PID Control of Quadcopters

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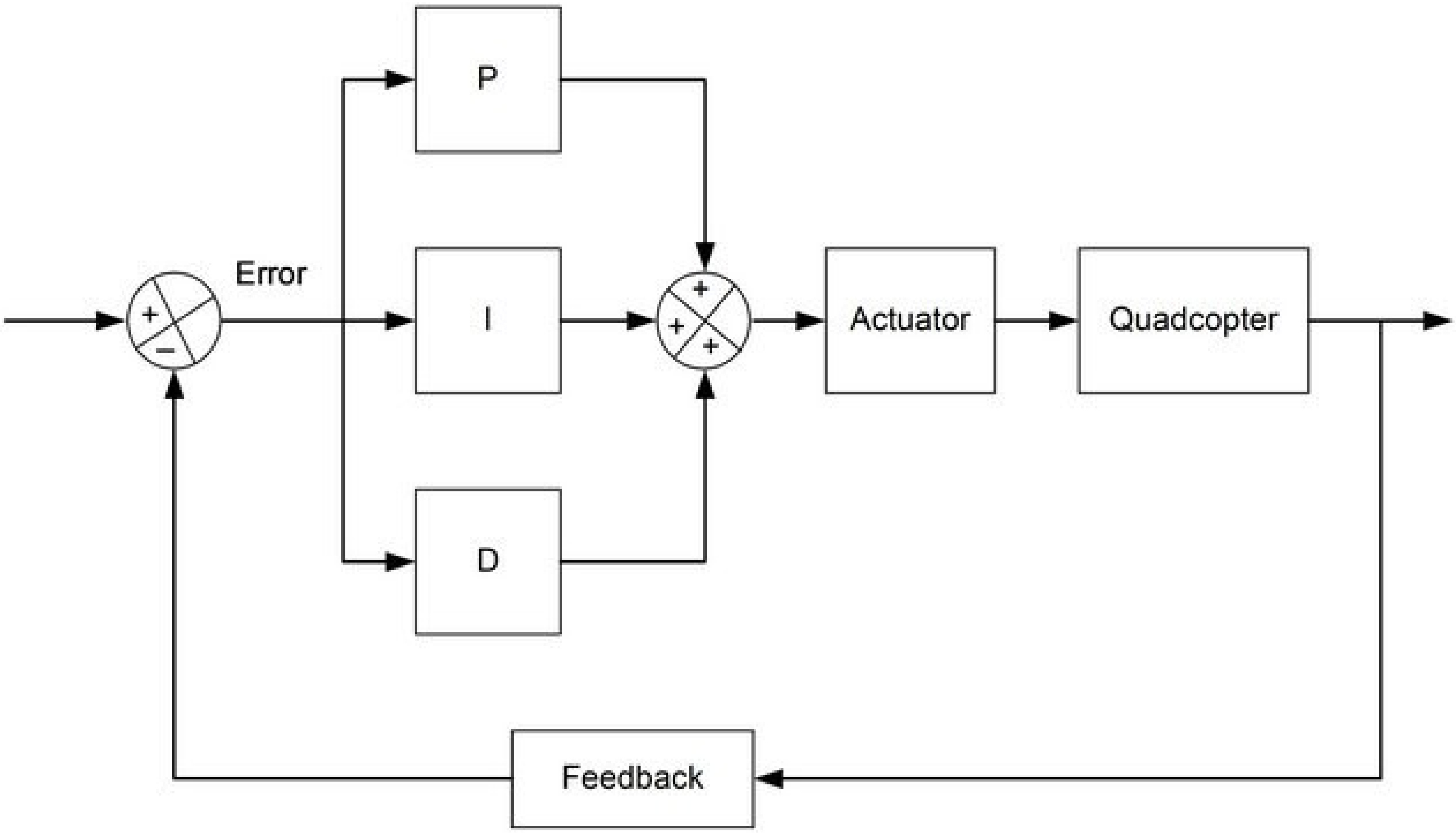
What is PID?

PID (proportional-integral-derivative) is a closed-loop control system that tries to get the actual result closer to the desired result by adjusting the input. Quadcopters or multicopters use PID controller to achieve stability.

Closed loop means that we're taking a feedback from the quadcopter, which is the angle read from the gyroscope.

Block diagram representation of PID control...



Equation of PID control:

Let, error(t) = angle read from gyroscope(t) – angle from the user(t)

Then,

$$\text{PID output}(t) = Kp*\text{error}(t) + Kd*(\text{error}(t) - \text{error}(t-1)) + \sum Ki*\text{error}(t)$$

Kp is known as the proportional gain constant

Kd is known as the derivative gain constant

Ki is known as the integral gain constant

Effects of each constant on quadcopter flight...

Kp (proportional gain constant)

This is the most important constant. It is always tuned first. The higher this constant, the higher the quadcopter seems more sensitive and reactive to angular change. If it is too low, the quadcopter will appear sluggish and will be harder to keep steady.

The quadcopter will start to oscillate with a high frequency when Kp is too high.

Kd (derivative gain constant)

This coefficient allows the quadcopter to reach more quickly to the desired attitude. It has the effect of amplifying the user input and damping the oscillations caused due to Kp.

It also decreases control action fast when the error is decreasing fast. This coefficient is normally tuned after setting Kp.

Ki (integral gain constant)

This coefficient can increase the precision of the angular position. It has the effect of smoothening quadcopter oscillations. It can remove angular offsets.

This term is especially useful with irregular wind and ground effect (for eg., turbulence from motors). However, if I value is too high the quadcopter might begin to have a slow reaction.

How to tune the PID coefficients?

- Trail and error:
  First tune Kp until the quadcopter begin to oscillate. Then tune Kd untill the oscillations are damped. After this, if there is any offset in angular position/smooth oscillations, adjust Ki untill they go away.

- Ziegler Nichols method:
  This is a heuristic method of PID tuning. Most effective in the case of first order systems.

Our test rig: