Study looks at sensing, movement and behavior

November 20 2007

Driving down a country road at night your car's headlights illuminate a deer in your path, and the creature doesn't move. Depending on your speed and other conditions, chances are good you will hit the deer. And if you do, it's because you are in what is fittingly defined as the "collision mode," according to a Northwestern University study, published online Nov. 13 by the journal *PLoS Biology*.

The Northwestern researchers are the first to clearly quantify the stopping motor volume (the amount of space it takes for an animal -- including one in a vehicle -- to come to a complete stop) and sensory volume (the amount of space an animal senses around it) for any animal. They then explored the relationships between the two volumes, defining three modes in which an animal could find itself in relation to another object -- collision (will collide every time), reactive (won't collide if on your toes) or deliberative (have lots of space to think about it).

The findings provide a fundamental scientific basis for quantifying and understanding the two volumes, insight that could be applied to understanding behavioral control strategies in animals as well as aid in engineering applications, such as designing autonomous robots or improving cockpit information systems for cars or airplanes to ensure that drivers and pilots are not in collision mode. The concepts can be applied to any situation in which an animal or object is moving through space guided by sensory information, including cars, airplanes, trains, bicycles and boats.

“We’ve now given people a way to think about sensory volume and a way to quantify and think about motor volume,” said Malcolm MacIver, assistant professor of mechanical engineering and of biomedical engineering at Northwestern’s McCormick School of Engineering and Applied Science and senior author of the paper. “For example, a person driving during daylight typically is in deliberative mode -- able to see objects far away with plenty of space to deliberate and form a response. That’s the ideal. But when the sun goes down, and the driver is relying on streetlamps and headlights to see, he or she is typically in reactive mode at best or collision mode at worst.”

MacIver was inspired to think about these original concepts by the unusual animal he prefers to study: the black ghost knifefish, found in the murky waters of the Amazon River. The fish does not use a passive sensing system such as sight or hearing to hunt. Instead, the knifefish has an active sensing system: it generates a weak electric field all around its body, and sensors, also all around its body, register any perturbations. By fluttering a ribbon-like fin along the entire length of its body, the knifefish can swim both forward and backward to catch its prey, the water flea.

After developing their mathematical definitions of the volumes, the researchers applied them to the knifefish, using the plentiful data available on the animal. They coupled video analysis of prey capture behavior with computational modeling of the fish’s electrosensory capabilities and let the simulations run for several weeks in a computer cluster operated by the Chicago Biomedical Consortium.

MacIver and his team are the first to quantify and compare in any animal the three-dimensional volumes for movement and sensation. They showed that the knifefish is truly omnidirectional in moving and sensing and discovered that the two volumes (stopping motor and sensory) are roughly equal, with sensory volume just a little greater than stopping motor volume. This places the knifefish in the reactive mode, critical if the fish wants to eat, and not collide with, its prey.

“Our results reveal that the knifefish invests just enough energy into active sensing to detect prey in time to stop,” said MacIver. “They have evolved an amazing movement system to match their omnidirectional sensing skills -- they can move backwards and do so all the time to catch prey.”

MacIver suggests that because it is too expensive, metabolically speaking, for the knifefish to sense beyond a certain point, the fish needs to restrict its sensory space, unlike passive-sensing animals like humans, which don’t invest energy in sensing.

Interestingly, the researchers also showed that when the knifefish is in water with increased conductivity, which decreases the fish’s sensing ability, the animal modifies its behavior by swimming more slowly, decreasing the stopping motor volume and keeping it roughly equal to the sensory volume. This modification ensures the fish can continue to catch food and not swim past or collide with its prey.

Back to the deer in the headlights. According to the National Highway Traffic Safety Administration, only 20 percent of driving occurs at night yet more than half of human fatalities occur at night. MacIver thinks this reflects the huge difference in the relationship between the sensory volume (diminished by darkness) and the stopping motor volume (greatly increased by the inertia of the car) -- very unlike the situation we are used to in broad daylight.

“Unlike the knifefish, humans don’t seem to be very good at modifying their behavior to reflect conditions. At best, it’s guesswork,” said MacIver. “If we had a system that could, at night, put us back in the deliberative mode, by alerting us if we are in reactive or collision mode, we could do a lot of good."

Such a system might take into consideration pavement conditions, fog, snow or sleet, the driver's eyesight, which may be reduced due to age, cataracts or not wearing necessary eyewear, and whether or not the driver is using a cell phone, which reduces reaction time.

Of course, the technology isn't there yet, but MacIver and his team, with their method of quantifying and comparing sensing and movement volumes, have given researchers a good place to start.

Source: Northwestern University

Citation: Study looks at sensing, movement and behavior (2007, November 20) retrieved 23 April 2024 from https://phys.org/news/2007-11-movement-behavior.html