Design and Development of Software for Geometric Data Quality Evaluation of Satellite Imagery

Submitted By

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Design and Development of Software for Geometric Data Quality Evaluation of Satellite Imagery

Major Project

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Computer Science and Engineering

Submitted By

Ghata Ilavia

(15MCEC14)

Guided By

Prof. Monika Shah

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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Certificate

This is to certify that the major project entitled **"Design and Development of Software for Geometric Data Quality Evaluation of Satellite Imagery"** submitted by **Ghata Ilavia (Roll No: 15MCEC14)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science and Engineering of Nirma University, Ahmedabad, is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project part-II, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Declaration

The Major Project entitled **"Design and Development of Software for Geometric Data Quality Evaluation of Satellite Imagery "** submitted by **Ghata Ilavia (15MCEC14)**, towards the partial fulfillment of the requirements for the degree of Masters of Technology in Computer Science and Engineering, Nirma University, Ahmedabad is the record of her work carried out by under my supervision and guidance. The submitted work has reached a level required for being accepted for examination. The results embodied in this Project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Date: Place: Ahmedabad

Mrs. Shilpa Prakash
Scientist/Engineer-SF,
IAQD/SIPG/SAC/ISRO
Ahmedabad

Statement of Originality

I, **Ghata Ilavia**, Roll. No. **15MCEC14**, give undertaking that the Major Project entitled "**Design and Development of Software for Geometric Data Quality Evaluation of Satellite Imagery**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Computer Science & Engineering** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

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- Ghata Ilavia
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Abstract

Geometric data quality evaluation is a of formal procedure for estimating the geometric quality coming from satellite image data. For Doing geometric data quality evaluation established mathematical techniques and qualified geometric references are used. To facilitate this, display satellite data, reference data and integration of mathematical techniques are required. The generic image display software having the capability of displaying satellite image and reference image is build. Software engineering approach is adopted for the requirement analysis and design purpose. Functionality is extended to display the open street map vector tile of satellite images. For this purpose offline tile server is implemented.

Conventions

Typesetting

This thesis is typeset using Latex software.
Font used in this thesis are of Times new roman family.

Referencing

Referencing and citation style adopted in this thesis is ieee transaction(ieeetr).
For electronic references, Last publication date is shown here.

Spelling

The Unites States English Spelling is adopted here.

Units

The Units used in This thesis are based in the International System of Units(SI Units), unless specified.

Abbreviations

BBR	Band to Band registration
CALVAL	Calibration Validation
DEM	Digital Elevation Model
DQE	Data Quality Evaluation
DQEF	Data Quality Evaluation Facility
EMR	Electromagnetic radiation
GCP	Ground Control Point
GCPL	Ground Control Point Library
GDQE	Geometric Data Quality Evaluation
IMGEOS	Integrated Multi-Mission Ground Segment for Earth Observation Satellite
IRS	Indian Remote Sensing
MOSDAC	Meteorological & Oceanographic Satellite Data Archival Centre
MTF	Modulation Transfer Function
MX	Multi Spectral
NRSC	National Remote Sensing Center
OSM	Open Street Map
PSF	Point Spread Function
PSLV	Polar Satellite Launch Vehicle
RDQE	Radiometric Data Quality Evaluation
SAN	Storage Area Network
SLOL	SideLap-OverLap

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Chapter 1

Introduction

This dissertation is concern about the data quality of remote sensing images. In remote sensing, assessment of geometric and radiometric qualities of satellite imagery is an important component of satellite data product generation and dissemination. The supply of data products to users, in response to their requests, is carried out at the data processing and product generation at the National Remote Sensing Agency, Hyderabad which has been identified as exclusive distributor of data from IRS series satellites. Data processing and product generation attempts to process the remotely acquired data which should faithfully represent the geometric and radiometric properties of the ground scene. However, the raw data received at ground reception station has a systematic errors produced due to the imagining sensor characteristics, stability and orbit characteristics of the spacecraft platform, motion of the earth and atmospheric effects.
Data Quality Evaluation system provides important feedback to mission about platform performance regularly using system corrected user product as an input for all earth observations satellites of ISRO. There are different kinds of activity performed in DQE, activities are like RDQE, GDQE, CALDQE. Various types of DQE softwares are operationalized at Data Centers (IMGEOS, MOSDAC) for providing regular feedback on Data Quality for IRS & INSAT type of missions. Types of DQE Software are DQE Scheduler, Data Product Extraction S/W, Image Display, Mathematical Algorithms for quality Estimation, Report Generation Software, Calibration S/w, Quality Monitoring (Analysis Tools) (e.g. Web portal). In this dissertation Image Display S/w is elaborated. This software consists of two modules:
i) Design of generic image display used for displaying satellite image and references.

ii) Implementation of offline open street map tile server and integration with image display software.

1.1 Objective

The objectives of this research work is:

- To display the satellite image and reference image
- To perform different operations on images like zooming, panning, enhancement, feature marking etc.
- To build the offline open street map tile server
- To measure the geo location accuracy

1.2 Purpose

- Analyze how OSM map vector data overlaid to satellite data
- Perform geometric data quality evaluation and provide feedback to mission

1.3 Scope

- Design and development of software using software engineering approach
- Tile server restricted to offline usage

1.4 Motivation

- For Evaluation of new High Resolution Satellites
- For High resolution satellite like Carto series
- Build Software for muti-mission
- Adopting Newer techniques

1.5 Challenges

- Understanding the requirements is difficult
- Image Display should support different mission
- Different data type, data size is difficult to handle
- Higher data volume
- Time constraints

1.6 Background

1.6.1 Remote Sensing

Remote sensing is gaining the information about the earth using instrument like aircraft or satellite which are remote to the earth surface. To obtain the data instrument may use infrared, visible light or microwave radar. Comparatively for the large areas remote sensing offers the ability to observe and collect data quickly. Satellite remote sensing described as the use of satellite borne sensors to monitor, measure, and record the electromagnetic radiation reflected or emitted by the planet and its environment for resultant analysis and extraction of data. Instruments that used to compute the electromagnetic radiation reflected/emitted by the target are referred as remote sensors.[1] There are two type of remote sensors: Active sensor provides their own energy supply for illumination. Passive Sensor which measure energy that is naturally obtainable. The sensor emits radiation which is directed toward the target to be inspected. The radiation reflected from that target is identified and measured by the sensor. Advantage of active sensor include the ability to acquire measurement anytime, regardless of time of day or season.[1]
Types of satellite can be classified by their orbit characteristics. Low earth - satellites mostly used in spy satellite for the military purpose. Sun synchronous satellite a polar orbit where the satellite always crosses the equator at the similar local solar time. Geostationary satellite - satellite at very high attitudes, which view the same portion of the earths surface at all time.

1.6.2 Indian Remote Sensing Programme

Indian space effort had its unassertive beginnings in 1962 with the establishment of rocket launching station at a place in the southern part of India through which geomagnetic equator passes. In 1972, the Department of Space was authorized by Government of India, to encourage development and application of space science and technology for identified national socio-economic objectives. DOS activities comes directly under the Prime Minister of India. The space technology and applications functionality are carried out through the crucial units of Indian Space Research Organization and the independent institutions established for specific programme. Bhaskar and Bhaskara2 satellites are the successful demonstration flights launched in 1979 and 1981[2], respectively, India began to ripen the homegrown Indian Remote Sensing (IRS) satellite program to support the national economy in the areas of forestry and ecology, geology, agriculture, aquatic fisheries,water sheds, water resources, and coastal management. Towards this end, India perceived the National Natural Resources Management System for which the Department of Space is the nodal agency, giving operational remote sensing data services. Information from the Indian Remote Sensing satellites is received and distributed by a few nations everywhere throughout the world. With the approach of high resolution satellites new applications in the areas of urban sprawl, infrastructure planning and other extensive scale applications for mapping have been initiated.

1.6.3 IRS launch log

Following are the recent launches.

Serial No.	Satellite	Date of Launch	Launch Vehicle
1	Cartosat-2B	12 July 2010	PSLV-C15
2	Resourcesat-2	20 April 2011	PSLV-C16
3	Megha-Tropiques	12 October 2011	PSLV-C18
4	RISAT-1	26 April 2012	PSLV-C19
5	SARAL	25 February 2013	PSLV-C20
6	INSAT-3D	26 July 2013	Ariane-5
7	Cartosat-2C	22 June 2016	PSLV-C34
8	INSAT-3DR	8 September 2016	GSLV-F05
9	Resourcesat-2A	7 December 2016	PSLV-C36
10	Cartosat-2D	15 February 2017	PSLV-C37

Table 1.1: IRS launches

Chapter 2

Literature Survey

2.1 Geometric Errors and Corrections

The flux radiance registered by a remote sensing system preferably represents the radiant energy leaving the surface of earth like vegetation, water bodies, urban land etc. Unfortunately, this energy flux is interspersed with errors, both internal and external which exist as noise within the data. The internal errors, otherwise called systematic errors are sensor created in nature and therefore are systematic and relatively predictable. The external errors are largely because of perturbations in the platform or atmospheric scene characteristics. The technique used to correct this degradation/noise created in the image is Image preprocessing, In this way to create a corrected image which replicates the surface characteristics as could reasonably be expected. The change of a remotely sensed image, to facilitate it possesses the scale and projection properties of a given map projection, is called geometric correction or geo-referencing. A related method essential for geo-referencing, known as registration that deals with fitting of coordinate system of one image to that of a second image, both of the same area.
Geometric distortion can be conceivable by sensor characteristics. Sensor characteristics comprise optical distortion, aspect ratio, non-linear mirror velocity, detector geometry and scanning sequence, viewing geometry, panoramic effect, earth curvature, position variation (altitude, slew), earth rotation etc.[3]

Process of geometric correction consists of several steps:

- Select the appropriate projection or reference map.

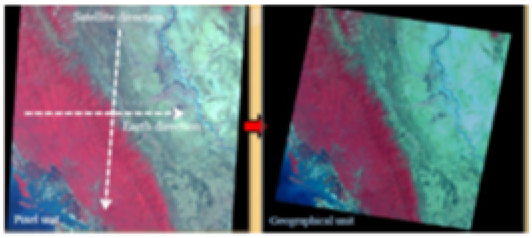

Figure 2.1: Geometric Correction

- Select a regular grid which fits the desired projection.
- Select a set of GCP whose locations in the base map can be determined accurately.
- Define the transformation and calculate the positions of the reference grid points in the image coordinate system.
- Resample the image data in order to assign gray values to each grid points.

2.2 Geometric Model

Imaging geometry model establishes a relation between an object point and its corresponding image coordinates. The relationship is established using a set of coordinate transformations utilizing the sensor, scene and platform related parameters. When images are required, images have to be referenced to ground. Since the ground projection of each pixel element is different, their geometry can be reconstructed using the payload parameters specified by instrument and mission team. Also, satellite is in motion during the acquisition process and its orientation parameter change as a function of time. There are single band and multiband detectors, for which same feature on ground is imaged at different times, hence images need to be registered. The orientation parameters need to be accounted while geometric correction and geo-referencing the imageries.[4] For carrying out above mentioned activities, the imaging geometry model forms the basis. This is achieved by collinearity model which utilizes the scene, sensor and platform specific parameters to map every point in image to ground.

Mathematics of Problem:

The relationship between the image and the corresponding ground coordinates is established by physical imaging condition model in the form of collinearity condition. Collinearity condition equation forms the basic model for geometric modeling software components. It states that the perspective center, image point and the corresponding ground point all line in a straight line. Imaging model can handle the individual stage alignment angles for TDI devices. Mathematically it can be stated as,

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = S.M. \begin{bmatrix} XA & - & XS \\ YA & - & YS \\ ZA & - & ZS \end{bmatrix}$$

where, (x,y,z) are image coordinate of a image point, s is a scale factor, M is the transformation matrix between object and image space. (XA,YA,ZA) are geocentric coordinates of a ground point. (XS,YS,ZS) are geocentric coordinates of the perspective center. (satellite position)

Input:

- Image/Ground coordinates
- Payload parameters which constitutes interior orientation parameter
- Time varying satellite orbit and altitude parameters which forms exterior orientation parameter
- Datum parameters
- Digital Elevation Model (DEM) of terrain

Methodology:

The mapping between image and ground adopted is based on photogrammetric collinearity condition which states that perspective center, object point and its corresponding image point should lie in a line. During image to ground transformation, ground coordinates is computed by making the look vector intersect with earths surface modeled as an ellipsoid. While ground to image transformation, though it is inverse problem, it requires searching of imaging time based on satisfying the collinearity condition.

Output:

- For a given image coordinates, computed ground coordinates in case of image to ground transformation.

- For a given ground coordinates, computed image coordinates in case of ground to image transformation.

2.3 Data Quality Evaluation Parameters

Data quality evaluation parameters are defined to qualify and quantify radiometric or geometric accuracy attained on user product. A range of DQE parameters are classified with respect to payload and platform stability.

Methodology

Data quality evaluation is mainly classified into two groups, geometric and radiometric.[3] In geometric assessment, the location accuracy of the data, attitude bias, internal distortion, band-to-band registration and scale is computed. Radiometric assessment is done in two ways, calibration based and scene related analysis.

Geometric data quality evaluation

- **Location accuracy**

  The difference between coordinates observed on satellite image and reference ground control points. The most widely used measure for representing accuracy is the root mean squared error. It is a dispersion measure, being almost equivalent to the average (absolute) deviation between two data sets. the location RMS error is computed:

$$Mean\ \mu_{x_i} = \Sigma_i^N (X_i - X_j)/N \tag{2.1}$$

$$RMS_{ERR} = \sqrt{\Sigma_i^N (X_i - X_j)^2/N} \tag{2.2}$$

$$StandardDeviation\ \sigma = \sqrt{\Sigma_i^N ((X_i - X_j) - \mu)^2/(N-1)} \tag{2.3}$$

  where Xi and Xj are the image coordinates and reference image coordinates, respectively and N is the number of samples.

- **Offset Correction**

  Further attempt has been made for updating and improving the geolocation accuracy of the data products by providing an offset improvement with the help of one ground control point as reference.

- **Internal Distortion**

  This term is defined to represent variation in location inaccuracy in the scene. This is calculated by keeping any one pixel and scan as reference and finding the distance from other control points, and the difference of distances between GCPs pairs and corresponding image point pairs:

$$ID = \sqrt{[((X_r - X_i) - (X_{ref} - X_j))^2/(n-1)]} \tag{2.4}$$

  where Xr and Xi are the reference and control point coordinates on the image; Xref and Xj are the coordinates of corresponding points in reference image/GCP; n is number of control points.

- **Band-to-band registration**

  For multispectral data BBR is one of very important parameters that need to be evaluated. The classification accuracy of the data and visual quality deeply depends on the precision of the BBR. For BBR evaluation, feature based correlation method is used to approximate BBR at sub-pixel accuracy.

2.4 Projection

Projection is a systematic transformation of the latitude and longitudes of locations on the surface of a sphere or an ellipsoid into location on plane.

2.4.1 Map Projection

In process of conversion of x,y to latitude/longitude tie-points and resolution of image is required for map projection.

$$MapX = TieX + ResolutionofImage * Pixel \tag{2.5}$$

$$MapY = TieY - ResolutionofImage * Scan \tag{2.6}$$

UTM Projection

the most familiar and commonly used Transverse Mercator whose natural origin lies on the equator. However, some territories use a Transverse Mercator with a natural origin

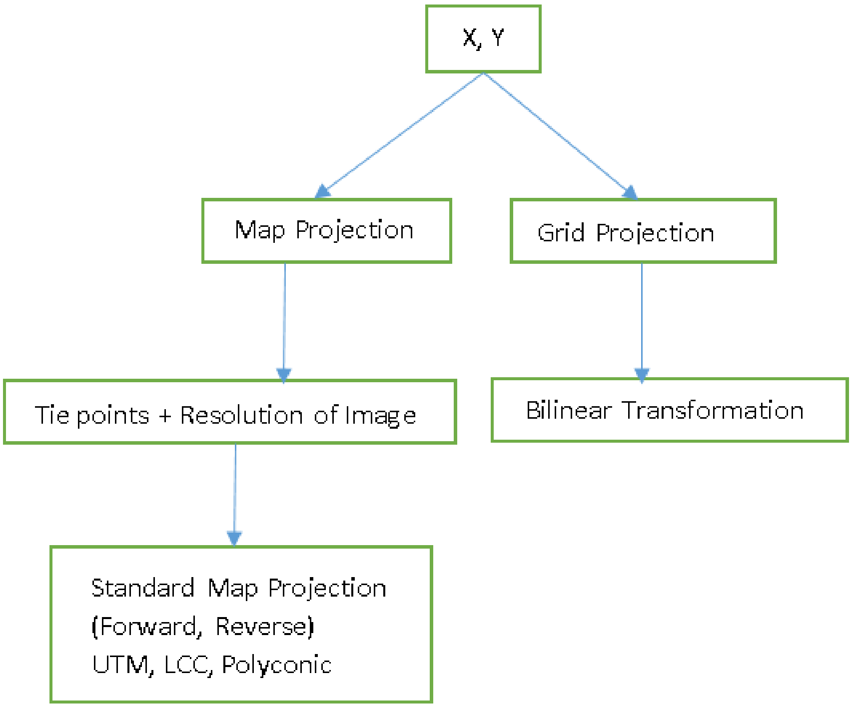

Figure 2.2: Conversion of X,Y into Latitude/Longitude

at latitude closer to that territory. In Epicentre the coordinate transformation method is the same for all forms of the Transverse Mercator Projection. The formulas to derive the projected Easting & Northing coordinates are in the form of series as follows:

Forward Map Projection:

Easting:

$$E = FE + k_0 v \left[A + (1 - T + c)A^3/6 + (5 - 18T + T^2 + 72C - 58e^{12})A^5/120 \right] \tag{2.7}$$

Northing:

$$N = FN + k_0 \left\{ M - M_0 + vtan\phi \begin{bmatrix} A^2/2 + (5 - T + 9C + 4C^2)A^4/24 + \\ (61 - 58T + T^2 + 600C - 330e^{12})A^6/720 \end{bmatrix} \right\} \tag{2.8}$$

where, $T = tan^2\phi$

$C = e^2/1 - e^2 * cos^2\phi = e'^2 cos^2\phi$

$A = (\lambda - \lambda_0)cos\phi$, with λ and λ_0 in radians

$$M = \alpha \begin{bmatrix} (1 - e^2/4 - 3e^4/64 - 5e^6/256 - ...)\phi \\ -(3e^2/8 + 3e^4/32 + 45e^6/1024 + ...)sin2\phi \\ +(15e^6/256 + 45e^6/1024 + ...)sin4\phi \\ -(35e^6/3072 + ...)sin6\phi + ... \end{bmatrix}$$ with ϕ in radians and M_0 for ϕ_0 , the latitude of the origin, derived in the same way.

Backward Map Projection Equation

The reverse formulas to convert Easting & Northing projecte coordinates to latitude & longitude are:

$$\phi = \phi_1 - v_1 tan\phi_1/\rho_1 \begin{bmatrix} D^2 - (5 + 3T_1 + 10C_1 - 4C_1^2 - 9e'^2)D^4/24 \\ +(61 + 90T_1 + 298C_1 + 45T_1^2 - 252e'^2 - 3C_1^2)D^6/720 \end{bmatrix} \tag{2.9}$$

where ϕ_1 may be found as for the cassini projection from:

$$\Lambda = \Lambda_0 + \begin{bmatrix} D - (1 + 2T_1 + C_1)D^3/6 \\ (5 - 2C_1 + 28T_1 - 3C_1^2 + 8e'^2 + 24T_1^2)D^5/120 \end{bmatrix} /cos\phi_1 \tag{2.10}$$

and where, $v_1 = \alpha/\sqrt{1 - e^2 sin^2\phi_1}$

$\rho_1 = \alpha - (1 - e^2)/(1 - e^2 sin^2\phi_1)^{3/2}$

$\phi_1 = \mu_1 + (3e_1/2 - 27e_1^3/32 + ...)sin2\mu_1$

$+ (21e_1^2/16 - 55e_1^4/32 + ...)sin4\mu_1$

$+ (151e_1^3/96 + ...)sin6\mu_1$

$+ (109e_1^4/512 - ...)sin8\mu_1 + ...$

$e_1 = 1 - (1 - e^2)^{1/2}/1 + (1 - e^2)^{1/2}$

$\mu_1 = M_1/\alpha(1 - e^2/4 - 3e^4/64 - 5e^6/256 - ...)$

$M_1 = M_0 + (N - FN)/k_0$

$T_1 = tan^2\phi_1$

$C_1 = e'^2 cos^2\phi$

$e'^2 = e^2/(1 - e^2)$

$D = E - FE/v_1 k_0$, with $v_1 = v$ for ϕ_1

2.4.2 Grid Projection

If point located in a grid corner x_1y_1 , x_2y_2 , x_3y_3 , x_4y_4 are known then latitude/longitude can be solved using bilinear equation.

$$\phi = ax + by + cxy + d \tag{2.11}$$

$$\begin{bmatrix} x_1 & y_1 & x_1y_1 & 1 \\ x_2 & y_2 & x_2y_2 & 1 \\ x_3 & y_3 & x_3y_3 & 1 \\ x_4 & y_4 & x_4y_4 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \end{bmatrix} = \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \\ \phi_4 \end{bmatrix}$$ Use the guassian method to solve the coefficient.

$$\lambda = a^{'}x + b'y + c^{'}xy + d' \tag{2.12}$$

$$\begin{bmatrix} x_1 & y_1 & x_1y_1 & 1 \\ x_2 & y_2 & x_2y_2 & 1 \\ x_3 & y_3 & x_3y_3 & 1 \\ x_4 & y_4 & x_4y_4 & 1 \end{bmatrix} \begin{bmatrix} a^{'} \\ b^{'} \\ c^{'} \\ d^{'} \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{bmatrix}$$ Use the guassian method to solve the coefficient.

2.5 Fetch Reference Image

Target image has four corner coordinates defines bounding box. Four corner coordinates are $\phi_1\lambda_1$, $\phi_1\lambda_2$, $\phi_2\lambda_1$, $\phi_2\lambda_2$ In target image there is some estimation of error that we take as a caution in calculation procedure.

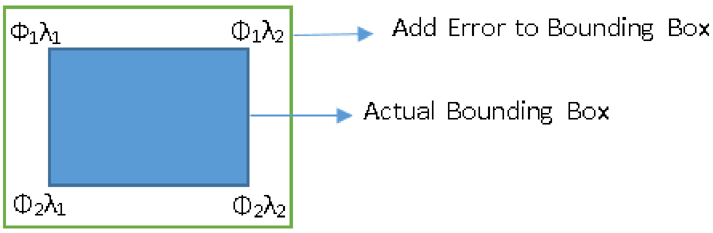

Figure 2.3: Bounding Box with Error Value

latitude: (ϕ_1,ϕ_2) + errϕ

longitude: (λ_1,λ_2) + errλ

So, the size of bounding box will increase. Bounding box represents the any of from four corners fall into reference image projected into the query image. If any of points of reference image fall into bounding box of target image that reference image will be fetched otherwise it is rejected.

e.g. $BoundingBox_{target}$ - ϕ_{1t} , ϕ_{2t} , λ_{1t} , λ_{2t}

$BoundingBox_{reference}$ - ϕ_{1r} , ϕ_{2r} , λ_{1r} , λ_{2r}

If ϕ_{1t} contains ϕ_{1r} OR ϕ_{2t} contains ϕ_{2r} AND λ_{1t} contains $_{1r}$ OR λ_{2t} contains λ_{2r} is true then reference is accepted and fetched otherwise rejected.

Chapter 3

Proposed System

3.1 Software Requirement Specification

ISRO has large number of microwave and optical remote sensing satellites for purpose of earth observation under the IRS programme. Each mission is designed with specific sensors onboard to acquire imagery suitable for end-application such as monitoring of land resources, ocean resources, agricultural studies, cartographic mappings and urban planning. Data acquired by IRS satellite is received and processed at IMGEOS facility set-up at NRSC. Major ground segment activities performed are data reception, ancillary & image data processing, data product generation, data quality assurance, data archival and data dissemination.

Objective of DQE: Data Quality Evaluation system provides important feedback to mission about platform performance regularly using system corrected user product as an input for all earth observations satellites of ISRO. There are different kinds of activity performed in DQE, activities are like RDQE, GDQE, CALDQE. Various types of DQE softwares are operationalized at Data Centers (IMGEOS, MOSDAC) for providing regular feedback on Data Quality for IRS & INSAT type of missions. Types of DQE Software are DQE Scheduler, Data Product Extraction S/W, Image Display, Mathematical Algorithms for quality Estimation, Report Generation Software, Calibration S/w, Quality Monitoring (Analysis Tools) (e.g. Web portal). In this document Image Display S/W is elaborated. Different types of operational DQE activities GLOC, RPCE, Targeting Accuracy, SLOL, BBR, RDQE, CALDQE-LEDCAL, Stellar Moon, Vicarious etc. are performed.

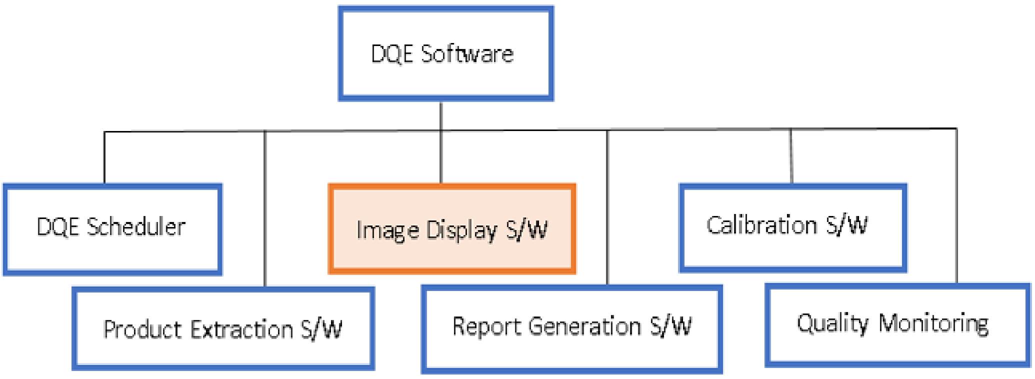

Figure 3.1: DQE Software

GLOC activity is for computing geo-location error, internal distortion and scale for the given product using control points identified on standard reference images.

SLOL is for computing common area between images of two adjacent strips in paint-brush acquisition or two scenes from multi-view mode. Sidelap is computed to estimate common area in across track direction, overlap is computed to estimate common area in along track direction.

Target accuracy is for estimating the targeting error i.e. the distance between intended and actual scene center trace for given scene. This parameter is mainly computed for agile platforms to find out the accuracy of targeting the user specified coordinates for acquisition.

BBR is for to estimate the mis-registration at sub-pixel level between different bands for MX data products. This activity will be carried out on RAD and GEO-Reference data Products.

RDQE is required to carry out radiometric evaluation of data products. RDQE facilities computation of scene based and target based radiometric quality parameters through interactive display. For identified homogeneous targets, target radiance, reflectance, SNR and spectral profile are computed.

Stellar calibration required to perform spatial characterization of sensor using stellar images. Parameter such as PSF, Effective spatial resolution, MTF and dark count will be estimated for each band/device for every stellar acquisition.

Moon Calibration is for to monitor radiometric stability at sensor level over the mission life time using moon as the stable radiometric source. Disc-integrated lunar irradiance/count and deep space statics shall be computed for each band for every lunar acquisition to study the temporal stability.

3.1.1 Overall Description of Software Product

Software Product Perspective

Proposed Software shall be used as Image Display tool for GLOC, GRPC, SLOL, & RDQE activities of DQE. However, the detailed requirements for GLOC activities are discussed in this document.

Purpose of GLOC activity is to compute geo-location error, internal distortion and scale for the given product of PAN & MX by using control points (features) identified on standard reference images. From the estimated location error, attitude biases will be computed. The generated results will be archived in database for mission monitoring.DQE activities, DQE parameters and it's purposes are listed in table2.1.

Activity	DQE Parameters	Type of Products	Purpose
Geometric DQE	1. Location Accuracy 2. Internal Distortion 3. Scale 4. Attitude Biases 5. Targeting Accuracy 6. Silelap/Overlap 7. Band-to-Band Registration	RAD, GEO	1. Platform Performance 2. Geometric Accuracy of Product
	8. Optiacal Butting mis-registration	RAD	
	9. RPC Evaluation	ortho-kit	
Radiometric DQE	**1. Scene based Parameters** Dynamic Rage Signal-to-Noise ration **2. Target Based Parameters** Signal-to-noise ration Spectral Profile Apparent Reflectance **3. Quality Verification Tool** Edge Spread/MTF	RAD	1. Payload Performance 2. Visuality of Images
Calibration DQE	1. Moon: Integrated radiance 2. Stellar: Point Spread Function	CAL products (RAD)	1. accuracy of Sensor 2. Radiometric Stability

Table 3.1: DQE Parameters

System Interfaces

There are two Modes of Operation Standalone, Through DQE Scheduler.

1. DQE Scheduler: It automates the process execution. DQE operation can perform jobs related to request fetching, request selection, data product extraction, execution of processing sequence and report generation for DQE activity. Through the DQE scheduler workfile is generated.

2. Data Product Extraction Tool: Data Product Extraction tool extract image and ancillary data from a data product, and organize it for performing the actual activity it is meant for. Data Product Extraction Tool generates the metafile.

3. Reference Database: Qualified references are available in the reference database like GCPL. Refimage.dat file that contains the information about references are obtained from reference database.

4. Tile Server: DQE activity pass the query to fetch the same region tile to the tile server. Tile server return the PNG tile to the DQE s/w.

5. DQE Result Database: Generated results (result.output) from the DQE activity will be archived in database for mission monitoring.

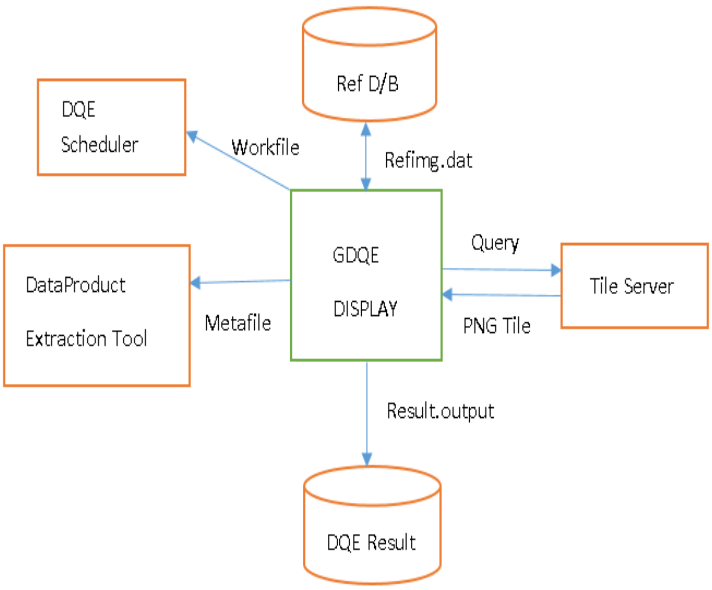

Figure 3.2: System Interfaces

System Features

The proposed software system shall be used for performing Geo-location error estimation, Sidelap/Overlap evaluation, RPC verification and Targeting Accuracy evaluation for different IRS missions. The software system shall be operated in two modes a) Standalone mode b) Invoked through DQE Scheduler for evaluation purpose. The input to the system shall be different types & levels of data products (referred as target image) of various IRS missions and references in raster/vector formats. The output of the system shall be control point information (generated from target & references) & geometric quality parameters derived from it. It shall have following major capabilities:

1. Extraction of Image & Ancillary Data from data products
   - If system operates in Scheduler mode, it shall read required inputs generated by Data Extraction Software
   - If the system operates in standalone mode, it should be able to independently extract image data & ancillary data (eg. Image Dimension, Format etc) from standard image formats (eg. TIF/HDF/netCDF).
   - It should extract all types of ancillary information related to geometry (Corner coordinates, Map Coordinates, Projection, Lat/Lon Grids, Satellite Ephemeris, RPC) from data product
   - It should support different levels of data products viz. RAW, RAD, GEO, Ortho-kit
2. Fetching of References & Extraction
   - If system operates in Scheduler mode, it should read & extract the reference images & ancillary data that is fetched by Reference Fetching software
   - If the system operates in standalone mode, it should fetch reference images corresponding to geometric extents of target from the reference image database
   - The System should also support fetching of references in vector format (eg. Open Street Map (Shape file)) for a given geometric location from off-line reference server/repository
3. Generic Image Display
   - It shall display the extracted target & reference image in Display Area in overview & detailed windows
   - It shall provide features for setting Image Display parameters like band-selection, zoom-factor and enhancement. It shall also support panning & scrolling in Images.
   - It shall display overlay vectors/polygons indicating boundaries of target & references on corresponding overview images
   - Image Display shall be generic to support viewing of single/multiple images for other DQE activities like Radiometric DQE or Image Analysis tools

- It shall support point feature identification on Target & Reference for Geometric DQE activity & also polygon features required for Radiometric DQE activity

4. Geometric Transformation of Images & Geo-linking

- The system shall make use of the geometric attributes of images (Projection, Grid or RPC) for purpose of conversion of image scan/pixel to Map Projection Coordinate System & Geographic Coordinate System

- The system shall also perform geometric transformation of image points to a defined common projection space

- The target & reference images shall be geo-linked. i.e By clicking on one image (target or reference), automatic navigation in other shall be done & displayed in display window, based on image geometry

5. Feature/Control Point Identification

- The system shall support identification of corresponding feature points on target & reference image. The identified control points shall be overlaid on image & displayed. Editing (delete, move, add) of points shall be provided.

- Probing facility shall be supported in the detailed image. In this selecting a location in the image (by placing a marker/cursor) shall display its location in different coordinate systems (scan/pix, lat/lon, easting/northing).

- The Selected points shall also be shown in text form in a table showing location of identified features in both images, their coordinates in common coordinate system like latitude-longitude or map-projected (in common map-projection)

- Facility to save the control points to a file & resume in a different session shall be provided.

6. Extraction & Visualization of Geometric Quality Parameters

- Based on the list of locations and errors of well distributed features in a common coordinate system, the system shall derive GDQE parameters - location accuracy, internal distortion, scale, residual attitude, sidelap-overlap and targeting accuracy.

- Statistics of location accuracy shall be reported in the form of mean, standard deviation and RMS in along, across and radial directions in both map-projected as well as image-space if relevant (RAD image).
- The internal distortion shall be reported in the image space
- Tools for visualization of geometric quality parameters shall be provided

User Interface

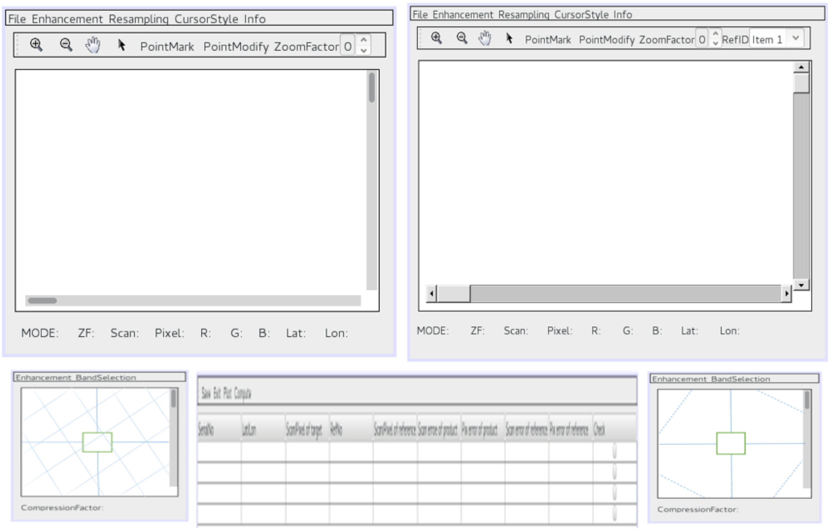

Figure 3.3: User Interface

Software Interfaces

Following software interfaces are required:
DQE Wrkfile: Workfile generated from DQE scheduler. It contains the information about different paths like input path, output path, intermediated path, history path etc.
DQE Meta-File: It generated from product extraction tool software. It contains the ancillary information about the image like number of scans, number of pixels, number of bands etc.
Refimg.dat: From the reference database refimg.dat is obtained. It contains the information about the reference images like type of reference and number of references.
PNG Tile: It generated from tile server. By querying the lat/lon information it fetches the tile from postgres database.

3.1.2 Software Product Functions

The top-level functional requirements of the software are shown in use-case diagram (Fig. 2.5) Description of each use-case is provided as follows:

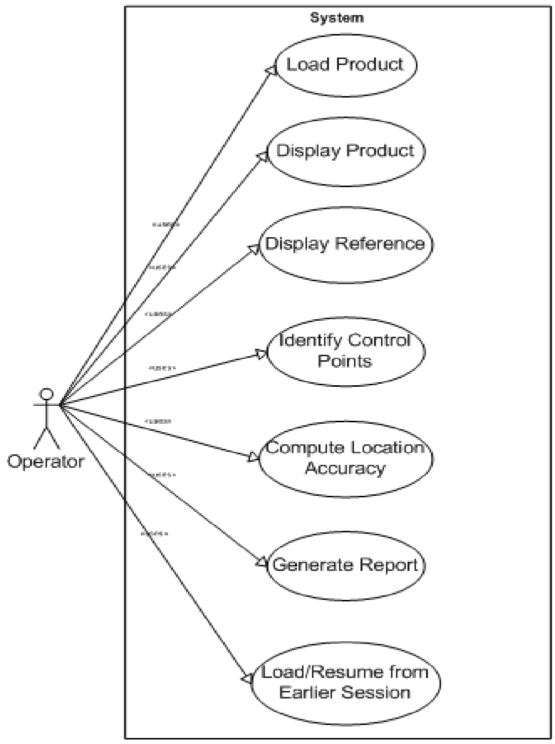

Figure 3.4: Top Level Functional Requirement use case

FUNC_REQ.1 Load Product

The software shall load data products (Ref. Def#1) of all IRS missions. The software shall be invoked in either stand-alone mode or through DQE Scheduler (External S/W) based on DQE work file.

The product specific input information (Meta-data & Image data) shall be generated by external software (Data Extraction Software) and provided in the form of Meta-file. Based on Meta-file, the software shall load the raster (image), ancillary & geometric information of selected data product. It shall support different levels of product i.e RAW, RAD, GEO, Ortho having single or multiple image bands. The image format supported by software shall be binary with data types Byte (8-bit), Unsigned Short (16-bit), Signed Short (16-bit), Float (32 bits).

FUNC_REQ.2 Display product

Loaded data product shall be shown in Overview and Detailed window. In Overview window, complete image will be displayed in a smaller size window. In detailed window, the any area of the image shall be viewable with selected zoom-level. For multi-band images, band selection option shall be provided. The detailed requirements for this use case are given in FUNC_REQ.2.1 & FUNC_REQ.2.2

FUNC_REQ.3 Load Reference

For the given data product, the information about the geometric reference images shall be generated by external software (Reference Selection software) and available in the form of a text file (RefImg.dat). The software shall load the ancillary, geometric & image information about the reference images from available text file for further use.

FUNC_REQ.4 Display Reference

Loaded references shall be shown in Overview and Detail window. If more than one references exist, option shall be provided to user for selection of reference image. In Overview window of product, boundaries of all the available references shall be shown in the form of polygons. The detailed requirements for this use case are given in FUNC_REQ.4.1 & FUNC_REQ.4.2

FUNC_REQ.5 Identify Control Points

The software shall provide Point Marking tools for identification of common features (or control points) in product & reference images. The identified control points shall be displayed in both the images. For each identified control point scan/pixel & geometric information i.e geographic Lat/Lon & Map coordinates as observed in each image shall be computed & stored for further use. Point editing facility shall be provided for moving/deleting or adding points. Facility of auto-navigation in reference (or vice-versa) shall be provided.

FUNC_REQ.5.1 Point Marking

FUNC_REQ.5.1.1 Point Marking Mode shall be provided for entering into point marking mode.

FUNC_REQ.5.1.2 For marking point, user should be able to select a feature in target OR reference detailed window by mouse click.

FUNC_REQ.5.1.3 The approximate location of the feature in other image shall be automatically determined based on auto-navigation & displayed to user. The user shall refine the point around approximate location by using point editing tools.

FUNC_REQ.5.1.4 The marked point should be displayed in different color in both windows detailed & overview for target & reference

FUNC_REQ.5.1.5 The scan/pixel, Lat/Lon & Easting/Northing of identified points shall be shown in a tabular format to the user. (Details in FUNC_REQ.5.1.5.1)

FUNC_REQ.5.1.6 The point details shall be stored in the form of a text file before exiting session

FUNC_REQ.5.1.7 Upon selection of a particular point from point table, corresponding point should be automatically displayed in target & reference detailed windows

FUNC_REQ.5.1.8 Point Editing Point Moving & Deletion shall be provided

FUNC_REQ.5.2 Auto-Navigation

FUNC_REQ.5.2.1 Scheme of auto-navigation in the other image for first point shall be based on image geometry.

FUNC_REQ.5.2.2 For second point, approximate position shall be refined based on the errors observed at previous point.

FUNC_REQ.5.2.3 From third point, approximate position shall be refined based on average error at first two points

FUNC_REQ.5.2.4 From fourth point onwards, approximate position shall be refined based on polynomial fitted error at previous points

FUNC_REQ.6 Compute Geo-Location Accuracy Parameters

Based on identified points Location error statistics & related parameters should be computed. Facility of visualization of selected quality parameter shall be provided. Following are detailed requirements.

FUNC_REQ.6.1 Facility to select model points from table as model or check points to compute Location Error Statistics

FUNC_REQ.6.2 Plotting panel to select columns from table interactively & visualize as plot

FUNC_REQ.6.3 Compute Scale, Internal Distortion & Attitude residuals

FUNC_REQ.7 Generate Report

FUNC_REQ.7.1 Geo-location Accuracy parameters generated through software shall be stored as a text file. Text file output shall be used for archival of computed parameters in DQE result database.

FUNC_REQ.7.2 A PDF report with details of all computed parameters & ancillary information shall be generated.

FUNC_REQ.8 Load/Resume from Earlier Session

FUNC_REQ.8.1 If point file is present for selected data product, the identified points shall be loaded & displayed at startup

FUNC_REQ.8.2 Editing of previously identified point & addition of new points should be possible

FUNC_REQ.2.1 Display product in Overview Window

In this section, the requirements of Product Overview Window (also referred as Target Overview Window) are listed. The use-case diagram shown in fig. 3.5 and design is shown in fig. 3.6

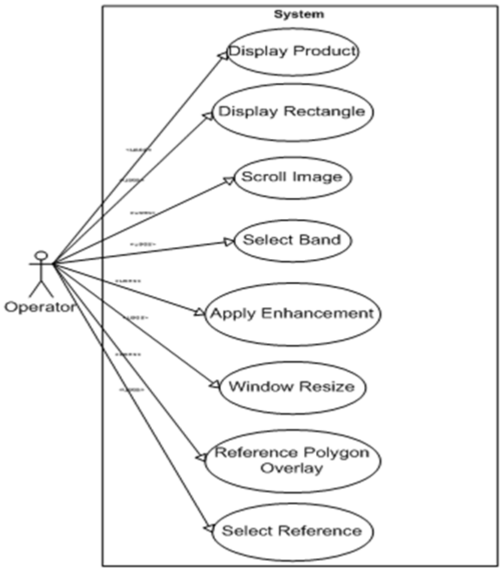

Figure 3.5: Target Overview Window UseCase

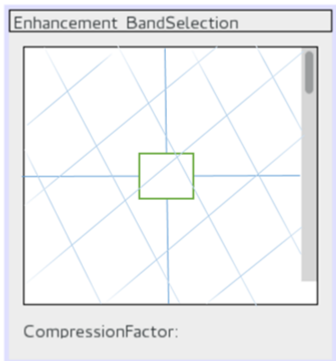

Figure 3.6: Target Overview Window GUI

FUNC_REQ.2.1.1 Display Product

FUNC_REQ.2.1.1.1 Complete Image shall be fitted & displayed in a smaller window of pre-defined size (depending on monitor size).

FUNC_REQ.2.1.1.2 Zoom factor will be computed as per the window size and image size.

FUNC_REQ.2.1.1.3 If the image size is too big then it will provide one scrollbar (horizontal/vertical).

FUNC_REQ.2.1.2 Display Rectangle

FUNC_REQ.2.1.2.1 In overview window, by default, the central portion of target image should be shown in rectangular box.

FUNC_REQ.2.1.2.2 Central portion of the image indicated by rectangle shall be shown in the detailed window, Cross hair at center to indicate current position in the detailed window.

FUNC_REQ.2.1.2.3 By dragging Rectangle, rectangle should move over overview window and corresponding image should get updated in detailed window

FUNC_REQ.2.1.2.4 Label showing current compression factor of overview window shall be provided

FUNC_REQ.2.1.3 Scroll Image

If scroll bar is updated, the Image shall be scrolled & shown in target overview window.

FUNC_REQ.2.1.4 Select Band

Band selection option should be provided. Handle for band selection will be common for both overview window as well as detailed window.

FUNC_REQ.2.1.5 Apply Enhancement

There should be provision for different enhancement techniques for each band

FUNC_REQ.2.1.6 Window Resize

FUNC_REQ.2.1.6.1 Window size shall be resizable. Aspect ratio of image to be preserved & total window size not exceeding a fixed value.

FUNC_REQ.2.1.6.2 Zoom factor & Scroll Bars will be re-computed as per the window size and image size

FUNC_REQ.2.1.7 Reference Polygon Overlay

Bounding boxes of reference images falling in the extent of target, shall be displayed & drawn as polygons in the Overview window with a different color.

FUNC_REQ.2.1.8 Select Reference

FUNC_REQ.2.1.8.1 Clicking on the reference polygon should provide the list of image references for selection.

FUNC_REQ.2.1.8.2 By selecting on a reference image, corresponding image should be displayed in Reference Window

FUNC_REQ.2.2 Display product in Detailed Window

In this section, the requirements of Product Detailed Window (also referred as Target Detailed Window) are listed. The use-case diagram is shown in fig. 3.7 and design is shown in fig. 3.8

FUNC_REQ.2.2.1 Display Product

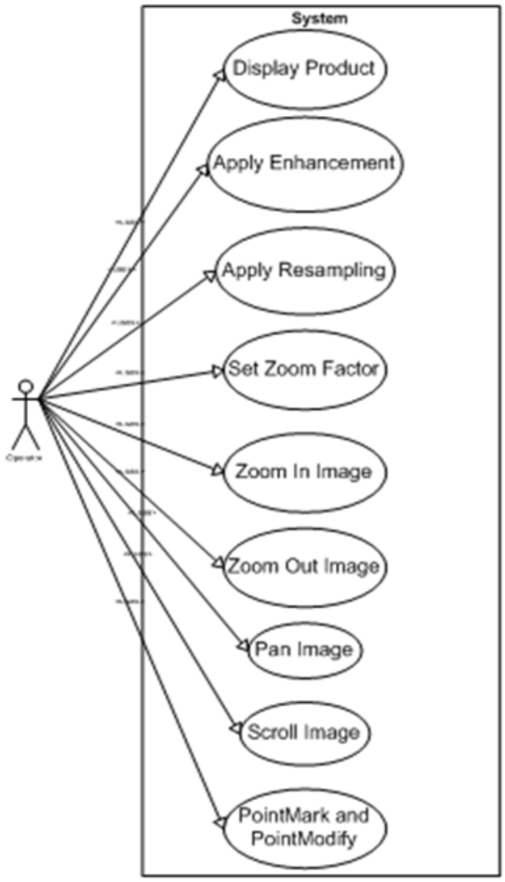

Figure 3.7: Target Detailed Window UseCase

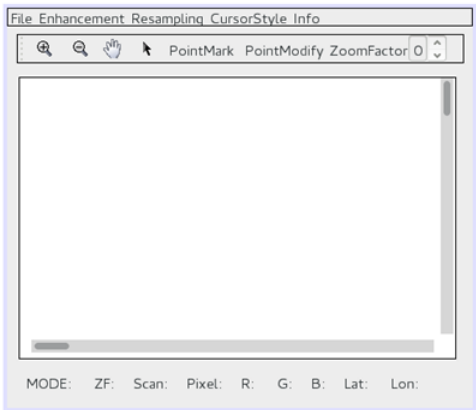

Figure 3.8: Target Detailed Window GUI

FUNC_REQ.2.2.1.1 The central position of target Image indicated by rectangular box of overview window should be shown in Detailed Window.

FUNC_REQ.2.2.1.2 Label Showing Zoom value, Mode, Cursor position and grey value of the target Image shall be provided.

FUNC_REQ.2.2.2 Apply Enhancement

It shall provide the different enhancement techniques for each band selection to the displayed area.

FUNC_REQ.2.2.3 Apply Resampling

It shall provide several resampling methods for the displayed image.

FUNC_REQ.2.2.4 Set Zoom Factor Click in the text area of Zoom Factor allows setting the zoom factor or by clicking the up and down arrow key of box allows changing the zoom factor.

FUNC_REQ.2.2.5 Zoom In Image

Zoom In shall allow any fractional values. It shall display the image in detailed level.

FUNC_REQ.2.2.6 Zoom Out Image

Zoom Out shall down sampled image in the factor of 1/2, 1/4, 1/6, and 1/8.

FUNC_REQ.2.2.7 Pan Image

By dragging the Pan cursor in the target detailed window it shall update the image displayed area of the target detailed window. It shall also change the rectangular box position of target overview window.

FUNC_REQ.2.2.8 Scroll Image

If scroll bar is updated, the Image shall be scrolled & shown in target detailed window.

FUNC_REQ.2.2.9 Point Mark and Point Modify.

It will allow marking and modifying the point on the image. (Details in FUNC_REQ.5.1)

FUNC_REQ.4.1 Display Reference in Overview Window

In this section, the requirements of Reference Overview Window are listed. The use-case diagram and design of Reference Overview Window is shown in Fig. 2.8

FUNC_REQ.4.1.1 Display Reference Image

FUNC_REQ.4.1.1.1 Reference Image will be down sampled in a tentative size of a smaller window.

FUNC_REQ.4.1.1.2 Zoom factor will be computed as per the window size and image size.

FUNC_REQ.4.1.1.3 If the image size is too big then it will provide one scrollbar (horizontal/vertical).

FUNC_REQ.4.1.2 Display Rectangle

FUNC_REQ.4.1.2.1 In reference overview window, rectangular box to indicate the portion of image displayed in detailed window should be shown.

FUNC_REQ.4.1.2.2 Central portion of the image indicated by rectangle shall be shown

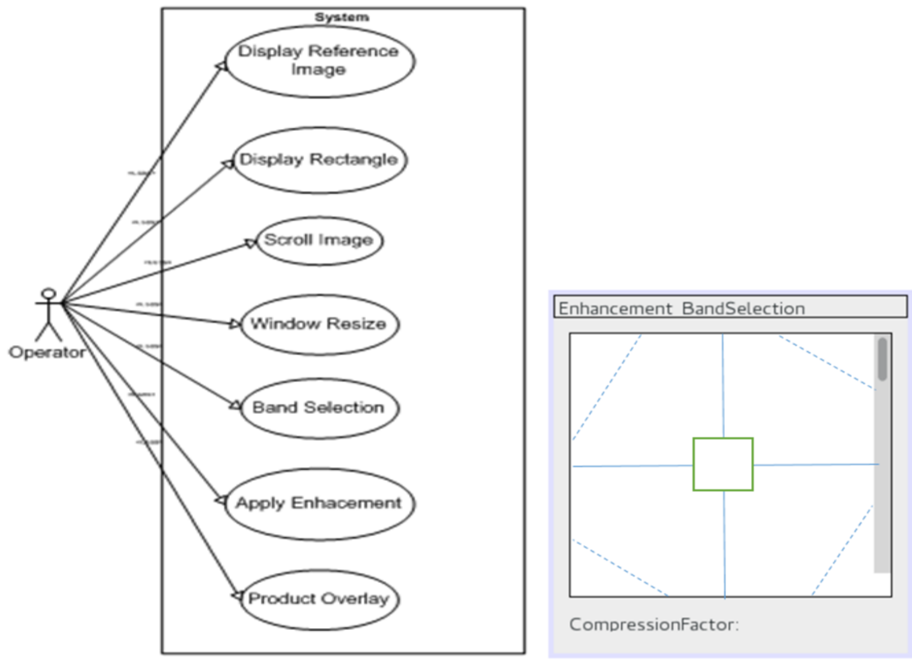

Figure 3.9: Reference Overview Window

in the detailed window, Cross hair at center to indicate current position in the detailed window.

FUNC_REQ.4.1.2.3 By dragging Rectangle, rectangle should move over reference overview window and corresponding image should get updated in reference detailed window

FUNC_REQ.4.1.2.4 Label showing current compression factor of overview window shall be provided

FUNC_REQ.4.1.3 Window Re-size

FUNC_REQ.4.1.3.1 Window size shall be re-sizable. Aspect ratio of image to be preserved & total window size not exceeding a fixed value.

FUNC_REQ.4.1.3.2 Zoom factor & Scroll Bars will be re-computed as per the window size and image size.

FUNC_REQ.4.1.4 Band Selection

Band selection option shall be provided. Handle for band selection will be common for both reference overview window as well as reference detailed window.

FUNC_REQ.4.1.5 Apply Enhancement There should be provision for different enhancement techniques for each band.

FUNC_REQ.4.1.6 Product Overlay

Bounding box of product image falling in the extent of reference, shall be displayed & drawn as polygons in the Overview window with a different color.

FUNC_REQ.4.2 Display Reference in Detailed Window

In this section, the requirements of Reference Detailed Window are listed. The use-case diagram and design of Reference Detailed Window is shown in Fig. 2.9

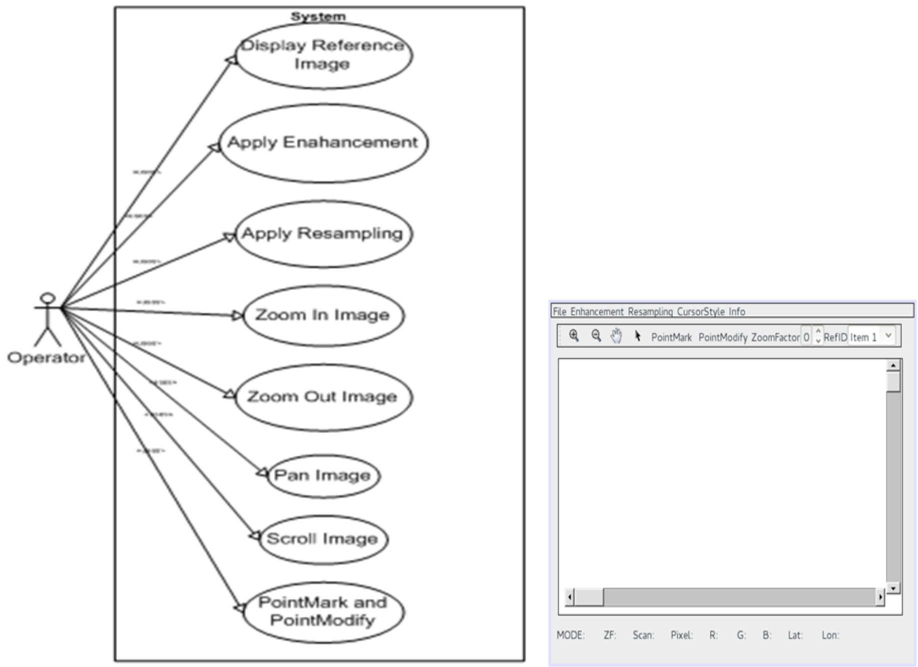

Figure 3.10: Reference Detailed Window

FUNC_REQ.4.2.1 Display Reference Image

FUNC_REQ.4.2.1.1 The central position of target Image indicated by rectangular box of overview window should be shown in Detailed Window.

FUNC_REQ.4.2.1.2 Label Showing Zoom value, Mode, Cursor position and grey value of the target Image shall be provided.

FUNC_REQ.4.2.2 Apply Enhancement

It shall provide the different enhancement techniques for each band selection to the displayed area.

FUNC_REQ.4.2.3 Apply Resampling

It shall provide several resampling methods for the displayed image.

FUNC_REQ.4.2.4 Zoom In Image

Zoom In shall allow any fractional values. It shall display the image in detailed level.

FUNC_REQ.4.2.5 Zoom Out Image

Zoom Out shall down sampled image in the factor of 1/2, 1/4, 1/6, and 1/8.

FUNC_REQ.4.2.6 Pan Image

By dragging the Pan cursor in the target detailed window it shall update the image displayed area of the target detailed window. It shall also change the rectangular box position of target overview window.

FUNC_REQ.4.2.7 Scroll Image

If scroll bar is updated, the Image shall be scrolled & shown in target detailed window.

FUNC_REQ.4.2.8 Point Mark and Point Modify

It will allow marking and modifying the point on the image. (Details in FUNC_REQ.5.1)

FUNC_REQ.5.1.5.1 Point Table:

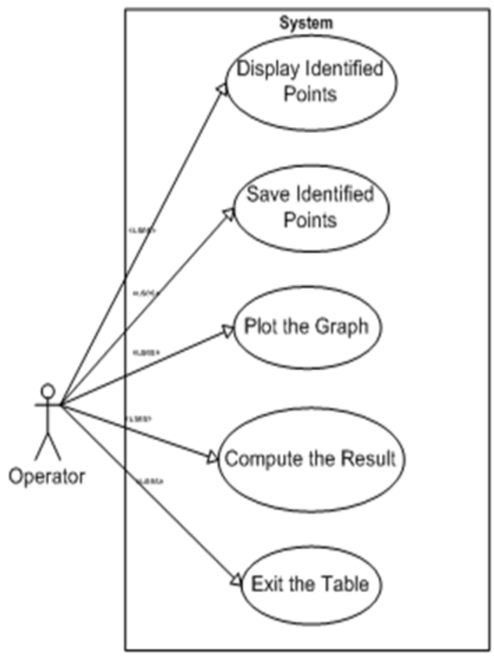

Figure 3.11: Table Window Function

FUNC_REQ.5.1.5.1.1.1 Displaying Identified points A table for displaying identified points shall be shown. For each point, table will show: serial number, latitude/longitude, target scan/pixel, reference number, reference scan/pixel, scan error of product, scan error of reference and check point status. One vertical scrollbar will be

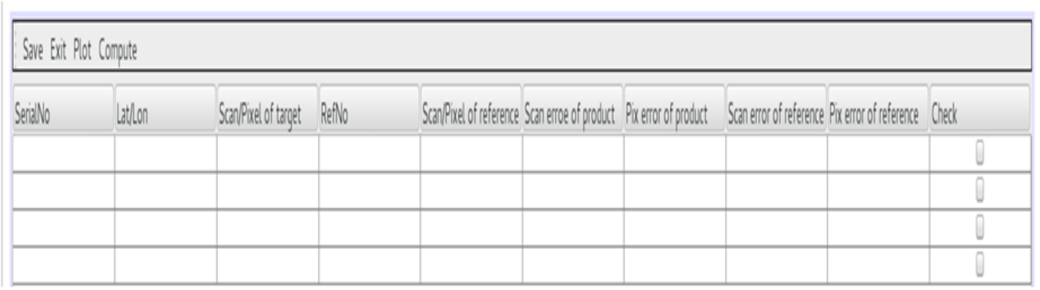

Figure 3.12: Table Window Frame

provided in the table. For operational use, following buttons are required: save, exit, compute and plot. Clicking on a point row in the table should display the point in target detailed window, select reference (if required), display in reference detailed window & highlight point in overview window.

FUNC_REQ.5.1.5.1.1.2 Save Identified Points Clicking on save button shall save the point information to file as per pre-defined format.

FUNC_REQ.5.1.5.1.1.3 Plot the Graph At click on the plot, it should generate plot tool box that provides the column chooser for X axis and Y axis. It should also provide the plotting chart type. After selecting all three options, click on the ok button it should generate the plot graph.

FUNC_REQ.5.1.5.1.1.4 Compute the Result At click on the compute, it should generate the compute panel that display computed errors of well distributed features in a common coordinate system. It should display the location accuracy, internal distortion, scale and residual attitude. The location accuracy can be reported in the form of mean, standard deviation and RMS in along.

FUNC_REQ.5.1.5.1.1.5 Exit the Table Save the points in a text file and generate a pdf. It should exit from the project.

3.1.3 Specific Requirements

External Interfaces

1. Facility to convert/extract data product into set of files in specified DQE format

Product Extraction Tool:

This tool should provide the facility to extract data Product.

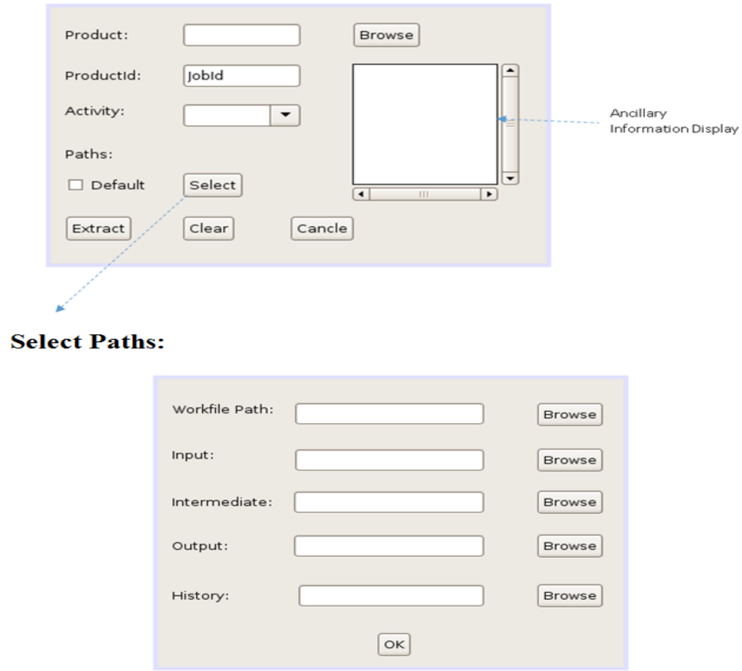

Figure 3.13: product Extraction Tool

INT_REQ.1.1

Products browse button should give the facility to select the data product.

INT_REQ.1.2

ProductId field should give the JobId.

INT_REQ.1.3

Activity ComboBox should provide the facility to choose one of the activity to be performed. Activities like GLOC, GRPC, RDQE, SLOL etc.

INT_REQ.1.4

Path Selection can be default or user selectable.

INT_REQ.1.4.1 On clicking the Select button: User Selectable Path should provide the path Selection for Workfile Path, Input Path, Intermediate Path, Output Path, and History Path.

INT_REQ.1.5

Text Area should display the ancillary information of product.

INT_REQ.1.6

There shall be buttons available like:

INT_REQ.1.6.1 Extract: It should convert/ extract data product into set of files in specified DQE format.

INT_REQ.1.6.2 Clear: It should clear all the fields of product selection tool.

INT_REQ.1.6.3 Cancel: It should close the product selection tool window.

2. UI/ tool for reference selection & extraction to specified path

Reference Selection Tool:

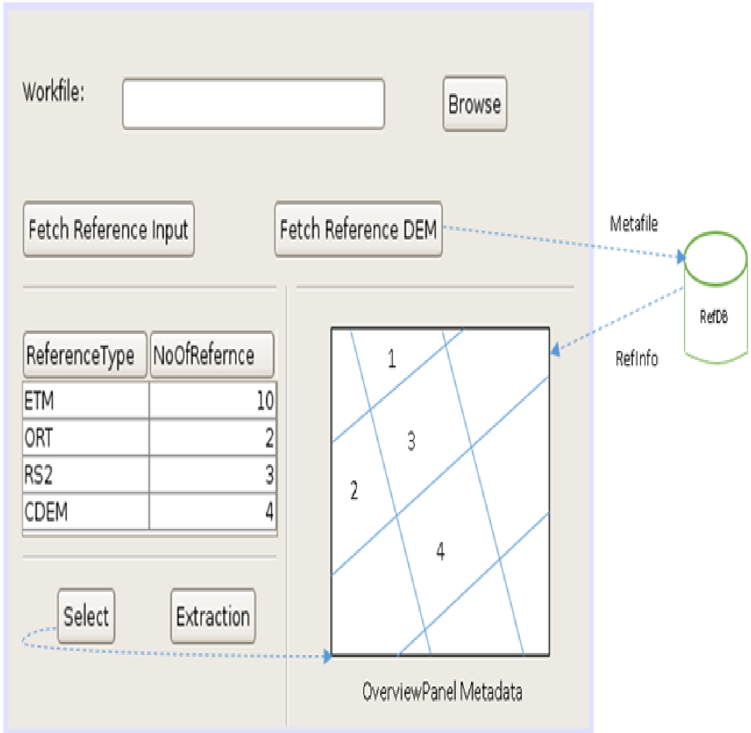

Figure 3.14: Refrence Selection Tool

This tool provides the facility for reference selection & extraction to specified path.

INT_REQ.2.1

Workfile browse button should provide the facility to choose the workfile from system.

INT_REQ.2.2

Fetch Reference Input and Fetch Reference DEM should fetch the reference from reference database using metafile.

INT_REQ.2.3

Reference database should display the reference information in the reference table.

INT_REQ.2.3.1 Table should have two columns: Reference Type and Number of Reference

INT_REQ.2.3.2 Reference type contains the type of references available like ETM, ORT, RS2, CDEM etc. NoOfReference should display the number of reference for each type available in corresponding field.

INT_REQ.2.4

Select Button: Select any of the reference type field and clicking on the select button, it should display the image in the Overview Panel.

INT_REQ.2.5

Extraction Button: At click on the extraction button

INT_REQ.2.5.1 It should create RefImage.dat

o/p: 1. Workfile (or workfile like JobId, Paths, Activity)

2. Extracted Image, grid, metafile.txt, Image Pyramids in input

INT_REQ.2.5.2 Extract RefImage if formatted (HDF, Mr. Sid, GTiff)

o/p: 1. RefImage.dat, Refdem.dat for selected ReferenceImage/DEM

2. Extracted References

3. RefImage Pyramids

INT_REQ.2.5.3 Create Reference Pyramids

3. Offline Tile Server

PostgreSQL is an Open Source relational database. PostgreSQL has geometry types.[5] The PostGIS extension for PostgreSQL is mostly used for geographic data. PostGIS insert geospatial functions and two metadata tables.[6] we do use all of these things on the tile server database when required by the Mapnik rendering engine.
osm2pgsql handles conversion of the planet data into the expected format. The mapnik database is populated by running an osm2pgsql.[7] Mapnik can generate map images to different formats JPEG, PNG, SVG, and PDF. OpenStreetMaps primary use of Mapnik involves rendering thousands of 256x256 pixel tiles.[8] Mod_tiles offers a dynamic mixture of efficient caching and on the fly rendering.

Functional Requirement:

INT_REQ.3.1 Get the tiles

Input:OpenStreetMap data in PBF format from http://planet.openstreetmap.org/

Output: Store pbf file to the specific location.

INT_REQ.3.2 Load tiles into database

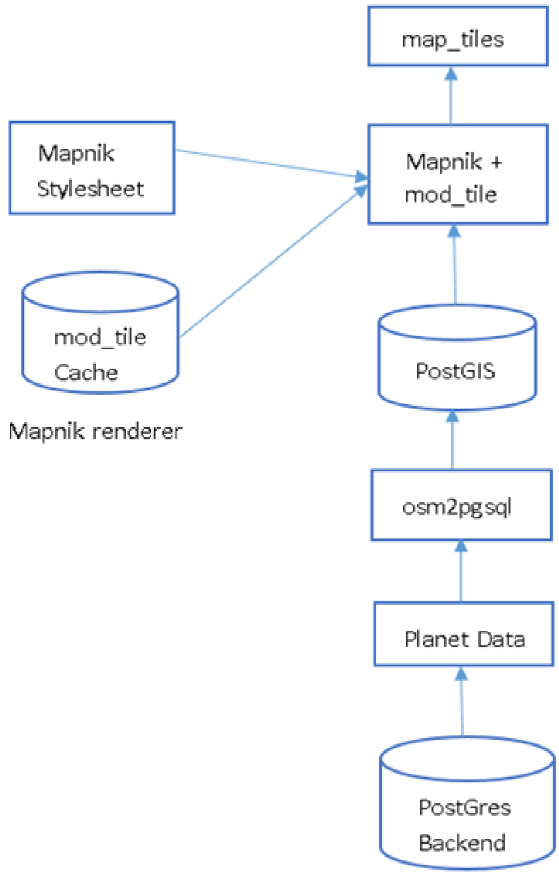

Figure 3.15: Tile Server Component

Input: Use osm2pgsql to load the data into database

Output: pbf file store in database format into the postgres

INT_REQ.3.3 Load tiles to the server

Input: renderd tile with the request on a browser

Output: store renderd tile in png format to the specific location

Interfaces:

PostgreSQL Server: To store the tile data we use the postgreSQL database. It has geometry types. For querying the tile it is used.

Apache Server: For the rendering request to tile the apache is needed.

Mapkit Application: It passes the query to the postgres which tile is needed and fetch that tile to display.

e.g. Identified the Latitude/Longitude of the required region and pass the zoom level.

For instance, if we pass the Lat:23.0, Lon:72.0, and zoom level:6 the it will return the tile of zoom level 6 with tile number x:44 and y:27.

Memory Requirement:

	City Sized Region	**Entire Planet**
Disk space	10 - 20GB	300GB+
RAM	4GB	24GB
Processor	a modern dual-core processor	a quad-core processor

Table 3.2: Memory Requirement for Tile Server

Database Requirement:

PostGIS: The PostGIS extension to PostgreSQL allows the use geographic extensions.

3.1.4 System Workflow

1. Quality Evaluation: Estimation of Geo-location error and related Parameters (GLOC)

1.1 Purpose

Purpose of GLOC activity is to compute geo-location error, internal distortion and scale for the given product of PAN & MX by using control points (features) identified on standard reference images. From the estimated location error, attitude biases will be computed. The generated results will be archived in database for mission monitoring.

1.2 Input/output Sequence

DQE workfile, extracted data product, geometric reference and vector tiles forms the basic input for this activity. GDQE operator is required to identify control points on the product and reference image. From the identified control points and using ancillary information of product & references, computation of Lat/Lon and projected coordinates for each of the control points will be carried out in common projection space. Further computation of location accuracy, scale, internal distortion computation and residual Roll, Pitch, Yaw will be carried out. At the end of activity, a geo-location accuracy report will be generated.

1.3 Functional Requirement

FUNC_REQ.1.3.1 Display facility to view product and reference images, handle to select different images from list of available references, displaying images in overview and detailed view, basic display related functionalities like zoom, pane, enhance, cursor selection and band combination selection.

FUNC_REQ.1.3.2 Facility to mark control points on target and reference images, edit the marked points and store scan/pixel information.

FUNC_REQ.1.3.3 Computation of map-coordinates, Lat/Lon for identified control points using ancillary information of the target and reference.

FUNC_REQ.1.3.4 Displaying location-error at each control point in a tabular format.

FUNC_REQ.1.3.5 Computation of location accuracy statistics (mean, standard deviation, RMS), scale, internal distortion and attitude (roll, pitch, yaw) residual.

FUNC_REQ.1.3.6 generate evaluation report to display consolidated output of analysis to the user in pdf format.

1.4 Configuration Parameters Requirement

Following are requirements for configurable parameters:

CONF_REQ.1.4.1 Details of system-id, database user on which references are stored

CONF_REQ.1.4.2 Valid reference types for a particular sensor

CONF_REQ.1.4.3 Path of reference images

CONF_REQ.1.4.4 Default projection, ellipsoid & datum for geometric computation

1.5 Logical Database requirement

Following are logical database requirements:

1.5.1 Capability to store computed parameters in along and across direction Location error, Internal distortion, Average scale, Residual roll, pitch, yaw and uncertainty in result database with proper units.

1.5.2 Capability to store product ancillary information and reference information

1.6 Assumption

1.6.1 Qualified references are available in reference database.

2. Quality Evaluation: Estimation of Targeting Accuracy (TRGT)

2.1 Purpose

Purpose of this activity is to estimate the targeting error i.e the distance between intended and actual scene center trace for a given scene. This parameter is mainly computed for agile platforms such as Cartosat-2C to find out the accuracy of targeting the user specified coordinates for acquisition.

2.2 Input/output Sequence

For this activity DQE work-file, extracted product, pass schedule file and information from database from the primary input. Reference images for selected product are also required for evaluation. Firstly, by using the inputs from pass scheduled file and database, the intended trace for the scene duration is generated. An interactive image display is shown to operator for identification of control points, the central pixel trace for given scene is generated. Central pixel coordinate and coordinate of corresponding point on intended trace is computed at regular time intervals. Average distance between above points is computed to compute targeting error in along and across directions. The output is displayed to the operator as a PDF report showing estimated parameters in graphical/tabular format.

2.3 Functional Requirement

FUNC_REQ.2.3.1 Generate intended trace for selected scene with inputs such as orbit number, session/strip/scene no. and scene start time. If required inputs are not available, exit the activity with proper error message.

FUNC_REQ.2.3.2 Fetch available reference images for input scene. If reference is not available, exit the activity with proper exit code. If successful, display list of available reference types to user. For selected reference type, fetch the reference information in form of a file.

FUNC_REQ.2.3.3 Display facility to view product and reference images, handle to select different images from list of available references, Displaying images in overview and detailed view, Basic display related functionalities like zoom, pan, enhance, cursor selection and band combination selection.

FUNC_REQ.2.3.4 Facility to mark control points on target & reference images, edit the marked points and store scan/pixel information.

FUNC_REQ.2.3.5 Generate of corrected central pixel trace from identified control points.

FUNC_REQ.2.3.6 Compute central pixel coordinate and coordinate of corresponding point on intended trace at regular time intervals

FUNC_REQ.2.3.7 Compute average along and across distance between above points for scene duration using suitable map projection.

FUNC_REQ.2.3.8 Generate report showing statics of targeting error (min, max, mean) in both directions in form of tables/plots.

2.4 Configuration Parameters Requirement

Following are configurable parameter requirements:

1. Path of L-0 outputs

2.5 Logical Database requirement

Following are logical database requirements:

1. Capability to archive estimated targeting accuracy in both directions (min, max, mean, standard deviation) in meters in result database.

2. Capability to store product ancillary information in database.

2.6 Assumption

1. Module for intended trace generation will be supplied by the mission team.

3. Quality Evaluation: Estimation of Sidelap/Overlap(GSLO)

3.1 Purpose

Purpose of this activity is to compute common area images of two adjacent strips in a paint-brush acquisition or two scenes from muti-view mode. Sidelap is computed to estimate common area in across track direction, Overlap is computed to estimate common area in along track direction. Overlap is computed between two adjacent scenes within a strip to verify the scene framing. During initial phase and maneuvers sidelap will be monitored.

3.2 Input/output Sequence

Input to this activity is DQE work-file and two extracted products belonging to adjacent strips or overlapping scenes from PB/Muti-view acquisition. An interactive image display is invoked for identification of common feature points between two scenes. For computation of sidelap and overlap, across track and along track distance between common points is respectively estimated. At the end, a detailed report in PDF format is generated to show sidelap/overlap statics.

3.3 Functional Requirement

FUNC_REQ.3.3.1 Simultaneous display of both the selected products. Basic display related functionalities like zoom, pan, enhance, cursor selection. Handle to choose band combination to display FCC.

FUNC_REQ.3.3.2 Capability to identify same features on both the products. To be able to edit a marked point. Deletion facility for an identified point is also required.

FUNC_REQ.3.3.3 Selection/rejection of points for computation should be possible.

FUNC_REQ.3.3.4 Automatic navigation in forward and backward direction for control point identification.

FUNC_REQ.3.3.5 Display side/overlap values with each control point in tabular format.

FUNC_REQ.3.3.6 Generate report for computed parameters in PDF format showing tables/plots.

3.4 Configuration Parameters Requirement

No configurable parameter requirements.

3.5 Logical Database requirement

Following are logical database requirements:

1. Capacity to archive computed parameters sidelap and overlap (min, max, mean) in meters, pixels and percentage in result database.

2. Capability to store product ancillary information in database.

4. Quality Evaluation: RPC Validation (GRPC)

4.1 Purpose

Purpose of this activity is to verify RPC coefficient for given product (ortho-kit) at product corners and identified control points. Internal distortion in product is also evaluated by making use of RPC computed image coordinates.

4.2 Input/output Sequence

DQE-workfile, extracted product and RPC file forms the primary input to this activity. For the selected product, reference image and DEM are also required for evaluation. After reference selection and fetching, the operator marks control points on target and reference image. At, these points, RPC scan/pix are computed using reference Lat/Lon/Height information & RPC coefficients. Error between RPC and actual coordinates is computed for all points. Internal distortion statistics are also computed by using error at control points. Error at product corners is computed by making use of product corner coordinates and mean elevation supplied with product. The output is in the form of detailed report displaying product ancillary information and computed parameters.

4.3 Functional Requirement

FUNC_REQ.4.3.1 Display facility to view product and reference images, handle to select different images from list of available references, Displaying images in overview and detailed view, Basic display related functionalities like zoom, pan, enhance, cursor selection and band combination selection.

FUNC_REQ.4.3.2 Facility to mark control points on target & reference images, edit the marked points and store scan/pixel information.

FUNC_REQ.4.3.3 Computation of scan-pix through RPC coefficient (ground to image mapping) for identified points using Lat/Lon/Height information of references.

FUNC_REQ.4.3.4 Computation of error between RPC scan/pix & observed scan/pix for each control point, estimate error statistics.

FUNC_REQ.4.3.5 Computation of Internal distortion by making use of RPC computed Scan/Pix.

FUNC_REQ.4.3.6 Verification of RPC generated Scan/Pix at product corners through ground to image mapping using mean elevation provided with product metadata.

FUNC_REQ.4.3.7 Generate evaluation report to display consolidated output of analysis to the user in pdf format.

4.4 Configuration Parameters Requirement

No configurable parameter requirements.

4.5 Logical Database requirement

Following are logical database requirements:

1. Capability to archive computed parameters in along and across directions- RPC error (mean, standard deviation, RMS) at control points/corners and Internal Distortion in result database with proper units.

2. Capability to store product ancillary information in database.

3.1.5 Performance Requirements

It shall able to handle the large size of images in bound time manner.

Accuracy Requirements

1. Geometric quality parameters shall be computed using qualified high resolution geometric references. Accuracy of the quality parameters shall be limited to the accuracy of the reference & accuracy of precise control points identified by the operator.

2. For computation of effective resolution, higher zoom levels shall be used.

Precision Requirements

All the quality parameters shall be reported with appropriate precision taking into account uncertainty involved in computation.

Latent Defect Requirements

All the critical defects observed in the software during testing shall be resolved before ope-rationalization. Other defects may be categorized as minor/significant.

3.1.6 Capacity & Scalability Requirements

Database Size requirements

GDQE Result database is required to support evaluation activity. This database is already exist in DQE software.

Data Volume Requirements

Data Product Size, Size of Intermediate/Output Files, Size of Reference Images Categorise :
Multi-Spectral
High Resolution (Cartosat-2S)
Medium Resolution, (RS-2/2A, RISAT)
Coarse Resolution (Oceansat-2)
Hyper Spectral (IMS, AVIRIS)
For extracted product(one scene):

Cartosat-2S	PAN	MX	
Data Product Size	512MB	360MB	
Resourcesat-2/2A	AWIFS	L-3	L-4
Data Product Size	522MB	260MB	780MB
RISAT-1	CRS	MRS	FRS
Data Product Size	540MB	280MB	240MB
Ocesansat-2	OCM-2 LAC		
Data Product Size	676MB		
IMS	MX	HySI	
Data Product Size	24MB	9.7MB	
AVIRIS/Hyperion			
Data Product Size	6.27MB		

Table 3.3: Data volume for extracted product

Reference Image Spatial Resolution	Mission/Sensor	Spectral Bands	Data Volume of Single Image of Single Image	Missions in which reference image will be used image will be used
2.5m, 5m	Cartosat-1(PAN)	PAN	890MB	C-1/C-2/2X, Cartosat-3
5m	Resourcesat-2(L-4)	B2,B3,B4	980MB	C-1/C-2/2X,Cartosat-3
15m,30m	Landsat-8	B8, B3,B4,B5	459MB	Resourcesat-2/2A GISAT-MX-VNIR Resourcesat-3/3A
15m	Landsat-7	B2,B3,B4	65MB	
25m	Resourcesat-1&2 (L-3)	B2,B3,B4,B5	70MB	
50m	Resourcesat-1&2	B2,B3,B4,B5	140MB	Resourcesat-2/2A Oceansat-2 GISAT-MX-VNIR Oceansat-3-OCM Resourcesat-3/3A

Table 3.4: Data volume for Reference Image

Network Traffic Requirements

High speed database connectivity with reference is required for fast response time during evaluation.

Server Hardware Requirements

Hardware configuration:

Processor	Intel xeon x7560@2.27GHz, 4 processors with 8 cores each
RAM	64GB
Operating System	64-bit Red-Hat 5 Linux or Higher
Database	ORACLE-10G or Higher

Table 3.5: Hardware Requirement

3.1.7 Operational Requirements

Interoperability Requirements

The reports/outputs produced by software shall be in standard PDF format.

Error Handling Requirements

1. Input validation checks such as valid combinations of product code, level of product and DQE activity type shall be carried out to prevent users from entering wrong inputs.
2. Appropriate error messages shall be shown to user if improper inputs are entered.

Backup/Restore Requirements

1. Periodic backup plan for data, executables and configuration files shall be prepared.
2. Restoring the executables and configuration files shall be done manually from the backed-up archives.

Report Generation Requirements

1. All reports shall have consistent margins, font size and color scheme so as to facilitate effective reading and printing if necessary.
2. The output reoprts shall display relevant information such as product ancillary information & estimated parameters with proper units.
3. The reoprt shall contain Image, text, tables & plots wherever required for proper interpretation of evaluation results.
4. The reoprt shall be generated in PDF format.
5. All graphs/plots shall be shown with proper titles, legends and line/text styles for better interpretability.
6. Reports shall be organized to give summary of evaluation results on first page, followed by detailed results in rest of the page.

Progress Display Requirements

For time consuming processing activities progress bar with processing status shall be displayed to user.

Data Analysis/ Log File Generation Requirements

It shall generate one log file that maintain the record of all operations and errors

Command Line Utilities

No command line utilities are planned.

3.1.8 Other Requirements

Maintainability Requirements

1. Software shall be designed such that the logic for user-interactive displays, quality parameter computation and database functionalities is separated.
2. Activity specific pacakages shall perform a well-defined functionality with minimum dependency on other packages.

Portability Requirements

Software shall be portable to any linux platform.

Reusability Requirements

New packages developed for Image Display, Vector Display, Computation, Result etc shall be re-used for missions.

3.1.9 Design Constraints

Design & development of the software shall follow the soft engineering approach. New packages shall be designed for multi-activity functionality.

3.2 Software Design

3.2.1 Package Diagram

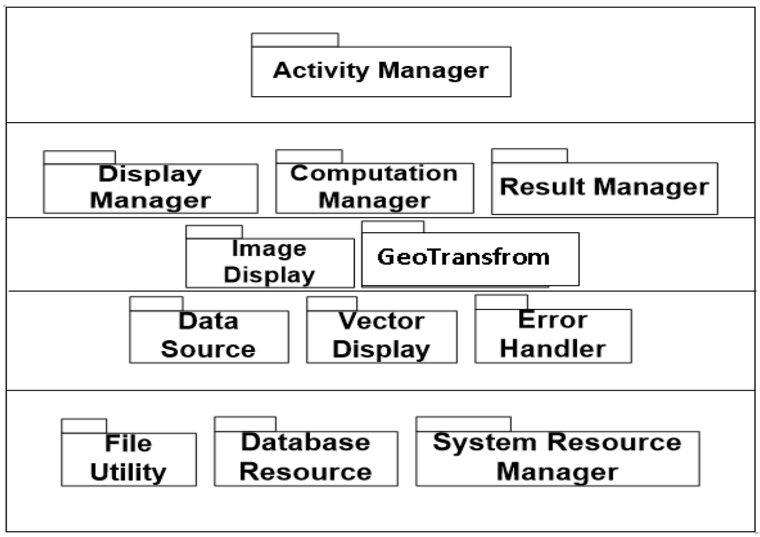

Figure 3.16: Package Hierarchy

Activity Manager supports the different kind of activities like GLOC, RDQE, SLOL etc. Display Manager handles the image display part. Computation manager computes the DQE parameter. Result manager generates the results file and store it.
Image display contains the display widgets. Geotransform contains the transformation and projection area. DataSource prepares the fileImage. Vector Display handles the vector and shapefiles view. Error handler handle the error codes and logs.
File Utility has the file reading functionality. It reads the workfile, metafile, reference file etc. Database resource has the database connectivity with reference database and result database. System Resource Manager computes the display setting, memory availability etc.

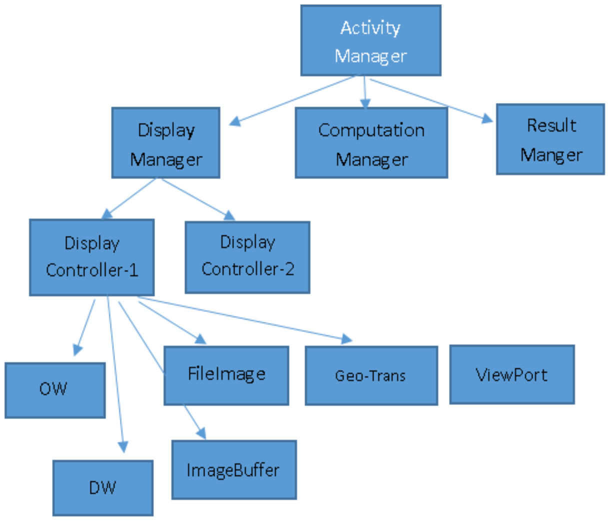

Figure 3.17: Class Hierarchy

3.2.2 Collaboration Diagram:

Events to be handled at widget + controller level:

1. Window Resize

Window Resize: Overview widget through resizing

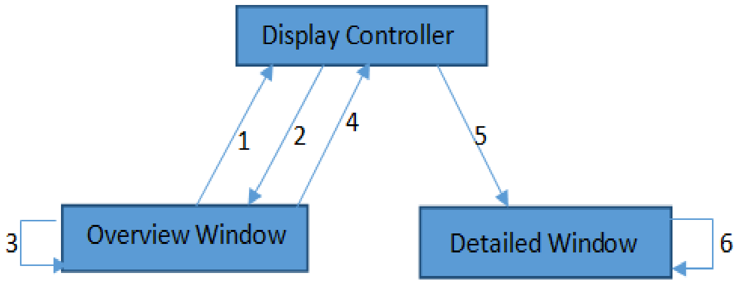

Figure 3.18: Window Resize Collaboration diagram

(1). Get New WindowSize ()

(2). Compute ViewPort (x, y, width, height)

(3). Refresh () Overview Window, Update Scrollbar, Update Label

(4.) Navigate refresh message towards Detailed Window

(5). Navigate message through Display Controller to Detailed Window

(6). Update Detailed Window ViewPort

CL_FR1.1: Window Resizing

CL_FR1.1.1: Check is new window size <= max size (width x height), check the zoom-Factor

CL_FR1.1.2: Compute new compression factor

CL_FR1.1.3: Prepare display buffer for new compression factor

CL_FR1.1.4: Repaint Image & Overlaid vectors

2. Zoom factor

Zoom factor Change: detailed Widget through spinner

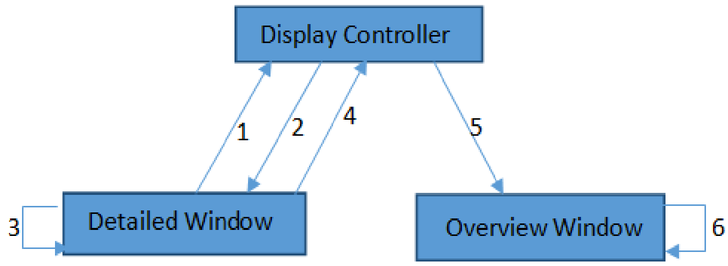

Figure 3.19: Zoom factor Collaboration Diagram

(1). Get New ZoomFactor ()

(2). Compute ViewPort (x, y, width, height)

(3). Refresh () Detailed Window, Update Scrollbar, Update Label

(4.) Navigate refresh message towards overview Window

(5). Navigate message through Display Controller to Overview Window

(6). Update Overview Window ViewPort Rectangle

CL_FR2.1: Zoom Factor

Click in the text area of ZoomFactor allows to set the zoom factor or by clicking the up and down arrow key of box allows to change the zoom factor.

CL_FR2.1.1: If the zoom factor is > Previous zoom factor, set_MODE=zoom_in.

- Validate current_zoom (e.g. Check for maximum zoom_in supported)
- Set current_zoom = current_zoom*2
- Call Zoom_IN_image(DW_ZF)
- Call Zoom_vector(DW_ZF)

CL_FR2.1.1.1: Event generate in the label: Refresh the zoom value and zoom_in mode in the label of detailed window.

CL_FR2.1.1.2: If the zoom factor < previous zoom factor, set_MODE=zoom_out , set current zoom = 1.0, Else set current_zoom=current_zoom/2

- CL_FR2.1.1.2.1: Validate current_zoom (e.g. Check for maximum zoom_out supported)
- Call Zoom_OUT_image(DW_ZF)
- Call Zoom_vector(DW_ZF)

Event generated in the label: it shows the zoom value and zoom_out mode in the label of detailed window.

CL_FR2.1.1.3: On mouse release: Scroll positions to be updated

CL_FR2.1.1.4: Generate Event on Overview window: Update the rectangular box & cross-hair displayed in overview window if current image center position is changed

CL_FR2.1.1.5: Events generated by other windows: (Action Listeners required)

- Update_Image_Position(): Called when rectangle/extent in overview window changes
- Update scroll bar position

3. Mode Select

3.1 ZoomIn/ZoomOut (Detailed Window):

same as zoomFactor(3.19)

3.2 Pan Mode: (Detailed Window)

3.2.1 Only set Pan Mode (local detailed Window): change cursorStyle to handle icon

3.2.2 When Pan Mode + Mouse Drag

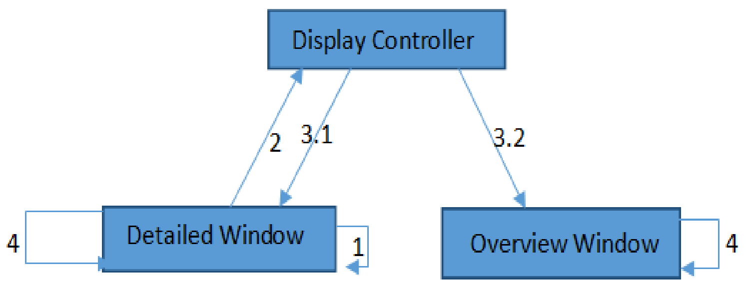

Figure 3.20: Pan Collaboration Diagram

(1). Get Mouse Update Point ()

(2). Compute Image Requirement ()

(3.1). Detailed ViewPort Update()

(3.2). Overview Rectangle ViewPort Update()

(4.) Update Label, Update Scrollbar

CL_FR3.2.2: PAN

CL_FR3.2.2.1: By clicking on the pan cursor, set DW_MODE=pan.

CL_FR3.2.2.2: Dragging the pan cursor on the image it will change the section of the image to be displayed in the main display window.

CL_FR3.2.2.3: Validate current_pan (e.g. check for maximum pan supported)

CL_FR3.2.2.4: Pan_image()

CL_FR3.2.2.4.1: Get image current cursor position(x,y)

CL_FR23.2.2.4.2: Prepare Image display buffer

- Calculate viewport to show an image with current zoom factor
- Drag the image and update the scrollbar according
- ImageBuffer:Calculate_Viewport()
- Display image buffer

CL_FR2.3.2.2.5: Event generate in the label: it updates the pan mode in the label of detailed window.

CL_FR2.3.2.2.6: Mouse release: Scroll positions to be updated

CL_FR2.3.2.2.7: Generate Event on Overview window: Update the rectangular box & cross-hair displayed in overview window if current image centre position is changed

4. Scrollbar Positioning

Detailed Window (Horizontal, Vertical Scrollbar) , Overview Window (Horizontal/Vertical Scrollbar)

4.1 When Widget Size changes

(1). New Window Size ()/ New ZoomFactor ()

(2). Update Overview ViewPort ()

(3). Update Detailed ViewPort (), adjust Scrollbar

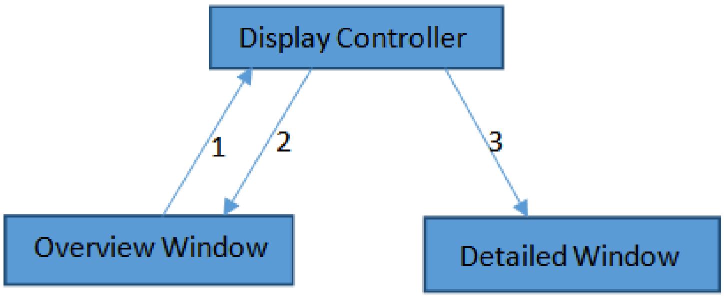

Figure 3.21: Scrollbar Collaboration Diagram

4.2 When Widget ViewPort changes:

4.2.1 When ViewPort x, y changes

4.2.2 When ViewPort w, h changes

4.2.3 When ViewPort ZoomFactor changes

3.2.3 Class Diagram

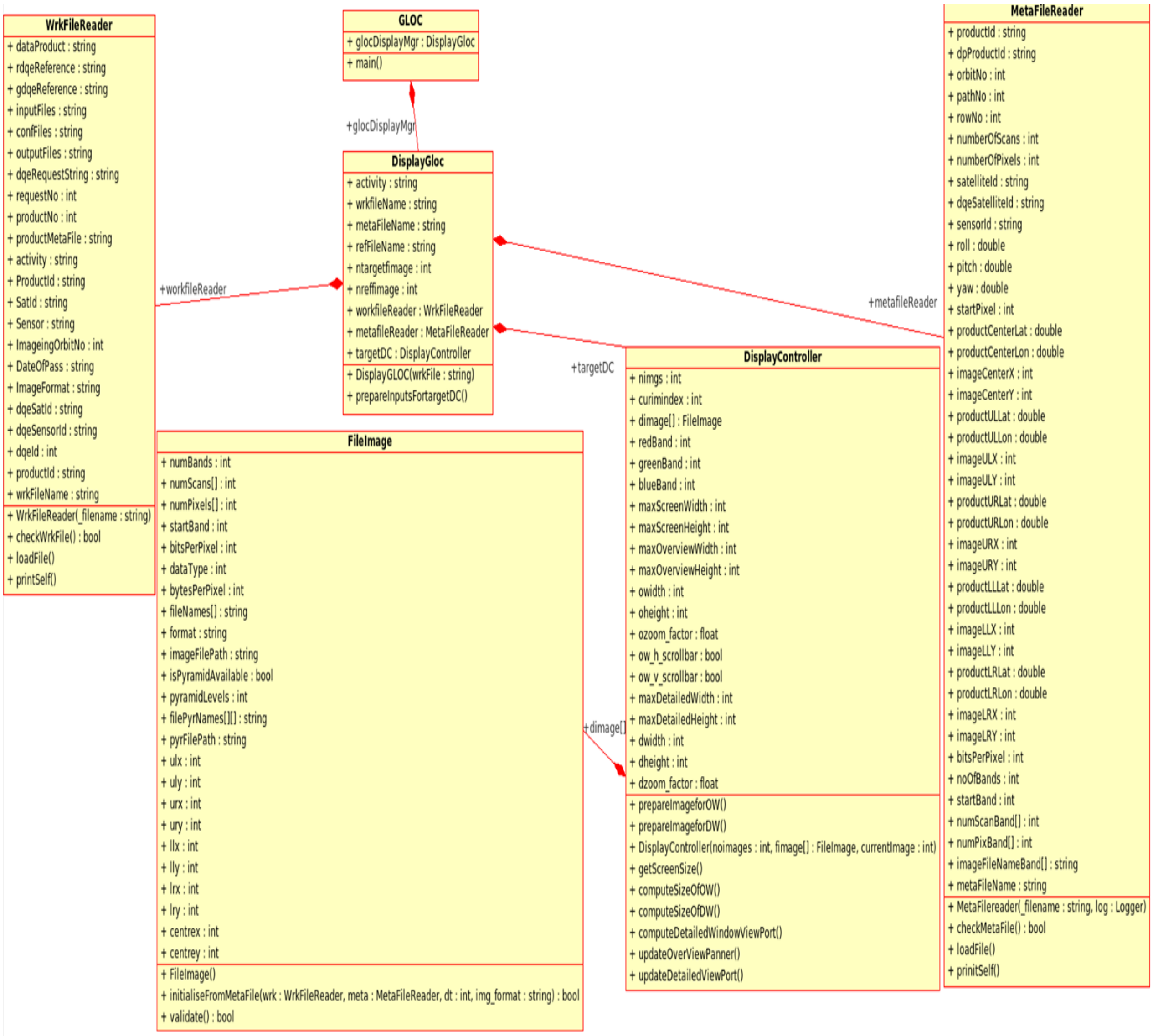

Figure 3.22: GDQE Class Diagram

3.3 Algorithm

3.3.1 Fetch vector Tiles

3.3.2 Compress Image Size using SkipByte

To display complete image in a smaller window,it need some compression. In algorithm using skip byte compression factor is computed.

Algorithm 1 Fetch vector Tiles

```
Enter Zoomlevel, Latitude, Longitude
Compute X,Y
Pass X,Y to browser
Fetch tile from browser
Display Vector Tile
```

Algorithm 2 CompressionFactor

```
widthFactor ← Pixel/overviewWidth
heightFactor ← Scan/overviewHeight
verticalSkip ← Pixel * heightFactor * bytesPerPixel
horizontalSkip ← pixel * widthFactor * bytesPerPixel
```

3.3.3 Get Pixel Value

We have pixel value stored in integer variable gray. To get each of the component value We know the ARGB is an integer value from 0 to 255.Alpha bits occupy 8 bits from index 24 to 31. Red bit occupies 8 bits from index 16 to 23. Green bits occupy 8 bits from index 8 to 15. Blue bit occupies 8 bits from index 0 to 7. Bitwise ADD with 0xff are left with the value of component we are interested in.[9]

Algorithm 3 GetPixel

```
A ← gray >> 24 & 0xff
R ← gray >> 16 & 0xff
G ← gray >> 8 & 0xff
B ← gray & 0xff
```

3.3.4 Set Pixel Value

Gray is an integer variable and holds the value of pixel. 8 bits of alpha component occupy the bit position from index 24 to 31. Then left shift the alpha value by 24 position and bitwise OR it with the gray value and so on for the remaining bits.[9]

3.3.5 Read Complete Image

Read the complete satellite image in a smaller size of window.

3.3.6 Read Image

Read the satellite image in a detailed size of window.

Algorithm 4 SetPixel

```
gray ← (A << 24) |(R << 16) |(G << 8) |B
```

Algorithm 5 ReadCompleteImage

```
for band=0,...,band_rgb do
    for scan=0,...,Height do
        Read Scanline
        for pixel=0,...,Width do
            getPixelValue * widthFactor * bytePerPixel
        Read verticalSkip
```

3.3.7 Read Pyramid Image

Read the down sampled pyramid image in a detailed size of window.

3.3.8 Linear Stretching

To display an image properly we need to apply linear stretching otherwise image will display black.

3.3.9 ZoomIn Image

ZoomIn function should provide the more detailed view of an image.

3.3.10 ZoomOut Image

ZoomOut function should provide the down sampled image in factor of 1/2, 1/4, 1/8, 1/16, and 1/32. Pyramid images are available in this down sampled factor.

3.3.11 Fetch References

According to the corner coordinates of target image fetch the reference image which falls under the boundig box of target image.

Algorithm 6 ReadImage

```
skipbyte ← verticalScrollBarValue * Pixel * bytesPerPixel
+ horizontalScrollBarValue * bytePerPixel
for band=0,...,band_rgb do
    Read Skipbyte
    for scan=0,...,Height do
        Read Scanline
        for pixel=0,...,Width do
            getPixelValue * bytePerPixel
```

Algorithm 7 ReadPyramidImage

```
PyramidScan ← Scan/2^zoomlevel
PyramidPixel ← Pixel/2^zoomlevel
ReadImage()
```

Algorithm 8 LinearStretching

```
minL ← 0
maxL ← 255
for scan=0,...,Height do
    for pixel=0,...,Width do
        for band=0,...,band_rgb do
            gray ← ((getPixelValue - minL)*255)/(maxL-minL)
            if gray < minL then
                gray ← 0
            if gray > 255 then
                gray ← 255
        setPixelValue
```

Algorithm 9 ZoomInImage

```
if zoomLevel < 5 then
    zoomLevel ++
    readPyramidImage()
else if zoomLevel >= 5 then
    reached at maximum zoomLevel
```

Algorithm 10 ZoomOutImage

```
if zoomLevel >= 1 then
    zoomLevel - -
    readPyramidImage()
else if zoomLevel < 0 then
    zoomLevel ← 0
    readImage()
```

Algorithm 11 Fetch Reference

```
Generate Bounding Box of Target
Add estimate error value in Bounding Box
Query database to get Reference
Generate BoundingBox of Reference
for Each reference image do
    if φ_1t.contains φ_1r || φ_2t.contains φ_2r && λ_1t.contains λ_1r || λ_2t.contains λ_2r
then
        Reference Fetched
    else
        Reference Rejected
```

Chapter 4

Experiment Setup

4.1 TestBed

Processor: Intel Xeon x7560@2.27GHz, 4 Processor with 8 cores each

RAM: 64GB

Operating System: 64-bit RedHat 7 Linux

Database: Postgresql 9.2

4.2 Offline Tile Server

After Successful offline installation of OSM tile server, rendering of tile is important to view the raw data as a map. Following are the steps to render the tile:

Renderd -f -c /usr/local/etc/renderd.conf

Render_list -a -z 0 -Z 19

If we wants to render one tile at a time then,

for browser based : http://localhost/osm_tiles/z/x/y

for the command line rendering: Render_list -z zoomlevel -x startXcoordinate -X endX-coordinate -y startYcoordinate -Y endYcoordinate[10]

4.2.1 Equation

To view the vector image of satellite image, it need to convert latitude and longitude of that satellite image into vector tile number.

Covert Lat/Lon to WorldCoordinate

$$siny = sin(Lat * \pi/180) \tag{4.1}$$

$$siny = min(max(siny, -0.9999), 0.9999) \tag{4.2}$$

$$worldCoordinateX = TILE\_SIZE * (0.5 + Lon/360) \tag{4.3}$$

$$worldCoordinateY = TILE\_SIZE * (0.5 - log((1 + siny)/(1 - siny))/4\pi) \tag{4.4}$$

Convert WorldCoorinate to Tile Number

$$x = \lfloor (worldCoordinateX * 2^{zoomlevel}/TILE\_SIZE) \rfloor \tag{4.5}$$

$$y = (worldCoordinateY * 2^{zoomlevel}/TILE\_SIZE) \rfloor \tag{4.6}$$

Latitude/Longitude to tile number formula:

$$Xtile = \lfloor ((longitude + 180)/360 * 2^{zoomlevel}) \rfloor \tag{4.7}$$

$$Ytile = \lfloor ((1 - ln(tan(lat * (\pi/180) + (1/cos(lat * (\pi/180))))))/\pi * 2^{zoomlevel}) \rfloor \tag{4.8}$$

4.3 Image Display

4.3.1 Equation

Location Accuracy

$$RMS_{ERR} = \sqrt{\Sigma_i^N (X_i - X_j)^2/n} \tag{4.9}$$

where Xi and Xj are the image coordinates and reference image coordinates, respectively and n is the number of samples.

Internal Distortion

$$ID = \sqrt{[((X_r - X_i) - (X_{ref} - X_j))^2/(n-1)]} \tag{4.10}$$

where Xr and Xi are the reference and control point coordinates on the image; Xref and Xj are the coordinates of corresponding points in reference image/GCP; n is number of control points.

Chapter 5

Result

5.1 Tile Server

5.1.1 Tile viewing using browser

Figure 5.1: (1)Tile: z:3 x:5 y:3 (2)Tile: z:10 x:718 y:444 (3)Tile: z:17 x:91982 y:56832

5.1.2 Fetch Tiles via Application

In following figure tiles at different zoom level for latitude:12.9716 and longitude:77.5946 is displayed.

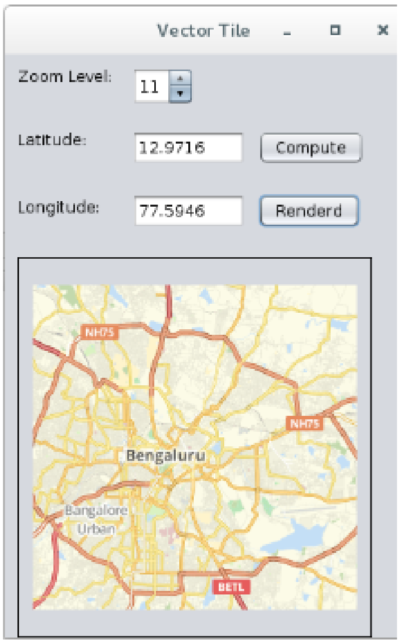

Figure 5.2: zoomLevel 11

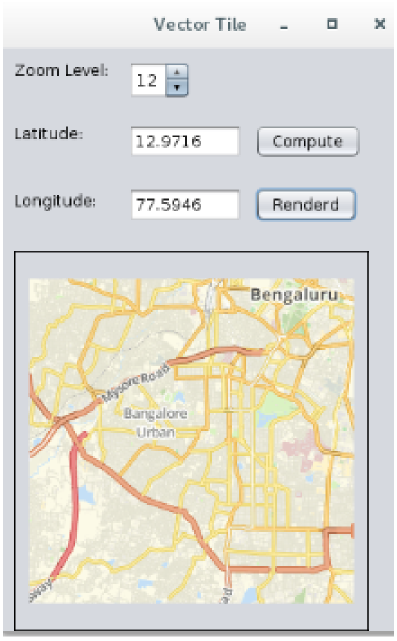

Figure 5.3: zoomLevel 12

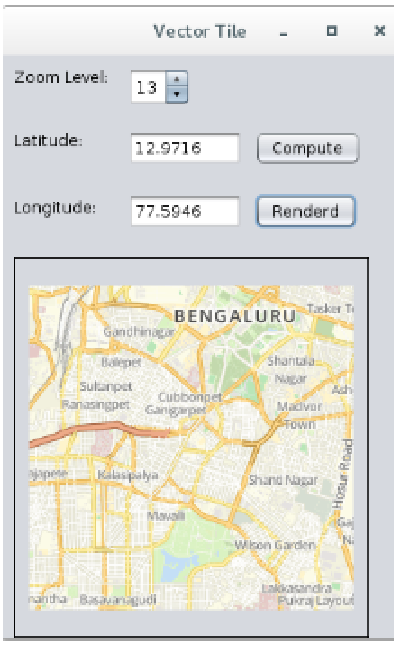

Figure 5.4: zoomLevel 13

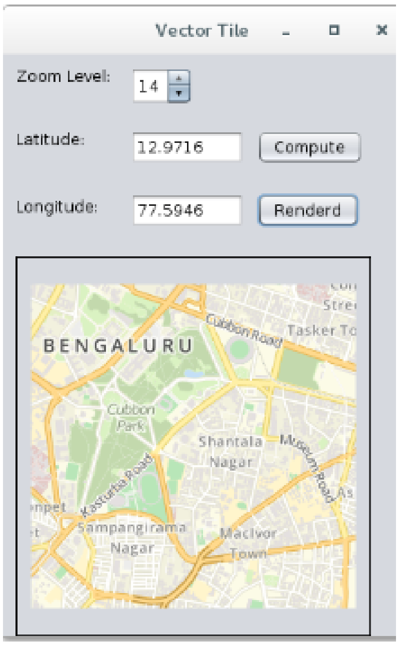

Figure 5.5: zoomLevel 14

5.1.3 Zoomlevel

Level	Degree	Area	#Tiles
0	360	whole world	1
1	180		4
2	90		16
3	45		64
4	22.5		256
5	11.25		1024
6	5.625		4096
7	2.813		16384
8	1.406		65536
9	0.703	wide area	262144
10	0.352		1048576
11	0.176	area	4194304
12	0.088		16777216
13	0.044	village or town	67108864
14	0.022		168435456
15	0.011		1073741824
16	0.005	small road	4294967296
17	0.003		17179869184
18	0.001		68719476436
19	0.0005		274877906944

Table 5.1: zoomlevel to tilenumber

5.2 Image Display

5.2.1 Target Overview & Detailed Window

Overview window display the target image with cross hair and rectangle at center position. It provides the option for band selection and enhancement. Detailed window display the target image in a detailed view with scrollbar. Initially it display the central portion of an image.

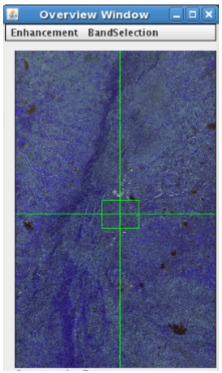

Figure 5.6: Target Overview Window

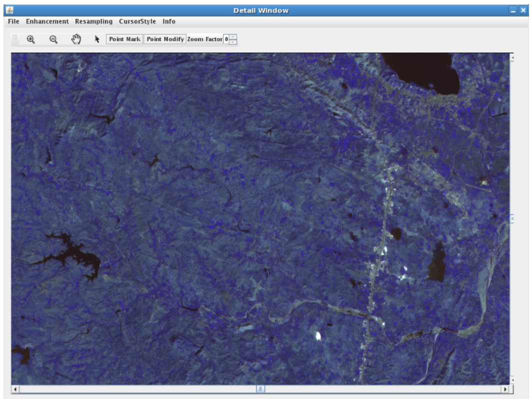

Figure 5.7: Target Detailed Window

5.2.2 Reference Overview & Detailed Window

Overview window display the complete reference image and show the cross hair and rectangle box at center position.Detailed window show the detailed view of reference image. Initially it display the central portion of an image and provides the scroll bar and pan option for scrolling.

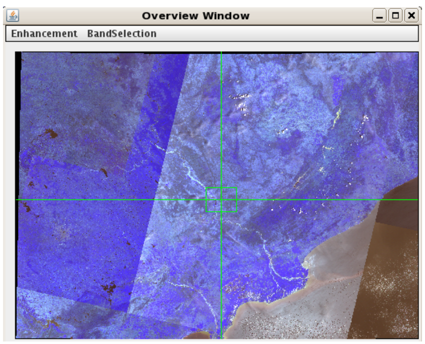

Figure 5.8: Reference Overview Window

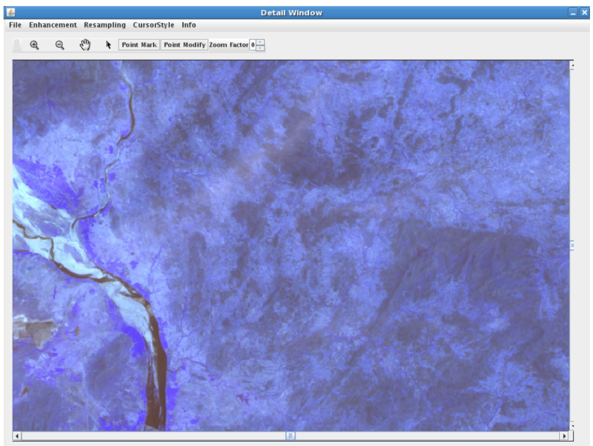

Figure 5.9: Reference Detailed Window

5.2.3 Location Accuracy Result

Product: RS2A

Sensor:L4FX

Resolution: 5.83

GCP Marked: 23

Location Accuracy

	Mean	Direction	StdDev	RMS
Along	-100.250	S	16.687	101.63
Across	294.295	E	17.879	294.83

Table 5.2: Location Error

Radial Error(m)

Mean	Min	Max	CE90
311.529	278.073	338.977	330.45

Table 5.3: Radial Error

Graph

Scan Vs. ErrorLat & ErrorLon:

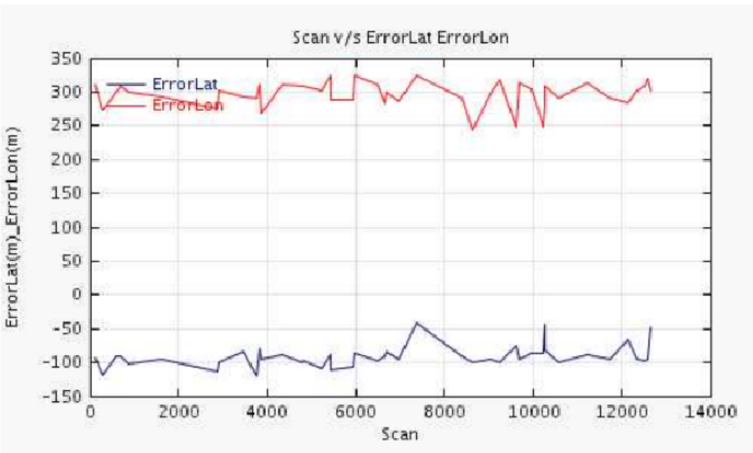

Figure 5.10: Scan Vs. ErrorLat ErrorLon

From the above graph, we can say that Number of scan vs. Error in latitude falls under the -50m to -100m and Error in longitude falls under the 250m to 325m. Error that comes above the given specification need to be feedback to product generation to correct the satellite product.

Pixel Vs. ErrorLat & ErrorLon:

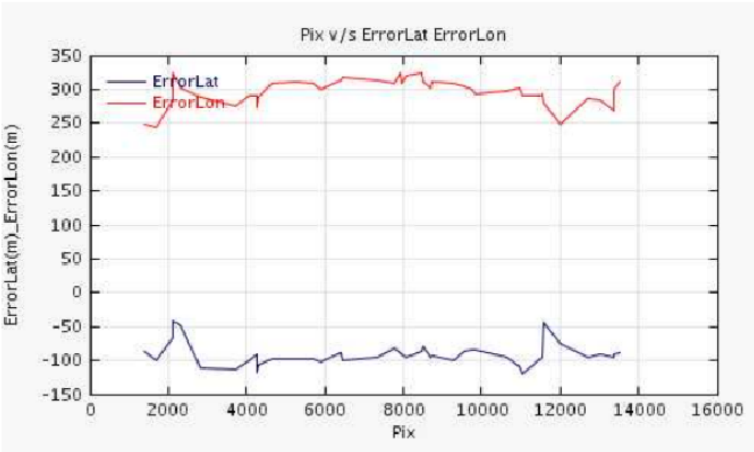

Figure 5.11: Pixel Vs. ErrorLat ErrorLon

From the above graph, we can say that Number of pixel vs. Error in latitude falls under the -50m to -100m and Error in longitude falls under the 250m to 325m. Error that comes above the given specification need to be feedback to product generation to correct the satellite product.

5.3 Result Comparision

5.3.1 Auto GDQE

Intialize the procedure via scheduler and it will mark the control points automatically and compute the result.

Product Information:

Satellite: RS2A

Sensor: L4FX

GCP Marked: 43

Resoltion: 5.83m

For the given product, computed parameters for location accuracy are listed below.

Location Accuracy(m)

	Mean	Direction	StdDev	RMS
Along	-96.278	S	9.289	96.725
Across	300.805	E	13.293	301.09

Table 5.4: Location Accuracy

Radial Error(m)

Mean	Min	Max	CE90
316.044	285.812	336.293	327.29

Table 5.5: Radial Error

Scan Vs. ErrorLat & ErrorLon

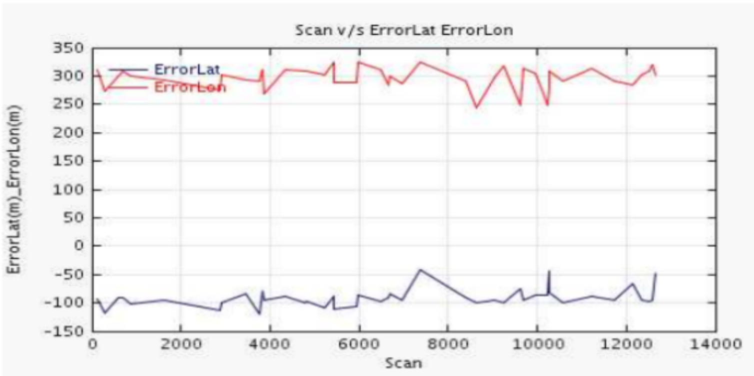

Figure 5.12: Scan Vs. ErrorLat ErrorLon

Number of scan vs. Error in latitude falls under the -50m to -100m and Error in longitude falls under the 250m to 325m.

Pixel Vs. ErrorLat & ErrorLon

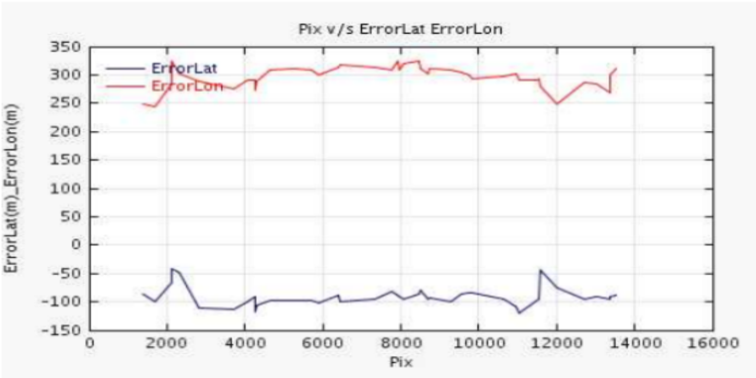

Figure 5.13: Pixel Vs. ErrorLat ErrorLon

Number of scan vs. Error in latitude falls under the -50m to -100m and Error in longitude falls under the 250m to 325m.

Compare the Auto GDQE results with Manual GDQE for the RS2A L4FX product. Following is the graph that shows the comparision between both.

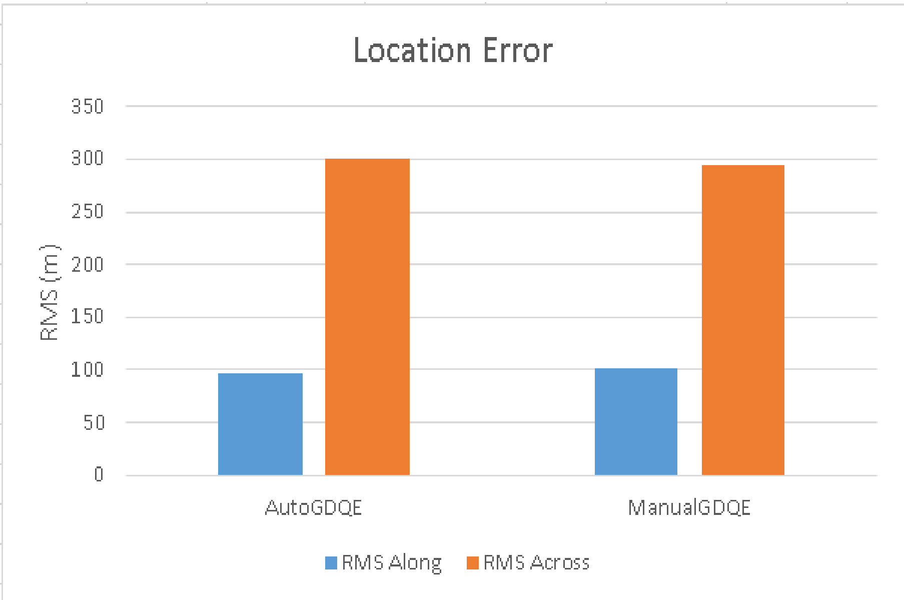

Figure 5.14: Location Error

From the above graph we can analyse that by an existing software auto control points giving an error are almost same error which is generated by developed software in which less control points are well distributed.

5.3.2 Compare Map Projection

Compare the computed Map projection with the ENVI software's Map projection.

Scan	Pixel	Computed MapY	Computed MapX	ENVI MapY	ENVI MapX
568	8958	2503592.7283	321247.9692	2503593.0000	321244.4431
3230	2895	2487619.5425	284867.5791	2487621.0000	284866.4431
1154	3416	2500076.4588	2879993.7814	2500077.0000	287992.4431
12699	1479	2430801.3650	276371.0358	2430807.0000	276370.4431
12025	1872	2429445.2662	278729.1914	2429444.0000	278728.4431

Table 5.6: Compare Map Projection

Pixel Vs. MapX

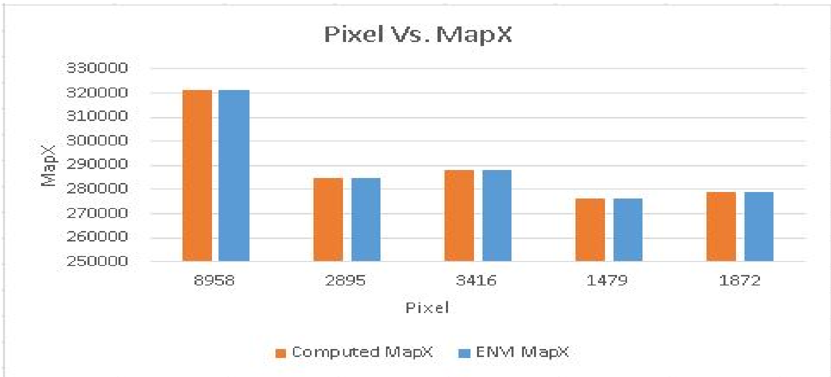

Figure 5.15: Pixel Vs. MapX

For the geometric transformation, we need to compute the pixel value into map projection MapX. Above graph describes the each MapX value corresponding to pixel value.

Scan Vs. MapY

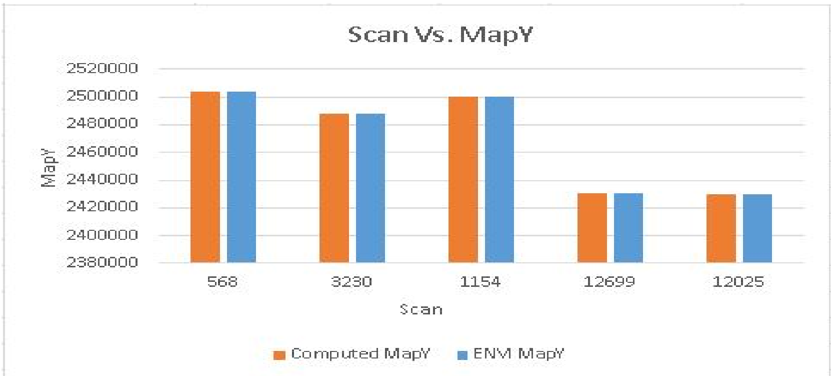

Figure 5.16: Scan Vs. MapY

For the geometric transformation, we need to compute the scan value into map projection MapY. Above graph describes the each MapY value corresponding to scan value.

Chapter 6

Conclusion

Based on requirement analysis software requirement specification document is generated and detailed design of GDQE display is made. To display vector tile according to satellite image offline tile server is implemented and application is designed. To fetch the tiles via browser or application the queries are tested. Computed Map Projection is tested with ENVI software. Geo location accuracy is computed using developed software.

Chapter 7

Future Enhancement

Implementation of advance features like geo-linking two images in geo-transform package and implementation of image processing techniques for image enhancement.

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