Running robots of future may learn from world's best two-legged runners—birds

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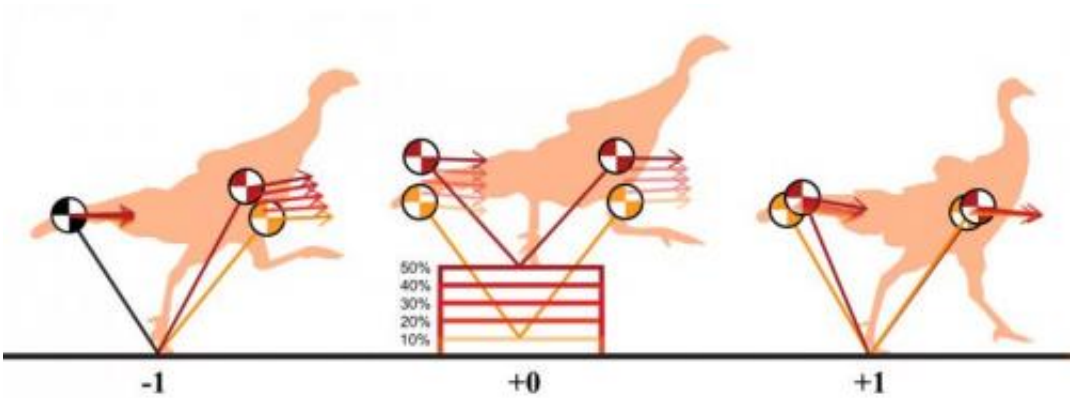


This model outlines the forces at work as a turkey hops over an obstacle. Credit: Oregon State University

With an eye toward making better running robots, researchers have made surprising new findings about some of nature's most energy efficient bipeds – running birds.

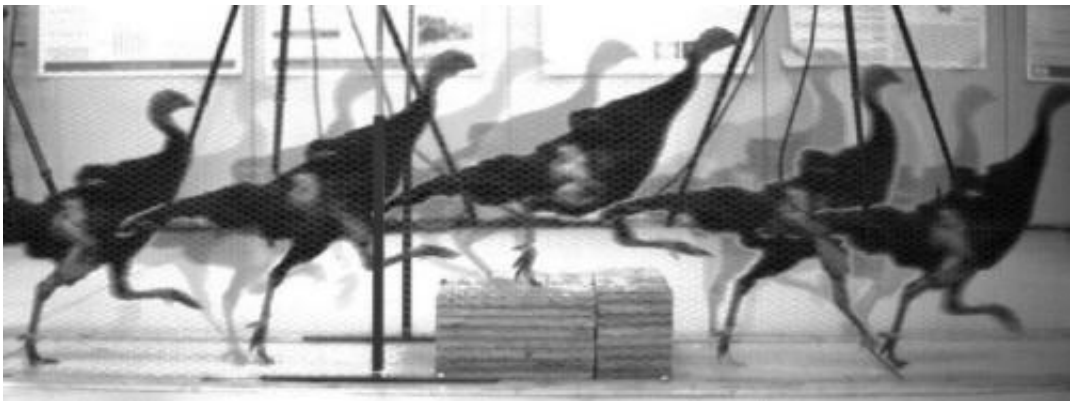
Although birds are designed primarily for flight, scientists have learned that species which predominately live on land and scurry around on the ground are also some of the most sophisticated runners of any two-legged land animals. These characteristics may have been evolving since the time of the dinosaurs and, some would say, now transcend the ability of other bipedal runners, including humans.

In a study published today in the *Journal of Experimental Biology*, researchers from Oregon State University, the Royal Veterinary College and other institutions outline how running birds have achieved an impressive ability to run while minimizing energy cost, avoiding falls or injury, and maintaining speed and direction.

"Birds appear to be the best of bipedal terrestrial runners, with a speed and agility that may trace back 230 million years to their dinosaur ancestors," said Jonathan Hurst, an associate professor and robotics expert in the OSU College of Engineering.

Running birds come in an enormous range of sizes, from tiny quails to an ostrich that has 500 times as much body mass. Most, but not all, can fly, but spend most of their lives on the ground, and they don't always look the most graceful when they run. But researchers found that they maximized the results while keeping their priorities straight – save energy and don't break a leg. In the wild, an injury could lead to predation and death; and in like fashion, when food resources are limited, economy of motion is essential.

"These animals don't care that they appear a little unstable or have a waver in their gait," Hurst said. "Their real goal is to limit peak forces, avoid falling, be safe and be as efficient as possible. If their upper body seems to lurch around a little as a result, that's okay. What they are accomplishing is really quite elegant."



Researchers observe the motions used by this turkey hopping over an obstacle in order to model its behavior. Credit: Oregon State University

Even more surprisingly, a wide variety of ground-running bird species with very different body sizes use essentially the same strategy to accomplish these sometimes conflicting tasks. In order to hop over obstacles on uneven ground, they use a motion that's about 70 percent a "vaulting" movement as they approach the obstacle, and 30 percent a more-crouched posture while on top of the obstacle.

"Evolution has shaped running birds into all different sizes and skeletal structures," said Christian Hubicki, a doctoral student at OSU who co-authored the study. "But we found their behavior in how they run is essentially the same."

In collaboration with Monica Daley at the Royal Veterinary College in London, the researchers studied five species of birds and developed a computer model in OSU's Dynamic Robotics Laboratory that closely matches that behavior.

"We should ultimately be able to encode this understanding into legged robots so the robots can run with more speed and agility in rugged

terrain," Hubicki said. "These insights may also help us understand the walking and running behaviors of all the common ancestors involved, including theropod dinosaurs such as the velociraptor."

The researchers began the study with a hypothesis that body stability would be a priority, since it might help avoid falls and leg injuries. That's not what they found, however.

Instead, running birds have a different definition of stability – they do avoid falls, but also allow their upper bodies to bounce around some, just so long as they don't fall. Like a scrambling football runner, their leg motion may sometimes speed up or slow down, in the interest of staying upright, dealing with obstacles and generally staying on course to where they are going. The process isn't always pretty, but it's functional.

Large animals are limited by the strength of their legs because peak loads increase with body mass, and they run with somewhat straighter legs to compensate. But the basic approach large birds use to run is similar to much smaller birds, and remains highly efficient.

Modern robots, by contrast, are usually built with an emphasis on total stability, which often includes maintaining a steady gait. This can be energy intensive and sometimes limits their mobility.

What robots could learn from running birds, the scientists said, is that it's okay to deviate from normal steady motions, because it doesn't necessarily mean you're going to fall or break something. Robotic control approaches "must embrace a more relaxed notion of stability, optimizing dynamics based on key task-level priorities without encoding an explicit preference for a steady gait," the researchers said in their conclusion.

"The running robots of the future are going to look a lot less robotic,"

Hurst said. "They will be more fluid, like the biological systems in nature. We're not necessarily trying to copy animals, but we do want to match their capabilities."

Provided by Oregon State University