Optimizing RPAS-based Thermal Infrared Camera Calibration using Ground Reference Panels under Changing Atmospheric Conditions

Drone-based thermal cameras can provide high quality surface temperature data that is useful in environmental, agricultural and industrial applications. However, multiple variables including atmospheric conditions, sensors internal temperature and measurement bias affect temperature readings. Studies showed that using ground reference data to adjust drone-based thermal measurement can enhance accuracy. Current methods are complex and fail to provide higher accuracy when atmospheric conditions change especially solar radiation. While, it is ideal to collect data during cloudless period, finding a cloud-free sky in tropical regions, is challenging. Here we develop an adjustment process that provides highly accurate surface temperature measurements under dynamic atmospheric conditions from various heights and easily replicable. Our results showed that recording atmospheric and surface temperature data at the beginning and end of each flight is crucial. By integrating these data, we have achieved a significant improvement in surface temperature measurement accuracy.

Abstract

This study proposes a new calibration method for remotely piloted aircraft systems (RPAS) thermography to achieve accurate and reliable surface temperature (ST) measurements under varying atmospheric conditions. Current ground reference panels (GRPs) based calibration methods are complex and fail to provide accurate ST measurements under changing atmospheric conditions. The proposed method uses two sets of GRPs, one group was placed closely on the field to measure GRPs temperature at the beginning and end of each RPAS flight, and the other set was randomly distributed on the field to create a thermal orthomosaic. The surface temperature was collected in the morning, midday, and afternoon from 30, 60, and 90 m above ground level. We found ±2 °C accuracy using GRPs at different times of the day and heights under stable atmospheric conditions that are better than the manufacturer-stated accuracy. However, when atmospheric conditions change during RPAS flights, the accuracy varies more than ±10 °C due to a non-linear relationship between thermal orthomosaics and ground readings. To improve calibration accuracy, we used ground reference temperature readings taken at the beginning and end of each RPAS flight and solar radiation data. By integrating solar radiation information and GRPs readings, we reduced the overall error from ±10 °C to 0.5 °C. The proposed method can be applied to optimize RPAS-based thermography in tropical regions with rapidly changing environmental conditions, which has significant implications for various applications, including urban planning, agriculture, forestry, and environmental monitoring.