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Doctoral Dissertation

Materials Science

Bio-inspired Propellers toward Safety Collision for Unmanned Aerial Vehicles

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ABSTRACT

There is an increasing demand for vertical take-off and landing vehicles, including drones, that are safe to use and can handle collisions. These vehicles face risks of damage from collisions with humans, environmental obstacles, and other drones. To address this issue, researchers have been looking to nature for examples of resilient structures that can be used to design propellers that reduce these risks and increase safety. My proposed solution is a bio-inspired drone propeller called the *Tombo* propeller, which is inspired by the flexibility and resilience of dragonfly wings. In this study, the design and fabrication process for the *Tombo* propeller is presented, which allows it to withstand collisions and recover quickly while still providing sufficient thrust to hover and fly. The performance characteristics of the propeller, such as thrust force, collision force, recovery time, lift-to-drag ratio, and noise, were also investigated through the development of an aerodynamic model and experiments. Additionally, a control strategy was designed for a drone equipped with *Tombo* propellers that could collide with an obstacle, recover from the collision, and continue flying. The results show that the maximum collision force generated by the *Tombo* propeller is less than two-thirds that of a traditional rigid propeller, indicating the potential for using deformable propellers on drones in cluttered environments. To enhance the collision sensing capabilities of the propeller, a novel hub was also introduced, with details on its design, fabrication, force modeling, and preliminary experiments with potential results. This research has the potential to inform the design of flying vehicles for agile and resilient performance.

Keywords: Bio-inspired design, Collision accommodation and sensing, Deformable propeller, Soft robotics, Drones' safety