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Fabrication of Fixed Wing UAV with EDF Engine for Surveillance

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Abstract

Unmanned aerial vehicles (UAVs) are becoming increasingly popular in a variety of civil applications, including real-time monitoring, wireless coverage, remote sensing, search and rescue, cargo delivery, security and surveillance, precision agriculture, and civil infrastructure inspection. This technology is rapidly expanding its influence in a variety of areas of human life. UAVs have become a critical component of the global aerospace industry's expansion and competitiveness. In wealthy countries, UAV investment is projected to be in the billions of dollars. Despite the rapid rise of unmanned aerial vehicles (UAVs), few studies have divided UAV technologies into distinct technologies or studied UAV technology development trends. To examine the technological developments and portfolio of UAVs, we adopted the latent Dirichlet allocation (LDA) method of topic modelling and network analysis. This report describes the design and fabrication of Airbus A380 scale model of 1/40 ratio. Use of fibers and epoxy needed in this project was determined by our team and the project was undertaken by each skilled in different fields.

Keywords: Epoxy, Latent Dirichlet allocation, Surveillance, Unmanned aerial vehicle,

1. INTRODUCTION

A UAV is an aircraft that flies without a human pilot on board. The aircraft is controlled by an operator on the ground using a radio-controlled transmitter. They can be classified into two main categories, which are, rotary-wing and fixed-wing. These two designs are differentiated based on the working principle of each design. The rotary-wing fully depends on the rotor for lift, while fixed-wing generates lift from the aerodynamic shape of the wing.

A fixed-wing UAV designed without tail and has no definite fuselage is called a flying wing configuration. This design is the most effective design from the streamlined perspective and auxiliary weight. Another advantage of flying wing configuration is that it has a high lift to drag ratio [1]. According to Bolsunovsky, the lift to drag ratio of flying wing design could be increased to about 20% compared to a traditional design [2]. This is because a flying wing design has fewer edges, less tip edge and less surface area which reduces parasitic drag. Parasitic drag is a drag that is not associated with the production of lift which comprises of form drag, friction drag, and interference drag.

1.1 UNMANNED AERIAL VEHICLE

An unmanned aerial vehicle (UAV), sometimes known as a drone, is an aircraft that does not have a human pilot, crew, or passengers on board. Unmanned aerial vehicles (UAVs) are part of an unmanned aircraft system (UAS), which also includes a ground-based controller and a communications system with the UAV. UAV flight can be controlled remotely by a human operator, as in a remotely piloted aircraft (RPA), or with varying degrees of autonomy, such as autopilot help, up to fully autonomous aircraft with no human interaction.

1.2 CLASSIFICATIONS

UAVs, like any other aircraft, can be categorized based on design features such as weight or engine type, maximum flight altitude, degree of operational autonomy, operational duty, and so on.

1.2.1 RELYING ON THE WEIGHT

Drones are categorized into five categories based on their weight: nano (under 250 g), micro air vehicles (MAV) (250 g - 2 kg), miniature UAV or small (SUAV) (2-25 kg), medium (25-150 kg), and big (above 150 kg) (over 150 kg).

1.2.2 IN ACCORDANCE WITH THE DEGREE OF AUTONOMY

Drones can also be categorized according to how autonomous their flying activities are. Uncrewed aircraft are classified as either remotely controlled or totally autonomous by the International Civil Aviation Organization (ICAO). Some unmanned aerial vehicles (UAVs) have varying degrees of autonomy. For example, a vehicle that can be operated remotely in most situations but can also return to its base autonomously. Some aircraft types, such as manned aircraft converted into uncrewed or Optionally Piloted UAVs, may fly manned or uncrewed (OPVs).

1.2.3 ON THE BASIS OF ALTITUDE

The following UAV classes have been used at industry events such as the ParcAberporth Unmanned Systems forum based on altitude:

- Hand-held 2,000 feet (600 meters) above sea level, with a range of around 2 kilometers Up to 10 km range at 5,000 ft (1,500 m) altitude

- NATO type with a 10,000 ft (3,000 m) height and a range of up to 50 km. Tactical height of 18,000 feet (5,500 meters), range of around 160 kilometers
- MALE (medium altitude, long endurance) can reach 30,000 feet (9,000 meters) and has a range of more than 200 kilometers.
- HALE (high altitude, long endurance) and infinite range over 30,000 ft (9,100 m)
- Supersonic (Mach 1–5) or hypersonic (Mach 5+) hypersonic high-speed 50,000 feet (15,200 meters) or suborbital altitude, with a range of more than 200 kilometers
- Low-Earth-Orbit (Mach 25+) Orbital Low-Earth-Orbit (Mach 25+) Orbit CIS Earth-Moon transfer on the lunar surface

1.2.4 USING A SET OF COMPOSITE CRITERIA

The United States Military's unmanned aerial systems (UAS) categorization of UAVs based on weight, maximum altitude, and speed of the UAV component is an example of classification based on composite criteria.

1.3 DESIGN

It can use electronic control methods that haven't been thoroughly tested. The quadcopter design has grown common for small UAVs, while it is rarely utilized for crewed aircraft. Because of the miniaturization, less powerful propulsion systems that aren't possible for crewed aircraft, like as small electric motors and batteries, can be utilized. Physical components of crewed and uncrewed aircraft of the same kind are often comparable. The cockpit and environmental control system, as well as life support systems, are the key exceptions. Some UAVs carry payloads (such as cameras) that are much lighter than an adult human, allowing them to be much smaller. Weaponized military UAVs are lighter than crewed counterparts with comparable weaponry, but carrying heavier payloads.

Because small civilian UAVs lack life-critical equipment, they can be made of lighter, but less durable, materials and shapes. UAV control systems are frequently different from crewed aircraft. A camera and video link nearly usually replace the cockpit windows for remote human control, and radio-transmitted digital commands replace physical cockpit controls. Both crewed and uncrewed aircraft employ autopilot software, which has different feature sets.

1.4 AIRCRAFT CONFIGURATION

The fundamental distinction from manned aircraft is the absence of a cockpit and its windows. Some varieties, on the other hand, are based on piloted models or are built for optional piloted or unmanned operation modes. Unmanned aircraft also have fewer requirements for air safety, giving the designer more leeway to experiment. These two considerations have resulted in a wide range of UAV airframe and engine layouts.

The flying wing and blended wing body are popular configurations for conventional flight because they offer small weight, low drag, and stealth. Larger variants with a variable payload are more likely to have a separate fuselage with a tail for stability, control, and trim, however wing layouts vary greatly.

The tailless quadcopter, which is prevalent for smaller UAVs, requires a relatively basic control system for vertical flight. However, bigger aircraft often utilize a single rotor with collective and cyclic pitch control, as well as a stabilizing tail rotor, thus the mechanism does not scale well.

1.5 PERFORMANCE CONSIDERATION

UAVs can be trained to undertake aggressive maneuvers or land/perch on incline surfaces before climbing to better communication locations. Some UAVs, such as VTOL designs, can regulate flight with variable flight modulization.

1.5.1 PROPULSION

For drones with a long range, traditional internal combustion and jet engines are still used. Electric power, on the other hand, has almost fully replaced nuclear power for shorter-range missions.

Lithium-polymer batteries (Li-Po) are used in most small drones, whereas hydrogen fuel cells are used in some bigger vehicles. Modern Li-Po batteries have a lower energy density than gasoline or hydrogen. Electric motors, on the other hand, are less expensive, lighter, and quieter. The purpose of developing complex multi-engine, multi-propeller installations is to improve aerodynamic and propulsive efficiency. Battery elimination circuitry (BEC), which is controlled by a microcontroller unit, can be utilized to centralize power delivery and reduce heating in such complicated power installations (MCU).

1.5.2 ENDURANCE

The physiological capacities of a human pilot do not limit the endurance of a UAV. Wankel rotary engines are employed in many large UAVs due to their tiny size, low weight, minimal vibration, and high power to weight ratio. Their engine rotors do not seize, and they do not require an enhanced fuel mixture for cooling at high power. These features cut down on fuel use while enhancing range and payload. Long-term drone endurance requires proper drone cooling. The most prevalent reason of drone failure is overheating and subsequent engine failure. Hydrogen fuel cells, which run on hydrogen, may be able to prolong the endurance of small unmanned aerial vehicles (UAVs) by several hours. Due to their lower Reynolds number, flapping-wing UAVs have the best endurance thus far, followed by planes and multirotors in that order. The AstroFlight Sunrise was the first to advocate for solar-powered UAVs.

2. LITRATURE SURVEY

B. M. Albaker et al, Mathematical modelling and realization of flight trajectories for an intelligent fixed-wing UAV presents detailed processing steps of how the flight trajectory is realized for an intelligent fixed-wing solar Unmanned Aerial Vehicles (UAV). It also covers the development of mathematical modelling of the flight trajectory using a three-dimensional aircraft maneuvering control vector, defined by turn, altitude and velocity commands. For computation and implementation purposes, each of these commands is discretized into three sets of finites and equally-spaced feasible trajectory options, bounded by the solar aircraft performance limit. The aircraft lateral and longitudinal three degree-of- freedom kinematics and aerodynamics are modelled and used with the flight path holding controller to accept commands issued by the high-level intelligent controller, and to simulate aircraft state response of the commanded trajectory. The flight conditions and physical dynamics and kinematics constraints of the fixed-wing solar-powered UAV are incorporated in simulating the flight trajectories.

Ma Tielin, et al, Fixed-Wing VTOL UAV has advantages of having less demand for landing space, high agility and high cruising speed compared with traditional air vehicle. It is one of the hotspots of aircraft's development. This paper described the development status of Fixed- Wing VTOL UAV and analyzed the technical characteristics of different types of Fixed-Wing VTOL UAV, prospected their development trends and put forward a feasible design plan of hybrid quadrotor UAV.

Jiawei Zhanget et.al, As a new type of aircraft, vertical takeoff and landing UAV has attracted wide attention in the industry. However, it still lacks relevant research about control strategies and solutions to extreme environments. This paper designs and validates two schemes for landing modes in two special environments, including landing in high altitude and mountainous and mobile landing on the ship. First, the design of the control law is carried out step by step. Then we have plenty of flight tests and analyze lots of data. We change the control parameters to achieve the desired results. The research indicates that the two schemes are feasible in engineering practice and can provide technical references.

KONG Weiwei et al, Autonomous control of running takeoff and landing for a fixed-wing unmanned aerial vehicle explains about the running takeoff and landing of fixed-wing unmanned aerial vehicles (UAVs). Firstly, a dynamic model of fixed-wing UAVs is developed. Then the takeoff and landing control strategies are designed. The flight control strategies are designed to be segmented. A fixed- wing UAV named "Petrel" is used as an experimental platform. Finally, the flight experimental results are proposed to validate the automatic running takeoff and landing controller.

Chao Wang et al, Stability control of unmanned aerial vehicle (UAV) is the most important technology when it is on the duty of taking area photos. This paper aims at analyzing the structures, the corresponding channel of control and control modes in small fixed-wing UAV, and focuses on flight control system, which systematically reveals the running rules of UAV. According to the control theories in UVA, the paper explains the method of stability controlling UAV from two major aspects, the longitudinal and lateral movement control, based on the UAV flight operation process. By understanding the structures, the modes, the rules and the theories, the paper achieves the goal that can catch the method of fully controlling UAV

M. H. Mohd Asri et al, Development of Multiple Configuration Flying Wing UAV paper discusses the development of a fixed wing Unmanned Aerial Vehicle (UAV) platform that can be customized into multiple configurations. This platform will be designed based on several requirements; low material cost, low manufacturing cost, portability for field operation, and stable flight design. Initially, a UAV platform is designed and manufactured for flight testing purposes. The first configuration was built for a twin tractor propulsion system. The prototype is built based on the design parameters using two types of foam core as based material. It is then fabricated using a CNC hot wire cutter machine. To reinforce the UAV structure, an advanced composite process is used by using fiberglass wet lay-up and vacuum bagging. The flight controller and its associated avionics system are then installed inside the UAV. Based on the flight test of the first configuration, the developed UAV has successfully flown in stable condition.

Jose Gomez et al, The authors presents an approach to obtain surveillance through a swarm of fixed wing airplanes and quad-rotor UAV (unmanned aerial vehicle). The approach is presented on a realistic situation where an autonomous fixed wing airplane and semi-autonomous swarm of quad-rotor UAV(s) work together to surveillance an area. The fixed wing airplane UAV determines the altitude, surveillance area, GPS location and provides communication and image recognition capabilities among the swarm and the ground station. The swarm quad-rotor UAV(s) are autonomous and can accept directives from the ground station and the fixed wing. Sensors deployed from the quad-rotor UAVs, directly communicate with the quad-rotors swarm. In this scenario, heterogeneous systems and human control interact in a system of systems architecture.

Basic Information About the Project

- Scale: 1/40
- Length: 182.5 cm
- Wingspan: 200 cm
- Material: Foam and Wooden pulp cardboard
- Servo Motors used: 10
- Type of Engines: EDF (Electric Ducted Fan) (3300 Rpm)
- No. of Engines: 4
- Thrust from each Engine: 2.5 Kgs (at maximum throttle)
- Power Supply: 2 x Lithium Polymer Batteries 14.8 volt each
- Weight: 10000 grams (approx.)

3.2 Components used:

1. Servo Motors used: 10
   a. micro servos: 3
   b. mini servos: 7
2. ESC (Electronic Speed Controllers): 8
   a. 4 x 85 ampere
   b. 4 x 40 ampere
3. LEDs: 15
4. 9V battery (for LEDs)
5. 10 channel Transmitter and Receiver

3.3 OTHER MATERIALS: -

1. Iron wires (for servo motors).
2. Wooden sticks (for supporting the frame).
3. Sanding paper 500 grit.
4. Fiberglass cloth and Carbon fiber (200 g per sq. feet) and epoxy for strength.

3.4 FEATURES:

- Retractable landing gears with suspension.
- Working ailerons, flaps, elevator, and rudder.
- Use of EDF (Electric ducted fan engines)

3.5 SPECIFICATION OF EDF ENGINES

- Fixed-wing UAVs use two types of propulsion, according to the study. One is a pusher, while the other is a puller. When evaluating two types of propulsion systems, the pusher type motor will be chosen since it is straightforward to mount with the frame and has no effect on cockpit visibility. The pusher motor is employed in hybrid UAVs to transition from hover to level flight. Due to Newton's third law of motions, horizontal mounting of the pusher motor with the frame and clockwise rotation of the propeller suckers the air in backwards and propels the model forward.
- 2.24KG Thrust 70mm EDF
- Dynamically balanced EDF for RC Jet models.
- Model: 70mm 6S
- Make: Power fun
- Material: Fiber Reinforced Nylon Rotor-
- Motor: 2300kv 6
- Plastic spinner
- Shaft adaptor to motor: 4mm
- Static Thrust :2.24KG
- Weight: 178g
- Working Voltage: 6S (22.2V)
- Weight of this complete unit: 178grams Amp's consumption at full throttle 65A
- Recommended ESC 70-80A

3.6 ESCS (ELECTRONIC SPEED CONTROLLERS)

- In a hybrid Unmanned Aerial Vehicle, an electronic speed controller is a critical component. It serves as a brushless dc motor's drive. It will run on a Lithium polymer battery and receive the signal from the transmitter. It causes the bldc motor to rotate. The ESC's job is to turn on electricity to the motor in the most efficient way possible. The switching is controlled by a 32-bit CPU, and the switching is carried out by MOSFET transistors. Each motor has its own ESC, which may change the direction of the motor and is also used to break the motor. It also has a Battery Elimination Circuit and can display data like as rpm, temperature, and current draw. The current rating of the ESC must be higher than the rated current of the maximum motor.
- A larger motor and a propeller with a higher pitch draw more current. 80A electronic speed controller was chosen based on our motor specs.
- Output: Continuous 80A, Burst 100A up to 10 seconds
- Input Voltage: 2-6S Lipo, 5-18 cells NiMH
- BEC: 5A / 5V Switch mode BEC
- Refresh rate of the throttle signal: 50Hz to 432Hz.1.5
- Max Speed: 210000rpm for 2 Poles BLM 70000rpm for 6 poles BLM

35000rpm for 12 poles BLM

- (BLM = Brushless Motor)
- Size: 86mm*38mm*12mm.
- Weight: 82g

Figure 3.2 Electronic Speed Controller

3.7 BATTERY

A lithium polymer battery, or more precisely a lithium-ion polymer battery, is a rechargeable lithium-ion battery that uses a polymer electrolyte rather than a liquid electrolyte. It is abbreviated as LiPo, LIP, Li-poly, lithium-poly etc.

This electrolyte is made out of semisolid (gel) polymers with high conductivity. These batteries have a higher specific energy than other lithium battery types and are utilized in applications where weight is a key factor, such as mobile devices, radio-controlled planes, and some electric cars.

3.8 CENTER OF GRAVITY

We selected LiPo batteries due to weight is the major factor in aircrafts where we want to balance center of gravity of whole plane by placing the batteries in correct position by calculating in theoretical way but usually it won't be accurate by practically, we can adjust the battery position to check the center of gravity.

3.9 TRANSMITTER

A transmitter is an electrical device used in telecommunications to generate radio waves so that data can be transmitted or sent using an antenna. The transmitter can produce a radio frequency alternating current, which is then applied to the antenna, which radiates it as radio waves.

3.10 RECEIVER

A radio frequency transmitter-receiver board receives data and transmits it wirelessly to different components via its antenna.

3.11 SERVO

A servomotor is a rotary or linear actuator that can control angular or linear position, velocity, and acceleration with precision. It is made comprised of an appropriate motor and a position feedback sensor.

3.12 LOW WING AIRCRAFT

Basically, most UAVs use high wing because it is easier to remove and remount, whereas we want to use other mounts to hold the low wing in place (for connecting the wings we are using carbon pipes which gives strength to the wings and shape of the wing wont deviate). Low-wing aeroplanes have wings that are lower than halfway up the fuselage. To improve lateral stability, expect to see some dihedral (upward angling of the wing tips compared to the wing root). One of the most common low-wing general aviation planes is the Piper Cherokee.

3.12.1 ADVANTAGES OF LOW WING AIRCRAFT

- Safer during emergency landings and gear up landings as wings will absorb some of the impact rather than all the force being concentrated on the fuselage as with a high wing aircraft
- In an emergency water landing, the low wings can float on the surface for several minutes. This allows time to evacuate.
- The fuel tank is easy to reach and fill from the ground
- Shortened takeoff distance thanks to enhanced ground effect
- Better overhead views of the sky
- Clear view on base to final turn
- May be lighter weight because the same spar is used for landing gear and wings
- Can accommodate a shorter, more widely spaced main gear which improves stability during taxiing (especially in high winds) and is less prone to structural failure.

3.13 AERODYNAMIC PARAMETERS CALCULATION

Wing area for trapezoidal wing = s * c Where,

s – wing span

c – average chord length

Wing area for trapezoidal wing = 27.25 * 200= 5500 cm2

Where,

Cr - Root Chord length = 44.5cm, Ct – Tip chord length = 10cm

- l/b = 182.5/200

  = 0.9125
- l/d = 182.5/18.725= 9.75
- Taper Ratio: -

  Ct/Cr = 0.22
- Root Chord = 44.5 cm

Tip Chord = 10 cm

- Mean Chord = 31 cm
- Aspect ratio of the commercial wing = (b2 / s)

  = (wing span)2 / wing area

  = (200)2 / 5500

A. R = 7.27

Wing loading n = (Body mass / wing area)

= (9/ 5500)

n = 0.00163 kg/cm2

= 16.3 kg/m2

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3.13.1 FLAPS

- Take-off flap angle is 45 degrees
- Landing flap angle is 60 degrees
- Selected Plain flap

3.13.2 LANDING GEARS

- Number of nose landing gears = 2
- Number of main landing gears = 4
- Fuselage Area

$SFuselage = ((\pi d2)/4)$

$= (\pi*18.752)/4$

$= 275.97\ cm2$

- Canopy area = 0.75*275.97

  Canopy area = 206.98 $cm2$

3.13.3 TAIL CONFIGURATION

Horizontal tail area

St = 0.21*Sw

= 0.21*5500

= 1115 $cm2$

Vertical Tail Area

Sv = 0.14*Sw

= 0.14*5500 = 770 $cm2$

Neutral Point: 92.94 cm from the nose – About 51% of the length of the fuselage – Found using VLMpc manual

- Could not find a given center of gravity location or a static margin for the A380
- Estimated center of gravity: 80.19 cm from the nose

3.13.4 SPECIFICATIONS OF MODEL

- Fuselage diameter: 18.75 cm
- Root Chord: 44.5cm
- Tip Chord: 10 cm
- Length of the fuselage: 182.5 cm
- Vertical stabilizer: 37.5 cm
- Horizontal stabilizer: 75.3 cm

4. EXPERIMENTAL RESULT

The Scaled Airbus A380 model was chosen for our project's fixed-wing Unmanned Aerial Vehicle. It has four Electric Ducted Fan Engines for movement such as take-off, climb, cruise, descent, and landing since it has independent propulsion systems.

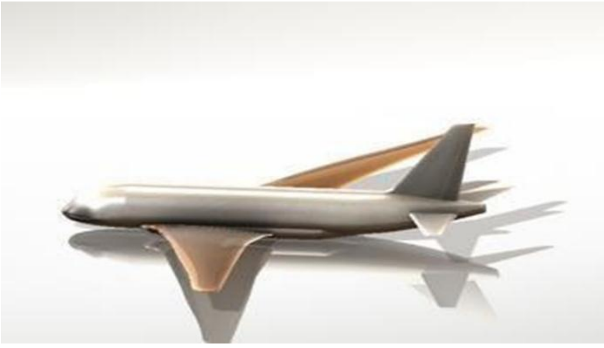

Figure 4.1 Airbus A-380 model

4.1 SELECTION OF AIRFOIL

For the construction purpose NASA SC (2)-0610 airfoil is used for making root of the wing and NASA SC (2)-0606 is used for building tip of the wing taken as areference from the aircraft Airbus A380.

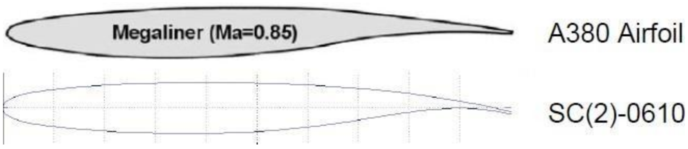

Figure 4.2 Airfoil

Figure 4.3 Fuselage of model

Figure 4.4 Fuselage setup with T-Tail configuration

Figure 4.5 Model with wings, Landing gear

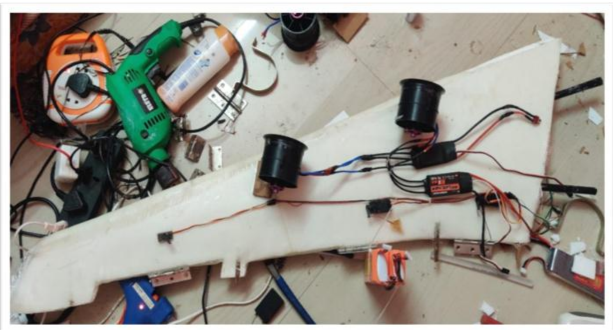

Figure 4.6 Propulsion system set-up

Figure 4.7 Final fabricated model

5. CONCLUSION

By visualizing the experts in UAV technology development trends, the quantitative data generated through the analysis process suggested in this study can be used as an intuitive reference index. Unlike previous simple aerospace trend analyses, this study used a text mining methodology to analyze patent data abstracts in the UAV industry, and it is the standard quantification method that is commonly used for patent analysis.

We built a scale replica of the Airbus A380 using a variety of materials, as well as designing and assembling electronic components. All of the control surfaces function in conjunction with EDF (electric ducted fan) engines, giving us a whole new perspective on designing and fabricating unmanned aerial vehicles. The aircraft is in terrific functioning order and is ready to fly.

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