'STUDY OF MODELLING AND TESTING OF FIRE-FIGHTING DRONE USING HOSE PIPE': A REVIEW.

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Abstract: Drones are the topic of interest for engineering professionals since many recent years. Application of unmanned air vehicle (UAV) for fire-fighting is also in focus now. In this paper we are reviewing various research papers regarding modelling and testing of fire-fighting drone. Modelling will consist of frame fabrication, selection of standard electronic components, assembly, implementation of controlling algorithms, preparation and installation of extinguishing system on drone, etc. and after that testing will be carried out. Challenge in this project is optimum balancing of the drone while operating it and discharging water at a required pressure and discharge. The prime aim is to develop a fire-fighting drone which is user friendly and can be faithfully added in fire-safety aides.

Keyword **- Drone, UAV, Fire-fighting, Construction, Simulation, Frame Design, Control.**

INTRODUCTION

Fires that occur in residential and non-residential buildings as well as fires in wild lands cause plenty of health issues; including death to humans and animals, in addition to great economic losses in structure, equipment and vegetation. Furthermore, the first response teams, such as fire-fighters, are exposing their lives to great risks in order to extinguish a fire. To overcome these issues, we decided to modify drone and use it for fire extinguishing purpose.

Drone stands for Dynamic Remotely Operated Navigation Equipment. An unmanned aerial vehicle is an aircraft without a human pilot on board. Its flight can be controlled autonomously by microcontrollers in the vehicle and remote control under the direct command of human. So, various research papers have been studied to gain a proper knowledge about the components and their specification.

LITERATURE REVIEW

[1] K.M. Zemalache and H Maaref "**Controlling a Drone- Comparison between a Based Model Method and Fuzzy Interface System"** vol.9, August 2008, pp. no.553-562, have stated in their research paper about the comparison between a based model method and a fuzzy interface system by using the X4 Stationary Flyer (XFS). The work describes an automatically on-line self-tunable fuzzy inference system (STFIS) of a new configuration of mini-flying called XSF (X4 Stationary Flyer) drone. A fuzzy controller based on on-line optimization of a zero order Takagi–Sugeno fuzzy inference system (FIS) by a back propagation-like algorithm is successfully applied. It is used to minimize a cost function that is made up of a quadratic error term and a weight decay term that prevents an excessive growth of parameters. The work is done on stabilizing and tracking control problem which was been solve by optimization technique allowing an online adjustment of the fuzzy controller parameter. The descent algorithm and capacity to adopt any unknown situation using fuzzy system made drone flying economical and safe. Simulation results and a comparison with a static feedback linearization controller (SFL), studied the robustness of the two controllers used in the presence of disturbances, are presented and discussed.

[2] Bernard Tat Meng Leong, Sew Ming Low, Melanie Po-Leen Ooi, **"Low-cost Microcontroller Hover Control Design of a Quadcopter"**, ISRIS July 2012, Engineering Procedia 41, pp. no.458-464, has shown a low-cost hover control mechanism which would be implemented in low cost microcontroller of a drone. The purpose of the paper was to control and stable the drone. A microcontroller board "Arduino duemilanove" would be installed in drone without affecting the existing operation. PID control algorithm was used in this because its performance is good and tuning is easy. The hover control system consists of three subsystems: quadcopter, sensor and microcontroller all the three subsystems would get integrated and used as a control mechanism of drone. The results shown that, the drone has stable hover with an error of 2cm more or less for a total flight time of 5 minutes.

[3] Dmitri Aleksandrov, **"Light Weight Multicopter Structural Design for Energy Saving"**, Thesis on Mechanical Engineering, August 2013, pp.no. 1-91, has reported Light-Weight Multicopter Structural Design for Energy Saving. He stated that optimal distance

between the rotors must be determined to reduce the consumption of energy by the motors and to maximize the lifting force created by the rotors, i.e. in this case mutual effect of air flows is minimal. He also mentioned that, since a rotor is working on the principle of a wing, they have similar problems in the tip of blades. Vortexes that are created near the rotor ends lead to pressure adjustment between the upper and the lower rotor surfaces. It was found that by increasing the spacing between the two coaxial rotors, the thrust coefficient of 19 the top rotor increases, but the total thrust coefficient is slightly reduced because the decrease of the bottom rotor thrust coefficient is larger than the increase of the top rotor thrust coefficient. It was found that rotors with a rim around are usually called shrouded rotors or ducted fans. These added safety benefits greatly accelerate the design and test flight process by allowing testing to take place indoors or out, by inexperienced pilots, and with a short turnaround time for recovery from incidents. Those shrouds around rotors can be also used to change properties of air flow around and near the rotor

[4] Anudeep M, G Diwakar, Ravi Katukam, **"Design of a Quadcopter and Fabrication"**, IJIET, vol.4, issue.1, August 2014, pp. no.59-65, concluded that in the design of the "Quadcopter" the regular design of the quadcopter is modified and the static analysis is done on the frame to sustain the loads generated in these vehicles and concluded that small deformation occurred on the centre plates are safe and within the limit. Simulation results suggested base frame used is X type, which gives better stability, strength, and easy to control. The material used for the frame is carbon fibre or aluminium. The motor used is a brushless motor for high rpm and low heat dissipation. The propellers selected are standard propeller 8045. The maximum stress obtained in the all the parts are below the ultimate strength we conclude that the frame is statically sustained and also It was found that very low loads are obtained in the top plate. By that by changing the shape of the base plate the performance of the Quad copter cannot be that there is a reduction 50% in the weight of the base plate so that the power consumption is reduced.

[5] Diego Domingos, Guilherme Camargo, Fernando Gomide, **"Automation Fuzzy Control and Navigation of Quadcopters"**, IFAC, vol.49, issue.5, July 2016, pp. no.79-78, concluded that SPARC (self-evolving parameter-free rule-based controller) fuzzy control outperforms classic fussy control system. The self-evolving parameters include stabilization of pitch, altitude, yaw, and roll. It also involves SAM (signal aggregation module) which uses data clouds of each parameter having error from fuzzy controller. The SPARC fuzzy control adapts to the change in environmental conditions to maintain stability of drone. Simulation results showed that SPARC fuzzy control achieves superior performance especially in stabilisation and navigation under unpredictable environmental disturbance simultaneously with parameter variations.

[6] Kyaw Myat Thu and A.I. Gavrilov, **"Design and Modelling of Quadcopter Control System using Adaptive Control"**, INTELS'16, October 2016, pp. no.528-535, have provided a systematic design and modelling process for the use of L1 adaptive feedback control in realistic flight control applications. They have selected L1 adaptive Control over other MRAC because it perfectly separates performance and robustness. Quadcopter dynamics includes mass of quadcopter, weight of quadcopter, roll, pitch and yaw angle. Their modelling process represents a step in the direction of more easily applying L1 adaptive control to real-world flight systems and taking advantage of its potential benefits. According to their research the controller includes a reference model and a lowpass filter C(s). Adding the low-pass filter C(s) does two important things. First, it limits the bandwidth of the control signal u being sent to the plant. Second, the portion of V that gets sent into the reference model is the high frequency portion.

[7] Tao Du, Adriana Schulz, Bo Zhu, Bernd Bickel, Wojciech Matusik, **"Computational Multicopter Design"**, 2016, pp. no.1-10, have stated various frames design and provided bunny examples to show expression of design tools. They proposed a new pipeline for users to efficiently design, optimize, and fabricate multicopters. Users can easily design a Multicopter by interactively assembling components in a user interface. They proposed a new optimization algorithm that can jointly optimize the geometry and controller to improve the performance of a given Multicopter design under different metrics, such as payload and battery usage, and can be further verified in a real-time simulator. The various types of Multicopter which the author mentioned in this paper are as follows:

Quadcopter- They designed a simple quadcopter with a 3D printed red body frame. The red frame is a parametric shape, so users can change its size by specifying different shape parameters in the interactive design tool. For simplicity the default quadcopter PID controller in ArduPilot is used here so Vicon is not needed, and no modification to ArduPilot firmware is required.

Hexacopter- They designed and fabricated a classic Y6 Hexacopter with three pairs of coaxial propellers. As in the previous example, the default Y6 PID controller in ArduPilot is applied and no additional hardware is needed. The hexacopter can change its heading, stabilize itself and fly to a target during the flight.

Bunny- A bunny copter is designed and fabricated by using our system. The bunny copter is challenging to fly as the four propellers have different sizes, their positions are not symmetric, and they are placed at different heights. Based on its dynamics we compute an LQR controller to control its position in the air. The bunny copter can take off, hover, and fly to a target and land.

[8] Yuvraj Akhade, Akash Kasar, Anuja Honrao, Nehal Girme, **"Fire Fighting Drone Using CO_2 Ball Extinguisher"**, IJIRCCE, vol.5, issue.2, February 2017, pp. no.2185-2187, concluded that a thermostat detector is used for detection of fire which is also referred to as the associate degree optical detector. Also, a three-flame sensor is connected to a processor which can detect fire. His work aims to

control and supply a solution for firefighting using a fire extinguisher and any such mechanism fitted on a Drone. It can be operated and controlled by the remote user and has the flexibility to extinguish the flame. It is designed to be controlled with a monitoring system and component communicates in wireless mode. To obtain stable flight, gather and store GPS data and auto commands like auto-landing, the existing Quadcopter can be modified. It will save human lives as well as animal we rely on human beings to enter burning buildings and extinguish fires. With help of such Drones, firemen work will be easier and effective regardless of security. It will make human lives easier and make maximum use of time available in emergency case. The drone that will start the process from the take-off after that it will move to all surrounding area and split water over it.

[9] Luis Merino, Fernando Caballero, J. Ramiro Martínez-de-Dios and I. Maza, **"Automatic Fire Monitoring and Measurement Using Unmanned Aerial Vehicles"**, 6th International Conference on Forest Fire Research, 2010, pp. no.1-15, concluded that it is feasible to develop UAVs for forest fire perception. They experimented that UAVs can be very helpful for fire-fighting activities like fire monitoring, as they can cover the gap between the spatial scales given by systems based on satellites and those based on cameras on towers. For the case of fire monitoring, employing several UAVs allows obtaining different and complementary views. Moreover, small UAVs could be employed by fire brigades to, at least, obtain local views of areas difficult to be accessed. It is stated that among the most important parameters for fire-fighting management are: the shape and position of the fire front, its rate of spread (how this front evolves with time) and the maximum height of the flames.

CONCLUSION

Thus, in this review we get to know about basic construction and working principal of a drone. Above studied research papers have focused on various factors like construction, performance, control, etc. of a multirotor. The data collected and studied from above papers is very useful while fabricating actual multirotor model and its testing. Selection of frame type, controlling elements and other important electronic components is the first step of drone building. Fire-fighting drones need more stability than any other application drones. We are going to use a hose pipe which will supply water from ground level, this kind of applications need extra stability in air while hovering. Considering extra stability, we decided to make hexacopter. Motor and propeller pair gives us the desired thrust, thus its necessary to check various pairs of motor and propellers considering required thrust and frame size. Required thrust can be calculated by using concepts of fluid mechanics. Static and dynamic weight of water column carried by hose pipe will play crucial role. For more stability flight controller must use various sensors like GPS sensor, gyroscope sensor, magnetometer sensor, barometer sensor, etc. Flight controller must be using advanced systems like fuzzy control or PID control. Big range of transmitter-receiver is available in market, we can use any of them which suits the application (no. of channels required). Flight time is also a major concern in case of fire-fighting drones. Flight time can be increased by either reducing weight of whole assembly or increasing battery capacity. But the increase in battery capacity increases the overall weight of assembly. Hence an intermediate battery capacity must be assigned which can give sufficient flight time with minimum weight.

According to related literature review, we will collect required data and will design and modified fire-fighting drone. The approach will be synthesis, design, development & testing of the machine. The various parameters such as design of frame, components specification, stability will be considered while making the fire-fighting drone.

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REFERENCES

[1] K.M. ZEMALACHE AND H. MAAREF, "CONTROLLING A DRONE COMPARISON BETWEEN A BASED MODEL METHOD AND FUZZY INTERFACE SYSTEM", APPLIED SOFT COMPUTING, ELSEVIER, VOL.9, AUGUST 2008, PP. NO.553-562.

[2] BERNARD TAT MENG LEONG, SEW MING LOW, MELANIE PO-LEEN OOI, "LOW-COST MICROCONTROLLER HOVER CONTROL DESIGN OF A QUADCOPTER", ISRIS JULY 2012, ENGINEERING PROCEDIA 41, PP. NO.458-464.

[3] DMITRI ALEKSANDROV, "LIGHT WEIGHT MULTICOPTER STRUCTURAL DESIGN FOR ENERGY SAVING", THESIS ON MECHANICAL ENGINEERING, AUGUST 2013, PP.NO. 1-91.

[4] ANUDEEP M, G DIWAKAR, RAVI KATUKAM, "DESIGN OF A QUADCOPTER AND FABRICATION", IJIET, VOL.4, ISSUE.1, AUGUST 2014, PP. NO.59-65.

[5] DIEGO DOMINGOS, GUILHERME CAMARGO, FERNANDO GOMIDE, "AUTOMATION FUZZY CONTROL AND NAVIGATION OF QUADCOPTERS", IFAC, VOL.49, ISSUE.5, JULY 2016, PP. NO.79-78.

[6] KYAW MYAT THU AND A.I. GAVRILOV, "DESIGN AND MODELLING OF QUADCOPTER CONTROL SYSTEM USING ADAPTIVE CONTROL", INTELS'16, OCTOBER 2016, PP. NO.528-535.
[7] TAO DU, ADRIANA SCHULZ, BO ZHU, BERND BICKEL, WOJCIECH MATUSIK, "COMPUTATIONAL MULTICOPTER DESIGN", 2016, PP. NO.1-10.
[8] YUVRAJ AKHADE, AKASH KASAR, ANUJA HONRAO, NEHAL GIRME, "FIRE FIGHTING DRONE USING CO_2 BALL EXTINGUISHER", IJIRCCE, VOL.5, ISSUE.2, FEBRUARY 2017, PP. NO.2185-2187.
[9] LUIS MERINO, FERNANDO CABALLERO, J. RAMIRO MARTÍNEZ-DE-DIOS AND I. MAZA, "AUTOMATIC FIRE MONITORING AND MEASUREMENT USING UNMANNED AERIAL VEHICLES", 6TH INTERNATIONAL CONFERENCE ON FOREST FIRE RESEARCH, 2010, PP. NO.1-15.