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Lab's virtual world helps researchers chart how humans navigate through the real world

by **Adam Voiland '05**

By using the largest virtual reality lab in the world to alter the laws of physics and optics, a Brown University team is narrowing in on a quantitative understanding of how people successfully navigate through our cluttered, complex world. The research takes place in the **Virtual Environment Navigation Lab (VENLab),** which is on the second floor of Metcalf, and is led by William Warren, professor and chair of cognitive and linguistic science.

At first glance, the VENLab looks like little more than an empty room, but when subjects don a Darth Vader-like headset, they plunge into one of the most sophisticated virtual reality systems ever created. Within the VENLab's realistic virtual world, participants encounter heart-stopping chasms, disorienting merry-go-rounds, and even an elevator that seems to fly.

Reporter Adam Voiland navigates a virtual tightrope in the lab

Part of what makes the VENLab world so believable is an advanced tracking system capable of discerning how much a participant's head has moved to the tenth of a degree. The VENLab experience is so authentic, Warren even hires research assistants - he calls them "wranglers" - to ensure that immersed subjects don't smash into the lab's brick walls or trip over the headset's cable as they race about.

The mobility the VENLab permits is unusual among virtual reality labs. Most, including Brown's other virtual reality lab dubbed the CAVE, only allow users to observe a 3-D environment, not move through one. Complete subject mobility is critical for Warren's research, which seeks to pinpoint precisely how people dodge and intercept moving and stationary objects en route to a goal. Ultimately, Warren's work could lead to the development of more effective navigation systems in robots. Better robots could relieve humans from a slew of perilous tasks such as cleaning up toxic spills, exploring the Martian surface, or scouring through the rubble of an earthquake.

Even the most sophisticated robots are unable to successfully steer through a cluttered room. This fact became all too clear last month when the nation's most advanced robotic vehicles fell far short of completing an unmanned race through the Mojave Desert. Of the 15 finalist robots that entered the grueling, 142-mile race, not one made it more than seven miles. Many ended up stuck in ditches or careening off cliffs due to ineffective navigational systems.

Although the mechanism behind navigation is an open question within the scientific community, Warren thinks that people and biological systems of all kinds have evolved very clever, relatively simple solutions to get where they're going without crashing into things.

"Biological systems have solved the navigation problem. Even fruit flies, with just a few thousands neurons, have solved it," Warren said. "Robots haven't."

Say, for example, that engineers wanted to design a robot capable of completing a simple navigational task, such as intercepting a fly ball. A common approach - and one that may have caused problems in the 142-mile race - is to program a robot to act like a math whiz kid.

First, the robot would observe and record the ball's initial velocity. Then, using that information, it would calculate the ball's parabolic trajectory and predict where it is likely to land. Finally, it would plot a course directly to that point, and scurry there. A computational model such as this one works well enough in a static environment, but if something unexpected occurs - say a gust of wind that changes the ball's velocity - the robot misses.

Using the unique environment of the VENLab, Warren and his postdoctoral students Patrick Foo and Philip Fink showed that people have developed a more elegant way to intercept a falling ball. "There is something about the motion of the ball that allows people to get to the right place at the right time without having to compute the trajectory," he said.

Put simply, people continuously track the ball's motion as it approaches. If they move forward and backward to "null" the ball's apparent vertical acceleration, and move side to side to keep the ball directly in front of them, they will eventually intercept it. Warren and his co-workers showed that Brown baseball and softball players attempting to catch fly balls in virtual reality made predictable adjustments when the researchers altered the ball's motion or manipulated gravity to create impossible trajectories.

"By breaking the laws of physics and tracking precisely how people respond, the VENLab allows us to test hypotheses about navigation that we simply can't test in the real world," Warren said.

The VENLab has completed a number of other experiments intended to uncover fundamental principles of navigation. Warren has tested whether people rely on landmarks to navigate (most of the time they do) and whether they use qualitative, topological information - for example, take the third right after the tree - or metric angles and distances to keep track of where they are going. (Topological knowledge seems to dominate.)

Though the field of virtual reality will likely lead to new technologies that revolutionize the way people live, Warren emphasizes that his lab seeks to create new theories, not new gadgets.

"The applications are far in the future," Warren said. "Right now, I'm focused on the theory."