PHYS358: Session 06

Ordinary Differential Equations (6): PID Controller

The PID controller (for Proportional, Integral, Differential) relates the error $e \equiv r - y$ between a reference value r and the measured value y to a control parameter k. Think of cruise control. The goal there is to keep the speed (y) at a specified value (r), by manipulating the throttle (k). The controller can be written as

$$k(t) = K_p e(t) + K_i \int_0^t e(\tau)\, d\tau + K_d \frac{de}{dt},$$

with the three weighting constants K_p, K_i and K_d for the proportional, integral, and differential terms. Here, you'll explore the behavior of the PID controller with the help of the lunar lander. We will first derive the control expression, and then will explore the effects of the various terms.

Step 1: Derive an expression for $k(t)$ for the lunar lander, assuming (a) a constant reference velocity and (b) a reference velocity $v_0(z)$.

Step 2: Download the class package, and run `lunarlander.py 0` . You should get the by now well-known result of a free-falling lunar lander. Check what the argument 0 does.

Step 3: Run `lunarlander.py 1`. Rerunning the lunar lander should give the same result as in Step 2.

Step 4: Locate `ode_init` in `lunarlander.py` and set k_p, i.e. the proportional weight, to $k_p = 1$ and $k_p = 10$. Identify the reference velocity, i.e. the velocity at which the lunar lander should descend. Run the lunar lander for both cases (`lunarlander.py 1`), and describe the results. Do they meet your expectations regarding the role of the proportional correction?

Step 5: Set k_i, the integral weight, to $k_i = 1$ and $k_i = 0.001$. Describe the results and check your expectations.

Step 6: Try $k_i = 0.1$ and $k_d = 1.0$. What happens?

Step 7: Finally, try $k_p = 0.5, k_i = 0.1, k_d = 1.0$ and compare to Step 6. What role do the differential and the proportional term play?

Step 8: And, finally, finally, try `lunarlander.py 2`. What does the PID controller attempt to do?