

DESIGNING LONGER-FLYING MULTIROTORS

AUTHOR

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AFFILIATIONS

This research was conducted under, and funded by, the Laidlaw Research Scholarship, with supervision and support of Dr Sophie Armanini of the Aeronautics department at Imperial College London.

INTRODUCTION

Multirotors (drones) have immense potential to benefit society but face a key limitation - flight time.

As someone who's been building multirotors for years and holds the World Record for Multirotor Flight Time (Pending Guinness Verification), I've noticed several efficiency/flight-time optimizations that aren't typically nailed in multirotor designs.

In this research project, I discussed, tested and showed through data what these optimizations are and the impact they have on improving flight time - to help others build longer-flying drones.

METHODOLOGY

The research methodology combined theoretical analysis, component optimization, and practical testing:

- Battery Design & Chemistry
- Frame and Structure Design & Composition
- Motor & Propeller Choice & Pairing
- Powertrain Electronics (Flight Controller, ESCs and Wiring)
- Design Principles

For each area, I compared various options and identified the best choices for improving flight time. Most notably, I delivered a:

- **Machine-learning model:** Developed XGBoost regression models trained on public manufacturer test data to predict the optimal motor-propeller combination at hover.
- **Proof-of-concept build and testing:** A multirotor was constructed using the optimized parameters, and flight time was evaluated under controlled conditions. Control scenarios were modeled to isolate the impact of individual design choices.

LITERATURE REVIEW - BENEFITS OF LONGER FLIGHT

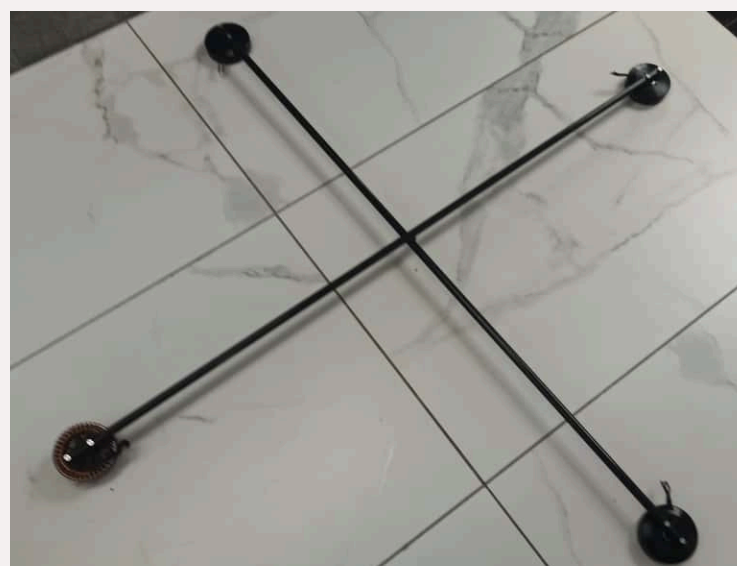
The short flight endurance of multirotors is a major limitation that restricts their operational scope. Current multirotors, with typical flight times of 30 minutes under payload, force frequent landings and battery swaps, reducing efficiency in applications like logistics, surveillance, and emergency response.

Improving existing applications:

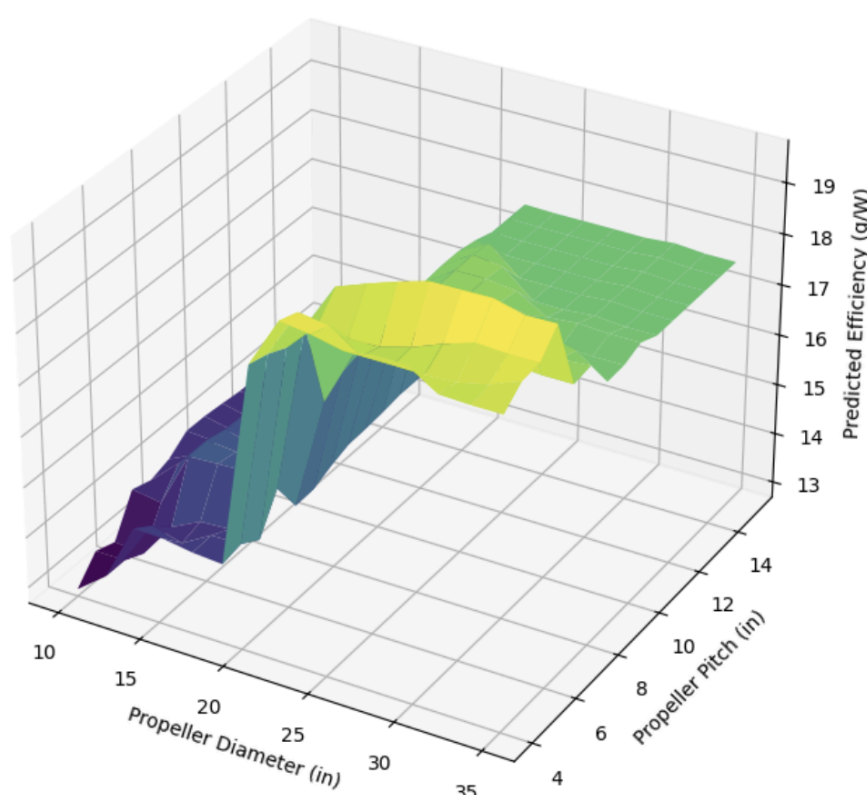
- **Logistics:** Longer flight times expand delivery drones from last-mile service to regional logistics, increasing delivery radius to 60-80 km and enabling multi-stop delivery routes. This improves operational efficiency and reduces fleet size and energy usage, supporting sustainable cities (SDG 11).
- **Environmental impact:** Extended flight times reduce energy consumption by requiring fewer drones and less charging infrastructure, enhancing the environmental benefits of electric UAVs, which can save up to 94% of energy per package compared to trucks.

Unlocking new applications:

- **Healthcare & emergency response:** Longer-endurance drones enable persistent overwatch during disasters and function as mobile medical hubs capable of delivering life-saving equipment across greater distances (SDG 3).
- **Continuous monitoring:** Multi-hour flight times allow drones to provide sustained observation of disaster-affected areas or large infrastructure, which is impossible with conventional 30-minute drones.



Efficiency Landscape for Motor KV=100.0, Mass=238.0g



OVERALL RESULTS

Final build & flight test:

- The proof-of-concept drone achieved a hover flight time of over 2.5 hours under calm conditions. Modeling confirmed significant gains from battery choice and optimized propulsion.

Machine-learning model & web tool:

- The XGBoost model enables easy, data-driven motor-propeller selection. Its public web interface allows hobbyists and researchers to optimize propulsion without trial-and-error.

The paper as a resource:

- The research paper itself is a core outcome, offering a practical, data-driven framework for designing longer-flying multirotors. It guides others in building high-efficiency drones and applying ML-assisted optimization.

Impact:

- The combination of the drone, ML model, and paper creates a reproducible system for designing efficient, long-endurance multirotors.
- Provides a practical resource for the wider drone community to overcome traditional endurance limits.

CONCLUSION

Endurance isn't limited by hardware - it's limited by optimization, where my research showed that flight time can be dramatically extended by looking at every subsystem together, not in isolation. Switching to high-energy Li-ion cells and carefully matching low-KV motors with large, low-pitch props produced the most significant efficiency gains. With deliberate, data-driven design, multirotor flight time was extended to 162 minutes (2 h 42 min) - over double the endurance of most "high-endurance" builds today. Machine Learning also adds a new tool for builders. The model I developed can help others find optimal motor-prop combinations quickly, making endurance optimization more accessible to the community.

Limitations: All tests were conducted in ideal, no-wind indoor conditions at sea level, so real-world flight times will be lower due to wind, temperature, and altitude effects. The drone was optimized purely for hover endurance with no payload capacity, used costly custom components, and the ML model's accuracy remains limited to static test data rather than dynamic flight.

Broader impact: Longer-flying drones can unlock major opportunities in logistics, research, and emergency response - directly supporting sustainability and efficiency goals. The optimizations researched and discussed help build these.

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