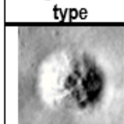
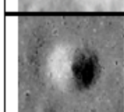
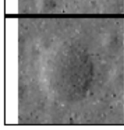
High-Resolution Automated Impact Crater Detection on LRO-NAC Images

J. H. Fairweather,[1] A. Lagain,[1] K. Servis,[1,2] G. K. Benedix,[1,3,4] P. A. Bland,[1,3]

[1]School of Earth and Planetary Sciences, Curtin University, GPO Box U1987, Perth, WA, 6845, Australia. [2]CSIRO, Pawsey Supercomputing Centre, Kensington, WA, 6151, Australia. [3]Department of Earth and Planetary Sciences, Western Australia Museum, Locked Bag 49, Welshpool, WA 6986, Australia. [4]Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tuscon AZ 85719-2395, USA. (john.fairweather@postgrad.curtin.edu.au).

Abstract: The Moon's surface is covered in impact craters, and with no major erosional processes or plate tectonics, the Moon provides a celestial cratering record spanning 4 Ga. Crater counting chronological techniques are well pioneered and used to derive meaningful information about the Moons geological past[1]. The ability to derive information is solely locked in the capability to detect and measure the lunar impact craters, where past studies have relied on manual detections. Using the Lunar Reconnaissance Orbital Camera (LROC) NAC image dataset, with resolutions of 0.5-2m/px and near global coverage[2], we can visibly perceive millions of small craters. Counting these, in a timely manner, are impossible for the historic approach of manual detection. Applying a lunar-trained Crater Counting Algorithm (CDA), first used on Mars[3,4], we can detect millions of small (D>1km) impact craters. Running the CDA on an area of the lunar surface, using NAC images, results in accurate detections of small craters (Tab.1). Tests of the CDA show that it performs exceptionally well (True Positive (TP) detection rate <90%) in the detection of 'fresh' craters. Although performance drops off the more degraded a crater becomes (Tab.1). Diameter estimation of the craters is good, where all are ±15% (Tab.1). The detection errors of all craters are still within the error of manual counting variations[5].

Table 1: Confusion matrix comparing the CDA detections against manually mapped craters across different diameter ranges and degradation states on a Highland terrain (NAC: M1338833866L), fresh craters are at the top and very degraded at the bottom, '+' diameter estimates indicate the CDA overestimated true crater diameters whereas '-' are underestimations.

Degradation type	Crater Diameter	TP %	FN %	Manual detections	CDA detections	Av. Diameter estimation (±2σ)
	≥100m	97.1	2.9	34	33	+9.9 (±17.6)
	≥250m	91.6	8.4	12	11	+10.7% (±9.1)
	≥100m	80.1	19.9	42	34	+7.5% (±34.3)
	≥250m	93.3	6.7	15	14	+11.2% (±16.9)
	≥100m	41.5	58.5	53	22	-5.5% (±30.2)
	≥250m	38.5	61.5	26	10	+9.4% (±18.8)

[1] Neukum G., Ivanov B., and Hartmann, W.K. (2001). Sp. Sci. Rev. 96, 55–86. [2]Robinson, M.S., et al. (2010). Sp. Sci. Rev. 150, 81-124. [3]Lagain, A., et al. (2021). Earth and Space Science. [4]Benedix, G.K., et al. (2020). Earth and Space Science. [5]Robbins, S.J., et al. (2014). Icarus. 234, 109–131.