RC DRONES: A BRIEF OVERVIEW

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The word "drone" means something that hums, such as bees. However, in recent years, it also means a pilotless, Remote Control (RC) aircraft or missile.

In this article, we talk to 2 women leaders. One is a specialist medical practitioner who runs a private clinic, leads a humanitarian organisation and has made high risk missions to help save lives.

The aircraft can be either lighter than air, fix-wing, rotary wing or more notably, can have a number and arrangement of smaller propellers comparative to the craft size. Piloted remote-control devices have evolved since the late 19th century when hydrogen-filled model airships were flown in a music hall using a basic form of spark-emitted radio signals.

Over the years, the advances made in radio signal processing have seen more and more advanced radio-control systems with almost limitless proportional control channels made possible in what we now see in today's RC drones.

The word "proportional" carries an important meaning here. For example, how many control channels are required in a typical fix-wing aircraft? In the most basic form, we need to control something that flies in 3-dimensional space with 6 degrees of freedom i.e. 3 translational and 3 rotational. To do this, the aircraft is fitted with elevator for pitching up and down, rudder for yawing, ailerons for rolling and some form of thrust producer in translating the aircraft forward.

Altogether 4 types of controls are required and all these need to be precisely controlled with the exact amount of output per given amount of input. This is where control proportionality comes in. In other words, the control in terms of on and off, is not going to cut in.

The difference between pilotless and piloted remote-control aircraft is that the latter is controlled manually by the person holding the transmitter while the former flies via commands through a prescribed program or algorithm.

Is control alone enough? No. Another element that is needed is stabilisation. As mentioned, to fly in a 3-dimensional space which is exposed to environmental conditions, an aircraft can be un-stabilised at any time. Typical fix-wing design with high wing at the front and tail feathers at the back will have high inherent stability but the same cannot be said about rotary wing or multiple copter aircraft. Even with the high inherent stability of a fixed wing aircraft, it is actually leaning towards passive stability, i.e. once disturbed from its current altitude, it will immediately take the latest altitude and only after a prolonged period will it go back to its original altitude. Depending on how high the initial altitude is prior to the disturbance, the aircraft may crash to the earth before it recovers.

For a piloted fix-wing aircraft, an ample time window will allow the ground pilot to dial in correction inputs to stabilise the aircraft. For a non-fixed-wing aircraft, the time window for correction input is too short for a human to react in time and it is only made possible with an artificial stabilisation system.

Take helicopters for example. The primary rotor blade rotational reaction on the fuselage will change rapidly if a gust or side wind impacts the blades, resulting in fuselage yawing if the tail rotor fails to react in time to correct the heading. Typically, this small tail blade pitch angle adjustment is achieved automatically via input from the tail gyro which senses the fuselage rotation torque.

Similarly, if the primary blade pitch angle is changed by the pilot, the resultant reaction torque on the fuselage will change as well and the correction of the tail blade is needed if the heading of the fuselage needs to be maintained. Again, the time window is simply too small for humans to react accordingly, especially when climbing out from hovering or from small forward speed.

The gyro mentioned here is an artificial stabilisation system only in a one dimensional plane; over time, it has evolved from rotational mass down to inertia-based gyros and currently, in the actual aircraft world, optic-based gyros. Just touching the base on these optic gyros, a single light source is split into two opposing beams projected into a single fibre optic coil at each end. The time for the light to return is the same if there is no rotational acceleration along the optic coil axis but it'll be different otherwise. This effect is known as Sagnac Interference, thus named after Georges Sagnac, a French physicist. The measured difference in time or error is used as a signal for flight correction.

For lateral and longitudinal stability of fix-wing aircraft and helicopters (to a certain extent), the pendulum effect (primary mass being hung at the bottom) creates an additional time window for humans to make corrections accordingly. For multi-rotor crafts however, there is basically no built-in stabilisation whatsoever and successful flying has been made possible only recently with the availability of 3-dimensional stabilisers. All 6 degrees of freedom need not only be controlled but also stabilised. Any uncalled for translational or rotation acceleration will be countered within milliseconds and therefore static hovering and lateral flying is then possible.

In general, control of a multi-rotor craft is via the adjustment of the rotational speed of the propeller. For example, a quad rotor achieves yawing stability via counter rotating pairs of the 4 propellers. It also achieves lateral and longitudinal stability via the adjustment of propeller speed through a much more complex stabilisation algorithm from on-board 3-dimensional rotational and translational acceleration sensors. It becomes complex as the changes of propeller rotation will also change the reaction torque; thus yaw will occur if we desire only yaw control. It seems to be enough but any reduction or increment of propeller speed will also induce reduction or increment of the thrust, resulting in lateral imbalance of the craft. This is where the milliseconds of stabilisation controls come in to counter the ill effects.

For a pilotless aircraft, the flight trajectory and path will be autonomous. Although we can see only a small piece of circuit board in these autonomous crafts, they are actually full-blown computers that are able to perform complex calculation functions based on the flight path mission inputs.

Apart from the stabilisation sensors for any real-time stabilising work, it also requires input from current position, air speed and altitude. Currently the best air speed feedback system is still the pitot pressure adopted for drones.

Similarly, altitude will also be using pressure altitude system although changes in altitude will be a little slow to be recognised (for real aircraft, given the same time, the height difference and the ambient pressure difference are quite large, for small UAV however, the height difference is relatively small).

The option to use radio altitude is available today but this is quite limited in terms of usable height. Certain advance systems may use a triangulation of the GPS signal to determine not only the current position in space but also its current height above the land surface. With all these inputs, the mission can then be executed following the required trajectory and height.

From the above, any high-end autonomous craft can be fully un-linked from the ground once the ground station has transmitted the flight mission. In the real world however, many operators will continue to link up as continuous system health monitoring of flight path, height, fuel quantity, operating temperature and other system parameters require manual observations. Not only that but a manual takeover of flight will be required in case the auto flight system fails, especially when flying over populated areas. This, at times, limits the operation radius of the flight vehicle.

We have advanced far in the development of RC drones. In time, with additional system redundancy and failsafe modes, the endurance and operating radius will be even bigger and sightings of a UAV flying overhead will be a common thing. ■

Authors' Biodata

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