Most complete exploration of fly landing maneuvers to advance future robots

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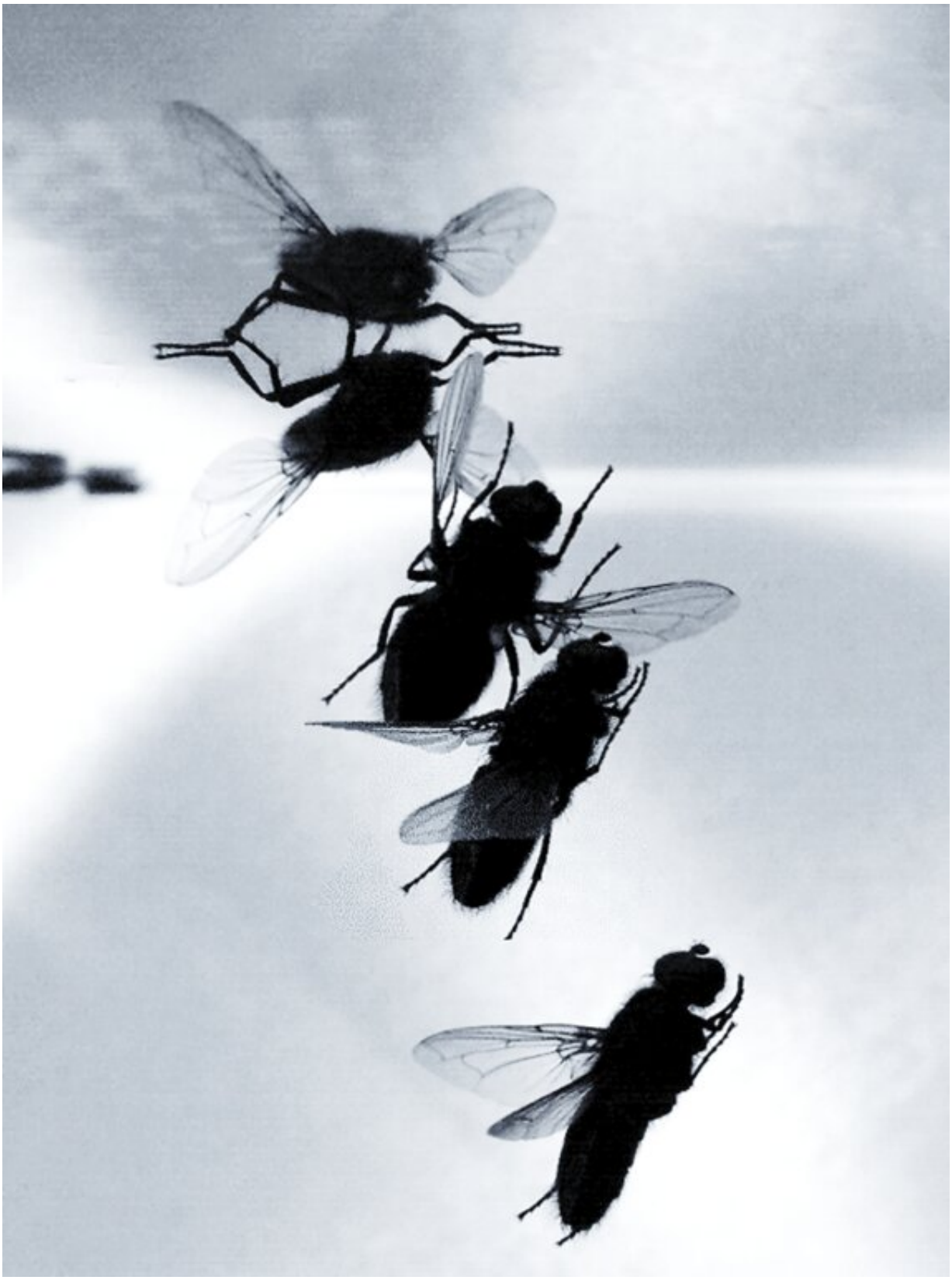

Researchers studying one of the least understood aerobatic maneuvers performed by flying insects, and who call their investigation the "most complete exploration of fly landing maneuvers" to date, report that blue bottle flies that land upside down on ceilings use a more complex series of behaviors than thought. Credit: Bo Cheng, Penn State

To inspire advanced robotic technology, researchers in the Penn State Department of Mechanical Engineering have published the most complete description of how flying insects land upside-down.

The paper was published today (Oct. 23) in *Science Advances*."Through this work, we sought to understand how a fly executes the maneuvers of landing upside down in the blink of an eye," said Bo Cheng, assistant professor of mechanical engineering and lead author of the paper.

It's arguably the most difficult and least-understood aerobatic maneuver conducted by flying insects, according to Cheng.

"Ultimately, we want to replicate that in engineering, but we have to understand it first," Cheng said.

Along with Penn State's Jean-Michel Mongeau, assistant professor of mechanical engineering, and Pan Liu, doctoral student in mechanical engineering, Cheng aims to understand the biomechanical and sensory processes that flies use to land on different surfaces like ceilings and moving objects.

To gather their data, the team first examined the flies' inverted landing behaviors in a flight chamber using high-speed videography. Their study found that the insects usually execute four perfectly timed maneuvers to land upside down: they increase their speed, complete a rapid body

rotational maneuver (likened to a cartwheel), perform a sweeping leg extension and, finally, land through a leg-assisted body swing when their feet are firmly planted on the ceiling.

The researchers also believe these actions are set in motion by a series of complex visual and sensory cues the flies perceive as they approach their desired landing spot.

"Within the blink of an eye, these flies can totally invert their body and land, which is quite spectacular," Mongeau said. "We see it all the time happening around us, but we've demonstrated the complexity of the maneuver. There is a lot of interest for robots to be able to do the same."

However, current robotic technology sorely lacks the speed and efficiency needed to execute the same maneuvers.

"We look at nature for inspiration," Mongeau said. "This helps drive the fundamental science of engineering, to understand how flies are able to solve these problems so we can apply them to future technologies."

In addition to advancing robotics, the implications of this work can also be applied to the field of neuroscience.

"How is a fly's nervous system able to do this so quickly?" Mongeau said. "This work reiterates how fast these maneuvers are executed within an extremely small nervous system. This data can lead to new hypotheses for understanding how brains function."

More information: P. Liu el al., "Flies land upside down on a ceiling using rapid visually mediated rotational maneuvers," *Science Advances* (2019). DOI: 10.1126/sciadv.aax1877 , advances.sciencemag.org/content/5/10/eaax1877

Provided by Pennsylvania State University

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