This air-powered robot requires no electronics for movements

Soft robots are intrinsically secure, highly durable and potentially inexpensive, making them appealing for a wide range of applications. They gained popularity in research circles, owing largely to the safety advantages they provide to humans who may be required to operate in their vicinity. Inflatable components and air pressure have played an important role in soft robotics study, from machines that can move as fast as a cheetah to inflatable grippers that handle fragile objects with caution. However, their evolution remains rather slower than in other fields of robotics, owing partly to the fact that soft robots cannot directly benefit from the huge growth in processing capacity and sensor and actuator supply that we have seen over the last few decades. Also, each of these approaches necessitates the use of electrical circuits, motors and power sources in order to operate, increasing the expense and quality of the final product.

When we think about what makes robots function, we tend to consider their electronic components. Even typical soft robots that are powered by compressed air use electronic circuits for control. However, recently, a group of researchers devised[1] a way to create a robot that does not need any electronics to work for application requiring less complex functions. All of its operations, including its controls and movement systems, require only a continuous supply of pressurized air. Engineers at the University of California, San Diego have created a soft quadruped robot that can walk using air pressure and a valve mechanism to monitor its motions. On the production, there are no circuit boards. The main goal here was to create the most basic air-powered nervous system required to regulate walking. This study was a major step toward fully autonomous, electronics-free walking robots for applications such as low-cost entertainment robotics and systems for service in areas where electronics might not be acceptable.

The new air-powered robot is operated by a lightweight, low-cost pneumatic circuitry system comprising of tubes and soft valves housed onboard the robot. The robot can move in response to cues it detects in its surroundings. The computational power of bot closely resembles mammalian reflexes, which are driven by a neural response from the spine instead of the brain. Natural species, such as quadrupeds, provide inspiration for this by using nervous system components called central pattern generators (CPGs) to prompt repeated movements of limbs used for walking, flying and swimming. This is clearly more complex in some animals than others, and is usually mediated by sensory feedback, but the fundamental mechanism of a CPG is essentially just a repeated circuit that drives muscles in sequence to create a steady, consistent gait.

The engineers created a system of valves that act as oscillators, regulating the order in which pressurized air reaches the robot's four limbs' air-powered muscles. The component that controls the robot's gait slows down the injection of air into its legs. The gait of the robot was inspired by side-neck turtles. Specific mechanical sensors are present in the form of tiny soft bubbles filled with fluid at the ends of booms protruding from the robot's body. When the bubbles are squeezed, the liquid in the robot flips a valve, causing it to change direction.

The robot is outfitted with three valves that act as inverters, causing a high pressure state to spread across the air-powered circuit with a delay at each inverter. Each of the four legs of the robot has three degrees of freedom, which are powered by three muscles. The limbs are 45-degree angled downwards and made up of three parallel, attached pneumatic cylindrical chambers with bellows. The limb bends in the opposite direction when a chamber is pressurized. As a matter of fact, the three chambers of each limb have the required multi-axis bending for walking. To simplify the control problem, researchers paired chambers from each leg diagonally across from one another. A soft valve changes the rotational direction of the limbs between counter-clockwise and clockwise. That valve functions as a latching double pole, double throw switch – a switch with two inputs and four outputs, with each input connected to two corresponding outputs. That mechanism is similar to switching the connections of two nerves in the brain.

The main distinction between the newly constructed robot and existing soft robots is that the latter, albeit powered by pressurized air as well, is controlled by electronic circuits. As a result, several complicated parts, such as circuit boards, valves and pumps, are placed outside the robot's body. The electronic equipment are critical to the robot, functioning as the brain and nervous system, and because of their significance, they are often costly and require a lot of space. The present device is a breakthrough in low-cost robotics applications, such as toys and robots that would run in situations where electronics cannot function. Normal robots cannot operate in areas such as MRI machines or mine shafts. Many researchers are especially interested in soft robotics because they can adapt to their surroundings and safely operate near humans. The researchers also want to develop the robot's gait in the future so that it can walk on natural terrain as well as rocky surfaces. This will help the robot to manoeuvre through a number of obstacles. This will necessitate a more complicated network of sensors and, as a result, a more advanced pneumatic system. The team would also investigate how the technology could be used to build robots that are powered in part by pneumatic circuits for certain functions, such as walking, whereas conventional electronic circuits manage higher functions. This study is analogous to the rover being developed by the Jet Propulsion Laboratory (JPL) to explore Venus; that rover is not a soft robot, but it functions under similar restrictions in that it cannot depend on conventional electrical equipment for autonomous navigation or control. It turns out that there are a plethora of innovative ways to use mechanical (or, in this case, pneumatic) intelligence to create robots with relatively complex autonomous behaviours, which means that in the future, soft (or soft-ish) robots could play significant roles in instances where using a non-compliant system is not a viable option.

1. Drotman, D. *et al.*, *Sci. Robotics*, February 2021; doi:10.1126/scirobotics.aay2627.

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