Fast Developing Drone Technology

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Drones have already consolidated their position as an essential tool of the modern world. Drones, or unmanned aerial vehicles were first developed by the US military in early 1920s, but it was not meant for public untill as recent as late 1980s. Since then, drone development accelerated quite dramatically due to the developments in electronic and computer industries. It was during that time where light-weight, accurate and cheap electronic sensors and actuator drones were first developed. Today, military forces in developed countries use drones for spying, surveillance and even attacking enemy targets, while commercial drone manufacturers such as Chinese DJI continue developing light-weight, easy to use small drones for public and individual use. With so much of capability built-in and reliable and safe, flight performance drones are being deployed for various professional activities as well.

Drone System Design

Drones are autonomous flying vehicles, that need accurate and fast sensors to detect the attitude (orientation in space), altitude, position, heading and speed. These sensors are all electronic items that need to be very light-weight to be put on a drone. Drones have a flight controller, a miniature computer, which reads the sensors, and decide how the propellers are to be actuated. The propellers that drones have are usually BLDC electric motors which are controlled by the flight controller through electronic speed controllers. A complete drone system is shown in Fig. 1 below

Every drone is connected with a remote controller, which provides the external pilot to intervene in controlling the drone as and when necessary. These remote controllers are usually operated in free spectrum band (ISM). The flight controller of the drone sends down through a telemetry radio transmitter all the information about the drone to the ground team who watch it on the ground control station screen. This radio link that connects the drone and the ground control station also operates in the free band (ISM). Usually, 433MHz, 915MHz, 2.4GHz are the common radio links in drones.

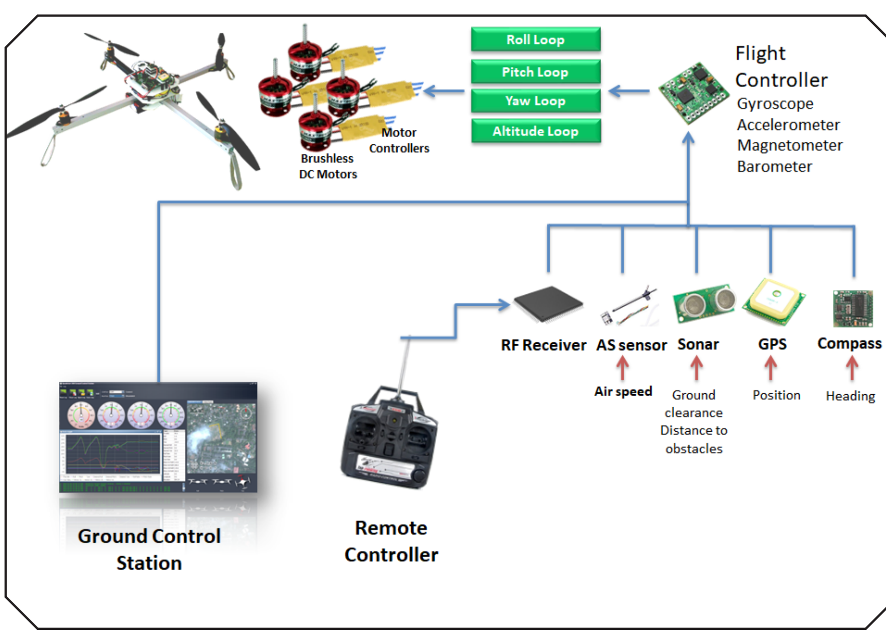

Fig 01 : Drone System

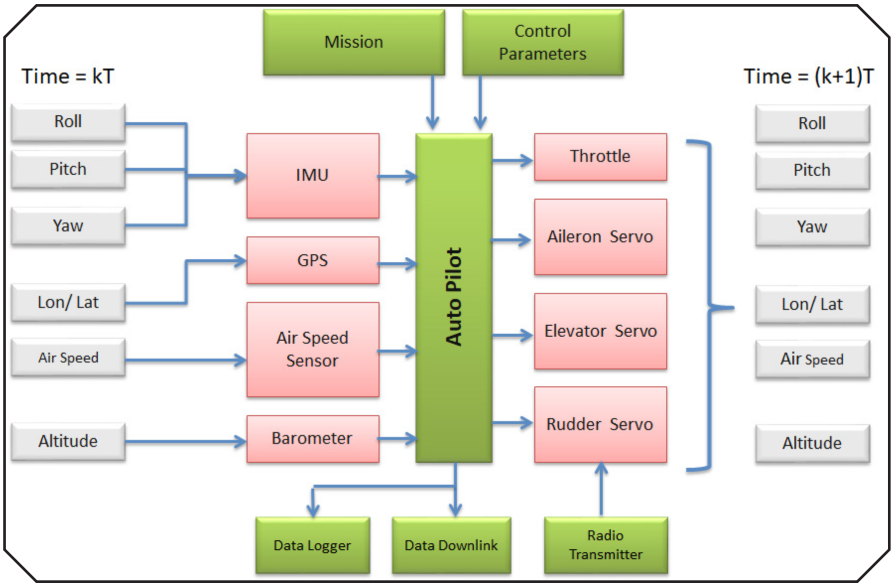

Fig 02: Drone control system

Fig : DJI Agras MG-1S drone spraying over crops

Fig : Autonomous package delivery drone of the University of Moratuwa delivering a package of 1kg

Fig : LiDaR Lite v3 sensor (905nm laser)

Drone Control

Flight controller is embedded with a number of gyroscopes, accelerometers, and a magnetometer for specific reasons. The gyroscopes and accelerometers are used to determine the attitude, and the orientation of the drone in space.

Altitude estimation is performed by the flight controller through multiple sensor fusion using a Kalman filter. The magnetometer inside the flight controller, and the compass connected to the flight controller externally are used to estimate the heading. When the drone is flying, GPS track is used to estimate the flight path. All these calculations are performed by the flight controller at 50-300 times a second, and in each calculation, it has to read the sensors and execute a complicated set of algorithms. Such capability in affordable consumer grade microcontrollers was not available until about the late 1990s.

To maneuver a drone to the left, the flight controller increases speed of the two right side propellers, and at the same time it reduces the speed of the two left propellers. This way, the drone tilts to the left and as a result it starts moving to

Fig 03 : Multi spectral drone camera (Green 550nm, Red 660nm, red-edge 735nm, Near Infra Red 790nm)

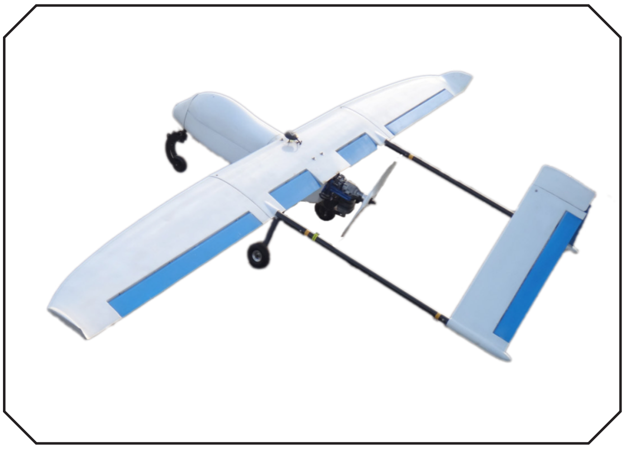

Fig 04: CeyHawk, 11kg engine powered long range drone developed at the University of Moratuwa

the left. On the other hand, if the drone has to be moved to right, the exact opposite controls will be implemented. This motion to the sideways which involved tilting the drone to the left or right is known as roll control as indicated in Fig. 1. In a similar way, flight controller controls the speeds of the propellers to move in other directions as forward/backward (pitch loop), up/down (altitude loop), or even to turn around its own vertical axis (yaw loop). In the case of winged type drones, ailerons and rudder are used together for roll control, while the elevator and throttle are used for altitude control. Fig 2 shows the control system for a fixed-wing drone.

Drone Capabilities

Drones need to have a good flying performance as well as payload carrying capability. Commercial drones in the weight range of 1-5kg have an exceptionally good set of flying skills already. Automatic take off/landing, hovering at an altitude, holding position, flying in a circular path around a specific point, are some of the major flying capabilities built-into small commercial drones. Detecting obstacles and avoiding collision with them, as well as vision based navigation and landing are the technologies currently being developed. Drones have also got a number of safety features such as automatic return to home in emergencies such as low battery voltage. They have get limitations in rolling and pitching to ensure safe flying, flight controller checks to see whether all of the sensors are working before taking off. As a result, drone deployment has now become quite safe and reliable.

Drone Applications

Drones can be equipped with a number of sensors required for the intended application. For example, a surveying drone carries a high resolution camera; a precision agriculture drone carries a multispectral camera (Fig.3); a package delivery drone carries a small package weighing 200g-1500g; a crop spraying drone carries a liquid fertilizer tank and nozzle system; a drone to map the ground profile in 3D carries a LiDaR (Light detection and Ranging) sensor.

Drone Types

There are three main types of drones: Multi-rotor, Fixed-wing and Hybrid. A Multirotor drone such as the one shown in Fig. 1 is easy to operate anywhere because its take-off and landing is gentle in a vertical motion. So, they do not need a huge open space. However, they consume more energy while flying because they do not have wings. The fixed-wing drones such as the one shown in Fig.2, are energy efficient because they can stay in air with a thrust smaller than their weight. However, they need open areas to take off and land, which is a detrimental feature.

The third type shown in Fig. 3 is the most recent drone type in which both multi-rotor capability and fixed-wing capability are available, so that it is able to take off and land vertically like a multirotor, and fly like a fixed-wing plane. This type is bit too complicated than the first two types. However, technology has been developed very recently for its reliable operation. Hence, in the near future, more of this type will be deployed for drone applications where longer flight times are involved.

Global Drone Market

With the rapid development of flying capabilities, safety features, user-friendliness and the

Fig 05: Hornet, quadrotor-wing hybrid drone of the University of Moratuwa (Funded by the National Research Council and the World Bank-AHEAD project)

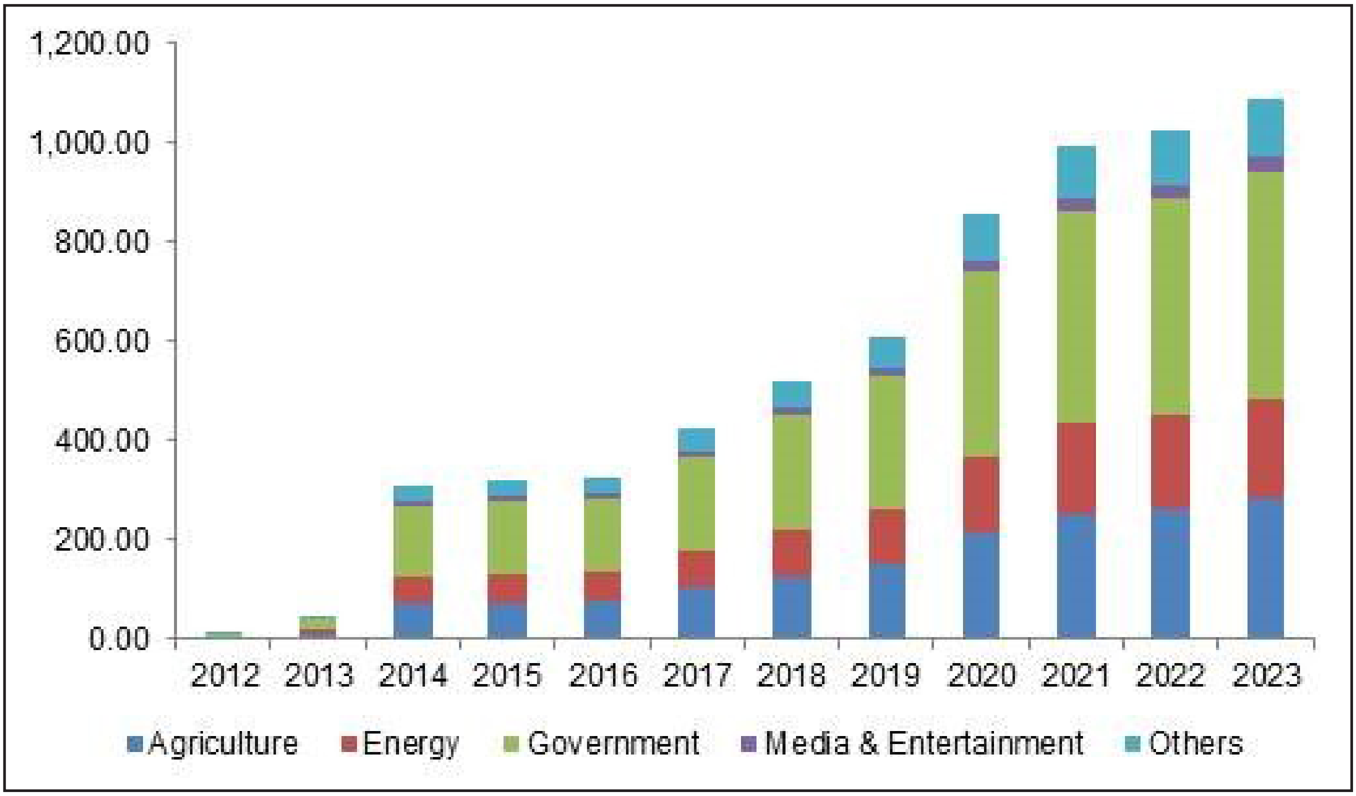

Fig 06 : North America commercial drone market size, by application, 2012-2023 (USD Million)

capability of handling a number of sensors and payloads, drones are increasingly deployed for a wide range of applications such as surveying, agriculture, surveillance, aerial photography, package delivery, construction site monitoring and gas/water/power-line inspection. Hence, the global drone market is expected to reach US$ 2 Billion by 2020. Fig. 6 shows the trend in drone deployment in the United States.

Drone Technology for Sri Lanka

Sri Lanka is a country which has a lot of potential for technology development. However, Sri Lanka is also a country where local innovations do not get commercialized and deployed. In the past, there have been many missed opportunities for Sri Lanka to become an innovative nation.

In this backdrop, it is extremely important that the local drone technology is developed and matured to be used for national development. In particular, Sri Lanka can use locally developed drones for improving our agriculture sector where drones equipped with multispectral sensors would fly over paddy fields monitoring plant health and other issues such as weed and pest invasions. With that information, it would be possible to manage the crop properly so that a higher yield can be achieved. Drones can be used for spraying the right amount of fertilizer which will reduce contamination of soil and ground water while reducing human exposure to chemicals. Locally developed drones can also be used to map and constantly monitor potentially unstable land masses, and alert authorities before hand landslides occurence. Locally developed hybrid drones can be used to take off from a naval ship and fly along the coastal line while monitoring any illegal activities in our seas. Package delivery drones such as the one shown in Fig 3 can be used to transport urgent blood samples between hospitals. The list goes on. Now it's time for Sri Lanka to turn those possibilities into reality.

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