SUCCESSFUL RECOVERY OF AN OBSERVED METEORITE FALL USING DRONES AND MACHINE LEARNING. S. L. Anderson[1], M. C. Towner[1], J. Fairweather[1], P. A. Bland[1], H. A. R. Devillepoix[1], E. K. Sansom[1], M. Cupak[1], P. M. Shober[1], and G. K. Benedix[1], [1]Space Science and Technology Centre, School of Earth and Planetary Science, Curtin University, Kent St., Bentley, Western Australia (seamus.anderson@postgrad.curtin.edu.au).

Abstract: We report the first-ever recovery of a meteorite fall using a drone and a machine learning algorithm. This success will hopefully spur the efficient recovery of many more meteorites with know pre-impact orbits.

Introduction: Most meteorites fall to Earth with no information regrading their orbit prior to impact. Fireball observatory networks such as the Desert Fireball Network (DFN) [1] in Australia are able to record the fireball event and calculate its trajectory. This allows us to determine which region in the solar system the meteoroid originated, as well as constrain where the meteorite landed on the ground (to within ~3 km^2). By recovering these meteorites, we can further uncover the link between meteorite geochemistry and asteroid types, and better understand mass transfer between the asteroid belt and the inner solar system.

Traditionally, searching for these meteorites required 4-6 people to walk in a line spaced ~5 m apart visually searching the ground. Although this method does yield success, it is highly inefficient and is thus plagued by extensive labor investments. To remedy this problem we successfully implemented our drone-meteorite searching methodology [2,3], which uses a drone to survey the fall zone, and a deep learning algorithm to process the data.

In December of 2021, we embarked on a field-trip to test the methodology on a recent fall near the Kybo homestead on the Western Nullarbor Plain in Western Australia. On the fourth and final day at the fall zone, we recovered the meteorite (Fig. 1).

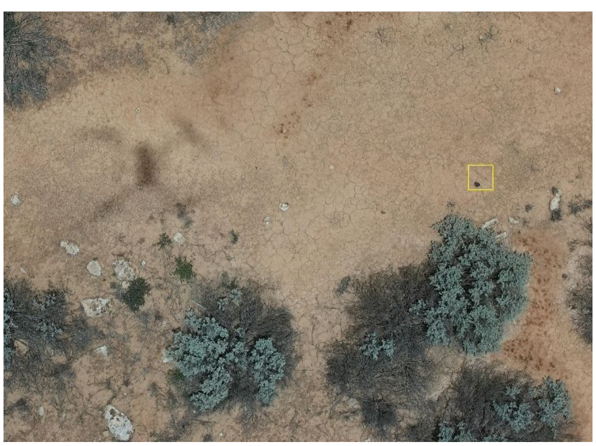

Fig. 1: The meteorite as seen by the drone and algorithm (Yellow box is 100 cm^2).

Methods: We used a DJI M300 drone to survey the fall zone at a resolution of 1.8 mm/pixel with an integrated Zenmuse P1 camera (35 mm lens). After each flight we transferred the data to our field computer equipped with an RTX 2080 Ti GPU. The algorithm [3] identified meteorite candidates, which were inspected by the team members on the trip in two rounds, in order to eliminate false positives, which were later used for retraining. The candidates that passed inspection were visited again using a smaller drone (DJI Mavic Pro), before being visited in-person if they continued to appear promising.

To train the algorithm, we brought with us 19 individual meteorite specimens (supplied by the Western Australian Museum) and imaged them in native backgrounds using the drone. We specifically chose meteorites with fresh fusion crusts, since our target meteorites also exhibit this feature. This local data was combined with a portion of our archived meteorite images to form the complete training set.

Results and Discussion: Recovering a network-observed meteorite fall with this methodology will hopefully spur the recovery of even more meteorites with known, pre-impact orbits. This reduction in labor will allow fireball observatory networks to more efficiently search and with greater success.

This result could also be used to find meteorites in known high density meteorite areas such as Antarctic ice fields or known strewn fields.

Although this meteorite (Fig. 2) has yet to be classified, the fusion crust is resembles that of an ordinary chondrite, and it deflects a compass needle when in close proximity.

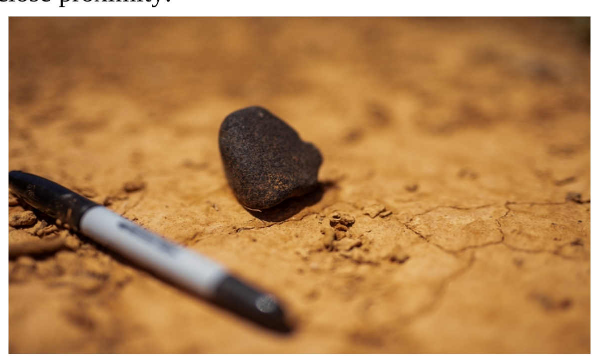

Fig. 2: The recovered meteorite (felt pen for scale).

Another interesting result from our efforts is the anomaly detection power of our algorithm as it also detects kangaroos, snakes, tin cans and other anomalous features not often found in the training data. We hope to apply our methodology towards other single-detection problems, such as wildlife monitoring and conservation.

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References:

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[2] Anderson S. L. et al. (2019) *Lunar and Planetary Science Conference 50,* Abstract # 2132.

[3] Anderson S. L. et al. (2020) *Meteoritics and Planetary Science 55(11)*, 2461-2471.