Drone-Based Aerial Thermal Imaging: Novel Failure Detection Algorithms for Power Line Maintenance Utilizing Fiber Optic Communication

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Power lines are critical components of modern infrastructure. Traditional methods of wireless drone-based maintenance are both expensive and vulnerable to electromagnetic interference emitted by high voltage. This project aims to test the viability of fiber optic tethered drones combined with aerial thermal imaging algorithms as a cost-effective and interference-immune alternative for identifying and assessing points of failure. An algorithm with dataset-driven emissivity compensation and dynamic distance correction estimated the maximum temperature of a heating element at variable distances. This data was then analyzed, compared to both the pre-processed and actual values. An algorithm utilizing the heat transfer equation was used to estimate the amount of heat lost from a given area–which was calculated from ultrasonic distance data. The drone design was validated by assessing the data transmission speed, reliability, and flight performance. Then, this data was compared against commercial drone datasets and analyzed. The post-processed estimation algorithm (SD 36.08 celsius, 29.76% Error) yielded more accurate results than pre-processed data (SD 67.8 celsius, 52.55% Error). The heat loss algorithm was 64.146% accurate at estimating heat lost (SD 4.904 Watts). The transmission speed at a distance of 50 meters (SD 0.53 ms) resulted in an average of 2.3 ms over ten trials. This project demonstrated that the temperature prediction algorithm was able to reduce attenuation, offering a 22.79% error reduction. The fiber optic drone also showed an 83.57% improvement in transmission speed over the fastest commercial platform with interference resistance. These results indicate that fiber-optic drones are a viable alternative for power line maintenance.

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