

AN OPEN SOURCE ALTERNATIVE FOR CRATER COUNTING USING QGIS AND THE CIRCLE-CRATERS PLUGIN. S. E. Braden¹, ¹HireIQ Solutions, Inc., 1101 Cambridge Square, Alpharetta, GA 30009, sarah.braden@hireiqinc.com.

Introduction: Statistical analysis of crater size frequency distributions (CSFDs) from impact craters on planetary surfaces is a method to derive ages on the basis of remotely-sensed image data [1-5]. Data required for the statistical analysis are area size and mapped geologic units, as well as measurements of primary impact crater diameters within the study area. Data collection techniques have changed over time. Initially, photogrammetric instruments were used to measure image coordinates on film transparencies, and then the coordinates were translated into crater diameters. More recently, measurements of impact crater diameters were made from projected raster images through measurements of pixels.

Geographic Information Systems (GIS) provided an environment for both the projected image data (raster data) and the measurements of digitized craters (vector data), however, a challenge remained for accurate crater diameter measurements. Distortions of distances and areas due to different map projections was still a significant source of error when making measurements from projected raster data [6]. In general, distortions produced by different map projections increase with distance from the projection center. The CraterTools extension for Environmental Systems Research Institute's (ESRI's) ArcGIS addressed this issue by performing undistorted re-projection of each digitized impact crater and using the undistorted crater diameter as the true measurement output [6].

At present, the only crater counting tool utilizing a Geographic Information System (GIS) is CraterTools [6]. There is not an open source alternative to the combination of ArcGIS and CraterTools.

This abstract presents a new open source tool, CircleCraters, for crater counting built as a QGIS plugin. QGIS is an Open Source Geographic Information System (GIS) licensed under the GNU General Public License [7]. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android. In contrast, ArcGIS limits the user by requiring a Windows operating system.

The advantages to using a combination of QGIS and a community developed open source plugin for crater counting are not only lower cost compared to using ArcGIS, but also the ability of independent individuals to make improvements to the code and long-term maintainability with transparent version control. Open source code is essential to the scientific process, not

only to support the reproducibility of results, but to contribute to the scientific community and develop methodologies over time [8].

Measurement Tool: CircleCraters uses the same three point crater digitizing method as ArcGIS CraterTools. The method assumes that impact craters have a near circular shape, which excludes oblique impact craters. Errors in diameter measurements due to projection related distortions are avoided by using spherical coordinates to create a circle through the three points defining the crater rim, and then using the haversine formula (Fig. 1) to calculate the diameter of the circle. When solved for distance, the haversine formula finds the shortest distance between two points given in latitude and longitude [9]. The haversine formula is accurate even for craters that cover a large portion of the planetary surface. The final undistorted diameter is saved as a property of the group of three

$$d = 2r \arcsin \left(\sqrt{\sin^2 \left(\frac{\phi_2 - \phi_1}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left(\frac{\lambda_2 - \lambda_1}{2} \right)} \right)$$

Figure 1. The haversine formula solved for distance where d is the distance in meters, r is the radius of the planetary body in meters, ϕ is latitude and λ is longitude for two points.

points selected by the user, along with the latitude and longitude of the center of the circle. On the screen a circle is drawn in the same projection as the raster data (Fig. 2).

When all study areas are mapped and the crater counting process is complete, data can be exported as a comma delimited file (.csv), shapefile (.shp), or as a crater-diameter list with a defined surface area (a .diam file) designed to be imported by Craterstats2, a tool for plotting crater counts and determining surface ages using the techniques described in [2-5, 10]. Craterstats2 requires the area containing the impact craters, which is calculated automatically by CircleCraters as long as the user has defined the area in a vector layer. The area is computed with an equal-area sinusoidal projection. In a sinusoidal projection, scales are true along parallels and along the central meridian, while being distorted in directions not along the parallels.

Source Code: The code and documentation for CircleCraters is on the GitHub website at github.com/sbraden/circle-craters. Github is a public source code repository for code hosting, sharing, and

collaboration using the version control system Git. Contributions to the code base of CircleCraters, or any comments, suggests, or other input are welcome from the planetary science community. Github provides an easy-to-use platform for documentation and feedback. CircleCraters will be included in the QGIS plugin repository (plugins.qgis.org), which allows the plugin to be installed with one click from within the QGIS desktop application. The plugin is written in Python, a relatively easily-adopted programming language. CircleCraters is made available under the BSD (Berkeley Software Distribution) 3-Clause (“BSD Simplified”) license [11].

Conclusion and Future Work: This open source tool provides planetary scientists with an alternative to the ArcGIS platform. The hosting of the code in a GitHub repository will promote long-term maintainability and transparency. Other scientists requiring crater counting software tools may use the source code from this repository. CircleCraters will evolve together with new QGIS releases and improvements.

Figure 2. An example of impact crater definition as a circle automatically generated after the user defines three points along the crater rim. The image data is a raster layer while the group of three points and circle are vector layers. The crater center latitude, longitude and diameter are stored as feature properties for later export and use in Craterstats2.

Immediate development priorities include:

- A crater size frequency distribution preview plot with isochrons, similar to what is available in CraterTools.
- Exporting crater counting data as a binned .stats file readable by Craterstats2 [10].
- An option to use more than three points to define the crater rim.
- Option for users to label craters within the crater counting vector layer as uncertain when considering possible secondary craters.
- A measurement scale/guide that includes a default minimum crater diameter spatial resolution limitation based on number of pixels.

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