# Experiences on Digital Photogrammetry and Remote Sensing - A Production Perspective

**By**
**Infotech Enterprises Ltd**

C. Hanuman Prasad
Asst. Project Manager
Infotech Enterprises Ltd
Plot-11, Software Units Layout
Cybercity, Madhapur
Hyderabad, India
www.infotechsw.com

## Abstract

The field of photogrammetry is a rapid science with new technologies being developed constantly. Within a short period of time, the practice of photogrammetry has changed from analog to digital. For the past five decades, conventional practice has been to fly aerial photography, manually process the negatives, diapositives, contact prints, and laboriously view the stereo images and capture features and topography. However, over the last decade, use of digital cameras and more importantly high resolution remote sensing satellite images have allowed firms like Infotech to use the latest technologies and serve various organizations/departments in the segments of utility management, natural resource information and urban planning to name a few. Most of the organizations use the digital data to streamline and enhance their decision-making process. Even in today's automated production environment, interactive data collection is still necessary. Infotech has mastered the synergy between automation and interactive photogrammetric tasks.

## Introduction:

The science of photogrammetry started early in the 20th century with simple mechanical devices to orient two photographs relative to each other and the resulting model relative to the ground. The technology progressed to the use of sophisticated optical-mechanical systems but the concepts remain the same.

The late 60's and early 70's saw the introduction of computers using the concept of analytical photogrammetry in order to control precision instruments to orient and measure the stereo models. The use of computers improved speed, efficiency, and accuracy.

The early 90's saw the introduction of soft copy photogrammetry. Soft copy is based on scanned photographs displayed on a computer screen with the same mathematical concepts. Soft copy displays two images on a single screen with special crystal glasses that allow the left and right eye to see the left and right images resulting in a 3D display. Soft copy photogrammetry allows us to view the ground with all the map data

superimposed on the stereo model in stereo and in color. Soft copy photogrammetry is now the leading technology for mapping.

**Transformation of Digital Photogrammetry in the fast moving world: A view on the Change of Technology Trends:**

(a) Aerial Triangulation with manual point selection – use of automatic point selection and autocorrelation combined with Bingo/Aerosys bundle adjustments for precise accuracies.

(b) Basic photogrammetry is to use aerial films - The present trend is to use digital images such as DMC, ADS40, Ultra Cam, or video sensors.

(c) Interactive collection of mass points with breaklines for creation of Digital Terrain Models – The present trend is to use LiDAR data for generation of contours and orthos and advanced Automatic DEM generation process with latest software.

(d) Repeated collection of survey ground control points and digital terrain model data for digital orthophotos – The present trend is to re-use all the high accuracy data in a process called “Second Generation Digital Orthophoto”.

(e) Low resolution Landsat and other satellite imagery - The current trend is to obtain high resolution (60 cm) high accuracy satellite imagery and RADAR Sat data.

**A Brief on the Technical approach on various processes by Infotech Enterprises in the present day scenario:**

Using softcopy photogrammetry in an advanced production environment is a challenge to satisfy two major elements - accuracy of data and speedy delivery. With the advent of latest trends in the technologies and unique customer requirements, photogrammetry production should imbibe the technical requirements of each process.

Automatic Aerial Triangulation is one of the major challenges in Digital Photogrammetry. Infotech is an expert in generating high accurate solutions using both semi-automatic and automatic methods. The semi-automatic methods are basically interactive and provide image-matching tools for identification of pre-selected tie points. In addition, digital imagery eliminates orientation procedures.

Conventional measurements were limited to the theoretical minimum of 9 points while special software such as ISDM allows measurements between 30 and 40 points including tie points between adjacent flight lines in half the time. This process results in better ties within the Aerial Triangulation block and can be refined and checked using interactive review and measurements. For large blocks exceeding 2000 images (photographs), auto-correlation method provides the best results when used with ABGPS/IMU data. Points

with high residuals are removed from the solution. With the help of foot print viewer, weak tie areas can be checked and edited manually.
Pre-surveyed controls would be measured with the help of sketches in the multi-photo environment. In case of second generation AT, the existing DOQQ or ortho photos are loaded into the project and the controls are measured simultaneously with their coordinates. This process is done automatically.

Once the point collection is completed in ISDM, the measurements are passed to Bingo bundle adjustment software which solves the block using Ground Control Points, ABGPS, or IMU data based on availability of data. We had identified the Bingo software as one of the best to solve big blocks of up to 10000 photos/images within a short span of time providing additional parameters for Quality Control and analysis. This gives the advantage of using only few GCPs and results in uniform block adjustment using ABGPS/IMU. This way, we are using the latest technology and combination of software to achieve high accuracies for a variety of projects ranging from engineering to land management.

The development of digital aerial cameras has advanced significantly over the past 4-5 years. At the same time, modern aerial film cameras have reached a high level of development with very high spatial resolution, geometric quality, and overall efficiency for mapping the ground data when combined with high-efficient photogrammetric scanners. For the aerial film camera to compete with the modern digital cameras film scanning has been automated and this has significantly reduced its cost. Film cameras are limited to one type of film for color, or cir, or panchromatic.

Digital cameras and sensors provide simultaneously four (4) colors (R,G,B, and IR) giving them an unsurpassed advantage over film-based image acquisition when multi-spectral imagery is required.

The use of digital aerial images would be more advantageous for all map and image production especially for ortho photo generation. Large scale mapping programs where ortho photo products are essential require speedy delivery with high accuracy. Since the digital aerial images are ready available as soon as aircraft lands, these images can be combined in the available elevation data to be put into ortho production. The high level of redundancy will enable near ‘real’ orthophotos based on the areas on each image around the principal point where relief displacement is a minimum. Another major advantage of digital aerial images is that it is devoid of scanning errors such as hair, dust, and unwanted film scratches.

With the advantage of high quality and high precision of digital images, the production speed of ortho photos will be high and this in turn leads to a most cost-effective method for photogrammetry production environment.

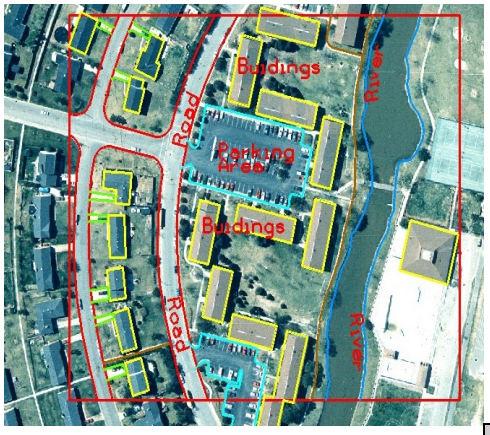
In order to provide users with digital orthophotos that have limited or no lean on tall buildings, Infotech generates “true” digital orthophotos. With the advent of digital

imagery, the orthophoto generation process can be carried out separately for the images having tall buildings with different angles. The ortho photo is generated using draw polygon method i.e. selecting each independent cluster of buildings with different leans. All the generated orthos with the same lean and shadow properties, will be mosaiced in Orthovista. Thereafter, these orthos are cut as bigger mosaic tiles as per the seamlines to join a perfect overlap. The main characteristic property in this type of ortho generation is compensation of occlusion by using patch of ortho image from adjacent ortho pair to overcome the lean and as per the cutline.

**Digital Elevation Models**

Creation of detailed elevation data has always been a time-consuming and challenging task. Although GPS technology and softcopy photogrammetric techniques have improved the process, there is still a considerable amount of effort and time involved in these tasks. With the latest trends in using LiDAR data, the processing time has been drastically reduced. Using the LiDAR technology, one can acquire thousands of square kilometers in a less than a day's time. Hence, the collection of mass points for creation of new DEM is no more required and break line collection is limited. Moreover, this process enhances the production efficiency and is advantageous to the mapping business. We have been integrating successfully LiDAR in various large-scale mapping programs across the globe. With the advent of software like Terrascan/Terramodeler and Interactive terrain editing tools in SOCET SET, the process has been made easy for generation of high accurate contour data.

Infotech uses sophisticated tools and wide variety of techniques to execute fast and high-quality planimetric mapping. Our experience encompasses a wide range of services and products ranging from stereo data compilation to 3D modeling. Utilizing a variety of platforms within the GIS and the CAD environment, Infotech has developed tools that enhance not only the speed of data collection, but also check the output for a consistent quality data.



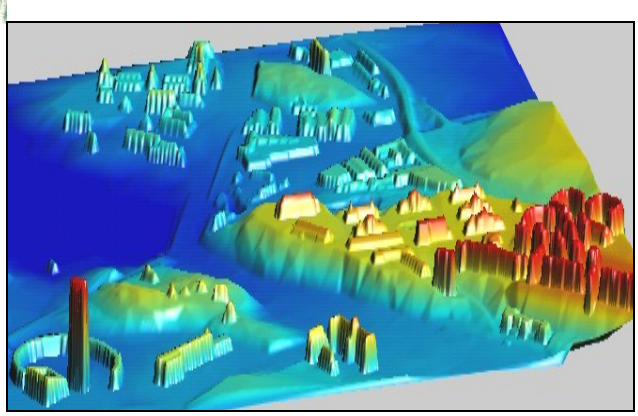



Fig-1 - Data Capturing Mode

Fig-2 - City Surface Modelling

We have developed number of tools which have improved our mapping processes and provide excellent quality for various applications such as urban management, transport management, vegetation mapping, town planning, and parcel mapping. Some of the tools which are used in our daily production are listed hereunder:

**Planimetric Tools**

**1) Linear and Polygon features digitization:**

- Auto ortho mode and close options will be used while digitizing buildings, ponds etc.
- Dynamic offsets will be used while digitizing roads

**2) Streams digitization:**

This tool ensures compliance to the downhill rule while digitizing streams or rivers. This tool restricts the operator to digitize uphill when the stream is running down.

**3) DTM Grid**

- DTM Points can be placed with the specified Grid Interval.
- User has to select Model Boundary & Start point for placing the mass points.

**4) Spot Label**

- Program places the spot height text along with the spot height cell

**MapEdit Tools**

**5) Break**

- Split the element into two/many elements

**6) Cell – Rotate**

- Tool to rotate an existing Cell with the specified Angle.

**7) Cell – Scale**

- Tool to Scale an existing Cell with the specified value.

**8) Cell - Replace**

- Tool for replacing an existing Cell with the given Cell.

**9) Deleting Masspoints vs Breaklines**

- Program will create bufferZone for all user selected linear elements level and delete the zero length element (Points) of user selected level.

**10) Quality Check Tools:**

- These tools run on a batch mode to give error logs for all quality checks listed based on the project requirements.

**LiDAR Data Processing**

LiDAR datasets contain vast amounts of information. Buildings, trees, and power lines are individually discernible features. This data is digital and is directly processed to produce detailed bare earth DEMs at vertical accuracies from 0.05 meters to .35 meter.

Derived products include contour maps, slope/aspect, three-dimensional topographic images, virtual reality visualizations, and more.

The most obvious advantages of LiDAR technology over the conventional photogrammetric mass-point collection are efficiencies involving time savings and point density. Conventional manual stereo- compilation techniques collect approximately 1,500 points per hour. LiDAR collects 10,000 points per second. LiDAR-collected data also are available for DTM generation and topographic mapping immediately following a scanning operation.

We, at Infotech, use a simple and native method of approach for LiDAR processing and the classification uses Terra Scan and Terra Modeler software.

Coordinate system and transformation for the dataset needs to be defined initially in the settings. Checking of the coverage of the dataset is done by reading every 10$^{th}$ point or 20$^{th}$ point depending on the area/size of the dataset. We have to draw the block boundaries so as to divide the entire project area into blocks having around approximately five million points in every block. We have to create the project for the dataset and read the laser points into the project by the block boundaries. We have to run the macros to ensure that the flight lines match each other and laser points and trajectories have matching number. It is suggested that classification of a single block should be carried out interactively starting from absolute elevation, low points, and ground depending on the classification schema. This is the best method for block assessment and planning. Thereafter, run the macro to classify big blocks in a batch mode. Create editable raster model and classify points using interactive tools by visually checking the raster surface model. Generate Surface and Contours for required contour interval.

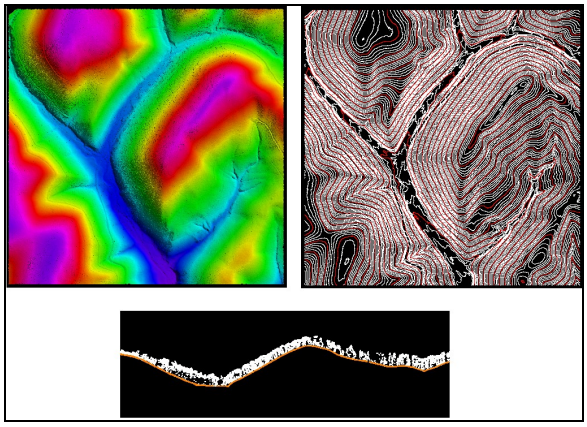


Fig-3 – LIDAR classification

**A brief review on Image processing ( Satellite Photogrammetry)**

In order to get high accurate ortho products from the satellite imageries, well-defined and distributed control points accompanied by Rational Polynomial Coefficients enable us to

get accuracies with no discernable loss. The accuracy of the control and tie points determine the accuracy of the multi-sensor bundle adjustment and, thus, the accuracy of the ground-to- image transformation. During the ortho-rectification process, the accuracy of the digital elevation model affects the final geodetic accuracy of the ortho-rectified image. Software such as SOCET SET, ERDAS, and PCI Geomatica can be used to get these high-precision products with uniform and seamless mosaics. These high-precision orthos are used for large-scale mapping with high accuracy.

The Basic QuickBird satellite imagery consists of Panchromatic(PAN) and Multi Spectral Sensor (MSS) images at the spatial resolutions 60 cm and 240 cm respectively. The data would be geo-referenced and ortho rectified to specific datum parameters. The PAN and the MSS data can be imported with the Ephemeris and Rational Polynomial data into the software environment. The images are controlled with enough Ground Control Points (GCP) collected from the reliable Ortho Quads as reference source data. The XY co-ordinates are supplemented with the Z co-ordinates taken from the DTED file as the DEM source. The images are subjected to photogrammetric triangulation method under SOCET SET environment. In the triangulation process, the images are supplemented with Rational Polynomial Coefficients to enhance the positional accuracy of the ortho output images. Under this process, the satellite images are first correlated with RPC information and then accuracy is tightened by using the GCPs.

The triangulated images are then ortho rectified using the DEM data. The PAN and MSS imagery would be rectified at 60 cm and 240 cm Ground Sample Distance (GSD) respectively.

The ortho-rectified PAN and MSS images are PAN-Sharpened under PCI Geomatica environment using UNB algorithm. This will be given a high quality Pan Sharpened data with minimized radiometric distortion and a perfect band to band registration. This product consists of high spatial resolution of 60cm with high spectral quality in multi band –Blue, Green, Red and Infrared output. This product enhances the features for ease of interpretation and presentation.

The pansharpened images are enhanced using various algorithms like Histogram Linear stretch, Standard deviations and by adjusting the look-up table to get the seamless radiometric appearance of the images.

**Conclusion**: With the advent of advanced technologies and latest software production environment, Remote Sensing and photogrammetry organizations can serve the customers around the world with highly accurate products delivered in time. In the present world of constant changes, engineering service providers with exposure to a wide variety of technical environments, would be able to cater to various segments of the industry.

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