Drone Communication for the Purpose of Surveillance Using Sensors

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***Abstract*—Surveillance and monitoring are indispensable in some large areas for purposes such as home security, road patrols, livestock monitoring, wildfire mapping, and ubiquitous sensing. Computer-controlled micro unmanned aerial vehicles (UAVs) have the potential to perform such missions because they can move autonomously in a surveillance area without being constrained by ground obstacles. However, the duration of flights is a serious problem with UAVs. A typical UAV can fly only for about 10 min using currently available Li-Po batteries, which makes it difficult to conduct tasks like aerial surveillance that clearly require longer flying periods. In this study, we developed an automatic battery replacement mechanism that allows UAVs to fly continuously without manual battery replacement along with the suggestion of the scalable and robust usage for the system. We conducted an initial experiment using this system and successfully assessed the possibility of continuous surveillance in both indoor and outdoor environments.**

Keywords: Unmanned Aerial Vehicle, Lithium Peroxide Batteries.

I.INTRODUCTION

Surveillance and monitoring are indispensable in some large areas for purposes such as home security, road patrol, pipeline security, livestock monitoring, wildfire mapping, and ubiquitous sensing. The demands of these tasks may require a system to work indoors, over large areas outdoors or under poor ground conditions. Also, the system may be required to operate continuously for long durations.

An unmanned aerial vehicle (UAV) is an aircraft without a human pilot on board. UAVs are usually equipped with embedded inertial sensors such as gyroscopes, accelerometers, and sonar altitude sensors; thus, their flight can be controlled autonomously by computer. They can move freely through the air and circumvent poor ground conditions such as uneven roads and non-graded areas. When the Tohoku-Pacific Ocean Earthquake occurred, human-controlled UAVs were used to survey the damage at the Fukushima Dai-1 nuclear plant. In a recent study, UAVs were used to capture 3D reconstructed images of indoor and outdoor environments using mounted cameras.

UAVs have the potential to perform surveillance and monitoring missions autonomously without being constrained in three dimensions or by ground obstacles. The trend toward UAV technology use in aerial surveillance is rapidly increasing. For example, aerial surveillance is used widely for the detection of oil spills and it is considered to be the most effective method for this task. The presence of NASP surveillance aircraft also acts as a deterrent to the illegal discharge of pollutants into seas.

However, a serious problem with UAVs is their flight time, as they rely on Li-Po batteries for energy. Li-Po batteries are used by many autonomous aerial vehicles because they have a high energy density and they can sustain high current loads. However, the heavy weight of the battery translates directly into increased energy requirements of the UAV's motors, which limits the flight time available for surveillance and monitoring applications.Flyer that allows UAVs to fly continuously without being constrained by battery limitations.(Fig.1) Our contributions are as follows:

- We described the design of the battery exchange platform and suggested the scalable and robust usage of the system.
- We conducted initial experiments on this system in both indoor and outdoor environments to examine further challenges for transferring the system to real-world applications.
- We used the experiment results to describe case scenarios for this system and proposed suitable applications, particularly for surveillance and monitoring.
- Finally, we considered future work to take the best advantage of this system.

Fig1: Endless Flyer: automatic battery replacement platform enables UAV to fly continuously without requiring manual battery replacement.

A. Wired/Wireless Energy Supplies

1) Method: A UAV can be provided with a continuous energy supply via a tether, containing a power cord and a wide-band wire to transmit information back to the main station. [4] Wireless systems include DARPAs Vulture program, which is a giant solar plane that, theoretically, could fly for five years. Wireless power delivery systems based on laser beams have also been developed by Laser Motive. UAVs carry photovoltaic cells that are optimized to the laser wavelength, and they convert about half of the laser power to generate a few watts of electricity, which is sufficient to power the motors of a small helicopter. [5]

2) Discussion: In actual scenarios, however, a wired elec-tricity supply might produce obstacles in the flight path, and a UAV may not be able to reach a wireless power source.

Although many studies have explored wireless supply methods, such as electrodynamic induction, electrostatic induc-tion, or electromagnetic radiation, none are efficient enough, a great amount of loss occurs, and a massive and expensive device is often required

Although either system might allow a UAV to remain in the air continuously, permanent flying can also lead to heating problems in the motor or other onboard circuits, so the UAV may have to land on a platform to cool down.

B. Battery Recharge Platforms

1) Method: Using a ground platform to supply energy is another solution that allows UAVs to fly continuously. When the UAV detects that its battery is running out, it returns to the platform and recharges/exchanges its battery automatically. Several institutions have already developed prototype battery recharge platforms.

C.Discussion: With a recharging system, waiting for a battery to fully recharge is time-consuming compared to swap-ping the battery with a new battery. For aerial surveillance in particular, real-time information may be the most important factor. To meet this demand, a large number of platforms may be required, which could be spatially inappropriate and expensive.

III. ENDLESS FLYER

The Endless Flyer system comprises an automatic battery exchange platform, a position measurement system, and a UAV. When the UAV detects that its battery is running out, it comes back to the platform and the battery is changed auto-matically. After the battery is exchanged, the UAV flies away to conduct tasks.(Fig.3) Several studies have worked on battery exchange platforms.[8]Although we looked to some of them for reference, we make the following unique contributions:

- We described the design of the battery exchange platform. This description allows us to share the construction details in a way, that everybody with a laser-printer could quickly rebuild the platform.
- Initial experiments were performed for both indoor and outdoor usage. Little research has been done on outdoor experiments despite the fact that it is critical to assess the feasibility of transferring the system to real-world applications.

- We also suggested the scalable and robust usage of the system. the results of our study revealed that motion capture.

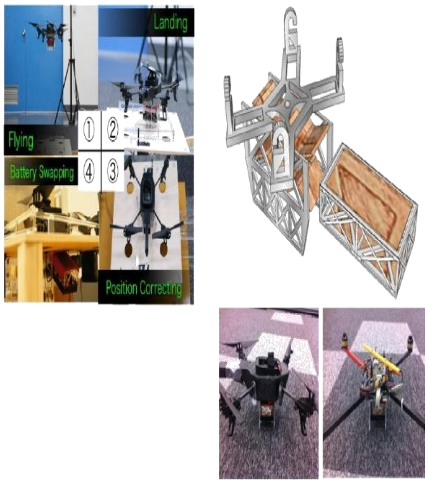

Fig. 3. Endless flyer platform : 1) UAV flies on platform. 2) UAV lands on platform 3): UAV is pushed to correct position for battery swapping. and 4) Battery exchange is conducted.

IV. DESIGN

A. Battery Exchange Mechanism

The battery exchange mechanism comprises a large landing pad, a battery connector/carriage, and a battery swapping mechanism. The size of the landing platform needs to be large enough for the UAV to land successfully on the landing pad. Even with precise position measurement systems such as motion capture that can provide position data with only slight errors, a UAV may be unable to land at the correct position owing to factors such as wind or loss of balance. To determine the sizeof the landing pad, we conducted an experiment to determine the landing error of the UAV. In the experiment, the UAV hovered at a specific point and tried to land directly under that point. Because of the above factors, the UAV landed to times, and the maximum error was 10 cm. Thus, we designed a 20 cm^2 landing pad, which we assumed to be sufficient for landing. While the landing pad can handle large errors.

VIII. CONCLUSION

This goal of this study was to pave the way for solving the limited flight time of UAVs. We developed an autonomous battery replacement platform and provided suggestions for the scalable and robust usage of the system. We conducted initial experiments on this system both indoors and outdoors because little research has been conducted outdoors with this type of system, where external disturbances may occur. In our system, the UAV could land on the platform with a 90% success rate, and once the UAV landed on the platform, the battery exchange had a success rate of 100%. We then addressed some modifications, including error detection that could increase the robustness of our system. We also detailed suggestions for using this system to perform aerial surveillance in real-world applications. Our system is a successful step toward finding a reliable solution to the UAV flight time limitations.

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