Design and Analysis of Unmanned Aerial Vehicle

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Abstract— UAV is a most rapidly growing sector today with its application ranging from Defense, Surveillance to personal hobbies. A UAV is a radio-controlled Aircraft which will have flying range of 500 meters' radius. It can be equipped with a camera which will be useful for surveillance purpose. The UAV can also be used in rescue mission to provide food, medicines and other utility products in areas affected by natural calamities, where it is out of human reach. The UAV's are also used by Army and Air force for short missions (e.g. dropping a bomb) in enemy dormitories. The advantage of the same is safety as no human is involved and because of its low cost. Our UAV will be controlled using a radio frequency of 2.4 GHz. The control surfaces will be controlled through servo motors and the engine will be a brushless DC motor connected with an electric speed control and the power source will be Lithium Polymer battery. The key components that will be designed are the Wings, Control Surfaces and the Structure of the Plane.

Keywords—Control, Design, Radio, Surveillance.

INTRODUCTION

U.S. Department of Defense Dictionary defines Unmanned Aerial Vehicle as "A powered, aerial vehicle that does not carry a human operator uses aerodynamics forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expandable, and can carry a lethal or non- lethal payload"

Unmanned aerial vehicle, popularly as UAVs, drones, and remotely piloted vehicles (RPVs). These vehicles have been a feature of aviation for much of its history, though often overlooked. For the purposes of distinguishing UAVs from guided missile, a UAV is defined as being capable of controlled, sustained level flight and powered by a jet or reciprocating engine, these days also by electric motors. The appeal of a military vehicle in which there is no risk of loss of life is quite strong, so the pace of development of UAVs has always reflected the pace of technology in general. Until recently, UAVs have tended to be small, so they depend on technology miniaturization even more than their manned siblings. In the 21st century, the technology has reached a point of sophistication that the UAV is now being given a greatly expanded role in war fighting.

The United States of America's leading Aerospace and Defense Consulting Teal Group Corporation reports in their Integrated Market Analysis that Unmanned Aerial Vehicles (UAVs) continue as the most dynamic growth sector of the world aerospace industry this decade. Teal Group's 2012 market study estimates that UAV spending will almost double over the next decade from current worldwide UAV expenditures of $6.6 billion annually to $11.4 billion, totaling just over $89 billion in the next ten years.

UAVs are the next generation of aerial platforms to be deployed by defenses organizations around the world. Demand for UAVs is fuelled by the successful deployment of these systems in combat operations in Iraq, Afghanistan and Pakistan. These unmanned platforms are used as force multipliers, performing intelligence, surveillance and reconnaissance (ISR) missions, target recognition, damage assessment and electronic warfare.

Also, UAVs are in use for a wide variety of civilian applications ranging from Famers for spraying pesticides to weather reporter and geologists to gather information for topographical mapping and various other needs.

Hence this industry of UAVs shows a great quotient of enthusiasm, excitement and a great potential for development and research work to be done leading to substantial contribution towards futuristic markets of Unmanned Aerial Vehicle.

LITERATURE SURVEY

Wang Honglun et al [1] This paper proposes a method for planning the three-dimensional path for low-flying unmanned aerial vehicle (UAV) in complex terrain based on interfered fluid dynamical system (IFDS) and the theory of obstacle avoidance by the flowing stream. Finally, taking path length and flight height as sub-goals, genetic algorithm (GA) is used to obtain optimal 3D path under the maneuverability constraints of the UAV. Simulation results show that the environmental modeling is simple and the path is smooth and suitable for UAV. Theoretical proof is also presented to show that the proposed method has no effect on the characteristics of fluid avoiding obstacles.

Max Messinger et al [2] Unmanned aerial vehicles (UAVs) offer new opportunities to monitor pollution and provide valuable information to support remediation. Their low-cost, ease of use, and rapid deployment capability make them ideal for environmental emergency response. Here we present a UAV-based study of the third largest coal ash spill in the United States. Coal ash from coal combustion is a toxic industrial waste material present worldwide. The technique used here allows rapid response to environmental emergencies and quantification of their impacts at low cost, and these capabilities will make UAVs a central tool in environmental planning, monitoring, and disaster response.

K. Y. Chee et al [3] This article reports the development of an unmanned aerial vehicle capable of attitude estimation and stabilization through the implementation of a nonlinear complementary filter and proportional-integral rate controllers. Experimental results have shown that the implemented attitude and altitude controllers are effective and the platform is capable of navigating autonomously with user-defined waypoints. The collision avoidance algorithms allow the platform to avoid obstacles, both reactively and during navigation routines.

Marina Torres et al [4] Three-dimensional terrain reconstruction from 2D aerial images is a problem of utmost importance due its wide level of applications. It is relevant in the context of intelligent systems for disaster managements (for example to analyze a flooded area), soil analysis, earthquake crisis, civil engineering, urban planning, surveillance and defense research. Illustrative examples show the potential of our algorithm in two senses: ability to perform the coverage when complex regions are considered, and achievement of better solution than a published result (in terms of the number of turns used).

Jonathan D. Stevenson et al [6] The small Unmanned Aerial Vehicle (UAV) has been proposed as an ideal platform for an increasing number of civilian mission roles. However, the small size of this class of UAV, while beneficial for acquisition and operational costs, presents a problem when it comes to their ability to be seen by other aircraft. These results have been compared against theoretical detection range estimates based on basic photonics and the capabilities of the human vision system, and the minimum sighting distances per current aviation regulations. Other technologies proposed to improve the delectability of the small UAV are also introduced. The outcome of this research is a proposed minimum set of safety equipment which should make the small UAV at least as safe as equivalent manned aircraft operating in the same airspace.

Sayed Ali AsgharShahidian et al [17] This paper studies the trajectory control problem for a pair of unmanned aerial vehicles (UAVs) equipped with time of arrival sensors to measure the time difference of arrival of the transmitted radio signal to localize the source. The extended Kalman filter is applied to estimate the source's position. The proposed trajectory control strategy encompasses three optimum experimental design criteria based on the position error covariance produced by the EKF. The control strategy steers the Avast the positions to minimize the uncertainty about the location of the source. The effectiveness of the proposed approach is illustrated through simulation examples.

Wei-Cai Qin et al [5] A small unmanned aerial vehicle (UAV) that can spray pesticide with high efficiency and with no damage to crops is required for the timely and effective spraying of small fields and/or those in hilly mountains. The deposition and distribution of droplets in the late stage of rice growth were closely related to the operational height and velocity of crop spraying as executed by the UAV, further affecting insect control. Both the insecticidal efficacy and the persistence period were greater than those achieved with a hand lance operated from a stretcher-mounted sprayer especially on the 5th day, indicating that UAV had a low-volume and highly concentrated spray pattern to enhance the duration of efficacy. This work offers abases for the optimized design, improved performance, and rational application of UAV.

KristofferRistSkøienet at [7] Pneumatic rotary feed spreaders represent essential equipment in the feeding system of present day industrial-scale sea cage aquaculture. This study presents experimentally obtained attitude measurements and corresponding surface distribution patterns of pellets to characterize the dynamic behavior and performance of such spreaders. Spreader attitude and direction were measured by employing an attitude and heading reference system along with a rotary encoder. Such a tool may be valuable for farmers and equipment producers which may easily evaluate the performance of various spreader designs. In addition, the results serve as valuable input for parameterization and validation of mathematical feed spreader models.

InciSarıçiçek et al [8] Recently, hub location problems have become more common with successful applications in air transportation. In this paper, we consider a hub-location and routing problem for border (Borders in this work refer to land borders, unless otherwise stated.) security in Turkey. Security is currently one of the most important issues. The first model is cost-oriented and there is one vehicle per hub. In the second mathematical model for routing, the monitoring frequency parameters which means the priority of monitoring of the demand nodes obtained by using ELECTRE are used to maximize the monitoring frequency of the demand nodes. The criteria for demand nodes are the need for UAVs, illegal border crossing, and the number of the illegal border activities and attacks. There are three vehicles per hub in the second model. The results of two mathematical models for routing problem are evaluated.

JaeyoungChoa et al [9] We describe a mathematical model for UAV aided security operations in the oil and gas industry. Operating UAVs can provide seamless awareness on possible emergency situations such as oil spills, shipping incidents, industrial accidents, acts of terrorism, and so on. The primary goal of this model is to generate an optimal UAV operational schedule to meet surveillance needs in the areas of interest in each time. The performance of these UAVs depends on the risk assessment on spatial and temporal characteristics of threats, specifications of available UAVs, and decision makers' critical information requirements. The models are designed to provide insights into issues associated with designing and operating UAVs for strengthened maritime and port security.

Chen Gao et al [10] This article presents a novel distributed algorithm for multiple unmanned aerial vehicles (UAVs) to solve the online search–attack mission self-organization problem under adversarial environment. Finally, a Dubbin's curve is used to connect the path points smoothly. In the threat avoidance mode, the path of avoiding a threat is generated based on Dubbin's curve. A series of simulations are carried out to verify the online application of the proposed SAMSOA algorithm.

Peter J. Kunz et al [11] Growing interest in micro-air-vehicles has created the need for improved understanding of the relevant aerodynamics. A reasonable starting point is the study of airfoil aerodynamics at Reynolds numbers below 10,000, here termed ultra-low Reynolds numbers. While these issues may limit the applicability of blade-element type methods for detailed rotor design at ultra-low Reynolds numbers, such methods are still useful for evaluating concept feasibility and rapidly generating initial designs for prototyping and for further analysis and optimization using more advanced tools. Moving toward controlled powered flight at centimeter scales, several prototype rotorcrafts have been fabricated and tested, exploring both the aerodynamics and system integration issues.

Michael S. Selig et al [12] An approach to low Reynolds number airfoil design is described, and several example design cases are presented and discussed. The overall approach involves using the inverse metoprolol for design and XFOIL for analysis. Validation of these methods and the low Reynolds number airfoil design philosophy is supported by UIUC wind tunnel experiments. These notes derive largely from four prior publications of the author (see Refs. 1–4) and the contributions of the respective co-authors are gratefully acknowledged.

Jae-Neon Lee et al [13] This paper describes an analysis of domestic and international trends of image processing for data in UAV (unmanned aerial vehicle) and explains about UAV and Quad copter. Overseas examples of image processing using UAV include image processing for totaling the total number of vehicles, edge/target detection, detection and evasion algorithm, image processing using SIFT (scale invariant features transform) matching, and application of median filter and thresholding. In Korea, many studies are underway including visualization of new urban buildings.

Iowan Ulrich et al [14] This paper presents a new vision-based obstacle detection method for mobile robots. Each individual image pixel is classified as belonging either to an obstacle or the ground based on its color appearance. The method uses a single passive color camera, performs in real-time, and provides binary obstacle image at high resolution. The system is easily trained by simply driving the robot through its environment. In the adaptive mode, the system keeps learning the appearance of the ground during operation. The system has been tested successfully in a variety of environments, indoors as well as outdoors

JoakimAndersson et al [15] The forest industry needs an up-to-date overview of certain areas of a forest, to either estimate damages after a storm or assess its overall health. Today, the use of unmanned aerial vehicles (UAV) have exploded. Almost anyone can own one and they are very easy to operate. They are often equipped with accurate sensors and cameras that can be used for several productive applications. This paper investigates if aural equipped with positional sensors and a high-resolution camera can be used for taking aerial photographs and together with a mobile device create a coherent orthophoto in real- or near real-time. Three different seam stitching algorithms are tested and evaluated based on speed, accuracy and visual appearance. The results of using a UAV together with an iPad Air is presented both qualitative and quantitative.

Juan Mauricio Salamanca et al [16] This paper presents the results of the design and implementation of a system for capturing and processing images of agricultural crops. The design includes the development of software and hardware for image acquisition using a model helicopter equipped with video cameras with resolution of 640x480 pixels. A software application was developed for performing differential correction of errors generated by the Global Positioning System (GPS) and for allowing the monitoring of the position of the helicopter in real-time. A telemetry system consisting of an inertial measurement unit, a magnetometer, a pressure and altitude sensor, one GPS and two photo cameras were developed. Finally, image processing software was developed to determine some vegetation indexes and generation of three-dimensional maps of crops.

E. Cetin soy et al [18] This paper presents aerodynamic and mechanical design, prototyping and flight control system design of new unmanned aerial vehicle SUAVI (Satanic University Unmanned Aerial Vehicle). SUAVI is an electric powered quad tilt-wing UAV that is capable of vertical takeoff and landing (VTOL) like a helicopter and long duration horizontal flight like an airplane. A hierarchical control system is designed where a high-level controller (supervisor) is responsible for task decision, monitoring states of the vehicle, generating references for low level controllers, etc. and several low-level controllers are responsible for attitude and altitude stabilization. Results of several simulations and real flight tests are provided along with flight data to show performance of the developed UAV.

Taizhong Pan et al [19] This paper proposed a spatial sampling method, this method had proved that using stratified random sampling, choosing area-scale index as auxiliary variable, using simulated MSR image and UAV image can improve the crop area estimation accuracy over large area, the crop area estimation accuracy can be more than 95%.

M. Kemal et al [20] In this study, design and implementation of control system of a vertical take-off and landing (VTOL) unmanned aerial vehicle (UAV) with level flight capability is considered. The platform structure includes both multirotor and fixed-wing (FW) conventional aircraft control surfaces; therefore, named as VTOL-FW. The proposed method includes implementation of multirotor and airplane controllers and design of an algorithm to switch between them in achieving transitions between VTOL and FW flight modes. Thus, VTOL-FW UAV's flight characteristics are expected to be improved by enabling agile maneuvers, increasing survivability and exploiting full flight envelope capabilities.

Spyridon G. Ontogenies et al [21] Following current trends towards UAV innovative designs, a small size light UAV was designed, constructed and tested in flight. The purpose of this light UAV aircraft is to serve as a reconnaissance plane capable of carrying state-of-the-art photography and video equipment. Next, the aerodynamic characteristics and efficiency of the airfoil section, the wing, and the full configuration were evaluated using CFD. Finally, further improvements of the aerodynamic efficiency of the full configuration were carried out through computational optimization.

Ian L. Turner et al [22] UAVs (Unmanned Aerial Vehicles or "drones") for routine survey applications at the coast have come of age, and are no longer 'the latest thing' more suited to the specialist researcher or amateur enthusiast. Off-the-shelf, survey-grade UAV equipment, data processing and analysis tools are now readily available to practicing coastal engineers, managers and researchers. This has extended the scope of this program to include detailed measurements of dune and beach face erosion spanning the full 3.5 km long embayment at a spatial scale and temporal resolution that were previously unfeasible. For both the researcher and practicing coastal engineer, UAVs now provide a practical option for routine coastal surveying

J.M. Pena et al [23] This paper presents a system for weed mapping, using imagery provided by unmanned aerial vehicles (UAVs). Weed control in precision agriculture is based on the design of site-specific control treatments per weed coverage. The experiments study the effect of the flight altitude and the sensor used. Our results show that an excellent performance is obtained using very few labeled data complemented with unlabelled data (semi-supervised approach), which motivates the use of weed maps to design site-specific weed control strategies just when farmers implement the early post-emergence weed control.

James J. Guglielmo et al [24] A new high-lift airfoil design philosophy has been developed and experimentally validated through wind-tunnel tests. A key element of the high-lift design philosophy was to make use of a concave pressure recovery with aft loading. Three codes for airfoil design and analysis (PROFOIL, the Pepper code, anises) were used to design. In wind-tunnel tests, the new airfoil yielded a maximum lift coefficient. With vortex generators and a 1%chord Gurney ape (used separately), the Cl,max increased . The airfoil demonstrates the rather dramatic gains in Climax over those airfoils previously used for high-lift low Reynolds number applications.

Mariah's et al [25] Classical height control loop usually uses a pitch angle measurement in an inner loop to properly damp the short period and phugoid modes for a fixed wing UAV. The pitch angle measurements from low cost sensors can have significant biases under large maneuvers. The controller parameters are tuned in a nonlinear optimization setup that satisfies various controller design requirements. The presented height control scheme is tested in a high fidelity nonlinear simulation of the King Saud University tested UAV with satisfactory results.

CONCLUSION

This project is an ideal representation of the kind of challenges that engineers face continuously in industry. The complexity level of the design aspects of each of the components vital for the proper performance of the aircraft, as well as a harmonized correlation of all of them, provide perfect grounds for a demanding project.

Having to make a series of studies and analysis for each component to determine the best result, will offer the chance to gain a hands-on experience of how decisions are taken in the real world. All factors affecting the overall performance of a given part are taken into consideration, and the perfect balance between efficiency and strength are what determine the best result. Many times, in the real world though, reaching that intersection point between maximum efficiency and strength come at a high price, which in many cases fall outside the margins of a predetermined budget. It is in this case when alternative solutions must be thought of an analyzed. The alternative yielding the highest price cost reduction with the least sacrifice for the optimal design is the most favorable solution.

This project serves a great guideline as to what is expected of engineers when working in the industry. The importance of meeting deadlines, the unavoidable necessity to co-relate and work with people from different disciplines and being able to communicate and present your own ideas effectively and the importance of using your own knowledge and creativity to solve problems are all addressed in this project. That is what makes it so unique and rewarding.

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