Failsafe Algorithms for Stabilization and Control of UAS Platforms

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Introduction

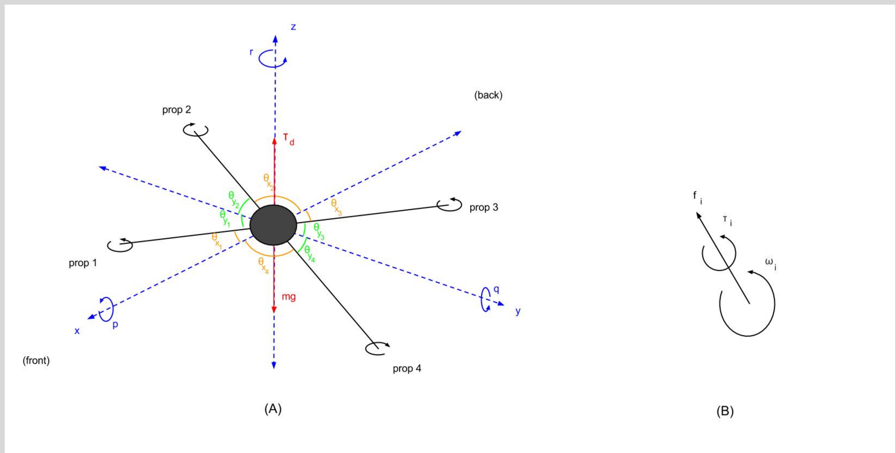
- Rapid Increase in the use of Unmanned Autonomous Systems (UAS) has caused the safety of these platforms to become a high priority.
- One of the main safety issues with these platforms is motor failure.
- In order to prevent crashes and injury, a failsafe mechanism is needed to stabilize and control the UAS platform in the event of a motor failure.
- Several failsafe algorithms have been developed to deal with motor loss on asymmetrical quadrocopters and hexacopters.

https://store.3drobotics.com/products/IRIS

http://goo.gl/l2yBPC

Problem

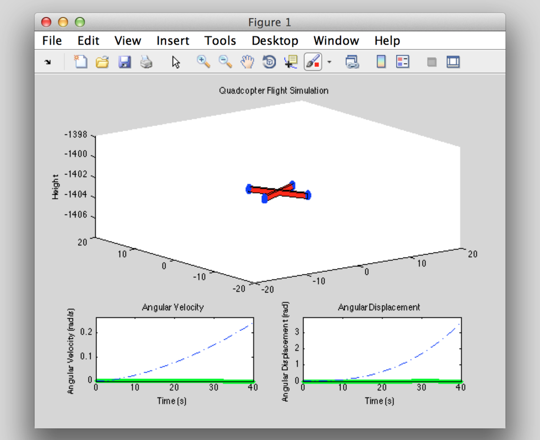
- Without a failsafe mechanism, the loss of a motor will cause a platform to fall uncontrollably out of the sky.
- With the loss of a motor, the dynamics of a platform change dramatically.
- By taking advantage of these new dynamics, a failsafe algorithm can return partial control to the platform which will allow it to land safely.
- Due to the different dynamics of various UAS platforms, a different failsafe algorithm is necessary for each type of platform.



(A) Mathematical model of an asymmetric quadrocopter.
(B) Forces and torques generated by a single motor.

Methodology

- For testing purposes, we adapted Andrew Gibiansky's quadrocopter simulator to work with hexacopters as well as added functionality for different flight controller methods.



Gibiansky, http://goo.gl/dGStgk

- For the asymmetrical quadcopter, we adapted a feedback linearization method.
- For the hexacopter, we adapted both the feedback linearization method and a redistributed pseudo inverse (RPI) method.

Results

- For the quadrocopter case, we were able to maintain semi-controllable flight for 400 seconds in the case of one motor loss using our adapted algorithm.
- With the feedback linearization approach on the hexacopter, semi-controllable flight was maintained by shutting off the motor opposing the one that failed.
- With the RPI method on the hexacopter, we were able to force the hexacopter to fly with five motors with semi-controlled flight for a short period of time.

Conclusions

- Our failsafe algorithm for the quadrocopter case maintains control for a long enough period of time that a safe landing should be possible in most situations.
- Our failsafe algorithm using feedback linearization on a hexacopter will allow for a safe landing by taking advantage of the redundancy and coupled dynamics of a hexacopter by allowing it to fly as a quad.
- Our failsafe algorithm using the RPI method allows a hexacopter to maintain control eith five motors, but is much less stable than our algorithm using feedback linearization due to the instability of a hexacopters dynamics in the five motor case.

References

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