**ROBOTS AS ANDROIDS**

Robotic factories are increasingly commonplace, especially in heavy manufacturing, where tolerance of repetitive movements, great strength, and untiring precision are more important than flexibility. Robots are especially useful in hazardous work, such as defusing bombs or handling radioactive materials. They also excel in constructing tiny components like those found inside notebook computers, which are often too small for humans to assemble.

Most people think of robots in science fiction terms, which generally depict them as androids, or simulated humans. Real robots today do not look human at all, and judged by human standards, they are not very intelligent. The task of creating a humanlike body has provided incredibly difficult. Many technological advances in visual perception, audio perception, touch, dexterity, locomotion, and navigation need to occur before robots that look and act like human beings will live and work among us.

**Visual Perception**

Visual perception is an area of great complexity. A large percentage of the human brain is dedicated to processing data coming from the eyes. As our most powerful sense, sight is the primary means through which we understand the world around us. A single camera is not good enough to simulate the eye. Two cameras are needed to give stereoscopic vision, which allows depth and movement perception. Even with two cameras, visual perception also involves understanding what the cameras are seeing. Processing the image is the difficult part. In order for a robot to move through a room full of furniture it must build a mental map of that room, complete with obstacles. The robot must judge the distance and size of objects before it can figure out how to move around them.

**Audio Perception**

Audio perception is less complex than visual perception, but no less important. People respond to audible cues about their surroundings and the people they are with without even thinking about it. Listeners can determine someone’s emotional state just by hearing the person’s voice. A car starting up when someone crosses the street prompts the walker to glance in that direction to check for danger. Identifying a single voice and interpreting what is being said amid accompanying background noise is a task that is among the most important for human beings—and the most difficult.

**Tactile Perception**

Tactile perception, or touch, is another critical sense. Robots can be built with any level of strength, since they are made of steel and motors. How does a robot capable of lifting a car pick up an egg in the dark without dropping or crushing it? The answer is through a sense of touch. The robot must not only be able to feel an object, but also be able to sense how much pressure it is applying to that object. With this feedback it can properly judge how hard it should squeeze. This is a very difficult area, and it may prove that simulating the human hand is even more difficult than simulating the human mind.

Related to touch is the skill of dexterity, or hand-eye coordination. The challenge is to create a robot that can perform small actions, such as soldering tiny joints or placing a chip at the precise spot in a circuit board, within half a millimeter.

**Locomotion**

Locomotion includes broad movements such as walking. Getting a robot to move around is not easy. This area of science is challenging, as it requires balance within an endlessly changing set of variables. How does the program adjust for walking up a hill, or down a set of stairs? What if the wind is blowing hard or a foot slips? Currently, most mobile robots work with wheels or treads, which limit their mobility in some circumstances but make them much easier to control.

**Navigation**

Related to perception, navigation deals with the science of moving a mobile robot through an environment. Navigation is not an isolated area of artificial intelligence, as it must work closely with a visual system or some other kind of perception system. Sonar, radar, mechanical “feelers,” and other systems have been subjects of experimentation. A robot can plot a course to a location using an internal “map” built up by a navigational perception system. If the course is blocked or too difficult, the robot must be smart enough to backtrack so it can try another plan.