Design and Manufacturing of a Smart Drone

DESIGN AND MANUFACTURING OF A SMART DRONE

A very great focus of many researchers and companies nowadays is the study of drones and smart drones. Smart drones have proven to be useful in many situations as they can carry out a myriad of tasks such as search and rescue, surveillance, mapping of unknown environments, and so on. This project intends to design a small smart drone to meet specific mission objectives. After the mission is chosen, a research will be carried out to come out with the best design and material for fabrication. The design will be made using CAD (CATIA) and will be tested using a CFD tool such as ANSYS. The design may then be iterated to optimize it for best aerodynamic performance before going into fabrication stage. The drone will be fabricated and then tested using stress testing and wind tunnel tests and the results will be compared to the results obtained from CFD analysis.

Introduction

An introduction serves to introduce the topic and give an insight about why it was chosen and its significance. In this project, the introduction will help in giving a broad and general idea about drones and what are the types of them. Also it will give an idea about the purposes for which drones are used.

a. Introduction about drones and their types, advantages and uses
b. Missions and how drone categorizes into them

Literature Search

The literature review is the first thing to carry out in any research. It is used to give an insight about previous work in the same topic. This allows the development of ideas and build on ideas already implemented. For the purposes of our research, a literature search will be carried on the following topics to find the most recent work on them and allow for innovation:

a. Multi-rotor drones
b. Method of Propulsion mentioning how each work
c. Types of aerodynamic and structural loads on a smart drone during various stages of flight (take-off, cruising, and landing)
d. Materials of which drones are fabricated and the advantages and the disadvantages of each, ending up with our chosen design to meet our requirements.

Mission and propulsion method

The main aim of this section is to search and describe the methods commonly used for propulsion of different kinds of drones. The advantages and disadvantages will be mentioned and a comparison is made to end up with a decision on which propulsion method will be used for the drone in the project.

a. Detailed description of mission
b. Choose the method of propulsion compatible with the chosen mission

Design and Analysis

After the mission is chosen and the type of drone is chosen, a design is to be created using CAD and then analyzed using a CFD tool to check its performance before fabrication. This step is vital as it saves a lot of time in fabrication and helps in anticipating the setbacks of the design and iterating the design to meet the optimal performance required. It also makes testing (simulation) different designs manageable and require much less effort. If this step is skipped, huge costs will be spent on iterating the design in hardware and testing it. The design and analysis will take at least two iterations (may require more) to solve the problems in the first design. The steps will be as follows:

First iteration of CAD model

a. Choice of drone specs according to mission chosen
b. Design the Preliminary Model on CATIA
c. Analysis and Material definition:
    - CFD analysis using ANSYS after which modifications will be applied to the design based on the distribution of aerodynamic loads.
    - Structural Analysis on ANSYS. This will be helpful to determine the ability of the chosen material to withstand the loads on it and anticipate failures due to bending, torsion, or even fatigue.

Second iteration of CAD model

a. Design iteration number two:
    - Based on the results of aerodynamic and structural analysis, some parts of the design will be modified to distribute the load over the body and avoid load concentrations and structural failure and ensure best aerodynamic performance.
b. Analysis iteration number two:
    - After the modifications are made, the CAD model will be tested again with ANSYS to check the new load aerodynamically and how the structure acts under the given loads.

Control Algorithm

The control algorithm is required to make sure the drone (assuming it is functional) works to meet the predefined mission. A dynamic model is implemented and the response of the system is tested. Afterwards, a control algorithm is chosen and implemented on software before deploying it on a microcontroller to test it on hardware. The steps of will be as follows:

a. Creating a dynamic model of the system taking into account its dimensions and physical properties (mass, inertia, etc.) and testing the response
b. Writing the code to control the drone and testing it on simulations using Simulink/ROS
c. Debugging and code optimization for best performance
d. Analysis of amount of data required to be processed and choice of suitable controller and battery according to power estimation

Fabrication

After the CAD model is finalized and tested using CFD and the material is chosen. Also, the control algorithm is ready to be implemented. The fabrication will involve 3D printing of small modules, and fabrication and assembly of the entire drone:

a. 3D printing to the designed CAD model
b. Fabrication of parts using the material chosen to build the frame
c. Adding all the electrical components including the motors, connections, batteries, controller, and sensors

Testing

Testing is a vital step and serves to prove the analysis results from the CFD program. The testing stage will involve, just like the analysis stage, both aerodynamic and structural testing of the fabricated drone.

a. Set up the test platform for structural testing. This will include the set-up of the experiment as well as preparing the measuring techniques and having in mind (before testing) the expected results and all the plots to be made. Also, considerations such as risks and warnings will be obtained before beginning any tests.
b. Limitations such as the maximum load from the simulations will be considered and not reached to avoid failure of the model
c. Wind tunnel testing and how it is done and the output and how it is analyzed

Verification

The verification stage is made to verify the data obtained from the physical experiments and compare them to the results of the simulations. This will allow the detection of unexplainable errors which will mean a problem in either the physical set up or the analysis made previously. This may result in further tests. Also, other differences in results will be explained:

a. A comparison will be held between the analysis data from ANSYS and the data from real testing using wind tunnel
b. Differences will be investigated and explained
c. A comparison between analysis stress analysis data and experimental stress testing; this may lead to a further iteration of the design

References

Flabel, J. (1997). *Practical stress analysis for design engineers*. 1st ed. Hayden Lake, Idaho: Lake City Pub. Co.

Lennon, A. (1996). *Basics of R/C model aircraft design*. 1st ed. Wilton, CT: Air Age Inc.

Niu, M. (2002). *Airframe structural design*. 1st ed. Hong Kong: Conmilit press.

Norris, D. (2014). *Build your own quadcopter*. 1st ed. New York: McGraw-Hill Education.

The University of Adelaide, (n.d.). *Classification of Unmanned Aerial Vehicles*. [online] Available at: http://www.academia.edu/2055673/Classification_of_Unmanned_Aerial_Vehicles [Accessed 3 Dec. 2016].

Zagaĭnov, G. and Lozino-Lozinskiĭ, G. (1996). *Composite materials in aerospace design*. 1st ed. London: Chapman & Hall.

Time Plan

This was implemented on a gantt chart to allow visualization of how the project will go including tasks that will be carried out in parallel and which tasks depends on previous tasks. This allows the breakdown of the project into smaller parts to make it more systematic in approach. The project time plan was designed to finish the project ahead of the deadline to accommodate any setbacks in the way.

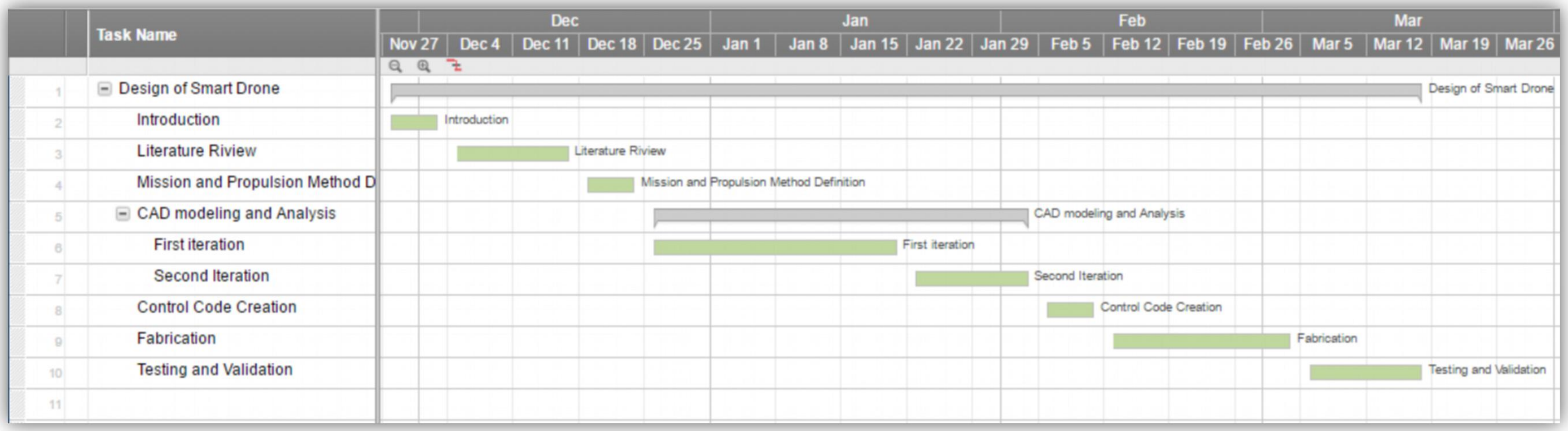

Figure 1: Gantt Chart created using (https://app.smartsheet.com/)

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