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A SURVEY ON CRATER DETECTION ALGORITHMS

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ABSTRACT

Impact craters are the geologic structures formed by the collision of meteoroids, asteroids or comets with planetary surfaces. Craters are common features on the surface of planetary bodies such as earth, moon etc. in the Solar System. In Moon, Mercury, or Mars we can see abundant of craters. Now-a-days many missions are launched to unknown planets to know about the life on planetary surface. The craters are studied more because craters are vital feature to estimate the age of the planetary surface. To detect craters manually is difficult and time consuming task. As there is a large volume of data from different satellite images and extracting efficient information from every image is a difficult task. There are different automatic and semiautomatic techniques to overcome this problems. In this survey I am going to discuss about the different techniques used for the crater detection and compare the efficiency of the techniques

KEYWORDS: Impact Crates, Crater Detection Techniques

INTRODUCTION

Daniel Barringer (1860-1929) is the one who first identified an impact crater Meteor in Arizona. Craters have approximately circular in the surface of a planet, moon, or other solid body in the Solar System. Crater are perfect route historic points, that are utilized for exact movement estimation for the land control arrangement of the planetary tests, for example, landscape relative route. Craters have been studied widely because they contain crucial information about the age and geologic formations of remote planet. Consequently, checking as well as the measuring the craters on the planet of solar framework is crucial work for planet science. Craters are of different types. They are impact craters, volcanic craters, subsidence crater, maar crater, pit crater, Crater Lake, explosion crater and Machtesh. Impact craters have approximately a circle shape (possibly elongated), even though its outline is often so jagged that it is hard to see a circle.

Therefore, to define a model that indicate a crater, the circular shape, being the feature more relevant, is actually a good candidate. An impact crater is a circular depression in the surface of a planet, the moon, or some other solid body in the solar system. Impact craters range from small, simple, bowl-shaped depressions to large, complex, multi-ringed impact basins. A volcanic crater is a circular depression in the ground caused by volcanic activities.

A crater can be of large dimensions, and sometimes of great depth .Craters are topographic features on planetary image surfaces result from impacts with the meteoroids. These are found on all the hard-surface bodies in the solar system, but are most contained on planets like the Moon or Mars where they can accumulate due to slow surface erosion rates [1]. The craters are one of the important landmarks for autonomous spacecraft and rover navigation and control, which have become the key technologies in deep space exploration [2]. The craters can be used for high-precision spacecraft landing missions, and accurate identification of potential hazards [3]. Impact crater detectors are used in space exploration. In order

to create crater databases, a number of scientists have examined the optical satellite images and gathered information about crater features. The most comprehensive data set, known as Barlow catalog, includes characteristic information for more than 40,000 craters on Mars (Bar88). Lonar Lake is a lake in Maharashtra, which is actually formed by the meteor impact and that is the only hyper velocity impact craters in basalite rock on earth. Ramghar crater is also in Maharashtra. Dhal crater is situated in Madhya Pradesh.

Below figure shows the diffent craters formed on earth, moon etc. On Top Left 500 km large crater Engelier on Saturn's moon lapetus. On Top Right: Impact crater on Mars. On Bottom Left: 50,000 year old Meteor Crater ,Arizona,U.S On Bottom Right: Crater tycho in southern highlands of Moon

Figure: Impact craters on solar system

CRATER DETECTION ALGORITHMS

In my survey I found that there are so many crater detection techniques are there. Now I am going to describe the different types of algorithms that we can use to detect the craters in the earth surface. Basically we can classify the crater detection techniques in to two, one is image based and the other is elevation based. The image based are often panchromatic and the elevation based is DEM/DET [1]. DEM is a raster-type dataset that stores the value of elevation in each cell.

Here the craters can be easily distinguished by their occurrence of shadow-bright pair. In panchromatic images, we want to identify and discriminate the bright and shadow parts of crater at first. is the widely used approach .To discriminate crater parts, we are using he threshold based technique in most of the detection algorithms. In an image-based approach, some techniques like gradient and texture analysis, Haar transform, pattern recognition, etc. will be used for the detection purpose. Haar transform plays an important role in the detection purpose. In the detection process edge detection, binarization and circular pattern detection will perform using the Haar transform.

Image Based Crater Detection

Image-based crater-detection approaches could be divided in to two areas. They are machine learning and those that exploit it. The machine learning based detection rely on pattern recognition techniques to find crater boundaries having

circular or elliptical features in an image. What we are doing in such methods is, preprocess an image to enhance the edges of the crater boundaries, and then use different variants of Hough Transform to detect the craters [2].Supervised machine learning mechanism and decision tree algorithms are used to distinguish the crater regions. The image based crater detection algorithms are widely dependent on the illumination and the view angle.

In the second type of methods, machine learning is used to facilitate crater detection. Two phases are there ,they are learning phase and detection phase. In the learning phase, training set of images will fed in to the algorithm. In the training set, it contains the craters labeled by domain experts . In the detection phase, the previously trained algorithm that will detects craters in a new, unlabeled set of images using a template-model technique ,which is a continuously scalable technique.

Digital topography data can be used instead of images for Machine Detection of Martian Impact Craters from Digital Topography Data[3]. Craters are delineated by topographic curvature. Thresholding maps of curvature convert topographic data to a binary image, and from which craters are identified using a combination of segmentation and detection algorithms.

Rotational pixel swapping method[4],is one of the best image based algorithms that we can used to detect the circular features in the satellite images. The method is based on a multiplication operation between the rotated images and the original images. Rotational pixel swapping method[4],is one of the best image based algorithms that we can used to detect the circular features in the satellite images. The method is based on a multiplication operation between the original image and the rotated images. Next we are going to discuss about Hough transform.

Hough Transform

Hough transform plays an important role in image segmentation. It deals with the edge linking means it fills the gaps in edges and detects boundary of objects in image. Hough transform has been used widely in crater detection. Hough transform has been applied on the gradient magnitude image of extracted edges (using Sobel filter) of the craters in the image. The Hough transform may be applied on the edges extracted through edge detection techniques like Wavelet transform followed by morphological operations. Hough transform has been applied on the morphologically closed edges extracted with the combination of thresholded curvature map and connected components of craters in DEM based crater detection algorithm for detecting Martian craters

Wavelet Transform

Wavelet based image segmentation techniques can be used in the image based crater detection. It will apply wavelet transform on the pre-processed image to get multistate 2-D wavelet decomposition of gray scale pre-processed image. Wavelet decomposition will done using Haar transformation. The main advantage of Wavelet Transform is that it gives the edge details at multiple scales in time-frequency domain. It also gives facility to get details of edge discontinuity at local position. Continuous Wavelet Transform (CWT) detects the abrupt transitions (edges) in the image.

DTM-Based Algorithm

In crater based algorithm, craters are detect from the DTM images using their depression. In the DTM image, crater depression will appear in a darker tone and the elevated rim will appear as a brighter region. Fill sink techniques are

also used to detect the craters. The planetary surface will contain small depressions due to rugged topography.so in order to remove his type of small depressions we can use a smoothening process on the DTM image.

After finding the depressions, it will fill the depressions, and then apply thresholding technique to construct binary image[5]. For filling the depressions we can use flooding algorithm. Then narrow down the craters using morphological closing and thinning operations. DEMs are much more fundamental descriptors of planetary surfaces than images. DEM means digital elevation model. They are the more suitable for geomorphic analysis and are also well suitable for the automatic detection of craters. A combination of segmentation and detection algorithm for automatic crater detection on Mars using digital topography (DEM) was developed by Bue and Stepinski (2007).The method applies thresholding of the binary images and segmentation approach for delineation of craters by topographic curvature as it is a preferred parameter to extract topographic rims of the craters. The algorithm gives a relatively easier tool for identifying small and fresh impact craters but fails to detect heavily degraded craters.

Watershed Transform

Watershed transform has been used as image segmentation technique under DEM based crater detection approach. It has been applied on the optical DEM data. After doing the pre-processing of DEM images, it will find the gradient of the image. To avoid the over segmentation of the we will not apply watershed transform directly on the gradient. Instead we will perform marker computation. Marker is a connected in an image. Foreground and Background makers are there. The foreground markers are generated by using the morphological operators. The background markers are generated to segment the background

Supervised and Unsupervised Leaning Methods

Almost all the proposed frameworks incorporate either unsupervised or supervised methods to identify features and whereabouts of impact craters. Unsupervised techniques focus on finding rims and merge the rims to locate the crater. The Hough transform based methods are generally incorporated in this class of techniques. The Supervised learning methods, on the other hand, involve kernel-based and neural network based learning methods for training. Support Vector. Machines are usually used as classifiers to detect craters.

Kim and Muller introduced an integrated approach[5] of crater detection using image and DEM data in which Hough transform was applied for grouping of edges of craters extracted from image as well as DEM with good detection accuracy. Hough transform is an edge linking process. Image segmentation techniques like edge detection is used in crater detection. The Hough transform is used to group the edges obtained during edge detection. Lunar craters can be detected using Morphological Crater Detection Algorithms [6] and also using Geography- Based Craters Recognition Algorithms [7].The paper [7] Presents a unique hybrid CDA that will exploit the topography renovated from optical images.

CONCLUSIONS

Automated impact crater detection algorithms have been developed to identify various sizes of impact craters under different conditions such as illumination and view angles and geographical complexity. In our study, we analyzed some techniques used for the crater detection. From the analysis, we can conclude that DEM based methods are more easy to handle. And also circular feature detection using rotational pixel swapping is an efficient method for crater detection.

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