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Department of Applied Mathematics and Computer Science

Coding Reusable Rockets

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1 Motivation

Reusable Rockets!

2 How Does the System Interact?

Figure 1 illustrates how the control system communicates with the rockets. Receiving information from the sensors it takes action to reach its desired goal.

overview.pdf

Figure 1: Interaction between system

2.1 Triple Modular Redundancy

We aim at imitating a triple sensor system, where the control system receives three sensor values. These values may at random be erroneous, and the control system takes the median of the received values.

3 Controlling the Rocket

We did two types of controllers.

3.1 Bang-Bang

Bang-bang control is a control technique used to reach some target. It is called "bang-bang" because the controller simply says on or off. There is no in-between. One big con is that it most likely will overshoot its target multiple times because the system does not adjust according to its current location.

3.2 Proportional–Integral–Derivative

Proportional–Integral–Derivative (PID) control is a more sophisticated technique that combines the current information, past and future to compensate and reach the desired goal.

$$t = K_p e(t) + K_i \int_t^0 e(\tau)d\tau + K_d \frac{de}{dt},$$

where all K's are non-negative values that should be adjusted by trial and error. $e(t)$ computes the current error term from the desired target t. τ denotes a constant for the slope. K_p, K_i, K_d denote the present, past and possible future values, respectively. Actually we made it work with on PD.

4 Simulation Results

Figure 2 presents how the altitude of the rocket is very similar while comparing the Bang and PD controller.

altitude.pdf

Figure 2: Comparison altitude over time for Bang and PD.

Figure 3 shows how the rocket's tilt changes radically when gimbal is not compensating for the current position. It actually gets worse.

tilt.pdf

Figure 3: Comparison of gimbal and tilt for Bang.

Figure 4 shows that the PD control is much better at reaching the target and eventually stabilises elegantly.

gimbal.pdf

Figure 4: Comparison of gimbal and tilt for PD.

Figure 5 illustrates how the thrust for Bang control looks very noisy because it turns on and off. The PD control is more controlled and stabilises eventually and earlier than the Bang control does.

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thrust.pdf

Figure 5: Comparison thrust over time for Bang and PD.

5 Conclusion

Check out the awesome simulation video!