

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.

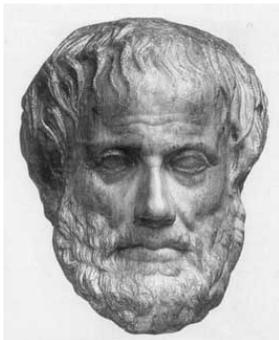
Talos, the bronze giant

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:

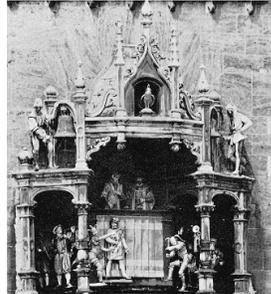
- one describing immortal, eternal principles, and
- one grounded in *embodiment*

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

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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



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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.

destabilizing social structures.



Descartes (1596 - 1650)

Duality:

humans are machines:

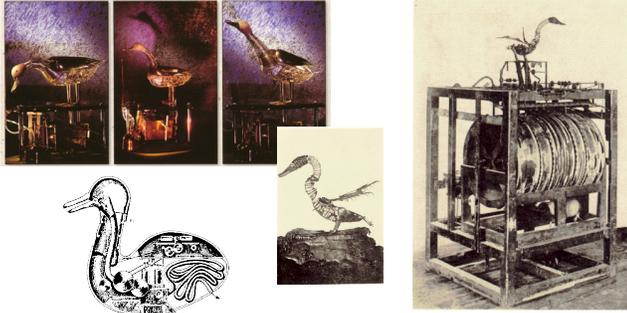
possessing an animal spirit that inhabits space and time to receive stimuli from the environment and produce motor responses.

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 food out of the exhibitor's hand, swallowed it, digested it, and excreted it, all before an audience. It could drink, muddle the water with its beak, quack, rise and settle back on its legs and, spectators were amazed to see, it swallowed 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



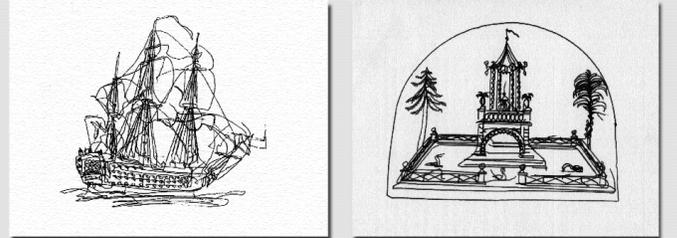
Writer

Draughtsman

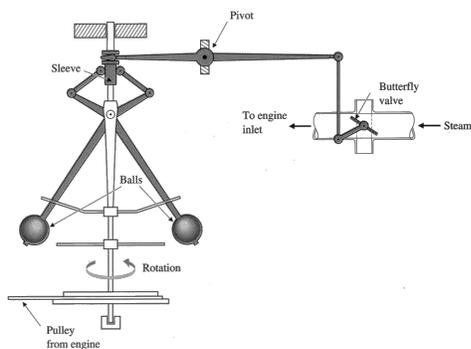
Maillardet, 1805 (Scorsese's 2011 Hugo)



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



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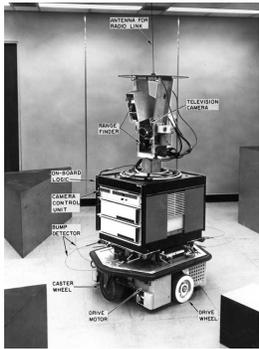
Isaac Asimov: "Runaround," 1942

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



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Star Wars - 1977

R2-D2 and C-3PO



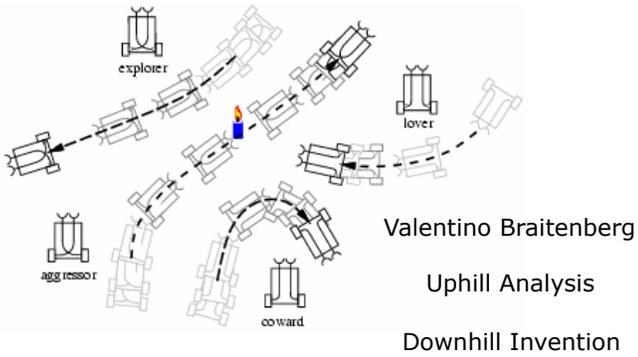
PUMA, 1978



Joseph Engelberger

Unimation's Programmable Universal Machine for Assembly (PUMA)

Synthetic Psychology - 1984



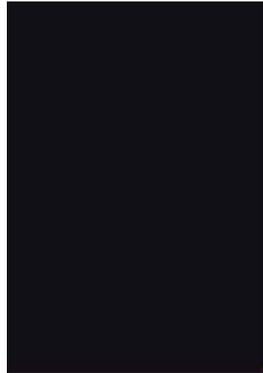
Biomemetics: Lobster 1992



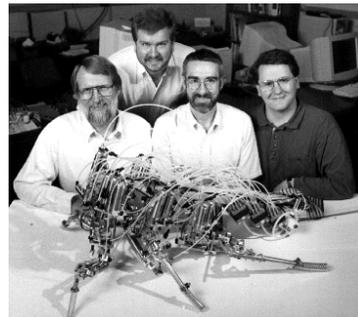
Joseph Ayers
Northeastern
full neural emulation

MIT Leg Lab - 1989-1995

Marc Raibert



Biomemetics 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

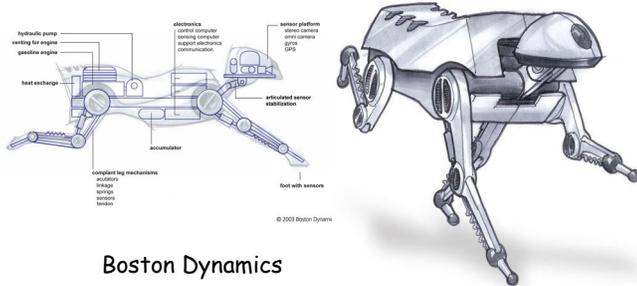


inexpensive, reliable, functional

HONDA Asimo



Biomimetics: BigDog 2008-2012



Boston Dynamics
Marc Raibert

Biomimetics: BigDog 2008-2012

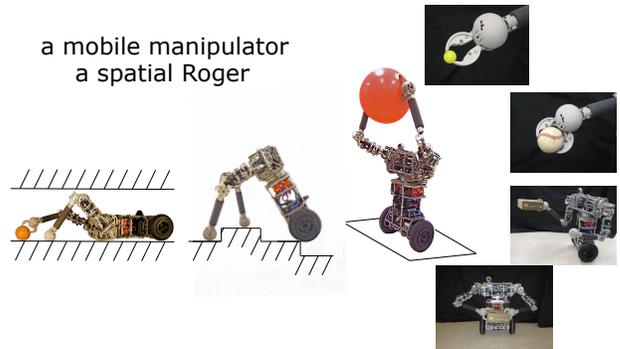


Biomimetics: Atlas 2019



uBot: 2004-2018

a mobile manipulator
a spatial Roger



uBot: 2004-2018

UMass
Laboratory
for Perceptual
Robotics



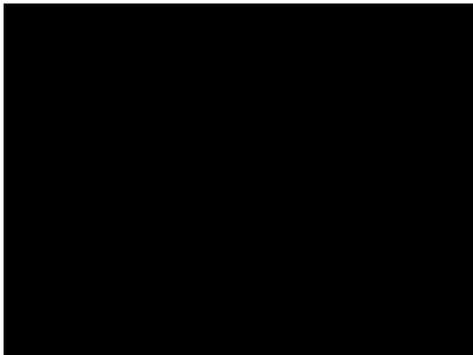
uBot: 2004-2018

UMass
Laboratory
for
Perceptual
Robotics



uBot-5: 2004-present

UMass
Laboratory
for
Perceptual
Robotics

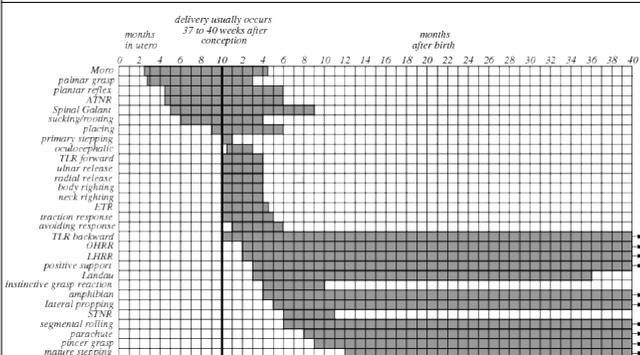


The Organized Infant



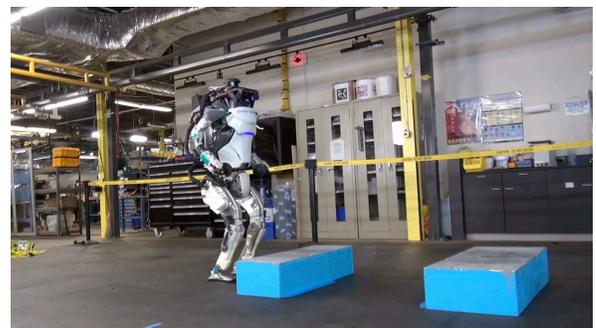
Landau Reflex -
"superman" pose, legs
reflexively drop down
into flexion when the
infant's head is pushed
down

Developmental Trajectory



the inspiration for our sequential
programming project hierarchy...

Boston Dynamics - Atlas



...the machines have caught up to the science fiction...

HRP- DARPA Robotics Challenge



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

this course is about control knowledge

tacit - encoded in *embodiment*

implicit - encoded in *policy*

explicit - codified and communicated