Testing automated vehicles in virtual off-road environments

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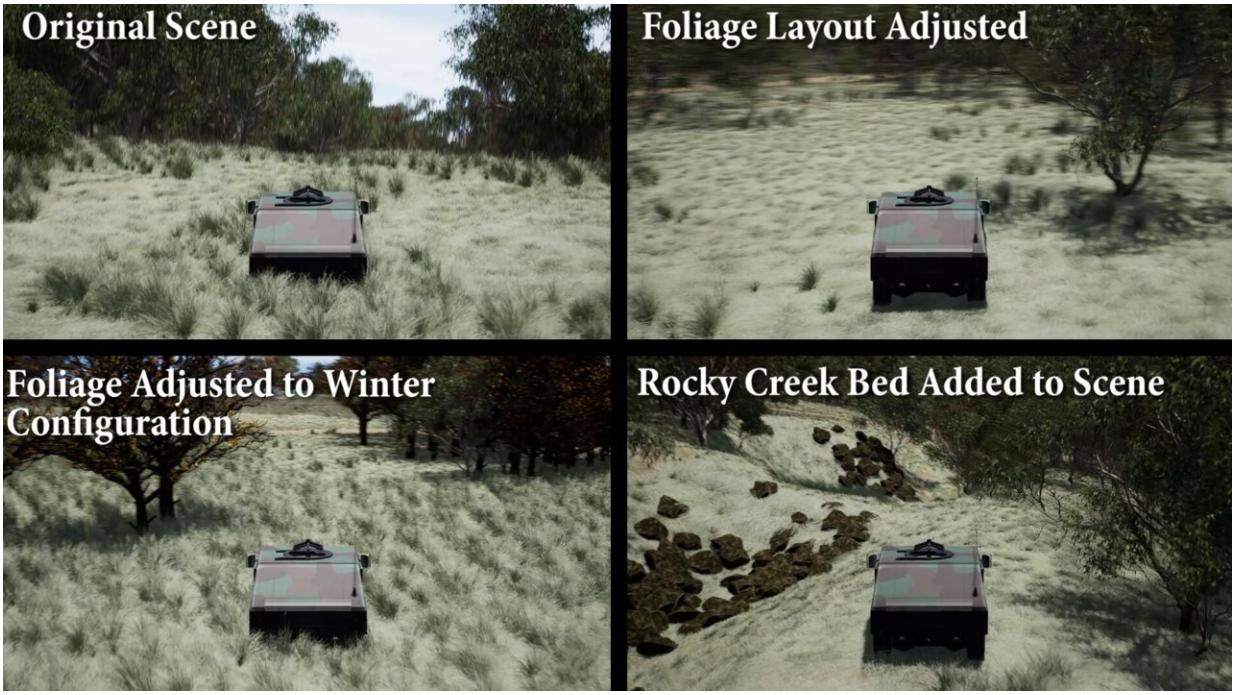

SwRI's Simulation Scene Adjustment Tool evaluates automated vehicles in 3D simulations of off-road environments. The image shows 3D scenes featuring different ground cover, simulating grass, foliage or rocks to virtually test military unmanned ground vehicles (UGVs). Credit: Southwest Research Institute

Southwest Research Institute (SwRI) has created a 3D simulation tool to test automated vehicles in virtual off-road environments modeled after real-world conditions. The research expands SwRI's investment into

software-in-the-loop solutions to test connected and automated vehicles (CAVs) in scenarios ranging from congested roadways to off-road terrain. A simulated environment, or a 3D "software loop," supports evaluations of an infinite number of scenarios that would be cost-prohibitive to test in the real world.

The technology meets U.S. Department of Defense demands for modeling and simulation tools to help advance the development of unmanned ground vehicles (UGVs), the military term for automated or autonomous vehicles.

SwRI developed a "pipeline" of technology with custom algorithms, off-the-shelf software, open-source tools and public map data. The project developed a "Simulation Scene Adjustment Tool" with a 3D video game-style interface to test virtual ground vehicles on off-road terrain. The simulator also creates a digital twin, a virtual representation of an automated vehicle that looks and behaves like its counterpart in the real world.

"Simulation with the digital twin is crucial for UGV testing and development," said Joe Auchter, an engineer who led the research for SwRI's Intelligent Systems Division. "Our Simulation Scene Adjustment Tool allows a user to push UGVs and AVs to the limit and explore 'what if?' scenarios in a variety of simulated environments more rapidly, safely and cost effectively than if all this testing was done in the real world."

SwRI's simulator consists of a graphics engine, dynamics engine, vehicle modeling tools, vehicle terrain interaction models and plug-ins to communicate with an autonomy software stack. It builds scenes with elevation maps captured from geographic information system (GIS) data and graphically renders topographical features in 3D.

The first round of research incorporated digital elevation models

(DEMs) from aerial scans conducted by the San Antonio River Authority and other government agencies.

"We developed algorithms to perturb DEM and GIS data in user-configurable ways that generate synthetic environments," Auchter said. "This allows for testing of new algorithms and techniques in simulation, building numerous test environments that share certain relevant characteristics with a real geo-specific location where vehicles will eventually operate."

Actual UGVs traversing real-world terrain after virtual testing in SwRI's Simulation Scene Adjustment Tool.Credit: Southwest Research Institute

SwRI's machine learning algorithms simulate computer vision and sensing outputs for lidar, radar, cameras, GPS and other systems to perceive scene objects, movements and position when calculating driving responses. A dynamics engine simulates forces caused by gravity

and motion as a vehicle model moves through an environment.

Simulated vehicles can be programmed with weight, speed, horsepower, center of gravity and other realistic characteristics. A graphics engine simulates trees, grass, terrain objects and visual effects such as sky and clouds.

SwRI has made safety and security a priority in the development of autonomous vehicles and automated driving systems as the technology reaches advanced levels of readiness for civilian and military use.

"If you look at field testing of automated vehicles, there are simply not enough miles or novel situations that you can throw at a vehicle to encounter all the edge cases for sensors and software," said Jerry Towler, assistant director of SwRI's Robotics Department. "Modeling and simulation help test AVs and Advanced Driver Assistance Systems (ADAS) to enhance safety and ensure capability before and alongside deployment into real-world testing environments."

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