

CSE 4360 / CSE 5364 - *Autonomous Robots*

Lecture 1

1 Introduction and History

What is a Robot ?

There are many different definitions for what a robot is. Here are the definitions of two important robotics associations:

- The Japanese Industrial Robot Association (JIRA) uses a very broad notion of robot which basically includes all devices which have controllable degrees of freedom. Robots here are divided into 6 classes:

Class 1: Operator controlled robot

Class 2: Fixed sequence robot

Class 3: Variable sequence robot

Class 4: Playback robot

Class 5: Numerical control robot

Class 6: Intelligent robot

- The Robotics Institute of America (RIA) uses a more narrow definition of robots which will only include devices which are at least in class 3 of the Japanese classification:

“A robot is a re-programmable, multi-functional manipulator (or device) designed to move materials, parts, tools, or specialized devices through variable, programmed motion for the performance of a variety of tasks.”

What do we mean by Autonomous ?

There are two definitions for autonomous in the dictionary [Webster 81] which represent two different types of autonomy when applied to robots.

“Weak autonomy”: undertaken without outside control

Robots are autonomous under this weak definition if they operate without any connection to the outside. This includes robots with embedded processing which repeat a fixed, pre-programmed sequence of commands.

“Strong autonomy”: having the power of self-government

Strong autonomy requires that the robot is able to make decisions based on its own sensor input and thus react flexibly to the environment.

For autonomous robots we will be mainly interested in the latter, more challenging type of autonomy.

A Brief History of Robotics

In its wider definition, the history of robotics dates back to the ancient greeks and egyptians.

Mechanical Automata

B.C. Greeks and Egyptians build mechanical automata driven by water power or hydraulics. These are mainly used as ornamentation at official ceremonies.

14th century Mechanical automata driven by clockwork mechanisms are designed in Europa and Arabia. Their use is mainly for ornamentation and entertainment.

18th & 19th century More complicated mechanisms are designed and the first “programmable”, clockwork-driven automata are built.

- 1738 Vaucanson builds a mechanical duck which can quak, dring water, and eat food.
- 1774 Droz designs an automatic scribe which can write a message with up to 40 characters.
- 1805 Maillordet builds a mechanical painter which can draw a picture or write in french or english.
- 1876 A large number of entertainment automata are presented at the world fair (e.g. musical and card playing automata).

Robots

1921 The word ‘robot’ is used for the first time by Czech playwright Karel Capek in his play “R.U.R.” (Rossum’s Universal Robots) in which artificially created servants revolt against their human masters.

The Czech word “robota” means “forced laborer”

1928 The first automaton with electrical motors is built in London.

1961 The first industrial robot is built at Unimation by George Devol and Joe Engelberger and used at a General Motors plant.

1967 The mobil robot “Shakey” demonstrates autonomous, sensor-driven operation. However, its performance is still very unreliable.

Trends in Modern Robotics

- More and more sophisticated and complex robot manipulators have been built. While many designs are anthropomorphic (including robotic hands) the construction of reliable sensors and the integration of sensor information into standard control approaches proves to be very difficult.
- To investigate the basic requirements for “intelligence” a number of researchers decide not to look at human performance but at the more primitive animal species. This leads to the design of reactive insect type robots.
- In recent years a number of companies and research institutions have developed new, very complex mechanisms (including humanoids and pet robots) with the goal of building autonomous robots which can operate in the real world and interact with humans.

2 Important Aspects of Autonomous Robots

To be able to develop and control autonomous robot systems it is important to address many different aspects of the robot.

- The robot mechanism

Kinematics: Description of the configuration of the robot

Dynamics: Understanding of the robot's behavior

- Actuator control

Dynamics: Basic understanding of the dynamics

Control: Stable execution of commanded motions

- Motion generation

Motion Planning:

- Sensing the environment

Sensors: Basic sensor functions

Sensor Interpretation: Sensor interpretation and representation

- Noise and uncertainty

Filtering: Filtering and planning

- Flexible behavior

Control Architectures: Control architectures for complex task execution

Sensor-driven Control: Reactivity to sensory events

Adaptation and Learning: Adaptation to task and environmental requirements