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Fabrication and Evaluation of the Inshore Fishing UAV Gripper

Mbaitiga Zacharie and Kyuhei Honda

Abstract: UAV is defined as Unmanned Aerial Vehicle with some greater or lesser degree of 'automatic intelligence' part of an unmanned aircraft systems. Although all UAV systems have many elements other than the air vehicles, UAVs are usually categorized by the capability or size of the air vehicle that is required to carry out the mission. However, it is possible that one system may employ more than one type of air vehicle to cover different types of missions, and that may pose a problem in its designation. However, these definitions are constantly being changed as technology advances, allowing a smaller system to take on the roles of the one above. The boundaries, therefore, are often blurred so that the following definitions can only be approximate and subject to change. The main challenge in design and making any system for integration into the main research system, such as robot or UAV, requires careful attention on the interaction of each electric and electrical unit or component on the circuit board. This paper highlights the fabrication and the evaluation of the Inshore Fishing UAV gripper, the acrylic board, and the wireless communication module. The communication transmission distance between the UAV on shore and UAV over the sea is about 1 kilometer with stable flight.

Keywords: UAV; UAS; Gripper; Drone; Seashore; twe-litle.

I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs) were the stuff of rumor and legend, identified in the press as new and mysterious. "New shapes in the sky," declared the headlines at one time in the recent past. Now this stuff and legend seem to be commonplace, on the battlefield at least, where UAVs are carrying out surveillance missions and deploying weapons with great accuracy. UAVs are now truly the solution to some of the dangerous tasks for which they were first proposed and more lives are saved almost every day around the globe [1]. Apart from military applications, UAVs perform many jobs in commercial and governmental applications in surveillance, monitoring and trouble-shooting in the field of utilities, marine rescue customs and excise, and agriculture to name only a few. Some police forces are presently collaborating with industry to develop systems to replace helicopters to operate in controlled airspace [2]. Unmanned Commercial Airplane may be seen in the airspace in the coming 50 years. An earlier view of military forces was that the UAV systems are appropriately uses in 3D roles. That is, roles which are too dull, dirty or dangerous, in which to engage human pilots. While this philosophy remains true, the foreseen roles for UAVs have been expanded far beyond that boundary but not yet for civilian applications. Since civilian uses imply the operation in open airspace, rather than on a battlefield or within military enclosures, the regulation authorities have yet to accept their general operation for the following reasons:

- How to prevent injury to persons or animals and damage to property due to failures of the UAV.
- How to prevent injury or damage caused by collision between UAV and other airborne vehicles.

Requirements exist for assurance of the airworthiness of the system and meeting these requirements to ensure the achievement ~~of~~ (i) does not constitute a problem other than, perhaps the cost of so doing. The problem ~~of~~ (ii) remains since the authorities look for a reliable means being in place of a UAV sensing the presence of another airborne vehicle and avoidance collision with it. This is currently required not only in open airspace dedicated to the use of the UAV system. In other words , should another aircraft stray into UAV dedicated airspace; the onus is currently upon the UAV to avoid it.

Corresponding Author: Mbaitiga Zacharie. Dept. of Media Information Engineering, National Institute of Technology, Okinawa College. 905 henoko, Okinawa, Japan. Tel: +81-98-055-4174, Fax: +81-980-55-4012, E-mail: zacharie@okinawa-ct.ac.jp

Despite the lockdown operation of the UAV in airspace due to the safety concerns by authorities, research evaluation performance of the UAVs are entering into a new phase. For example, Dr. K. C. Wong [2] highlights the recent work on a UAV project at Sydney University that included remote-controlled flight platforms and the design development and operation of flight research platforms. Autonomous Helicopter group at Carnegie Mellon University is working on vision-based stability [3]. A group at Stanford University is trying to achieve acrobatic maneuvers using apprenticeship and reinforcement learning as a control method [4]. Reinforcement Learning is a type of Machine Learning, a branch of Artificial Intelligence. It allows the machines and software agents to automatically determine the ideal behavior within a specific context, in order to maximize its performances [5]. After the Earthquake that hits Tohoku in 2011 in Japan, the use of small. UAVs for surveillance, such as for checking the initial situation after a disaster, is attracting much interest. The NEC Guidance and Electro-Optics Division has been developing aerial surveillance systems using small-motorized UAVs mounted with optical sensors and image transmission modules [6]. In [7], the authors have made a preliminary assessment on how to expand the UAV applications to the fishing industry, especially on shore fishing. Because good species of fish are rarely found close to the shore, almost invariably, a descent cast is required to reach feeding fish. Most of the delicious fish, such as sardine, summon, common carp, Atlantic bonito etc., cannot be caught near shore. Add in the weather conditions and other constraints, fishing on shore seems to be a challenge for fishing enthusiasts. Most of the fishermen seen on shore do not want to bring their families even if their families are willing to take part of the journey with them. Most fishermen decline the offer for the simple reason that they cannot predict how long they will have to stay on shore and how many fish they would like to catch. However, if there is a fishing UAV on use on the market, perhaps the number of fishermen will not only be increased, but also a good opportunity for family to gather and enjoy the beautiful colorful sea while catching fish together will be created. The Inshore Fishing UAV (ISFUAV) being developed could be in the future into sport events and consequently be part of the Olympics games event, too. The above-mentioned reasons have motivated the authors to make a gripper for the ISFUAV currently being developed. The SFUAV gripper is made with TWE-LITE, the most suitable device for wireless communication. The next sections will provide detailed information on the materials used for making the gripper and the evaluation test performance.

II. TODAY UAV APPLICATION OVERVIEW

The development of a UAV for divers purposed for civilian applications is a privilege for those who have the chance to do so. In every research activity and domain, the outlook on the previous applications or research made on the domain where the research project will be done is essential. This outlook will give a deep understanding of the area, the machines and the materials to use or the method used so far, the difficulties encountered, and the ways these difficulties have been overcome to better reach the research goal. In this section, the current role of UAV systems in the Naval and in civilian operations will be explored. The operations which have received the greatest press reportage in recent years have been the tasks of long-range, long-endurance UAVs conducting surveillance over the theaters of war from medium to high altitudes and more recently, being equipped with armament in order to immediately attack a recognized enemy rather than risk delay in calling up ground troops or attack aircrafts. The types of UAVs suited to these operations are large *Horizontal Take-Off and Landing (HTOL, Fig1)* aircraft, such as *Predator* (Fig.2) o*r Global Hawk* (Fig.3) conflict, but controlled from even further airfield.

Fig.1. Horizontal Take-Off and Landing UAV

Fig.2 Predator UAV

Fig.3. Global Hawk UAV

A. Naval Operation

- ***Mission Decoy***

In the naval operation, the UAVs are usually fitted with a payload capable ~~to~~ of emitting the sources of detection used by anti-ship missiles. The UAVs are deployed to appropriately attack the incoming enemy missiles. The naval mission is one of the most dangerous missions because there is no chance for escape if an enemy missile hits the ship. So, the loss of a UAV would be a small price to pay in saving the loss of costly naval vessels and their crews.

- ***Port protection***

Naval vessels in port are vulnerable to enemy attack. Damage to the port facilities can deprive the fleet of vital operational support. To protect the vessels and all the ports, UAVs are used to maintain a visual surveillance for attacks mounted from land or sea. If a UAV detects any intruding vessels, the UAV has the choice between the following two options: 1) Alert a defensive strike or 2) initiate the strike in order to keep the enemy vessels from approaching friendly vessels, consequently protecting the port.

- ***Fishery Zone Protection***

Fisheries protection [1] implies ensuring that illegal fishing is not carryed out within the protected waters. This is carried out customarily by naval vessels protecting the fishing zone, which may be quite extensive in area. It is an extended task, requiring the location of suspected vessels and their intent. It is not illegal for unlicensed vessel to be present within the fishery zone as long as it is not fishing or if the vessel is unaware of the zone being protected. Here is the problem. The crew of an illegal fishing vessel will be alerted to an approaching ship as soon as that ship appears over the zone. They then have plenty of time to haul in their net before the patrol vessel is close enough to see the activity. Thus giving the patrol vessel's crew no other reason to board the suspected vessel. In some cases, if the illegal vessel is equipped with weapons and have decided to keep fishing by all means, the illegal vessel may open fire on the patrol vessel with the intent to keep the patrol vessel from chasing them. Depending on the distance of the patrol vessels and the position, the crews may suffer damages and consequently loss of lives Therefore, the UAVs are used often to survey the protected zone and monitor for illegal fishing vessels. These fishery zone protection UAVs are equipped with passive sensors that can closely approach a suspected vessel without alerting the crew.

*B. Agriculture Operation*s

- ***UAV Crop Duster Sprayers***

With the news on every TV station around the globe reporting about the application of the UAVs and the result they produced, engineers have designed small to medium UAVs for agriculture applications, which proves results on efficiency. To this end, the Homeland Surveillance & Electronics LLC [8] has designed AG-UAV Sprayers. Some of the benefits of crop spraying with UAV Sprayers include a significant reduction in application costs by utilizing a UAV aircraft and a notable improvement in coverage and control through consistent application of the best suited droplet size for better penetration of crop canopy, decreased drift potential and evaporation, and greater adherence of chemicals to the leaves. The spray system was designed to promote economically and ecologically sound spray methods that are the future of agricultural aviation. The following are some of the agricultures areas in which UAVs have proven efficient:

- Disease detection and mitigation
- Disease outbreak tracking
- Livestock tracking
- Locate invasive species and diseased areas
- Assess environmental impact and wildlife habitat
- Parasite monitoring
- Moisture monitoring
- Crop monitoring
- Irrigation
- Soil and field analysis
- Planting
- Cattle herd monitoring

III. UAV SPECIFICATIONS

The authors' previous article explored a preliminary assessment from different perspectives on how this project should be processed including the key features of the UAV to be used. The outcome of the assessment concluded the UAV Phantom 2 Standard as the aircraft to be used. Unfortunately, the manufacturer has discontinued the production of the Phantom 2, forcing the authors to make a new choice of the project engine for the simple reason that in case the project is completed and that the ISFUAV is made commercially available, , it will be ~~so~~ difficult to provide the aircraft ~~for~~ to the public. After reconsidering the assessment, the new choice for the aircraft is the **Phantom 3 Standard** shown in Fig.1 for the following reasons:

Fig.4 Phantom 3 Standard for Inshore fishing development

The Phantom 3 Standard is an easy-to-fly quadcopter for aerial photography and filmmaking. It includes a high-quality camera, a custom-built remote controller, the Intelligent Flight Battery (IFB), and is compatible with the DJI GO app for mobile devices. The remote controller features a 2.4 GHz Wi-Fi Video Downlink, 5.8 GHz aircraft transmission system, and a built-in battery. It is capable of transmitting a signal to the aircraft up to 0.62 miles (1 km) away that matches the exact distance the UAV will fly. There is also a foldable mobile device holder attached to the remote controller used to mount to the smartphone if needed. The flight controller provides stability and safety ~~to~~ for controlling the UAV. The supported flight modes are designed to optimize aircraft control for different conditions and purposes. The flight controller allows the aircraft to automatically Return-to-Home (RTH) if the remote controller signal is lost or when instructed by the pilot, ensuring the safe return of the aircraft. Flight data is stored to the device every time the UAV flies and can be accessed anytime. The DJI Intelligent Flight Battery has a capacity of 4480 mAh, a voltage of 15.2 V and a smart change or discharge functionality. The on-board camera features a 1/2.3 inch Complementary Metal-Oxide Semiconductor (CMOS) sensor that captures up to 2.7 K ultra HD video at 30 fps and 12 Mpx still photos. Video can be recorded in Mp4 or MOV format. MOV is an MPEG-4 video container and common multimedia format using a proprietary compression algorithm developed by Apple Computer. Those formats still can be saved in both Joint Photographic Experts Group (JPEG) and Digital Negative (DNG) formats. Shooting modes include burst, Auto Exposure Bracketing (AEB) and time-lapse. A live HD video feed from the camera can be viewed on the mobile device through the DJI GO application. The 3-axis gimbal is also on stage. It provides a stability platform for the camera attached, allowing the operator to capture crisp, clear images. The gimbal can tilt the camera across a 120° range.

IV. GRIPPER HARDWARE AND METHODOLOGY

A. Hardware

The main challenge in design and making a system. Designing a gripper from scratch and integrating it into the ISFUAV is not an easy task. It requires the fulfillment of certain criteria such as choosing the right electrical, electronic and mechanical components of each unit and their interaction. The interaction, weight of each component and their placement on the circuit board is crucial and should be distributed carefully [9]. These criteria include the compatibility of the new components with other components already integrated on the ISFUAV, cost and the flexibility to maneuver tasks ~~on~~ at a given time. The following figures are the mechanical and electronic components chosen for making the gripper.

Fig.5 Motor gear

Specification:

Speed reduction ratio: 297.2
Rated Load current 0.169A
Load-less rotational speed: 60rpm

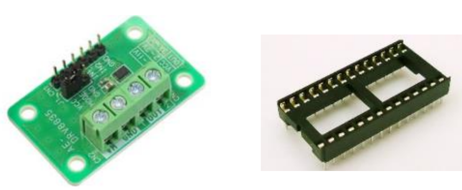
Load-less current: 0.05A
Normal load torque: 0.051N-m (0.520Kgf-cm)
Rated load rotational speed: 50
Weight: 905 g
Gear mod: Spur wheel gear

Twe-lite b) Spur gear module

Fig.6 TWE-LITE wireless and module

a) Battery Box b) Tact stwich

Fig.7 Battery box and tact switch



b) DC motor kits b) IC scoket

Fig.8 DC motor and IC socket

Fig.9 wire connection

B. Methodology

The current developed ISFUAV will carry out its mission from the seashore to approximately 1 km out to sea. Therefore, a wireless communication module capable of maintaining communication without interruption with the fisher agent on the shore at a distance of 1 km is necessary. Upon assessment of all wireless communication systems, we have chosen the twilight wireless communication module TWE-LITE-DIP-WA. TWE-LITE constitutes the core of the gripper because it is only capable of sending a communication signal to the gripper but is also well suited to interact with other gripper mechanical and electronic components. We have use two TWE-LITE-GIP-WA. The communication signal has been performed with up to 2.4 GHz, enough for a communication distance of 1 km. The TWE-LITE allows us to reset or override interlocks, display fault status, view the direction in which the crosshead or actuator is moving, position the crosshead or actuator, and start, stop, and hold the test. The controller panel contains hydraulic controls, which allow the operator to turn on power to the Hydraulic Power Unit (HPU) and Hydraulic Service Manifold (HSM). The compensators compare the command with the corresponding sensor feedback to ensure that the command is fully applied to the specimen. If the sensor feedback indicates that the specimen is not reaching the commanded level, the compensator alerts the command until the desired result is achieved. The main window of the TWE-LITE application is divided into the following sections: The top section contains menus, toolbar, a system control panel, and test status information. The middle section contains panels for project editing. The bottom section contains the Error List, Application Log, and Test Log panels. Two DC driver motor kits of reference DRV 8835 are used. We have chosen the DC motor over the AC motor due to its low-cost, its light weight (9.6 g) and its capability for driving constant-torque loads of 0.520 kgf-com. These motor driver kits and corresponding Python library make it easy to control a pair of bidirectional. The expansion board features DRV8835 dual H-bridge motor driver IC, which allows it to operate from 1.5 V to 11 V and makes it particularly well suited for driving small, low-voltage motors such as the gear motor shown in Fig.5. Its deceleration speed is about 297.6 m/s, enough for the application. The gear attached to the motor axis is for transmitting rotary motion and force to the gripper. The acrylic board connected to the gripper over the motor for carrying out the fishing materials in order to trigger the gripper to rotate in an appropriate direction. Two-battery boxes with lead wires and switches, IC socket 28P 600 millimeter and 4 pieces of black color tact with switch were used. The gripper components layout displayed on the floor is shown in Fig.10.

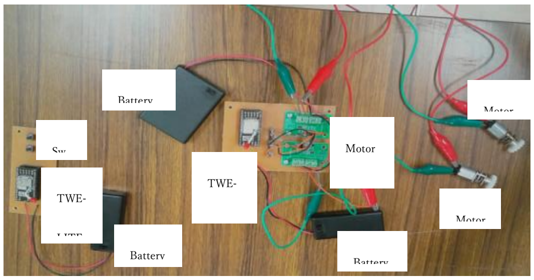


Fig.10 ISFUAV gripper layout prototype

Depending on the rotation angle of the gripper, the grasping and releasing movement is determined. For a constant rotation of the motor, we can keep continuous grasping and releasing states at any given time without any problem. Next, the DC motors are used to produce a maximum current of 3A. As the ISFUAV is supposed to load two hooks along with the fish bait at the same time, two DC motors are used. One for the left gripper and the other one for the right gripper. To supply a power to all component units, 7 cell batteries were used as follows: Three cell batteries providing 4.5 V for driving the dc motor, 2 batteries providing 3V for the TWE-LITE transmission unit and 2 batteries providing 3V for the TWE-LITE receiver unit respectively. All items mention above are assembled together on the circuit board called printed circuit board (PCBE). To make connections between all electrical, electronic and mechanical components, heat resistant electronic wire 2 m × 7 color with outer diameter of 1.22 mm (Fig.9) was used. Fig.11 shows the completed left gripper mounted on the ISFUAV and ready for an evaluation test.

Fig.11 Gripper mounted on the ISFUAV

V. EVALUATION TEST RESULTS

The gripper was tested to ensure it was strong enough to carry the fishing materials from the sea shore to the sea. In addition, testing made sure that the grippers were not too heavy for the ISFUAV to cause an unstable flight during the fishing mission. Testing also provided an opportunity to check the communication application between the aircraft on the air and ground control station (GCS). The following four experiments were carried out:

Experiment-1:

The aircraft rose with the gripper holding two colored 500 ml water bottles horizontally for about 60 seconds first to check the stability of the aircraft. During this experiment, the aircraft was not flown to the left or right but but horizontally. The stability was excellent and weight of the grippers mounted onto the ISFUAV did not have any influence on the aircraft stability (Fig.12)

Fig.12 Stability flight experiment

Experiment-2:

Again, the aircraft rose with the gripper holding two colored 500 ml water bottles horizontally for about 60 seconds. After 60 seconds elapsed, the ISFUAV released or dropped the first bottle on the ground. The ISFUAV then flew about 100 m from the point where the first bottle was released on the ground and dropped the second bottle. After the release of the two bottles was completed with excellent stability and flight control, the ISFUAV returned to the GCS. The weight of the loaded bottles and the flight time was measured.

Experiment-3:

For this experiment, two colored water bottles of about 150 g were held with a stability of about 60 seconds was tested. Then the ISFUAV flew from the point that the experiment has started for about 150 m of distance and dropped the first bottle. Next, it flew again for about 80 m from the point the first bottle has been dropped on the ground and dropped the second bottle. At this point, the distance from the point the second bottle was released and the GCS is about 150 m. After two of the bottles were released successfully, the ISFUAV returned to the Ground Control Station and landed. The flight route of the aircraft was designed in the form of a triangle (Fig.13). The time it took to complete this experiment was 6 minutes and 30 seconds.

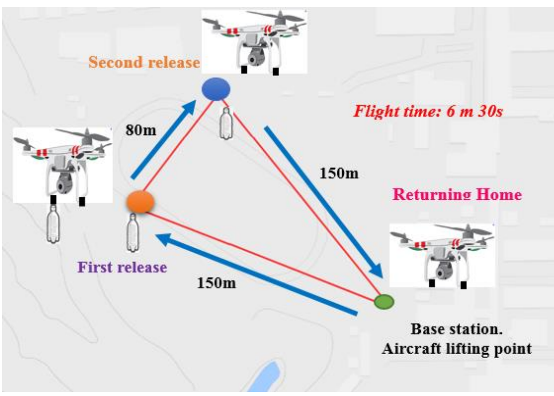


Fig.13 Gripper mounted on the ISFUAV

Experiment-4:

Experiment 4 was similar to Experiment 3 but increased the flight stability check from 60 seconds to 120 seconds. The flight speed was increased with heavy material at sea level. The first bottle was released at about 150 m from the GCS. The time it took from the GCS to the point the first bottle was released was 60 seconds. Next, the ISFUAV flew again for about 80 m from the point the first bottle was released, like Experiment 3, with a 60 second of flight duration. Then the ISFUAV returned to the GCS. The time it took to completed this experiment was 4 minutes. During all four experiments, no trouble has been encountered. Everything was done as expected.

VI. CONCLUSION

This paper describes the fabrication and validation experiment tests of the ISFUAV gripper. The gear motor with a speed reduction ratio of 297.2, a rated load current 0.169A, wire connection, DC motor and Integrated Circuit (IC) socket, battery boxes and tact switch, Spur gear module and the Twilight wireless communication module TWE-LITE-DIP-WA was used. This TWE-LITE constitutes the core of the gripper because it is only capable of sending a communication signal to the gripper but also it is well suited to interact with other gripper mechanical and electronic components. Four experimental tests were carried out to make sure the gripper was strong enough to hold the fishing materials when it comes to use in the sea. All four experiments were successful. The tests showed excellent stability of the aircraft and successful results were obtained

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