Complementary filter

상보필터를 얘기하기 전, Pros and Cons of accelerometer and Gyroscope

**What's bad about the accelerometer?**

The problem with the accelerometer is that it is ***noisy***. It becomes especially noisy in the presence of any sort of mechanical noise (e.g. a DC motor attached to the pendulum). In the [demonstration video](https://vanhunteradams.com/Pico/ReactionWheel/Complementary_Filters.html#Demonstration-video), you can see the accelerometer angle plotted on the VGA display as I move the inverted pendulum back and forth. When I turn on a DC motor attached to the pendulum arm, the noise increases. **This is *much* too noisy to use in a feedback controller**.

**What's good about the accelerometer?**

Because gravity always points in the same direction, the measurement error from the gyroscope *remains* ***zero-mean***. The accelerometer does not accumulate any measurement *bias*, like the gyroscope does. The measured acceleration is equal to the *true* acceleration plus zero-mean Guassian noise, where the variance of that Gaussian noise can be quite large.

충격에 과하게 반응 -> 필요이상의 noise 발생, 이는 고주파에서의 단점

### What's bad about the gyro?

By integrating the gyro measurements to maintain an estimate for angle, we are doing **dead reckoning**. This works great over short periods of time, but eventually leads to a **large bias in our angle estimate**. You can see this in the [demonstration video](https://vanhunteradams.com/Pico/ReactionWheel/Complementary_Filters.html#Demonstration-video). Even as I hold the pendulum at a constant angle, the **gyroscope error continues to accumulate a bias**. This bias is driven by a random process, so it may wander in any direction.

### What's good about the gyro?

Over short periods of time, the amount of noise in the gyroscope measurements is **much lower than that from the accelerometer**. You can see this in the [demonstration video](https://vanhunteradams.com/Pico/ReactionWheel/Complementary_Filters.html#Demonstration-video). As I move the **pendulum back and forth, note that there is very little noise on the (red) gyroscope measurements, and a lot of noise on the (white) accelerometer measurements.**

저속상태시 값이 축적되어 흐르는 drift 발생 -> 저주파 단점

상보필터를 쓰는 이유 ?

## Complementary filter

We desire the short-term accuracy of the gyro angle estimates, and the long-term stability of the accelerometer angle estimates. A complementary filter achieves this! A complementary filter low-passes the accelerometer measurements and high-passes the gyroscope measurements. This gives us the benefit of the gyro over short time periods, and the stability of the accelerometer over long time periods.

The algorithm is summarized as follows:

1. Gather a set of accelerometer and gyro measurements
2. Compute the accelerometer angle
3. Compute the change in angle that the gyro measures, by multiplying the raw measurement by the timestep (0.001 seconds in the example code below)
4. Compute the new complementary angle estimate by performing a weighted average of the accelerometer angle and the sum of the previous complementary angle estimate and the change in angle measured by the gyro.

