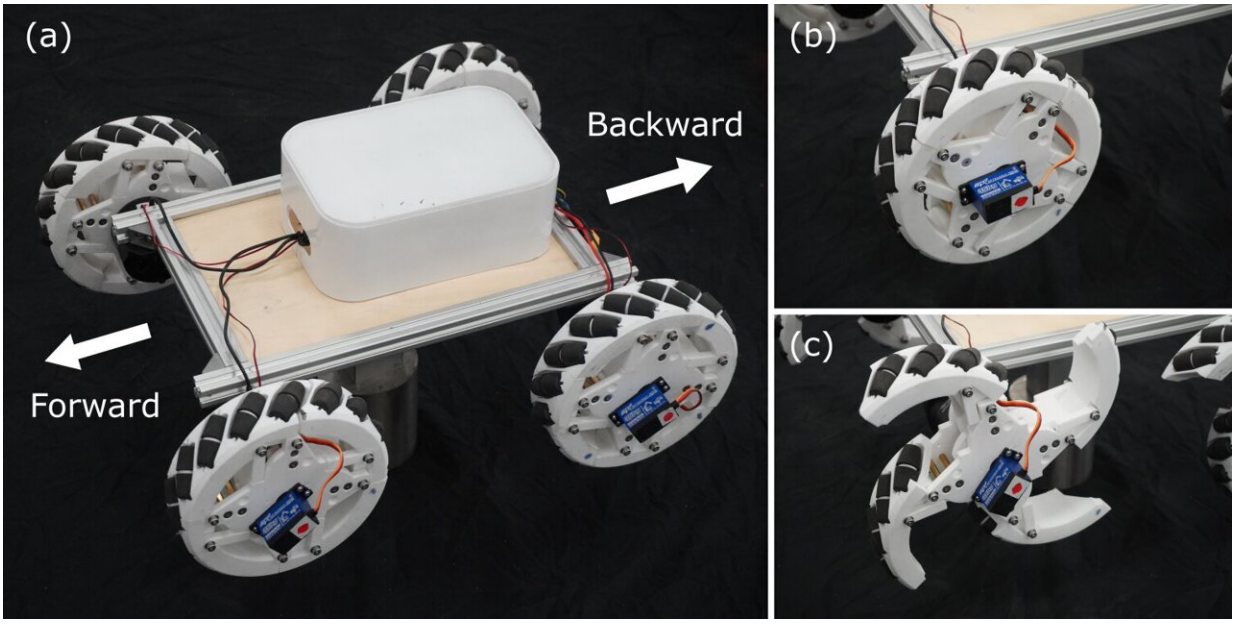
A transformable robot with an omnidirectional wheel-leg

December 7 2022, by Ingrid Fadelli



Credit: Andre Rosendo and Ruixiang Cao

Researchers at Worcester Polytechnic Institute recently created OmniWheg, a robotic system that can adapt its configuration while navigating its surrounding environment, seamlessly changing from a wheeled to a legged robot. This robot, introduced in an IEEE IROS 2022 paper, pre-published on *arXiv*, is based on an updated version of the so-called "whegs," a series of mechanisms design to transform a robot's wheels or wings into legs.

"Quadruped and biped robots have been growing in popularity, and the reason for that might be the search for 'anthropomorphization' that the general audience commonly engages in," Prof. Andre Rosendo, one of the researchers who developed the robot, told TechXplore. "While 'being capable of going everywhere we go' sounds like an exciting appeal, the energetic cost of legs is very high. We humans have legs because that is what evolution gave us, but we wouldn't dare to create a 'legged car,' as we know that this ride wouldn't be as comfortable or energy efficient as a wheeled car ride."

The key idea behind the recent work by Rosendo and his colleagues is that while legs make robots more relatable, giving them a human- or animal-like quality, they are not always the optimal solution to ensure that robots complete tasks quickly and efficiently. Instead of developing a robot with a single locomotion mechanism, the team thus set out to create a system that can switch between different mechanisms.

"Looking around our homes and workplaces we can see that our environments are 95% flat, with an eventual 5% of uneven terrain that we need to face when 'transitioning' between spaces," Rosendo said. "With this in mind, why not develop a system that performs at a 'wheel-like' efficiency in these 95% of cases and specifically transitions to a lower efficiency in the remaining 5%?"

Rosendo and his colleagues set out to create a wheel that could change its configuration to climb stairs or circumvent other small obstacles. To accomplish this, they explored the concept of "whegs" (i.e., wheel-legs or wing-legs), which has been around for over a decade and has since received considerable attention in the field of robotics.

Several wheel-leg systems were developed and tested in the past few years. However, most of these systems did not perform particularly well, mainly due to difficulties in coordinating the right and left side of the

wheel-leg system, which need to be perfectly aligned when a robot is climbing stairs.

"To solve the coordination issues commonly associated with wheel-leg mechanisms, we used an omnidirectional wheel," explained Ruixiang Cao, the leading student behind the creation. "This is the last piece of the puzzle, as it enables the robot to align on-the-fly without rotating its body. Our robot can move forward, backwards, and sideways at a very low energy cost, can remain in a stable position with no energetic cost, and can swiftly climb stairs when needed."

To operate correctly, the wheg system created by Rosendo and his colleagues requires the addition of one servo motor per wheel and a simple algorithm. Other than that, its design is basic and straightforward, so it could be easily replicated by other teams worldwide.

"The advantages of this system are so abundant, and the drawbacks are so few that we can't help but think that they pose a threat to the 'legged robot hype' seen in the robotics field," Cao said. "Any robot application that has an eventual need to climb stairs could adopt this design, especially if paired with a robot manipulator to manipulate objects when running over the flat ground while shifting its center of gravity when climbing stairs."

The researchers evaluated their OmniWheg system in a series of experiments focusing on a multitude of real-world indoor scenarios, such as circumventing obstacles, climbing steps of different heights and turning/moving omnidirectionally. Their results were highly promising, as their wheel-leg robot could successfully overcome all the common obstacles it was tested on, flexibly and efficiently adapting its configuration to effectively tackle individual locomotion challenges.

In the future, the system created by Rosendo and his colleagues could be

integrated in both existing and new robots, to enhance their efficiency in navigating indoor environments. In addition, the team's work could inspire the development of similar wheg systems based on omnidirectional wheels.

"Our first design iteration adopted a fairly 'expensive' brushless motor, and we now think that a lighter motor, paired with a gear reduction, would have been more effective," Rosendo added. "We also plan on adding a manipulator to the base of the robot so that we can test the dynamics of ascending and descending stairs with a higher center of gravity."

More information: Ruixiang Cao et al, OmniWheg: An Omnidirectional Wheel-Leg Transformable Robot, *arXiv* (2022). DOI: 10.48550/arxiv.2203.02118