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DEVELOPMENT OF AN UNMANNED AERIAL VEHICLE (UAV) AND ITS REMOTE CONTROLLING SYSTEM

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ABSTRACT
This investigation explores controlling of an UAV from a remote place by sending signals. The signals are sent from wireless remote keyboard. When a controller presses buttons one after another randomly or sequentially, then the signals are received in the form of analog signals and these analog signals are converted into binary form. Though a microcontroller is capable of receiving and processing both binary and analog signals (Or data), but it is not possible to recognize any remote signal by the microcontroller directly. So it is necessary to build a signal receiver to recognize them. Signal receiver can recognizes the signals that can be in any frequency and can converts the frequencies in the four digits binary number through the four output pins Q_1, Q_2, Q_3 and Q_4. Just like 0001 when the button "1" is pressed and 0010 when the button "2" is pressed and so on. In this remote controlled system, twelve possible signals can be utilized to control the operations separately. For an unmanned aerial vehicle, it is enough to control it by twelve different frequency signals. This UAV is controlled according to the signal received from remote control system which is sent to the microcontroller pins and corresponding controlling motors. This is a model investigation to run an unmanned aerial vehicle by five motors out of which three motors are for lifting, one for propulsion and the rest one for the ladder or aviation direction control. Final model test will be made with an unmanned aerial vehicle having fixed wing, flap and navigation ladder and propulsive motor with necessary self-balancing facilities.

Keywords: Unmanned aerial vehicle, remote control system, vehicle balance.

1. Introduction

The UAV is an acronym for Unmanned Aerial Vehicle, which is an aircraft with no pilot on board. UAVs can be remote controlled aircraft (e.g. flown by a pilot at a ground control station) or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. UAVs are currently used for a number of missions, including reconnaissance and attack roles. For the purposes of this article, and to distinguish UAVs from missiles, a UAV is defined as being capable of controlled, sustained level flight and powered by a jet or reciprocating engine. In addition, a cruise missile can be considered to be a UAV, but is treated separately on the basis that the vehicle is the weapon. The acronym UAV has been expanded in some cases to UAVS.

The FAA has adopted the acronym UAS to reflect the fact that these complex systems include ground stations and other elements besides the actual air vehicles.[1] UAV systems, despite having no onboard human pilots, require a high amount of human involvement to accomplish successful operations. A typical modern UAV system involves a launch crew (1-3 people), a mission crew (2-5) people, personnel using the imagery data captured from the UAV onboard sensors, such as forward ground troops or intelligence analysts, and possibly others, including lawyers and politicians. Furthermore, since a single UAV mission can last for over 24 hours, missions often involve one or more shift changes of the mission crew. Thus, there is a significant amount of human-human and human-vehicle interaction involved in UAV system operations. Much of this collaboration is done between geographically distributed people (e.g. the mission crew may be in the United States while the launch crew and information consumers may be in Afghanistan). Officially, the term 'Unmanned Aerial Vehicle' was changed to 'Unmanned Aircraft System' to reflect the fact that these complex systems include ground stations and other elements besides the actual air vehicles. The term UAS, however, is not widely used as the term UAV has become part of the modern lexicon. [1]

The military role of UAV is growing at unprecedented rates. In 2005, tactical and theater level UA alone, had flown over 100,000 flight hours in support of Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF). Rapid advances in technology are enabling more and more capability to be placed on smaller airframes which is spurring a large increase in the number of SUAS being deployed on the battlefield. The use of SUAS in combat is so new that no formal DOD wide reporting procedures have been established to track SUAS flight hours. As the capabilities grow for all types of UAV, nations continue to subsidize their research and development leading to further advances enabling them to perform a multitude of missions. UAV no longer only perform intelligence, surveillance, and reconnaissance (ISR) missions, although this still remains their predominant type. Their roles have expanded to areas including EA, strike missions, SEAD/DEAD, network node or communications relay, CSAR and derivations of these themes. These UAV

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range in cost from a few thousand dollars to tens of millions of dollars, and the aircraft used in these systems range in size from a MAV weighing less than one pound to large aircraft weighing over 40,000 pounds.

Research and development - used to further develop UAV technologies to be integrated into field deployed UAV aircraft . Civil and Commercial UAVs - UAVs specifically designed for civil and commercial applications.

In the past, UAVs were known by many different names, such as robot plane, drone, pilotless aircraft, and RPV. Later, the Federal Aviation Administration implemented a generic class name for them, UAS, to indicate that these aircraft systems also comprise a data link, control systems, ground stations, and other related support equipment. However, they are generally known as UAVs. UAVs are powered, aerial vehicles without an onboard human operator and can fly independently from pre-programmed flight plans or through a remote pilot. They are capable of carrying a lethal or nonlethal payload and come in different sizes, from the size of an insect to that of a commercial airliner. These devices have proven their effectiveness in recent warzones, such as Kosovo, Afghanistan, and Iraq.

When compared to manned aerial vehicles, UAVs are believed to provide two important benefits - they are cost effective and reduce the risk to a pilot's life. However, accident rates in today's UAVs are over 100 times than that of manned aircraft. Therefore, improved safety and reliability are still required.

The first pilotless aircrafts, called aerial torpedoes, were developed shortly after World War I and resembled modern cruise missiles. The current UAVs originate mostly from radio controlled pilotless target aircrafts built in the US and UK in the 1930s. [2]

An unmanned system is not just a vehicle. It is composed of the vehicle, communications, data links and control stations[2]. Degree programs at UVU take a systems engineering approach. Graduates will enter the unmanned career field in the areas of R&D, vehicle design, sensor development, vehicle communications and data links, sense and avoid systems, human machine interfaces, autonomous control, vehicle navigation, alternative power and operations.

The International Journal of Unmanned Systems Engineering (IJUSEng journal promotes the advancement of the applied science, technology and operation of unmanned systems through the dissemination of original research representing significant advances in the design, development, testing and operation of unmanned systems. IJUSEng provides a platform for authors and researchers for communicating their latest findings, ideas and methods at the forefront of technology in the field of unmanned systems engineering. The scope is wide, covering research, design, development, operation, safety and reliability. For more information on the journal visit. [3]

Hengyu"Robbie" Hu,conducted research investigation[4] on Autonomous Quadrotor for the 2013and reported that the quadrotor that is capable to traversing through narrow corridors of an unknown building using Simultaneous Localization and Mapping (SLAM) algorithms. While exploring, the vehicle uses image recognition program to identify the assistive Arabic signs and the flash drive ultimately, a passive Retrieval mechanism consist adhesive and magnet secures the flash drive and releases a decoy through mechanical levers. Include returning, all mission shall be completed within ten minutes limit.

The forerunner of today's UAV is reported to be the American Navy Curtiss/Sperry "flying bomb"[4]. This primitive cruise missile first flew on March 6, 1918. The Charles Kettering Aerial Torpedo, also known as the Kettering Bug, was a parallel effort backed by the American Army. Orville Wright acted as a consultant on the project. The "Bug" was a gasoline fueled propeller driven biplane which flew on a preset course for approximately 50 miles late in 1918. The guidance systems for both aircraft, composed of a gyroscope and barometer/altimeter were designed by Elmer Sperry.

The German Fiesler FI 103 V1, "Buzz Bomb" or "Doodle Bug" of 1944, was the first successful cruise missile.[5] This ram jet powered weapon traveled at speeds up to 400 mph and was able to strike London from launch sites in France. Germany also developed and used the Henschel Hs 293 and Fritz-X radio controlled glide bombs. These weapons were launched in midair from a controlling mother ship and steered to the target by radio commands made by a human operator. On Sept.9, 1943, the Italian battleship Roma was sunk by two Fritz-X bombs.

The first UAVs developed for surveillance were not utilized until the Vietnam War, where many Fire bee drones were introduced for simple reconnaissance activities. Initially, these drones were equipped with simple cameras and later fitted with communications, night photo and electronic intelligence. [5]

Some early UAVs are called drones because they are no more sophisticated than a simple radio controlled aircraft being controlled by a human pilot (sometimes called the operator) at all times. More sophisticated versions may have built-in control and/or guidance systems to perform low level human pilot duties such as speed and flight path stabilization, and simple prescript navigation functions such as waypoint following. From this perspective, most early UAVs are not autonomous at all. In fact, the field of air vehicle autonomy is a recently emerging field, whose economics is largely

driven by the military to develop battle ready technology for the war fighter. Compared to the manufacturing of UAV flight hardware, the market for autonomy technology is fairly immature and undeveloped. Because of this, autonomy has been and may continue to be the bottleneck for future UAV developments, and the overall value and rate of expansion of the future UAV market could be largely driven by advances to be made in the field of autonomy.

M. M. Syed Ali[6] conducted research work with pneumatic powered robot and firefighting system. A mobile phone was used to operate the firefighting system and the pneumatic powered robot. The firefighting system and pneumatic power robot were operated and controlled by mobile phone guided GSM Network perfectly. This was shown in national TV and ATN News channel in 2008. Later on M. M Syed Ali took an undergraduate research project on GSM Network Base Remote Control System for an Unmanned Vehicle [7]. This scheme is known as Dual Tone Multi-Frequency (DTMF), Touch-Tone or simply tone dialing. The test result showed that mobile phone guided wireless remote control system is applicable to control, surface vehicle and low height aerial vehicle wirelessly. M. M. Syed Ali et al. also conducted research works on automatic firefighting system and robot assisted firefighting system using this mobile phone guided GSM Network where it is found to work satisfactorily.[8]

2. Methodology

Here a model UAV has been constructed to control by a remote control system. To control an UAV, here a mobile phone is used to send signal by pressing button. These signals have been utilized for controlling the vehicle. A receiver is placed in the UAV to read the incoming signals from pilot and these signals are prepared to send in the micro controlling unit. When the pilot will press a button, according to the preprogrammed, the controlling unit or autopilot will lead the UAV to take off from land. Three motors are used for lifting and one for going ahead. Another motor is used for ladder or aviation direction control.

Autonomy is commonly defined as the ability to make decisions without human intervention. To that end, the goal of autonomy is to teach machines to be "smart" and act more like humans. The keen observer may associate this with the development in the field of artificial intelligence made popular in the 1980s and 1990s such as expert systems, neural networks, machine learning, natural language processing, and vision. However, the mode of technological development in the field of autonomy has mostly followed a bottom-up approach, and recent advances have been largely driven by the practitioners in the field of control science, not computer science. Similarly, autonomy has been and probably will continue to be considered an extension of the controls field. In the foreseeable future, however, the two fields will merge to a much greater degree, and practitioners and researchers from both disciplines will work together to spawn rapid technological development in the area. To some extent, the ultimate goal in the development of autonomy technology is to replace the human pilot. It remains to be seen whether future developments of autonomy technology, the perception of the technology, and most importantly, the political climate surrounding the use of such technology, will limit the development and utility of autonomy for UAV applications.

The receiver's signals can be transmitted over a radio to switch ON or switch OFF home appliances, flash lights, motors, cameras, warning systems, irrigation systems and so on. These encoded data can be stored and processed in a microcontroller to perform different tasks.

3. Design & construction of UAV body

3.1 Design of the main frame of the UAV

The designs and construction of the model UAV are shown in figure 1. MS channel (12mm X 12mm) are selected for main frame of the structure as shown below.

Fig.1 Structure of the main frame of the UAV.

3.2 Assembly of the model with motors

All the five motors are assembled on the main frame of the UAV as shown in figure1.

Fig. 2 Construction of UAV body.

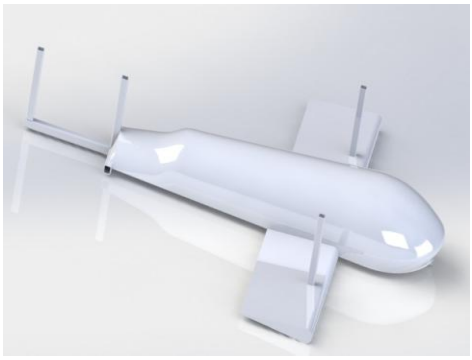

Fig. 3 Recommended model for future development.

4. Controlling system of UAV

4.1 Layout of the UAV Controlling System

The layout of the whole controlling system is shown in figure 4 below.

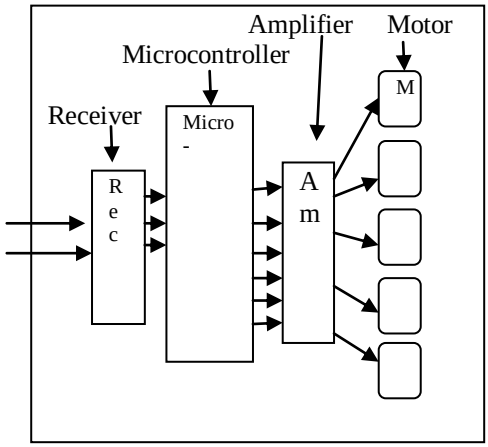

Fig. 4 Layout of signal receiver by microcontroller and transmission to power supply unit.

The design of the signal receiver unit with circuit diagram is shown in figure 5. It just contains IC chip, some diodes, resistors, capacitors and crystal.

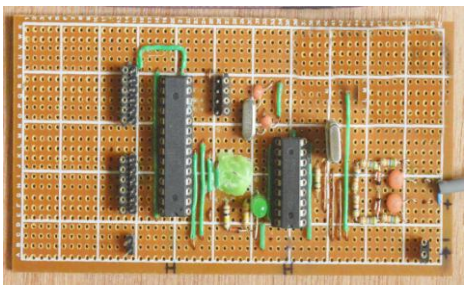

Fig.5 Combination unit of both signal receiver and microcontroller

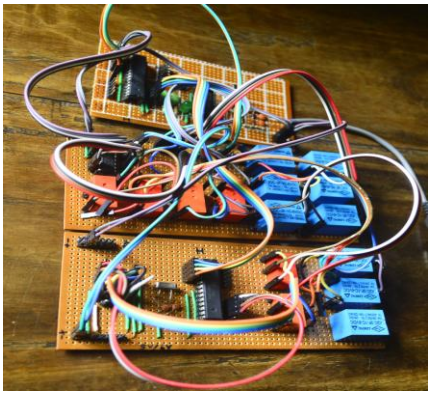

Fig. 6 Power supply system with controlling system.

4.2 Controlling of motors

In UAV the devices are controlled by controlling power supply in the respective motor. During take-off, one propulsive motor and 3 nos. lifting motors are started by a single command from ground station for generating propulsive and lift force. Again direction of the aviation control is done by changing rotational direction of the controlling motor.

Generally, brushless motors having high ampere current capacity and high speed are used in such cases. A brushless motor with 14,000-15,000 rpm and 4-5 ampere rating can lift 5-6 kilogram weight.

5. Performance test

The assembly of the controlling system and UAV body has been tested in the laboratory and it is seen that the remote control system is working properly. Thus UAV can be controlled from remote place necessary for aviation control.

The performance of the UAV is tested in the laboratory to ensure the operation of controlling system and preparation of flying. It has some sequential procedure to start and control the UAV.

a) UAV is connected with the controlling system from remote distance.
b) All the 4 motors for lifting and propulsion are operated in its design mode for low speed and high speed operation.
c) The direction of aviation control is tested by operating the 5^{th} motor in clockwise and anti-clockwise rotation.
d) Finally, UAV can be operated from remote place according to the pre-programmed loaded in microcontroller.

The tested result shows that the controlling system is working properly. Since there is no visual camera attached in the UAV body and motor powers are insufficient so the operation of motors are tested in the laboratory only.

6 . Result and discussion

The test result shows that all motors can be controlled by the remote control system successfully in the laboratory. The construction of UAV body and its controlling system are accomplished to fulfill are the requirements of aviation for an UAV. However the major objective is to develop a body and a controlling system, so that the test result can help for future development of UAV. These test results can help in

- developing controlling device
- assessment of the material required for body construction
- motor power necessary to operate the UAV.
- and assessing cost and power weight ratio of a UAV

The reduction of the weight of the UAV body reduces the power consumption and cost of the vehicle. If the motors are of desired rating are used then the UAV will able to fly. Finally, the performance of all the five motors required for flying of the UAV is found satisfactory.

7. Conclusion

In this research project, remote control system a similar to a previous study[7] is used with a different vehicle model shape for easy balancing of the UAV. The test result shows that

- the operation of the model motors can be started by this remote control system.
- the motors power installed are not sufficient to develop sufficient lift force for flying this UAV. Brass- less motors are required to be installed which could not be managed
- development of surveillance control system is also required with remote control system.
- the model needs a further development for better sensing, balancing and development of remote control system before aviation test.

NOMENCLATURE

UAV	= Unmanned aerial vehicle
UAVS	= Unmanned aircraft vehicle system
UAS	= Unmanned aircraft system
RPV	= Remotely piloted vehicle
EA	= Electronic attack
SEAD	= Suppression of enemy air defense
DEAD	= Destruction of enemy air defense
CSAR	= Combat search and rescue
MAV	= Micro air vehicle
TCS	= Tactical control system

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