Uncertainty Guided Recognition of Tiny Craters on the Moon

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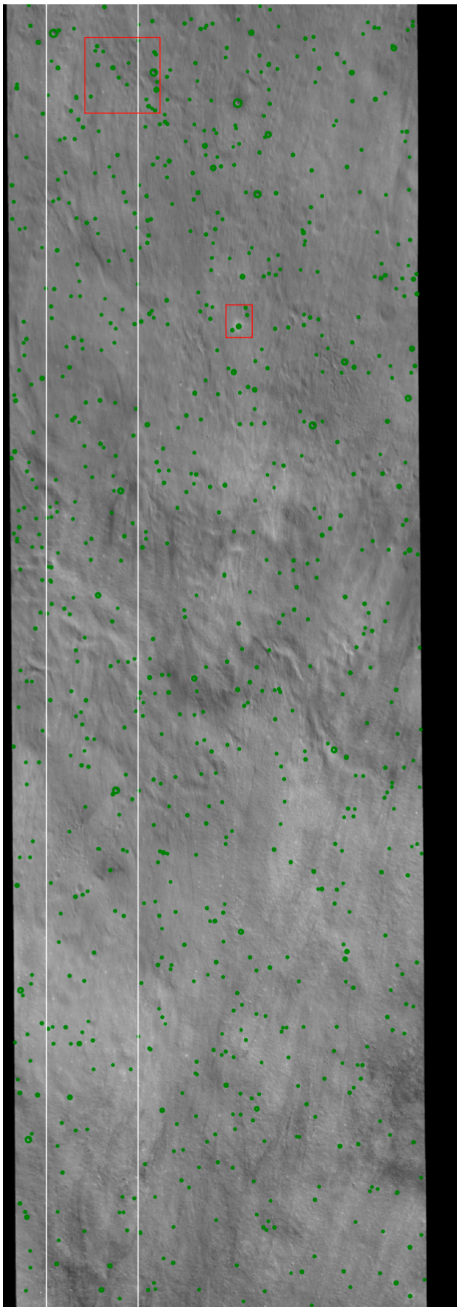
Introduction

- Accurately detecting craters is important when analysing the properties of planetary bodies.
- Small craters are important when estimating the age of young surfaces.

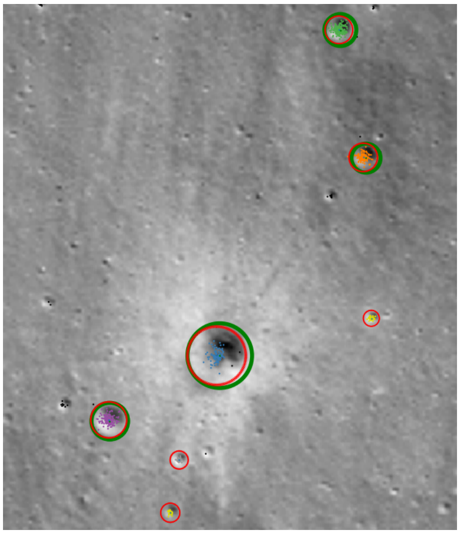
Study Area

- Area north of Crater Hell Q (33.0°S, 4.4°W).
- Impact crater sizes 5m–41m (5px – 41px).
- 2,441 x 7484 px (41 km^2).
- NAC image M126961088LE.

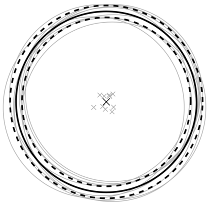


Detections

- Modified YOLO architecture [11].
- Detections tightly group (coloured).
- Occasional outliers (black).



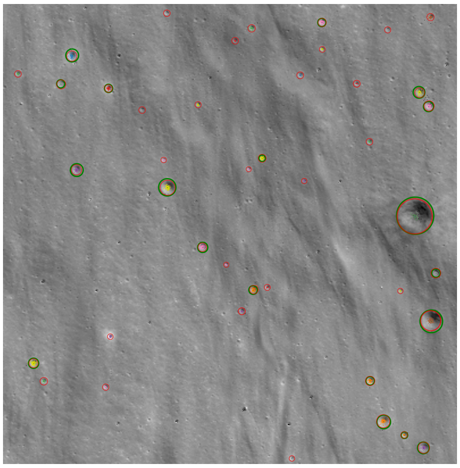
Uncertainty Estimation



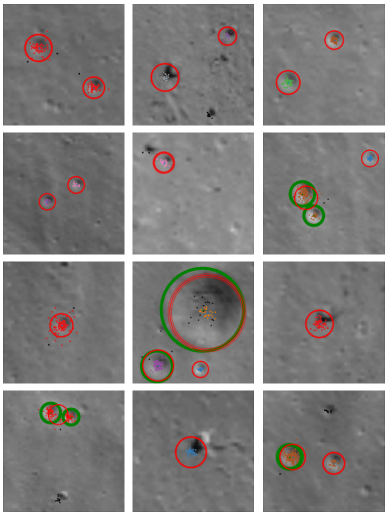
- Group detections (OPTICS [19]).
- Compute mean centre and radius.
- Estimate the confidence intervals, assuming normally distributed detections [20]:

$$\left(\hat{r}_c - t_{\alpha,\upsilon}\frac{s_c}{\sqrt{N_c}}, \hat{r}_c + t_{\alpha,\upsilon}\frac{s_c}{\sqrt{N_c}}\right).$$

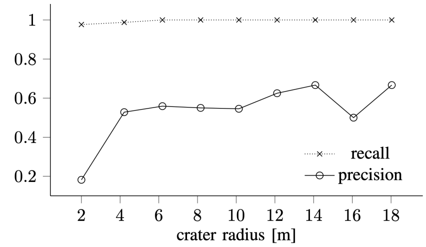
Qualitative Results

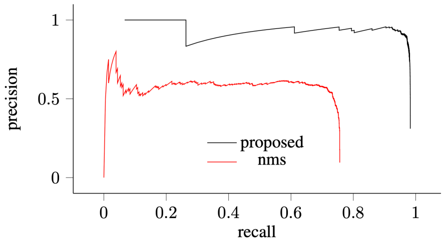


Qualitative Results (cont.)



Quantitative Results





- Annotating small craters is challenging.
- Craters are sometimes overlooked, missed, or disregarded during annotation.
- Well known issue within the community.
- Thus, precision is different for differently sized craters and increases with increasing crater size.
- Larger craters are more easily distinguished.
- Non-maximum suppression leads to many false detections.

Conclusion

- Uncertainty estimates are an excellent way to improve the detections.
- It also allows for an easier interpretation of the detections.
- Outperforms non-maximum suppression.

Selected References

[11] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You only look once: Unified, real-time object detection," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016, pp. 779– 788.

[19] M. Ankerst, M. M. Breunig, H.-P. Kriegel, and J. Sander, "Optics: ordering points to identify the clustering structure," *ACM Sigmod record*, vol. 28, no. 2, pp. 49–60, 1999.

[20] K. Krishnamoorthy, *Handbook of statistical distributions with applications*. CRC Press, 2016.

Acknowledgements

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