APPLICATION OF DRONE-CAPTURED THERMAL IMAGERY IN AIDING IN THE RECOVERY OF METEORITES WITHIN A SNOW-COVERED STREWN FIELD.

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Introduction: With advancements in astromaterial acquisition capabilities, such as the use of ground-based observatories to capture fireball and respond to meteorite-dropping events, our ability to recover pristine astromaterials quickly after fall events has greatly improved in recent years [1]. Though our means of detecting and modelling these events have advanced, to a large degree our means for recovering meteoritic material have remained the same, i.e. systematic searching utilizing human sight and magnetics, which is both labor and time-intensive. To prepare for any future searches, we have examined the application and feasibility of utilizing drone-based imagery to aid in finding potential meteorites. In particular, given Canada’s cold climate and the prevalence of snow-covered fields in Alberta for large portions of the year, we examine the application of using thermal imagery to find potential meteorites if they landed on a snow-covered field.

Methodology: Several specimens from the University of Alberta Meteorite Collection were placed in a snow-covered field on March 12, 2021, to act as an analogue strewn field, and imaged by both visible and thermal sensors on drones. Field West 240 located on the University’s South Campus was chosen for this study. Six samples were placed in the field: 3 meteorites (2 samples of Bruderheim (L6 Ordinary Chondrite) and 1 sample of Allende (CV3 Carbonaceous Chondrite)), 2 “meteorwongs” (a 3D printed model of a meteorite and a sample of diabase), and 1 touchable ordinary chondrite sample used in outreach and public engagement. The 4 meteorite specimens were placed on PTFE Teflon bags to prevent interaction between the meteorite and surrounding environment. The temperature ranged from 5°C when the samples were first placed in the field at 10:00 MST to a high of 9°C by 13:00 MST.

To image the field, a Mavic 2 Zoom with 1/2.3-inch 12 MP sensor was used to capture visible imagery of the analogue strewn field. The field was captured at 20 m, 40 m, and 80 m altitude to determine the ideal altitude for capturing the scene while minimizing time-of-flight to maximize efficiency. A mosaic of all the images captured were stitched together to form a high-resolution image of the field. A second drone was flown to acquire thermal imagery of the individual meteorites. A Matrice 210 by DJI with dual gimbal attachment was flown at various altitudes (5 m, 10 m, 15 m, 20 m, 40 m, and 80 m). Two sensors were attached to the drone: Zenmuse XT Advanced Radiometric and Zenmuse Z30. The Zenmuse XT Advanced Radiometric captures 640 × 512 pixel scenes using 13 mm lens with a 7.5 – 13.5 µm spectral band. The Zenmuse Z30 allowed for visible imagery to be captured alongside the thermal images and was used for navigational purposes. The Z30 could be zoomed to 30x magnification to ensure that the thermal scene was in fact of the desired subject and not other extraneous thermally-bright objects. The thermal imagery was captured at 11:00 MST when the samples were first placed in the field and then again at 13:30 MST and 14:30 MST.

Results: At 5 m of altitude, all six samples were clearly identifiable in the thermal images as compared to the surrounding snow. The samples were still visible at higher altitudes: however, many were not discernible at an altitude of 80 m. Compared to visible imagery captured at the same elevation, as well as the visible imagery mosaics captured at a similar altitude, the samples are much more easily identifiable in the thermal imagery. Slight differences between the meteorites and “meteorwong” samples were observed in the lower altitude thermal imagery. Specifically the diabase was significantly less bright and less distinct in the imagery. Though the samples were clearly identifiable, as the field was not completely snow-covered (i.e., patches of underlying vegetation and dirt were exposed), the images captured at higher altitudes had numerous thermally bright areas similar to the meteorites. With regards to operations, multiple battery changes were required for both drones. In addition, half-way through operations all the batteries had to be recharged as a batch for an ~1-hour period, though efficiency could be improved by having an inverter-generator in the field for continuous operations.

Discussion: Overall the contrasting thermal properties of the samples as compared to the snow meant that they were easily identified in the thermal imagery. Compared to the visible imagery, it was much easier to identify the samples in a given scene. This is not to say that visible imagery was not important - on the contrary, it was key to confirming that the thermally bright object being imaged at a given time was in fact the sample of interest. At higher elevation it was harder to discern the samples from other thermally bright objects. Where the snow cover was more intact the samples were easily identifiable at altitudes up to 40 m; however, in areas where this was not the case the samples became less easily distinguished. For example, at the 40 m altitude, several other features appear in the image alongside the Allende sample, which could be easily confused for the meteorite. Uniquely, the Allende sample was the only sample that was observable at 80 m. Ultimately this analogue test provided insights into how thermal imagery captured by a drone can aid in the recovery of meteorites from snow-covered terrains, as well as highlighting operational logistics that will need to be taken into account before implementation in a real search following a fireball event.