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M.S. Ramaiah Institute of Technology
(Autonomous Institute, Affiliated to VTU)
Department of Computer Science and Engineering

Course Name: Artificial Intelligence
Course Code: CSE551
Credits: 3:0:0:0

Term: September – December 2020

Faculty:
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Professor and Chief Proctor

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References

1. Stuart Russel, Peter Norvig: Artificial Intelligence - A Modern Approach, 2nd Edition, Pearson Education, 2012.
2. Elaine Rich, Kevin Knight, Shivashankar B Nair: Artificial Intelligence, 3rd Edition, Tata McGraw Hill, 2011.
3. Nils J. Nilsson: Principles of Artificial Intelligence, First Edition, Elsevier, 2002.
4. Luger, G. F., & Stubblefield, W. A., Artificial Intelligence - Structures and Strategies for Complex Problem Solving. New York, NY: Addison Wesley, 5th edition (2005).
5. http://aima.cs.Berkeley.edu

Acknowledgement:

We acknowledge the authors listed above and all the course materials available on the Internet in the area of Artificial Intelligence and Machine Learning.

UNIT V

Genetic Algorithms: Genetic Algorithms Introduction, Significance of Genetic Operators, Termination Parameters, Niching and Speciation, Evolving Neural Networks, Theoretical Grounding, Ant Algorithms.

Robotics: Introduction, Hardware Perception, Planning to Move, Planning Uncertain Movement, Moving, Robotic Software Architecture, Application Domains.

Philosophical Foundations: Weak and Strong AI, The Ethics and Risks of Developing AI,

AI: The present and Future.

(Chapter 23 of Text Book 2, Chapter 25, 26, 27 of Text Book 1)

Robotics: Outline : 24.12.2020

Contents for discussion

- Introduction
- Hardware Perception
- Planning to Move, Planning Uncertain Movement, Moving
- Robotic Software Architecture
- Application Domains.

Introduction to Robotics

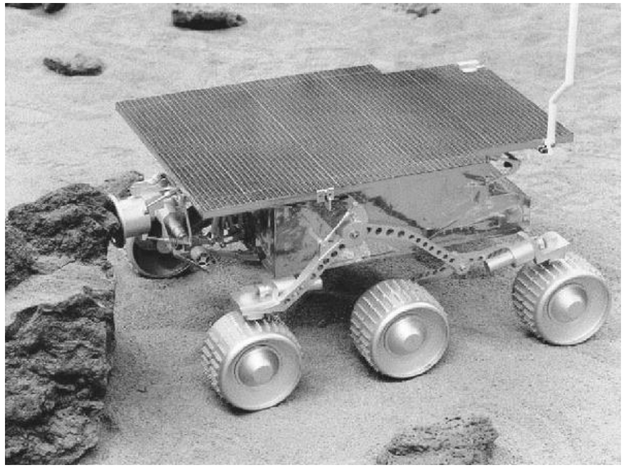
- Robots are physical agents that perform tasks by manipulating the physical world.
- To do so, they are equipped with effectors such as legs, wheels, joints, and grippers.
- Effectors have a single purpose: to assert physical forces on the environment.
- Robots are also equipped with sensors, which allow them to perceive their environment.

Effectors	Actuators
Assert a force on the environment	Communicates a command to an effector

Types of Robots

1. Manipulators
   - Anchored to the workplace.
   - Common industrial robots.

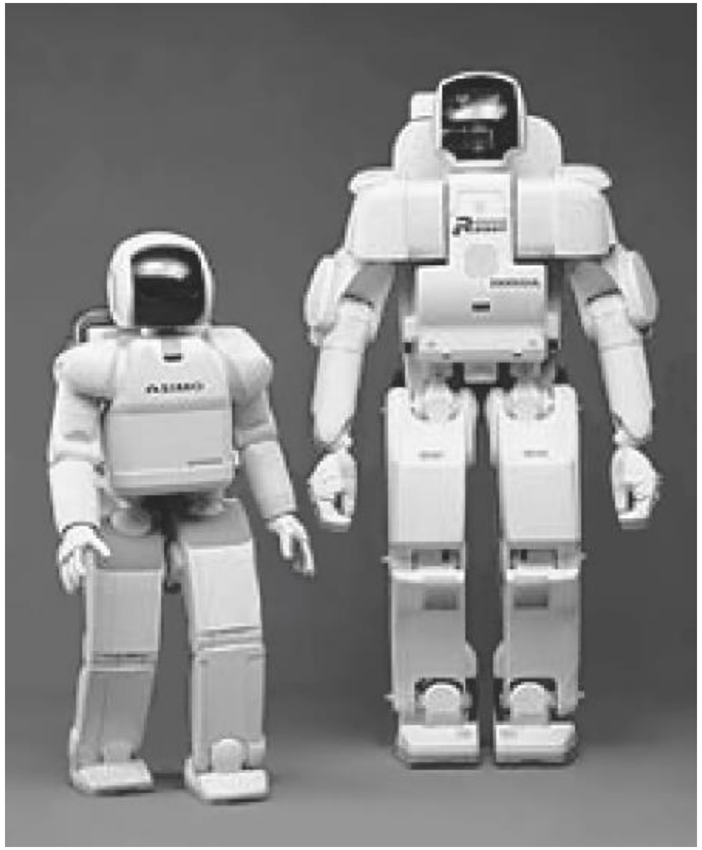
2. Mobile Robots
   - Move using wheels, legs, etc.
   - Examples: delivering food in hospitals, autonomous navigation, surveillance, etc.



Types of Robots

3. Hybrid (mobile with manipulators)

- Examples: humanoid robot
  (physical design mimics human torso)
  Made by Honda Corp. in Japan.



Robot Hardware

Sensors:

a. Passive sensors.

True observers such as cameras.

b. Active sensors

Send energy into the environment, like sonars.

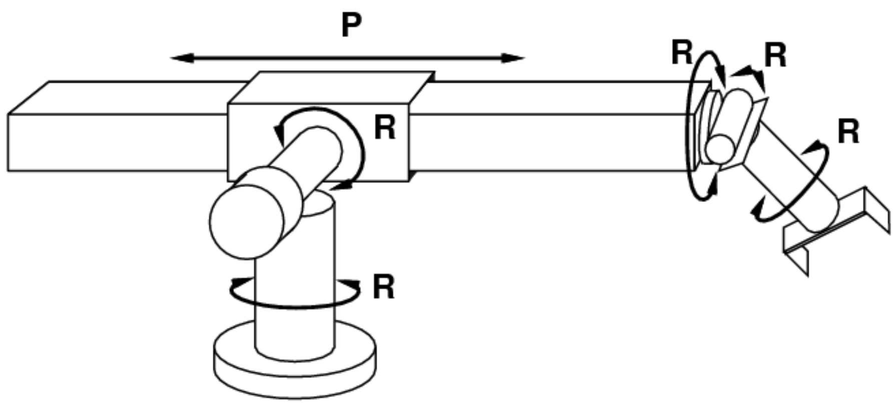
Sensors

Examples of sensors:

- Tactile sensors (whiskers, bump panels)
- Global Positioning System
- Imaging sensors
- Odometry (distance travelled)

Effectors

- Characterized by the degrees of freedom DF.
- DF counts one for each independent direction of movement.
- 6 degrees of freedom are required to place an object at a particular orientation.



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Other types of Effectors

- Unlike wheels, legs can handle tough terrains, but they are slow on flat surfaces.
- Devices vary from one leg to dozens of legs.

Robots can be

- dynamically stable
- dynamically unstable

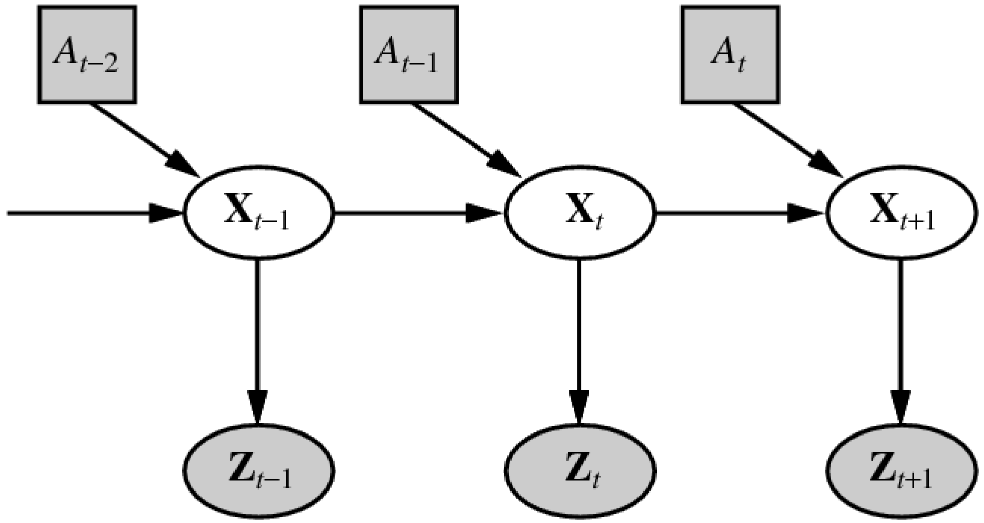
Sources of Power

- The electric motor is the most popular source

- But you may also see:
  - Pneumatic actuation using compressed gas.
  - Hydraulic actuation using pressurized fluids.

Robotic perception

- Can be illustrated using a Bayesian Belief Network.
- It can be defined as a temporal inference from sequences of actions and measurements.



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Planning to Move

Types of motion:

a.Point-to-Point.

Deliver robot to target location.

b.Compliant motion.

Move while in contact to an obstacle (robot pushing a box).

Dynamics and Control

- Keeping a robot on track is not easy.
- Use a controller to keep the robot on track.
- Controllers that provide a force in negative proportion to the observed error are known as P controllers.

Robotic Software

1. Three layer architecture
   - reactive layer (low-level control)
   - executive layer (which reactive behavior to invoke?)
   - deliberative layer (planning)

- **The reactive layer** provides low-level control to the robot. It is characterized by tight sensor-action loop. Its decision cycle is often on the order of milliseconds.
- **The executive layer** serves as the glue between reactive layer and the deliberative layer. It accepts directives by the deliberative layer, and sequences them for the reactive layer.
- **The deliberative layer** generates global solutions to complex tasks using planning. Because of the computational complexity involved in generating such solutions, its decision cycle is often in the order of minutes. The deliberative layer uses models for decision making. Those models might be either learned from data or may utilize state information gathered at the executive layer.

Robotic Software

2. Subsumption architecture

- Task achieving behaviors are represented in separate layers
- Individual layers work on individual goals concurrently and asynchronously
- No global memory, bus or clock
- Lowest level description of a behavior is an Augmented Finite State machine
- A (purely reactive) behavior-based method
- Sound-bites
  - The world is its own best model
  - No central world model or global sensor representations
  - All onboard computation is important
  - Systems should be built incrementally
  - No representation. No calibration, no complex computation, no high bandwidth computation

Robotic Software

3. Pipeline architecture

- Just like the subsumption architecture, the pipeline architecture executes multiple process in parallel.
- However, the specific modules in this architecture resemble those in the three-layer architecture.
- Figure shows the example pipeline architecture, which is used to control an autonomous car.
- Data enters this pipeline at the sensor interface layer. The perception layer then updates the robot's internal models of the environment based on this data.
- Next these models are handed to the planning and control layer, which adjusts the robot's internal plans turns them into actual controls for the robot. Those are then communicated back to the vehicle through the vehicle interface layer.

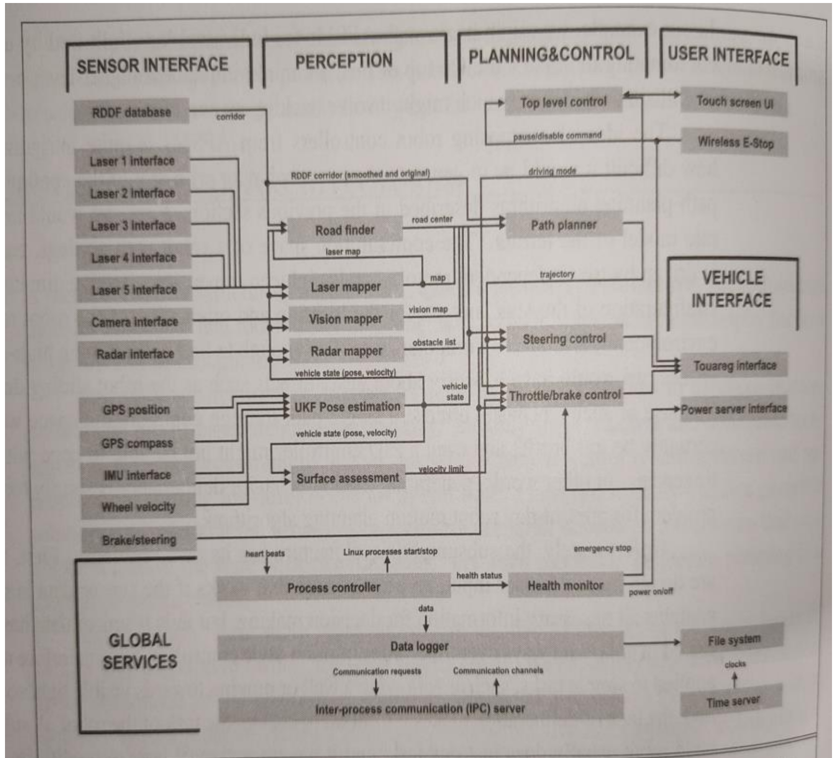

Figure 25.26 Software architecture of a robot car. This software implements a data pipeline, in which all modules process data simultaneously.

Applications

- Industry and Agriculture
  - Assembly lines
  - Harvest, Mine
  - Excavate earth
- Transportation
  - Autonomous helicopters
  - Automatic wheelchairs
  - Transport food in hospitals

Applications

- Hazardous environments
  - Cleaning up nuclear waste
  - Collapse of World Trade Center
  - Transport bombs
- Exploration
  - Surface of Mars
  - Under the sea
  - Military activities
- Health Care (surgery)
- Personal Services

Applications

- Entertainment
  Dog-like robots
- Human Augmentation

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Summary

Robotics concerns itself with intelligent agents that manipulate the physical world. In this chapter, we have learned the following basics of robot hardware and software.

- Robots are equipped with **sensors** for perceiving their environment and effectors with which they can assert physical forces on their environment. Most robots are either manipulators anchored at fixed locations or mobile robots that can move.
- Robotic perception concerns itself with estimating decision-relevant quantities from sensor data. To do so, we need an internal representation and a method for updating this internal representation over time. Common examples of hard perceptual problems include localization, mapping, and object recognition.
- Probabilistic filtering algorithms such as Kalman filters and particle filters are useful for robot perception. These techniques maintain the belief state, a posterior distribution over state variables.

Summary

- The planning of robot motion is usually done in configuration space, where each point specifies the location and orientation of the robot and its joint angles.
- Configuration space search algorithms include cell decomposition techniques, which decompose the space of all configurations into finitely many cells, and skeletonization techniques, which project configuration spaces onto lower-dimensional manifolds. The motion planning problem is then solved using search in these simpler structures.
- A path found by a search algorithm can be executed by using the path as the reference trajectory for a PID controller. Controllers are necessary in robotics to accommodate small perturbations; path planning alone is usually insufficient.
- Potential field techniques navigate robots by potential functions, defined over the distance to obstacles and the goal location. Potential field techniques may get stuck in local minima, but they can generate motion directly without the need for path planning.

Summary

- Sometimes it is easier to specify a robot controller directly, rather than deriving a path from an explicit model of the environment. Such controllers can often be written as simple finite state machines
- There exist different architectures for software design. The subsumption architecture enables programmers to compose robot controllers from interconnected finite state machines. Three-layer architectures are common frameworks for developing robot software that integrate deliberation, sequencing of subgoals, and control. The related pipeline architecture processes data in parallel through a sequence of modules, corresponding to perception, modeling, planning, control, and robot interfaces.

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Sample Questions

- List different types of Robotic sensors and list the applications where these sensors are used.
- Identify a technique that makes a perfect perception for a robot.
- Describe the hybrid and pipeline robot software architecture.
- Categorize Robots based on their types, Manipulation, environment and the device its made of. Give examples for each type.
- Explain how robots are used in Industry, transportation, hazardous environments, healthcare and human augmentation.

Thank you