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Extending the Mission Duration of Agriculture UAVs through Wireless Power Transfer

Unmanned Aerial Vehicles (UAVs) have been a reliable tool for enabling remote interaction with our surroundings for a considerable time. Despite having attained wide-scale application in recent years, this technology continues to experience rapid growth across numerous sectors. Established firms such as PricewaterhouseCoopers predict that by 2030, UAVs will contribute up to $50 billion to the UK economy alone, as they expand their reach into both civilian and military domains [1]. Thankfully, it is not challenging to find connections between various aspects of current UAV research and **sustainable** technology domains. For instance, they offer energy efficiency by eliminating human overhead from transportation and can be deployed in Smart Cities for monitoring and other Internet of Things (IoT) applications. Additionally, they could serve as a foundation for sustainable management for establishing new settlements in extraterrestrial environments. One area that is witnessing a rapid increase in interest is the use of UAVs in agriculture.

Customized UAV systems that cater to the agricultural industry can perform various tasks such as conducting land and crop surveys [2], spraying, planting, growth assessment, and artificial pollination [3]. Moreover, using UAVs can significantly reduce the need for workers to handle hazardous materials, thereby minimizing their exposure [3]. While the use of UAVs in agriculture is on the rise, it still confronts several technical challenges, such as low flight times, communication distance, and battery efficiency [3]. To address some of these limitations, we are currently investigating an efficient way of wirelessly transmitting power and data between an aerial vehicle and a base station to prolong its task duration and transfer mission-critical data.

Wireless power transfer is increasingly gaining popularity across various applications. Qi charging is one such popular form of wireless inductive charging. However, this type of charging is only efficient when the source and load are in close proximity and coaxial [4]. This limitation hinders the widespread use of wireless charging systems for UAVs since numerous applications require higher power levels, longer charging distances, and are unable to attain perfect alignment of the source and load. Hence, there is a critical need for a solution that enables the transfer of high power levels over greater distances, even when coil misalignment occurs, with high efficiency.

In this study, we propose and implement a Strongly coupled magnetic resonance (SCMR) system that enables power distribution up to 0.145m with a power transfer efficiency of over 70%. SCMR is among the most promising forms of magnetic coupling that are presently under investigation and can deliver power transfer efficiencies [4]. Additionally, it enables medium-distance wireless power transfer, reaching as far as 2 meters away from the source [4]. Moreover, SCMR permits wireless charging with the benefits mentioned earlier regarding reduced physical degradation/exposure of components. Our setup follows a Concentric SCMR

(CSCMR) system where the resonant and source or load coils are coplanar. This design offers high-efficiency power transfer, even for greater separation distances and coil misalignment, while decreasing the usage of materials such as wires and connectors. The isolated SCMR system eliminates the necessity for direct exposure to live high voltage lines [5] and can also wirelessly transmit data through backscatter modulation [6].

Our proposed SCMR wireless power and data transfer system has the potential to revolutionize the use of UAVs in the agricultural industry. By providing high-efficiency power transfer over longer distances, even with coil misalignment, our system can significantly improve the reliability of UAVs. This can help overcome the challenges currently faced by UAVs in agriculture, such as limited flight times, communication distance, and battery efficiency. Furthermore, our system reduces the need for materials like connectors and wires, making it a **sustainable** solution.

References:

[1] PricewaterhouseCoopers. “Skies without Limits v2.0.” PwC, PricewaterhouserCoopers, 15 July 2022,

https://www.pwc.co.uk/issues/emerging-technologies/drones/the-impact-of-drones-on-the-uk-economy.html.

[2] L. Gipson, “A Civil Future for Unmanned Aircraft Systems,” *NASA*, May 09, 2016. https://www.nasa.gov/aeroresearch/programs/iasp/uas/civil-future-for-uas

[3] J. Kim, S. Kim, C. Ju, and H. I. Son, “Unmanned Aerial Vehicles in Agriculture: A Review of Perspective of Platform, Control, and Applications,” *IEEE Access*, vol. 7, pp. 105100–105115, 2019, doi: https://doi.org/10.1109/ACCESS.2019.2932119.

[4] K. André, A. Karalis, R. Moffatt, J. D. Joannopoulos, P. Fisher, and S.Marin, “Wireless power transfer via strongly coupled magnetic resonances,” *Science*, vol. 317, no. 5834, 2007.

[5]Y. Yan, W. Shi, and X. Zhang, “Design of UAV Wireless Power Transmission System based on coupling coil structure optimization,” *EURASIP Journal on Wireless Communications and Networking*, vol. 2020, no. 1, 2020.

[6] H. Hu, “Optimal and miniaturized strongly coupled magnetic resonant systems,” *FIU Electronic Theses and Dissertations*, Nov. 2016.