Robotic Flight Inspired by Bat Wings

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*Abstract*— This project explores optimized actuation and gait pattern strategies to enhance the locomotion speed and agility of multi-modal robots designed for aerial mobility. Inspired by Palla’s long-tongued bat (*Glossophaga soricina*), the research initially focuses on modeling gliding and landing mechanics, leveraging the bat's adaptive wing morphology and precise control enabled by its elastic wing membranes. Following our professor's suggestion, the study later incorporates a flapping mechanism to improve the robot's versatility and maneuverability. The findings contribute to bio-inspired robotics by advancing foldable wing designs and informing the development of agile drones for navigation in cluttered environments, with applications in rescue missions and automated surveys.

Keywords— Bio-inspired robotics, foldable robotics, adaptive wing morphology, energy-efficient design

# System Model Definition

This bio-inspired robotics project's system model design aims to create a robotic system that simulates the gliding and flapping motions of the Glossophaga soricina bat species. In order to maximize performance in terms of agility, stability, and energy efficiency, the main objective is to simulate the robot's dynamic and physical behaviors.

## Objective

The objective of the system model is to optimize the performance, stability, and energy efficiency of the bio-inspired robot by simulating its dynamics and understanding the interactions between its components. The model aims to predict gliding trajectories, aerodynamic forces, and landing impacts, enabling the evaluation of various wing configurations and actuation strategies.

The approach makes it easier to build a robotic system that is precise, efficient, and adaptable by examining how material qualities and control inputs affect system outputs. It also acts as a basis for testing and prototyping, offering vital information on important variables including system inertia, actuator dynamics, and wing size.

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## Key components

### A Wing System: The initial prototypes utilized basic materials such as wax paper for the wing structure. However, the final wing design featured a two-layer lamination composed of a thin vinyl sticker sheet and a flexure material. This advanced design incorporated vein-like structures inspired by bat wings.The advanced design included vein-like structures inspired by bat wings that acted as hinges for flapping and made the wings foldable. This foldability allowed the wingspan to adjust dynamically, improving the robot's agility and adaptability in flight.

### Body Structure: This mechanism employs a gear-driven actuation system, converting rotational motion into the movement of connected mechanical links. It utilizes servo motors to achieve multi-link folding, mimicking the dynamic adaptability of bat wings. The actuation, guided by torque and angular speed control ,ensures precise motion and responsiveness. Additionally, experiments on stiffness and compliance optimize the system’s load response, with lightweight materials like balsa or flexible silicone membranes enhancing rigidity and precision for efficient performance.

### Actuators: This is a single actuator system. Both the wings of the robot are actuated by a single servo motor. This motor is situated at the center of thebase plate where gears are mated. This position provides optimum torque as well as maintains the centre of Gravity of the system.

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##### Acknowledgments

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This template was adapted from those provided by the IEEE on their own website.

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