One less accurate but easy to understand analogy I often use is playing golf. What PID does, is like trying to get the golf ball into the hole. Every time you hit the ball, it might end up too far, or too short, but hopefully it gets closer and closer. You repeat until you eventually get it.

PID tuning is like improving your golf skills, so you can get the golf ball into the hole in as few strikes as possible.

P gain determines how hard the flight controller works to correct error and achieve the desired flight path (i.e. where the pilot wants the quad to go by moving the transmitter sticks).

Think of it as a sensitivity and responsiveness setting. The snappy response provided with a high P gain can even make it feel like you have increased your rates.

Generally speaking, higher P gain means sharper control while low P gain means softer control.

If P is too high, the quadcopter becomes too sensitive and tends to over-correct, eventually it will cause overshoots, and you will have high frequency oscillations.

You can lower P to reduce the oscillations, but reduce it too much and your quadcopter will start to feel sloppy. I term determines how hard the FC works to hold the drone’s attitude against external forces, such as wind and off-centered CG.

Think of it as the stiffness setting in the stall motion of your quadcopter, and how well it holds its attitude.

In Betaflight, default I gain works pretty well on most setups. But if you notice some drifting without user command, then increase it. When I is too low you might find yourself having to correct the quad’s flying path a lot more with your sticks, especially when you are active with the throttle.

When I gain gets too high, your quadcopter will be overly constrained by this, and start to feel stiff and unresponsive. It’s similar to having a slower reaction and a decreased P gain. Excessive I gain in extreme cases can create a low frequency oscillation.

Another issue that I gain can address or improve is “throttle dips“.

In the real world, no two ESC’s, motors or propellers are identical, thus they will provide different levels of thrust even when spinning in the same air. When you do a punch out and immediately lower your throttle, one motor might increase and decrease RPM faster than the others, this will cause an unwanted dip movement.

D gain works as a damper and reduces the over-correcting and overshoots caused by P term. Like a shock absorber stops the suspension from being bouncy, adding D gain can “soften” and counteract the oscillations caused by excessive P gain, as well as minimizing propwash oscillations.

When D is too low, your quad will have bad bounce-backs at the end of a flip or roll, and you will also experience the worst propwash oscillations in vertical descents.

Increasing D gain can improve these problems, however, an excessive D value can introduce vibration in your quadcopter because it amplifies the noise in the system. Eventually this will lead to motor overheat and quad oscillation

Another side effect of excessive D term is the decrease in the quad’s response, this effect is often described as “mushy”.

Advices for PID Calibrate drone:

1. Backup your current PID values, so you can go back if something goes wrong
2. Always tune your quad in Rate Mode (aka Acro Mode)
3. Make sure your quadcopter’s CG (centre of gravity) is right in the middle, CG has an effect on how well your quad will fly, and how easy it is to tune. You can simply shift your battery to move the COG forth and back.

Let`s calibrate drone :

Every time you change a value, you should ask yourself: “is it getting better or worse?” Try to find the peak where the quad has the best flight characteristics before performance starts to degrade again.Tune one axis at a time: first roll, then pitch, and finally yaw. I adjust one value at a time on each axis, starts with P, then D, and finally I. You might need to go back and forth to fine tune each value because changes to one, will affect the others.Tuning a quad can take time, it might take 10 mins, an hour or even days to get a perfect tune. It really depends on the quality of the parts, the build, and especially your expectation!

If Setpoint Weight is high, the quad will feel more snappy, robotic, precise and locked-in, but it will also feel rougher. When it’s low, the quad feels smoother but also looser and more sluggish. Racers prefer to have it higher, while freestyle pilots prefer a lower value. I personally use 0.9-1.0, which I believe is a good balance and should work for most people.

Your hardware configuration plays a big part in the performance of your quadcopter, there are a few things you should check and get right first.

Not all oscillations are caused by high P or D gains. You need to eliminate vibration sources as much as possible on your quadcopter before tuning PID. The balance of motors and propellers, soft-mounting flight controllers and motors, even frame rigidity, can factor in vibrations. With a vibration-free copter, you can set much higher P and D gains for smoother yet more locked-in flight characteristics..

Ideally, the center of gravity (CG) to be right in the middle of your quadcopter, where the 4 motors intersect on a horizontal plane, and be as close as possible to the line of propellers on the vertical plane.

When your CG is off-centered, some motors will have to work harder than others, which will affect stability, cause motors to overheat, and limits your maximum speed.

For example – if the LiPo battery is mounted too far back in a quad, it shifts the CG further towards the rear. Now the 2 rear motors might be pushing at 100%, while the 2 front motors are only at 80%. At this point, if you want to push the throttle harder, you can’t! You quad might wobble back and forth, but it will fail to deliver any extra power because the rear motors have already maxed out. Quadcopters with more centralized mass tend to feel more precise, snappy and responsive. When there is more mass on the outside of a quad, it takes more force to rotate it, and longer to accelerate to the desired velocity. Likewise, due to the higher angular mass and inertia, it’s also harder to stop it from rotating.

That’s why X frames (mini quad frame shape) have taken over the racing drone industry from “H designs” when people realized the benefits. Apart from the frame design, lighter motors and ESC’s also help to reduce rotational inertia.vbs.

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