A generative design and 3-D printing approach for the fabrication of micro-drone for wind turbine inspection

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Introduction:

Unmanned Aerial Vehicles, popularly known as drones have found significant use in aerospace, strategic, and inspection purposes. The parameters that determine the success of a Quadcopter are its manufacturing cost and structural integrity. It is essential to reduce the weight of the drone frame so that it can have a longer flight time.
Generative design is an innovative approach to design that utilizes algorithms and computational power to generate and explore a vast number of design possibilities. It involves creating a design space and defining constraints, objectives, and parameters for a specific problem or project. The software then generates numerous design options and evaluates them based on predefined criteria, such as weight, strength, and manufacturability.
Commercial drones range from hundreds to thousands of dollars. We aim to reduce the cost of manufacturing by 3-D printing by limiting our expenses to only the necessary electronic components

Objectives:

1. The main aim of this project is to design and fabricate a low-cost 3-D printed micro drone for wind turbine inspection. The novelty of this project lies in the drone frame. With the help of Generative Design as an optimization tool, we focus on fabricating a cost-effective, lightweight, and aerodynamically efficient quadcopter.
2. The frame will be printed using **PLA, ABS, and PETG** and tested for crashworthiness, and structural integrity. Crashworthiness will be tested using **drop tests** from different heights, as for the structural integrity a structural analysis is performed to check if the frame can sustain the thrust from the propellers and carry the electronics. **The modal analysis** will be done to determine the natural frequencies, an **impact hammer** will be used to verify the natural frequency of the frame with the modal analysis. An **Accelerometer** sensor is used to check the vibrations of the motor to see if it matches any of the natural frequencies of the frame so that necessary damping can be provided. The data from the accelerometer will be viewed using **Lab-view software**
3. The second objective was to 3-D print the propellers, but after printing the propellers it was determined to be structurally unstable. Therefore, the propellers will be purchased.

Methodology

The Project is divided into 4 stages:

1. **Literature Study:**
   - Understanding the theory and dynamics of drone
   - Study generative design and topology optimization in Additive Manufacturing applications. Identifying and understanding the electronic components required.
2. **Fabrication:**
   - Design the drone frame using the Generative method on Fusion 360
   - Analyze each possible outcome obtained from the generative design on ANSYS.
   - 3-D print of the structurally stable and least compliant outcome from the above-mentioned analysis using PLA, ABS, and PETG.
3. **Testing:**
   - The PLA, ABS, and PETG frames are tested on a vibration shaker machine, and an impact test is performed.
   - The frame is tested in a wind tunnel to determine and reduce the drag force produced.
4. **Electronics:**
   - Identifying all the electronic components and their procurement.
   - Generating the wiring diagram and assembling the electronic components.
   - Calibration of Components.

This work aims to build a unified body of a quadcopter frame structure with the help of additive manufacturing. The followings are the advantages and outcomes of the proposed project

1. Reduced assembly time.
2. There will be no joint failures as the entire frame is unified.
3. Enhanced structural integrity.
4. A drone that has increased flight time due to reduced weight
5. An aerodynamic structure to reduce the drag force.
6. Limited use of fasteners as the entire frame will be 3-D printed.

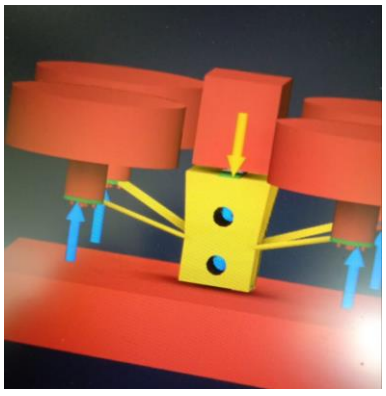


Figure 1 Constraints, Obstacle, Preserve Geometries.

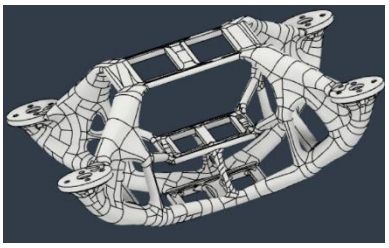


Figure 2: CAD outcome of Generative Design

Figure 2 Electronic Components purchased

Figure 4:-D printed frame using PLA

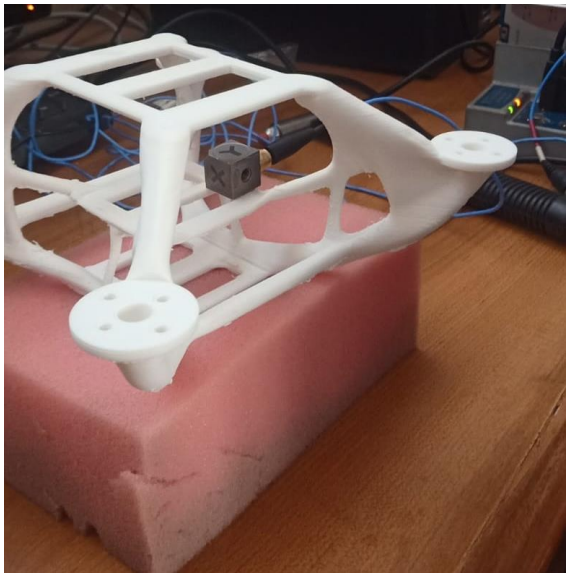
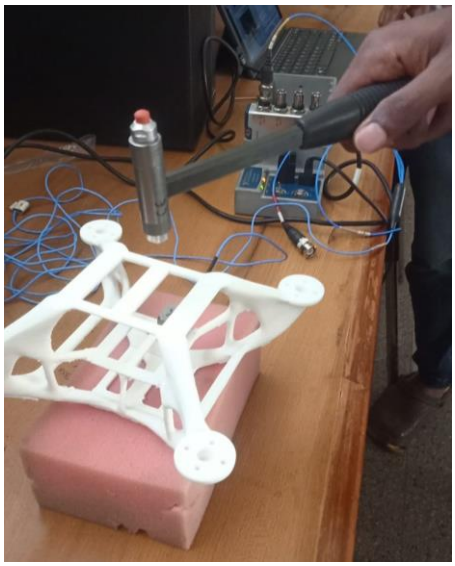


Figure 1 Impact testing to determine natural frequency



Results and Expected Outcome of the project:

This work aims to build a unified body of a quadcopter frame structure with the help of additive manufacturing. The followings are the advantages and outcomes of the proposed project

1. Reduced assembly time.
2. There will be no joint failures as the entire frame is unified.
3. Enhanced structural integrity.
4. A drone that has increased flight time due to reduced weight
5. An aerodynamic structure to reduce the drag force.
6. Limited use of fasteners as the entire frame will be 3-D printed.

Scope for future work:

In future research, the aim is to understand the optimization tool of generative design to have designs that are structurally stable having reduced mass and aesthetically appealing. Unique frames which have very limited use of fasteners, durable and increased flight time can be obtained.