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Mutually opposing forces during locomotion can eliminate the tradeoff between maneuverability and stability NOAH COWAN, SHAHIN SEFATI, Johns Hopkins University, IZAAK NEVELN, Northwestern University, EATAI ROTH, TERENCE MITCHELL, Johns Hopkins University, JAMES SNYDER, MALCOLM MACIVER, Northwestern University, ERIC FORTUNE, New Jersey Institute of Technology — A surprising feature of animal locomotion is that organisms typically produce substantial forces in directions other than what is necessary to move the animal through its environment, such as perpendicular to, or counter to, the direction of travel. The effect of these forces has been difficult to observe because they are often mutually opposing and therefore cancel out. Using a combination of robotic physical modeling, computational modeling, and biological experiments, we discovered that these forces serve an important role: to simplify and enhance the control of locomotion. Specifically, we examined a well-suited model system, the glass knifefish Eigenmannia virescens, which produces mutually opposing forces during a hovering behavior. By systematically varying the locomotor parameters of our biomimetic robot, and measuring the resulting forces and kinematics, we demonstrated that the production and differential control of mutually opposing forces is a strategy that generates passive stabilization while simultaneously enhancing maneuverability. Mutually opposing forces during locomotion are widespread across animal taxa, and these results indicate that such forces can eliminate the tradeoff between stability and maneuverability, thereby simplifying robotic and neural control.

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