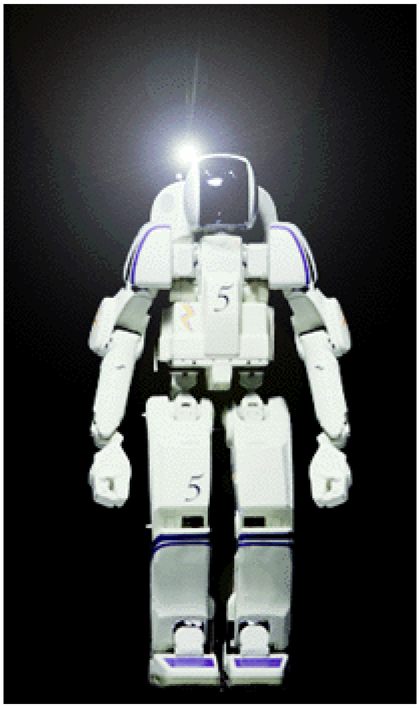
Robotics

Where AI meet the real world



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Introduction

Imagine

You and I are sitting in our futuristic, 21st century plastic living room, watching a space opera on our TV set. You decide that you'd like a can of artificial beer, and I press a small button on the coffee table. Almost instantly, a silver man with glowing eyes steps softly into the room, bows debonairly and says in a pleasantly modulated tone, "How may I serve you, master?"

Now try this

A cute, cone-shaped metal machine rolls through the crowd at a busy shopping center. Multi-colored lights flash around its gleaming circumference and a wide smile is painted over the speaker on its "face". Occasionally it will stop in front of a bemused pedestrian, shake hands and announce, in a high-pitched, electronic voice, "Hi! I'm Herbie the robot!"

The two scenes just enacted describe machines that are commonly known as *robots*. However, experts would only call one of them *a_ real_ robot*.

For many centuries one of the goals of human kind has been to develop machines. We envisioned these machines as performing all cumbersome and tedious tasks so that we might enjoy a more fruitful life. The era of machines making began with the discovery of simple machines as lever, wheel and pulley. Nowadays engineers and scientists are trying to develop intelligent machines, i.e. Robot with the help of the A.I.

Robotics is a popular source of inspiration in science fiction literature. It is branch of engineering which deals with robots. It is a science or art involving both artificial intelligence (to reason) and mechanical engineering (to perform physical acts suggested by reason).

The word robot comes from the Czech word *'robota'*, meaning "forced labor" or "compulsory service". It is one of those words, created by science fiction writer.

What is a Robot?

"*A re-programmable, multifunctional manipulator designed
to move material, parts, tools, or specialized devices
through various programmed motions for the
performance of a variety of tasks.*"

***** From the Robot Institute of America, 1979 *****

As currently defined, A robot must have the following ***essential*** **characteristics**:

- **Mobility:** It possesses some form of mobility.
- **Programmability:** implying computational or symbol- manipulative capabilities that a designer can combine as desired (a robot is a computer). It can be programmed to accomplish a large variety of tasks. After being programmed, it operates automatically.
- **Sensors:** on or around the device that are able to sense the environment and give useful feedback to the device
- **Mechanical capability:** enabling it to act on its environment rather than merely function as a data processing or computational device (a robot is a machine); and
- **Flexibility:** it can operate using a range of programs and manipulates and transport materials in a variety of ways.

More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand.

A computer is not a robot because it lacks mobility. Special-purpose machines are not robots because they automate only a few tasks. Remote-control devices work only with human participation and therefore are not robots.

History

Man has been dreaming of sophisticated, mechanized devices that perform human-like tasks for thousands of years. He has constructed automatic mechanisms and toys and imagined robots in science fiction movies, books, drawings, and plays. The concept of robots is a very old one, yet the actual word robot was invented in the 20th century from the Czechoslovakian word '*robota*' or '*robotnik*' meaning slave, servant, or forced labor. Robots don't have to look or act like humans but they do need to be flexible so they can perform different tasks.

Unimation became the U.S. leader in 1979 and was the only company in the world which actively marketed an advanced assembly robot. GM became the largest single user of robots in the world by 1982, and signed an agreement with Fanuc Ltd. for a joint robotics venture to make and market robots in the United States. More than half of the 100 robots sold by the joint venture went to GM within the first six months of operation, locking out other U.S. companies from the largest single buyer in the market.

The joint venture between GM and Fanuc Ltd. was not the only one: Bendix signed to market Yaskawa robots, while Yaskawa was already selling through Hobart Industries and Nordson Corporation; IBM signed with Seiki to market the SCARA assembly robot, which sells for one-half the price of the Unimation advanced PUMA model but does 85% of what the PUMA does. These American companies did so well that the U.S. market was valued at more than $170 billion at the end of the 1980s.

By 1990, giants like Hitachi and Mitsubishi were amongst 40 plus Japanese companies that were producing robots for commercial use. In the U.S., there were not nearly as many robotics companies, with a mere one dozen U.S. firms, led by Cincinnati Milacron and Westinghouse's Unimation.

Interestingly, Japan, imported its first industrial robot from AMF in 1967, when the United States was a good 10 years ahead in robotics technology. The reason why Japan eventually outdid the U.S. was that Unimation was forced to hand over its pioneering robot technology to Kawasaki Heavy Industries in a licensing deal in 1968.

A Short History of Robots

Robot Timeline

~270BC - Ctesibus, an ancient Greek engineer, made organs and water clocks with movable figures.
1801 - Joseph Jacquard invented a textile machine which was operated by punch cards. The machine went into mass production and was called a programmable loom.
1818 - "Frankenstein", which was written by Mary Shelley, was about a frightening artificial life form, much like a robot in modern day movies.
1830 - American Christopher Spencer designed a camera-operated lathe.
1892 - A motorized crane with gripper to remove ingots from a furnace was designed in the U.S. by Seward Babbitt.
1921 - The term "robot" was born in a play called "R.U.R." or "Rossum's Universal Robots" by the Czech writer Karel Capek. In this play, a man made a robot which killed the man. The

idea of robots and their destructive nature became so popular that most movies that followed R.U.R. portrayed robots as harmful, menacing machines.

1928 - An electromechanical robot was built in London. This robot could not operate if it left its platform even though the robot contained an electric motor, electromagnets, pulleys, and wheels.

1938 - Americans Willard Pollard and Harold Roselund designed a mechanism that could be programmed to spray-paint for the DeVilbiss Company.

1940 - Westinghouse created two of the first robots that made entire body motion in the rectangular coordinate plane using the electric motor. The name of the robot was "Electro" which danced, counted to ten, smoked, and announced the latest products being sold by Westinghouse. The second robot was Electro's motorized dog companion which walked, barked, and stood on its hind legs.

1940s-50s –

- Grey Walter's "Elsie the tortoise" ("Machina speculatrix")
- Johns Hopkins' "beast."
- The General Electric Walking Truck was a large (3,000 pounds) four legged robot with a maximum walking speed of four miles a hour. The walking truck was the first legged vehicle with a computerized brain, and was developed at General Electric Corporation by Ralph Moser.

1942 - The word "robotics" was first used by science fiction writer Isaac Asimov to describe the technology of robots and his prediction of the rise of a powerful robot industry.

In 1942, Asimov wrote "Runaround", a story about robots which contained the "Three Laws of Robotics" and he later added a Zero^th law. Isaac Asimov also introduced the idea of a "positronic brain" (used by the character "Data" in Star Trek).

Isaac Asimov's Three Laws of Robotics	
Law Zero	A robot may not injure humanity, or, through inaction, allow humanity to come to harm.
First Law	A robot may not injure a human being, or, through inaction, allow a human being to come to harm.
Second Law	A robot must obey orders given it by human beings, except where such orders would conflict with the First Law.
Third Law	A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

[An interesting article on this subject: *Clarke, Roger, "Asimov's Laws for Robotics: Implications for Information Technology", Part 1 and Part 2, Computer, December 1993, pp. 53-61 and Computer, January 1994, pp.57-65.* The article is an interesting discussion of his Laws and how they came to be in his books, and the implications for technology today and in the future.]

The third and lowest level law creates a robotic survival instinct. This ensures that, in the absence of conflict with a higher order law, a robot will

- Seek to avoid its own destruction through natural causes or accident;
- Defend itself against attack by another robot or robots; and
- Defend itself against attack by any human or humans.

Are we following Asimov's Laws? See Summary.

1948 - Norbert Wiener, a M.I.T. professor, published "Cybernetics" which influenced artificial intelligence research and outlined the concept of communications and control in biological, electronic, and mechanical systems.
1951 - Raymond Goertz designed an articulated arm which was teleoperator-equipped for the Atomic Energy Commission.
1954 - "Unimates", one of the first modern industrial robots, were created by George Devol and Joe Engleberger. "Unimation", the first robotics company, was started by the "father of robotics", Joe Engleberger. Until 1975, Unimation did not show any profit.

1959 - At the M.I.T. Servomechanisms Lab, a demonstration of computer-assisted manufacturing was held.
1959 - Planet Corporation marketed the first commercially available robot.
1960 - Unimation was purchased by Condec Corporation who then began development of Unimate Robot Systems. Also, American Machine and Foundry (AMF Corporation), marketed a robot, called the Versatran, which was designed by Veljko Milenkovic and Harry Johnson.
1962 - The first industrial robot saw service in a General Motors car factory in Trenton, New Jersey. This robot was a Unimate and was given the task of lifting hot pieces of metal from a die-casting machine and stacking them.
1963 - The Rancho Arm was designed. This artificial robotic arm was the first to be controlled by a computer and was used by the handicapped. This robotic arm was especially useful because it had the flexibility of a human arm with it's six joints.
1964 - Artificial intelligence research laboratories are opened at M.I.T., Stanford Research Institute (SRI), Stanford University, and the University of Edinburgh.
1965 - DENDRAL, the first expert system or program, was designed to utilize the combined knowledge of experts.
1968 - Marvin Minsky developed the octopus-like Tentacle Arm.
1968 - SRI built and tested Shakey, a mobile robot with vision capability. Shakey was the first mobile robot equipped with artificial intelligence. "Besides moving between rooms and avoiding objects, Shakey II was able to stack wooden blocks according to spoken instructions. It looked to see if the blocks were properly aligned, and if not, it adjusted the stack. Shakey was once asked to push a box off a platform, but could not reach the box. The robot found a ramp, pushed the ramp against the platform, rolled up the ramp, and then pushed the box onto the floor."
1974 - The Silver Arm was designed. This arm was equipped with touch and pressure sensors so that it could perform small-parts assembly using the feedback.
1974 - From the developer of the Stanford Arm, Professor Scheinman, came Vicarm Inc - a company formed to market another version of the Stanford Arm for industrial applications. This newer version was controlled by a minicomputer.
1976 - Viking 1 and 2 space probes used robot arms. Vicarm Inc.incorporated a microcomputer into the Vicarm design.

1977 - A European robot company called ASEA, offered two sizes of electric powered robots for use in industries. Both robots used a microcomputer controller for programming and operation. Also in 1977, Unimation purchased Vicarm Inc.
1978 - Unimation developed The Puma (Programmable Universal Machine for Assembly) Robot from Vicarm techniques and with support from General Motors.
1979 - The Standford Cart, a cart equipped with a tv camera was able to cross a chair-filled room without any human assistance. The cart was able to do this with the help of its mounted camera which took pictures from various angles and relayed them to a computer. The computer then analyzed the distance between the cart and the obstacles.
1980 - A new robot or company entered the market every month leading to the rapid growth of the robot industry.

Construction & Working of the Robot

Technically speaking, a Robot is a perfect combination of Mechanics, Electronics and Programming (and also Technology).

A robot can include any of the following components:

- Effectors - arms, legs, hands, feet, etc;
- Sensors - parts that act like senses and can detect objects or things like heat and light and convert the object information into symbols that computers understand.
- Computer - the brain that contains instructions or algorithms to control the robot.
- Equipment - this includes tools and mechanical fixtures.
- Characteristics - that make robots different from regular machinery are that robots usually function by themselves, are sensitive to their environment, adapt to variations in the environment or to errors in prior performance, are task oriented and often have the ability to try different methods to accomplish a task.

Robot 'architecture' primarily refers to the software and hardware framework for controling the robot. The development of programming code modules and the communication between them begins to define the architecture. Robotic systems are complex and tend to be difficult to develop. They integrate multiple sensors with effectors, have many degrees of freedom and must reconcile hard real-time systems with systems which cannot meet real-time deadlines. System developers have typically relied upon robotic architectures to guide the construction of robotic devices and for providing computational services (e.g., communications, processing, etc.) to subsystems and components. These architectures, however, have tended thus far to be task and domain specific and have lacked suitability to a broad range of applications. For example, an architecture well suited for direct teleoperation tends not to be amenable for supervisory control or for autonomous use.

Mechanical platforms -- the hardware base

A robot consists of two main parts: the robot body and some form of artificial intelligence (AI) system. Many different body parts can be called a robot. Mechanical platform is one on which all other components are mounted. For mobile robots scientists are trying to make lighter platforms, so that during movement less power is used.

Sensors

Sensors are the parts that act like senses and can detect objects or things like heat and light and convert the object information into symbols or in analog or digital form so that computers understand. And then Robots react according to information provided by the sensory system.

Current robots have advanced sensory systems that process information and appear to function as if they have brains. Their "brain" is actually a form of computerized artificial intelligence (AI). AI allows a robot to perceive conditions and decide upon a course of action based on those conditions. In most systems a sense of time is built-in through the circuits and programming. For this to be productive in practice, a robot has to have perceptual hardware and software, which updates quickly. Regardless of sensor hardware or software, sensing and sensors can be thought of as interacting with external events (in other words, the outside world). The sensor measures some attribute of the world. The term transducer is often used interchangeably with sensor. A *transduce*r is the mechanism, or element, of the sensor that transforms the energy associated with what is being measured into another form of energy. A sensor receives energy and transmits a signal to a display or computer. Sensors use *transducers* to change the input signal (sound, light, pressure, temperature, etc.) into an analog or digital form capable of being used by a robot.

Some of the most commonly used sensors are as below.

➢ ***Vision*** *:* A machine that can see is a robot builder's dream. Unfortunately, the reality of computer vision is often a big pile of expensive hardware and complex image processing software that took several man-years to develop. Many image processing problems remain unsolved. However, recent advances in imaging technology have greatly simplified some of the hardware. A typical robotic vision system has three main components:

- ✓ Camera
- ✓ Frame grabber
- ✓ Image processing unit

The camera captures an image and sends out a stream of video data. The frame grabber receives this stream of video data and stores it in memory as an array of digital pixels. The processing unit identifies features of interest in the digital image. A simple color image acquisition system is based on the Spectronix RamCam RCM-1-C. The RCM-1-C is a 160x120 pixel Bayer color-filtered CMOS digital camera combined with a frame grabber and 128K image memory buffer. The entire unit fits in a 2x2x2 inch cube!

Proximity sensors : A proximity sensor measures the relative distance between the sensor and objects in the environment. The vision sensor and Proximity sensor work together to estimate the distance between robot and object.

Consider the below figure in which it is clearly shown that as the distance between robot and object increases the angle to focus that object reduces. From this it is clear that a robot must have at least two cameras to measure the approximate distance. (The German scientists believe this “Un-biological” number of eyes renders more easily the acquisition of 3-D scenes of the environment)

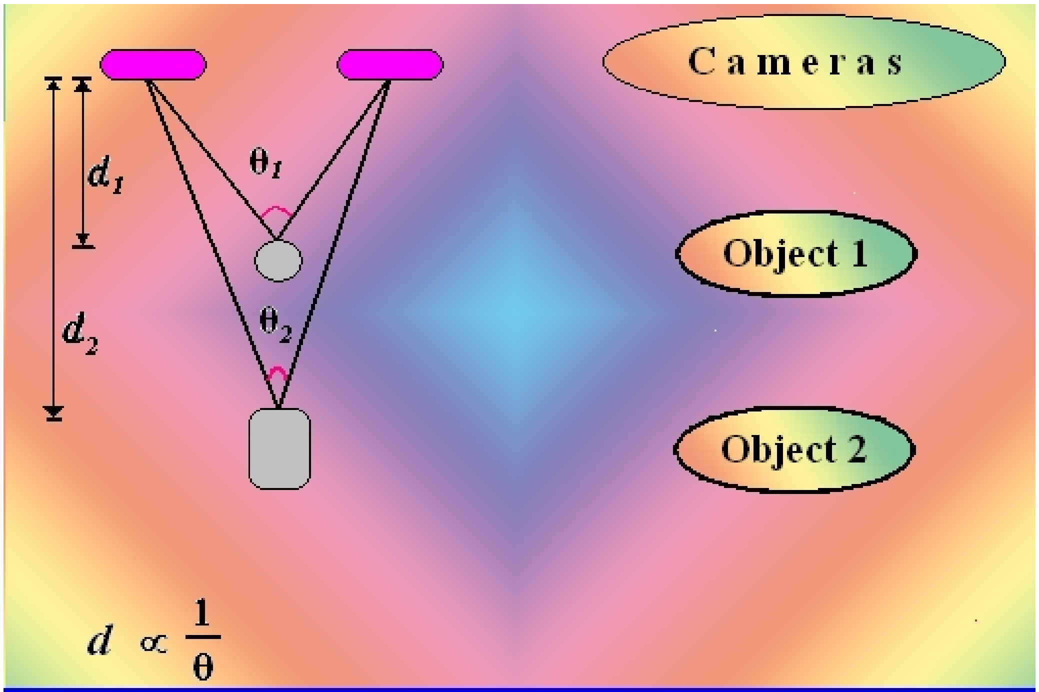

Figure Shows how the distance is estimated between the robot and object using vision sensor.

- ***Logical sensors :*** One powerful abstraction of a sensor is a logical sensor, which is a unit of sensing or module that supplies a particular percept. It consists of the signal processing, from the physical sensor, and the software processing needed to extract the percept.
- ***Proprioceptive sensors :*** Proprioception is dead reckoning, where the robot measures a signal originating within itself.
- ***Infrared (IR) sensors :*** Another type of active proximity sensor is an infrared sensor. It emits near-infrared energy and measures whether any significant amount of the IR light is returned.
- ***Bump and feeler sensors :*** Another popular class of robotic sensing is tactile, or touch-based, done with a bump and feeler sensor. Feelers or whiskers are constructed from sturdy wires. A bump sensor is usually a protruding ring around the robot consisting of two layers.

Motors

A variety of electric motors provide power to robots, allowing them to move material, parts, tools, or specialized devices with various programmed motions. The efficiency rating of a motor describes how much of the electricity consumed is converted to mechanical energy. Let's take a look at some of the mechanical devices that are currently being used in modern robotics technology.

- ***DC motor :*** Permanent-magnet, direct-current (PMDC) motors require only two leads, and use an arrangement of fixed- and electro-magnets (stator and rotor) and switches. These form a commutator to create motion through a spinning magnetic field.

- ***AC motor :*** AC motors cycle the power at the input-leads, to continuously move the field. Given a signal, AC and DC motors perform their action to the best of their ability.
- ***Stepper motor :*** Stepper motors are like a brushless DC or AC motor. They move the rotor by applying power to different magnets in the motor in sequence (stepped). Steppers are designed for fine control and will not only spin on command, but can spin at any number of steps-per-second (up to their maximum speed).
- ***Servomotors :*** Servomotors are closed-loop devices. Given a signal, they adjust themselves until they match the signal. Servos are used in radio control airplanes and cars. They are simple DC motors with gearing and a feedback control system.

Driving mechanisms

One more most common task in designing robots is driving mechanisms. These mechanisms are used in operating robotic arm, moving legs and other mechanical parts. The following are some mechanisms whish are commonly used in a typical robot.

- ***Gears and chains :*** Gears and chains are mechanical platforms that provide a strong and accurate way to transmit rotary motion from one place to another, possibly changing it along the way. The speed change between two gears depends upon the number of teeth on each gear. When a powered gear goes through a full rotation, it pulls the chain by the number of teeth on that gear.
- ***Pulleys and belts :*** Pulleys and belts, two other types of mechanical platforms used in robots, work the same way as gears and chains. Pulleys are wheels with a groove around the edge, and belts are the rubber loops that fit in that groove.
- ***Gearboxes :*** A gearbox operates on the same principles as the gear and chain, without the chain. Gearboxes require closer tolerances, since instead of using a large loose chain to transfer force and adjust for misalignments, the gears mesh directly with each other. Examples of gearboxes can be found on the transmission in a car, the timing mechanism in a grandfather clock, and the paper-feed of your printer.

Power supplies

Power supplies are generally provided by two types of battery. Primary batteries are used once and then discarded; secondary batteries operate from a (mostly) reversible chemical reaction and can be recharged several times. Primary batteries have higher density and a lower self-discharge rate. Secondary (rechargeable) batteries have less energy than primary batteries, but can be recharged up to a thousand times depending on their chemistry and environment. Typically the first use of a rechargeable battery gives 4 hours of continuous operation in an application or robot.

The robot platform runs off of two separate battery packs, which share only a ground. This way, the motor may dirty up one power source while the electronics can run off of the other. The electronics and the motors can also operate from different voltages.

Electronic controls

There are two major hardware platforms in a robot. The mechanical platform of unregulated voltages, power and back-EMF spikes, and the electronic platform of clean power and 5-volt signals. These two platforms need to be bridged in order for digital logic to control mechanical systems. The classic component for this is a bridge relay. A control signal generates a magnetic field in the relay's coil that physically closes a switch. MOSFETs, for example, are highly efficient silicon switches, available in many sizes like the transistor that can operate as a solid state relay to control the mechanical systems.

On the other hand, larger sized robots may require a PMDC motor in which the value of the MOSFET's "on" resistance Rds(on) results in great increases in the heat dissipation of the chip, thereby significantly reducing the chip's heat temperature. Junction temperatures within the MOSFET and the coefficients of conduction of the MOSFET package and heat sink are other important characteristics of PMDC motors.

Microcontroller systems

Microcontrollers (MCUs) are intelligent electronic devices used inside robots. They deliver functions similar to those performed by a microprocessor (central processing unit, or CPU) inside a personal computer. MCUs are slower and can address less memory than CPUs, but are designed for real-world control problems. One of the major differences between CPUs and MCUs is the number of external components needed to operate them. MCUs can often run with zero external parts, and typically need only an external crystal or oscillator. The four basic aspects of a microcontroller are :

- Speed
- Size
- Memory
- Other

Speed is designated in clock cycles, and is usually measured in millions of cycles per second (Megahertz, MHz). The use of the cycles varies in different MCUs, affecting the usable speed of the processor. Size specifies the number of bits of information the MCU can process in one step -- the size of its natural cluster of information. MCUs come in 4-, 8-, 16-, and 32-bits, with 8-bit MCUs being the most common size. MCUs count most of their ROM in thousands of bytes (KB) and RAM in single bytes. Many MCUs use the Harvard architecture, in which the program is kept in one section of memory (usually the internal or external SRAM). This in turn allows the processor to access the separate memories more efficiently. The fourth aspect of microcontrollers, referred to as "other", includes features such as a dedicated input device that often (but not always) has a small LED or LCD display for output. A microcontroller also takes input from the device and controls it by sending signals to different components in the device. Also the program counter keeps track of which command is to be executed by the microcontroller.

Languages

A robot without programming can't do ant thing that you expect. The following are the programming languages which are used in a Robot.

- ***RoboML (Robotic Markup Language):*** RoboML is used for standardized representation of robotics-related data. It is designed to support communication language between human-robot interface agents, as well as between robot-hosted processes and between interface processes, and to provide a format for archived data used by human-robot interface agents.
- ***ROSSUM:*** A programming and simulation environment for mobile robots. The Rossum Project is attempts to help collect, develop and distribute software for robotics applications. The Rossum Project hopes to extend the same kind of collaboration to the development of robotic software.
- ***XRCL (Extensible Robot Control Language):*** XRCL (pronounced zircle) is a relatively simple, modern language and environment designed to allow robotics researchers to share ideas by sharing code. It is an open source project, protected by the GNU Copyleft.
- ***Open System Architecture for Controls within Automation Systems (OSACA):*** OSACA is a joint European project that aims to improve the competitiveness of the manufacturers of machine tools and control systems in the world market. The main goal of the project is to specify system architecture for open control systems, which is manufacturer independent.

R/C Servos

Servomotors, used in radio-controlled models (cars, planes, etc.) are useful in many kinds of smaller robots, because they are compact and quite inexpensive. The servomotors themselves have built-in motor, gearbox, position-feedback mechanisms and controlling electronics. Standard radio control servomotors which are used in model airplanes, cars and boats are useful for making arms, legs and other mechanical appendages which move back and forth rather than rotating in circles.

Pneumatics

Pneumatics is the name for fluid power used in a large number of commercial robots. Pneumatics is also used in a variety of animatronics systems that fall under the category of fluid power. A better known branch of fluid power is hydraulics.

The other important points that must be remembered during designing a robot is :

Driving High-Current Loads from Logic

One of the most common tasks in designing and building robots is the interfacing of logic circuitry to high current loads such as motors, solenoids, or Nitinol wire. These loads can have peak current requirements greater than 10 amps. Most logic circuitry can sink and source loads in the range of 1 to 20 mA. Find a complete article on this topic at http://www.acroname.com/robotics/info/articles/articles.html.

Controllers

- ***Task Control Architecture:*** The Task Control Architecture (TCA) simplifies building task-level control systems for mobile robots. "Task-level" refers to the integration and coordination of perception, planning, and real time control to achieve a given set of goals (tasks). TCA provides a general control framework, and is intended to control a wide variety of robots. TCA provides a high-level machine-independent method for passing messages between distributed machines (including between Lisp and C processes). TCA provides control functions, such as task decomposition, monitoring, and resource management, which are common to many mobile robot applications.

- ***EMC (Enhanced Machine Controller):*** The EMC software is based on the NIST Real time Control System (RCS) methodology, and is programmed using the NIST RCS Library. The RCS Library eases the porting of controller code to a variety of UNIX and Microsoft platforms, providing a neutral application programming interface (API) to operating system resources such as shared memory, semaphores and timers. The EMC software is written in C and C++, and has been ported to the PC Linux, Windows NT, and Sun Solaris operating systems.

- ***Darwin2K:*** Darwin2K is a free, open source toolkit for robot simulation and automated design. It features numerous simulation capabilities and an evolutionary algorithm capable of automatically synthesizing and optimizing robot designs to meet task-specific performance objectives.

One of the most interesting and recent trend in robotic has been a focus on behavior-based or reactive systems, which requires a form of intelligence. Behavior based refers to the fact that these systems exhibit various behaviors, some of which are emergent. These systems are characterized by tight coupling between sensors and actuators, minimal computation, and a task-achieving "behavior" problem decomposition. The simplest behavior of a robot is locomotion. Typically, wheels are used as the underlying mechanism to make a robot move from one point to the next. And some force such as electricity is required to make the wheels turn under command.

In the below figure it is clear that if a robot want to perform a behavior such as dance with the person B than it will require sensors such as vision for identifying the object or person, proximity sensor for estimating the relative distance, etc; All of these sensors provides data to the controller and the microprocessor takes decision on them and send some data to perform that behavior, by which the robot can set it self to dance with the person B.

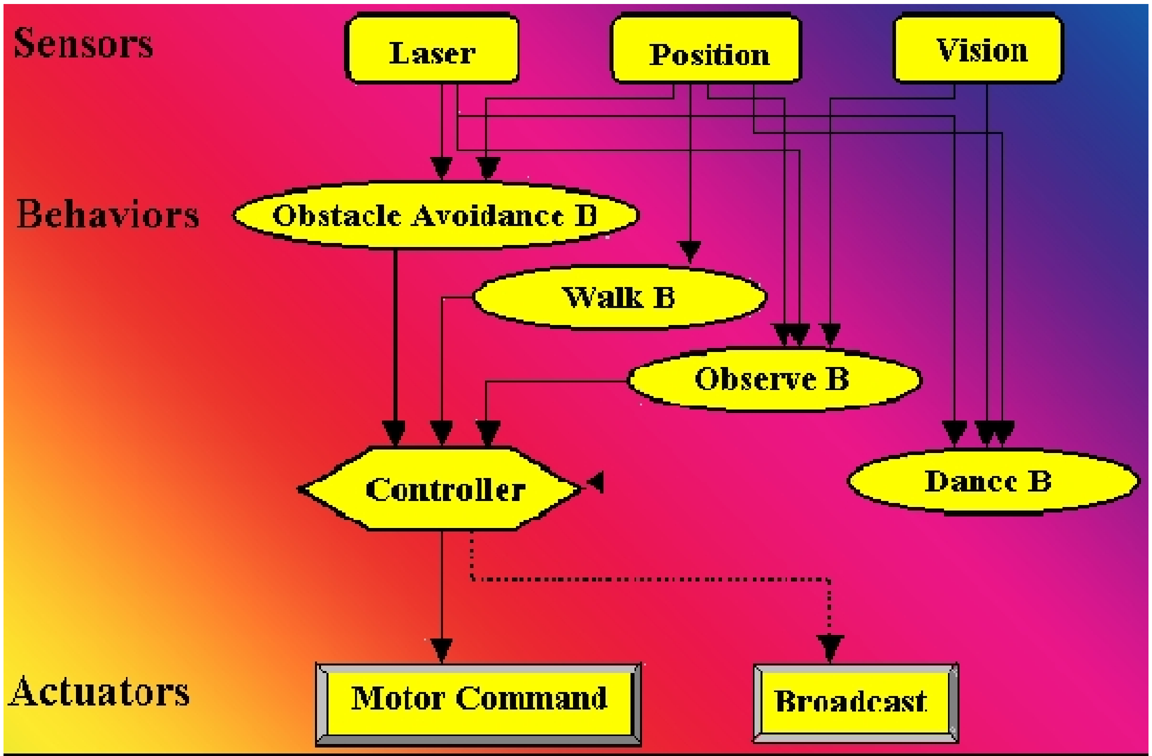

Figure : A Robot System Architecture. (Analysis of an Action)

Artificial Intelligence

What is artificial intelligence?

It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable. Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

After WW II, a number of people independently started to work on intelligent machines. The English mathematician Alan Turing may have been the first. He gave a lecture A few people think that human-level intelligence can be achieved by writing large numbers of programs of the kind people are now writing and assembling vast knowledge basis of facts in the languages now used for expressing knowledge.

Can a machine think?

There are good reasons to believe a sufficiently complex machine could one day perform thinking and analyzing problems. Whether or not that constitutes sufficient or necessary proof of intelligence or consciousness, will be the subject of continuing philosophical debate. Machines have been created (e.g., Deep Blue) which outperform humans in many niche areas. Some make extensive use of the particular strengths of computers such as rapid search and large memory, while others try to simulate human problem-solving or some of the machinery of the brain. Some of Deep Blue's predecessors tried to reproduce the methods of human grandmasters, i.e., recognizing key configurations of pieces on the board. Deep Blue relies more on massive and rapid searches of possible sequences of moves.

While it is not possible to predict which of the three major approaches to artificial intelligence might be the basis for an intelligent machine (perhaps all of them will be incorporated to some degree), it seems a safe bet that a major component will resemble the functioning of a human brain at the level of individual neurons. If we can simulate the functioning of the brain at a deep level, the resulting network would literally be a *tabula rasa*, a blank mind. It would not show intelligence nor consciousness unless it was subjected to experiences similar to those of a human brain. It must be able to investigate the environment around it, interact with that environment, and learn common sense and all the other things which contribute to intelligence, since you cannot directly program in intelligence. A few people think that human-level intelligence can be achieved by writing large numbers of programs of the kind people are now writing and assembling vast knowledge basis of facts in the languages now used for expressing knowledge.

However, most AI researchers believe that new fundamental ideas are required, and therefore it cannot be predicted when human level intelligence will be achieved.

Why do we believe only
- *We can construct a "Thinking Machine?"* -
What a computer can and cannot do?

We now know that we can make computers excel on limited problems such as recognizing speech (if it is grammatical, carefully pronounced and the context is restricted), scheduling a factory, recognizing a particular object in a scene, designing a jet engine, or even performing a complex medical diagnosis. But we are very far from creating a computer which can an unrestricted Artificial Intelligence. Computers have mastered intellectual tasks, such as chess and integral calculus, but they have yet to attain the skills of a lobster in dealing with the real world. Given the gap between these niche capabilities and the requirements of the unrestricted Artificial Intelligence, why do we think we can create an intelligent machine--a machine which can deal with the real world? Why do we think computers may have the "right stuff?" The reasons are among some of the most significant philosophical concepts of the late 20th century.

The philosophy which dominated thinking about the mind for almost three centuries is called Cartesian dualism; the position first set forth by the French mathematician and philosopher Rene Descartes in the early-1600's, that there are two kinds of substances in the world: mental and physical or immaterial "mind stuff" apart from material substance. If we held this belief today, there would be little reason to suppose we could make much progress creating intelligence using a computer. Today, most philosophers instead argue that the mind (and intelligence) is an emergent property of material processes at the micro-level. That is to say, intelligence, which includes thinking, arises from brain's biochemistry, which is shaped by heredity and environment. The fundamental insight about biology and mind suggests that if we simulate the brain at the right level of detail, mind and intelligence may also emerge from the simulation. The open issue is how far down in the structure do we have to go? Can we get mind and intelligence by simulating brain processes at the higher "psychological" level-- how we read, for example--or do we require lower-level neuro-physiological detail?

Intelligent Robots

As the genial W. Grey Walter predicted (and experimented with), the future of truly intelligent robots lay in the conjunction of Artificial Intelligence and Robotics, two disciplines which are already very much interwoven.

A technology called "artificial neural networks" tries to imitate the organization and functioning of the brain by means of artificial elements that behave like networks of neurons (the basic cell of the nervous system), but using silicon microchips instead. Neural networks present the great advantage of learning complex tasks such as 3-D recognition of obstacles, controlling movement of joint articulation in robotic arms, and so on. In the long term, we could except that artificial neural system video be used in applications involving vision, speech, decision making and reasoning.

Our nervous system perform well complex tasks such as correctly frying an egg because:

- Neural networks are adaptive, that is, they learn with experience (after breaking a dozen eggs, and not doing it right some 10 or 20 times, the network gets the correct sequence);

- Neural networks are capable of generalization, that is, they perform equally well with eggs of different colors, shapes, positions, and so forth, and are able to correctly solve situations with a certain degree of variability;
- Neural networks are capable of recognizing complex patterns, visual or otherwise, such as shape, color, sound, texture, if properly connected to the suitable sensors.
- New neural robots have dozens of modular neurocomputer systems which independently control each joint, motor, sensor and so on, as well as integration and coordination subsystems. From this point of view, they are increasingly alike, both in structure and function, to the living matter!

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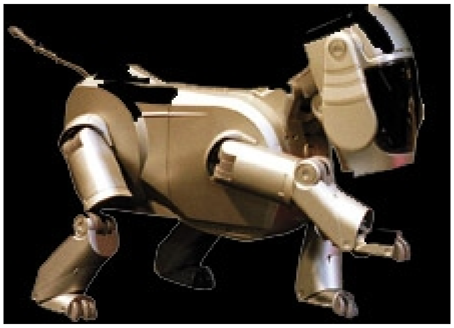
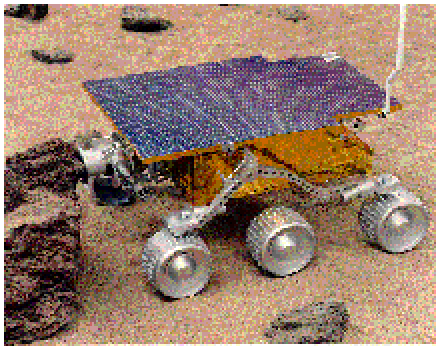
The first robots that display such advanced technology have shown amazing flexibility and adaptation capabilities. It is thought that an autonomous robot will have several hundreds of such little "brains", controlled by a major computer, and that they will act in an integrated manner with sensors and motors, exactly as it happens with a real nervous system. Reflexes, intelligent decision-making and automatic systems will make the robots of the future very similar to what Isaac Asimov and other anticipated so vividly. What is difficult to guess is how long it's going to take.

To understand the enormity of this capability, it is enough to imagine, for example, how extremely difficult it would be to build an industrial robot to perform such a simple task as to break an egg and scramble it over a pan, up to the point it can be served. For this, the robot would need a sense of **vision** (to see the egg); **tactile** sense (in order not to smash it by excessive pressure when the egg is picked up); the sense of **propioception** (sensors that indicate the position of arms and fingers); as well as the delicate control required to break the egg exactly in the middle of its shell and over a frying pan (which needs to be at the right temperature) and so forth.

Several researches made at the advanced robotic centers in the USA, Europe and Japan are managing to create models of future robots with a minimum degree of "intelligence". For instance, a Japanese laboratory creates a robot with vision that is capable of reading a musical score and interprets it over the piano. A German university developed an autonomous robotic vehicle that "navigates" through a room full of obstacles, thanks to a visual system composed of three eyes (the German scientists believe this “Un-biological” number of eyes renders more easily the acquisition of 3-D scenes of the environment). Another company is already marketing the first robotic hands that have the sense of touch and automatically regulate the pressure exerted over the objects they handle.

Another robotic sensation was the Sojourner rover (mobile robot on wheels) that landed on Mars in 1998 and was remotely controlled from Earth (other example is Mars Pathfinder). As soon as it escaped from the delivery vehicle on the harsh surface of Mars, little Sojourner began to explore the surrounding terrain and examine its rocks. This was surely something that called the attention of newspapers, magazines and television, and robots, which were somehow forgotten, returned suddenly to center stage. Also in 1998 a high-tech Japanese company launched a robot that remarkably resembled a walking astronaut. The robot can





move up and down stairs, run on flat terrain, avoid obstacles, and so on, in an autonomous manner (that is, it is not necessary that a human being remotely controls the robot, as is the case of Mars Pathfinder). Another Japanese company generated a big frisson when it begun selling $2,000 robot-dogs, capable of several apparently affectionate and intelligent behaviors and sold them out in a few hours.

Appling Robots

Today the robots are only limited to the industrial field. They are not applied in our daily routine. But no doubt in future you and I are using them as servants.

Typical applications where robots are used are welding cars, spraying paint on appliances, assembling printed circuit boards, loading and unloading machines, and placing cartons on a pallet. The automobile and metal-manufacturing industries have been the main users. From military technology and space exploration to the health industry and commerce, the advantages of using robots have been realized to the point that they are becoming a part of our collective experience and every day lives.

They function to relieve us from danger and tedium:

- **Safety:** Robotics have been developed to handle nuclear and radioactive chemicals for many different uses including nuclear weapons, power plants, environmental cleanup, and the processing of certain drugs.
- **Unpleasantness:** Robots perform many tasks that are tedious and unpleasant, but necessary, such as welding or janitorial work.
- **Repetition and precision:** Assembly line work has been one of the mainstays of the robotics industry. Robots are used extensively in manufacturing and, more glamorously, in space exploration, where minimum maintenance requirements are emphasized.

Robotic Articulated arms are used in welding and painting; gantry and conveyor systems move parts in factories; and giant robotic machines move earth deep inside mines.

Common industrial robots are generally heavy rigid devices limited to manufacturing. They operate in precisely structured environments and perform single highly repetitive tasks under preprogrammed control. There were an estimated 720,000 industrial robots in 1998.

Teleoperated robots are used in semi-structured environments such as undersea and nuclear facilities. They perform non-repetitive tasks and have limited real-time control.

Animatronics systems: Animatronics systems are robotic systems which mimic and look like humans or animals. An android is an anthropomorphic robot -- in other words, a robot that looks like a human. These types of robots are used for making films with special effects such as Jurassic Park.

Today the most important field in which robot are used is the Space where in some regions it is not possible for humans to reach. In this situation generally two types of robots are used:

- Those which gets instructions from earth and manipulates the task.
- Those which are totally programmed for every type of situation to handle.

Today Robots are touching the surface of Mars, Saturn, Jupiter, etc; The recent example is Pathfinder.

Examples of some interesting Robots

Up to now, most of the approximately 800,000 robots installed worldwide have been used in manufacturing.

Aibo, a pet which has the ability to perform mostly all of the expression that a dog can do. (http:/www.aibo.com)

Robot Ants, James McLurkin invented micro robots that work together as a community.
(http://inventors.about.com/gi/dynamic/offsite.htm?site=http://web.mit.edu/invent/www/inventorsI-Q/mclurkin.html)

Future

The first dream: Perhaps the first mention of these ideal servants was in the story of the Greek god Hephaestus (or Vulcan). Only think a moment. A few years ago, these machines (Robots) did not exist. Now, we have robots assembling delicate radio parts in factories and venturing into nuclear reactors to handle radioactive material. A robot was the first to touch the planet of Mars, and its more sophisticated cousin may soon be strolling across the Martian terrain**.**

Artificial neural networks technology is still very new and is developing quickly. We are witnessing fast expansion of neural network-based intelligent. Hopefully, this will enhance the quality of our lives and make many difficult tasks easier to accomplish. Artificial neural networks are the way by which the Artificial Intelligence is implemented. The incremental growth of computer power suggests an incremental approach to developing robot intelligence, probably an accelerated parallel to the evolution of biological intelligence that's its model. Unlike other approaches, this path demands no great theories or insights (helpful though they can be): natural intelligence evolved in small steps through a chain of viable organisms, artificial intelligence can do the same. Nature performed evolutionary experiments at an approximately steady rate, even when evolved traits such as brain complexity grew exponentially.

Scientists are working on such robots which train themselves (they got this idea from a new born child who doesn't know any thing about this world but learns everything from experience). Today Artificial Intelligence is not much developed but its future is very bright. Future robots will not only depend on programming but also on AI.

Teen-aged students are now guiding simple assemblies through programmed actions that were considered major scientific problems 20 years ago. What will those same students be building 20 years from now? So nothing can be *predicted* about future.

Summary

Advantages:

Robotics offers benefits such as high reliability, accuracy, and speed of operation. Low long term costs of computerized machines may result in significantly higher productivity, particularly in work involving variability within a general pattern. Humans can be relieved of mundane work and exposure to dangerous workplaces. Their capabilities can be extended into hostile environments involving high pressure (deep water), low pressure (space), high temperatures (furnaces), low temperatures (ice caps and cryogenics), and high- radiation areas (near nuclear materials or occurring naturally in space).

Disadvantages:

On the other hand, deleterious consequences are possible. Robots might directly or indirectly harm humans or their property; or the damage may be economic or incorporeal (for example, to a person's reputation). The harm could be accidental or result from human instructions. Indirect harm may occur to workers, since the application of robots generally results in job redefinition and sometimes in outright job displacement. Moreover, the replacement of humans by machines may undermine the self- respect of those affected and perhaps of people generally.

Where gone Asimov’s law?

In future robots, robots are used in Wars (*Jung - e - Maidan*) where robots may injure humans beings (enemies), at that time are we forgetting the Asimov’s Laws? The question remains unanswered because we are designing robots for our safety so a designer first keep in mind that a robot must obey orders given it by its master. That’s the reason why a robot will not follow Asimov’s Laws.

Conclusion

Robotics is in many respects Mechanical AI. It is also a lot more complicated, since the data the robot is receiving is real-time, real-world data, a lot more complicated that more software-based AI programs have to deal with. On top of this more complicated programming required, algorithms to respond via motors and other sensors are needed.

The field of robotics is where AI is all eventually aimed; most research is intended to one day become part of a robot.

Nothing is totally **impossible**. *Perhaps one day we will be able to produce robots that are practically indistinguishable from ourselves. In the meantime, it would be wise to examine what we've got now, and where we're going.*
And that, in itself, is quite a trip.

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http://www.thetech.org/exhibits_events/online/robots/
And also some other web-sites.

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