Propulsion Unit Optimization for Small UAS

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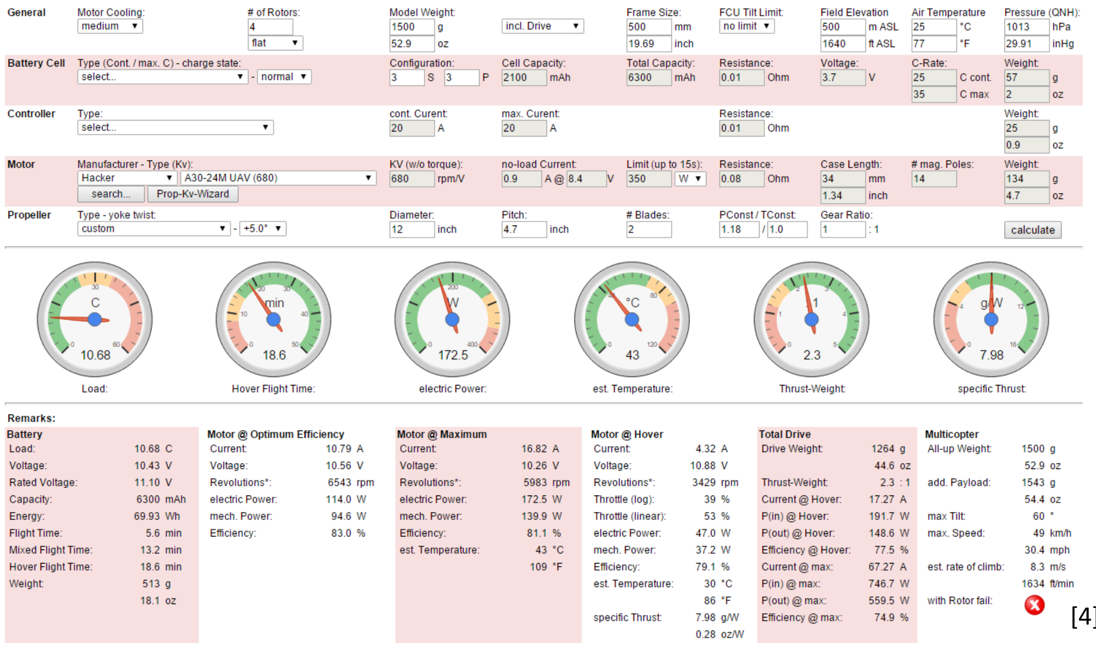
Research Objective

- Investigate algorithms for optimizing electric propulsion units for small Unmanned Aerial Systems (UAS).

[1]

Research Justification

- No literature found for optimizing using commercial, off-the-shelf parts.
  - Examples of optimizing custom propellers [2,3].
- Current modelling software has little to no optimization capability.
- Increasing use of UAS demands efficient tools.



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Database Creation

- Assembled a database of commercial components from databases available online.

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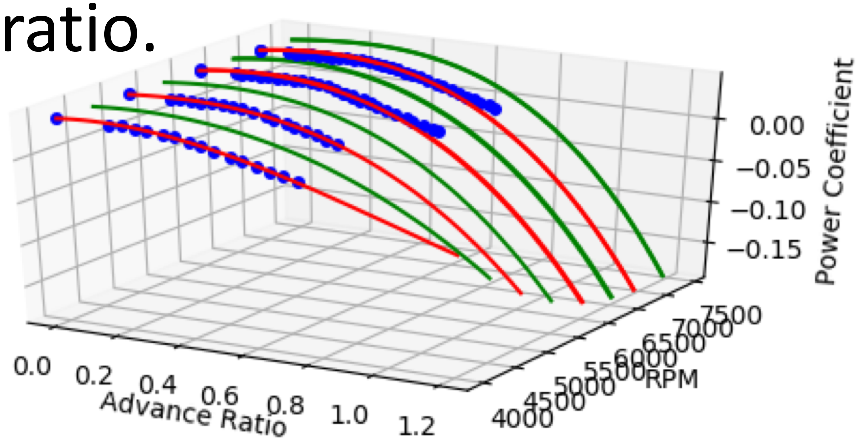
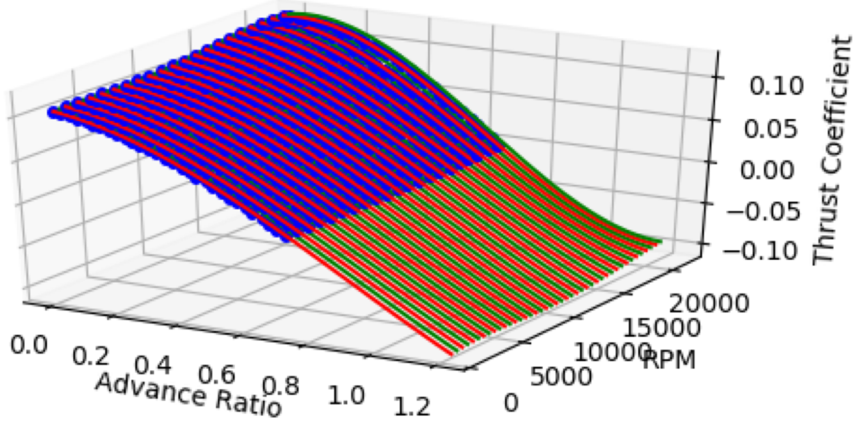
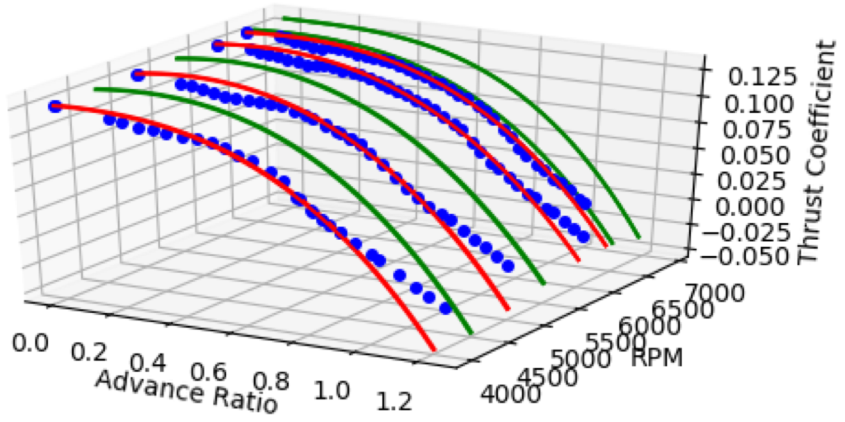
Propeller Modelling

- Created polynomial fits of thrust and power as functions of angular velocity and advance ratio.

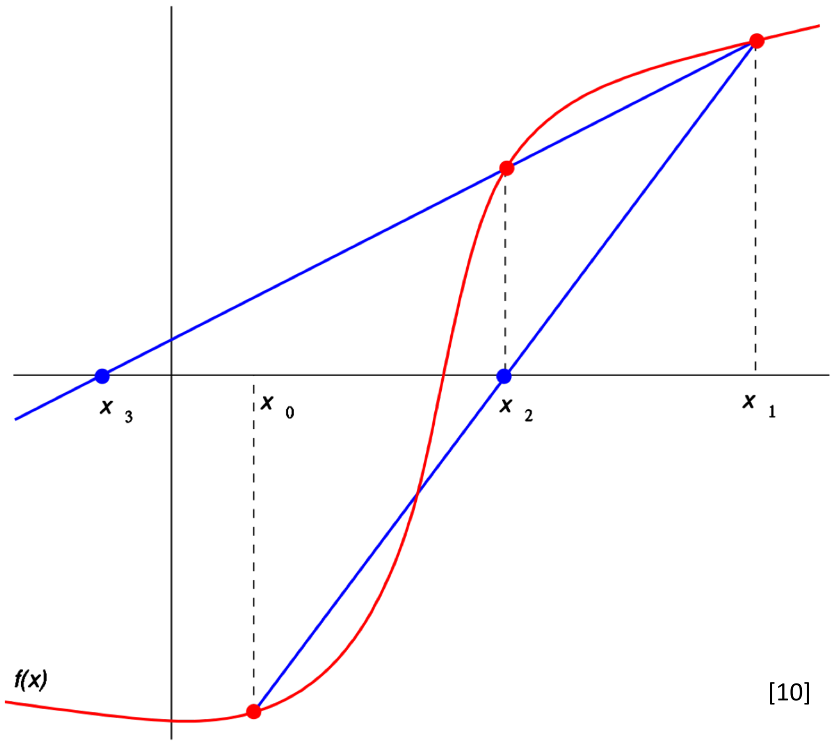






Unit Modelling

- Calculated flight time at a given thrust for a given combination of propeller, motor, ESC, and battery [9].



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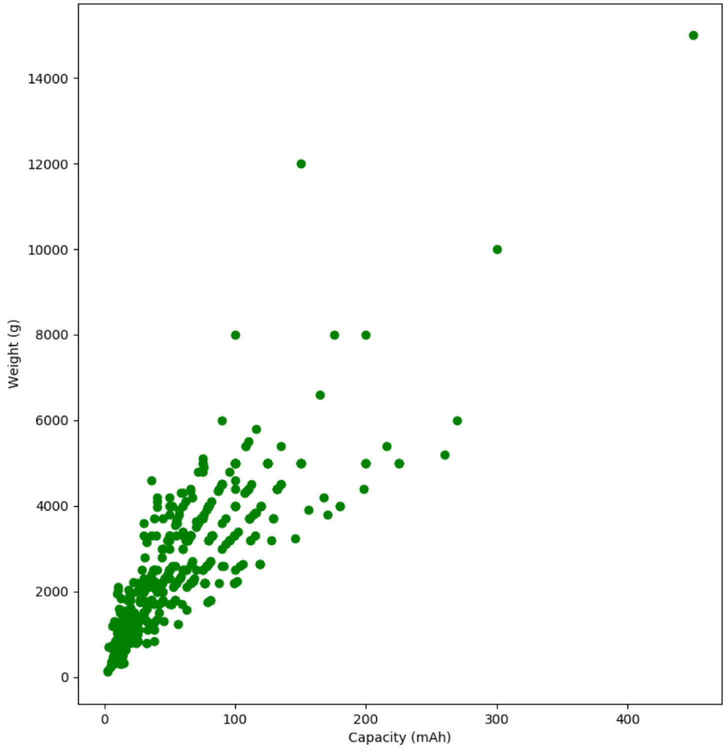
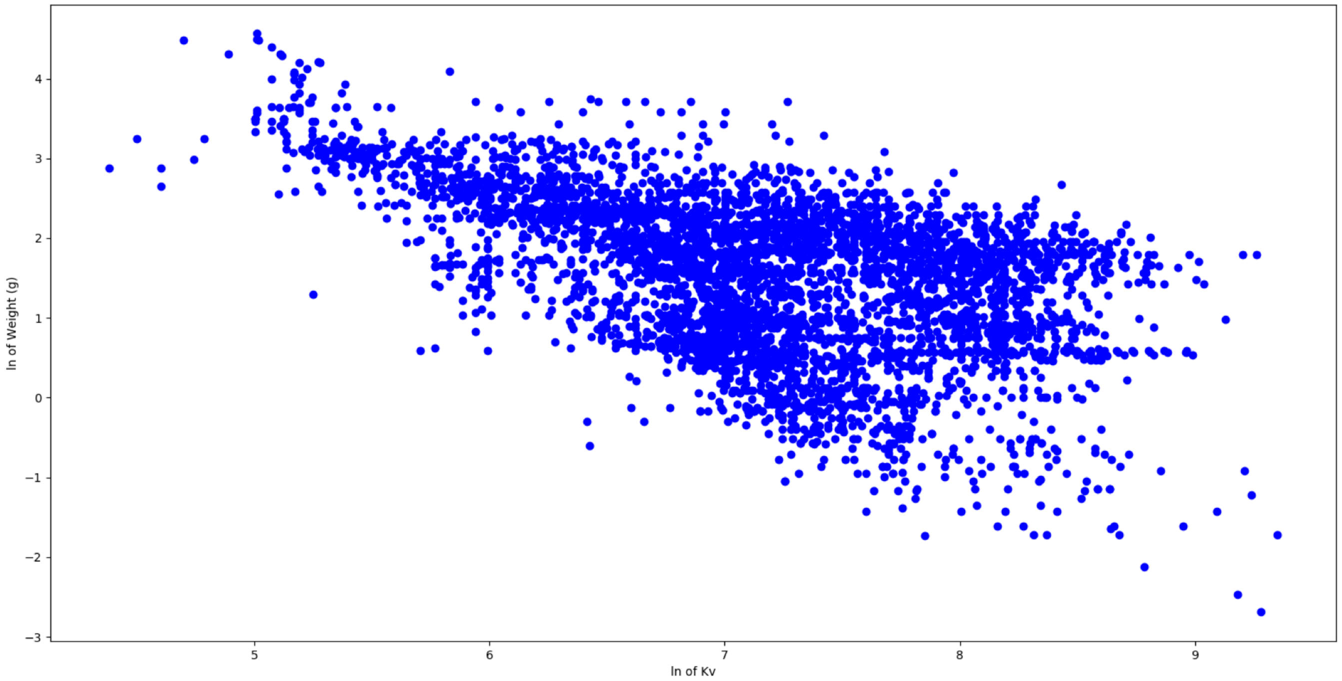
Discrete vs Continuous Optimization

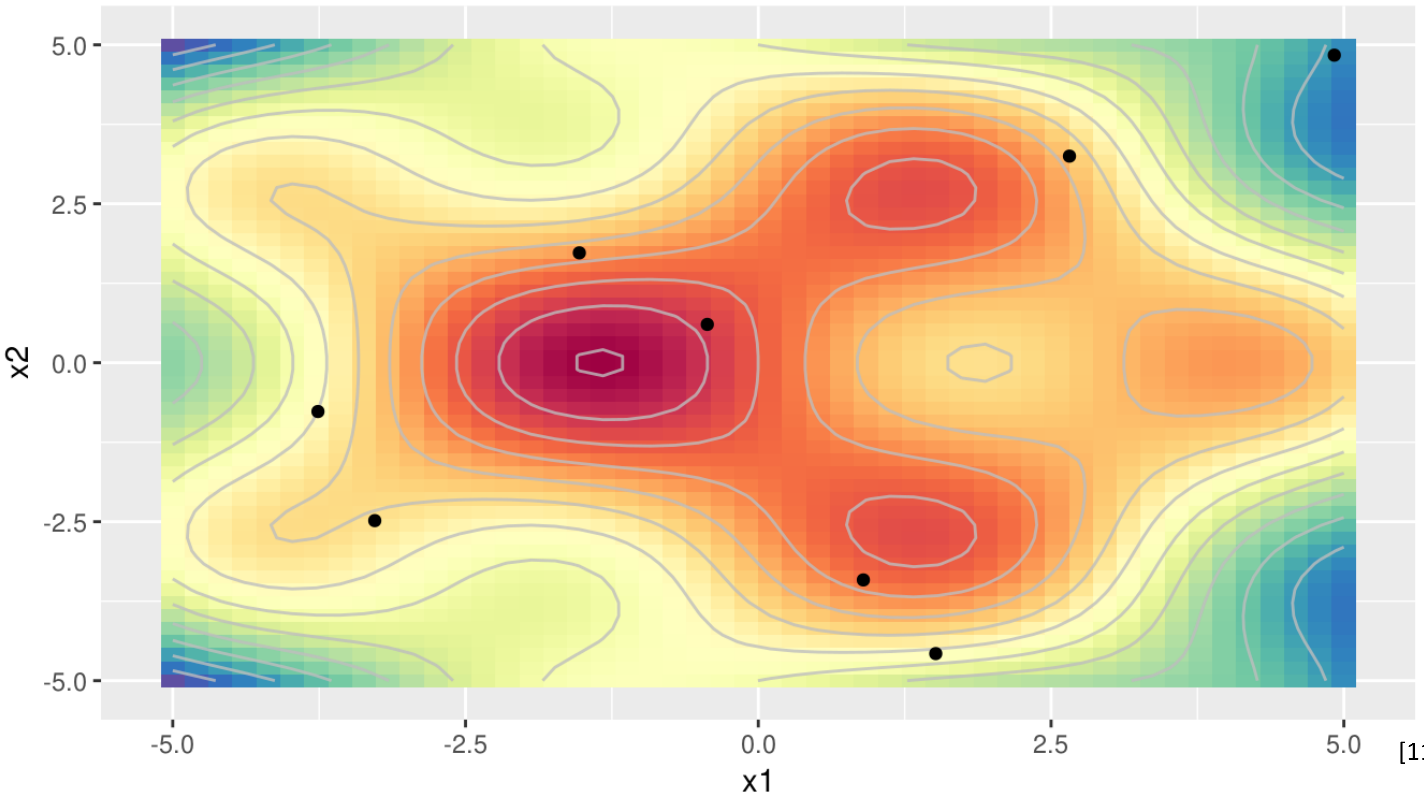
- Some parameters can be modelled as continuous functions; however, this is inaccurate for commercial, off-the-shelf parts.





Random Search Method

- Simplest choice for discrete optimization.



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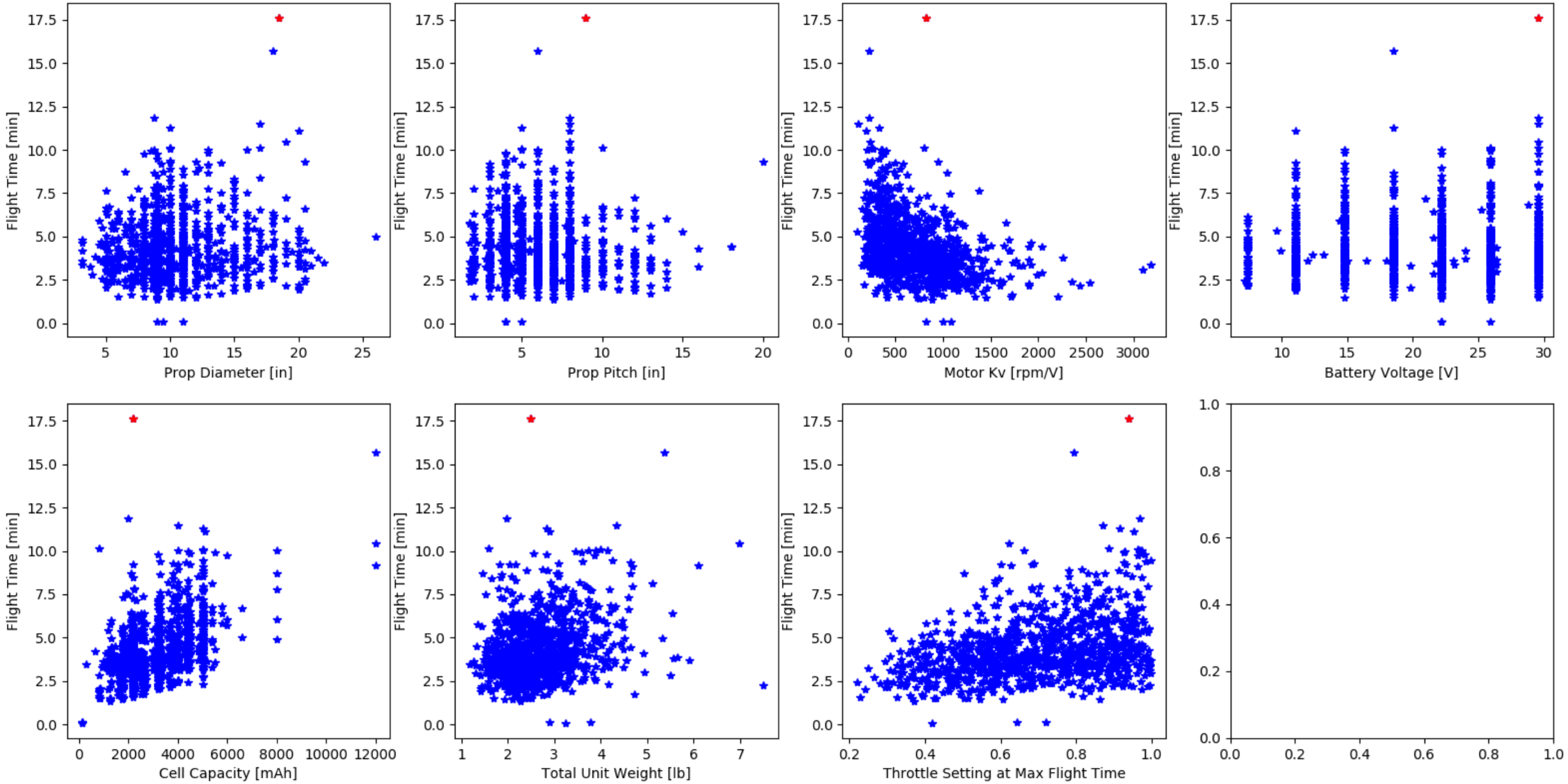
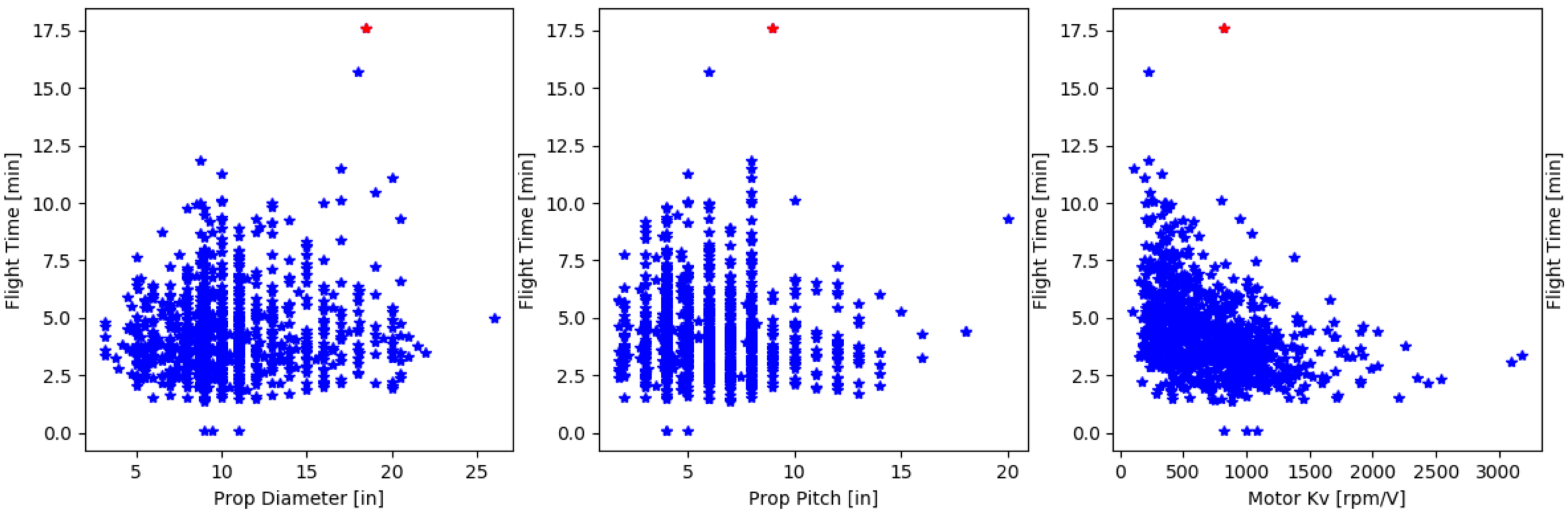
Performance Trends

- Identify trends in the design space for optimizing flight time.



Algorithm Weaknesses

- Very susceptible to outliers.
- Computationally inefficient.



Future Work

- Improve quality of database.
- Analyze other discrete optimization techniques:
  - Genetic
  - Simulated annealing
  - Branch and cut
- Research how to effectively constrain the optimization.

[1] https://newatlas.com/laser-powered-stalker-uas/23283/

[2] Gur, O. *Optimization of Propeller Based Propulsion System*, Journal of Aircraft, 2009.

[3] Gur, O. *Optimizing Electric Propulsion Systems for UAVs*, AIAA/ISSMO Conference, 2008.

[4] https://i.stack.imgur.com/LbTmc.png

[5] https://ecalc.ch/

[6] http://umdpsyc.blogspot.com/2012/05/research-electrophysiology-as.html

[7] https://hobbycenter.ru/imglib/icon_brand/201608151648__0f39d6ed.png

[8] www.motocalc.com

[9] Phillips, W. F., *Electric Motors Summary*, whitepaper, 2007.

[10] https://en.wikipedia.org/wiki/Secant_method

[11] https://mlr-org.com/docs/2017-03-13-first_release_of_mlrmbo_the_toolbox_for_bayesian_black_box_optimization/