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A STUDY ON DRONE AUTONOMY

K Nived Maanyu
Dept. Of ECE
Sreenidhi Institute Of Science And Technology
Hyderabad,India
knivedmaanyu@gmail.com
D Goutham Raj
Dept. Of ECE
Sreenidhi Institute Of Science And Technology
Hyderabad,India
gouthamdasa007@gmail.com
Shruti Bhargava Choubey
Dept. Of ECE
Sreenidhi Institute Of Science And Technology
Hyderabad,India

Abstract- A quadcopter, also called a quadrotor helicopter or quadrotor,[1] is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers). An autonomous agent is an intelligent agent operating on an owner's behalf but without any interference of that ownership entity.

INTRODUCTION:

An unmanned aerial vehicle (UAV) (or uncrewed aerial vehicle,[2] commonly known as a drone) is an aircraft without a human pilot on board and a type of unmanned vehicle. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers.[3]
Compared to crewed aircraft, UAVs were originally used for missions too "dull, dirty or dangerous"[4] for humans. While

The term unmanned aircraft system (UAS) was adopted by the United States Department of Defense (DoD) and the United States Federal Aviation Administration in 2005 according to their Unmanned Aircraft System Roadmap 2005–2030.[8] The International Civil Aviation Organization (ICAO) and the British Civil Aviation Authority adopted this term, also used in the European Union's Single-European-Sky (SES) Air-Traffic-Management (ATM) Research (SESAR Joint Undertaking) roadmap for 2020.[9] This term emphasizes the importance of elements other than the aircraft. It includes elements such as ground control stations, data links and other support equipment. A similar term is an unmanned-aircraft vehicle system (UAVS), remotely piloted aerial vehicle (RPAV), remotely piloted aircraft system (RPAS).[10] Many similar terms are in use.

they originated mostly in military applications, their use is rapidly expanding to commercial, scientific, recreational, agricultural, and other applications,[5] such as policing and surveillance, product deliveries, aerial photography, infrastructure inspections, smuggling, and drone racing. Civilian UAVs now vastly outnumber military UAVs, with estimates of over a million sold by 2015.
An unmanned combat aerial vehicle (UCAV), also known as a combat drone or simply a drone, is an unmanned aerial vehicle (UAV) that usually carries aircraft ordnance such as missiles, ATGMs, and/or bombs and is used for drone strikes. These drones are usually under real-time human control, with varying levels of autonomy. Aircraft of this type have no onboard human pilot. As the operator runs the vehicle from a remote terminal, equipment necessary for a human pilot is not needed, resulting in a lower weight and a smaller size than a manned aircraft. China, Israel, Iran ,and the United States are widely recognized as industry leaders in UCAV technology. Several other countries have operational domestic UCAVs and many more have imported armed drones or have development programs underway.

CLASSIFICATION:
UAVs typically fall into one of six functional categories (although multi-role airframe platforms are becoming more prevalent):

1. Target and decoy – providing ground and aerial gunnery a target that simulates an enemy aircraft or missile.
2. Reconnaissance – providing battlefield intelligence.
3. Combat – providing attack capability for high-risk missions (see: Unmanned combat aerial vehicle (UCAV)).
4. Logistics – delivering cargo.
5. Research and development – improve UAV technologies.

6. Civil and commercial UAVs – agriculture, aerial photography, data collection.

UAV components:

Crewed and uncrewed aircraft of the same type generally have recognizably similar physical components. The main exceptions are the cockpit and environmental control system or life support systems. Some UAVs carry payloads (such as a camera) that weigh considerably less than an adult human, and as a result can be considerably smaller. Though they carry heavy payloads, weaponized military UAVs are lighter than their crewed counterparts with comparable armaments.

Small civilian UAVs have no life-critical systems, and can thus be built out of lighter but less sturdy materials and shapes, and can use less robustly tested electronic control systems. For small UAVs, the quadcopter design has become popular, though this layout is rarely used for crewed aircraft. Miniaturization means that less-powerful propulsion technologies can be used that are not feasible for crewed aircraft, such as small electric motors and batteries.

Control systems for UAVs are often different than crewed craft. For remote human control, a camera and video link almost always replace the cockpit windows; radio-transmitted digital commands replace physical cockpit controls. Autopilot software is used on both crewed and uncrewed aircraft, with varying feature sets.

Body

The primary difference for planes is the absence of the cockpit area and its windows. Tailless quadcopters are a common form factor for rotary wing UAVs while tailed mono- and bi-copters are common for crewed platforms.

Power supply and platform

Small UAVs mostly use lithium-polymer batteries (Li-Po), while larger vehicles rely on conventional airplane engines. Scale or size of aircraft is not the defining or limiting characteristic of energy supply for a UAV. At present,[when?] the energy density of Li-Po is far less than gasoline. The record of travel for a UAV (built from balsa wood and mylar skin) across the North Atlantic Ocean is held by a gasoline model airplane or UAV. Manard Hill in "in 2003 when one of his creations flew 1,882 miles across the Atlantic Ocean on less than a gallon of fuel" holds this record. Electric power is used as less work is required for a flight and electric motors are quieter. Also, properly designed, the thrust to weight ratio for an electric or gasoline motor driving a propeller can hover or climb vertically. Botmite airplane is an example of an electric UAV which can climb vertically.Battery elimination circuitry (BEC) is used to centralize power distribution and often harbors a microcontroller unit (MCU). Costlier switching BECs diminish heating on the platform.

Computing

UAV computing capability followed the advances of computing technology, beginning with analog controls and evolving into microcontrollers, then system-on-a-chip (SOC) and single-board computers (SBC).System hardware for small UAVs is often called the flight controller (FC), flight controller board (FCB) or autopilot.

Sensors

Position and movement sensors give information about the aircraft state. Exteroceptive sensors deal with external information like distance measurements, while exproprioceptive ones correlate internal and external states.Non-cooperative sensors are able to detect targets autonomously so they are used for separation assurance and collision avoidance.Degrees of freedom (DOF) refers to both the amount and quality of sensors on board: 6 DOF implies 3-axis gyroscopes and accelerometers (a typical inertial measurement unit – IMU), 9 DOF refers to an IMU plus a compass, 10 DOF adds a barometer and 11 DOF usually adds a GPS receiver.

Actuators

UAV actuators include digital electronic speed controllers (which control the RPM of the motors) linked to motors/engines and propellers, servomotors (for planes and helicopters mostly), weapons, payload actuators, LEDs and speakers.

Software

UAV software called the flight stack or autopilot. UAVs are real-time systems that require rapid response to changing sensor data. Examples include Raspberry Pis, Beagleboards, etc. shielded with NavIO, PXFMini, etc. or designed from scratch such as Nuttx, preemptive-RT Linux, Xenomai, Orocos-Robot Operating System or DDS-ROS 2.0.

Loop principles

Typical flight-control loops for a multirotor ,UAVs employ open-loop, closed-loop or hybrid control architectures.

Open loop – This type provides a positive control signal (faster, slower, left, right, up, down) without incorporating feedback from sensor data.

Closed loop – This type incorporates sensor feedback to adjust behavior (reduce speed to reflect tailwind, move to altitude 300 feet). The PID controller is common. Sometimes, feedforward is employed, transferring the need to close the loop further.

Flight controls

UAVs can be programmed to perform aggressive manœuvres or landing/perching on inclined surfaces, and then to climb toward better communication spots. Some UAVs can control flight with varying flight modelisation, such as VTOL designs. UAVs can also implement perching on a flat vertical surface.

Communications

Most UAVs use a radio for remote control and exchange of video and other data. Early UAVs had only narrowband uplink. Downlinks came later. These bi-directional narrowband radio links carried command and control (C&C) and telemetry data about the status of aircraft systems to the remote operator. For very long range flights, military UAVs also use satellite receivers as part of satellite navigation systems. In cases when video transmission was required, the UAVs will implement a separate analog video radio link.

In the most modern UAV applications, video transmission is required. So instead of having 2 separate links for C&C, telemetry and video traffic, a broadband link is used to carry all types of data on a single radio link. These broadband links can leverage quality of service techniques to optimize the

C&C traffic for low latency. Usually these broadband links carry TCP/IP traffic that can be routed over the Internet.
The radio signal from the operator side can be issued from either:
Ground control – a human operating a radio transmitter/receiver, a smartphone, a tablet, a computer, or the original meaning of a military ground control station (GCS). Recently control from wearable devices. human movement recognition, human brain waves was also demonstrated.
Remote network system, such as satellite duplex data links for some military powers. Downstream digital video over mobile networks has also entered consumer markets, while direct UAV control uplink over the cellular mesh and LTE have been demonstrated and are in trials. Another aircraft, serving as a relay or mobile control station – military manned-unmanned teaming (MUM-T). A protocol MAVLink is increasingly becoming popular to carry command and control data between the ground control and the vehicle.

AUTONOMY:

ICAO classifies uncrewed aircraft as either remotely piloted aircraft or fully autonomous.[67] Actual UAVs may offer intermediate degrees of autonomy. E.g., a vehicle that is remotely piloted in most contexts may have an autonomous return-to-base operation.
Basic autonomy comes from proprioceptive sensors. Advanced autonomy calls for situational awareness, knowledge about the environment surrounding the aircraft from exterioceptive sensors: sensor fusion integrates information from multiple sensors.
Path planning: determining an optimal path for vehicle to follow while meeting mission objectives and constraints, such as obstacles or fuel requirement Trajectory. generation (motion planning): determining control maneuvers to take in order to follow a given path or to go from one location to another .Trajectory regulation: constraining a vehicle within some tolerance to a trajectory.

FEATURES OF AUTONOMY:

- Self-level: attitude stabilization on the pitch and roll axes.
- Altitude hold: The aircraft maintains its altitude using barometric or ground sensors.
- Hover/position hold: Keep level pitch and roll, stable yaw heading and altitude while maintaining position using GNSS or inertal sensors.
- Headless mode: Pitch control relative to the position of the pilot rather than relative to the vehicle's axes.
- Care-free: automatic roll and yaw control while moving horizontally
- Take-off and landing (using a variety of aircraft or ground-based sensors and systems; see also:Autoland)
- Failsafe: automatic landing or return-to-home upon loss of control signal
- Return-to-home: Fly back to the point of takeoff (often gaining altitude first to avoid possible intervening obstructions such as trees or buildings).
- Follow-me: Maintain relative position to a moving pilot or other object using GNSS, image recognition or homing beacon.
- GPS waypoint navigation: Using GNSS to navigate to an intermediate location on a travel path.
- Orbit around an object: Similar to Follow-me but continuously circle a target.
- Pre-programmed aerobatics (such as rolls and loops)

APPLICATIONS:

Civil-Recreation, Disaster relief, archeology, conservation of biodiversity and habitat, law enforcement, crime, and terrorism,
Commercial-Aerial surveillance, filmmaking, journalism, scientific research, surveying, cargo transport, mining , Transmission and Distribution , Forestry and agriculture
Military-Reconnaissance, attack, demining, and target practice

COMMERCIAL:

Military
The global military UAV market is dominated by companies based in the United States and Israel. By sale numbers, The US held over 60% military-market share in 2017. Four of top five military UAV manufactures are American including General Atomics, Lockheed Martin, Northrop Grumman and Boeing, followed by the Chinese company CASC. Israel companies mainly focus on small surveillance UAV system and by quantity of drones, Israel exported 60.7% (2014) of UAV on the market while the United States export 23.9% (2014); top importers of military UAV are The United Kingdom (33.9%) and India (13.2%). United States alone operated over 9,000 military UAVs in 2014. General Atomics is the dominant manufacturer with the Global Hawk and Predator/Mariner systems product-line.
Civilian
The civilian drone market is dominated by Chinese companies. Chinese drone manufacturer DJI alone has 74% of civilian-market share in 2018 with $11 billion forecast global sales in 2020.[86] DJI is followed by Chinese company Yuneec, US company 3DRobotics and French company Parrot with a significant gap in market share. As of March 2018, more than one million UAVs (878,000 hobbyist and 122,000 commercial) were registered with the U.S. FAA. 2018 NPD point to consumers increasingly purchasing drones with more advanced features with 33 percent growth in both the $500+ and $1000+ market segments.
The civilian UAV market is relatively new compared to the military one. Companies are emerging in both developed and developing nations at the same time. Many early stage startups have received support and funding from investors as is the case in the United States and by government agencies as is the case in India. Some universities offer research and training programs or degrees. Private entities also provide online and in-person training programs for both recreational and commercial UAV use.
Consumer drones are also widely used by military organizations worldwide because of the cost-effective nature

of consumer product. In 2018, Israeli military started to use DJI Mavic and Matrice series of UAV for light reconnaissance mission since the civilian drones are easier to use and have higher reliability. DJI drones is also the most widely used commercial unmanned aerial system that the US Army has employed.

The global UAV market will reach US$21.47 billion, with the Indian market touching the US$885.7 million mark, by 2021.Lighted drones are beginning to be used in nighttime displays for artistic and advertising purposes.

Transport

The AIA reports large cargo and passengers drones should be certified and introduced over the next 20 years. Sensor-carrying large drones are expected from 2018; short-haul, low altitude freighters outside cities from 2025; long-haul cargo flights by the mid-2030s and then passenger flights by 2040. Spending should rise from a few hundred million dollars on research and development in 2018 to $4 billion by 2028 and $30 billion by 2036.

Agriculture

As global demand for food production grows exponentially, resources are depleted, farmland is reduced, and agricultural labor is increasingly in short supply, there is an urgent need for more convenient and smarter agricultural solutions than traditional methods, and the agricultural drone and robotics industry is expected to make progress. Agricultural drones have been used in areas such as Africa to help build sustainable agriculture.

CONCLUSION:

Finally, autonomy of drones is influenced by both AI and engineering. To demonstrate, let’s assume the aerospace industry were to adopt the automotive industry’s five levels of autonomy. If so, then we can define:

Level 0: There is no autonomy.

Level 1: There are autonomous systems, like altitude control, but the pilot is in control.

Level 2: There are multiple autonomous systems running simultaneously, but the pilot is in control.

Level 3: The craft operates autonomously under certain conditions, but a pilot must monitor its progress.

Level 4: The craft is autonomous in most situations; the pilot can take over but generally doesn’t have to.

Level 5: The drone is fully autonomous.

Currently, the technology is between Level 3 and Level 4, where the drone can make some decisions, but a certain level of human supervision is necessary.

Autonomous drone technologies will need to be designed, tested and — in the case of artificial intelligence (AI) — trained to ensure public safety.

These tasks would include simulation models of environments, cities and weather conditions that the UAV might face. By tweaking each simulation, we can test, optimize and certify the safety of autonomous technology faster than we ever could using physical prototypes.

Eventually, drones will become autonomous as many have dreamed, but for now the role of human operators in drone services is essential. It would benefit us all to think levelheadedly of the current capabilities of drone technology—to expect the success of a use case that has been prematurely promised only to be let down by the true results can severely hinder adoption for the industry overall.

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