famous **Icarus**) fashioned a statue of Venus that came to life when quicksilver was poured into it (according to Aristotle).

Plato claimed that these statues had to be prevented from running away.

Aristotle (384-322 BCE) — knowledge



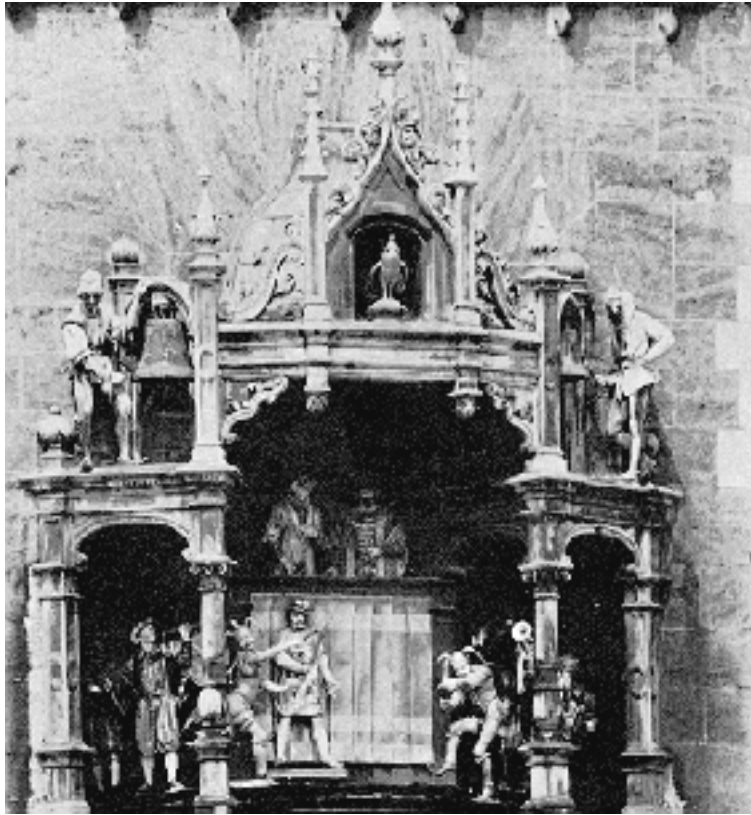
Aristotle conceived of two kinds of knowledge:

- one describing immortal, eternal principles, and
- one grounded in *embodiment*

A form of dualism that Descartes would later pick up again.

European Renaissance Period

1350 Rooster flapping wings and on top of Cathedral in Strasbourg, France



Town Hall, Munich, Germany
Renaissance



1497 Clock Tower in Piazza San
Marco, Venice, Italy

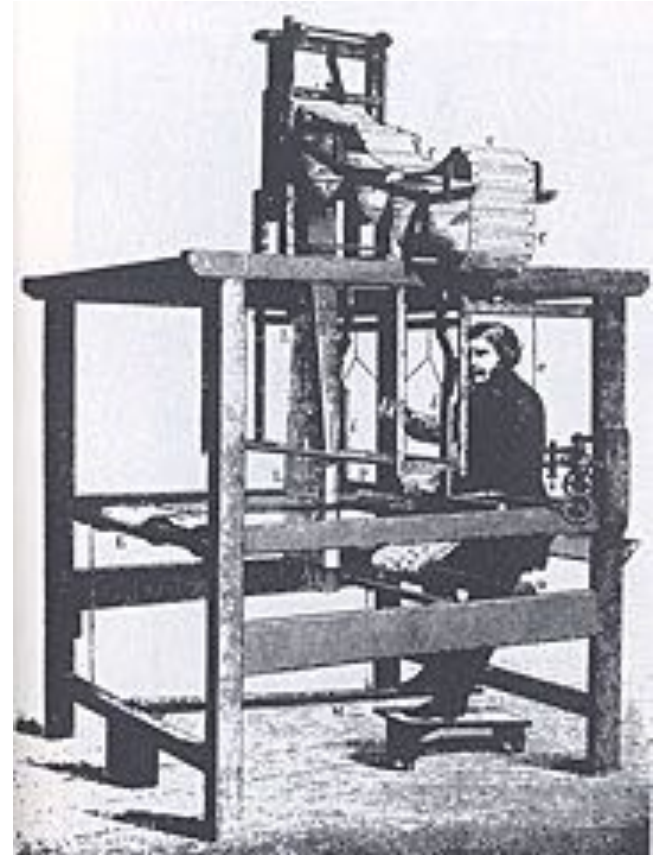


Ned Ludd and the Luddite Movement

King Edward VI of England (1552)
bans automatic sheep shearing
machines in response to peasant
uprisings

His sister, Elizabeth I
outlawed the loom for the same
reason.

**both monarchs worried that
machines like this would
destabilize important social structures**



Descartes (1596 - 1650)

Duality:

humans are machines:

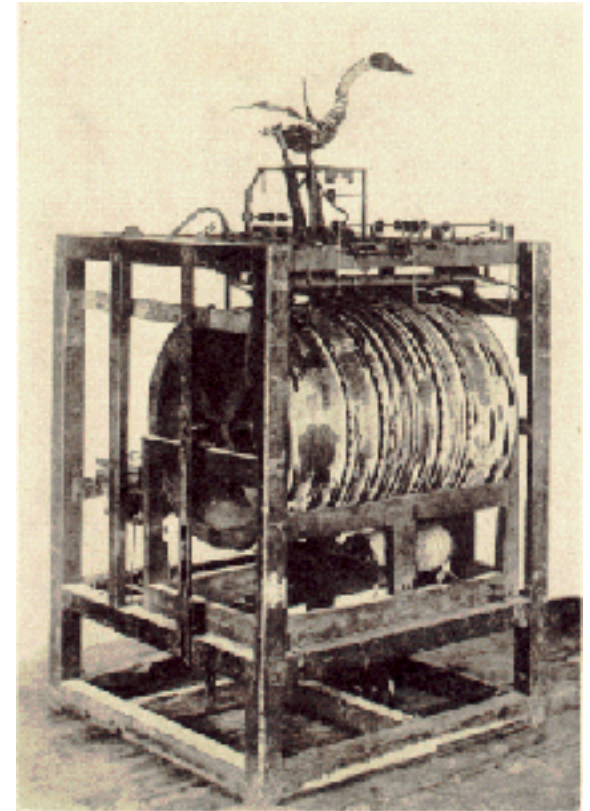
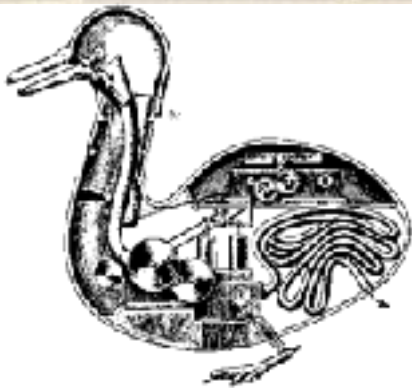
possessing an animal spirit that inhabits space and time to receive stimuli from the environment and produce motor responses.

humans are conscious spirits

consciousness transcends physics

the two spirits intersect in the pineal gland to create the dual nature of the human condition.

Jacques de Vaucanson's Duck (ca. 1738)



... it ate and drank, swallowed, digested, and excreted...it could quack, rise and settle back on its legs, and swallow food with a quick, realistic gulping action in its flexible neck.

“without the shitting duck, there would be nothing to remind us
of the glory of France.”
Voltaire

The Writer of Droz, 1774



Writer



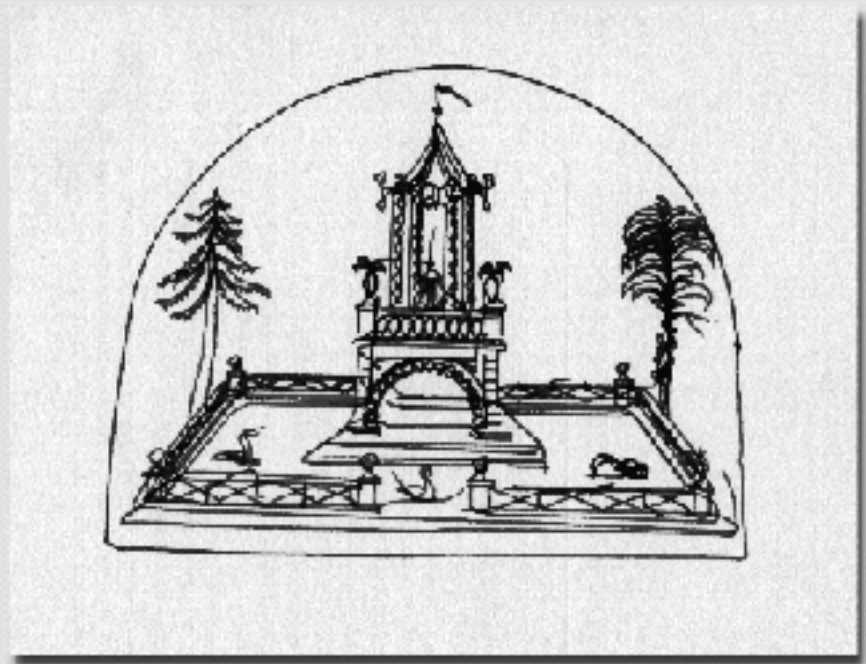
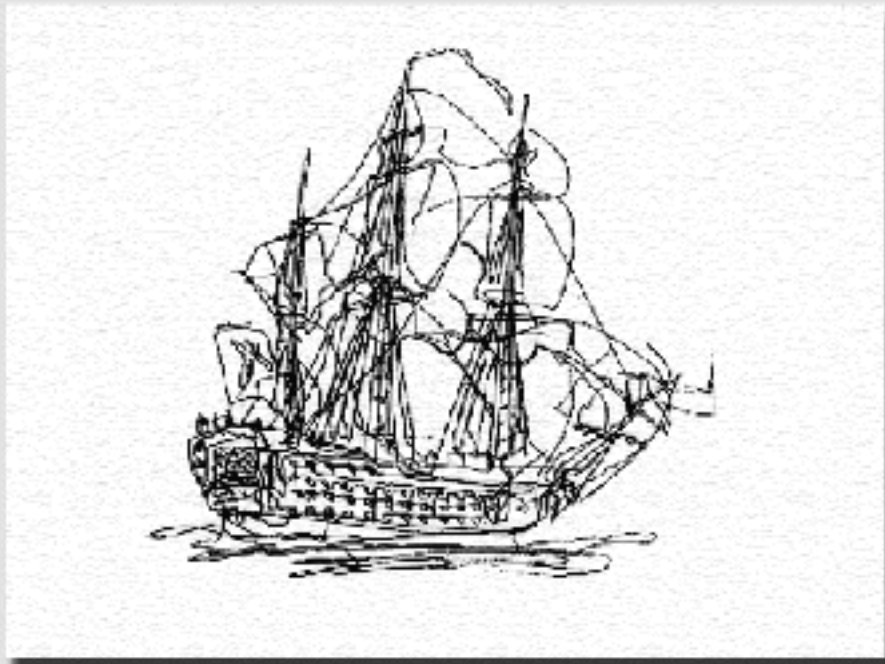
Draughtsman



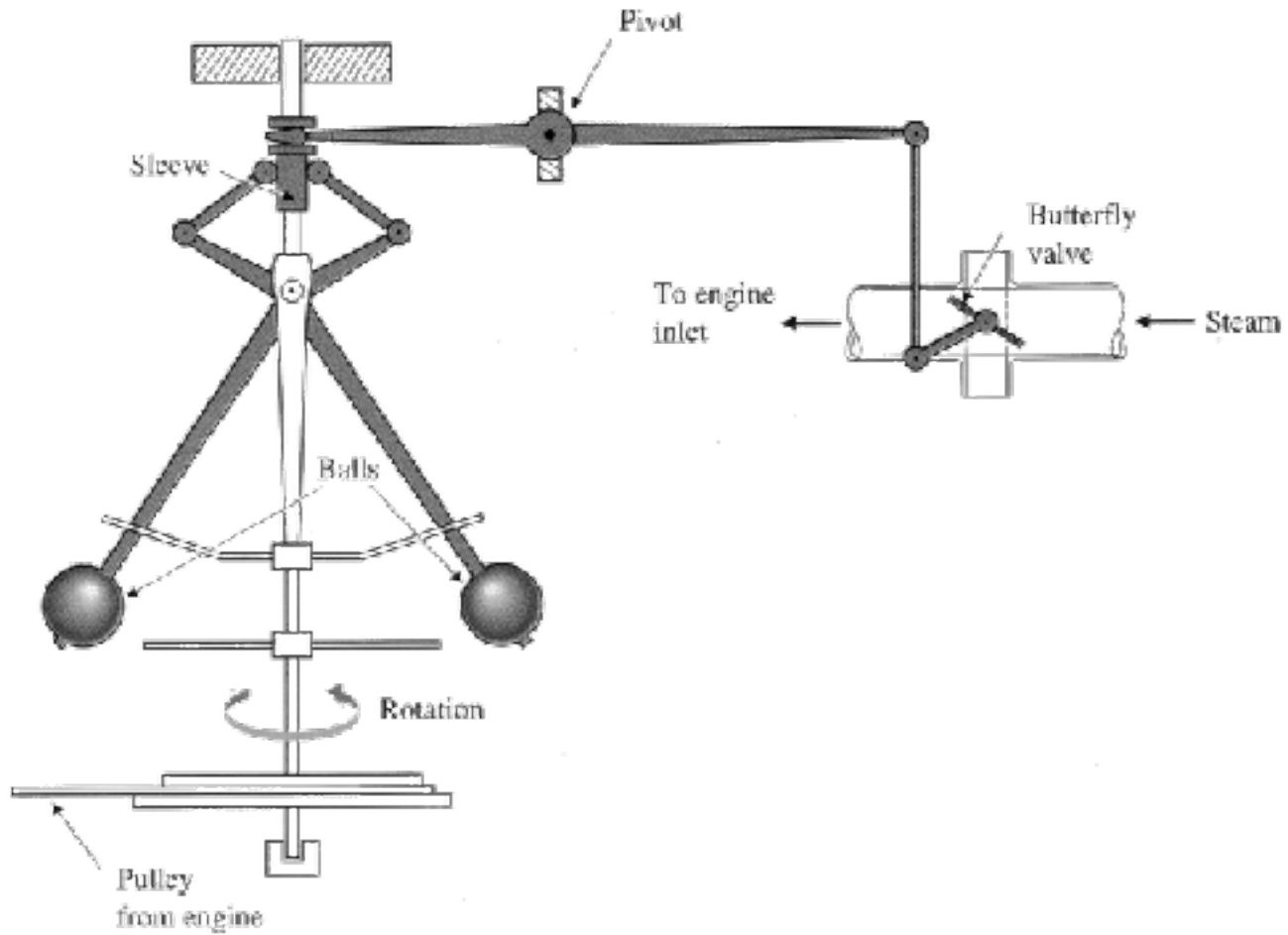
Maillardet, 1805 (Scorsese's 2011 *Hugo*)



Maillardet, 1805



Watt's Governor (1788)



Galvani (1791)

University of Bologna - experimental **bioelectrogenesis**.

electric current causes the contraction of the muscles in the leg of a frog when applied directly to the muscle or at a distance through a nerve.

conceived of **animal electricity** - a fluid secreted by the brain that flows through nerves to activate muscles.

Mary Shelley (1818)

Karel Čapek's R.U.R., 1920

robot - from *robota*, meaning serf labor, drudgery, hard work, servitude



Isaac Asimov: “Runaround,” 1942

0. *A robot may not injure humanity or, through inaction, allow humanity to come to harm.
(added after the initial three laws in Robots and Empire)*

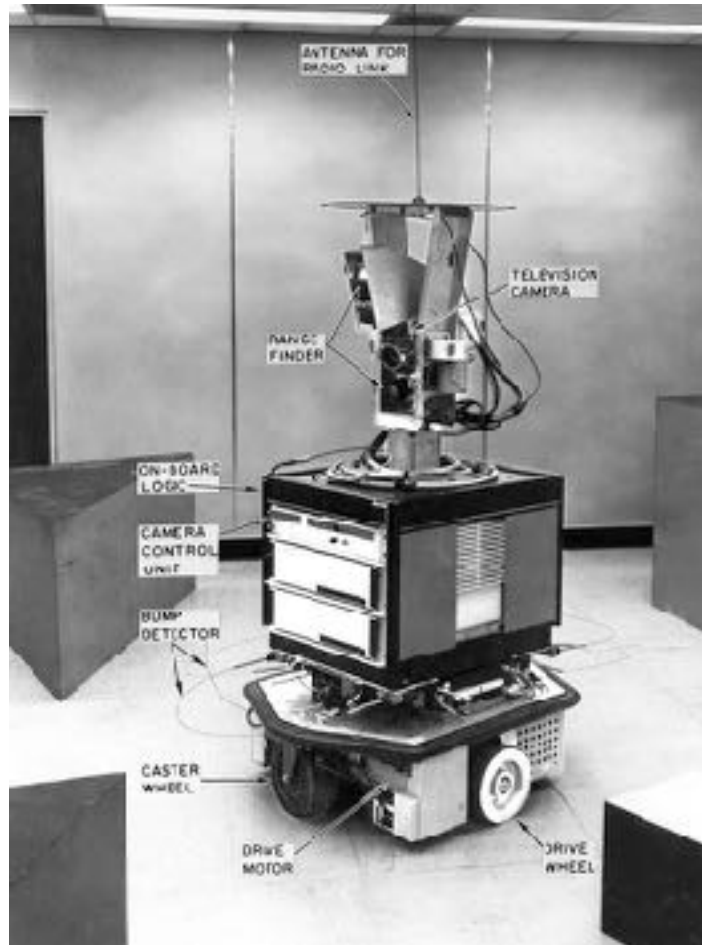
1. A robot may not harm a human being, or, through inaction, allow a human being to come to harm.

2. A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.

3. A robot must protect its own existence, as long as such protection does not conflict with the First or Second Law.



Shakey (SRI, 1968) and Mobie (Stanford,?)



Stanford Scheinman Arm, 1969



Star Wars - 1977

R2-D2 and C-3PO



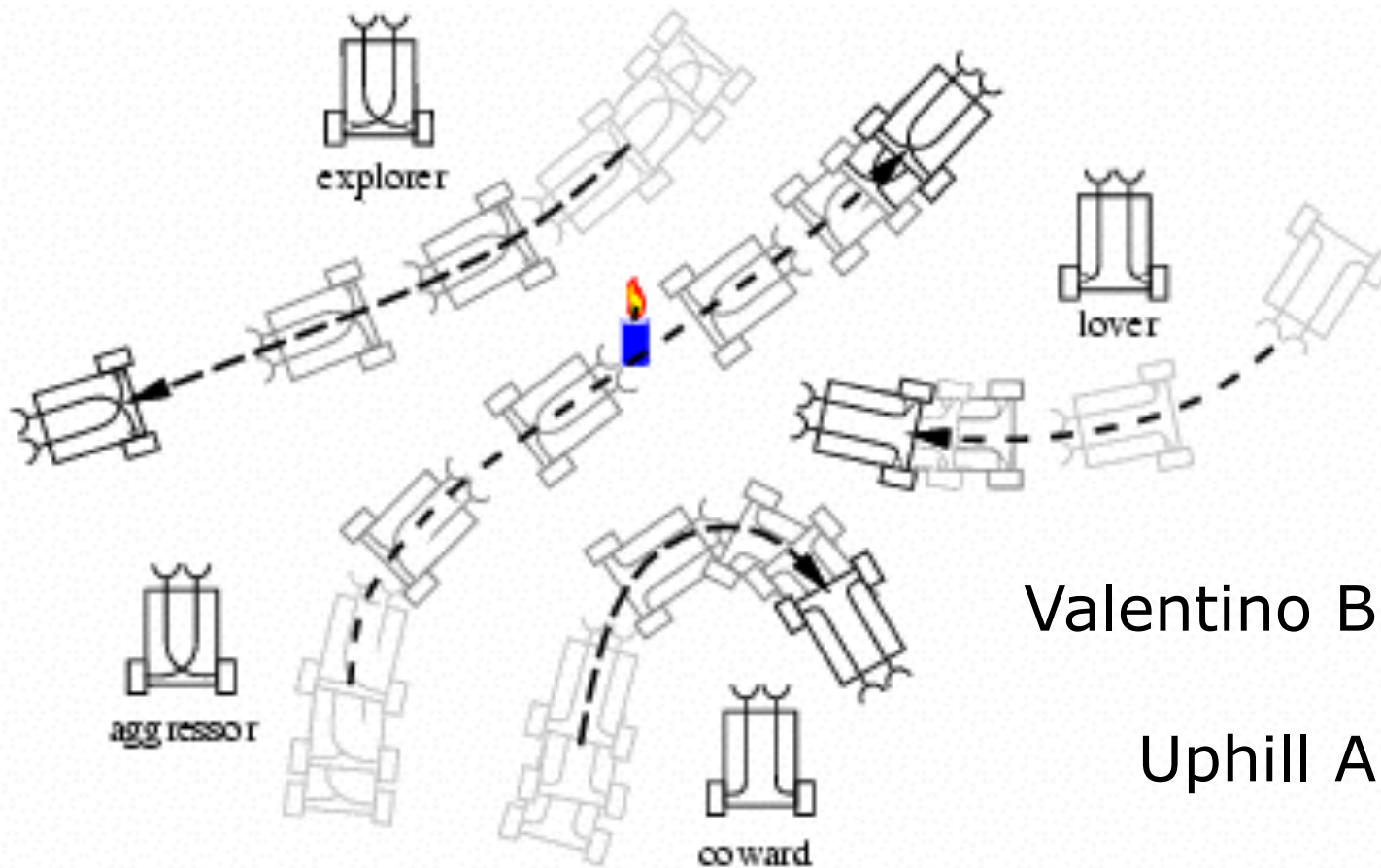
PUMA, 1978



Joseph Engelberger

Unimation's Programmable Universal Machine for Assembly
(PUMA)

Synthetic Psychology - 1984

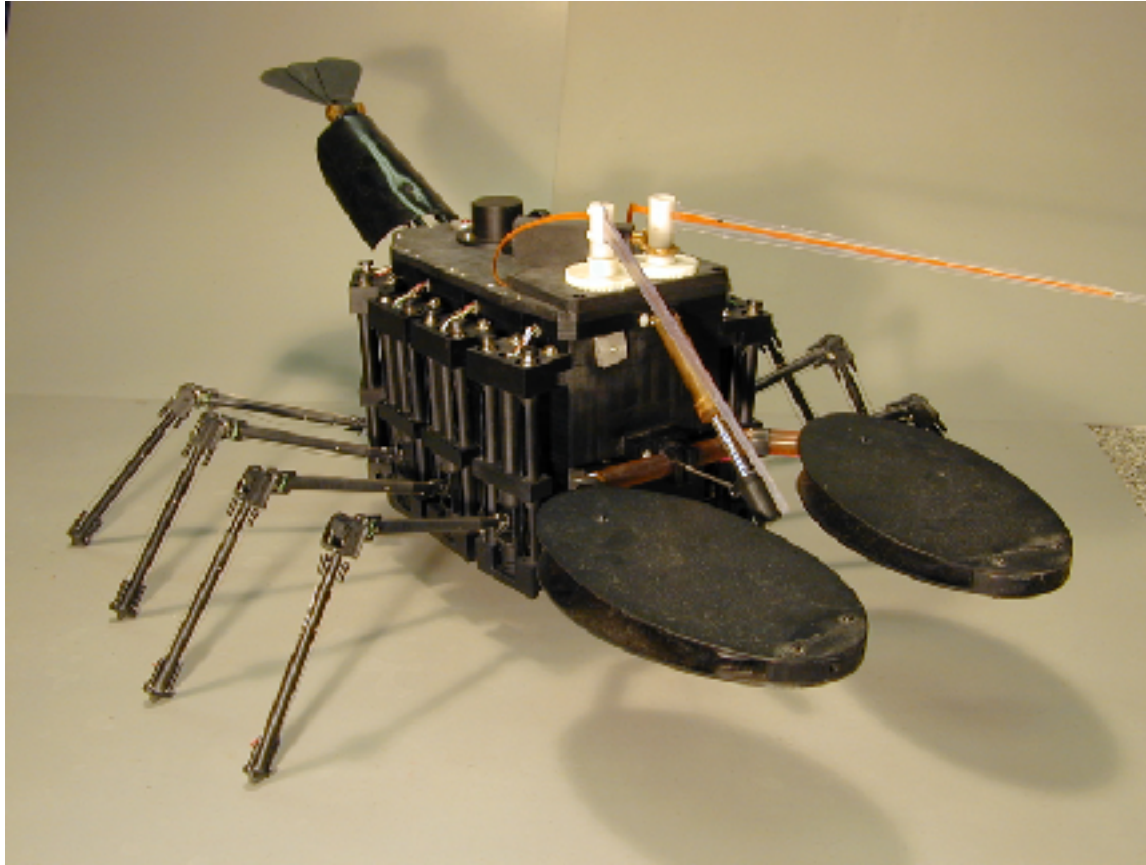


Valentino Braitenberg

Uphill Analysis

Downhill Invention

Biomimetics: Lobster 1992



Joseph Ayers
Northeastern

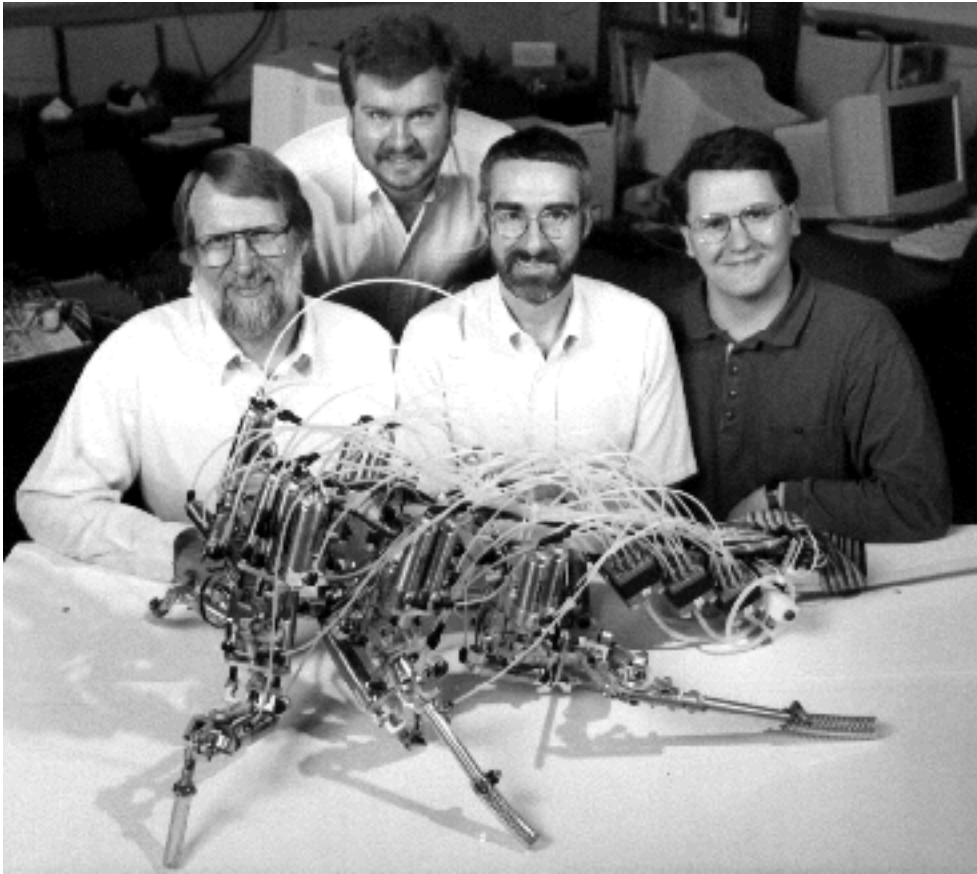
full neural emulation

MIT Leg Lab - 1989-1995

Marc Raibert



Biomimetics Deaths Head Cockroach - 1998



death head cockroach

full gait simulation

full neural simulation

Commercial Toys



1998
Furby
\$30



1999
AIBO
\$2000

Da Vinci Surgical Robot - ca. 2000



\$1.2M

Market Acceptability - Roomba - 2002



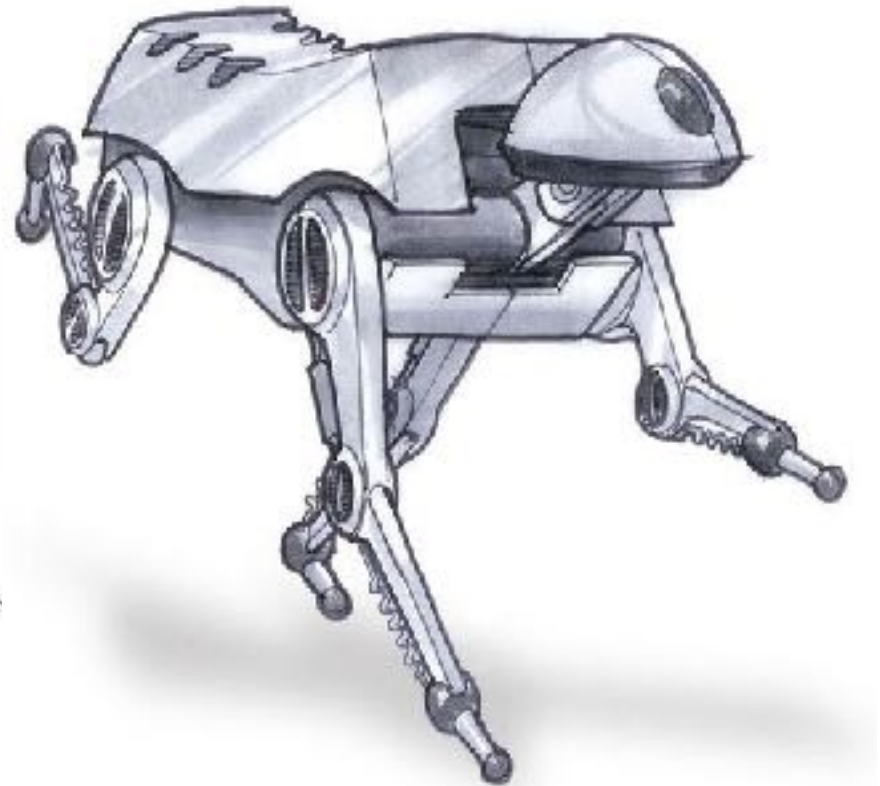
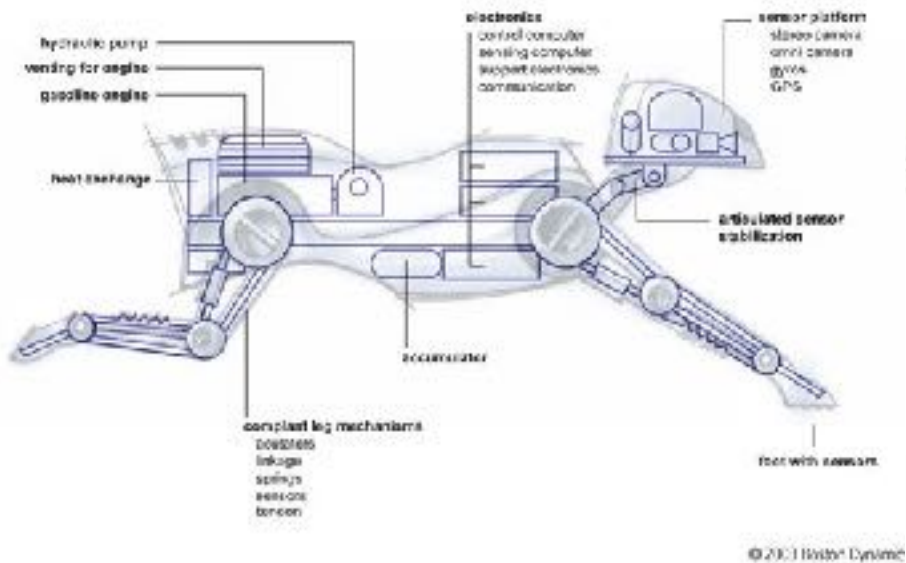
inexpensive, reliable, functional



HONDA Asimo



Biomimetics: BigDog 2008-2012



Boston Dynamics
Marc Raibert

Biomimetics



BigDog 2008-2012

SpotMini 2016-2020



Boston Dynamics - Atlas (2019-present)



...the machines have caught up to the science fiction...
we will use the type of control architecture employed by
Boston Dynamics

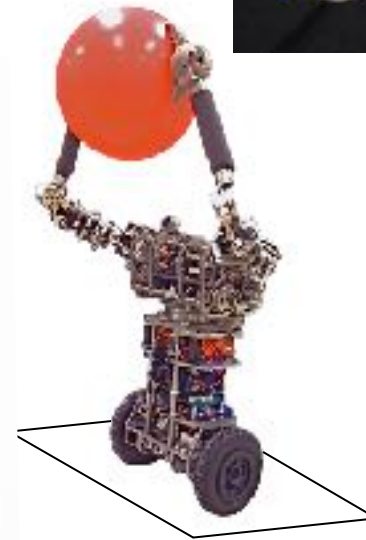
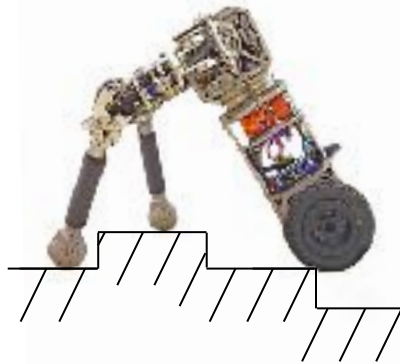
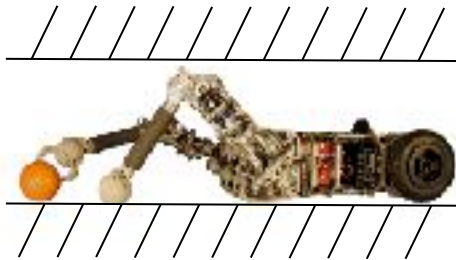
HRP- DARPA Robotics Challenge



...but they have very limited means of acquiring the background control knowledge required to interact autonomously with the world...

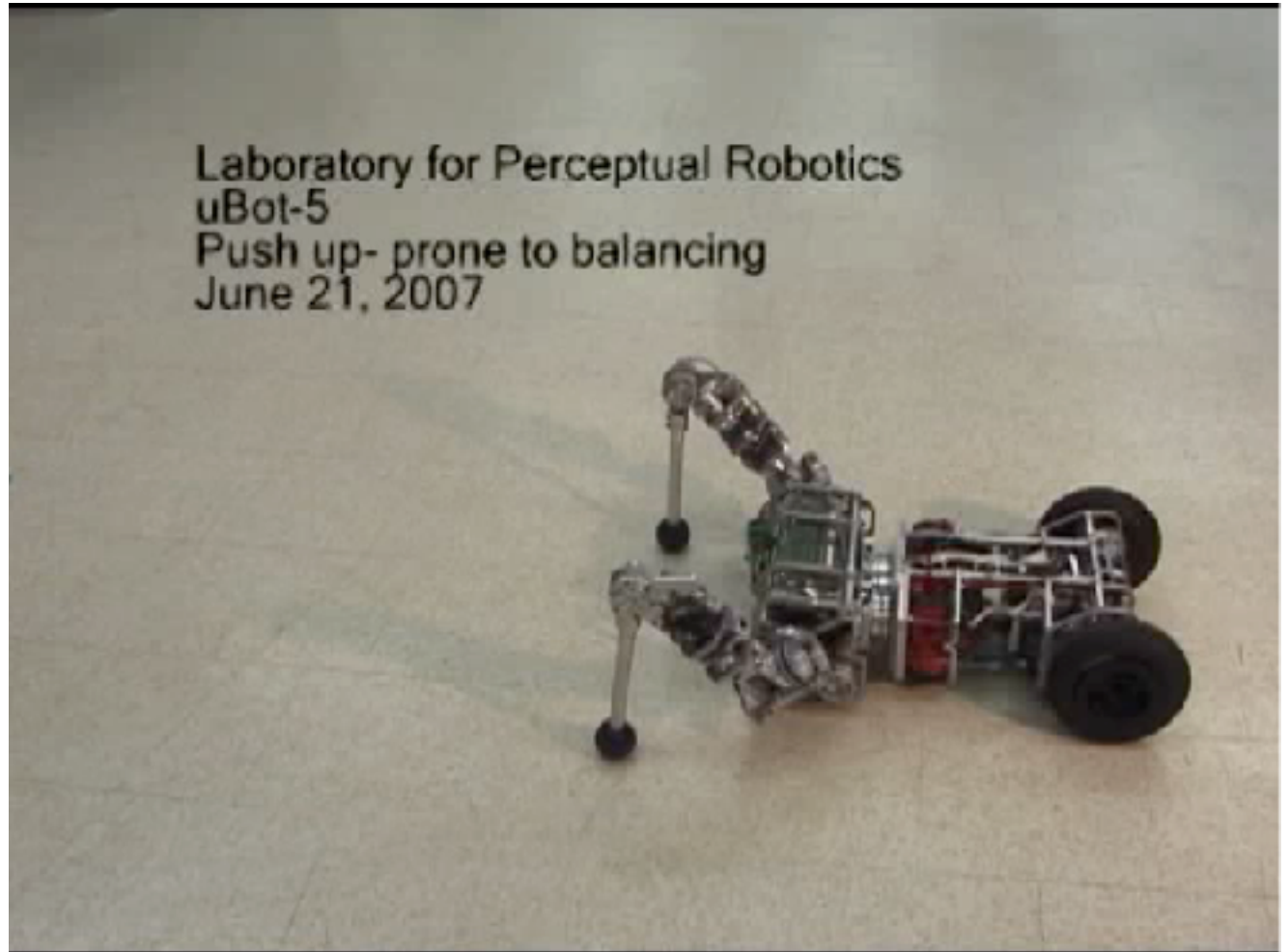
uBot: 2004-present

a mobile manipulator
a spatial Roger



uBot: 2004-2018

UMass
Laboratory
for Perceptual
Robotics



uBot: 2004-2018

UMass
Laboratory
for
Perceptual
Robotics



uBot-5: 2004-present

UMass
Laboratory
for
Perceptual
Robotics

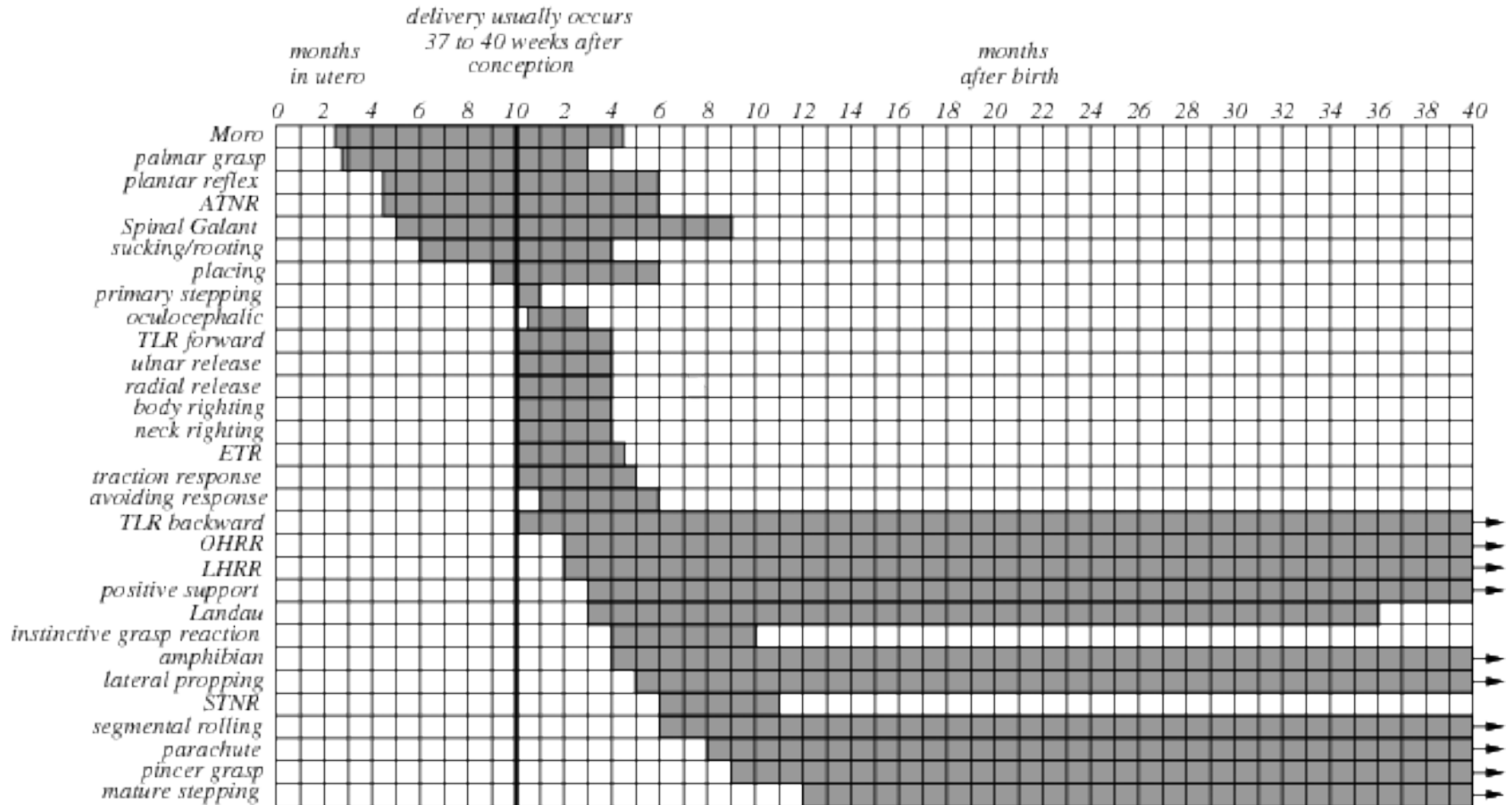


The Organized Infant



Landau Reflex -
“superman” pose, legs reflexively drop down into flexion when the infant’s head is pushed down

Developmental Trajectory



□
 the inspiration for our sequential programming project hierarchy...