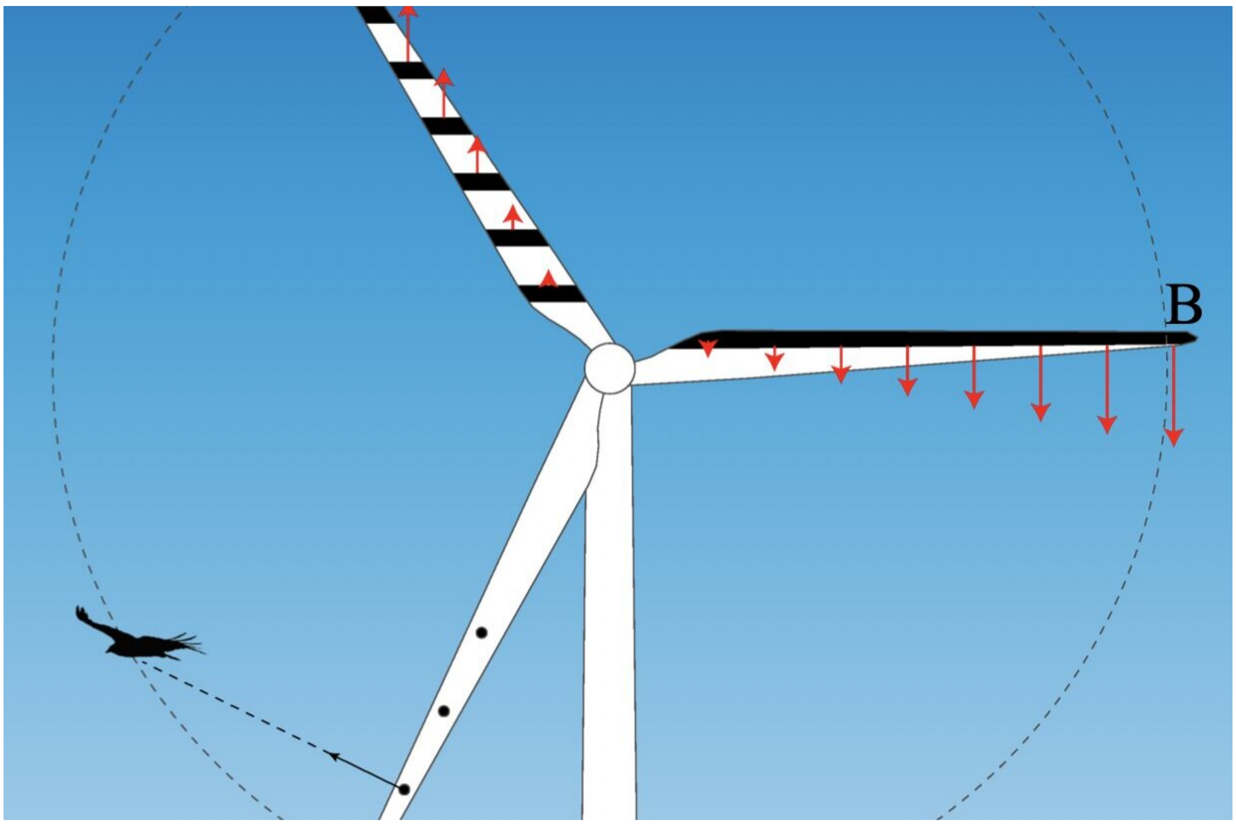
Could striped wind turbines save millions of birds?

May 12 2026, by Pranjal Malewar



Bio-informed blade patterns that exploit the principles of bird vision. (A) Oblique stripes, designed to cause the blade's rotation to generate a combined looming and rotational stimulus (red arrows). (B) Trailing-edge stripe, designed to direct edge-targeting behavior away from the leading edge and to maximize rotational optic flow (red arrows). (C) Object markers, designed to promote collision avoidance: at the instant shown, there is no motion cue directly indicating the bird's risk of being struck by the blade tip, whereas the second marker will be perceived as a collision hazard promoting evasive action (black arrow).

Wind energy is quickly becoming a key pillar in the fight against climate change, with its turbines rising like modern monuments to a greener future. Yet the rapid growth hides a dark side: the spinning blades that produce pollution-free energy also kill birds.

Birds are highly adept at navigating complex forests and cluttered environments. Still, they often crash into wind turbines because the sensory systems they've evolved to avoid obstacles do not account for large, moving structures (turbine blades). This is a serious problem: it is important to reduce bird deaths from wind turbines without hindering renewable energy development.

This problem has been addressed in only a few studies by viewing the environment from a bird's-eye perspective, observing birds in flight as a picture, and modifying blade markings to minimize collisions.

One recent study, in the *Journal of the Royal Society Interface*, actually proposes an ingenious solution: paint patterns on turbine blades that change "optic flow" seen by birds, the changing visual contrast experienced as a bird flies through its environment. Changing this optical flow could make turbines more visible, helping birds avoid them more effectively.

Researchers note, "The ultimate goal is to enhance the overall conspicuity of turbines under a range of natural conditions, ensuring that birds detect the structure in time to avoid collisions."

"By looking at the world through a bird's eyes, we are exploring new ways to prevent deadly turbine collisions. The idea is to blend sensory ecology with natural flight strategies, how birds scan, steer, and avoid obstacles, and use that knowledge to redesign turbine blades."

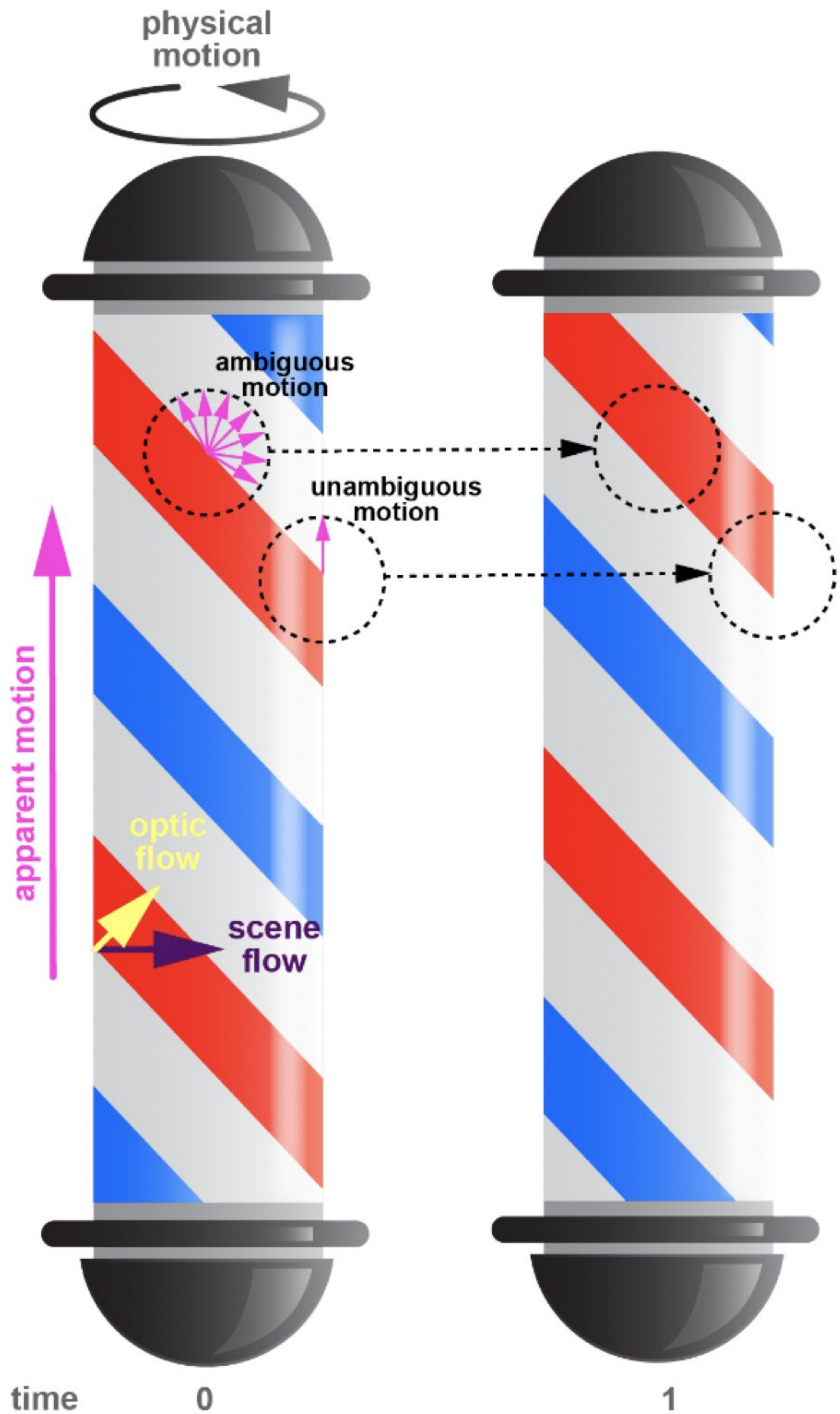

physical motion
ambiguous motion
unambiguous motion
apparent motion
optic flow
scene flow
time
0
1

Illustration of the barber-pole illusion seen by humans, highlighting the biases implicit in our visual processing. When a diagonally striped pole rotates about its vertical axis, a human perceives the stripes as moving vertically (magenta arrow), despite the local optical flow (yellow arrow) being perpendicular to the stripes and despite the local scene flow (purple arrow) being horizontal. The apparent direction of motion is partly determined by whether the ends of the stripes are visible. If the edge of the pattern is visible, then the motion of a stripe can be inferred from the movement of its end (small magenta arrow), giving the appearance of vertical motion; if the edge of the pattern is not visible, then the direction of the stripes is ambiguous (small magenta arrows) and cannot be determined. This ambiguity is known as the aperture problem.

The science of avian sight

Understanding the eye anatomy and how birds process motion and their surroundings offers vital clues on why birds sometimes crash into human-made structures. Bird vision is shaped by specialized optics, retinas, and brain pathways, and what they see depends on their head position.

Most birds can see four colors, sharpened by oil droplets, plus a special cone for brightness and motion. They can often see into the ultraviolet range, which should help them spot objects better than humans. But in larger bird species, UV sensitivity is reduced by the lens and cornea, which may explain why UV-reflective paint on turbines doesn't stop collisions.

The structure of the eye allows these birds to have sharp vision because it is densely packed with retinal cells. Their brains are optimized for motion (some neurons fire when light level goes up, "ON cells," while others, which detect light-level decreases = "OFF cells" as well; these can detect bright and dark edges, needed to detect an obstacle).

Optic flow, the integrated motion pattern across the retina, helps them track moving objects while ignoring static backgrounds and judge speed and distance.

Sharp vision zones provide detail on the sides or front, while binocular overlap improves depth perception and motion detection straight ahead. But birds don't always process motion the way humans do. For example, pigeons focus only on local motion cues rather than the whole pattern: they do not see a turbine blade spinning over and over, but only changing edges.

This could impair their ability to recognize and avoid an impending collision, underscoring the importance of designing wind turbine blades that account for birds' specific motion perception.

Birds are generally good at dodging natural hazards, so wind turbine collisions are something of a mystery. There are three broad explanations: birds don't see the turbine; they do, but don't react as if it's a threat; or they do, but can't fly away in time.

Promising results, but small samples

One way to avoid birds smashing into wind structures is to change the appearance of turbines so that birds see them as an obvious threat and avoid them. Some studies suggest that painting towers and blades black, with reference to a bird's visual perception, can reduce collisions for some species.

In lab tests, kestrels and red-tailed hawks could spot turbine blades best when they had two wide black bands across a white surface. Narrower stripes were less effective.

A retinal study of kestrels tested computer-simulated turbine blades and found that staggered thin stripes on all three blades, or a mix of one black blade and two white blades, provided the clearest visibility by reducing motion blur.

For all that, lab studies mostly looked at how well blades could be seen, hardly a collision-avoidance measure. So far, only two full field trials and one small UV-paint test have been done, all at Norway's Smøla wind farm.

Painting one rotor blade black reduced bird deaths more than 70%, primarily of raptors, but based on only a small number of turbines. Another study revealed that painting the lower sections black virtually halved the ptarmigan death rate, sometimes more, sometimes less. Though these results are promising, the designs tested may not have been the best possible solutions.

Edge-focused designs for sharper detection

In this new study, researchers suggest that internal contrast on the blades could enhance birds' ability to estimate optic flow as they near turbines, making stripe patterns more effective in various backgrounds and lighting conditions.

Researchers suggest turbine blades should be painted with diagonal stripes of different angles along their length so that birds detect both an expanding and a rotational cue when flying toward them.

Patterns should emphasize the edges of blades because birds tend to fixate on the boundaries of an obstacle, though the best placement depends on their gaze strategy. On the other hand, more complex or randomized textures may simulate natural habitats and will help birds confirm blades as risks.

Because visibility depends on the pattern and speed of the blades, different parts of the blade are noticed with varying success. With them, nonuniform designs (such as radial or fractal patterns) can provide distance-specific motion cues to birds; that is, birds will detect blades sooner than they would in more uniform designs.

More information: Caroline Helen Brighton et al, Bio-informed blade patterns for mitigating bird collisions with wind turbines, *Journal of the Royal Society Interface* (2026). DOI: 10.1098/rsif.2025.0719