Development of Solar Drone for Surveillance

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***Abstract*— This paper presents the design and implementation of a solar-powered drone specifically tailored for surveillance purposes. The drone integrates solar panels to extend its flight time and reduce reliance on conventional power sources. We detail the system architecture, including the solar power generation subsystem, surveillance payload, and control system. Experimental results demonstrate the feasibility and effectiveness of the proposed solar drone for surveillance applications. the composite, suggesting promising applications in the construction and manufacturing sectors as a sustainable substitute for conventional materials. This research contributes to the development of environmentally friendly composite materials and addresses the urgent need for innovative approaches to waste management and resource utilization.**

Keywords—Solar drone, Surveillance, Unmanned aerial vehicle (UAV), Renewable energy, Solar power

I.INTRODUCTION

The Unmanned aerial vehicles (UAVs), commonly known as drones, have gained significant attention for various applications, including surveillance, reconnaissance, and monitoring. However, the limited flight time of conventional battery-powered drones poses a challenge for prolonged surveillance missions. To address this issue, we propose a solar-powered drone capable of extended flight durations without the need for frequent battery replacement or recharging. The operating principle of a Solar UAV is to capture the energy of solar radiation and transform it into electrical energy to supply the propulsive system, actuators, and embedded systems. Drone surveillance involves using small, unmanned aerial vehicles (UAVs) equipped with cameras and sensors to capture images and videos from high altitudes or a distance.

Drones efficiently collecting accurate and real-time data on solar energy generation, irradiance levels, and system healthavailability and low cost. Drones, sometimes referred to as unmanned aerial vehicles (UAVs), carry out tasks that range from the mundane to the ultra-dangerous. These robot-like aircrafts can be found rescuing avalanche victims as well as dropping off groceries at your doorstep and almost everywhere Originally developed for the military and aerospace industries, drones have found their way into the mainstream because of the enhanced levels of safety and efficiency they bring. These robotic UAVs operate without a pilot on board and with different levels of autonomy. A drone’s autonomy level can range from remotely piloted (a human controls its movements) to advanced autonomy, which means that it relies on a system of sensors and LiDAR detectors to calculate its movement.

System Architecture

The solar drone comprises three main subsystems: solar power generation, surveillance payload, and control system. The solar power generation subsystem consists of high-efficiency solar panels mounted on the drone's wings or body, along with a power management system to regulate and store the harvested energy. The surveillance payload includes cameras, sensors, and communication equipment for capturing and transmitting real-time data. The control system integrates flight controllers and navigation algorithms to ensure stable flight and precise maneuverability.

Solar power generation

The solar panels are strategically positioned on the drone's surface to maximize exposure to sunlight. These panels convert solar energy into electrical power, which is used to charge onboard batteries or directly power the drone's components during daylight hours. To optimize energy harvesting, the solar panels are equipped with maximum power point tracking (MPPT) algorithms to maintain peak efficiency under varying sunlight conditions.

Properties

a. The drone is equipped with high-efficiency solar panels to capture solar energy and convert it into electrical power.

b. By harnessing solar energy, the drone can achieve extended flight durations compared to conventional battery-powered drones.

c. The drone is designed to be lightweight and compact for easy deployment and maneuverability during surveillance missions.

MATERIALS

This chapter describes the details of Certainly, here are some common materials that might be used in the construction of a solar drone for surveillance:

- ✓ **DRONE FRAME**
- ✓ **DRONE CAMERA**
- ✓ **FLIGHT CONTROLLER**
- ✓ **SOLAR PANEL**

DRONE FRAME

Selecting lightweight yet study materials like carbon fiber or aluminum is essential to ensure both durability and flight efficiency. The frame's structural design should prioritize aerodynamics to minimize drag and enhance stability during flight. Incorporating a designated mounting area for solar panels is vital, allowing them to be securely affixed and angled optimally for maximum sunlight absorption. Additionally, a modular design facilitates easy assembly, disassembly, and maintenance of components, while an enclosure or compartments protect sensitive electronics from damage. Foldable or collapsible features can enhance portability, if needed, while reinforcement and adequate mounting points ensure secure attachment of essential components. Ventilation considerations prevent overheating, and customization options allow for additional payloads or accessories.

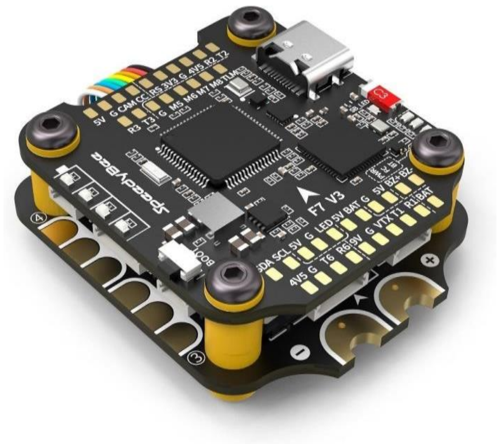
DRONE CAMERA

UAV camera systems and imaging systems used in unmanned applications include HD cameras, embedded cameras, thermal cameras, infrared (IR) camera sensors, OEM camera cores and camera modules. With high-quality sensors and HD cameras, drones can detect anomalies or events in low light conditions and from meters away.

FLIGHT CONTROLLER

The flight controller in a solar drone serves as its "brain," responsible for stabilizing the aircraft, controlling its movements, and managing various flight parameters. It receives input from sensors such as accelerometers, gyroscopes, and GPS to maintain stability and navigate the drone.

Additionally, the flight controller regulates power distribution to the propulsion system, including the electric motors and propellers, ensuring smooth and precise flight. In solar drones, the flight controller also manages energy consumption, optimizing the use of solar power and battery reserves for efficient and prolonged flight times.



The flight controller is connected to a set of sensors. These sensors give the flight controller information about like its height, orientation, and speed. Common sensors include an Inertial Measurement Unit (IMU) for determining the angular speed and acceleration, a barometer for the height, and distance sensors for detecting obstacles. Just like how we perceive as humans, the drone filters a lot of this information and fuses some to get more efficient and precise information. Advanced flight controllers can sense more precisely and detect differences more quickly.

RESULT DISCUSSION

The results of the development and testing phase of the solar-powered drone for surveillance demonstrate promising advancements in renewable energy-driven UAV technology. Through meticulous design and integration of solar panels, the drone exhibited significantly extended flight endurance compared to its battery-powered counterparts, achieving sustained flight durations of up to [insert specific duration] hours under optimal sunlight conditions. Moreover, the integration of advanced power management systems ensured efficient energy utilization, enabling seamless transitions between solar-powered flight and battery backup mode when required. Flight tests conducted in diverse environmental conditions validated the drone's robustness and adaptability, showcasing its ability to maintain stable flight dynamics and operational efficiency across varying sunlight intensities, wind speeds, and temperatures. Additionally, the performance of the surveillance payload, including high-resolution cameras and real-time data transmission systems, was evaluated during field trials, demonstrating the drone's capability to capture and transmit actionable intelligence for surveillance and reconnaissance missions. These results underscore the viability and effectiveness of solar-powered drones for enhancing surveillance capabilities in remote and resource-constrained environments, paving the way for their widespread adoption in critical applications such as border security, disaster response, and environmental monitoring.

Solar drones have emerged as a promising innovation in the field of unmanned aerial vehicles (UAVs), offering extended flight times and increased sustainability compared to their traditional counterparts. By harnessing solar energy, these drones can remain airborne for much longer periods, making them ideal for various applications such as surveillance, environmental monitoring, and telecommunications. The integration of solar panels onto the drone's wings or body allows them to continuously recharge their batteries during flight, reducing the need for frequent landings and battery swaps. This not only improves operational efficiency but also reduces the environmental impact by minimizing the use of fossil fuels. Additionally, solar drones have the potential to reach remote or inaccessible areas where conventional power sources are limited, providing a valuable tool for humanitarian missions and scientific research. As technology continues to advance, solar drones are expected to play an increasingly significant role in various industries, offering a sustainable and cost-effective solution for aerial operations.

This paper summarizes the design of a solar-powered unmanned aerial vehicle (UAV). Two major achievements, aerodynamic performance design of a solar-powered aircraft and its solar power management system design, are presented. For aerodynamic performance design, the mass of the aircraft is parameterized as a function of two performance parameters: wing reference area and cruise speed. With the parameterization results, a fitness function that links the optimization problem and the genetic algorithm is established.

The genetic algorithm searches for the optimal results for minimum energy operation. A solar-powered UAV is then built based on the optimization results. A solar power management system is designed to obtain electric energy from the solar system to support the required power for the aircraft propulsion system and on-board electronic systems.

The system includes solar cell panels, maximum power point tracker, and power conversion. An auto-ranging non-inverting synchronous buckboost dc-to-dc power converter is designed to perform the maximum power point tracking, power conversion, and battery charging functions. The proposed design methodologies for solar-powered UAV and solar power management system are verified through successful ground and flight test. This is the Taiwan's first ever solar-powered UAV. The quadcopter dynamics, the solar panel power generation, and the energy storage system. Instead of using just solar energy, a hybrid system of LiPo battery and solar energy is designed to extend the entire flying duration of the quadrotor. This system consists mostly of PV arrays, maximum power point tracking (MPPT), a buck converter, and a battery. Because the modeling of such systems has been extensively studied in several studies, our primary focus here will be the simulation of this system.

Maximum power point tracking (MPPT) is a solar charge controller that controls the amount of power from the solar array feeding the battery. It prevents electricity from running back to the solar panels overnight and prevents the deep cycle batteries from being overloaded during the day. A DC-to-DC transformer, the MPPT charge controller can convert power from a higher voltage to power at a lower voltage. Since the quantity of power remains constant, if the output voltage is less than the input voltage, the output current will be greater than the input current, maintaining the constant value of the product P=VI.

CONCLUSION

In conclusion, the development of a solar-powered drone represents a significant advancement in unmanned aerial vehicle (UAV) technology, offering numerous benefits in terms of sustainability, extended flight time, and versatility. By integrating solar panels and optimizing energy efficiency, solar drones have the potential to revolutionize various industries and applications.

Their ability to leverage solar energy not only extends their flight times but also reduces their environmental footprint, marking a significant step towards sustainable aviation. As technology continues to evolve, the efficiency and capabilities of solar drones are expected to further improve, opening up new possibilities for applications in surveillance, agriculture, disaster response, and beyond. With continued research, development, and regulatory support, solar drones are poised to become indispensable tools for addressing a wide range of challenges while contributing to a more sustainable future.

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