ROBOTS on the Job

Robots are on the verge of replacing humans in a wide variety of tasks. As designers overcome ever-sophisticated challenges, automatons now make coffee, assist during surgery, and even teach schoolchildren. Meet the robot workers that are taking on the tough jobs we once thought only humans could handle

WORK 'BOTS

It's one thing to create robots that perform repetitive, unchanging tasks, such as assembling cars. It's another to build a robot that can interact with people in the workplace. If robots are to work alongside us, they'll have to seem empathetic, fit in the same spaces, move in familiar ways. But combining these complex capabilities into a single robot, and giving that robot the capacity to recognize and adapt to various social situations, is perhaps the greatest design challenge of all.

Schoolteacher

NAME Saya

BACKGROUND Electrical engineer Hiroshi Kobayashi of the Tokyo University of Science originally developed a prototype of Saya in 1993 in an attempt to use facial expressions to allow robots to communicate emotions. Now the robot can teach class at a Tokyo elementary school, answer phones, and greet visitors in an office.

CAPABILITIES Saya behaves much like a real schoolteacher. In experiments at elementary schools, it gave children homework, observed and responded to their speech and behavior, called their names, and made eye contact with them. When prompted by an operator, the 'bot encouraged or warned them verbally or through its lively facial expressions. Saya can also use speech recognition and speech-synthesis systems to function as a receptionist. The robot speaks Japanese and English and could learn to speak more languages with voice-synthesis software.

CHALLENGES Saya's creators hope they can make its face even more lifelike. Today it can express surprise, fear, disgust, anger, happiness and sadness. The researchers' aim is to make its expressions more realistic using new mechanisms to move the muscles and new skin materials. Facial expressions aren't just important for communication between people, they're also important for a teacher seeking to get information across to a roomful of schoolchildren.

EMOTIVE BOOST

Engineers have put a lot of effort into giving Saya a lively face. They have provided it with artificial muscles that expand and contract with the aid of pneumatics. A mechanical system using blasts of air lies beneath the robot's skin and drives these muscles. As a result, Saya can, for example, lift its eyebrows while crinkling its nose or smile with its mouth and eyes. The robot's artificial skin (made of soft urethane resin) is cast in a mold and feels as soft and pliable as human flesh.

High-Precision Surgeon

NAME RIO

BACKGROUND The RIO robotic arm began with a 'bot developed at the Massachussetts Institute of Technology that could catch and throw a ball. The arm was adapted by MAKO Surgical Corp. in Florida, and RIO performed its first surgery in 2006.

CAPABILITIES In partial knee surgery, the arm uses a CT scan to help plan the size and placement of an implant and then aids the physician in precisely carrying out the surgery. The result should mean a less invasive and less traumatic surgery, with fewer complications and faster recovery for the patients.

CHALLENGES Designers want to make the arm capable of adjusting even if patients move, and they hope to eventually extend the technology to joints other than the knee.

Babysitter

NAME Rovio

BACKGROUND Launched in 2008, Rovio relays live video feeds to a user over the Web. It can also be taught to navigate through rooms by itself, inform users when its power is running low, and return to its charging station.

CAPABILITIES The little robot is equipped with a video camera, speakers and a wireless Internet connection. Users—say, parents running an errand—can control and communicate through Rovio remotely over the Internet. A clip-on headlight allows Rovio to capture video even at night.

CHALLENGES Rovio could make impromptu teleconferencing as natural as speaking to someone in the room. Rovio's designer, Hong Kong–based WowWee, is investigating adding high-resolution audio and video in future versions, as well as environmental, temperature and motion sensors.

Nurse's Aide

NAME GuiaBot

BACKGROUND Its designers at MobileRobots intended GuiaBot for face-to-face interactions with humans, and since its unveiling in 2008, it has been used for office and hospital work.

CAPABILITIES The 40-inch, 110-pound robot, equipped with a laser, a high-definition camera and a touchscreen, can navigate autonomously through a hospital (it even says "Excuse me") and act in the roles of receptionist, night watchman or guide.

CHALLENGES Its designers hope to adapt it for use in hotels, airports and stores. Since users can extensively customize the robot and its interface, GuiaBot could soon have dozens of abilities and applications.

CLOCKWISE FROM TOP LEFT: MAKO SURGICAL CORP.; WOWWEE GROUP; MOBILEROBOTS INC.; PRECEDING PAGES: I. KATO/REUTERS/SCANPIX

HOME 'BOTS

Robots are becoming part of the family. Today they can vacuum, shovel snow, and play with the kids, and in the next few years, the number of robots found in the home could rise markedly. Sensors and intelligence need improvement so that they can understand and interpret the world and then choose appropriate action. High on the list is facial recognition and the ability to identify emotions.

FROM LEFT: Y. TSUNO/AFP/SCANPIX; HONDA

Butler

NAME Asimo

BACKGROUND When the first version of Honda's Asimo was built in 1986, the robot needed five seconds to take a single step. Today the robot is capable of jogging. Several companies have made humanoid robots similar to Asimo, such as Mitsubishi's Wakamaru robot, which reminds patients to take their medicines, and Toyota's Partner Robot.

CAPABILITIES Asimo is one of the world's most advanced humanoid robots. It is 4'3" and 119 pounds, is able to climb stairs, and can run a mile in about 16 minutes. Asimo responds to voice commands, postures and gestures and can maneuver among people, moving aside if it encounters someone in an elevator or on the stairs.

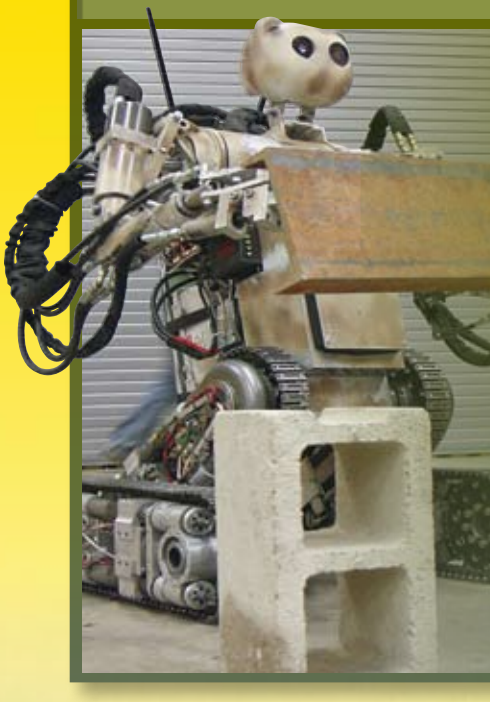
CHALLENGES The newest model of this 24-year-old robot can cooperate with other Asimos to complete its tasks. The robots share information by wirelessly informing each other what they are doing and where they are located. They can, for example, work together to serve refreshments to humans. If one Asimo takes a break to get its batteries recharged, another will step in to take its place.

Additionally, Asimo can recognize up to 10 people's faces and address each by the correct name. The team that created it hopes to go further and make a humanoid robot that can behave completely autonomously and be truly intelligent, but such a feat will require a better understanding of the human brain.

MIND CONTROL

The Asimo design team has developed technology that allows a human to control the 'bot with his or her thoughts. Helmet sensors gauge tiny changes in the brain's electrical impulses and blood flow—the first time these measurement methods have been combined for this purpose. The helmet's software assesses changes in the brain in real time and translates them into commands. They are transmitted to Asimo, which then lifts its arm, for instance, or takes a step.

Battlefield Extractor



NAME BEAR

BACKGROUND Vecna Robotics created the Battlefield Extraction Assist Robot, or BEAR, with support from the U.S. Army. It could hit battlefields in six years.

CAPABILITIES BEAR can carry heavy cargo or tiny, fragile objects while crouching behind cover or traveling over obstacles. Its cameras and microphones allow for remote or semi-autonomous operation.

CHALLENGES Expected improvements include the ability to navigate complex environments, such as dangerous buildings, on its own.

Spybot

NAME T-Hawk

BACKGROUND This flying spybot was successfully battle-tested in Iraq and is on its way to having a permanent position in the American and English militaries. T-Hawk was a collaboration between the U.S. Department of Defense and the contractor Honeywell.

CAPABILITIES T-Hawk is equipped with an ordinary video camera plus an infrared camera for night vision. Soldiers can use the camera to find roadside bombs and other threats. The robot can fly for up to 50 minutes at speeds of up to 50 mph and, at 17 pounds, can be carried in a backpack. It takes off and lands vertically, and soldiers can either control it manually using a console or send it out on a preprogrammed route that the robot will navigate by flying from one GPS landmark to the next.

CHALLENGES Honeywell is looking to outfit T-Hawk with radar and other sensors to detect chemical, biological and radiation threats. Eventually, the robot may have interchangeable payloads. It is being tested for police use and could have commercial applications as well—inspecting pipelines and bridges, for example.

Rescue and Recovery

NAME RoboCue

BACKGROUND RoboCue was developed in 1994 in Japan for rescues where hazardous substances made the area too dangerous for firefighters. Tokyo's fire department uses a RoboCue half the size of the first model [below].

CAPABILITIES Operated by remote control, RoboCue retrieves and revives victims in dangerous circumstances. It can be fitted with as many as three cameras, a communication device for speaking with victims, an oxygen supply and a device to analyze the environment for firefighters.

CHALLENGES RoboCue had to be made as small as possible while remaining extremely strong and durable. Although it is more compact, the latest RoboCue can still use its arms to lift an adult man to its conveyor belt and drag him to safety.

CLOCKWISE FROM TOP LEFT: T. HANAI/REUTERS/SCANPIX; HONEYWELL; COURTESY TOKYO FIRE DEPARTMENT

DANGER 'BOTS

The number of robots found in the world's war and conflict zones is likely to increase in the near future. Both the American and English militaries are working with civilian companies to design and deploy robots for battle. One of the challenges is to develop robots that can move over rough ground—places four-wheeled vehicles would find hard to pass. Another challenge is to integrate delicate sensors and expensive devices into robots that will have to tolerate rugged, often dangerous conditions and operate day and night.

BigDog can carry up to 330 pounds of baggage and supplies through most terrain.

BOSTON DYNAMICS

Beast of Burden

NAME BigDog

BACKGROUND For decades, engineers have sought to understand how people and animals move and maintain their balance. Researchers at Boston Dynamics developed a stable four-legged robot named BigDog that can function as a soldier's mule.

CAPABILITIES BigDog is about the size of a small donkey and weighs 240 pounds. It can walk at about 3.5 mph, cross mountainous terrain, and climb a 35-degree slope. It can carry 330 pounds of ammunition or supplies over a flat surface and up to 120 pounds through mud and rocks. The robot has four legs, a GPS receiver and a 15-horsepower go-kart engine that powers its movement. It is equipped with four hydraulic actuators on each leg, and 50 sensors, including some on the legs that monitor resistance encountered by each actuator. A computer processes input from the sensors and calculates where to place the next step. BigDog can maintain its footing even on slippery surfaces like ice and snow.

CHALLENGES The ultimate goal for a legged robot like BigDog is to be able to reach the same places as people and animals. This means crossing water, walking in deep snow, and climbing muddy hillsides. It is well on its way—a future BigDog model could soon have better balance and be able to cover harsher terrain and get back up if it falls. This would make it even more useful as a mule, especially for military transport.

BALANCE BREAKTHROUGH

Whereas a mechanical gyroscope maintains stability by spinning, BigDog uses a laser gyroscope to measure and maintain its orientation with beams of light. Laser gyroscopes are more reliable than mechanical ones, and combining information from this gyroscope with the robot's sensors and guidance system provides BigDog with a fantastic sense of balance. The guidance system adjusts BigDog's balance 500 times per second and directs the robot's movements, making even the present version very hard to tip over.