ECSE 6410 Robotics and Automation

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THE ALLURE

Anthropomorphic, mechanical Friday (R2D2 in Star Wars, Data in Star Trek): High in intelligence, strength, but low on emotion, intuition -- slavish interpretation of commands (Hal in 2001 Space Odyssey)

THE REALITY

- Mostly relying on human intelligence (through direct human operation or playback of human specified motion program)
- Application specific (designed for specific tasks)
- Extending human reaches and capabilities, reducing drudgery and danger for human
- Perpetual appeal: humanoid and robotic animal (first mechanically, then in intelligence), e.g., Honda humanoid, Sony Aibo
BRIEF HISTORY


- 1940’s: Teleoperation (master/slave) for radioactive material handling (Ray Goertz) [http://www.centres.com/nuclear/manip/maniphis.htm](http://www.centres.com/nuclear/manip/maniphis.htm)

- 1950’s: Numerically controlled (NC) machines (John Parsons), first programmable articulated robot (George Devol)

- 1960’s: PUMA, vision, artificial Intelligence, industrial robots (auto industry)

- 1970’s: T3, welding, programming language, direct drive robots, mobile robots

- 1980’s: SCARA robot, vision, robot world, multi-finger hand

- 1990’s: Medical robotics, hazardous environment, space robot, miniaturization

- 2000’s: Micro and nano-robots, humanoid, cooperative robots, swarm robots, biologically inspired robots
MOTIVATION

- Utilitarian:
  - Repetitive and mundane tasks
  - Heavy/bulky payload
  - High precision / high speed tasks
  - Hazardous environment (space, underwater, nuclear, toxic waste, high voltage lines, battle field)

- Romanticism
  - Anthropomorphism
  - Challenging tasks: balancing, juggling, hopping, cycling
  - Emulation of other organisms: insects, chimpanzees, bats (individually or in groups)
APPLICATIONS

- Industrial / Manufacturing: material handling, welding, painting, spraying, automatic assembly
- Electronics: material handling, testing, grinding/polishing
- Medical (surgery)
- Service: information/parts carrier, sentry, handicap assistance
- Agriculture / forestry / mining
- Underwater: Titanic salvage (Jason)
- Military: mine sweeping, unmanned ground and air vehicles
- Entertainment: robotic animation
- Hazardous environment: space/planetary exploration, nuclear reactor inspection, toxic waste site inspection and cleanup
TECHNOLOGIES

• Mechanism (gear: backlash, linkage: cable, chain, rod, materials: stiffness, weight)

• Control (sensors: encoders, potentiometers, tachometers, proximity sensors, vision, force/torque, actuators: motors, “smart materials”)

• Computer (centralized vs. distributed, real-time vs. event driven, sensor fusion, computer architecture, network)

• Algorithm (task planning: task decomposition, coordination, path planning: collision avoidance, trajectory generation: acceleration/velocity constraints, trajectory tracking, planning and control under feedback, sensor processing: noise removal, scene analysis, machine learning)

• Human Interaction (teleoperation, share control, human teaching)

• Safety, Reliability, Fault Tolerance
Training

- Kinematics/Dynamics (Fundamental of Robotics ECSE.4490, Robotics and Automation ECSE.6410, Multibody Dynamics MANE.6420)
- Control (Control System Engineering ECSE.4440, Systems Analysis Techniques ECSE.6400)
- Vision (Computer Vision ECSE.6650, CSCI 6270)
- Planning (Mobile Robotics CSCI 6280, Robot Motion Planning CSCI 4290/6290, Robotic Algorithm CSCI 4190)
- Actuators/Sensors (Mechatronics MANE.4250, MANE.4490)
- Graphics (Computer Graphics ECSE.4750)
- Software Engineering (ECSE6770, ECSE.6780)
- Manufacturing (Manufacturing Processes, MANE.4550, MANE 6800, 6810)
What does this course cover?

- Fundamentals in kinematics and dynamics for open and closed chain manipulators and wheel robots.
- Robot control: kinematics based / dynamics based / force control
- Trajectory generation and path planning
What Does the Future Hold?

- Great autonomy, intelligence for remote exploration (ocean, volcano, space)
- Human still in the loop but more in supervisory role through a variety of interfaces (surgery)
- Greater use in service sector, with enhanced safety (rehabilitation, care-giving, entertainment)
- Security and military (surveillance and reconnaissance, search and rescue, de-mining)
- Smaller in scale (microassembly, biological applications)

Further information

Robotics server: [http://www-robotics.cs.umass.edu/robotics.html](http://www-robotics.cs.umass.edu/robotics.html)

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