A TECHNOLOGY IN ACTION™ BOOK

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Robot Building

for Beginners

Unlock the mysteries of robot anatomy and fundamentals

Master digital multimeters, LEDs, breadboards, soldering irons, and more

Complete step-by-step instructions for building a spectacular line-following robot from scratch

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CHAPTER 1

Welcome Robot Inventor!

YOU'VE CHOSEN A STIMULATING and rewarding hobby. It's more expensive than bug collecting, but less expensive than stock-car racing.

Think of it: One day your hands will be giving birth to new life forms. Initially, they'll be rudimentary, but like all handcrafted art, each piece will be unique. And like a great artist's works, your pieces will gradually become more complex and more wonderful.

Despite decades of public fascination with the concept of robots, helpful personal robots remain an unfulfilled dream. Other than industrial robots, most advancements in the field of robotics are actually due to somewhat unrelated consumer products, such as personal computers, CD players, toys, remote controls, and household appliances.

Disheartening? No. It's exciting to be involved in a field that's rife with world-changing potential. You can make a difference because there is still so much room for new inventions. So, welcome to robotics and let's get started!

Four Disciplines

Robotics comprises at least four major branches of learning:

- Electrical Engineering (circuits and sensors)
- Mechanical Engineering and Machining (gears, motors, and body)
- Computer Science (pseudo-intelligent behavior)
- Arts (expression, style, and fun)

You don't need to be an expert in each field in order to build a decent robot. However, if you happen to have a background in one field, your creations will naturally revolve around that strength. Along the way, robotics provides an exciting opportunity to learn new skills and find hidden talents.

Think of the Renaissance artist and scientist, Leonardo da Vinci. If he were around today, he'd be making robots.

Anatomy of a Homemade Robot

Robots come in a wide variety of shapes and sizes. The point at which an electronic or mechanical object becomes a robot is open to debate. Movement seems a basic requirement to be a robot, as do sensors and some form of intelligence.

Figure 1-1 shows a typical homemade robot. This robot is capable of finding opposition robots (or any objects) on a table and knocking them off. It does so without any human control. Would most people identify this as a robot?

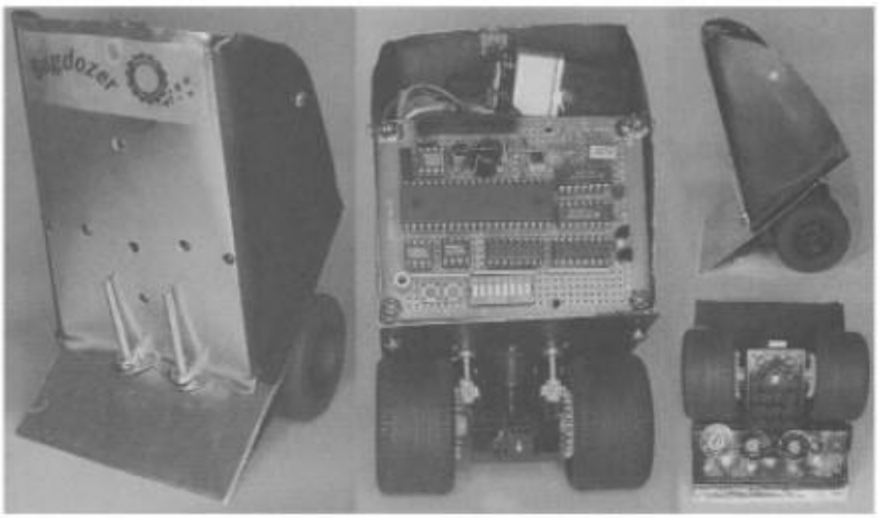

Figure 1-1. Multiple views of the battered champion sumo robot, Bugdozer

People are more likely to identify an object as a robot when it has all the rudimentary sections of a complete being. People look for eyes and a mouth (generally a face), legs, and a torso, as though they were examining an insect or exotic animal.

From an anatomical perspective, robot parts generally fit into one or more of the following categories:

- Brains
- Electrical Power
- Sensors
- Action and Feedback
- Body/Aesthetics

As a robot doctor, you'll become familiar with robot guts. The next sections of this chapter describe some common things you'll find under a robot's hood.

Brains

Robots can be built without a brain, such as those robots operated by a human via remote control or a joystick. Robots can also be built with distributed brains, where simpler chips handle individual parts (such as a leg or an arm) without knowing anything about what the rest of the body is doing. Or, robots can even be built with the brains located away from the body, such as on a laptop computer.

But, all in all, the top choice for robot brains is the microcontroller chip (see Figure 1-2). Microcontrollers are very similar to microprocessors, which are found in personal computers. A microcontroller differs in that it is almost like an entire tiny computer merged into a single piece.

Figure 1-2. A Motorola GP32 microcontroller

Microcontrollers have small amounts of memory and storage space built directly into the chip. Where the PC microprocessor dedicates its channels to high-speed memory connectors, a microcontroller has a diverse variety of input and output ports. These ports can connect directly to sensors, buttons, and other odd devices.

Unsung heroes, microcontrollers surround us, yet few people know about them. Microcontrollers are in automobiles, household washers, dryers, VCRs, and other appliances. The multi-billion-dollar market for microcontrollers makes them inexpensive and plentiful.

That's right, one day your robots are going to have the brains of a dishwasher! Put some wheels on a Maytag® and you've got a great robot. To make things easy, the robot built in this book uses a simple comparator chip instead of a microcontroller.

Electrical Power

Although robots can be built with gasoline-powered engines and pneumatic actuators, at some point almost every robot contains electronic components. The electrical power supply consists of a raw power source, a regulating circuit to stabilize and process the source, and a switch to activate and deactivate.

Power Source

Except in extreme circumstances, hobby robots are supplied power from popular consumer batteries (see Figure 1-3). Batteries are safe, inexpensive, readily available, reliable, and standardized. The main robot presented in this book uses a 9 V consumer battery for those reasons.

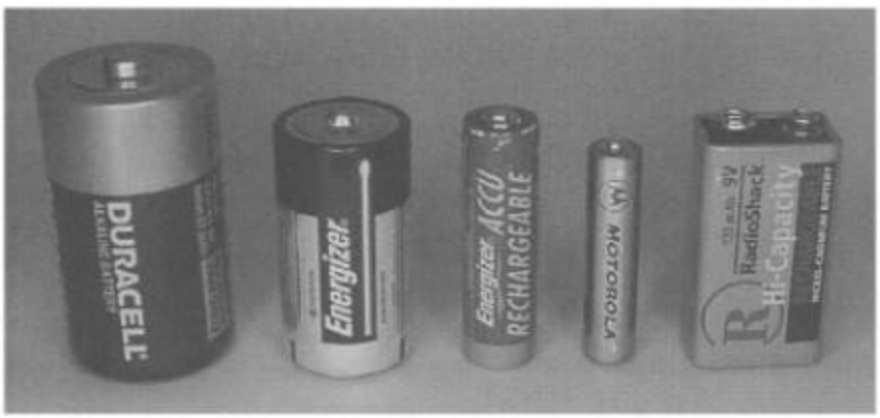

Figure 1-3. Common battery sizes

Rechargeable batteries are preferable. Although their initial cost is higher, they'll save the experimenter a lot of money in the long run.

Solar power is also an option. Because light isn't constantly available, rudimentary solar-powered robots operate in repeating charge and discharge cycles, powering off between bursts of activity. More sophisticated solar-powered robots recharge batteries during optimal lighting conditions, with the batteries maintaining power to the brains during dark conditions.

Power Regulation

Most robots have a small portion of their bodies dedicated to keeping a steady, specific level of power available to all of the electronics. This is called power regulation (see Figure 1-4).

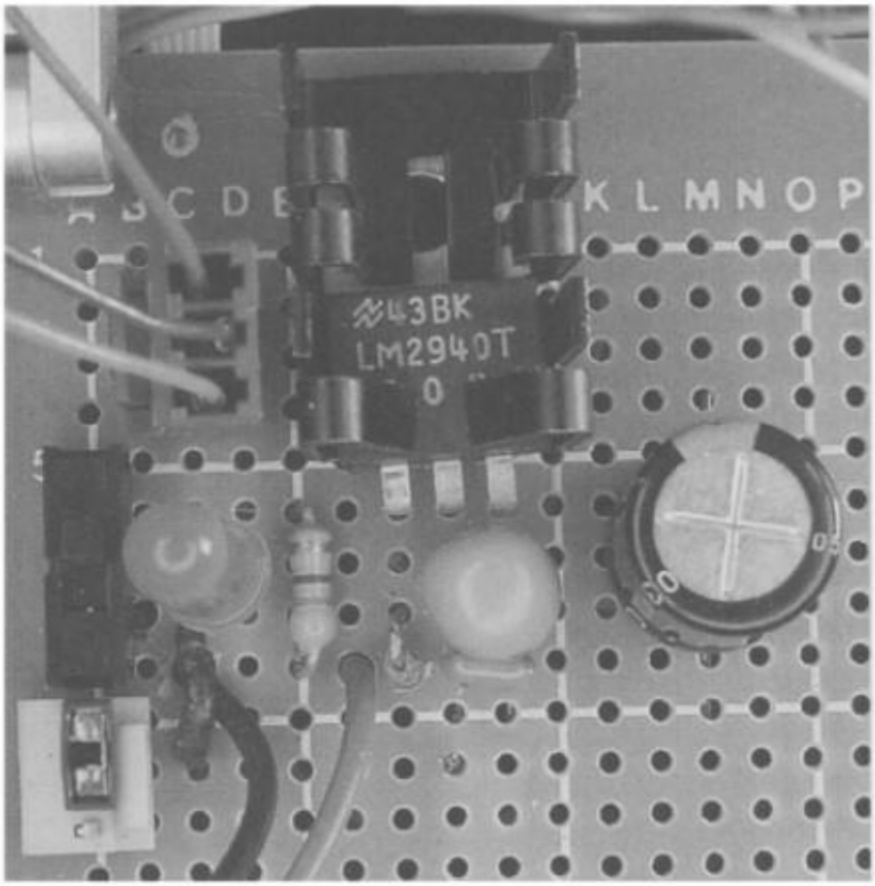

Figure 1-4. Power regulating circuit based on LM2940T-5.0

As batteries are used up, they provide less and less power. Unless stabilized, this would result in a robot that moves at different speeds and has different light brightness and sensor readings based on battery freshness.

Another reason for power regulation is that some parts of the robot need more power than other parts. For example, motors require more power than logic chips or blinking lights. The power regulation module steps down (or, conversely, boosts) the battery power to the range needed by each major part. To reduce the complexity of the robot presented in this book, all of its parts can operate at the varying voltages of the battery. As such, no voltage regulator is necessary.

On/Off Switch

Most robots have power switches (see Figure 1-5). This allows the robot to be disabled for maintenance or storage.

Figure 1-5. A heavy-duty power switch

Interestingly, solar-powered robots usually *don't* have a power switch. Those robots wake up in the morning sunshine and dance all day.

Sensors

There are more sensors in a single crease of your brow than there are in any robot ever built. With the exception of the pixel elements of a vision module, most homemade robots end up with fewer than a dozen sensors of four or five major types.

A complicated homemade robot might have infrared object detection, touch switches, brightness sensors (see Figure 1-6), a battery tester, tilt switches, and perhaps a temperature probe. Even with so few inputs, the robot can do really interesting things.

A couple of pushbuttons are usually dedicated for human input. Buttons can trigger a change in modes or the beginning of an experimental sequence. Alternatively, crafty engineers can discard dedicated buttons and instead wave a hand in front of various sensors to indicate a desired action.

Action and Feedback

Robots perform actions coordinated with the processing of sensor information. Most often the action is in the form of movement. However, sounds, displays, indicator lights, and other forms of feedback are also actions, which are usually intended to provoke humans to act.

Movement

Most homemade robots move around with only a single pair of wheels (see Figure 1-8). Unlike an automobile's four wheels and one motor, a robot's two wheels and two motors provide agile turning and sufficient force without the additional weight of elaborate drive trains.

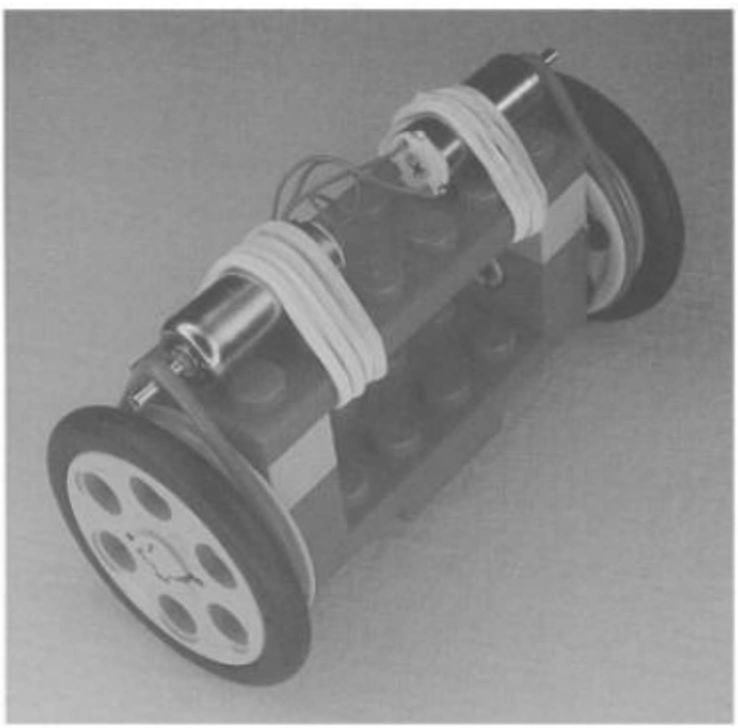

Figure 1-8. Pair of tiny pager motors attached to wheels via belts

Mechanical legs are a blast to see in action, but are more complicated to actually build. There are some simple wire-feet and six-legged variations that are easier to implement, although with less dexterity.

Motor Controller

Like the power regulator, a motor controller section (see Figure 1-9) is required on most robots. The sudden starting and stopping (and stalling) of motors involves bursts of power; much more power than the brains can supply by itself. So, a portion of the robot is dedicated to managing the enabling of the motors and is responsible for protecting the rest of the electronics from backlashes and surges.

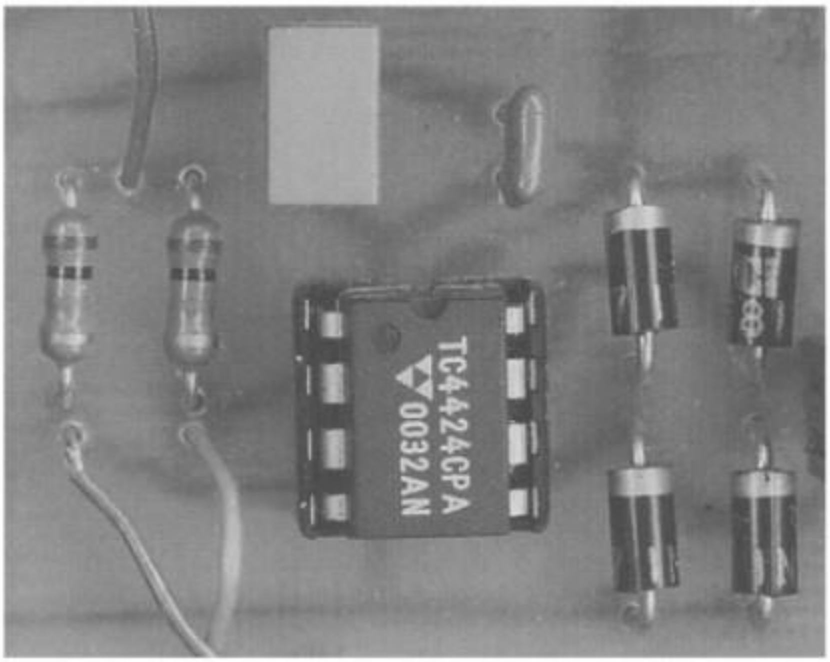

Figure 1-9. Motor control circuit with MOSFET chip and Schottky diodes

Indicator Lights

Lots of tiny lights adorn most robots. LEDs (light-emitting diodes) indicate power status, motors engaging, sensor detection (see Figure 1-10), and decision-making. This display of the robot's state makes error correction and design improvements a lot easier. Of course, the lights also make a robot look more fascinating.

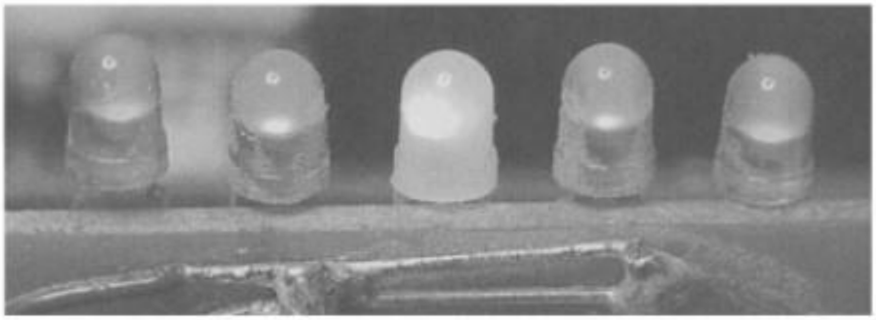

Figure 1-10. A row of LEDs for target detection

LEDs are simple to use. They're inexpensive, lightweight, cool to the touch, and are being produced in an increasing variety of colors.

Miscellaneous Components

You'd be amazed at how quickly the connections to the brains can get used up. A few support chips are commonly used to gather connections together before reaching a microcontroller. Support chips can also preprocess signals (such as from sensors and buttons) to decrease the workload of the brains.

A lot of other stuff is needed, too! Wires, connectors, capacitors, resistors, diodes, and other components (see Figure 1-11) play important roles in bringing circuits together.

Body

Unless you're building a jellyfish or paper-bag robot, all of the parts must be attached to a primary frame. Surprisingly, many designers fail to pay enough attention to the robot's body. They end up with a mess that either collapses under its own weight or limps around in an awkward way.

Not only does a good body hold the pieces together, but it also protects them against injury. An unfortunate number of homemade robots turn out to be too delicate, with wires hanging out and circuit boards exposed.

Aesthetics

The other important aspect of a body is visual appeal (see Figure 1-12). No matter how technically amazing your robot, the finishing touches in appearance greatly affect how onlookers perceive the robot. Never underestimate showmanship.