

Robotics, laser and wireless technologies make driving safer for wheelchair users

Engineers at Lehigh and Carnegie Mellon universities, working with a Philadelphia-based start-up, have integrated robotics, laser and wireless technologies into a new system that promises to make it safer and cheaper for wheelchair users to drive a car.

The Automatic Transport and Retrieval System (ATRS), scheduled to go on sale next spring, allows wheelchair users to get in and out of their vehicles, stow and retrieve their chairs, and drive while sitting in standard automobile seats.

The new system is the product of a collaboration between the two universities; Freedom Sciences LLC, a robotics company located at the Philadelphia Navy Yard; and Freedom Lift Corp. of Green Lane, Pa. Freedom Sciences has signed a licensing agreement on the ATRS with Lehigh.

John Spletzer, assistant professor of computer science and engineering, says the ATRS has achieved a breakthrough by enabling wheelchair users to drive while sitting in standard automobile seats that meet federal safety regulations.

Current solutions for wheelchair users who desire independent mobility require operators to sit in their chairs while driving. Because they are often poorly secured and not crash-test-approved, wheelchairs provide far less protection than standard seats. According to the U.S. National Highway Traffic Safety Administration, 35 percent of all automobile fatalities related to wheelchairs result from inadequately secured chairs.

The ATRS is also modular, says Spletzer, and can be installed without making permanent – and expensive – changes to the vehicle. Drivers trading in their cars merely remove the ATRS from the old vehicle and install it in the new one.

By contrast, wheelchair users who now wish to drive must convert their vehicles, which requires lowering or replacing the floor of their van or minivan; rerouting fuel lines, heating and air-conditioning systems; and relocating the fuel tank.

"These changes severely restrict the resale value of the vehicle," says Spletzer. "With the ATRS, however, you can buy or lease a vehicle, usually a van, and install the ATRS without making permanent changes to the vehicle. If you decide to buy another vehicle, you simply remove the ATRS, sell or return your van, and install the ATRS in your new vehicle.

"This gives you a lot more freedom and personal choice."

The ATRS will cost \$15,000 to \$20,000, versus the \$30,000 and up that wheelchair users now pay to convert vehicles. The figures do not include the cost of the wheelchair or vehicle.

Spletzer and Tom Panzarella, CEO of Cook Technologies, parent company of Freedom Lift Corp., say the ATRS should be a boon to the six million people who, according to the U.S. Bureau of Transportation, have difficulty finding transportation.

"This is a major contributor to the unemployment rate of the disabled population nationally, which is estimated at over 65 percent by the U.S. Census Bureau," Spletzer and Panzarella wrote in a report.

How it works

The ATRS contains three key components: an articulated power seat that extends outside the vehicle to facilitate wheelchair-to-seat transfers, a power lift platform, and a "smart" wheelchair system.

The ATRS works in the following manner:

You move your powered wheelchair next to the driver's side of your vehicle. Using a remote-control device similar to a key fob, you open the vehicle door and direct the vehicle to lower the driver's seat alongside your wheelchair. You then slide over from your wheelchair into the driver's seat. Once in the driver's seat, you deploy the power lift platform from the rear of the vehicle through the touch of a button.

Using a joystick for remote control, you then guide your empty wheelchair to the rear of the van. There, the chair is switched to autonomous mode, and drives itself onto the lift platform using position feedback from an integrated laser system at a rate of 10 times per second. The lift platform then raises and stows the chair in the back of the van.

At this point, you press another button to raise the driver's seat, in which you are sitting, up into the van. The driver's seat is then restored to its normal driving position and secured.

When you arrive at your destination, you reverse the entire procedure.

Spletzer, who directs Lehigh's Vision, Autonomous Devices, and Experimental Robotics (VADER) Laboratory, says the ATRS represents a cutting-edge application of mobile robotics.

"There have been many advances in mobile robotics in recent years," says Spletzer, who has worked two years with Freedom Sciences on the ATRS. "But most of these outdoor applications are in mining and other environments where people are excluded by design. The ATRS, on the other hand, is designed to assist humans and to be used with their direction. We believe it has the potential to become one of the most widespread outdoor applications of commercial robotics to date."

The ATRS contains several other features that add value while enhancing reliability and safety, says Spletzer.

-- The laser system on the rear lift platform takes corrective action if an obstruction or slick spot causes the wheelchair to veer off course as it moves toward the platform.

"The laser system is constantly monitoring itself," says Spletzer. "If it is not 99.9 percent sure that the docking will be successful, it will back the chair up and perform corrective action."

-- A camera above the platform lift, working in tandem with a human-robot user-interface computer on the ATRS dashboard, lets the driver know when to use the joystick to close the rear hatch of the ATRS-equipped vehicle.

-- Once the chair has been stowed, two hooks on the rear platform grip a plow bar on the chair and lock it in place.

"In the event of a vehicle accident or collision, the locking mechanism prevents the chair from becoming a dangerous projectile inside the vehicle," says Spletzer.

-- To help drivers move from wheelchair to car seat, the ATRS Freedom Seat is fully articulated. Its adjustable height allows drivers to always move down when they slide from wheelchair to car seat or vice versa.

-- The system's modularity enables the ATRS to accommodate almost all sizes and models of wheelchairs and to offer easy upgrades for wheelchair users who have progressive diseases.

Next year, says Spletzer, Freedom Sciences is planning to develop an advanced ATRS for wheelchair users who have difficulty sliding themselves from the chair to the car seat. The new system will be fully automated, using a small "smart" camera instead of a joystick.

The modifications required to make a wheelchair ATRS-compatible are invisible, says Spletzer, as the computing, gyroscope and encoders that are added to the chair are transparent to the user. "In normal day to day use," he says, "it is no different from a standard power chair."

The ATRS is going to market at an opportune time, say Spletzer and Panzarella.

The expected increase in the population of Americans aged 65 and over will no doubt cause a corresponding rise in the number of wheelchair users, they say.

"We've already received a number of e-mails from people who say the ATRS will really help them in their daily lives," says Spletzer.

Spletzer developed the algorithms, or sets of rules, for autonomous navigation of the ATRS. These were first validated in simulation using MATLAB, a technical computing language, before being ported to the actual hardware.

Source: Lehigh University

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