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Perspective

Characteristics of Robots and Energy-Saving Adaptable Aerial Manipulators

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DESCRIPTION

Aerial robots can perch on high-rise structures to save energy or stay firmly in place while interacting with the environment. These bio-inspired aerial robots use independent perching modules, similar to how birds have wings for flying and legs for perching. However, the robot's size and weight both increase as a result of the modular design, limiting its access to areas. We draw inspiration from gliding and tree-dwelling mammals like sugar gliders and sloths to mitigate these issues. Sloths optimized their physiology to encourage energy-efficient perching, and gliding mammals morph their entire limb to transition between flight and perch. Using these insights, a quadrotor robot is made that uses a single-direction tendon drive to switch between flying and perching morphologies. The bi-stable arm of the robot is rigid in flight but will conform to its target in 0.97 seconds when perched, requiring minimal energy to hold. By combining this capability into a single body, we were able to reduce our overall mass by 30%. To avoid turbulent aerodynamic effects, the robot perches during a controlled descent or a freefall. The requirement for small perching robots in cluttered environments can be met by our design solution.

For the conservation and management of threatened plants and animals, oftentimes the most important parts of the forest are hidden from view. The leafy treetops can act as a barrier, despite the fact that aircraft and satellites can view the forest from above. Access to soundscapes from above the treetops and views of the forest floor can be hindered by the canopy. There are also microclimate enclaves in denser forests that can be vastly different from the climate above the canopy. It has been demonstrated that multirotor unmanned aerial vehicles (UAVs) are ideal for imaging areas with low vegetation height and above forest canopy. However, there aren't many options for deploying remote sensors in these small spaces, especially in a forest.

Aerial robots that live in forests need to have a lot of endurance, be small enough to get deep into a dense forest, and be able to change with the environment. Due to the aerodynamics of propellers, high flight endurance and small robot size is direct trade-offs among these requirements. However, data can be collected while the robot is stationary for environmental sensing. The phases of an environmental sensing mission can be divided into flights through the forest and periods of rest during which the robot takes sensor readings. As a result, we propose a small, multirotor-equipped metamorphic perching aerial robot that can grasp onto tree branches.

For aerial robots and their biological counterparts, perching between intermittent movements from tree to tree has frequently been highlighted as a means of conserving energy, escaping predators, and hiding from unpredictable weather. These animals can also be placed in a good spot for surveillance by perching and resting. Sloths and koalas, for example, have demonstrated that they can preserve, recover from, and maintain homeostasis while resting on trees. Additionally, the sloth's arm muscle structure is designed so that it can retract and perch securely, saving weight and energy by requiring few abducting muscles.

Roboticists have been able to rethink how to approach adaptable perching robot designs based on bioinspired principles. Utilizing van der Waals forces, there are mechanically activated fiber-based dry adhesives inspired by geckos. On the other hand, there are mechanical interaction-based solutions that rely on interlocking and surface friction. Both passive microspines and preloaded deployable spikes are able to perch on rough surfaces.

Using string entanglement or magnetic anchors on ferromagnetic surfaces, spider-web-inspired methods are used to perch and suspend the robot in midair. Using active and passive avian-inspired graspers, cylindrical perch sites like tree branches and pipes are specifically targeted. They are considered mechanical methods because they encircle the target with a grip resembling a claw.

The aforementioned perching techniques currently add additional modules and would make a drone heavier. Therefore, a compromise must be reached between flight time and mission endurance, which includes the time spent perched by the robot. A platform that can intelligently transform and adapt its body to perch on various sized and shaped structures without penalty would be the ideal aerial robotic solution.

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