A MODEL BASED PREDICTIVE BATTERY MONITORING SYSTEM FOR MULTIROTOR DRONES

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OBJECTIVES

CAPACITY ESTIMATION

Warn the user of lower capacity than expected early in the flight.

INTERNAL RESISTANCE ESTIMATION

Accurately estimate the battery internal resistance.

CELL DIFFERENCE MONITORING

Give meaningful output of inter-cell performance statistics.

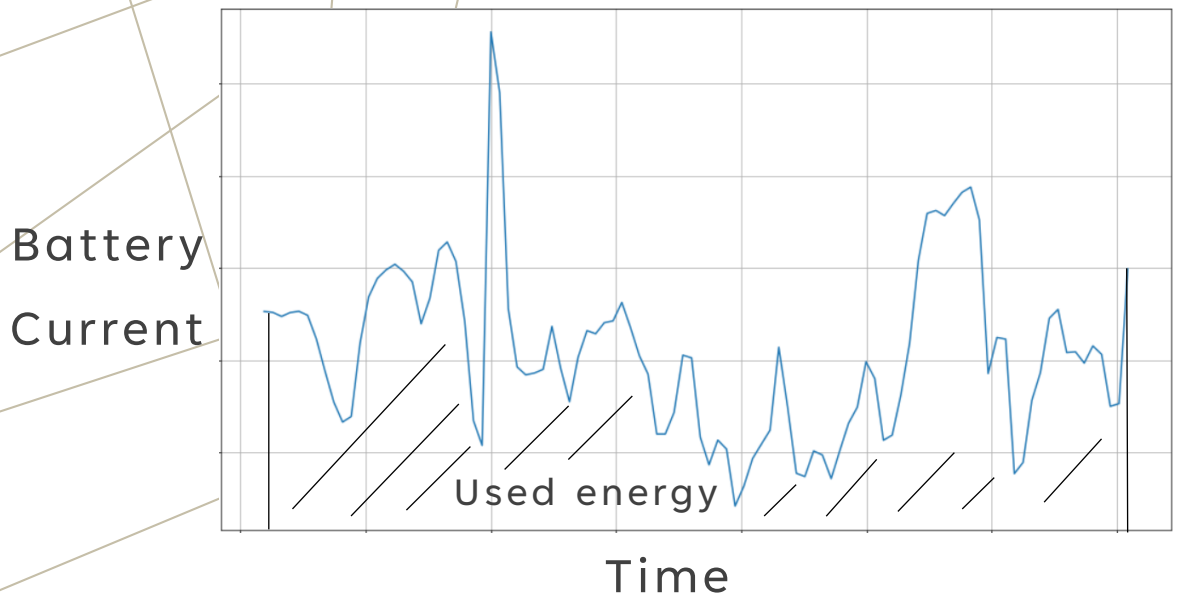
BACKGROUND

Lithium-Ion Batteries

- High energy, power density
- Several cells, each with a limited voltage, highest when charged
- Batteries have rated capacity, but this can be changed by external factors.
- Internal resistance causes wasted energy, and generated heat.

Drones

- Require certain voltage to maintain flight.
- Loss of power can lead to dangerous outcomes.
- Ensuring battery data is available can increase safety.



RELATED WORK

State-of-Charge: Coulomb Counting

- Integrates current over time
- Finds used energy
- Requires total, and initial battery energy to give state of charge

Model-Based Capacity Estimation

- Runs a battery simulation based on the battery used
- Outputs from this can be compared to real performance
- The difference in performance can be used to estimate battery state
- Model by Olivier Tremblay is used in this project

Cell Difference Estimation

- Per-cell voltage data used with statistical calculations
- Performs real-time outlier detection
- Method proposed by Changhao Piao

REQUIREMENTS

LIGHTWEIGHT

Minimise impact on flight characteristics.

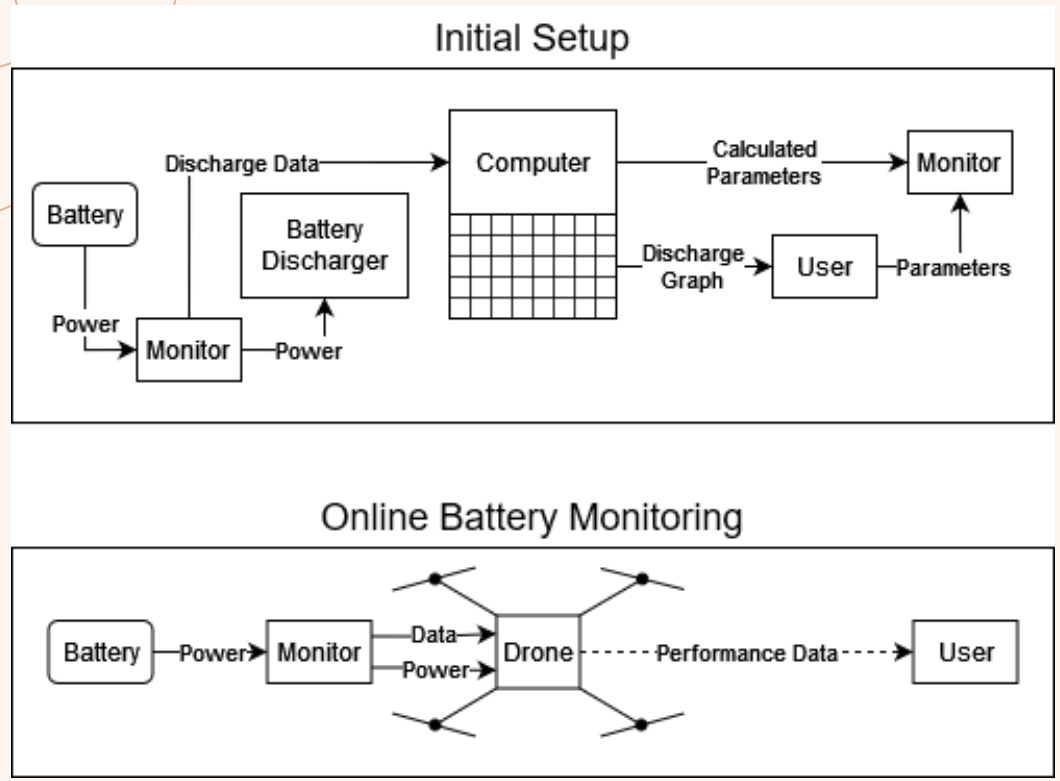
COMPACT

Ensure mounting is easy on drones of all sizes.

EASY TO USE

Non-expert end-users should be able to set up the monitor.

DESIGN



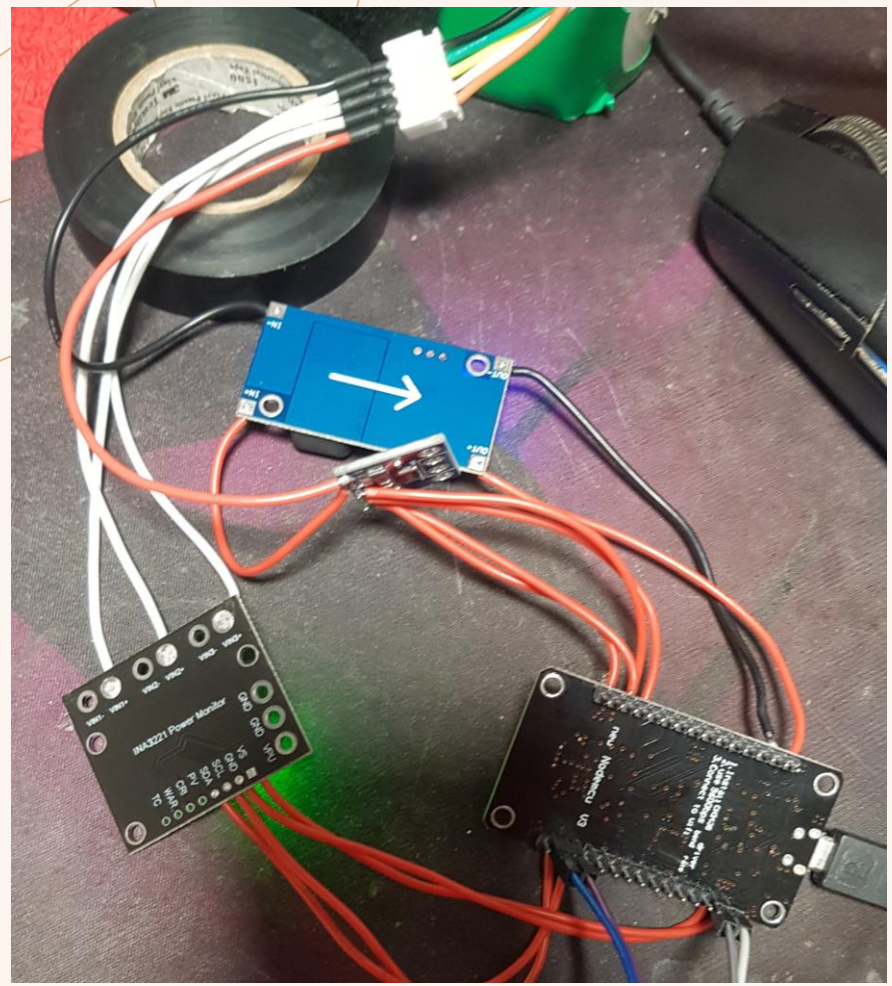
Hardware

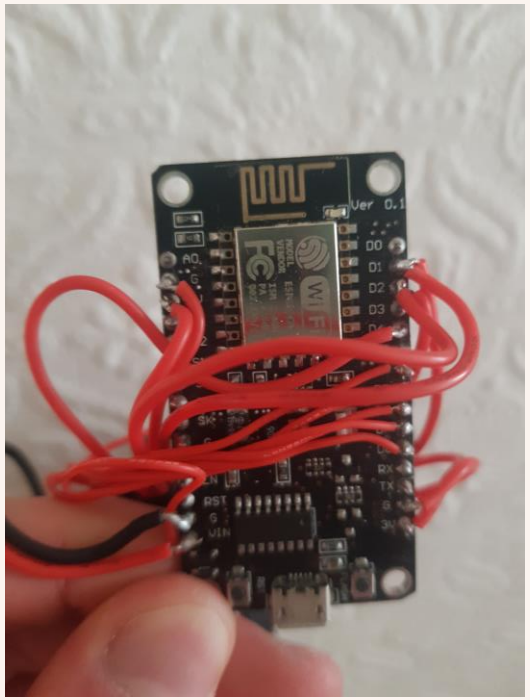
- Microcontroller for processing
- Several options for measurement devices depending on specific setup requirements

Software

- First section: Setup for battery model by finding parameters
- Computer program processes this data to outputs required
- Second section: Live monitoring based on the model generated from parameters
- Battery capacity estimate updated based on performance compared to model
- Data is output via several methods

IMPLEMENTATION





Top: ESP8266

Left: Connected to INA chips

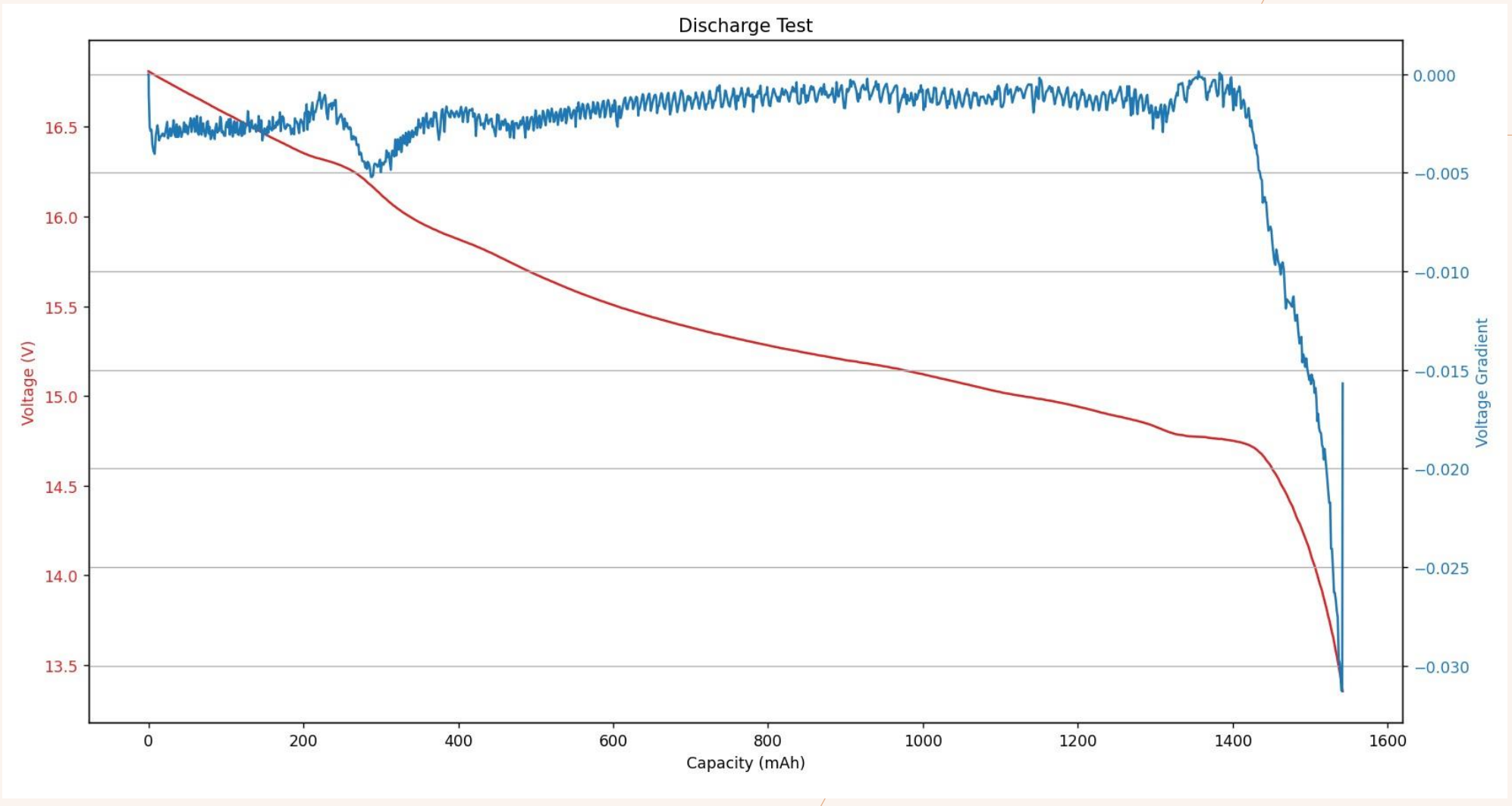
Hardware

- ESP8266, widely available, lightweight, low cost
- External INA226 and INA3221 ADCs, can perform processing independently and have wide input range and high resolution
- This allows minimal missed voltage/ current readings

Software

- Arduino/ C++ used on monitor
- Internal resistance estimation adapted from Ardupilot code
- Monitor stores discharge data
- Computer program processes this data, generates output and visual graph
- Results are uploaded to monitor which then performs live simulation and estimation

TESTING



Generated discharge graph

CONCLUSION

CAPACITY ESTIMATION

Functions after modification to model input parameters.

Input methodology cannot be used without modification.

RESISTANCE ESTIMATION

Functions well.

Performs as expected during flight.

CELL DIFFERENCE ESTIMATION

Further testing required.

Appears to work based on visual inspection.

FUTURE WORK

GUI FOR MODEL SETUP

Increase usability for manual model setup.

INTEGRATION WITH FLIGHT CONTROLLERS

Ardupilot/ Betaflight software integration allowing for communication/ advanced features.

CIRCUIT BOARD DESIGN

Minimise weight and size, increase physical usability.

THANK YOU!