Whirling Apparatus based Fabrication and Development of Unmanned Air vehicle

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***Abstract*:-In this paper a Hover craft has been built with the properties of the "Whirling Apparatus" constructed by Sir. George Caley in 17th century. This paper describes about the fabrication of an Unmanned Air Vehicle (UAV) which can be used for surveillance and for agriculture. This is air vehicle is having a single rotor that works on the principle of Coanda effect. In this paper, the rotorcraft model is fabricated and is successfully flown by remote control mechanism. The rotor craft is controlled through graphical user interface (GUI). Communication between GUI and spy craft is done by using wireless communication system. . This rotorcraft is fitted with better controlling and manoeuvring ability.**

1. ***Index Terms—morphed, fabric wing, optimizationlift force*.**

INTRODUCTION

Research and development of unmanned aerial vehicle (UAV) and micro aerial vehicle (MAV) are getting high encouragement nowadays, since the application of UAV and MAV can apply to variety of area such as rescue mission, military, film making, agriculture and others. In U.S Coast Guard maritime search and rescue mission, UAV that attached with infrared cameras assist the mission to search the target.

Rotorcraft or Spy rotor aircraft is one of the UAV that is major focuses of active researches in recent years. Compare to terrestrial mobile robot that often possible to limit the model to kinematics, Rotorcraft required dynamics in order to account for gravity effect and aerodynamics forces. Rotorcraft operated by thrust that produce by four motors that attached to it body. It has for input force and six output states (x,y,z) and it is an under-actuated system, since this enable rotorcraft to carry more load.

Rotorcraft has advantages over the conventional helicopter where the mechanical design is simple. Besides that, Rotorcraft changes direction by manipulating the individual propeller's speed and does not require cyclic and collective pitch control.

Rotorcrafts and quad rotors in particular, are able to adeptly fly in 3-D environments with the ability to hover in place and quickly maneuver around clutter and obstacles. For this reason, rotorcrafts are an attractive platform for search and- rescue and first-response applications. However, one of the key challenges for autonomous flight is the lack of low power and lightweight sensor solutions for state estimation. While 3-D lidars are used in many settings, their mass exceeds most MAV payload capacities.

1.1 History of UAVs

Though modern-day technology is quickly advancing and improving UAVs and drones, developments in this field began decades ago, even before the first manned airplane flight occurred in 1903. The first and most primitive designs centered on balloons. The first attempts began in France in 1782 by the Montgolfier brothers1. These attempts continued through the years, one of which was developed by Charles Perley in February 1863, two years after the Civil War began. Perley attempted to design an aerial bomber, a hot-air balloon that carried explosives in its basket. The explosives were attached to a timing mechanism, and upon the timer going off, the explosives dropped out and a fuse was ignited.**[Krock, Lexi][1]** However, due to the unpredictability of air currents and weather patterns then, Parley's aerial bomber was never successfully deployed and experimentation into other designs was expanded3. Another model reliant upon wind and weather was a surveillance kite. A novelty put together by Douglas Archibald in 1883, the concept was successfully applied during the Spanish-American War in 1898. A corporal captured hundreds of images through a kite with a camera attached, with a long shutter release attached to the string.

Beginning in mid-1800s, winged designs were also taking shape. One such example is the Aerial Steam Carriage, shown in Figure 1, which was built in 1848 by John String, fellow and William Henson in England. Their initial model flew successfully for roughly 60 yards. In 1868, the pair also developed a model based on a tri-winged structure attached to a wire guide that could effectively generate lift and only used the wire guide to steer around obstacles1. 1896 saw the development of a model created by Samuel Langley. Steam-powered, his “Aerodrome Number 5” flew for almost a mile. In the years leading up to and during World War I, development began to expand even more, especially with war demands for fighter aircraft. One such model was the Kettering Aerial Torpedo, a 300-pound plane with the capacity of carrying an equal load that could be launched at a pre-programmed target. Though ordered in great numbers in the final few months of World War I, the close of the war led to the cancellation of the orders2. 1917 saw the advent of the first radio-controlled UAV, invented by Dr. Peter Cooper and Elmer A. Sperry after they received the first military contract for an unmanned flight system5. It also employed the use of their automatic gyroscopic stabilizer to help it fly straight and level. Though it could successfully travel for 50 miles with a 300-pound bomb loaded, it was never employed in combat after the Navy cancelled the project in 1922.

[Terault, Cam][1] After World War I, the development in this field abruptly declined until almost 1940 when an impactful design called the “Queen Bee” was developed in Great Britain. Though initially designed as a practice target during training, it expanded as its capabilities were capitalized on; it could reach a height of 17,000 feet and fly for 300 miles at a speed over 100 mph. Radio-controlled, the 380-strong fleet was used until its retirement in 1947, although its primary use was still for training3. A key aspect of this UAV was its ability to land and be recovered for reuse. This drone was the most prominent one until World War II when the Interstate BQ-4 was effectively employed in combat in 1942. In 1944, the United States reached 18 hits on targeted Japanese units with this drone1. Advancement was the V-1 in Germany, which Adolf Hitler claimed would be used for non-military targets. Flying at 470 mph, it had a 2,000 pound load capacity and could fly 150 miles. With such a dangerous UAV in Germany’s control, programs within the United States significantly took off in an effort to counteract and destroy them. In the years following World War II, there were many improvements, not only to the propulsion and guidance systems, but also to overall capabilities of the UAVs1. The United States Naval and Air Force programs began to convert surplus aircraft into practice target drones and the first jet-propelled UAVs, Ryan Firebees, came onto the scene in the early 1950’s. These drones were responsible for over 34,000 surveillance flights in the 1960’s and 1970’s3.

Developments in Israel in the late 1970’s and 1980’s had a significant impact on the programs within the United States. The Israeli “Scout” and “Pioneer” UAVs began the trend towards lighter drones with more of a glider-based design. These drones also began the transition to less expensive, smaller models, which increased their stealth capabilities3.

In the last two decades, UAV research and development has continued to focus on military surveillance and attack applications. However, recently UAVs have become more popular in the civilian sector as well. The applications of these drones have been broad. These include disaster relief, crop dusting, and mapping new geographic areas. These UAVs have also functioned as toys controlled by smart phones. The surge in the popularity of drones in the civilian sector demonstrates that they still have the potential for growth and further developments.

1.2 Definition of UAVs

Most of the (non-)commercially available UAV systems on the market focus on low cost systems, and thus a major advantage of using UAVs is also the cost factor, as UAVs are less expensive and have lower operating costs than manned aircrafts have. But, sometimes as mentioned in the previous section - depending on the application - the cost can be similar to manned systems. As for small-scale applications the expenses for manned aircrafts are not maintainable, projects are quite often not feasible or terrestrial systems have to be used as alternative systems, recognizing not all project requirements are met. Thus, UAVs can be seen as supplement or replacement to terrestrial photogrammetry in a certain area of applications. In the case of combination of terrestrial and UAV photogrammetry, it is even possible to use the same camera system and having the same distance to the object, which simplifies the combined data processing. In addition to these advantages, the UAV-images can be also used for the high resolution texture mapping on existing DSMs and 3D-models, as well as for image rectification. The rectified images and derivates, like image mosaics, maps and drawings, can be used for image interpretation. . **[Scheve, Tom]**[18]

The implementation of GPS/INS systems as well as the stabilization and navigation units allow precise flights, guaranteeing, on the one hand, sufficient image coverage and overlap and on the other hand, enabling the user to estimate the expected product accuracy pre-flight.

Looking at rotary wing UAVs, the platform allows vertical take-off and landing vanishing the need for an available runway. Furthermore, the use of VTOL (Vertical take-off and landing) systems permits the image acquisition on a hovering point, while the camera is turning in vertical and horizontal direction.

1.3 Advantages of UAVs

Major advantages of UAVs compared to manned aircraft systems are that UAVs can be used in high risk situations without endangering a human life and inaccessible areas, at low altitude and at flight profiles close to the objects where manned systems cannot be flown. These regions are for example natural disaster sites, e.g. mountainous and volcanic areas, flood plains, earthquake and desert areas and scenes of accidents. In areas where access is difficult and where no manned aircraft is available or even no flight permission is given, UAVs are sometimes the only practical alternative. Furthermore, in cloudy and drizzly weather conditions, the data acquisition with UAVs is still possible, when the distance to the object permits flying below the clouds. Such weather conditions do not allow the data acquisition with large format cameras integrated into manned aircrafts due to required larger flight altitude above ground. In addition, one fundamental advantage of using UAVs is that they are not burdened with the physiological limitations and economic expenses of human pilots. Moreover, supplementary advantages are the real-time capability and the ability for fast data acquisition, while transmitting the image, video and orientation data in real time to the ground control station.

1.4 Limitations in the use of UAVs

UAVs, especially low-cost UAVs, limit the sensor payload in weight and dimension, so that often low weight sensors like small or medium format amateur cameras are selected. Therefore, in comparison to large format cameras, UAVs have to acquire a higher number of images in order to obtain the same image coverage and comparable image resolution. Moreover, low-cost sensors are normally less stable than high-end sensors, which results in a reduced image quality. In addition, these payload limitations require the use of low weight navigation units, which implies less accurate results for the orientation of the sensors. Furthermore, low-cost UAVs are normally equipped with less powerful engines, limiting the reachable altitude.

Existing commercial software packages applied for photogrammetric data processing are rarely set up to support UAV images, as through no standardized workflows and sensor models are being implemented.

In addition to these drawbacks, UAVs do not benefit from the sensing and intelligent features of human beings. Thus, UAVs cannot react like human beings in unexpected situations, e.g. unexpected appearance of an obstacle. . **[Krock, Lexi][17]** In general there are no sufficient regulations for UAVs given by the civil and security authorities (Colomina, et al., 2008). Low-cost UAVs are not equipped with air traffic communication equipments and collision avoidance systems, like manned aircrafts. Therefore, due to the lack of communication with the air traffic authorities, UAVs are restricted to the flight in line-of-sight and to operate with a back-up pilot. The flight range of the UAV is also, in addition to the line-of-sight regulation, dependant on the skill of the pilot to detect and follow the orientation of the UAV-system. To take full advantage of the impressive flying capabilities of UAVs, like the fully automated operating rotary wing UAVs, there needs to be a well trained pilot, due to security issues. The pilot should be able to interact with the system at any time and maneuvers. Based on the communication and steering unit of UAVs, we can state that the operation distance depends on the range of the radio link for rotary and fixed wing UAVs, which is equivalent to the length of the rope for kites and balloon systems used in the past. In addition, the radio frequencies (35 and 40MHz in Switzerland) maybe subject to interferences caused by other systems (remote controlled cars and model aircrafts, as well as citizens' band radio), which use the same frequencies, or may suffer from signal jamming. Thus, depending on the local situation of the area of interest, the frequency for the communication between GCS and UAV has to be selected carefully. Nowadays, UAVs are also controlled via 2.4GHZ radio connection, while the video link has to be shifted to 5GHz.

1.5 UAV photogrammetry

The new terminology UAV photogrammetry (Eisenbeiss, 2008c) describes a photogrammetric measurement platform, which operates remotely controlled, semi- autonomously, or autonomously, without a pilot sitting in the vehicle. The platform is equipped with a photogrammetric measurement system, including, but not limited to a small or medium size still-video or video camera, thermal or infrared camera systems, airborne LiDAR system, or a combination thereof. Current standard UAVs allow the registration and tracking of the position and orientation of the implemented sensors in a local or global coordinate system. Hence, UAV photogrammetry can be understood as a new photogrammetric measurement tool. UAV photogrammetry opens various new applications in the close range domain, combining aerial and terrestrial photogrammetry, but also introduces new (near-) real time application and low-cost alternatives to the classical manned aerial photogrammtery. A detailed study on real-time data collection using airborne sensors including UAVs can be found **[Blom, John D][16]**.in 2008.

Existing UAVs can be used in large-scale and small-scale applications. The system price may vary within some orders of magnitude, depending on the complexity of the system. With costs between €1000 up to several millions of Euro, the system can be similar or even higher priced compared to a standard manned aircraft system. However, the focus of this study is more on low-cost UAV systems for applications. The subsequently presented advantages and limitations of UAV photogrammetry in comparison to the existing methods are thus mostly valid for low-cost systems and small-scale applications only.

1.6 Application of rotorcraft

The major application of the rotorcraft is surveillance and mainly a defense application. It can cover a range of 100m other defenses related applications are patrolling, bombing, detonating, ferrying missiles.
Aerial Surveillance and Intelligence for Law Enforcement and Hobbyist and Professional Aerial Photography and Video and Property Assessment and Real Estate Promotion and Traffic pattern Analysis and identification in Agriculture anEducation learning Platforms.

5. FABRICATION

5.1 System Components

When developing a UAV, there are several parts that are combined in the system in order for it to achieve its objectives. Mechanical and electrical components, such as motors, propellers, sensors, and microcontrollers, must be integrated to create a fully functional drone. The correct implementation and selection of all these different parts will determine the success of the project, which is the reason why having a deep knowledge of all of these concepts is key to be able to correctly design the UAV

5.1.1 Motors

Figure: 1.4 Brushless Motor

Since the saucer is a single rotor, it necessitates four motors and four propeller. The motor is the device that converts electrical power output from the battery into mechanical power. The mechanical power then turns the propellers and generates the force needed by the robot to fly. This motor also creates a torque that rotates the robot either in a clockwise or counter clockwise direction. As mentioned before, this torque is cancelled by the torque generated by one of the other motors which produces a torque of the same magnitude but opposite direction.

There are many types of motors, such as DC brush motors and AC motors. For this single rotor, 1 DC brushless motors were implemented into the design. This type of motor has 2 constants which are important. These are the Km and the Kv values. Km is known as the motor constant and it is a ratio of the motors torque and the square root of the resistive power loss. Kv is known as the motor’s velocity constant and it measured in RPM (revolutions per minute) per volt. This last constant is the ratio of the unloaded motor’s RPM to the peak voltage output. In other words, if a motor has a Kv value of 1000 RPM/volt and a supply of 11.1 volts, the nominal speed would be 1500 RPM.

5.1.2 Propellers

The propellers are the components of the propulsion system that provide the thrust and lift needed by the single rotor lo leave the ground, hover, turn, and rotate. These forces are produced as the propellers rotate. The propeller hubs are attached to the motor and then a nose cap is screwed on top of the propeller to secure it to the motor.

Propellers can be set up into two different ways. These are the pushing configuration and the pulling configuration. The difference between these two configurations is the direction the propeller is facing and the position it is with respect to the aircraft. For the pushing configuration, the propeller is pointing to the back of the aircraft and is usually located behind the wings, which makes the propeller push the aircraft through the air. On the other hand, the pulling configuration has the propeller pointing to the front of the aircraft and it is usually at the front of the wings, which makes the propeller pull the aircraft through the air. At the same time the group had to select the size of the propellers to be used.

After browsing for the available options and calculating the static thrust created while being used with the chosen motor, it was decided to use 6x3 standard propellers. Theoretically, these propellers will be capable of generating 2.59 Kg of thrust while running at max speed. At the same time, these propellers are not too heavy, allowing the motor to run at the desired speed without getting too hot or breaking.

In a single rotor, the propellers are usually on top of the vehicle, i.e. in front of it, and usually pulling the aircraft up while they push the air down. They are also separated into clockwise and counter clockwise configurations (CW and CCW respectively)13 since single rotor need to have a balance between the number of motors turning in a clockwise direction and those turning in a counter clockwise direction

5.1.3Transmitter

There were a few parameters considered for the selection of the router. The most important ones were: range, speed, and cost. It needed to reach an altitude of 100 feet and be able to communicate with a base station. It is necessary to have reliable communication all the time, which is the reason why having an efficient router is so important. The desired range was at least 100 feet outdoors with a transmission speed over a few megabytes per second. Multiple images are sent every second and each image is only a few hundred kilobytes. From the math, a 54 Mbps router is plenty to gather all of the pictures and send information to the single rotor at the same time. It was even considered that with this router, multiple single rotors could be attached and controlled by the ground station.

Figure: 1.5 Propeller Blades

Fig: 1.6 Transmitter

A more likely problem for limiting the processing power is that the Raspberry Pi can't gather the image data fast enough. Another objective for this project was to make the UAV low-cost, so the router chosen had to meet all three of these parameters.

The Linksys WRT54GL, below, was the router selected for this project and is shown below. It has a range of 300 feet outdoors and a maximum speed of 54 megabytes per second, which clearly meets all the design parameters defined previously. The 300 feet range also allows for an estimated 280 foot movement in longitude and latitude. The price for this router was Rs.3,800/-, which is also between the desired price ranges.

5.1.4 Batteries

Fig: 1.7 Battery

When looking for a battery to use for a single rotor, there are a number of specifications to consider in order establishing a balance between the weight of the battery and its capacity. A battery cannot be chosen solely on its own specifications, but the other components of the drone must also be taken into consideration. Each part has an impact on each other and therefore there are multiple combinations of components that could be used to create the ideal UAV. An initial consideration must be the weight of the vehicle. Generally speaking, a good guideline is to have the total weight at around half of what the motors' thrust value is equal to. By doing this the motors will not overheat and fail, and they will be able to lift the drone off the ground and hover at approximately 50% throttle. For instance, if there are four motors that each produce rotor - LiPo Batteries value, 1308g in this case. Subtracting the total weight of the system from that number will give an ideal range to work with to determine the weight of the battery. Beyond just looking at the weight, the capacity of the battery must also be considered. Looking for batteries can be confusing to those who are not familiar with how they are named. For instance, "Free Fly LiPo 4S 11.1V 2200mAh 25C" and "G6 Pro Lite 6600mAh 25C (5S)" are names of different batteries. A consumer needs to know how they are categorized so that the proper battery for their needs is purchased. The S-number is the number of battery cells in series, so a 3S is three cells, a 4S is four cells, and so on. Each cell is equivalent to 1.7V, so the voltage of a 3S battery is 11.1V. The more battery cells there are in series, the higher the voltage, which makes it more efficient while lessening current flow16. Batteries can also be listed in a form such as 3S1P, where the 3S is the same as before, but the added 1P indicates one parallel block. Adding more cells in parallel increases the capacity of the battery as it adds more amps. The mAh is the milliamps per hour discharge rate, which is essentially the battery capacity. Using the two batteries cited above, it is seen that the Free Fly LiPo (lithium polymer) discharges at a rate of 9 amps per hour, while the G6 discharges at amps per hour. Finally, the C rating gives an indication of how long the battery will be able to run on full power, so the two mentioned above have the same capability, but a battery with a 30C rating will be able to run longer15. Though this is a good indication for the capabilities of the battery, the battery should never be run at its max for an extended period of time in order to avoid damaging the unit. In general, batteries with higher capabilities (4S Vs 3S, 30C Vs 25C) add more weight to the battery, so it is important to balance capabilities with weight. Unfortunately, there is no graph to give an easy indication of what would be ideal for a system, so it needs to be calculated for every system according to its needs and components. However, the chart below gives a good example of the impact the weight of a system has on batteries with varied capacity.

654g of thrust each, the system's has a total thrust of 2616g14. Dividing that total in half gives its 50% " single rotor - LiPo Batteries." Single

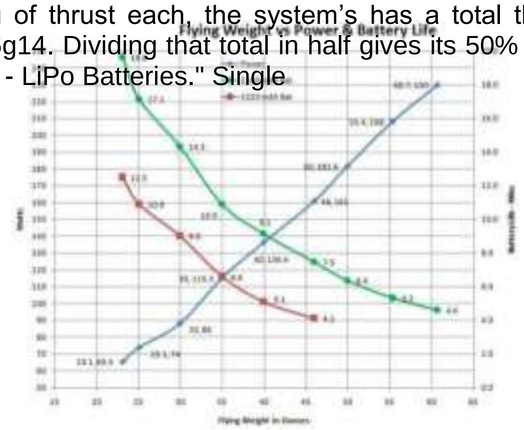

Fig:1.8 Battery Weight vs. Power Example Comparison 18

The motors play an important role in choosing a final battery. For example, if a motor recommends a 3S1P battery, that is an indication of a recommended 11.1V. A 2200 mAh 30C battery for this system can output 66 A of current safely. If the maximum current for each motor is 14 A, then having four of them will require four times this amount, so 56 A16. Therefore, this battery would be a good fit for this system. Now, a 3S battery pack with these specifications would weigh about a quarter less than a 4S since it has one less cell, but it requires more amps to accomplish the same amount of work. A 4S require fewer amps, but due to the heavier weight it would require more work to be done due to its added weight16. Again, the graph above can be utilized to see the relationship between the weight, capacity, and power output of different batteries. There are tradeoffs for each scenario, so an ideal battery must be chosen based on the factors discussed above.

5.1.5 Camera Model, Feature Detection and Tracking

Fig: 1.9 HD Quality Camera

One of the most important sensors that is often used in UAVs is a camera. There are many different types of cameras and they can be configured on the UAV in several different ways. There are some systems that have space for external cameras like the GoPro, but for most of the UAVs the cameras are built-in. Most of the built-in cameras are printed circuit board (PCB) cameras that connect directly to a microcontroller. The PCB board is fairly small because it doesn’t need all of the extra functions of a normal digital camera. For most of the commercial UAVs, the cameras are HD quality, which provides high quality video footage for the user. The use of high quality cameras also affects the system overall because it has additional requirements like higher transmission rate, a better processing memory, and more memory space. Both cameras in the system are modeled with a spherical camera model and calibrated using the Omni direction Calibration Toolbox. For the primary camera that runs at 25 Hz, we detect and track Shi-Tomasi corners [16] using the KLT tracker. It is worth noting that due to the limited motion that occurs between image frames, we are able to perform the feature detection and tracking calculations on the distorted fisheye camera image, reducing the overall computational burden of this step. Using the camera calibration parameters, all features are transformed into unit length feature observation vectors uCij for further processing. Here we denote uCij as an observation of the i^{th} feature in the j^{th} image in the camera body frame.

5.1.6 Electronic Speed Controller

Fig:2.1 Electronic Speed Controller

In order to control the amount of current being fed into the motor, it is imperative to use a motor controller. This motor controller would prevent the motor from breaking or burning, and it would also prevent a short circuit from happening. Since the motors chosen for the project were small and did not need huge amounts of current to operate, the speed controller could actually have a low amp value. For the project the Mystery 12A Brushless Speed Controller was chosen. As its name suggests, it allows up to 12 amps of current to flow. This speed controller has some safety functions like reducing power if the temperature goes above 120°C and reducing power or shutting off as a low current protection. This speed controller will be connected to the motors on one of their ends, and to the battery.

CONCLUSION

In this project the fabrication of rotorcraft is done by collecting the parts from various sources and assembled with great care and skills. The test drive of the rotorcraft is successfully done. This project given a clear idea about how the rotor will operate and it given a good handling over the movements of the rotorcraft. During the time of the fabrication we learned various skills such as time management, leadership, forgiveness, planning and we also overcome with many problems. It gave us a hope to go further to complete the project; we learned to never give up and with the complete team coordination we successfully done our project.

FUTURE WORK

In future we are planning to add much additional equipment Man devices for better combat operations. We are planning to add night view cameras and thermal view cameras for better visual effects and also we are on decision to implement a self- destructive technology in the rotorcraft to keep the data away from reach of the enemy's hands. If we are financially supported then we could make this plan to a successful one with better new version of a rotorcraft.

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