Two-legged robot mimics human balance while running and jumping

Date: October 30, 2019
Source: Massachusetts Institute of Technology

Rescuing victims from a burning building, a chemical spill, or any disaster that is inaccessible to human responders could one day be a mission for resilient, adaptable robots. Imagine, for instance, rescue-bots that can bound through rubble on all fours, then rise up on two legs to push aside a heavy obstacle or break through a locked door.

Engineers are making strides on the design of four-legged robots and their ability to run, jump and even do backflips. But getting two-legged, humanoid robots to exert force or push against something without falling has been a significant stumbling block.

Now engineers at MIT and the University of Illinois at Urbana-Champaign have developed a method to control balance in a two-legged, teleoperated robot - an essential step toward enabling a humanoid to carry out high-impact tasks in challenging environments.

The team's robot, physically resembling a machined torso and two legs, is controlled remotely by a human operator wearing a vest that transmits information about the human's motion and ground reaction forces to the robot.

Through the vest, the human operator can both direct the robot's locomotion and feel the robot's motions. If the robot is starting to tip over, the human feels a corresponding pull on the vest and can adjust in a way to rebalance both herself and, synchronously, the robot.

In experiments with the robot to test this new "balance feedback" approach, the researchers were able to remotely maintain the robot's balance as it jumped and walked in place in sync with its human operator.

"It's like running with a heavy backpack -- you can feel how the dynamics of the backpack move around you, and you can compensate properly," says Joao Ramos, who developed the approach as an MIT postdoc. "Now if you want to open a heavy door, the human can command the robot to throw its body at the door and push it open, without losing balance."

Swarm of tiny drones explores unknown environments

Date: October 23, 2019
Source: Delft University of Technology

Researchers have presented a swarm of tiny drones that can explore unknown environments completely by themselves. This work, presented in *Science Robotics* on 23 October, forms a significant step in the field of swarm robotics. The challenge comes from the fact that the tiny 33-gram drones need to navigate autonomously while having extremely limited sensing and computational capabilities. The joint research team -- with researchers from TU Delft, University of Liverpool and Radboud University of Nijmegen -- tackled this challenge by drawing inspiration from the relative simplicity of insect navigation.

Inspiration from nature

Insect swarms have inspired roboticists to think that small robots may also be able to overcome their individual limitations by operating in a swarm. Swarms of small and cheap robots would be able to perform tasks that are currently out of reach of large, individual robots. For instance, a swarm of small flying drones would be able to explore a disaster site much quicker than a single larger drone. Such swarms have not been realised yet.

Search-and-rescue

Over the last four years, a joint research team of the universities of TU Delft, University of Liverpool, and Radboud University of Nijmegen, financed by the Dutch national science foundation NWO Natural Artificial Intelligence programme, has strived to design a swarm of tiny drones able to explore unknown environments. The goal of the research project was to make steps towards using swarms of drones in search-and-rescue scenarios.

The main idea was that in the future, rescue workers will be able to release a swarm of tiny drones to explore a disaster site such as a building that is about to collapse. The swarm of drones will enter the building, explore it, and come back to the base station with relevant information. The rescue workers can then focus their efforts on the most relevant areas -- for instance, where there are still people inside.

Finding victims

In the project tiny drones were equipped with cameras and sent out in an indoor office environment to find two dummies representing victims in a disaster scenario. This proof-of-concept search-and-rescue task clearly showed the advantage of having a swarm. Within 6 minutes, a swarm of 6 drones was able to explore about 80% of the open rooms -- which would be impossible for one of the drones alone. Furthermore, swarming also turned out be useful for redundancy. One drone found a victim, but due to a hardware failure of the camera, it could not bring back any images. Luckily, another drone captured the victim on camera as well.

Artificial intelligence to run the chemical factories of the future

Date: November 13, 2019
Source: University of Illinois at Urbana-Champaign, News Bureau

A new proof-of-concept study details how an automated system driven by artificial intelligence can design, build, test and learn complex biochemical pathways to efficiently produce lycopene, a red pigment found in tomatoes and commonly used as a food coloring, opening the door to a wide range of biosynthetic applications, researchers report.

The results of the study, which combined a fully automated robotic platform called the Illinois Biological Foundry for Advanced Biomanufacturing with AI to achieve biomanufacturing, are published in the journal *Nature Communications*.

"Biofoundries are factories that mimic the foundries that build semiconductors, but are designed for biological systems instead of electrical systems," said Huimin Zhao, a University of Illinois chemical and biomolecular engineering professor who led the research.

However, because biology offers many pathways to chemical production, the researchers assert that a system driven by AI and capable of choosing from thousands of experimental iterations is required for true automation.

Previous biofoundry efforts have produced a wide variety of products such as chemicals, fuels, and engineered cells and proteins, the researchers said, but those studies were not performed in a fully automated manner.

"Past studies in biofoundry development mainly focused on only one of the design, build, test and learn elements," Zhao said. "A researcher was still required to perform data analysis and to plan for the next experiment. Our system, dubbed BioAutomata, closes the design, build, test and learn loop and leaves humans out of the process."

BioAutomata completed two rounds of fully automated construction and optimization of the lycopene-production pathway, which includes the design and construction of the lycopene pathways, transfer of the DNA-encoding pathways into host cells, growth of the cells, and extraction and measurement of the lycopene production.

"BioAutomata was able to reduce the number of possible lycopene-production pathways constructed from over 10,000 down to about 100 and create an optimized quantity of lycopene-overproducing cells within weeks -- greatly reducing time and cost," Zhao said.

Zhao envisions fully automated biofoundries being a future revolution in smart manufacturing, not unlike what automation did for the automobile industry.

"A hundred years ago, people built cars by hand," he said. "Now, that process is much more economical and efficient thanks to automation, and we imagine the same for biomanufacturing of chemicals and materials."

On the way to intelligent microrobots

Date: November 6, 2019
Source: Paul Scherrer Institute

Researchers at the Paul Scherrer Institute PSI and ETH Zurich have developed a micromachine that can perform different actions. First nanomagnets in the components of the microrobots are magnetically programmed and then the various movements are controlled by magnetic fields. Such machines, which are only a few tens of micrometres across, could be used, for example, in the human body to perform small operations. The researchers have now published their results in the scientific journal *Nature*.

The robot, which measures only a few micrometres across, is reminiscent of a paper bird made with origami -- the Japanese art of paper folding. But, unlike a paper structure, the robot moves as if by magic without a visible force. It flaps its wings or bends its neck and retracts its head. These actions are all made possible by magnetism.

Researchers at the Paul Scherrer Institute PSI and ETH Zurich have assembled the micromachine from materials that contain small nanomagnets. These nanomagnets can be programmed to assume a particular magnetic orientation. When the programmed nanomagnets are then exposed to a magnetic field, specific forces act on them. If these magnets are located in flexible components, the forces acting on them cause the components to move.

Programming the nanomagnets

The nanomagnets can be programmed again and again. This reprogramming results in different forces, and new movements result.

For the construction of the microrobot, the researchers fabricated arrays of cobalt magnets on thin sheets of silicon nitride. The bird constructed from this material could then perform various movements, such as flapping, hovering, turning or side-slipping.

"The movements performed by the microrobot take place within milliseconds," says Laura Heyderman, head of the Laboratory for Multiscale Materials Experiments at PSI and professor for Mesoscopic Systems at the Department of Materials, ETH Zurich. "But programming of the nanomagnets only takes a few nanoseconds. This makes it possible to program the different movements one after the other. This means that the tiny microbird can first flap its wings, then slip to the side and afterwards flap again. "If needed, the bird could also hover in between," says Heyderman.