Planetary geochronology using machine learning.

G.K BENEDIX[1], A. LAGAIN[1], K. CHAI[2] S. MEKA[2], C. NORMAN[1], S. ANDERSON[1], P.A. BLAND[1], J. PAXMAN[3], M.C. TOWNER[1], K. SERVIS[1,4] AND E. SANSOM[1],

[1]Space Science and Technology Centre, School of Earth and Planetary Sciences, Curtin University, Perth, WA, Australia (g.benedix@curtin.edu.au)

[2]Curtin Institution of Computation, Curtin University, Perth, WA, Australia

[3]School of Civil and Mechanical Engineering, Curtin University, Perth, WA, Australia,

[4]CSIRO Resources Research Centre (ARRC) Kensington WA 6151, Australia

Impact craters on solar system bodies are used to determine the relative ages of surfaces. The smaller the limiting primary crater size, the higher the spatial resolution in surface/resurfacing age dating. A manually-counted database [1] of ~385,000 craters on Mars >1km in diameter exists. Because crater size scales as a power law, the number of impact craters in the size range 10m to 1km rises to tens of millions. To analyse this data requires an automated method.

To interrogate this crater size population on a planetary scale, we developed an automated Crater Detection Algorithm (CDA) [2] based on the YOLOv3 object detection system. The CDA was trained by annotating images of the controlled Thermal Emission Imaging System (THEMIS) daytime infrared dataset. The training library contains 7,048 craters that the CDA used as a learning benchmark. We applied our algorithm to the THEMIS (100m/pixel) global mosaic (as an unknown) of Mars between ± 65° of latitude. Compared to the handcounted database, our method achieved a true positive detection rate of 91% and a diameter estimation error (~15%) consistent with typical manual count variation.

We demonstrate that automatic counting can be routinely used to derive robust surface ages, by applying it to the highest resolution Mars image dataset: that of the ConTeXt Camera [3] (5m/pixel). This dataset comprises GB of image data. Our algorithm counted *~17 million craters > 40 m* in the mid-latitudes (±45° latitude) *in 2 months*. For comparison, the manually counted database [1] took several years to amass.

[1] Robbins & Hynek (2012) *J. Geophys Res. Planets*, 117, 1–18. [2] Benedix et al., (2020) *J Earth Space Sci.*, Accepted. DOI: 10.1029/2019EA001005. [3] (http://murray-lab.caltech.edu/CTX/index.html