Lecture Notes for

A Geometrical Introduction to Robotics and Manipulation

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CRC Press

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April 28, 2011

Chapter 1 Robotics History

1.1 Robots and Robotics

Definition: Robot

"A *mechanical device* that sometimes resembles a human and is capable of performing a variety of often complex human tasks on command or being programmed in advance."
"A *machine* or *device* that operates automatically or by remote control."

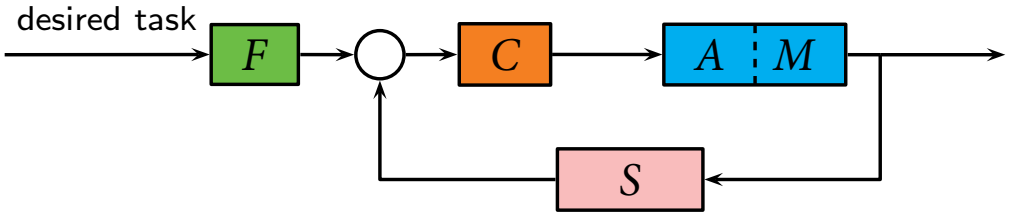
American Heritage Dictionary

Definition: Robotics

Science and technology of robots.

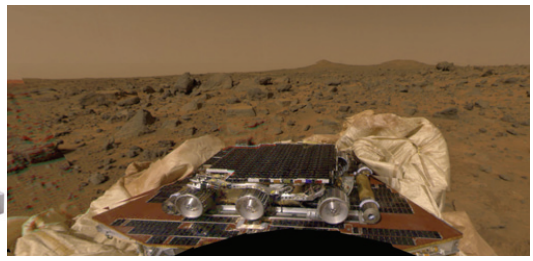
1.1 Robots and Robotics

♢ Function block description:



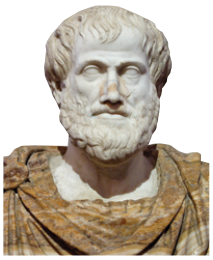
C: Control (Kinematics, dynamics, control)
A: Actuators (Motors, drives, servos, and transmissions)
M: Mechanisms (Synthesis and design)
S: Sensors (Signal processing, estimation, data fusion)
F: Feedforward (Motion planning and generation)

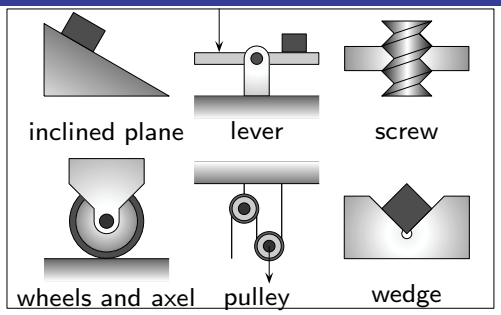




1.2 Ancient History (3000 B.C.-1450 A.D.)

Figure 1.1: Egyptian statues (3000 B.C.)





''If every tool, when ordered, or even of its own accord, could do the work that befits it... then there would be no need either of apprentices for the master workers or of slaves for the lords.''

Figure 1.2: Aristotle (384-322 B.C.): Six basic machine elements and description of a robot

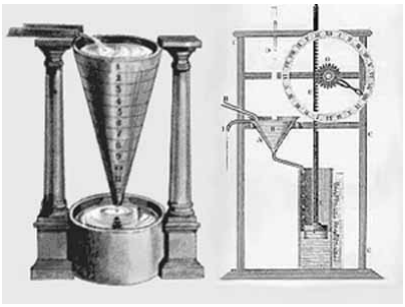


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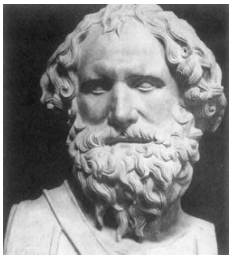
Figure 1.3: Ctesibius (Greek engineer, 270 B.C.): Water clock



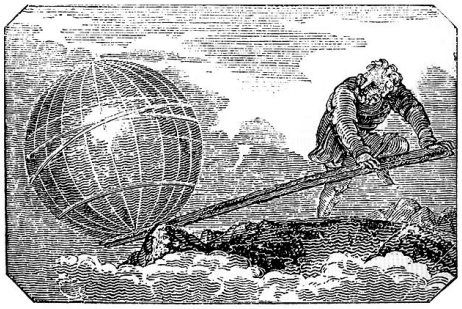


Figure 1.4: Archimedes (287 - 212 B.C.): Using six machine elements for machine design

1.2 Ancient History (3000 B.C.-1450 A.D.)

Play/Pause Stop

Figure 1.5: Heron of Alexandria (85 A.D.): Automatic theater and a steam engine

Play/Pause Stop

Figure 1.6: Zhang Heng (100 A.D.): South-pointing Chariot (non-magnetic differential mechanism)

Play/Pause Stop

Figure 1.7: Al-Jazari (1200 A.D.): Automata and first use of crank

1.3 Early History (1451 A.D.-1960)

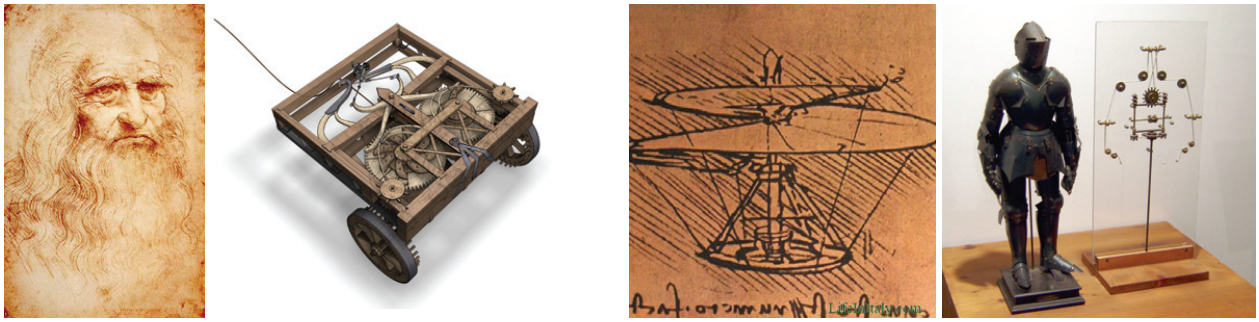


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Figure 1.8: Leonardo da Vinci (1452-1519): Numerous machine designs recorded in Codex Atlanticus, Manuscript B and Codex Madrid (watch the da Vinci movie).

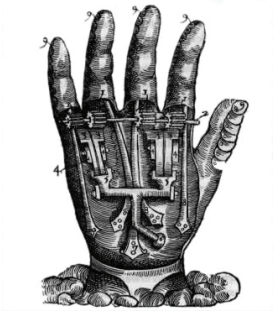


Figure 1.9: P. Ambroise (Paris 1564): Design of a mechanical hand.

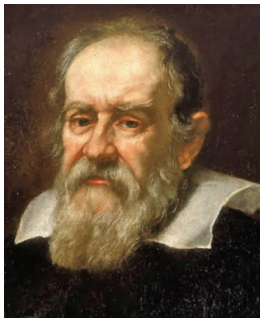
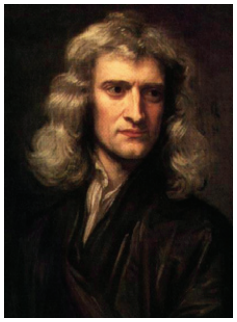


Figure 1.10: Galileo Galilei (1564-1642): Mechanics of motion

1.3 Early History (1451 A.D.-1960)



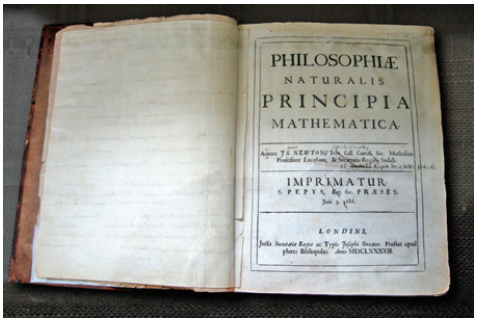


Figure 1.11: Isaac Newton (1642-1727): Calculus and Laws of Motion

Figure 1.12: L. Euler(1707-1783): Rigid dynamics and Euler's equations

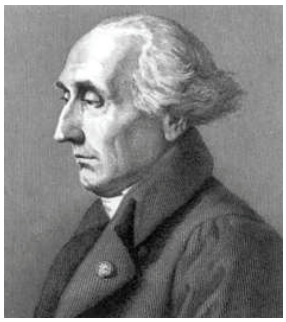


Figure 1.13: J. Lagrange (1736-1813): Calculus of variation and Principles of least action.

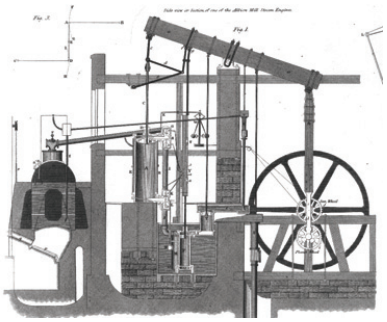


Figure 1.14: J. Watt(1736-1819): Sun and planet gear, centrifugal governor, parallel motion linkage, and double acting engine.

1.3 Early History (1451 A.D.-1960)

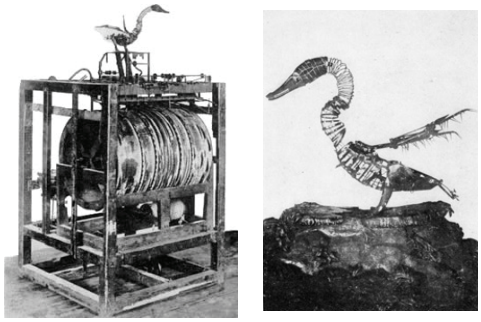


Figure 1.15: J. Vaucanson (French 1738): Automata and the duck.

Figure 1.16: P. Jaquet-Droz (1770): The writer and piano player.

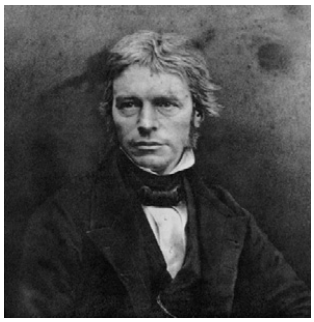
Figure 1.17: A.M. Ampere (1175-1836): Kinematics.

Figure 1.18: J. Jaquard (1801): Automated loom controlled by punched cards.

1.3 Early History (1451 A.D.-1960)

Figure 1.19: F. Kaufmann (1810): Mechanical Trumpeter.

Figure 1.20: G. Boole (1815-1864): Theory of binary logic.



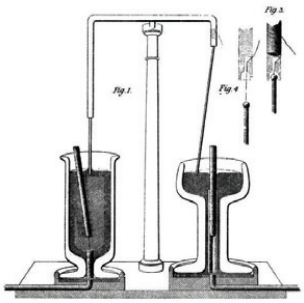


Figure 1.21: M. Farady (1821): electromagnetic rotation and motors.

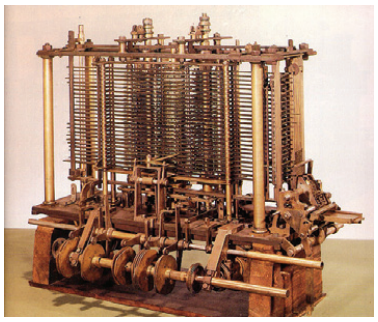
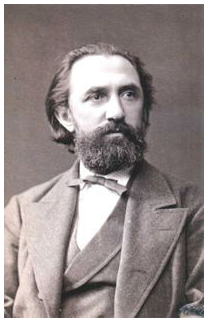


Figure 1.22: C. Babbage (1822): Difference and analytic engines.

1.3 Early History (1451 A.D.-1960)



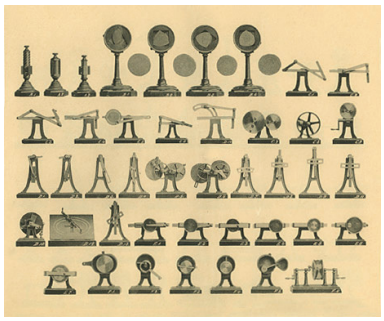


Figure 1.23: F. Reuleaux (1829-1905): Lower pairs and modern kinematics.

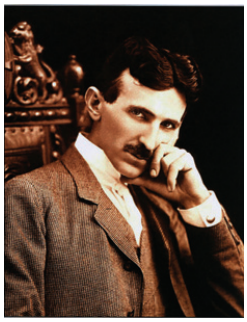


Figure 1.24: Nikola Tesla (1898): Remote controlled robot boat.

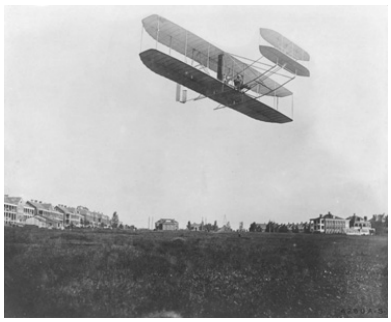


Figure 1.25: O. Wright (1908): First powered flight.

Figure 1.26: Henry Ford (1903): Assembly-line method of automated production.

1.3 Early History (1451 A.D.-1960)

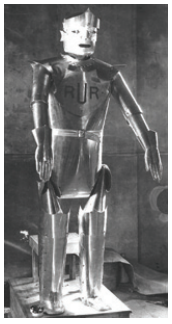


Figure 1.27: Karel Capek (1921): Coined the word "ROBOT" in a play called "RUR" (Rossum's Universal Robots)

Figure 1.28: V. Bush (1927): Analog computer.

Figure 1.29: Nyquist and Bode (1932, 1938): Classic control.

Figure 1.30: A. Turing (1936): Machine Intelligence

1.3 Early History (1451 A.D.-1960)

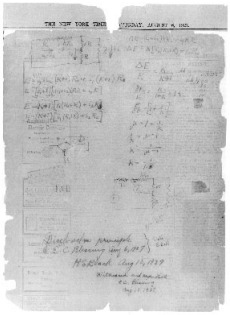


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Figure 1.31: H. black (1898-1983): Negative feedback

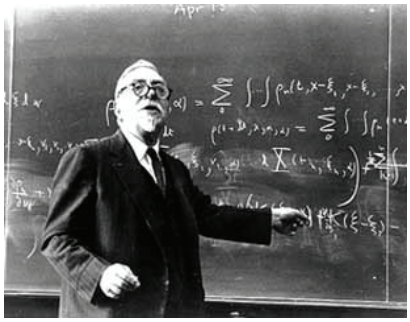

Figure 1.32: N. Wiener (1894-1964): Cybernetics

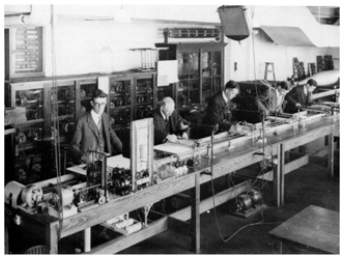

Figure 1.33: Hazen (1934): Theory of servomechanism.

Figure 1.34: R. Kalman (1930-): Modern control and Kalman filter

1.3 Early History (1451 A.D.-1960)

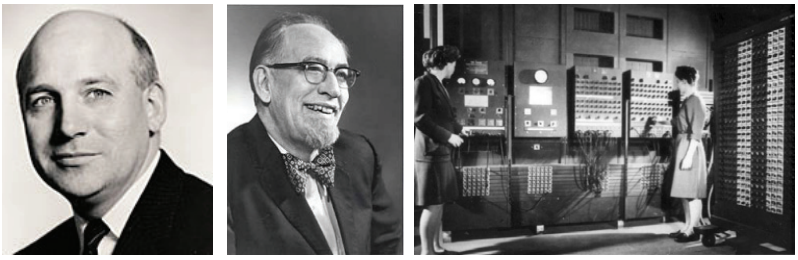

Figure 1.35: J. Eckert and J. Mauchley (1946): developed ENIAC, electronic digital computer

Figure 1.36: J. Von Neumann (1903-1957): Game theory and Von Neumann architecture.

Figure 1.37: Goertz at Argonne & Oakridge National Lab (1948): Telemanipulator.

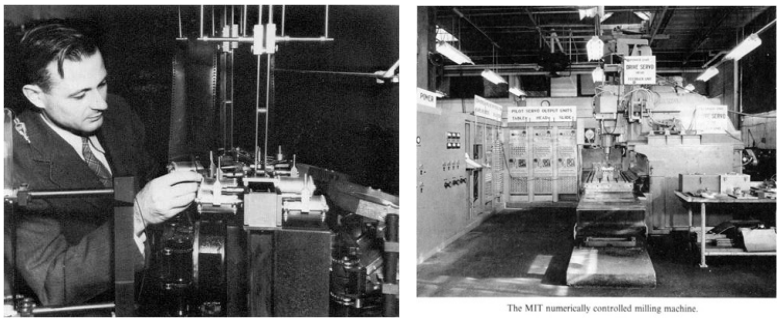

Figure 1.38: G. Brown (1952): First CNC machine and APT

1.3 Early History (1451 A.D.-1960)

"1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey any 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."

Figure 1.39: I. Asimov (1950): Three Laws of a robot

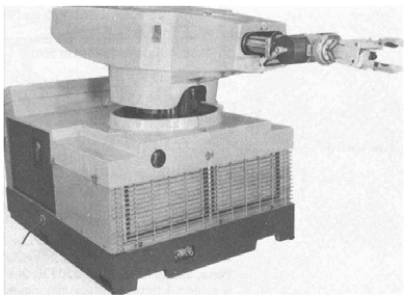

Figure 1.40: George Devol filed first robot patent (1954).

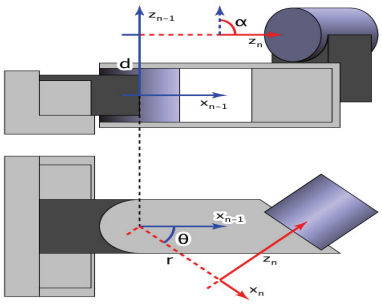

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Figure 1.41: J. Denavit and R.S. Hartenberg (1956): Homogeneous transformations for Lower-pair mechanisms.

Figure 1.42: A. Newell and H. Simon (1956): Expert system

1.3 Early History (1451 A.D.-1960)

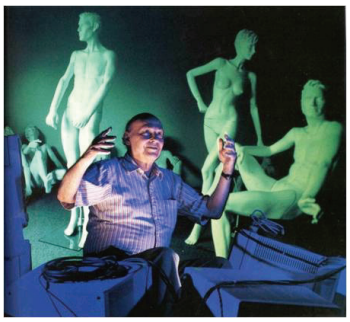

Figure 1.43: Marvin Minsky and John McCarthy (1956): AI lab at MIT

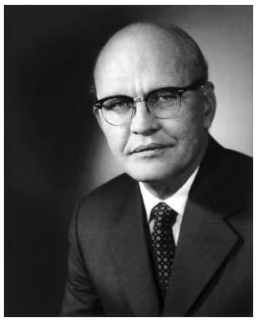

Figure 1.44: J. Kilby and R. Noyce (1958-1959): Integrated circuit

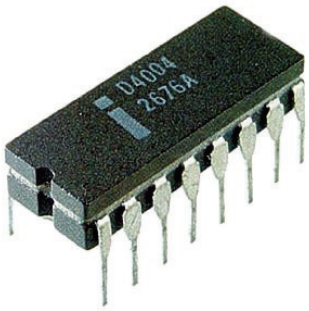

Figure 1.45: F. Faggin, T. Hoff and S. Mazor (1971): First microprocessor