Medical Xpress

How understanding GPS can help you hit a curveball

June 22 2015, by Monique Patenaude

University of Rochester pitcher Rob Mabee [L] throws a curveball to catcher Nolan Schultz in a composited sequence of seven images to illustrate a new study co-authored by Duje Tadin, an associate professor of brain and cognitive sciences at the University of Rochester, June 15, 2015. The study asserts that human brains apply an algorithm known as a Kalman filter when tracking an object's position, which helps the brain process less than perfect visual signals, such as when objects move to the periphery of our visual field where acuity is low. However, the same algorithm that helps our brain track motion can be tricked by the pattern motion of an object, such as the seams on a spinning baseball, which causes our brain to 'see' the ball suddenly drop from its curved path when, in reality, it curves steadily. Credit: J. Adam Fenster, University of Rochester

Our brains track moving objects by applying one of the algorithms your phone's GPS uses, according to researchers at the University of Rochester. This same algorithm also explains why we are fooled by several motion-related optical illusions, including the sudden "break" of baseball's well known "curveball illusion."

The new open-access study published in *PNAS* shows that our brains apply an algorithm, known as a Kalman filter, when tracking an object's position. This algorithm helps the brain process less than perfect visual signals, such as when objects move to the periphery of our visual field where acuity is low.

However, the same algorithm that helps our brain track motion can be tricked by the pattern motion of an object, such as the seams on a spinning baseball, which causes our brain to "see" the ball suddenly drop from its path when, in reality, it curves steadily.

Though we often rely on Global Positioning System (GPS) to get us to our destination, the accuracy of GPS is limited. When the signal is "noisy" or unreliable, your phone's GPS uses algorithms, including the Kalman filter, to estimate the location of your car based on its past position and speed.

"Like GPS, our visual ability, although quite impressive, has many limitations," said the study's coauthor, Duje Tadin, associate professor of brain and cognitive sciences at the University of Rochester.

We see an object's position with great accuracy when it's in the center of our visual field. We do poorly, however, at perceiving position when it shifts into our visual periphery; then our estimate of its position becomes unreliable. When that happens, our brain gives greater emphasis to our perception of the object's motion.

"And, this is where we start seeing fascinating phenomena like the curveball illusion," said Tadin. "We've found that the same algorithm that is used by GPS to track vehicles also explains why we perceive the curveball illusion."

"A curveball pitch does indeed curve," said the first author Oh-Sang Kwon, assistant professor at Ulsan National Institute of Science and Technology, South Korea. "But when it is viewed in the visual periphery, the spin of the ball—the motion of the seam pattern—can make it appear to be in a different location than it really is.

"Here, the brain 'knows' that position estimates are unreliable in the periphery, so it relies more on other visual cues, which, in this case, is the motion; the spin of the ball," said Kwon, who led the study while serving as a research associate in the Center for Visual Science at the University of Rochester.

The perceived motion and position of the curveball depends on where it is in your visual field. So, when the ball enters your periphery, it appears to make an abrupt shift: The infamous and sudden "break" of the curveball as it nears home plate.

The Kalman filter algorithm, named after its coinventor, mathematician Rudolph Kalman, is used to find optimal and integrated solutions from noisy or unreliable data whether in GPS or our brains.

Most of the time our vision does a really good job, but in some cases, such as a breaking curveball, the optimal solution that our brain comes up with belies the actual behavior—and trajectory—of the ball, and the result is an optical illusion.

Therefore, Tadin explained, you have a better chance of hitting a curveball by realizing that our brains, like GPS, can lead us to "see" changes in speed or direction that don't actually occur when the ball moves from the center of our visual field to the periphery.

"These illusions should not be seen as evidence that our brains are poor at perceiving the world around us, though," explained Tadin. "They are interesting side-effects of neural processes that, in most cases, are extremely efficient at processing 'noisy' visual information."

"This study shows that the solutions that the brain finds for dealing with imperfect information often match optimal solutions that engineers have come up with for similar problems, like your phone's GPS."

More information: Unifying account of visual motion and position perception, Oh-Sang Kwon, [DOI: 10.1073/pnas.1500361112](http://dx.doi.org/10.1073/pnas.1500361112)

Provided by University of Rochester