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Conceptual Design of a Single Rotor Modular Unmanned Aerial Vehicle with Structural and Thermal Analysis for Water Health Monitoring

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Abstract:

Harmful Algal Blooms (HABs) in the Great Lakes, particularly in Lake Erie, pose significant threats to aquatic ecosystems, public health, and local economies. Monitoring and mitigating these blooms require innovative and efficient approaches. This project presents the conceptual and preliminary design of a Single Rotor Modular Unmanned Aerial Vehicle (SRUAV) developed to monitor water health and collect samples in affected areas. Utilizing commercial-off-the-shelf (COTS) components and 3D printing technology, the SRUAV achieves cost-effective manufacturing while maintaining high performance and reliability.

The SRUAV incorporates structural and thermal analyses to ensure durability and operational efficiency under diverse environmental conditions. Its modular design facilitates straightforward assembly, repair, and adaptability for various missions. With a weight of approximately 1.5 kg, the vehicle features a thrust-controlled propulsion system, 25 minutes of flight time, and the capability to hover close to the water surface for sampling. A key innovation includes a water collection mechanism integrated with a pulley system, allowing precise sample retrieval while maintaining flight stability.

This work details the engineering methodologies applied during the conceptual and preliminary design stages, including computational fluid dynamics (CFD) and finite element analysis (FEA) for aerodynamic and thermal optimization. Static simulations validate the structural integrity of critical components under operational loads. The SRUAV offers a scalable and sustainable solution for monitoring HABs, demonstrating the potential for broader environmental and resource management applications.