A TECHNICAL SEMINAR REPORT

ON

MEDICAL DRONE

In

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

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BONAFIDE CERTIFICATE

Certified that this technical seminar report **"Medical Drone"** is the bonafide work of "**A Y S HARSHA"** who carried out the seminar presentation under my supervision.

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ABSTRACT

In today's world, Drone is capable of delivering the medical needs to the hospital. These Drones help in transferring the medical supplies to the hospitals in rural areas as soon as the hospital requests for it. It will be economically and practically faster than the transportation as rural areas have awful roads and are located in really tough locations to reach out. Hence, the drone is the most efficient way of transferring the medical supplies.

In some emergency cases, hospital will be in the need of blood, at that time instead of the regular transportation, Drones can play a very important role. When the required blood is requested by the hospital authorities immediately the blood is sent through Drone to the hospital. This not only saves many lives but also it is the most efficient way of transport.

They can also be used for transport of blood samples for forensic test.

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1. INTRODUCTION

The use of current drone technologies is reviewed, optimized, and used to demonstrate the feasibility of medical supply delivery to remote areas via UAV (unmanned aerial vehicle). It focuses on the design of a biocompatible payload and a modified drone to accomplish medical supply delivery to remote areas. The design of the payload and UAV arm mechanism must consider the safety of medical supplies, medical equipment and blood biocompatibility throughout the duration of the delivery. Multiple drone and payload design iterations were created to address the lack of medical attention in remote areas. Various designs were implemented in a prototype to create a demonstration of concept feasibility. Each design has its own parameters and components that collectively make up the payload and drone delivery system. This research paper describes, analyzes and reports experimental results of the final drone delivery and payload design.

1.1 MEDICAL DRONE

The tremendous growth in the number of digital cellular subscribers is making service providers increasingly uncertain with the limited capacities of their existing networks. This demand has brought in the deployment of Smart antenna systems throughout major metropolitan cellular networks. These Smart antenna systems have typically active multi beam technologies and provide considerable performance improvements in FDMA, TDMA and CDMA networks. This paper mainly concentrates on use of Smart antennas in mobile communications that enhances the capabilities of the mobile and cellular system such as faster bit rate, multi-use interference, space division multiplexing), increase in range, multipath, mitigation and reduction of errors due to multipath fading. The best application of Smart antenna is its suitability for demand based frequency allocation as flexible antenna pattern are obtained electronically and no mechanical movement of receiving antennas is necessary. The advantage of Smart antennas application in the mobile systems are decreased inter symbol interference, decreased co-channel interference and the adjacent channel interference, better bit error rate due to decreased amount of multipath, reduction in power consumption and RF pollution. Smart antennas are most efficient for use in cognitive radio and the greatest advantage of smart antenna is its high security. The main hindrance to high-performance wireless communications is the intervention from other users, the inter-symbol interference (ISI) and signal fading caused by multipath.

2. LITERATURE REVIEW

Drones, in this paper, are referred to as any small unmanned aerial vehicle that is remotely or automatically controlled. There are many types of drones, but the two main designs consist of rotary-wing drones or fixed wing drones, both of which have advantages and disadvantages. Drones are very small and land and take off with very little need for clearance. Overall, current drone technologies can be understood by examining UAV classification, definition and applications in various fields. This includes the analysis of each respective operating system, various sensors and routing systems. According to the National Defense University's Library, a drone is any "land, sea, or air vehicle that is remotely or automatically controlled". Drones have various purposes and are currently used by the United States Government in the private sector for purposes including "investigation of agricultural crops, observation of weather, relay broadcasting and communication, investigation of the extent of damage during disasters, recognition of traffic flow, and unmanned security". There is a wide range of potential drone applications that may be optimized through a better understanding of the use of UAVs. Therefore, the engineering principles involving drones must be reviewed.

A dimensional analysis is necessary in this project to obtain meaningful results from a cost efficient prototype. According to Ain Sonin, former mechanical engineering professor at MIT, "at the heart of dimensional analysis is the concept of similarity". For a prototype to yield any useful results, a dimensional analysis must be performed to define any relationships between physical properties with respect to certain variable conditions. These similarities must be found through mathematical transformations of the certain variables. Variables pertaining to the aerodynamics of a drone may include lift (L), air velocity (V), density (p), wing surface (S), speed of sound (a), and viscosity (u). All units must be broken down into simplified units. A Newton can be broken down into a kilogram-meter per second squared. For mass, length and time, the dimensional analysis must use the most basic units of M, L and T respectively. Using these simplified components, we can apply the Buckingham Pi-Theorem. The Buckingham Pi-Theorem rewrites an original equation, which relates important variables, in terms of a set of dimensionless parameters. Using the Buckingham Pi-Theorem we use the known relationships between variables to determine relationships between additional dimensions that would otherwise be unknown.

3. DESIGN OF THE DRONE

This project utilized a vast range of hardware components and software platforms that were integrated into the overall design of the medical drone. It is not in the scope of the project, nor in this paper, to delve into the details and logistics of the electrical and computer engineering relationships involved in the overall design.

There is an abundance of existing software platforms (Paparazzi, APM, MultiWii Copter, KK, Dji naza, pixhawk) and hardware components used for drone prototyping. The most common hardware components involved in prototyping include GPS and compass, flight control unit, data transmission module, data receiving module, remote controller, electronic speed control, motor(s), battery, motor powerhub, servo(s), voltage sensor, current sensor, remote controller, camera, video transmission module, on screen display, powerboard, battery, and a voltage converter. Using these components, the UAV's body design was developed to allow for an appropriate implementation of each component while carefully considering the weight, the balance, and the drone's overall center of mass. The most important electrical component used for drone prototyping is called a flight controller, or flight control unit. The flight controller is essentially the brains of the UAV. This component is what allows the drone to maintain balance, and it does this by gathering data through sensors and computing the necessary changes for the motors. The flight control unit dynamically controls each motor to keep the drone from becoming unbalanced based on the sensory information it is processing. The fight control unit must be configured to the number of motors being used. If the drone is a quadcopter, the flight control unit must be configured to control four motor units, thus controlling four degrees of freedom, yaw, roll, pitch and lift or altitude. There are various types of flight controllers on the market so it is important to determine which flight control unit will fit the needs of a particular project or UAV design. When considering flight control units for UAV implementation it is important to consider its capabilities. Capabilities that are important include gyro stabilization, mobile self-leveling, care free capabilities, hovering capabilities (altitude and planar position hold), and return home and waypoint navigation. These features should be considered so that the needs of the UAV can be met to satisfy the UAV's purpose. Additionally, the price of the flight control unit is worth considering, especially depending on the particular budget for the creation of the UAV. Moreover, the flight control unit is the most important component integrated on the body of the drone.

3.1 Design Specifications

Flight Controller: ArdupilotMega (APM) is an open source flight controller. We use it to maintain the balance of the UAV by PID algorithm.

Camera and Video Transmission Module (VTM): Camera can capture image data and VTM can send the image data to the user, providing the user with information around the UAV.

Data Transmission Module (DTM): Use the DTM for UAV and terminal connection. The terminal includes smart phones and computers. Can send commands from mobile phones or computers to control the UAV.

Electronic Speed Controller (ESC): ESC uses the information and signals gathered by the sensors of the flight controller to control the current provided to the motors.

Global Positioning System (GPS): GPS module can receive signals from the GPS satellite to find the position of the UAV during flight navigation.

Motor: Motor converts electrical energy into mechanical energy to rotate the propellers which provide the aircraft with lift.

Motor Power Hub: The power from the battery is divided into four parts for the motors and is made by PCB (printed circuit board) board.

On-Screen Display: Displays the current flight information to the user. Provide information about the performance of the UAV as well as video.

Power Hub: This module converts the battery voltage (22.4V in our case) to the standard voltage (5V) and controls part of the power supply.

Remote Control: Converts the physical change of the joysticks and buttons on the remote control to information that is converted to electrical signals and sent to the wireless signal receiver.

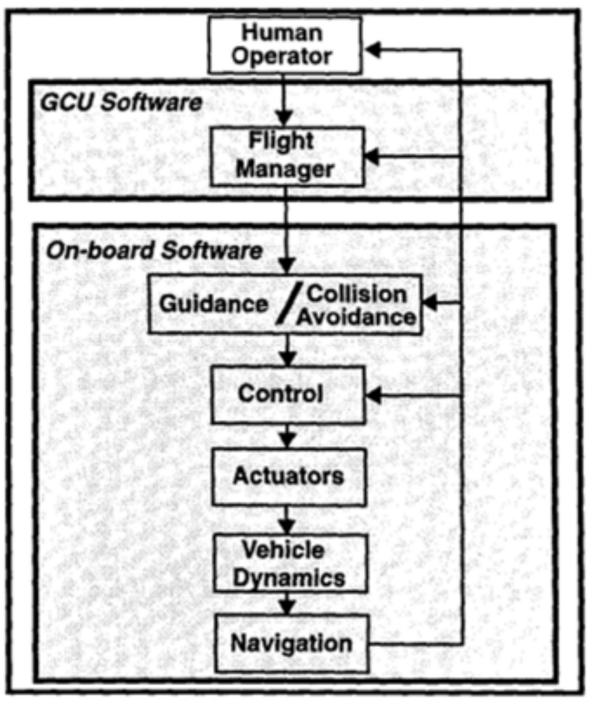
Receiver: Converts the wireless signal from the remote-control and sends information to the flight control unit.

Servo: Provides control of a desired operation through the use of feedback. It can be rotated to the angle needed for control of the UAV arm.

4. CONTROL ENGINEERING

Hierarchical control structures for unmanned aerial vehicles are frequently used for operation of Autonomous drones. Lateral position (roll), longitudinal position (pitch), heading (yaw), and altitude (throttle) are the key drone components that can be utilized to adjust and control drone position [9]. Both the Draper Small Autonomous Aerial Vehicle (DSAAV) and BErkeley AeRobot (BEAR) utilize microcomputers and navigation sensors to develop a control system successful in controlling autonomous air vehicles [9, 10]. Analysis and comparison of the key system components for these successful drone projects will provide necessary information to base the development of a control system capable of the autonomous delivery of medical supplies.

The DSAAV control system's hierarchy has an inner-loop hover control system at the lowest level that acts as an autopilot. This system is commanded by a waypoint guidance system that can be changed/controlled by a grounded flight manager. Each level of this hierarchy, illustrated in Figure 2, is reliant upon a navigation filter. To achieve this autonomous control, on-board hardware must remain as minimal as possible to maintain hovering capabilities and maneuverability. Table



DSAAV CONTROL ARCHITECTURE

The navigation filter requires a continuous-discrete extended Kalman filter to merge data from the GPS system, sonal altimeter, and digital compass. Local drone position (north-east-down frame), velocities (taken at CG and aligned forward, starboard, and down), altitude, and the magnitude of gravity are the required filter inputs. A state vector using the inertial measurements of angular velocity and inertial acceleration are also propagated in the filter. Since this is a rigid body equation of motion, each time the sensor data is updated the state vector and Kalman filter equations are updated.

At the lowest level, position, heading, and velocity are controlled based upon the navigation system and can be divided into four PID control loops of roll, pitch, yaw, and throttle. The next level of control for these commands is in the outer-loop guidance which is dependent upon the current guidance mode of the drone. The nine guidance modes used in DSAAV are:

1. Ground mode: executed when drone is on the ground, guidance algorithm commands in a low throttle setting.
2. Run-up mode: throttle is ramped up to takeoff level but no lift is produced.
3. Take-off mode: run-up throttle commands continue and pitch or main rotors in increased to create lift.
4. Waypoint hover mode: drone is specified a location, altitude, and hover time and guided through the most direct trajectory.
5. Waypoint through mode: drone passes through specified waypoint (no hovering occurs).
6. Track hover mode: same as mode 4 with the additional command to follow a straight ground track.
7. Track through mode: same as mode 5 with the additional command to follow a straight ground track.
8. Waypoint land mode: composed of several sub-modes that guide the drone to a safe landing.
9. Pilot assist mode: operator controls movement with a joystick.

To prevent a faulty landing, when in land mode the drone is prompted to hover when at an altitude of 3 feet. From there it descends at a rate of 0.5 feet per second until it is 1.5 feet from the ground, at this point it prepares for the final stage of landing where the commands are decreased so that position and velocity errors are not corrected. If the control loops continued eliminating these errors the chance of a false landing increases. Additional system performance algorithms to prevent collisions are in place during drone use. A collision avoidance system, which overrides the guidance loop, is always running when the drone is operating to move the drone away from any objects posing as a potential threat. The final control algorithm in place for DSAAV is a flight manager software that controls communication between the DSAAV, operator, and sends guidance commands to the drone. Commands such as reading operator inputs, starting a mission, and telling the drone to return home are all functions of the flight manager. So, overall this last algorithm oversees the drone and guides it to the final destination by following five steps:

1. Checking that the drone is prepared for the next guidance mode
2. Determining the next waypoint of interest
3. Transitions drone through run-up and takeoff
4. Notifies the drone of the next mode
5. Switches into the new guidance mode

4.1 Mathematical Relations

Lift:

$$L = C_L \text{ x } \left(\frac{1}{2} pV^2\right) \text{x } S$$

where, $\quad S = wing\ area$

Drag:

$$D = Cd\ \frac{r\ V^2}{2}\ A$$

where, $\quad Drag = coefficient \text{ x } density \text{ x } \frac{velocity\ squared}{2} \text{ x } reference\ area$

Vertical Ascent:

$$F_{net} = -W - D$$

$$a = -g - \frac{Cd\ \ A\ \ pV^2}{2}$$

$$V = V_t \frac{V_0 - V_t \tan\left(t\ \frac{g}{V_t}\right)}{V_t + V_0 \tan\left(t\ \frac{g}{V_t}\right)}$$

$$y = \frac{V_t^2}{2g} \ln\left(\frac{(V_0^2 + V_t^2)}{V^2 + V_t^2}\right)$$

Vertical Descent:

$$F_{net} = -W + D = 0$$

$$a = 0$$

$$V = V_t$$

Linear Acceleration:

$$a = \frac{v - v_0}{t}$$

Radial Acceleration:

$$a_r = \frac{v^2}{r}$$

Angular Acceleration:

$$\alpha = \frac{1}{r}\frac{dv}{dt}$$

5. EXISTING TECHNOLOGIES

Drone applications in the United States have the potential to shape the future of the economy, society and the daily lives of people. In today's society, there are many negative connotations that are associated with drones. When people think of drones they usually associate them with video surveillance or military warfare purposes. Drones are currently being used in the U.S. for surveying, inspecting, and imaging. Strict regulations and licensing requirements are enforced by U.S. federal agencies, which currently hinder the exploration of drone technologies. Some regulations include; drones under 55 pounds that are being flown for routine non-hobbyist use have to remain in visual line of sight of the pilot; operation is allowed under appropriate lighting during daylight hours only; maximum groundspeed of 100 mph; maximum altitude of 400 feet; and pilots must hold a "remote pilot airman certificate" issued by the FAA. However, the use of drones for commercial application has been an increasing topic of exploration for many companies. The top three companies that are exploring the use of commercial drone applications are Amazon Prime Air, DHL and Google

Express Business Delivery: The implementation of UAVs for the delivery of goods and services is being developed and tested for business. Packages, similar to that of a shoebox, can be transported for the rapid distribution of goods. The delivery UAV is programmed with the recipients GPS location for a precise and accurate delivery. In the last few years express delivery industry has gained the interest of companies, such as SF Express, to aid in developing and testing drone applications for this business

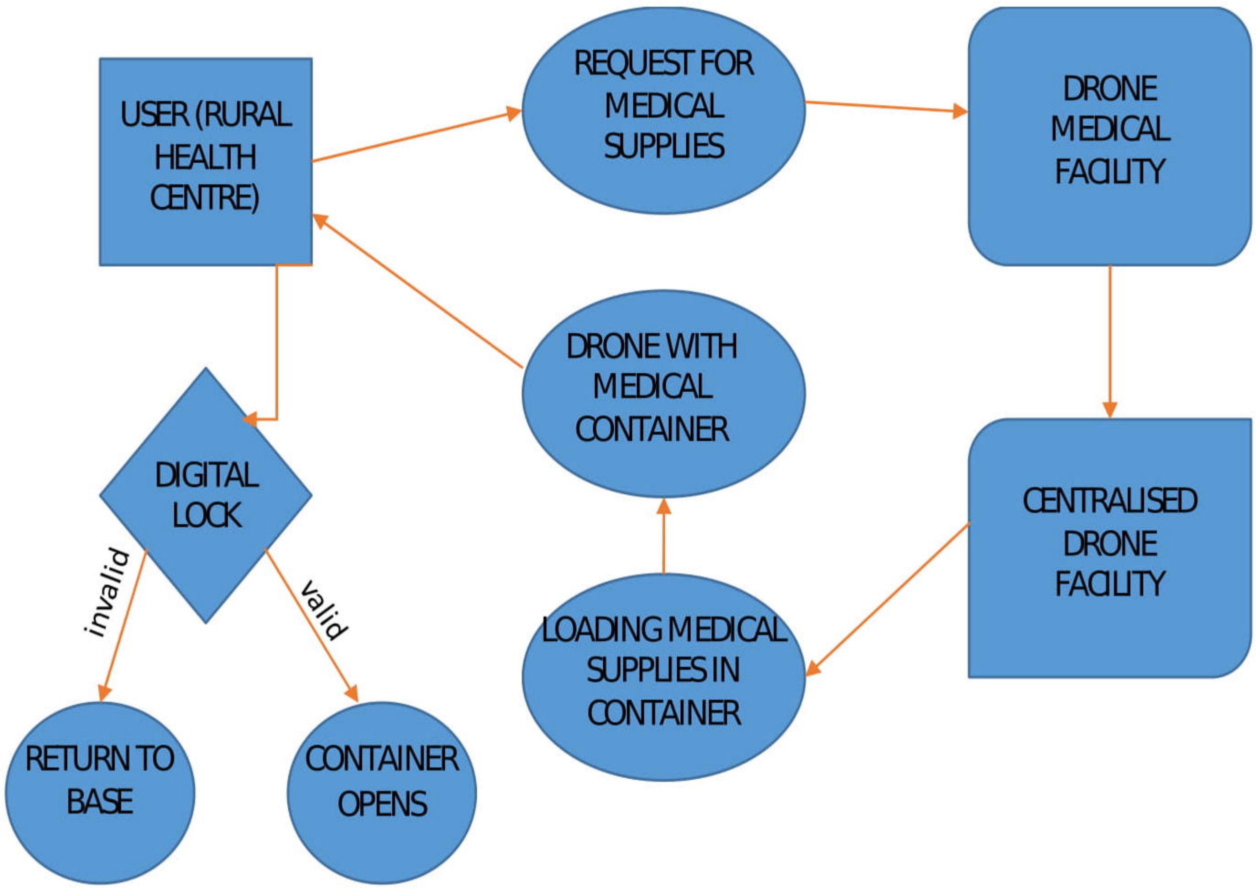
Electrical inspection: Drones equipped with high-definition digital video and still cameras can be used to autonomously target locations along the grid through the use of a GPS positioning system. Transmittance of real-time video allows for synchronization and enables the monitoring personnel to view and manipulate the UAV via computer based controller. Compared to the traditional way of performing power line patrol, UAVs can retrieve information electronically through an intelligent inspection procedure and improve work efficiency of the overall power line inspection process. In the case of natural disasters, UAV applications for electrical inspection can help avoid dangerous situations by eliminating the need to climb an electrical tower or survey an area.

Disaster relief: The use of a high-definition imaging apparatus equipped to a UAV for aerial photography of the affected areas to provide real-time images. UAVs act quickly, and take off to landing can take as little as only seven minutes while covering 100,000 square kilometers of aerial coverage. Time is of the essence when a disaster strikes and therefore it is a race against time for disaster relief work. In addition, unmanned aerial vehicles protect the safety of rescue teams by helping to avoid danger zones that involve the collapse of a building. Furthermore, the UAV realtime monitoring of the situation in the affected areas, and in all directions, will help to prevent secondary disasters triggered.

6. ETHICAL ISSUES/ENVIRONMENTAL ISSUES

There were many ethical considerations to take into account for this device. The design of the device is not necessarily invasive, life-threatening, or morally questionable, but there are a few ethical issues that must be considered. The most important objective for this device was that it has to be safe, and the team argued that this was even a constraint of the device. If the device is not safe, it is not a successful device. Therefore, if the device does not preserve the blood and medicine by preventing contamination, and physical or chemical damage, it is not a safe device. If the contaminated/damaged blood was accidentally transfused to a patient, it could have potentially harmful effects on the person. This device had to be safe enough to store the blood for up to 1-hour in the climate of India. Thus, the insulated payload was used to maintain internal payload temperature. Theoretically, a Styrofoam-like material is used to perform this function. Moreover, an important consideration for the prototype would be if the device failed while in use. To avoid this, the design should predict potential modes of failure for the device. Some types of failure may be generated form low battery, failure due to inadequate material strength and fatigue, loss of Bluetooth connection, or any other electrical failure. An external temperature gauge could be added to the outside of the payload to indicate internal temperature. This function would help the user to protect themselves against potentially harmful blood even if the device failed in its foremost function of keeping the blood cool and safe. The team worked to prevent failure but if the device does fail during tests, precautions, such as implementing safety protocols, can be considered to ensure patient's wellbeing. Furthermore, the addition of safety protocols helps the team avoid any potential ethical conflicts in respect to the device.

7. USECASE DIAGRAM



8. FUTURE SCOPE

Other improvements and future work include improving the mechanical and biomedical designs implemented in the current UAV. Additionally, the future team should consider a fixedwing design to increase the distance that can be traveled. Furthermore, adding a GPRS to use instead of using a Bluetooth module will enable long distances to be traveled. The material of the drone arm should also be improved upon since the material used was PLA to allow for the 3D printing and rapid prototyping of the design. The arm might also be improved if carbon fiber or a light weight, durable metal alloy is used.

Moreover, the next group should consider changing the flight control unit from APM to PixHawk. Pixhawk will improve data transmission by increasing the speed of transmission and it is also functionally more compatible with a fixed-wing drone design. Moreover, the team should also consider using a flight control unit that is closed source rather than open source because the respective company will offer tech support and the unit will be overall more stable and less sensitive than an open source unit. The future group should improve upon the battery life of the UAV to allow for further distances to be traveled. The team should also consider designing a payload that is specific for organ delivery, rather than general medical supplies. Dimensional analysis for multiple component sizes. The team should also keep in mind when designing the drone that the efficiency increases when the motor to motor distance increase, therefore, if a rotocopter is used then explore various motor to motor distances.

9. CONCULSION

In summary, there are many different medical needs across the remote areas, therefore, to adequately address the various needs there must be a medical drone network implemented to provide various supplies to people in remote areas. These supplies include blood, medicine, and portable medical equipment. Implementing a medical delivery system via UAVs would be helpful to an enormous magnitude of people.

In conclusion, this project provided insight on the feasibility of the goals set out to be accomplished. The team successfully designed and built a drone with an arm attachment to enable the transportation of medical supplies. Thus, the design and testing of the semi-automatic UAV successfully demonstrated the concept feasibility of implementing medical supply delivery drones in the healthcare system.

The usage of Drone in transport of medical supplies to the rural area hospital has many advantages over the present problems faced by the regular procedure of transport of medical supplies to the hospitals. It is way faster and efficient than the regular method. It is safe and secured as it provided with the digital lock system. **Upgrading the components used in the drone improves the efficiency and working of the Drone**.

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