# DEM ASSESSMENT DERIVED FROM CLOSE RANGE PHOTOGRAMMETRY: A CASE STUDY FROM KADAVUR AREA, KARUR DISTRICT, TAMIL NADU, INDIA

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**KEY WORDS:** Digital Close Range Photogrammetry (DCRP), DEM Assessment, Commercial Digital camera.

**ABSTRACT:**

Close-Range Photogrammetry is an accurate, cost effective technique of collecting measurements of real world objects and conditions, directly from photographs. Photogrammetry utilizes digital images to obtain accurate measurements and geometric data of the object or area of interest, in order to provide spatial information for Engineering design, spatial surveys or 3D modeling. The benefits of close-range Photogrammetry over other field procedures are purported to be: Increased accuracy; complete as-built information; reduced costs; reduced on-site time; and effective for small and large projects. The same basic principle of traditional Aerial Photogrammetry can be applied to stereoscopic pictures taken from lower altitudes or from the ground. Terrestrial, ground-based, and close-range are all descriptive terms that refer to photos taken with an object-to-camera distance less than 300m (1000 feet). (Matthews, N.A, 2008). Close range Photogrammetry is a technique for obtaining the geometric information (e.g. position, distance, size and shape) of any object in 3D space that was imaged on the two dimensional (2D) photos, (Wolf, P.R, et.al, 2000) DEM Generation requires many processing and computation, such as camera calibration, stereo matching, editing, and interpolation. All the mentioned steps contribute to the quality of DEM. Image on close range Photogrammetry can be captured using three kind of camera: metric camera, semi-metric camera, and non-metric camera (Hanke, K., et.al, 2002). In this paper DEM quality assessed at Kadavur area, Karur district, Tamil Naudu, India using Close Range Photogrammetry technique, Commercial Digital Camera and Leica Photogrammetry Suite.

# 1. INTRODUCTION

## 1.1 Digital Elevation Model

Digital Elevation Model (DEM) is a digital data represented an easting northing and height of object position, in which it can be derived from many data sources and techniques. One such method is a close-range Photogrammetry. It is a technique for obtaining three dimensional (3D) geometric information of any object that was imaged on two dimensional (2D) photographs by an analytical stereo model. Analytical stereo model involves three main steps; interior, relative, and absolute orientations. It requires Ground Control Points (GCP) to determine positions and orientation of the camera and also parameters of coordinate transformations. By these orientations coordinates all features on overlapping area can be transformed into ground coordinate system.

## 1.2 DCRP Technique

Digital Close Range Photogrammetric digital methods have been successfully applied to many applications such as archaeology, architecture, automotive and aerospace engineering, accident reconstruction and etc (Carbonell, 1989; Atkinson, 1996). With the rapid development in technology, improvement of hardware and software products have affected development in digital close range Photogrammetry. Some studies can be made more economically, more accurately and faster using the recent digital close range Photogrammetry technology or technique. A major advantage with photogrammetric methods is the positive relationship between photo scale and precision. Typically high precision is required for studies involving small areas (i.e large scale photography) and a lower precision is acceptable for larger areas (i.e smaller scale imagery is most efficient) (Chandler *et al.*, 2001).

## 1.3 The concepts of precision, accuracy and reliability in relation to DEM Quality Assessment

The overall "quality" of the elevation data produced using stereomatching algorithms is of fundamental importance in this research, because this will directly affect any roughness statistics calculated from the DEMs. The quality of a DEM is a function of the accuracy, reliability and precision of the survey/photogrammetric measurements and the block bundle adjustment itself. In order to construct a thorough, systematic data quality assessment procedure, it is necessary to identify the different types of potential errors and their sources (Table 1) and to quantify the probability of there being errors of a specified size and type. Blunders or mistakes which occur during survey measurement, photogrammetric measurement or stereomatching may be referred to as *gross errors*; these can be considered to determine the *reliability* of the DEM (Table I). Cooper and Cross (1988) define reliability as "a measure of the ease with which outliers may be detected". In their assessment of the quality of survey data sets, Cooper and Cross (1988) also make the distinction between *internal reliability* and *external reliability.* Internal reliability is seen as the size of the marginally detectable gross error in a measurement whereas external reliability is a measure of the effect of this error on the parameters (for example, co-ordinates) or on data computed from them. The tau factor (*ti*) can be used to quantify the internal reliability of a particular survey measurement and this is simply the ratio of the standard error of a measurement to that of the corresponding correction (Cooper and Cross, 1988).

| *Sources/causes of error* | *Methods of assessment* | *Methods of correction* |
|---|---|---|
| RANDOM ERROR (PRECISION) | | |
| (i) **W.r.t. survey measurements** | | |
| Variation in the measurement process. | Repeat measurements of the same element. Covariance matrix used to compute local and global measures of precision. | Cannot be removed. |
| (ii) **W.r.t. digital photogrammetry** | | |
| Low SNR. | Precision estimate calculated during stereomatching from the SNR and the negative curvature of the correlation curve. | Improve image quality. |
| GROSS ERROR (RELIABILITY) | | |
| (i) **W.r.t. survey measurements** | | |
| Incorrect measuring/recording procedures. | Assessment of individual measurement residuals obtained from least squares estimation. | Selective removal of gross errors. |
| *Internal reliability* is the marginally detectable gross error. *External reliability* is the effect of undetected error on derived co-ordinates. | Calculation of the tau factor ($\tau_i$) and computation of the upper bound on the gross error that can be detected in the *i*th measurement with a given probability. | |
| (ii) **W.r.t. digital photogrammetry** | | |
| *Internal reliability*. Incorrect fixes during stereomatching due to: poor image contrast/quality; poor triangulation; non-optimal DEM collection parameters; errors in ground point measurement and identification; effects of viewing geometry. | Analysis of DEM collection results and comparison of DEM points with independent elevation data to identify individual blunders. Overlapping DEMs (redundant data) can also be used to provide (semi-) independent estimates of surface elevation. | Blunder editing. Improve image contrast and quality; improve triangulation by reviewing functional models; optimize DEM collection parameter set for specific applications; re-measure GCPs. |
| *External reliability*. Effect of false fixes on DEM derived data (for example, roughness parameters). | Analysis of the effect that a marginally detectable error in the *i*th measurement has on a particular parameter. | |
| SYSTEMATIC ERROR (ACCURACY) | | |
| (i) **W.r.t. survey measurements** | | |
| Atmospheric and other physical effects. Instrument errors and incorrect pointing. | Extension of functional models to include systematic errors. Systematic errors which can be successfully estimated from the survey measurements can then be modelled. | Cannot be fully eliminated but review of functional models where necessary can be used to mitigate against their effects. |
| (ii) **W.r.t. digital photogrammetry** | | |
| Insufficiently convergent imagery. | Ensure convergence angle of 20° to 40° when acquiring imagery. | |
| Over-simplification of the measurement process (for example, ignoring the effects of lens distortion when these should be considered). Physical effects include camera lens distortions, atmospheric refraction, film unflatness. | Independent accuracy assessment and assessment of the significance of additional (for example, interior orientation) parameters within the functional models. | |

Modified from Cooper and Cross (1988).

**Table 1. Types and sources of error in conventional survey and close range digital photogrammetry.**

Local measures of precision require the variance of individual parameters to be computed from the covariance matrix of the parameter. Global measures of precision, such as the a posteriori variance of unit weight (the variance factor), can be used to quantify the effects of random errors in a complete set of co-ordinates or other derived quantities. The precision of automated image measurement and stereomatching is positively related to (i) the number of pixels that are associated with a target (Chandler and Padfield, 1996); and (ii) the signal-to-noise ratio (SNR) of the imagery (Vision International, 1995). Higher image SNRs also lead to fewer gross errors (false fixes) in the stereomatched DEMs

In this paper a method for to trace the mm size structures and minerals by increasing the point density in Aero Triangulation process.

## 1.4 Instrumentation

Since the aim of this research is to assess the DEM derived from Digital Close Range Photogrammetry. The equipment and software used were easy to get and its availability.

*i)* *Sony Digital Camera*: 10.2 Mega Pixels


**Figure: 1 Sony Digital Camera**

| | |
|---|---|
| Megapixel | 7.2 MP |
| Imaging Device | 1/2.5" Super HAD™ CCD |
| Recording Media | 22MB internal Flash Memory, optional Memory Stick™ DUO Media, optional Memory Stick DUO PRO™ Media |
| LCD | 2.4" (112K Pixels TFT LCD Screen) |
| Lens Construction | 6 Elements in 5 Groups (including 3 aspheric elements) |
| Lens Type | Sony |
| Still Image Mode(s) | JPEG: Normal, Burst |
| Focal Length | 5.8 to 17.4 mm |
| 35mm Equivalent | 35-105mm |
| Focus | 5-Area Multi-Point AF, Center AF |
| Focal Distance | Normal Minimum: 19 3/4" (50cm) |
| Aperture | Auto and Program Auto: f2.8(W) - f9.7(T) |
| Optical Zoom | 3X |
| Digital Zoom | 0-2.0X (Precision) |
| Minimum Focus Distance | W: Approx. 19 11/16(50cm) - Infinity / T: Approx. 19 11/16(50cm) - Infinity |
| Dimensions (Approx.) | 3-5/8" x 2-3/8" x 1 1/8" (91.4 x 61 x 29.1 mm) |
| Weight (Approx.) | 4.9 oz (140 g) Body; 6.7 oz. (189 g) including Battery and optional Memory Stick® DUO Media |
| Operating System Compatibility | Microsoft® 2000 Professiona, XP Home and Professional, Macintosh® OS 9.1/9.2, OS X (10.0-10.4) |

**Table 2: Technical Specifications of SONY DSC S730**

*ii)* Leica Photogrammetry Software.
*iii)* Global Mapper.
*iv)* Garmin GPS.

## 2. STUDY AREA

### 2.1 Study Area

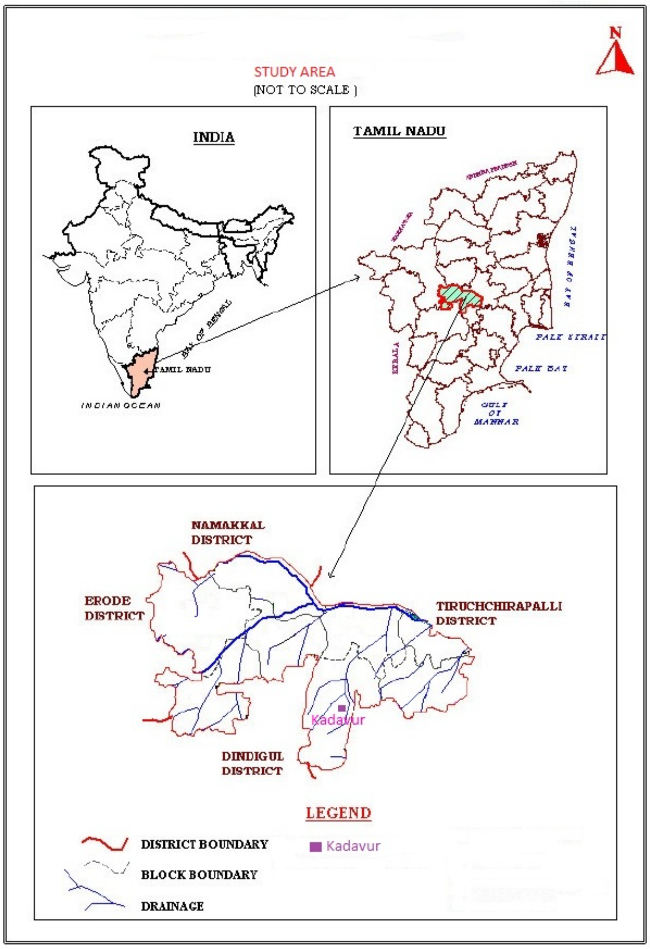


**Figure 2: Location map**

Karur district is divided into 4 taluks. The taluks are further divided into 8 blocks, which further divided into 203 villages.

| S.No. | Name of taluk | Area in ha. | No. of villages | Name of blocks | Area in ha. | No. of villages |
|---|---|---|---|---|---|---|
| 1 | Karur | 60643 | 52 | 1. Karur | 24335 | 26 |
| | | | | 2. Thanthoni | 36308 | 26 |
| 2 | Aravakurichi | 97616 | 58 | 1. Aravakurichi | 43689 | 22 |
| | | | | 2. K.Paramathi | 53927 | 36 |
| 3 | Kulithalai | 49081 | 45 | 1.Kulithalai | 18903 | 24 |
| | | | | 2. Thogamalai | 30178 | 21 |
| 4 | Krishnarayapuram | 82217 | 48 | 1. Krishnarayapuram | 39503 | 28 |
| | | | | 2. Kadavur | 42714 | 20 |
| | | | | | | |
| | Total | 289557 | 203 | | 289557 | 203 |
| Source: Department of Statistics, Karur | | | | | | |

**Table 3: Karur Taluk and Block details**

### 2.2 Geology of Tamil Nadu and Kadavur

Crystalline rocks of Archaean to late Proterozoic age occupy over 80% of the area of Tamil Nadu, while the rest is covered by Phanerozoic sedimentary rocks mainly along the coastal belt and in a few inland River valleys. The hard rock terrain comprises Charnockite and Khondalite groups and their migmatitic derivatives, supracrustal sequences of Sathyamangalam and Kolar groups and Peninsular Gneissic Complex (Bhavani Group), intruded by ultramafic-mafic complexes, basic dykes, granites and syenites. The sedimentary rocks of the coastal belt include fluviatile, fluvio-marine and marine sequences, such as Gondwana Supergroup (Carboniferous to Permian and Upper Jurassic to Lower Cretaceous), marine sediments of Cauvery basin (Lower Cretaceous to Paleogene), Cuddalore Formation (Mio-Pliocene) and sediments of Quaternary and Recent age. The crystalline rocks of the state are derived through a complex evolutionary history during Archaean and Proterozoic times with multiple deformations, anatexis, intrusions and polyphase metamorphic events, (GSI, 2010-11).

### 2.3 Geomorphology of Karur

The entire area of the district is a pediplain. The Rangamalai hills and Kadavur hills occurring in the southern side of the district constitutes the remnants of the much denuded Eastern Ghats and rise to heights of over 1031 m above mean sea level. From these hills the district slopes gently towards north east and forms a vast stretch of plain country till the eastern boarder of the district. There are numerous small residual hills represented by Ayyarmalai, Thanthonimalai and Velayuthampalayam hills. The general elevation of the area is ranging between 100 m and 200m above mean sea level The prominent geomorphic units identified in the district through interpretation of Satellite imagery are 1) Structural hill, 2) Pediments, 3) Shallow Pediments, 4) Buried Pediments and 5) Alluvial plain.

### 2.4 Soils of Karur

The soils of Karur district can be broadly classified into 4 major soils types viz., Red Soil, Thin Red Soil, Red Loam and River Alluvium Soil. Red soil is the predominant one covering major part of the district followed by Thin Red soil and Red loam. The red soils are predominantly seen in Kadavur, Kulithalai, Krishnarayapuram, Thanthoni and Thogamalai blocks. The thin red soils are seen in Aravakurichi and K.Paramathiy blocks. Major portion of the Karur block is covered by red loam.

## 3. METHODOLOGY

### 3.1 METHODLOGY

Image management follows the standard approach in LPS_PM (Leica Photogrammetry Suite – Photogrammetry Management) software as follows

| Steps | Process Flow |
|---|---|
| 1 | Image Acquisition |
| 2 | Create New project |
| 3 | Add imagery to the block file |
| 4 | Define the Camera Model |
| 5 | Perform automatic tie point collection |
| 6 | Perform Aerial Triangulation |
| 7 | DEM Generation |
| 8 | DEM Assessment |

**Taple 4. Process Flow**

#### 3.1.1 Image Acquisition

The Photogrammetric accuracy is dependent on image scale so 3D Modeling of Quarry must be taken by overlapping digital images acquired with Non-Metric camera Sony Alpha DSLR-A230 and focal length vary from 18mm to 55mm lens. Special care was undertaken so as the horizontal image angles be of small values. This is a fundamental restriction imposed by the structure of the Digital Photogrammetric Stations which are used for Photogrammetric mapping. Wide angles between stereo-pairs do not permit stereoscopic view and as a consequence calculations and three dimensional restitution. The overlapping images has been taken with 20˚ to 45˚ angle in Kadavur Quarry

#### 3.1.2 Create New Project

A new project using Sony digital camera images (7.2 mega pixels) of Kadavur Quarry, Tiruchirappalli, India. The images are in the format of .jpg format. Here transformed Cartesian Co-ordinate system is used as mentioned

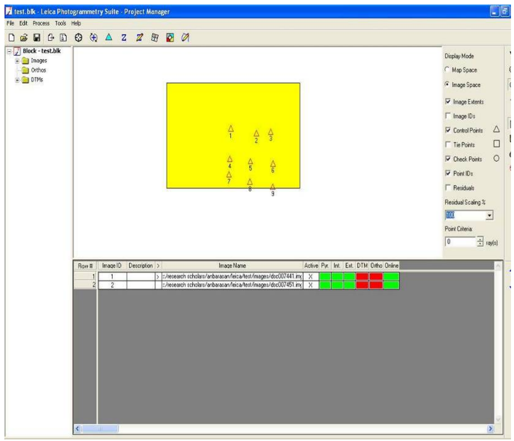

**Figure 3: Project Manager in LPS - GCP Points**

Decimal numbering of all sections is recommended. If bold printing is not available to you, use underlining, instead, but only for subheadings and subsubheadings, not for Major Headings.

#### 3.1.3 Add imagery to the block file

Using Add frame tools all the images are added in the LPS project Manager.

#### 3.1.4 Define the Camera Model

According to this paper, the Sony Digital camera- Cybershot has been used which is entered in the Digital Camera Frame Editor dialog box. And other parameter such as Focal Length, Interior Orientation (pixel size of X0, Y0) and Exterior Orientation.

#### 3.1.5 Perform automatic tie point collection

At this point in the process the control points (Fig.4) are collected in overlapping areas of images in the block file that determine the approximate exterior orientation parameters. Using point Measurement tool the Automatic tie point extraction have been carried out.

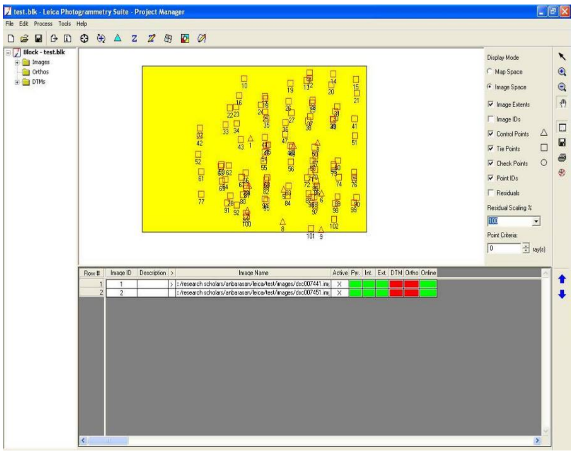

**Figure 4: Automatic Tie Points**

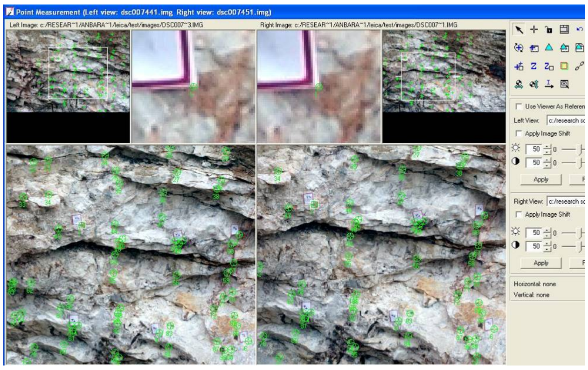

**Figure 5: Point Measurement (GCP, Tie points, Check points residual checking)**

**3.1.6 Perform Aerial Triangulation:** Now the control points are added using control point sketch. Then Aerial Triangulation property was setup and the run the AT process. Based on the GCP points and Image points residual error (Fig.7) the adjustment was repeated until the residual error within tolerance.

| Point # | Point ID | > | Description | Type | Usage | Active | X Reference | Y Reference | Z Reference |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | | | Full | Control | X | 78.265 | 306.500 | 10.665 |
| 3 | 3 | | | Full | Control | X | 78.365 | 305.500 | 10.780 |
| 4 | 4 | | | Full | Control | X | 78.160 | 307.500 | 10.500 |
| 5 | 5 | | | Full | Control | X | 78.200 | 306.250 | 10.625 |
| 6 | 6 | | | Full | Control | X | 78.300 | 305.250 | 10.600 |
| 7 | 7 | | | Full | Control | X | 78.175 | 308.000 | 10.525 |
| 8 | 8 | | | Full | Control | X | 78.325 | 306.000 | 10.500 |
| 9 | 9 | | | Full | Control | X | 78.350 | 305.500 | 10.575 |

| X Std. | Y Std. | Z Std. | X Residual | Y Residual | Z Residual |
|---|---|---|---|---|---|
| 10.000 | 10.000 | 10.000 | -0.061 | 0.228 | -0.042 |
| 10.000 | 10.000 | 10.000 | 0.003 | 0.524 | -0.020 |
| 10.000 | 10.000 | 10.000 | 0.000 | -0.063 | 0.016 |
| 10.000 | 10.000 | 10.000 | -0.001 | 0.271 | -0.024 |
| 10.000 | 10.000 | 10.000 | 0.073 | 0.155 | -0.098 |
| 10.000 | 10.000 | 10.000 | 0.000 | -0.063 | 0.000 |
| 10.000 | 10.000 | 10.000 | -0.119 | 0.322 | 0.127 |
| 10.000 | 10.000 | 10.000 | 0.008 | 0.036 | -0.103 |

GCP points residual

### 3.1.7 DEM Generation

DEM was generated from all coordinate points resulted from previous stage and then interpolated by Triangular Irregular Network (TIN) method. The TIN method was selected because of the simplicity and it's characteristic to maintain the position of known points.

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### 3.2 DEM Assessment

The DEM was generated by adding 10% of measured points to the particular surface, which the points were well distributed on the surface. The same process was repeated adding each time an additional 10% of the measured points, until the last DEM was created with 100% of the points. The point density ranging from 10% to 100% given. Each model was then compared to the reference DEM. Each model was then compared to the reference DEM so the morphological of the rock surface were viewed and determined.

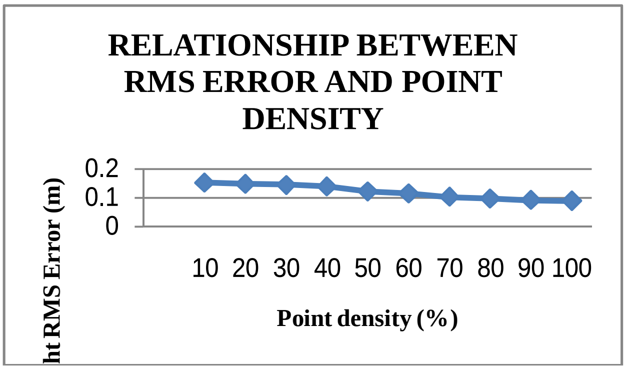


**Figure 6: Relationship between RMS Error and Point Density**

### 3.3 Field Photos:

The following photos are Field survey photo at Kadavur area.

**Figure 7: Field Photos**

### 3.4 References and/or Selected Bibliography

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## 4. CONCLUSION

### 4.1 Conclusion

DEM can be derived by using point-based matching from stereo photographs by Digital Stereo Model for Kadavur area. Significant improvement on the DEM quality was achieved by adding point density up to 60%. Increasing point density above 60% shows minimal variation on the error in elevation interpolation. Digital Close Range Photogrammetry (DCRP) can be applied due to reliability, accuracy, safety and cost advantages over conventional measurement techniques. In addition to these advantages, the 3D models which are obtained can be used for to measure the finite particles of rock surface and it's orientation of structural weakness such as small fracture , small cracks and cleavage. The geological structures are identified such as cleavage, minor cracks and minor fractures and mica assemblages. And any irrespective of the field to gather more finite detail information using DCRP technique.