HISTORY OF ROBOTS

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CHRISTOPHER HAGIS

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Introduction

Robots are the next great wave of the technological boom. Over the past 40 years, man has invented many mechanical marvels but none compare to the robot builders' dreams for tomorrow. The surface of possibilities in the field of robotics has barely been scratched. Autonomous machines will affect nearly every aspect of society. Our childhood cartoons are now our inspiration for experiments. Battling Robots were a cartoon of the 1980, when the Megabots faced the Deceptacons in "Transformers "; and we now have the first robotic vacuum cleaner that certainly resembles the idea of "Rosey" the robot maid from the cartoon "The Jetson's". Our culture is rapidly changing with great credit due to the technological advances and high educational demands on the everyday man. My partner and I are embarking on an educational journey into the world of robotics. We are on a mission to learn about, and build a semi-autonomous robot with the ability to see, to touch, to lift and carry, and to respond to a variety of physical tests. This will require great amounts of time, research and education in a number of fields. Robotics is a discipline that has no specific field or degree; it encompasses modern circuitry, computer and electrical engineering, modern physics, computer science, and mathematics as well as human physiology, psychology, biology, chemistry. To say that those are the only disciplines used in Robotic Engineering would be a gross understatement. The truth is robotics envelops the entire society; it is a problem solving technique in its most infantile stages. Robotics is both art and science in its purest form because it is a clean template, there are no common practices taught in classes or proper methods to be used. A development and creation process is limited only by your imagination, understanding, and knowledge.

History of Robots

The notion of robots or robot-like automates can be traced back to medieval times. Although people of that era did not have a term to describe what we would eventually call a robot they were nevertheless imagining mechanisms that could perform human-like tasks. In medieval times, automatons, human-like figures run by hidden mechanisms, were used to impress peasant worshippers in church into believing in a higher power. The automatons created the illusion of self-motion (moving without assistance). The clock jack was a mechanical figure that could strike time on a bell with its axe. This technology was virtually unheard of in the 13th century. In the 18th century, miniature automatons became popular as toys for the very rich. They were made to look and move like humans or small animals.

In literature, humankind's vivid imagination has often reflected our fascination with the idea of creating artificial life. In 1818, Mary Shelly wrote Frankenstein, a story about the construction of a human-like creature. For Shelly, a robot looked like man but had the ability to function like a machine. It was built of human components, which could be held together by nuts and bolts. Shelly considered that a robot had to be bigger than a regular person and had to have super human strength. In 1921, Karel Capek, a Czech playwright, came up with an intelligent, artificially created person, which he called "robot". The word "robot" is Czech for worker, and was gradually incorporated into the English language without being translated. As you can see, even a hundred years after Shelly's Frankenstein, Capek's idea of a robot is still one in which the creation resembles the human form. While the concept of a robot has been around for a very long time, it was not until the 1940's that the modern day robot was born, with the arrival of computers.

The term robotics refers to the study and use of robots; it came about in 1941 and was first adopted by Isaac Asimov, a scientist and writer. It was Asimov who also came up with the "Laws of Robotics" in his short story Runaround: One, a robot may not injure a human being or through inaction, allow a human being to come to harm. ... Two, a robot must obey the orders given it by human beings except where such orders would conflict with the First Law. … Three, a robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

The robot really became a popular concept during the late 1950's and early 1960's. With the automotive industry in full expansion at that time, industrial robots were employed to help factory operators. Industrial robots do not have the imaginative, human-like appearance that we have been dreaming of throughout the ages. They are computer-controlled manipulators, like arms and hands, which can weld or spray paint cars as they roll down an assembly line.

Robots were created to help humans, especially in high risk or dangerous situations. A robot can deactivate a bomb, go to the edges of an active volcano, transport dangerous materials, explore the ocean floor and even perform tasks in the most hostile environment known to man: space. Without the proper protection, like a spacecraft or even the EVA suit used by space walkers, survival in space is not possible. When repairs have to be made outside a spacecraft, astronauts are sometimes required to leave the space shuttle or the Space Station. These extravehicular activities are very dangerous; so, robots are used to carry out tasks in space in order to limit the number of risks taken. As we have discovered, today's robots do not necessarily resemble humans. A human is made up of a number of different visible components, like a head where the brain sends messages to the rest of the body; arms and hands to grasp and maneuver objects; a torso to which all of the components are attached and legs to move. Robots need all these different components to operate. A number of robots make up the Mobile Servicing System. The Mobile Servicing System is Canada's contribution to the International Space Station. Canada created the Mobile Servicing System to help in the construction of the Space Station; it will first build the Space Station and then help maintain the Station throughout its lifetime.

Just like humans have a brain that sends messages to the rest of the body; there is a main computer that communicates with the robotic system. The Space Station Remote Manipulator System (SSRMS), Canada's new robotic arm, will be able to lift and move objects the size and mass of the Space Shuttle. The crew of STS-100 with Canadian Space Agency Astronaut Chris Hadfield will deliver and install the new arm to the International Space Station as it orbits high above the Earth. This second generation Canadarm is Canada's primary contribution to the Station. The Space Vision System (CSVS), another critical piece of Canadian robotics innovation, is comprised of several cameras and targets. These are located in key areas of the Space Station and on the robotic arm; it will serve to pinpoint the exact movement and location of components for the building and maintenance of the Station. Therefore, astronauts from inside the Space Station are able to operate the Mobile Servicing System by using this Space Vision System.

Aside from the CSVS, the next Canadian robot to be brought to space is the SSRMS. When it is brought to space to be installed to the Space Station during STS-100, its predecessor, the Canadarm will lift it from the payload of Space Shuttle Endeavour and bring it to the International Space Station. This will be the first in a series of handshakes in space performed by these robots.

Microcontrollers

A microcontroller is, simply put, a computer. It is a computer that does one thing very well. A microcontroller can also be referred to as a "special purpose computer". There are a number of other common characteristics that define microcontrollers. If a computer matches a majority of these characteristics, then you can call it a "microcontroller". Microcontrollers are usually embedded into something else. They are in things like cell phones, TVs and cars. Microcontrollers are dedicated to one task and run one specific program. The program is stored in ROM (read-only memory) and generally does not change.

Microcontrollers are often low-power devices. A desktop computer is almost always plugged into a wall socket and might consume 50 watts of electricity. A battery-operated microcontroller might consume 50 mill watts. A microcontroller has a dedicated input device and sometimes has a small LED or LCD display for output. A microcontroller also takes input from the device it is controlling and controls the device by sending signals to different components in the device.

For example, the microcontroller inside a TV takes input from the remote control and displays output on the TV screen. The controller controls the channel selector, the speaker system and certain adjustments on the picture tube electronics such as tint and brightness. The engine controller in a car takes input from sensors such as the oxygen sensors and controls things like fuel mix and spark plug timing. A microwave oven controller takes input from a keypad, displays output on an LCD display and controls a relay that turns the microwave generator on and off. A microcontroller is often small and low cost. The components are chosen to minimize size and to be as inexpensive as possible.

The actual processor used to implement a microcontroller can be very different. For example, a cell phone usually contains a Z-80 processor. The Z-80 is an 8-bit microprocessor developed in the 1970s and originally used in personal computers at the time. Commonly, GPS systems contain a low-power version of the Intel 80386.

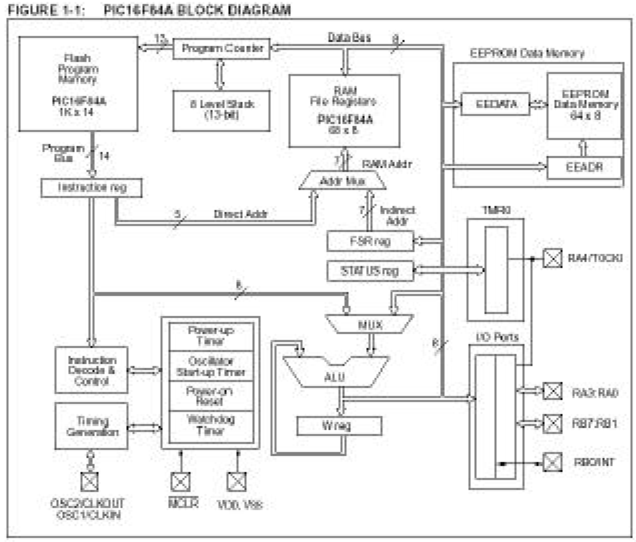
In many products, such as microwave ovens, the demand on the CPU is fairly low and price is an important consideration. In these cases, manufacturers turn to dedicated microcontroller chips -- chips that were originally designed to be low-cost, small, low power, embedded CPUs. The Motorola 6811 and Intel 8051 are both good examples of that. There is also a line of popular controllers called "PIC microcontrollers" created by a company called Microchip. By today's standards, these CPUs are incredibly minimalist; but they are extremely inexpensive when purchased in large quantities and can often meet the needs of a device's designer with just one chip.

A typical low-end microcontroller chip might have 1,000 bytes of ROM and 20 bytes of RAM on the chip, along with eight I/0 pins. In large quantities, the cost of these chips can sometimes be just pennies. You certainly are never going to run Microsoft Word on such a chip --

Microsoft Word requires perhaps 30 megabytes of RAM and a processor that can run millions of instructions per second. But then, you do not need Microsoft Word to control a microwave oven, either. With a microcontroller, you have one specific task you are trying to accomplish, and low-cost, low-power performance is what is important.

Keeping this in mind for our application, we will more than likely be using a type of PIC microcontroller. One of the most common PIC controllers is the PIC16F84 microcontroller unit (MCU).

FIGURE 1-1: PIC16F84A BLOCK DIAGRAM



Above is a simplified diagram of the architecture of a PIC16F84 microcontroller unit.

The reason for picking this type of MCU is because of its fairly low cost and its ease of use. In the programming aspect of it, all we will be using some type of C based programming language for the basic programming of the robot. We will be using a C based language because it is the most common type used for this type of microcontroller unit and we both know how to write in this type of code.

Sensors

Sensors are an integral part of any robot. Sure, you can build a robot without any sensors but if it starts banging into walls and falling down stairs, it is not going to be very useful and the repairs can get costly. Sensors are the perceptual system of a robot and measure physical quantities like contact, distance, light, sound, temperature, inclination, pressure, or altitude. Sensors provide the raw information or signals that must be processed through the robot's computer to provide meaningful information. Robots are equipped with sensors so they can have an understanding of their surrounding environment and make changes in their behavior based on the information they have gathered.

Sensors can permit a robot to have an adequate field of view, a range of detection and the ability to detect objects while operating in real or near-real time within its power and size limits. Additionally, a robot might have an acoustic sensor to detect sound, motion or location, infrared sensors to detect heat sources, contact sensors, tactile sensors to give a sense of touch, or optical/vision sensors. For most any environmental situation, a robot can be equipped with an appropriate sensor. A robot can also monitor itself with sensors.

There are many different types of sensors. The simplest is the bumper sensor or switch. They can detect collisions, limit travel, and even detect drop-offs. Their use is almost a requirement to backup other sensors that may fail. This sensor consists of a switch and a lever of a certain length to server as an actuator for the switch.

Another simple sensor for robots uses the light sensitivity of Cadmium Sulfide or CdS cells. These change resistance based on the intensity of light shining on them. These work well for finding light and dark areas or in line detection in line following robots. Infrared sensor circuits have many varieties. The simplest uses an IR LED to deliver the light and an IR sensitive phototransistor to see it. The phototransistor turns on when IR light hits it, whether from the LED or ambient sources or reflected. IR sensors are commonly used to detect distance. The IR LED would bounce off walls or other stationary objects and transmit back to the phototransistor to tell the robot how far away it is from the object. Sonar provides another method of telling your robot where things are. Sonar rangers have been good at providing the distance to an object through pinging a transducer and waiting for a return echo. Many sensors exist; just getting them to work for the robot is the real challenge.

The sensors that we will be using will be infrared, touch and possibly sound. We will be using the infrared sensor to give the robot a sense of direction and so that it will be aware of its surroundings. This will be its vision. We will be using touch sensors for the hand of the robot. Since we want the robot to pick up various objects without damaging them, the touch sensors will tell the robot when to let up on the pressure so that it will not damage the payload. Lastly, we might use sound sensors for yet again to give the robot some more sense of its surroundings. These sensors will work like radar telling the robot if anything or anyone is around it. These sensors will make the robot a lot more aware and therefore more useful and less prone to damage.

Power Supplies

Energy is the sustenance of life and without which no action can take place. The same holds true for robots, without significant power a robot will be nothing but a pile of mechanical parts. The movies often exaggerate the ability to power a robot; some Hollywood Bots have had miraculous nuclear power supplies that were the size of a lunch box. In reality, scientists have had a very difficult time in producing power supplies that are both efficient and have a large storage capacity. Science has given us the ability to use solar power, Wind powered electric turbines, hydroelectric power, Nuclear power, and Electricity (in the form of a direct connection to an Alternating Current outlet or a Direct Current battery). When researching power supplies for the robot, I learned that though there are many varieties of power out there, most cannot be stored easily, others are very dangerous, and most are unpractical. When deciding which type of power supply to use, we took into account: Cost, Efficiency, and Practicality. Which lead us to choose

Electrical DC battery power, but what we did not realize was that there are many types of batteries and not all are suitable for robotics.

There are seven main types of batteries, which come in a variety of shapes, sizes, and configurations.

<u>ZINC:</u> Zinc batteries are often referred to as flashlight cells and are considered to be the staple of the battery industry. There are two chemical makeups of zinc batteries: Carbon Zinc and Zinc Chloride. The Carbon Zinc is the everyday or "regular-duty" battery often used around the house, but not very useful in robots. The Zinc Chloride battery is thought to be the more heavy-duty of zinc batteries but also will not be very useful in building a robot.

<u>ALKALINE:</u> Alkaline cells use a special alkaline manganese dioxide formula. They last approximately 800 percent longer than carbon zinc batteries and are very good for use in robotics with one downfall. They have only recently begun making rechargeable alkaline batteries and replacement could be costly.

<u>NICKEL-CADMIUM:</u> "Ni-Cad" or Nickel Cadmium is known for being rechargeable, inexpensive and easy to acquire. Ni-Cads are often used in handheld vacuums and photoflash cameras. One downside is that they contain cadmium, a highly toxic material. Nickel Cadmium batteries are a good choice for the money and variety, but they do not last nearly as long as alkaline or zinc batteries.

<u>NICKEL METAL</u>

<u>HYDRIDE:</u> Nickel Metal Hydride batteries, also referred to as "NiMH", are among the best in price and performance. They outperform the Ni-Cads significantly in very high current situations, but are known to have a problem holding a charge. They tend to lose juice quickly (even while in storage) and often need to be recharged.

<u>LITHIUM &</u>
<u>LITHIUM ION:</u> Lithium & Lithium Ion batteries are among the most expensive batteries and are often used in notebook computers. One major advantage is that they have the highest "energy density" of almost any other commercial battery. They can retain their charge for months or even years, but cost is always an issue.

<u>LEAD-ACID:</u> Best known for being your car battery, Lead-Acid batteries are also rechargeable and are known to have an impressive between-charge life. These are known to be the most effective for use in robotics. Though many types of this battery are very heavy, the motorcycle battery is often thought to be the perfect robot battery. It is easy to get, compact, powerful, and relatively lightweight.

Accounting for the voltage variability, efficiency (re-chargeable or not), and cost. We chose to go with lead-acid batteries. It should supply us with ample power for all of our motors, microcontroller and many sensors. Though it is significantly heavier than the other types of batteries, we believe it to be the best option for cost, reliability, efficiency, and practicality. Now we must do our calculations, because powering a robot is very complex. Voltage ratings must be taken into account, as well as capacity, recharge rate, and internal resistance. Many parts require power and it is in your best interest to check into voltage requirements and settings. Each motor requires a certain voltage, without which it may not operate or may get damaged. Another smart step to take is to incorporate fuses into your wiring, to ensure they blow before any of your expensive parts.

Locomotion

The ability to get from one place to another is often not necessary in industrial robots, but in our case is very important. There are three common methods of locomotion: Legs, Wheels, and Tracks. Without thought, you could say, "Let's just puts some motors and wheels on it and watch it go," but locomotion is one of those subjects that require a little thought. What type of environment is my robot going to be in? Heavy terrain, Indoor Carpeting or something else? Are there steps that the robot will need to climb? Will the robot be able to ride over any objects that might get in its path? All of these questions are just meant to spark to thought as to the requirements you might have for your robot.

Wheels and Tracks

Wheels and tracks are the most common methods used in the locomotion of robots. Wheels are most popular for a number of reasons. They are inexpensive, durable, efficient, and easy to use, but there are a few designs configurations to think about. The width of your wheels can affect the precision of your robot, narrower wheels have a tendency to favor one side and will curve slightly, rather than drive in a straight line. Two or four wheels? Two wheels are sufficient when placed on either side of the robot and balanced by one or more casters. Four wheels will resemble the functionality of tracks, they will tend to skid and cause friction with their drive surface. Tracks are less common but still popular for functionality. They take your robot where it needs to go, but with wear and tear on the driving surface along the way (Don't use it on your nice hardwood or tile floors). Tracks turn by skidding or slipping, and they are most suited for use on dirt.

Legged Robots

Popularity of legged robots is growing due to a lowering cost in servos and a ready availability of smart microcontrollers. Legged robots are more complex and require greater precision in assembly to make them work. At the minimum, legged robots require two servos to control the right and left leg, but more legs are often used due to the complexity of building two legged robots. It certainly takes less time to assemble and coordinate the legs, but there is ONE MAJOR SETBACK – Balancing. Balance is an intelligence that is difficult to explain and even harder to program. You must take into account the center of gravity of your robot as well as weight distribution (you don't want it to be too top heavy). The problem with balancing a robot when it walks and/or runs has aroused engineers around the world to try to conquer the task. Currently the Chinese are leading the way with their experiments with robots playing soccer.

Taking all these questions, and all this information into account, we have decided that we will be building a robot with two drive wheels fashioned at opposite ends and casters in place for balance. Wheels are very inexpensive, efficient, versatile, and practical in our work environment. Had we wanted to build a robot to travel outdoors on grass and dirt we would have certainly chosen tracks, but using tracks in a house would just scuff and mark the household floors.

Motors

The muscles of robotics are motors. They are used for all processes of movement, from walking or driving, to lifting and carrying. Motors can be divided into two classes, AC and DC, which depend upon the power supply they require. These are just classes of motors of which there are many types. When shopping for a motor, do your research because they come with a wide variety of options. Torque, speed, operating voltage, gears, continuous or stepping, and current draw are all to be thought of when deciding what task your motor will be used to perform.

Direct Current motors are very popular in the engineering of a robot, but a suitable motor should always be reversible, unless you are completely sure that this motor will be used for one specific task that does not require it. Alternating Current motors are a possibility, but are very rarely used for robot due to a lack in portable AC power supplies. Continuous and stepping motors have one variation in their operation. Continuous motors rotate their shaft continually with power, and the power needs to be pulsed. A stepping motor rotates the shaft only a few degrees with power and can run on continuous power.

CONCLUSION

Due to the constraints of time and money that student status has placed on us we are unable to explore our topic as much as we would hope. Our robot project is still in the research and design phase, until we receive sufficient funds to purchase the necessary parts to begin production. We have a project deadline of April 1st, but we are planning to complete the construction and begin testing in mid February – early March. This will allow us to record our observations and data about the operating of our robot under test conditions. We are hoping to perform a series of diagnostic tests, on our programming as well as the engineering design.

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