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Parallel Processing for Detection of Lunar Crater Morphometry-A Review

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Abstract— Craters appears on the lunar's surface in high density and the most interesting landform features of any planetary surface. Craters are important landform features on the lunar surface. Hence, detection and analyzing quantitative information (Morphometric) are key role of present day research. Morphometric measuring are useful for understating formation and evolution of surface features. It is also useful for landing site identification, counting, age determination, etc. Nowadays remote sensing orbital missions play a major role in mapping the entire surface of the planet. Lunar orbital data are huge in size and resolutions are significantly higher. Analyzing these data sets requires higher computational power. High performance computers provide higher computational power and getting output in real time. This review paper focuses on automatic identification of lunar crater and morphometric parameters (morphometry) using lunar orbital data sets using parallel computing approach.

I. INTRODUCTION

Craters are rimmed as large depression on lunar surface. Lunar have the different type of craters like simple, complex, oblique. Image analysis does an important role in methods for archive, retrieve, process, interpretation for the huge size of image data. Examples such as remote sense data including satellite image acquired in the visibility, infrared spectrum of data, Digital elevation model based data, and the radar data. Classification of satellite images are does the important role in image processing. That will take more time to classification process.

The finding of ellipse was fast and efficient manner. That takes the advantages of major axis of an ellipse in this method. To accumulate length of the minor axis of the ellipse we need only 1-D accumulator array. Binary oriented storage space is only the cheaper method compare than the previous methods.

A. High Performance Computing

High performance computing is a method used to solve high convolution problems. Analyze and process massive process of data, and concentrated analysis. High performance computing to moderates the processing time and therefore the outcomes are shaped as professionally and the conclusion must be faster [18]. The basic approaches from the HPC are parallel, distributed and hybrid computing. That was useful for to solve multipart problems for the engineering and government and business places.

B.HPC Architecture

The HPC architecture have the three basic types namely parallel process (that system have multiple processors), distributed process (using the network the multiple systems are connected), hybrid process (combination of parallel and distributed).Each systems have their own benefits and difficulties. Every organization will use that systems according by the needs and budget. HPC was classified as both shared and distributed memory [14]. High performance computing was characterized by four types namely single instruction single data (SISD), single instruction multiple data (SIMD), multiple instruction single data (MISD) and multiple instruction multiple data (MIMD) [16].

1. Parallel process

That parallel process has the more limitations. In this (fig.1) architecture, two or more processors calculate many tasks instantaneously. There are many processing units (PU) in the shared memory that shares the equal memory at only at once. In this Fig.1 Data can be accessed by all processors.

2. Distributed memory system

The data access is in distributed manner. It same as a shared memory but it only shares a local memory. This system requires a connection path to connect inter processor memory. Each processor had own resident memory. One processor memory address that can't map to another processor. Fig. 2 explains the concept of distributed system.

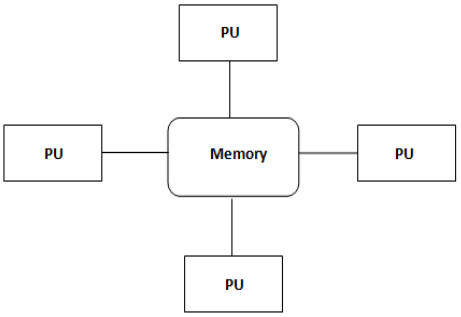

Fig 1.Parallel Processing [17]

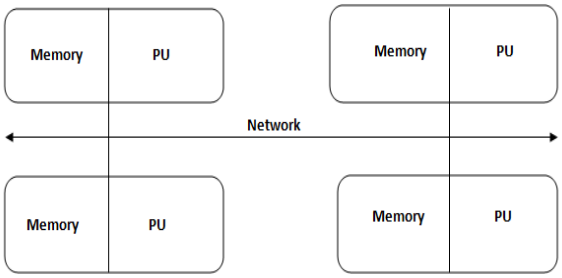

Fig 2.Distributed Memory [17]

3. Hybrid system

That was the new technology used by the all organizations for the great outcome and fast accessing of data in parallel manner. Figure3 explains the concept of hybrid system for distributed memory. Data move from one shared memory machines to another memory because the requirement of network communications.

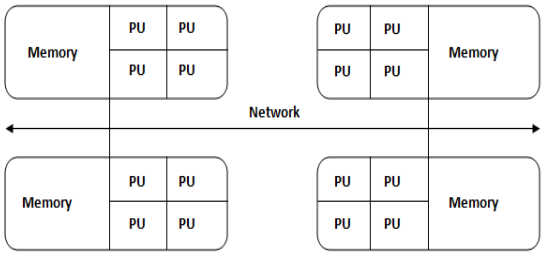

Fig 3.Hybrid system [10]

C. Crater Morphology

The collection of non-linear operation in the image processing was called as morphology. The morphology is the structural study of the binary image. In this given morphology technique, an image with a small shape or the template was called as structuring elements. The structuring element is the region of the neighborhood around pixels. The morphological process on a binary image creates new raster image in which the pixels has a non-zero value only if the test is succeed at that location in the input image. Erosion is the way to detect crater and also ignore the unwanted portion in a crater.

II. CRATER DETECTION METHODS

A. Hough Transform

One of the feature extraction techniques was called as Hough transform. That was used in image analyzing, computer vision and digital image processing. The Hough transform is the generalized version for circles and ellipses. For the straight line transform, we need to suppress non local maxima. The input image could also benefit from edge thinning. Hough transform is a common approach to finding the parameterized line segmentation. Hough transform can also use for detect circle and edge detection.

The (fig.4) $r\ \theta$ represents the distance between the line and origin. Represents the angle of the vector to this closed point .For the line the equation can be written as [1],

$$y = \left(-\frac{\cos\theta}{\sin\theta}\right)x + \left(\frac{r}{\sin\theta}\right) \qquad (1)$$

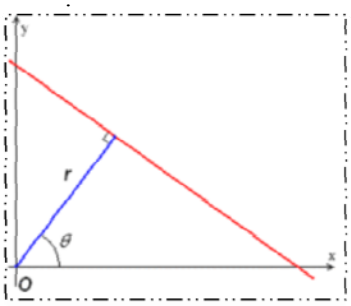

Fig 4.Hough transforms [1]

The hough transform is a method of parameter extraction whose properties can make it particularly for the detection of shapes within worst segmented imagery parts. This takes pieces of local evidences and the votes for all the parameter combinations which consistent with this evidences.

$$r^2 = (y - b)^2 + (x - a)^2 \qquad (2)$$

This is the equation (2) for circular hough transform. Here a, b are mentioned for the coordinates and r is mentioned for the radius.

1. Center detection

Center detection is the most important stage in the detection of crater. One common method is the determination of the mid-point of the line between two points of the image with parallel tangents. If these two points are on the same crater then the middle point is the center of the crater. This given principle can be used as the basis of a hough transform method. The first step of the procedure is to extracting pairs of image points whose gradients are the same. The next is to construct a 2-D histogram of the mid-points of such pairs.

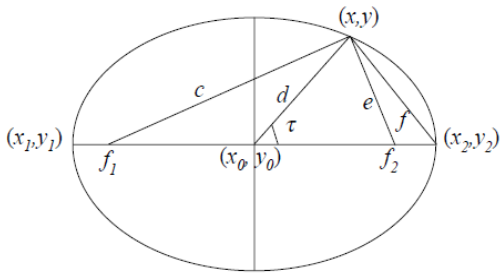

Fig 5.Ellipse geometry [19]

Fig.5 shows the concept geometry of ellipse. *f1, f2 mentioned* for foci of ellipse. *(x, y)*is for calculate the fifth parameter. *(x,y),(x0,y0)*these two distances should be less than the

distance between$(x_0,y_0),(x_1, y_1)$or the distance between$(x_0,y_0),(x_2,y_2)$.

B. Morphometry& Parameter Space Analysis process

The important second part of the lunar crater was depth calculation. The morphometry and parameter space analysis will do the important role for that. Ratio between the radius and the rim end is defined at a range between the parameters. Different radial angle, relationship between the equations calculated for the each crater [10].Position was mentioned as sor. In this M&PSA, TCP (Topographic Cross Profile) can be calculated according to that equation. TCP is used for calculate average elevation from the lunar's crater. Some pixels from digital topography was sampled at more than once on smaller craters and except that are all for the larger crater. The result must be a three dimensional crater shape with the two dimensional representation. [10].

C. Depth and Diameter

Once the morphometry process and Hough transform completed, next we will move to the Depth and diameter calculations. [10].According to [10] [11], diameter will be elevated and depth will be calculate. The following equation (3) was used for depth and diameter calculations.

$$d = \max_{j=0}^{sor-1} (tcp(sor) - tcp(j)) . \quad (3)$$

D. Ellipse Fitting

A crater in a lunar, that was in circular and ellipse shape with bright and contrast of shading in a bowl shape. Opening, closing techniques are under the morphology concepts. These distinguishing characteristics are used extensively in crater detection. The proposed crater detection algorithm employs image smoothing followed by gradient image and thresholding. Image smoothing is applied on the gray scale image. [9]

$$\text{Opening} = f \circ b = (f \ominus b) \oplus b$$
$$\text{Closing} = f \bullet b = (f \oplus b) \ominus b$$

Ellipse fitting using least square error method is done using following equations. Parametric equation of an ellipse is [9]

$Ax2 + Bxy + Cy2 + Dx + Ey + F = 0$

Orientation is calculated using

$\Theta = 1/2 \tan{-1} B/(C - A)$

Plot ellipse using below equation

$X = X0 + a \cos \Theta$

$Y = Y0 + b \sin \Theta$

To obtain coordinates of points on the tilted ellipse multiply points with rotation matrix to rotate the axis with respect to Θ.

E. DEM-Based CDA

Crater detection in DEM based is from the previous work [10] utilizes fuzzy, Shen Castan, canny edge detection methods followed by Radon-Hough transform from fuzzy.DEM based CDA have the Central peak volume, circularity in topology, parameter space, rim volume, depth/diameter ratio that all are under the extraction of numerous features. The CDA on interpolated based was specially developed for crater shape based- interpolation method [12] [13]. This method was considerably for to detect the very small crater also. In that research, crater was detected by the DEM based method. This DEM based crater detection method not for to detect depth as clearly.

F. Finding Ellipse Parameter

For an arbitrary ellipse, there are some unknown parameters, (y0, x0) for the orientation and the center, (a, b) are mentioned for the major, minor axes. Normally we need a set of five edge pixels to calculate parameters off all. To determine the position of an ellipse, we have to perform a additional part of pixel detection and the additional pixel detections. In this paper I introduced a new approach to achieve. For the each pair of pixels (x1, y1) & (x2, y2), assume that for the major axis for an ellipse there are two vertices. For the minor axis also we can assume there are two vertices, but it will need a more processing time because of the larger amount of image. In that larger image that had a larger binary bit values.

III. CONCLUSION & FUTURE WORK

This present study reviewed details of lunar crater detection and morphometric parameters measurement algorithms and methods using satellite image. To the best of our knowledge there are currently no study is presented for measuring crater morphometric parameters based on high performance computer. Hence, researcher may focus on parallelizing for automatic crater detection and measuring morphometric parameter.

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