DEM Reconstruction for Mizoram Area Using CARTOSAT Data and Preserving it by Cloud Computing Method

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1 Introduction

Digital elevation models (DEMs) are considered as one of the most important data used for geospatial analysis, as the detailed information we are getting from it. Thus, elevation modeling has become important for geospatial analysis. The large-scale mapping system is the result of development of remote sensing technology.

Cloud computing provides a solution to create, store, retrieve, and analyze data. Implementation of cloud computing is a transformative paradigm that enables scalable, convenient, and on-demand access to a shared pool of configurable computing and network resources for efficiently delivering applications and services over the Internet. Cloud computing involves provisioning of computing, networking, and storage resources on demand. Geographic information system has huge data and same is increasing day-to-day. CARTOSAT-I and II are the first two satellites of ISRO designed to provide high-resolution stereoimagery of earth's surface for the purpose of cartographic applications including generation and updation of topographic maps. CARTOSAT-I and II provide stereoscopic data with spatial resolution of 2.5 m and 0.8 m, respectively, and are uniquely designed with a high radiometric resolution of 10 bits and spectral bandwidth of 500–850 nm. In local language, the word Mizoram means "The land of highlanders". Basically, Mizo hill dominates the majority of the topography. The steep hills are separated by rivers flowing on either direction of north and south, creating gorges between the hills. Hence, high spatial resolution data is to enhance the capability of identification of best possible detail of features on image, improve accuracies and cartographic quality of mapping, produce accurate digital elevation models of the terrain, and extract relevant terrain parameters from DEM.

2   Objective of the Study

- The objective of the study is to reconstruct DEM using stereogrammetry and radargrammetry techniques on stereopairs of CARTOSAT 1 and RADARSAT 1 data products and subsequently the accuracy assessment using the available reference SRTM DEM.
- The objective is to attain the above result and to store huge data storage, processed data, and spatial data analysis, and is to develop the new application by implementing the Cloud Computing technologies.

3   Terrain Characteristics of the Mizoram

Mizoram is situated between 21° 58′ and 24° 29′ north latitude and 92° 29′ to 93° 22′ east longitude. It shares its geographical borders with Assam, Manipur, and Tripura extended over, respectively. The present investigation falls in the north Mizoram which is located nearly 30–35 km away from Aiwal, the capital of Mizoram (Fig. 1). The corresponding toposheets are 84A/9, 84A/13 and part of 84A/10, 84A/14, 83D/12, 83D/16 [1]. The geographical coordinates of the test site are as follows.

92° 27' 40.52'' E 24° 03' 28.01''N, 92° 59' 42.27'' E 24° 03' 28.01''N

92° 27' 40.52'' E 23° 38' 52.45''N.92° 59' 42.27'' E 23° 38' 52.45''N

Fig. 1. Study area, North Mizoram

4 Methodology

The methodology adopted in the present study can be categorized into two parts:

- Reconstruction of DEM and
- Accuracy assessment.

4.1 DEM Generation Using OPTICAL Data

Using PCI Geometica software, the automatic DEM extraction module allows you to create digital elevation models (DEMs) from stereoimages (CARTOSAT Data). Processes involved are as follows:

- **Data input**: A project file has been created with specified math model (Rational Function) and projection parameters (UTM, 43S D000). B and A and B and F along with its RPC (Rational Polynomial Coefficients) files are used for registration process.
- **GCP/TP collection**: Tie points were located carefully to compute transformation in order to improve the fit between two images, i.e., B and A and B and F. In the present investigation, 79 GCP/tie point and its RMS error are collected.
- **Epipolar pair generation**: Epipolar image reprojects the left and right images to a common orientation and the common features of the images to the same axis. B and F were selected as left image and B and A as right image.
- **Automatic DEM extraction**: Once the epipolar pair was constructed, then DEM has been extracted specifying the input parameters such as minimum and maximum elevation value of the region, failure and background value with the desired pixel spacing of the DEM. However, in this analysis, 100 and −150 are considered as the default failure value and background value, respectively. As the spatial resolution of the raw data is 2.5 m, hence, the spatial resolution of the reconstructed geo-coded DEM of 20 m can be obtained.

4.2 DEM Generation Using Field GCP

DGPS data are used to rectify the flight path/geometric error for scene no 5 data products. In order to achieve online positioning with high accuracies, the GPS is used in differential mode or differential GPS (DGPS). Since the field area is thick vegetation and undulation, the transmitting signals and line of sight are the major problems in real time, so data has been taken in static mode. Base station was established at Assam rifle camp, Seling [2]. This is nearly 30 km s from Aizwal city. Info/details of base station are

Job: 031106,
az Point ID,
ref: 1 antenna height 1100, and
GDOP: 2.3.

DGPS survey was carried out from Tuiaini suspension bridge to Darlawn. Total 34 GCP were collected which are homogeneous and well identifiable on the ground and records its location using the GPS receiver. These locations were plotted over an image, and DEM has been reconstructed as mentioned earlier.

4.3   Mosaic

Six scenes of CARTOSAT DEMs have been mosaic Using Ortho Engine of PCI Geomatica. Mosaic file had been defined and then by adding adjacent products.

4.4   DEM Generation Using RADARSAT 1 Data

The reconstruction of stereo-DEM has been carried out using the stereopairs of RADARSAT images with the help of Radar Mapping Suite of ERDAS imaging software for the overlapping regions of the two images: correlation image and constructed DEM.

4.5   Data Fusion or Merging

Scene no 3 (path/row no 0611-0286) has a huge cloud cover area; DEM has not come properly, and hence RADARSAT data has been used to mask the cloud cover area to get better DEM. Data merging or fusion procedure is as follows:

Cloud covered area has been masked using bitmap layer in which bitmap layer acts as a graphical layer having the same pixel and line dimensions as the image data. The masked region is assigned by value 1. Three new image channels, CARTOSAT (Bitmap), RADARSAT (translate data), and merge of both the data (EASI), were created, respectively. Translate utility is used to translate RADARSAT (.img) supported file format to CARTOSAT (.img) file from a geo-gateway format. While translating file, geo-referenced source and destination files are defined and then the layer information between the two files is shared.

The **Engineering Analysis and Scientific Interface** (**EASI**) is a full-featured interpreted programming language. EASI supports control structures such as for, while, and if statements, the definition of variables and structures, the definition of functions taking any number of arguments and providing a return value, and a powerful set of built-in intrinsic functions [3]. For present data fusion, small program has been used:

```
if %1 = 1 then
%3 = %2
end if
if %1 > 1 then
%3 = %1
end if
```

Here, %1 represents CARTOSAT product, %2 represents RADARSAT product, and %3 represents fused product.

5   Architecture of the New Application

To deploy this, application will not take more time and the application can be used for a more number of users in a short. SaaS model due to its varied advantage is quite attractive to enterprises. SaaS cloud is the latest model in deployment of software, where a GIS application is hosted as a service provided to customers across the Internet [4]. It is defined as a software application delivery model, where the same is deployed and hosted on a cloud platform for its customers to operate the application [5]. This innovative technology gives a full access to GIS tools such as creation of data, analysis of data, editing, and visualizing the data. When we compare the conventional GIS software with cloud, application has some unique features, i.e., this application hosted as web application and not being installed on-premise as it does not require the deployment of a large infrastructure at the client's location [6]. For the integration of SaaS, web services have become a widely adopted interface. SaaS applications represent their functions through web services, so that they can be easily accessed by on-premise applications and the same can be accessed from outside [7] (Figs. 2 and 3).
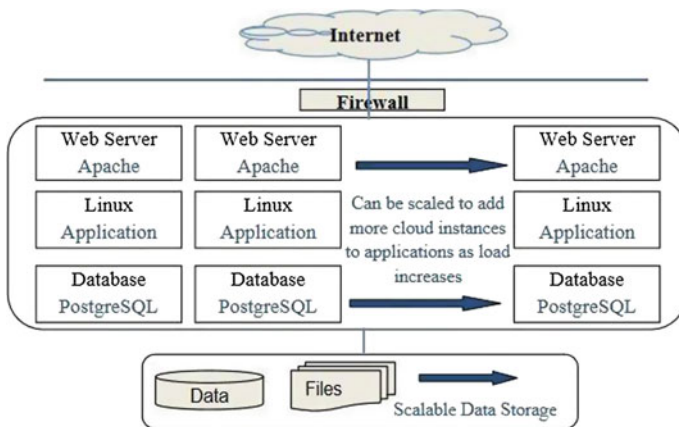
Fig. 2. Shows multiuser SaaS model

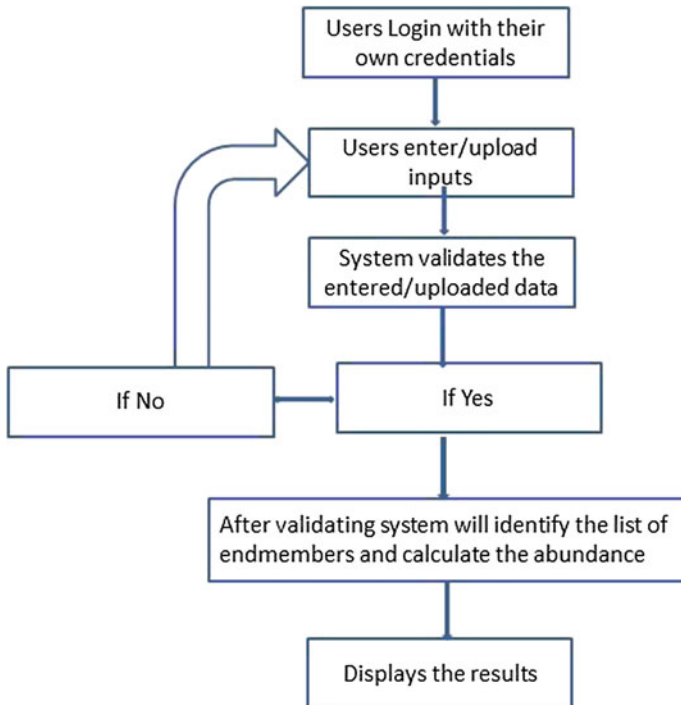## 6   Flow Diagram for the Application

See Fig. 3.

Fig. 3. Flow diagram of application

7   Result and Discussion

In order to check the accuracy of the reconstructed DEMs with respect to the reference SRTM DEMs, an accuracy assessment scheme is developed in-house. The validation of constructed high-resolution CARTOSAT DEM and SAR DEM was done with respect to **SRTM DEM** as "**Reference DEMs**" [7], using ERDAS Imagine s/w. The pixel spacing of the reference DEMs was resampled from 90 to 20 m to match with the spatial resolution of the reconstructed DEMs. Subsequently, the difference images were generated for common area, which are the product of pixel-to-pixel change detection of reference image from the corresponding subset of the target image under evaluation. When the height error is plotted against frequency of observation as histogram, it is observed that the histogram peak is shifted by few meters. This is because of datum shift as no external GCP was used in the initial images for registration. Hence, the plot

was shifted in X direction to account for highest number of pixels at 0 height error. Moreover, a correction factor was given to the reconstructed image based on the regression analysis results to scale the image with respect to "Reference DEM" and histogram was plotted based on the new difference image data. Subsequently, the error estimation was carried out on the difference images with respect to relief, slope, and slope-aspect categories. In below figure, the pixel deviation shown in red color has huge cloud patches. After replacing cloud patches with SAR data, the deviation has been improved which is represented in blue color (Fig. 4).
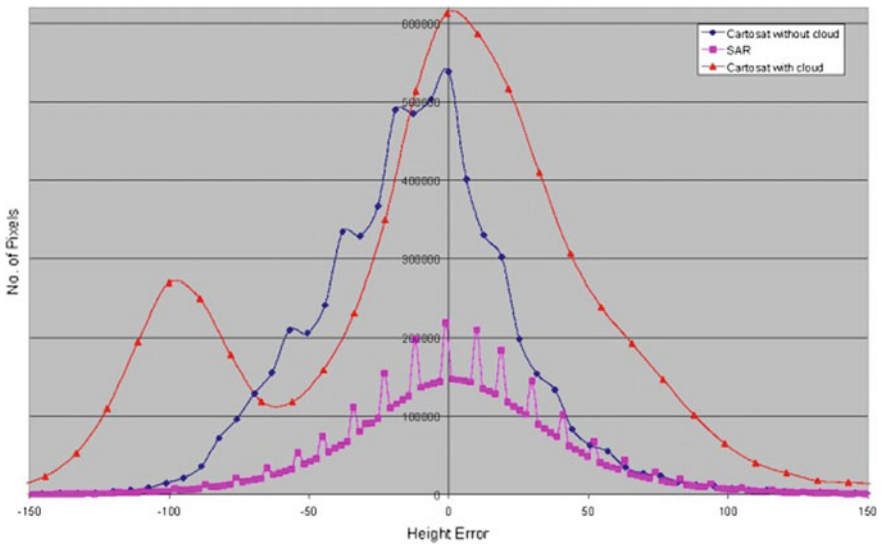
Fig. 4. Error histogram of CARTOSAT and SAR stereo-DEM

8   Conclusions

The extracted elevation values are compared with a derived topography of DEM available with DTRL and SRTM DEM [8]. While comparing all the possible combinations of the stereo-DEMs and CARTOSAT DEM, it is observed that the elevation results are better with less error in comparison with reference DEM using stereopairs of CARTOSAT data and the error standard deviation is consistently lesser for all types of terrain and slope conditions such as relative relief, slope, and slope aspect. The analysis of accuracy assessment revealed that the quality of DEM marginally degrades with increase in height of the terrain (SD 22.18 m, 31.13 m, and 33.41 m, respectively, for low, moderate, and high relief terrain). Comparison of DEM with reference to slope categories indicated that higher the slope, the poorer the results (SD 5.50, 19.93, and 19.66 m for Gentle, Moderate, and Steep Slope) although it demonstrated better results than absolute height ranges. The orientation of slope also plays a role in generation of

DEM [9]. The DEM of the region facing NW-N and W-NW has the most accurate pixels with least deviation (SD 9.59 and 11.52, respectively) from the reference height values, whereas S-SW and NE-E oriented slopes could generate least accurate DEM and their mean standard deviation in the difference image are 31.59 and 27.09, respectively. Better DEM can be achieved using field GCP, when compared to manually GCP/tie points collected. Comparative study of DEM accuracy shows more accurate that can be achieved using field GCP with respect to elevation and slope. Different data products can be used to remove bad data using data fusion/ merging techniques. Fusion of RADARSAT DEM with CARTOSAT DEM gives better result.

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