Characterisation of Fixed-Wing Versus Multirotors UAVs/Drones

P. K. Garg
Indian Institute of Technology - Roorkee, Roorkee 247667, Uttarakhand, India
Email: pkgiitr@gmail.com

(Received: Dec 02, 2021; in final form: Sep 15, 2022)

Abstract: Drones are Unmanned Aerial Vehicles (UAVs) that do not carry a human operator, fly remotely or autonomously, and carry lethal or non-lethal payloads. Advances in fabrication, navigation, remote control capabilities, and power storage systems have made possible the development of a wide range of drones. The most popular ones are fixed-wing and multirotor drones. They have several advantages and disadvantages and can be deployed quickly to obtain very high resolution imagery/point cloud data. With sophisticated computer vision, robotics and data, and low cost digital cameras, it is possible to get centimeter-level resolution and accuracy. Advances in technology have made the increased uses of drones for various applications. The uses of UAVs/drones are increasing allowing 2D and 3D maps to be created and used for creation of 3D maps and digital elevation models (DEMs). This paper describes in details about the two broad categories of UAVs; fixed-wing and multirotor UAVs. Their salient characteristics along with advantages and disadvantages are also given. It also provides insights to the users for selection of right kind of UAV.

Keywords: UAV, Fixed-wing drones, multirotors, Endurance, Selection of UAV

1. Introduction

Different types of drones have been around since as early as 1917. Although initially they were used for military applications, but today drone operations have much more use in business industry. Drones are flying robots which include Unmanned Air Vehicles (UAVs). Aerial vehicles that do not carry a human operator, fly remotely or autonomously, and carry lethal or non-lethal payloads are considered as drones. Advances in fabrication, navigation, remote control capabilities, and power storage systems have made possible the development of a wide range of drones/UAVs which can be utilized in various situations where the presence of human is difficult, impossible, or dangerous. The UAV images/data belong to the Big Data category, and are particularly useful to assess large and not easily accessible areas or dangerous sites (Gupta, et.al., 2016). These images can be collected at regular intervals with much lower cost than the traditional photogrammetric images from the aircraft. They have several advantages, such as deployed quickly and repeatedly, flexible in terms of flying height, timing of missions, and very high resolution imagery/point cloud data. With sophisticated computer vision, robotics and data, and low-cost digital cameras and sensors, it is now possible to get centimeter-level resolution and accuracy from drone data (Colomina and Molina, 2014). Providing a swath width of 50–500 m and a spatial resolution of 1-20 cm, UAV platforms are able to provide very high resolution inputs (Garg, 2020). The high spatial revolution and high temporal resolution make the UAV an ideal platform to apply in various fields and conduct a variety of research in remote sensing.

The UAVs/drones are very useful in many applications due to availability of high resolution images and laser data, and thus save time & efforts to collect the field data of a large area. The use of drones for surveying and mapping has expanded in recent years as many organisations realise the benefits of using geospatial data provided by these systems. Drones can provide much more detailed data at high resolution than the traditional surveying and remote sensing methods, allowing 2D and 3D maps to be created and used for various applications. These images are processed to produce 3D models, like Digital Elevation Models (DEMs) for viewing the terrain or for volume computations. They can provide up to centimeter-level accuracy of a GPS rover. In addition, the UAV derived orthophotos, point clouds and DEMs could significantly enhance the extraction of relevant information from the UAV images (Boon et al., 2017).

The drones are used in a wide range of civil and military applications, and can perform both outdoor and indoor missions in challenging environments. These applications can be categorized in different ways; based on the type of missions (military/civil), the flight zones (outdoor/indoor), and the environments (underwater/ water/ground/air/space), as shown in Figure 1.

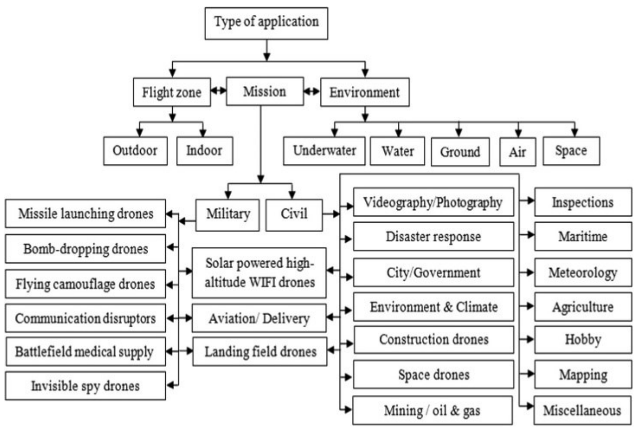

Figure 1. Various applications of UAVs

Drones can be used for surveying and mapping, search and rescue missions, agricultural crop mapping, environmental protection, damage assessment, mailing and delivery, performing missions in oceans or other planets, inside buildings, in the battlefield and several other applications. The UAV systems have shown remarkable progress in terms of performance, reliability, increased capabilities, and ease of use. In coming years, the UAVs will establish themselves as a viable alternative to conventional mapping and surveying.

2. Types of UAVs/Drones

Today, there are several types of UAVs available commercially with different configurations and specifications. There is no standard classification system of UAVs available. Defense agencies have their own standard, while civilians have their own categories for UAVs. Generally, UAVs can be categorized by their performance characteristics. Features including weight, wing span, wing loading, range, maximum altitude, speed, endurance, and production costs, are important parameters that distinguish different types of UAVs/drones, and classify theminto several categories. Furthermore, UAVs can be classified based on their engine types, size, weight, range and endurance, applications, and also use a tier system that is employed by the military. The UAVs often vary widely in their configurations depending on the platform and mission. The classification according to size includes: Very small UAVs, Micro or Nano UAVs, Small UAVs, Mini UAVs, Medium UAVs, and Large UAVs.They have also been classified according to the ranges they can travel and their endurance in the air: Very low-cost close-range UAVs, Close-range UAVs, Short-range UAVs, Mid-range UAVs, and Endurance UAVs, as given in Table 1. These are mainly used for reconnaissance and surveillance tasks.

Table 1. Drone types, their ranges and endurance time (Abdullah, 2019)

Types	Range (km)	Endurance time (min)
Very low-cost, close range UAVs	5	20 to 45 min
Close range UAVs	50	1 to 6 hrs
Short range UAVs	150 km or longer	8 to 12 hours
Mid-range UAVs	650 km working radius	-
Endurance UAVs	300 km working radius	36 hours

The latest innovation in UAV is the Small Unmanned Aerial Vehicle (sUAV) which are light-weight under 55 pounds (lbs), and are designed for commercial and civilian uses (Garg, 2020). Micro-UAVs are even further smaller systems that weigh less than 4.4 lbs. According to the U.S. Department of Defence, UAVs are classified into five categories, as shown in Table 2.

In general, there are two broad categories of UAVs; fixed-wing and multirotor drones. Both the types have their own advantages and disadvantages, including their suitability for some specific applications. Fixed-wing UAVs normally have longer flight endurance capabilities, while multirotors can provide stable image capturing and easy vertical take-off & landing characteristics. Therefore, the main aim of this paper is to assess the capabilities of fixed-wing versus multirotor UAVs for their suitability and applicability.

Table 2. UAVs Classification according to the US Department of Defense (Fahlstrom and Gleason, 2012)

Category	Size	Maximum Gross Takeoff Weight (lbs)	Normal Operating Altitude (ft)	Airspeed (knots)
Group 1	Small	0-20	<1,200	<100
Group 2	Medium	21-55	<3,500	<250
Group 3	Large	<1320	<18,000	<250
Group 4	Larger	>1320	<18,000	Any airspeed
Group 5	Largest	>1320	>18,000	Any airspeed

AGL– Above ground level, MSL- Mean sea level

2.1 Fixed-wing UAVs

Fixed-wing UAVs use wings like a normal aeroplane to provide the lift as opposed to vertical lift by multirotors. They are available with a number of different configurations, but typically have a fuselage with two wings and a single rotor. Because of this reason, they only need to use energy to move forward and can't hold themselves at a point up in the space. A fixed-wing drone is always moving forward faster than a multirotor drone, and manoeuvring longer times for monitoring the area. They provide greater efficiency, and are able to cover longer distances, thus mapping much larger areas in short time. Due to their superior engine efficiency, most commercial models can fly for an hour or more and cover around 400 hectares. It is also possible to use gas engines as their power source, and with the greater energy density of fuel many fixed-wing drones can work for 16 hours or more. Fixed-wing drones can also carry heavier loads than the multirotor drones. The fixed-wing structure provides exceptional stability that allows the drones to carry loads of up to 50 kg.

Fixed-wing drones are most advantageous in agricultural sector, electricity pylons and oil & gas industries as they can cover large areas at a higher speed. They are less common for surveying applications, where area covered is small. As fixed-wing drones fly much faster than the multirotors, so they work efficiently for large worksites. For certain jobs, flying just one fixed-wing drone over a site is far more efficient than flying multiple quadcopters (multi-rotors), as they can stay in the space much longer on a single battery charge. Other greatest advantage of fixed-wing drones is their ability to recover from a total power failure, whereas the sudden loss of power in a multirotor can result in complete loss of the aircraft. These drones are able to continue flying, and more importantly, can land safely without power. Since, fixed-wing drones are better able to withstand side winds, the windy areas, such as electricity pylons in open countryside can easily be surveyed with these drones.

The disadvantages include the requirement of ground distance for take-off & landing, as well as long sweeping turns, however, the actual distance required will depend on the model and its configuration. For their launching and landing, a runway or catapult launcher is needed to get them into the space, and either a runway, parachute or net to recover them safely again at the end. Fixed-wing UAV requires a trained pilot to land it smoothly in order to avoid any damage to the UAV and sensors. Only the smallest fixed-wing UAVs are suitable for hand launch and 'belly landing' in an open field. As fixed-wing UAVs fly like normal aircraft, operators need to plan ahead to avoid obstacles, which may be a real challenge for operators to fly them. The airframes of fixed-wing UAVs are significantly larger than a similarly specified multirotor, and thus would require a significant amount of space for transportation. They are usually much more expensive than the multirotor drones; although the prices are coming down as the technology grows.

The fixed-wing UAVs are unable to hover at one spot constantly, which makes them unsuitable for any general aerial photography work. The other disadvantage of these drones is that they are less manoeuvrable than the multirotor UAVs, so they provide a challenge for some surveying applications, especially in confined spaces (small areas, urban environments or construction sites) where the UAV needs to turn quickly. Finally, a big challenge when operating fixed-wing UAVs is big Eagles which are a menace as they can strike to UAVs and cause damages.

2.2 Multirotor UAVs

These are the most common types of UAVs used in commercial and consumer market. Several configurations are available but they generally follow the same design principle. The four-propeller multirotor (quadcopter) is the most popular design, as it provides the best balance between lift, control, manoeuvrability and cost. A central frame connects up to eight fixed-pitched propellers that control the speed, direction and height of the drone. The multiple rotors provide power to the propellers, enabling flight and manoeuvrability. By changing the speed of each propeller, varying amount of thrust and torque is produced that controls the speed and height of the drone. It provides the drone a unique capability allowing it to fly with precision in both indoor and outdoor.

Multirotors are easy to fly and control, and can easily perform autonomous flights (Thamm et al., 2015). The main reason of wide-spread use of multirotors is that they are easy to get started, as they are cheaper and easier to fly, with some skills and little practicing, which isn't the case with the fixed-wing drones. They can also operate in headless mode which aligns drone movements relative to the controller, so the drone always moves forward irrespective of the direction it is facing. Multirotors are much more cost-effective than the fixed-wing drones that can cost almost twice. They are the easiest, economical and perfect option for collecting the images with great control over position and framing. If a small camera is to be operated in the air for a short period of time for aerial photography work, then multirotor drones are the best option. Multirotors can carry much more payload than a fixed-wing drone. The eight-rotor drones are capable of lifting more payloads as compared to four-rotor or six-rotor drones. As a general rule of aerodynamics, the larger the rotor blade is and the slower it spins, the more efficient it is. This is why a quadcopter (four rotors) is more efficient than an octocopter (eight rotors), and special long-endurance quads have a large prop diameter.

They can hover in a stationary position, and provide VTOL (vertical take-off & landing) capability (Garg, 2020). The other advantage of multirotor UAVs is their manoeuvrability as compared to fixed-wing UAVs, as these can easily fly in areas where other types of UAVs can't reach. The ability of UAVs to fly low with appropriate sensors provides the opportunity to collect data at fine spatial resolution (Anderson and Gaston, 2013), and makes them ideal tools for land mapping. Multirotors are compact in design, and therefore easy to transport and carry around as they don't have wings that makes them suitable for surveying professionals who transport them from site to site for various jobs. The multirotor drones provide a number of advantages for surveying work as compared to fixed-wing drones but these should not be used by default in all kind of surveying works.

The multirotor UAVs have disadvantages due to their reduced range and speed as compared to fixed-wing UAVs. The main disadvantage of multirotors is their limited endurance and speed, making them unsuitable for large scale aerial mapping, long endurance monitoring and long distance inspection, such as pipelines, roads and power lines. Since, the multirotors can't take flight for longer time, therefore the area coverage is limited (Cai et al., 2014), whereas the fixed-wing UAVs have very good flight endurance and can cover large areas in one flight. To survey a large area more than 7 km long, a fixed-wing drone may not be used. Multirotors are fundamentally not efficient and require a lot of energy just to fight with gravity and keep them in the air. With current available battery technology, they are limited to fly around 20-30 minutes when carrying a light-weight camera payload. Heavy-weight lift multirotors are although capable of carrying more weight, but they have much shorter flight time. Due to the need for fast and high-precision throttle changes to keep them stabilised, the use of multirotors is restricted to only electric motors, as it is practically not possible to use a gas engine to power them. They use more energy, and are more sensitive to weather conditions. Lastly, this type of UAV requires complex and regular maintenance, due to its elaborate structure.

3. **Selection of a UAV/Drone**

For new users, many times it becomes a difficult task to choose the right type of UAV/drone for the work to be performed. A systematic and efficient approach for the selection of the UAV is necessary to choose the best UAV for the critical tasks under consideration. When selecting the most suitable UAV type, firstly it is necessary to decide what task is going to be performed with it, and consequently what is most important for that task, such as speed and long range, manoeuvring ability, and accuracy. Other selection criteria depend on several basic characteristics of UAVs, for example, the flight duration(endurance) which determines how much area can be covered during a single flight, and hence determines the economic efficiency. The UAVs with flight endurance of a few minutes to several hours are now available. A UAV's endurance depends on two factors: its wing type (fixed-wing have a higher flight endurance) and weather conditions as some UAVs are very sensitive to it. If a UAV flies against the wind, it is going to consume a lot of energy, which has an impact on its endurance. The flight duration should be considered together with the carrying capacity and take-off weight. Some companies publish flight times for the UAVs without a payload (camera) and under ideal conditions (e.g., no wind, at 68°F/20°C), but when a payload is attached, the operational flight time of UAV can be reduced by over 50% (Kroetsch, 2014).

The UAVs can be equipped with various payloads; cameras and sensors, so selection of a suitable payload is also critical. Changing from one payload to another needs to be seamless for the operator. The UAV must provide the ability to swap payloads in all weather conditions, and includes electronics and software that recognise the different payloads automatically. Without the ability to quickly adapt to the needs of the operation, valuable time can be lost reconfiguring/calibrating the system after each change. The weight of payload and UAV affects the UAV's stability in the air, so the heavier it is, the more stable its trajectory and the higher the image quality. It is essential that a UAV is reliable, portable and easy to fly. It should be light and strong enough to carry loads during flight and, more importantly, during landing. The UAVs of composite materials provide the necessary rigidity and strength, but may not be sufficiently flexible and robust to take heavy impact loads. Polymeric materials are able to withstand impact, do not break in case of deformation, and retain their shape, but are not able to provide structural rigidity. The combined use of polymers and composite materials is considered the best. The UAV's portability is critical which is achieved through solutions, such as a folding frame or modular design. The time needed to prepare a UAV for flight by a single operator should not exceed a few minutes.

The safety of the operator and the people and property over which flights are performed are very important when choosing a UAV. It is best to choose the UAVs with intelligent control of the application having best practice guidelines for safe operations and trouble-shooting procedures, and built-in safety functions, such as warning system for low battery levels and radio communication quality, automatic flight mission, automatic return to the starting point when connection is lost or the battery is critically low, and geofencing. This will ensure the safety of property and people in the areas adjacent to the site as well safety of the UAV, and also enables the operator to focus on the collection of images and data with confidence. The UAVs with network and streaming capabilities can provide additional benefits in surveillance and search &rescue applications.

Price is a key factor when choosing a UAV. A comparison of prices can be done considering their maintainability, availability of spare parts and the service life of their components. Fixed-wing and VTOL UAVs are typically around 2-3.5 times the cost of a multirotor UAV but they last longer in the air. The capabilities of a UAV to operate in a range of environmental temperatures are also required to be considered while selecting a system (Kroetsch, 2014). With any UAV, the ability to operate safely in windy conditions is a requirement, and many UAVs adjust flying altitude as per existing wind speed.

Hamurcu and Eren (2020) have proposed multicriteria decision-making (MCDM) approaches that are well suited to deal with the intricacy in selection of a UAV for military applications. It also proposes an integrated methodology based on the analytical hierarch process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate UAV alternatives for selection process. Petkovics et. al., (2017) have discussed specific UAV characteristics in order to facilitate the selection of right kind of UAV according to the farmers' heterogeneous requirements regarding the data collection on their crops. Selection of appropriate UAV for specific needs of farmers was carried out by using a MCDM approach. The weighting parameters for the selection, evaluation software parameters and selection of the best conditions were formulated based on data recording, data collection and data processing, supporting software, selective sputtering/fertilization, data collection/recording and data processing in greenhouses.

When choosing a drone for surveying, the first decision is either select a fixed-wing or a multirotor drone, as each one has its own advantages and disadvantages. The right choice of drone, however, depends on the type of surveying and data collection job intended to be carried out, the size of area, the terrain type, and finally the applications for which the spatial data/maps are to be used. There are some hybrid models also available designed specifically for mapping purposes. The VTOL drones represent a blended approach, combining elements from both the multirotor and fixed-wing drones. They take-off and land vertically like a multirotor, but act like a fixed-wing drone in flight to facilitate the high efficiency for large-scale mapping.

Chapman (2016) has presented a comparison between multirotor and fixed-wing drones as well as single rotor and hybrid rotor drones, including their typical uses, as given in Table 3. While a multirotor has many rotors to hold it up, a single rotor has just one, plus a tail rotor to control its heading. A single-rotor helicopter has the benefit of much greater efficiency over a multirotor, and also that it can be powered by a gas motor for longer endurance. It is the best if hovering is to be done with a heavy payload (e.g., an aerial LiDAR laser scanner) or have a mixture of hovering with long endurance or fast forward flight. A single-rotor allows for very long blades which are more like a spinning wing than a propeller, giving greater efficiency.

Table 3. A comparison between multirotor, fixed-wing drones, single rotor and hybrid rotor drones, including their typical uses

Types of UAV	Advantages	Disadvantages	Typical uses
Multirotor	Accessibility Ease of use VTOL and hover flight Good camera control Can operate in a confined area	Short flight time Small payload capacity	Aerial photography and Video, Aerial inspection
Fixed-wing	Long endurance Large area coverage Fast flight speed	Launch and recovery needs a lot of space No VTOL/hover Harder to fly, more training needed Expensive	Aerial mapping, Pipeline and Power line inspection
Single-rotor	VTOL and hover flight Long endurance (with gas power) Heavier payload capability	More dangerous Harder to fly, more training needed Expensive	Aerial LiDAR laser scanning
Fixed-wing Hybrid	VTOL and long-endurance flight	Not perfect at either hovering or forward flight Still in development	Drone delivery

The disadvantages of single-rotors are their complexity, cost, vibration, and also the danger of getting hurt from their large spinning blades. In terms of difficulty, single-rotor drones lie somewhere between multi-rotors and fixed-wing aircraft. They can hover over the area, but they aren't as stable as multirotors, and also require a lot of maintenance and care due to their mechanical complexity. The hybrid drones combine the benefits of fixed-wing drones with the ability to hover, and also can take-off and land vertically. With the availability of modern autopilots, gyros and accelerometers, these types of drones are feasible because the autopilot can keep them stable, and human pilot can guide them flying in the space. There are only a handful of hybrid fixed-wing aircraft currently in the market, such as Amazon's Prime Air delivery drone, but more are expected in the future as the technology is refined.

Boon et.al., (2017) have evaluated the performance of a Skywalker fixed-wing UAV versus a Raven multirotor UAV for environmental mapping applications. The completely automated computer vision Structure from Motion (SfM) pipeline provided by Agisoft PhotoScan Professional software package was used for 3D point cloud generation. They found that the cost, maintenance and flight time was lower in case of Skywalker fixed-wing, while the multirotor was found to provide much accurate data, although the quality of data of fixed-wing drone was also found to be satisfactory for most environmental mapping applications. The fixed-wing drone provided the data with elevation of the study area that ranged from 1564.5 to 1545 m above mean sea level (*msl*), which equates to a height difference of 19.5 m with a slope of 1.7%. Whereas, the elevation using the multi-rotor data ranged from 1560.5 to 1543 m above *msl*, providing a height difference of 17.5 m with a slope of 1.59%. The height information differed with exactly 2 m between the two UAVs; this difference is equivalent to height error of data derived from the fixed-wing UAV. Suitability for different attributes for both types of UAVs is also presented by them, as shown in Table 4.

Table 4. Suitability for different attributes for both types of UAVs

Attributes	Fixed-wing (Skywalker)	Multi-rotor (Raven)
Payload capacity		√
Flight time	√	
Stabilisation		√
Georeferencing	√	
Cost	√	
Maintenance	√	
Vegetation representation		√
Erosion gully representation		√
Wetland slope mapping	√	√
Contour mapping	√	√

Overall, the multirotor data was found to be more accurate and better represented the environmental features. Nevertheless, the basic identification and estimation of environmental impacts from the fixed-wing data was still satisfactory. For other applications, like close proximity inspections and when more detailed data is required for smaller areas in land surveying, a multirotor will definitely be more suitable. Boon et.al., (2017)gave several recommendations, such as (i) data should be collected during mid-day when the position of the sun is higher that results in high amount of the sun's illumination under clear sky conditions, and less shadows in the data, (ii) the GCPs (ground control points) should be placed in a grid format ensuring that they do not merge with the vegetation cover, (iii) a flying altitude of below 150 m is advised for environmental mapping purposes to enhance the features, such as vegetation and erosion gullies in the imagery, (iv) the self-calibration method for calibrating the camera prior to the flight should be done to improve the quality of data, and (v) the camera settings, such as the exposure should be standardised to achieve repeatable and comparable results.

On the basis of various literature review, a brief discussion on comparison between fixed-wing and multirotor UAVs is given below as well as presented in Table 5. These observations might help the users to make a right selection of drone for their applications.

Table 5. A comparison between fixed-wing and multirotor UAVs

Capability	Fixed-wing	Multirotor
Speed	High	Low
Flight time	High	Low
Coverage	Large	Small
Object resolution	Cm/inch per pixel	mm per pixel
Take-off and landing area	Large	Very small
Landing in case of power failure	Can land safely without power	Can result in complete damage of UAV
Wind resistance	High	Low
Skill required to fly	High	Low
Projects	Large area mapping	Small area mapping, Machine and industrial plant monitoring, Indoor inspection
Applications	Land surveying, Agriculture, Mining, Environmental, Humanitarian etc.	Inspection, Urban survey, Construction sites, Emergency response, Law enforcement, Transport of medicines and light goods, Cinematography and videography etc.

1. A multirotor drone is not successful for large area mapping. It is because of its low speed as compared to fixed-wing drone. Obviously, the area covered per day by a fixed-wing drone will be greater that the multirotor. The disadvantage of multirotor drone is their reduced range and speed as compared to the fixed-wing drone. The time that is taken in mapping and the cost incurred is directly proportional to the area that is to be mapped. The rotors of a multirotor drone consume a lot of energy and that is why they are suitable only for small mapping projects. On the other hand, fixed-wing and hybrid drones can stay in the air for a long time, fly faster and map with more efficiency, while maintaining a consistent quality of data captured. This makes fixed-wings and hybrid drones preferable when large land areas have to be mapped.

2. The multirotor drone is not stable in windy areas due to thrust on the drone by the winds, whereas the fixed-wing drone is much more stable due to its smooth aerodynamics and design, like a conventional aircraft. Wind speed can profoundly influence the completeness of a drone dataset. Turbulences lead to adaptive flight manoeuvres. Constant wind increases the power consumption of the engine, and can reduce the flight time enormously. Side wind affects the orientation of the drone as fixed-wing drones tend to correct their position against the wind.

3. In multirotor drones, aerodynamics is not the highest priority in the design. The vibrations are more in multirotor drone as compared to fixed-wing drone, so it would affect the image quality used for mapping purpose. Comparatively, higher resolution cameras would be needed to generate orthophotos of the same resolution of a fixed-wing adding significantly to the processing time requirements. Vibration from the motors in multirotor drone (at least four motors) during the flight can affect the sharpness and contrast of the images.

4. Fixed-wing drone can fly with a constant cruising speed, however, the data collection from these drones require specialised skills.

5. Fixed-wing drones have more flight time compared to the multirotors. Larger flight time up to one hour or more of fixed-wing drone against multirotor drone whose average flight time is 20-25 minutes, allows mapping of several km during one flight. In addition, they have some advantages from the aspect of durability and flight height. Fixed-wing systems with the ability to fly at high attitude have long durability.

6. Other overlooked advantage of fixed-wing drones is their ability to recover from a total power failure. The sudden loss of power in a multirotor can result in complete loss of the aircraft. But a fixed-wing drone can continue gliding, and more importantly, land safely without power.

4. Conclusions

Drones can be used for surveillance, aerial photography, search & rescue, agriculture, disaster, cinematography, inspections of structures, delivery of goods, etc. There are two broad types of drones: multirotor and fixed-wing types. Each type of drone contributes to the amount of weight they can carry (payload), efficiency, duration of flight and application. Multirotors have four, six or eight rotors; four being the most common for small to regular-sized drones. The more rotors it has, the more it can manoeuvre. However, they are not as efficient as fixed-wing drones. On the other hand, fixed-wing drones need either a catapult or a runway to take-off the ground and landing. These drones are sometimes used for surveillance, like in the military, and are more commonly flown for the purpose of long-distance. Fixed-wing drones require quite a bit more drone flying experience and training, mainly with take-off and landing.

As more UAVs become available, choosing the right type of UAV is important. In most cases, a multirotor has good range, excellent manoeuvrability, easy to fly, cost-effective, and can be fitted with a range of sensors. If a large open tract of land is to be surveyed, a fixed-wing UAV will suit well. The UAVs have a number of key values that define their performance, such as weight, maximum speed, maximum flying height above sea level, maximum flight time, operating temperature, hover accuracy, dimensions, etc. The multirotor is the preferred choice for most surveying applications, but fixed-wing drones also have some specific advantages, like speed. It is expected that in future, drones would be designed that have the speed and range advantage of a fixed-wing, with the manoeuvrability and practicality of a multirotor drone. This would allow the drones to take-off and land like a multirotor, but fly like a fixed-wing drone. This combination can cover ten times more ground area than a multirotor while collecting two times more data, thus providing efficiency. The future of drones appears to be very promising for spatial data collection as well as deriving results for the applications in hand.

References

Abdullah Q. A., (2019), Classification of the unmanned aerial systems, The Pennsylvania State University, https://www.e-education.psu.edu/geog892/node/5).

Anderson K. and J. G. Kavin (2013), Lightweight unmanned aerial vehicles will revolutionize spatial ecology, Frontiers in Ecology and the Environment, March

Boon M A., A.P. Drijfhoutand and S. Tesfamichael (2017), Comparison of a fixed-wing and multi-rotor UAV for environmental mapping applications: a case study, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W6, International Conference on Unmanned Aerial Vehicles in Geomatics, 4–7 September 2017, Bonn, Germany.

Cai G., J. Dias and L. Seneviratne (2014), A survey of small-scale unmanned aerial vehicles: Recent advances and future development trends. Unmanned Systems, 2(02), 175-199.

Chapman A. (2016), Types of drones: multi-rotor vs fixed-wing vs single rotor vs hybrid VTOL, Australian UAV (June), https://www.auav.com/au/articles/drone-types/ [https://perma.cc/Z7SY-ECCM].

Colomina I., and P. Molina (2014). Unmanned Aerial Systems for Photogrammetry and Remote Sensing: A Review." ISPRS Journal of Photogrammetry and Remote Sensing 92 (June): 79– 97. doi:10.1016/j.isprsjprs.2014.02.013.

Fahlstrom P. and G. Thomas (2012), Introduction to UAV Systems, 4th Edition, Wiley & Sons, https://www.wiley.com/en-ax/9781119978664.

Garg P. K. (2020), Introduction to Unmanned Aerial Vehicles, New Age International Publishers Ltd., New Delhi.

Gupta L, R. Jain and G. Vaszkun (2016), Survey of important issues in UAV communication networks," IEEE Communications Surveys & Tutorials, Vol. 18, no. 2, pp. 1123–1152

Hamurcu, M. and E. Tamer (2020), Selection of unmanned aerial vehicles by using multicriteria decision-making for defence, Journal of Mathematics, Hindawi, Open access, Volume 2020, https://doi.org/10.1155/2020/4308756.

Kroetsch D. (2014), Choosing the right UAV, Geospatial World, 16 Sept 2014, https://www.geospatialworld.net/article/choosing-the-right-uav/

Petkovics I., S. Janos, P. Armins and C. Zlatko (2017), Selection of unmanned aerial vehicle for precision agriculture with multi-criteria decision making algorithm, IEEE 15th International Symposium on Intelligent Systems and Informatics, September 14-16, Subotica, Serbia.

Thamm H. P., N. Brieger, K. P. Neitzke, M. Meyera, R. Jansenaand and M. Mönninghof (2015), SONGBIRD- an innovative UAS combining the advantages of fixed wing and multi rotor UAS, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-1/W4, 2015 International Conference on Unmanned Aerial Vehicles in Geomatics, 30 Aug–02 Sept, Toronto, Canada.