ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
Your ult-MATE Research Paper !!!

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

AUTONOMOUS FIXED WING

MUBINA.J, AUSHA.M,
, [2] E.AISHWARYA DHARA
,[2] Assistant Professor
[1] Department of Aeronautical Engineering,[2]Departmentof Aeronautical Engineering
PSN College of Engineering & Technology, Tamil Nadu.

ABSTRACT

Fixed-wing micro air vehicles (MAV) are very attractive for outdoor surveillance missions since they generally offer better payload and endurance capabilities than rotorcraft or flapping-wing vehicles of equal size. They are generally less challenging to control than helicopter in outdoor environment. However, high wing loading associated with stringent dimension constraints requires high cruise speeds for fixed-wing MAVs and it has been difficult so far to achieve good performances at low-speed flight using fixed-wing configurations. The present paper investigates the possibility to improve the aerodynamic performance of classical fixed-wing MAV concepts so that high cruise speed is maintained for covertness and stable hover flight is achieved to allow building intrusion and indoor surveillance. Monoplane wing plan forms are compared with biplane concepts using low-speed wind tunnel measurements and numerical calculations including viscous effects. Wind-tunnel measurements including the influence of counter-rotating propellers indicate that a biplane-twin propeller MAV configuration can drastically increase low-speed and high-speed aerodynamic performances over the classical monoplane fixed-wing concept. Control in hover flight can highly benefit from the effect of counter-rotating propellers as demonstrated by flight tests. After describing the flight dynamics model including the prop wash effect over control surfaces, a control strategy is presented to achieve autonomous transition between forward flight and hover flight. Both hardware and software architectures necessary to perform real flight are presented.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
Your ult-MATE Research Paper !!!
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

Introduction More often, homeland security, search-and-rescue, and disaster mitigation efforts have taken place in unforeseen environments which include caves, tunnels, forests, cities, and even inside urban structures. Performing various tasks, such as surveillance, reconnaissance, bomb damage assessment, or evacuating the injured within an unfamiliar territory is dangerous and also requires a large, diverse task force. However, unmanned robotic vehicles could assist in such missions by providing situational awareness without risking the lives of soldiers, first responders or other personnel from a remote location. Moreover, a fixed-wing platform capable of hovering would allow potentially long hover and stare modes while maintaining long flight times and a dash capability to avoid enemy fire [3]. The hovering mode would also allow flight in caves, tunnels, and other tight, enclosed labyrinths (see Figure 1). Designing such a vehicle requires a large thrust-toweight ratio (T /W > 1). This enables the aircraft to overpower its way through the stall regime and into a hovering position (i.e. the longitudinal axis of the fuselage is vertical). Once in the vertical orientation, the large T /W ratio enables it to hover by balancing the weight of the aircraft with the thrust from the motor. However, the aircraft is unstable in this configuration and requires an expert human pilot to constantly manipulate the aircraft's yaw and pitch control surfaces in order to sustain a hover. With full autonomous operation in mind, taking the hu man out of the loop during this difficult maneuver is a logical first step. An onboard control system and inertial measurement unit (IMU) were used to sustain the hover. To the best of our knowledge, this is the first work in the open literature which documents autonomous hovering of a fixed-wing aircraft 1. This paper illustrates the usefulness of a hovering, fixed-wing aircraft for flight in cluttered terrain. Section 2 discusses the platform characteristics and weight breakdown of the most recent prototype. Section 3 describes the demanding task of manually hovering a fixed-wing MAV while Section 4 details the attitude sensor and controller used to achieve the maneuver autonomously. Section 5 presents the experimental results and the paper concludes with sections on future work

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
Your ult-MATE Research Paper !!!
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

Platform Design To be capable of surveilling inside a cave or tunnel, a hovering platform is required. Hovering platforms such as helicopters and ducted fans [5] are not rapidly maneuverable and also lack the endurance advantages of fixed-wing aircraft. Lighter-than-air platforms like blimps [8] are typically too large for flight in cluttered terrain because buoyancy is proportional to size. A fixed-wing platform can be designed to be both small and rapidly maneuverable. Furthermore, incorporating a high thrust-to-weight ratio into the design would enable the aircraft to perform a maneuver known as prop-hanging. Adopted from the radiocontrolled (R/C) community, prop-hanging enables a fixed-wing aircraft to hover by balancing the weight with the thrust generated by the propeller. In order to transition into and sustain a hover, a thrust-to-weight ratio greater than one is required. With a weight estimate of 600 grams as shown in Table 1, a brushless motor was selected which can generate more than 1000 grams of thrust (i.e. a T/W = 1.67). Another design factor is that the aircraft must be controlled with limited airflow (i.e. prop wash) over the control surfaces once in the hovering position. As a result, the control surface areas of the vertical and horizontal tails and wing must also be increased. The net result is that a small drag force can be used to regulate rotation about all three axes. Figure 2 shows our prototype in its hovering orientation

FIXED WING MAV DESIGN The most common scenario for MAV mission today is urban surveillance. While flying over buildings is already achieved by commercial mini-UAVs, MAV specificity is to be able to fly both outside and inside buildings. Flying outdoor requires the ability to fly fast in order to fulfil the mission in windy condition (wind speed up to 10 m/s, wind gust up to 15 m/s). One common way to achieve this is to use a high wing loading and a powerful propulsion unit with a small diameter, high-pitch propeller. High wing loading is also convenient to counter wind gust disturbance. Flying indoor implies the ability to hover with almost no aerodynamic speed. Although rotating wing systems seems to be the most suitable vehicle for that mission, fixed-wing MAV could prove to be very attractive as well. It is now common in the RC model community to perform hover flight with foam aircraft smaller than 1

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

meter in wingspan. However that kind of aircraft have a very low wing loading and use large propeller with low pitch to obtain significant static thrust. They are therefore unable to perform forward flight in strong wind conditions nor able to carry the necessary hardware to achieve autonomous flight and the payload. Off the shelf small RC aircraft able to fly both outdoor and indoor does not already exist. Some ideas to conceive such an aircraft will be presented in this chapter.

Hovering a Fixed-Wing MAV To enter the hovering flight mode, the MAV must first transition through the critical high angle-of-attack regime. During this phase, there exists an angle-ofattack, α, for which the wings are no longer a contributing factor to the lift component (i.e. stall). To achieve the maneuver, the aircraft has to leverage its momentum and essentially overpower its way through the stall regime (see Figure 3). The aircraft's high thrust-to-weight ratio helps to preserve momentum through this transition, thus avoiding stall. This maneuver occurs in under two seconds as seen by the captured flight data in Figure 4. After a successful transition to the secondary flight mode, sustaining a hover under manual control is very challenging. The maneuver requires an expert human pilot to continuously manipulate four channels of a radio-controlled transmitter (see Figure 5). Assuming the aircraft is in, or close to, the hovering attitude (i.e. fuselage is vertical), the formidable process s as follows: (i) increase/decrease the throttle if the plane begins to lose/gain altitude, (ii) apply left/right rudder deflection if the plane begins to yaw to the left/right, (iii) administer up/down elevator if the aircraft starts to pitch forward/back, and (iv) counter the moment created by the motor torque by deflecting the ailerons. The four steps above must be done in parallel, however, once a throttle position is found which balances the weight of the aircraft, the pilot focuses more on the remaining three channels. F

Monoplane Wing optimization

Planform influence An easy way to maximize lift of the monoplane wing under a maximum dimension Lmax constraint would be to maximize its surface adopting a disc plan form of diameter Lmax. Although maximum lift is an important parameter for low speed flight, other aspects need to be

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

IJARMATE
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 5, Issue 4, April 2019

studied such as lift to drag ratio. Hence, a thorough experimental study has been performed in SUPAERO low speed wind tunnel to determine the best wing plan form in order to maximize lift while maintaining a good lift-to-drag ratio [1]. The different planforms presented in figure 1 were compared using a fixed wing span of 0,2m and a cruise condition of 10m.s-1 for 80g mass. Although each planform has its own surface, the 0.2m diameter disc was used as a reference to determine undimensioned coefficients. Maximum lift to drag ratio is shown as well as maximum lift to cruise lift ratio. This last parameter represents the ability to fly at low speed. It clearly appears that the disc planform has low aerodynamic performances in cruise condition and does not provide the best low speed capacity. Plaster and Zimmerman planforms seem to be the best performers at low speed while keeping a good lift-to-drag ratio in cruise conditions.

ASPECT RATIO INFLUENCE

Classical lifting line theory predicts that aspect ratio is the main parameter affecting lift-to-drag ratio. However the Reynolds number and the aspect ratios of MAVs are too low to apply with confidence the lifting line theory results. Therefore, there is a real need for experimental or numerical results. Yet, we can predict that a higher aspect ratio will lead to a higher lift-to-drag ratio but will decrease the maximum lift coefficient. Experimental testing on elliptical plan forms of different aspect ratio confirmed A thumb rule to ensure a safety margin in cruise condition is to keep a maximum lift coefficient at least twice as large as the cruise lift coefficient. This rule will lead to limit the aspect ratio to a maximum value of approximately

Sensors and Control for Automation In order to make the secondary flight mode autonomous, the aircraft's attitude needs to be measured and fed back to an onboard control system. Microstrain's 3DM-GX1 inertial measurement unit (IMU) consists of three orthogonal accelerometers and gyros which are interpreted to output orientation at a rate of more than 100 Hz. The sensor's small size (65 mm x 90 mm x 25 mm) and weight (30 grams out of protective casing) enable it to be easily mounted to the MAV platform. The IMU interfaces with a control circuit which includes a PIC16F87 microcontroller and a RS232 converter chip to communicate serially with the sensor.

CONCLUSION

This study on monoplane wing has lead to three important design rules in order to reach low speed flight while keeping good aerodynamics performance in cruise: • Plan form is of great importance; Zimmerman and Plaster are the best candidates. • Aspect ratio should be kept under 1.7 to perform low speed flight. • A maximum lift-to-drag ratio is reached for a moderate camber value.

BIBLIOGRAPHY

[1] Aerodynamic Performance of Biplane Micro Air Vehicle. Accepted for publication in the Journal of Aircraft, 2007. Jean-Marc Moschetta, Chinnapat Thipyopas. Ecole nationale supérieur de l'Aéronautique et de l'Espace.

[2] A Low-Speed Fixed-Wing Micro Air Vehicle. EMAV 2006. Chinnapat Thipyopas, Jean-Marc Moschetta. Ecole nationale supérieur de l'Aéronautique et de l'Espace.

[3] Conception of an UAV Generic Mission System. ICAS 2006. Damien Poinsot, Jacques Lamaison, Alain Hostallier, Caroline Bérard. Ecole nationale supérieur de l'Aéronautique et de l'Espace.

[4] The Dynamics of Flight – The equations. Wiley 1998. Jean Luc Boiffier. ONERA centre de Toulouse Département commande des système et dynamique du vol. & ENSAE.

[5] Contribution au développement du pilote automatique de la Drenalyn. Projet de Fin d'Etude 2005- 2006. Tiago de Castro Grossinho, Damien Poinsot, Jacques Lamaison, Caroline Bérard. Ecole nationale supérieure de l'Aéronautique et de l'Espace.

