EVALUATION OF QUICKBIRD DATA FOR TOPOGRAPHIC DETAIL MAPPING

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ABSTRACT

The latest technology of high resolution satellite imagery has provided its metric potential for mapping. Quickbird imaging systems offer ortho-image products which comply with the specification of map accuracy for scales as large as 1:10,000. This study is to determine the ability of Quickbird satellite imagery to be used for topographic detail mapping. In this study, the systematic procedure and the suitable technique to extract ground features from Quickbird data were carried out. The procedure includes the Digital Elevation Model (DEM) extraction to remove the relief displacement of the Quickbird image. The DEM was extracted using scanned aerial photograph and processed by stereo correlation technique. Visual interpretation technique was used to extract the point features, while the Edge Detector filters to extract the linear features. In order to extract polygon features, Canny Filter and Region Growing Segmentation were used. The accuracy of the results comprises of Root Mean Square Error (RMSE). In this study, the accuracy of the topographic detail plan derived from Quickbird image is 3.1068 meters, which fulfill requirement mapping of 1:1,000 scales. This leads to conclusion that Quickbird image can be used as a data source for topographic detail mapping.

1.0: INTRODUCTION

The era of a meter and sub meter satellite imagery presents new and exciting opportunities for users of spatial data. High resolution imagery such as Quickbird and IKONOS add an entirely new level of geographic knowledge and details to the intelligent maps created from satellite images. Higher resolution images provide more information on the extraction or interpretation of man-made objects. The main application fields for satellite data including topographic and urban maps updating, illegal building detection, agricultural and cadastral parcel updating.

In medium resolution imagery, details like road, building and water bodies are represented as thin features. Whereas, with higher resolution, road features are really elongated features of sizeable width, while the buildings are no longer point objects, but appear as blocks with prominent shadows. Map accuracy should be determined by the intended use of the map. The map accuracy determines the scale at which the map would be drawn. The availability of imagery with spatial resolution 80 meters to 30 meters enable to be used for mapping in scale 1:100,000 (Puissant and Weber, 2002).

Quickbird is a commercial satellite data with spatial resolution of 0.61 meter on the panchromatic mode. The Quickbird data are used as a source of information for detailed mapping because of its high geometrical resolution especially for large scale projects, which enables it to be used for scale mapping of 1:1,000 to 1:25,000 (Puissant and Weber, 2002), multispectral capabilities and radiometric sensitivity. Besides, it has a good positioning accuracy and large image size (Livio, 2003).

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Quickbird image was provided as Basic Imagery Products, which are designed for users who have advanced image processing capabilities. DigitalGlobe also supplies Quickbird camera model information with each Basic Imagery Product to permit photogrammetric processing such as orthorectification and three dimension feature extraction (Robertson, 2003). Basic imagery is the least processed image product, which only corrected for radiometric distortions and adjustments for internal sensor geometry. The optical and sensor distortions have been performed on each scene that ordered and the image orientation approximately corresponds to a North-South direction (Toutin and Chenier, 2001).

Topographic detail plan is a plan that represents the features on the ground in a large scale plan which is 1:50 and 1:1000 (Baharin, 2001). The features plotted include the man made and natural objects. A large scale map will show more detail than a small scale map. This plan is used for development purposes and engineering projects. Accuracy is a technique to represent the quality of measurement and it might be done based on Root Mean Square Error (RMSE) (Azmi,2003).

Geographic Information System (GIS) community assumes that high resolution satellite imagery such as Quickbird and IKONOS can deliver sufficient information. Unfortunately, there are many corrections and processing must be conducted on the image to ensure that it can be fulfill to the required scale mapping. In addition, the technique to extract the information in high resolution data is different. So, a suitable technique must be identified to extract the features in order to fulfill the requirement of the detail plan.

2.0 OBJECTIVES

The objectives of this study are:

a) To evaluate the orthorectified Quickbird image.
b) To determine the procedure and processing steps to produce topographic detail plan from Quickbird image.
c) To determine the accuracy of the detail plan derived from Quickbird data.

3.0 SCOPES OF STUDY

The Quickbird satellite data used in this study is in panchromatic mode which has 0.61 meters ground resolution. In order to remove the error on the image, a Digital Elevation Model (DEM) was generated using stereo correlation technique from a pair of aerial photograph. The control points were obtained from the field measurement. In this study, the extracted features were based on the term of reference from Ministry of Housing and Local Government. The features were divided into point, linear and polygon features. Visual interpretation technique was used to extract the point features, where the approximate location is based on the detail plan from conventional survey. The Edge Detector was used to extract the linear features. Canny filter and Region Growing Segmentation were used to extract the polygon features. The accuracy of the extracted features was calculated through RMSE which compares the coordinate with the detail plan that is produced from the ground survey.

4.0 STUDY AREA

The study area of this project is located at Ampang, Selangor. The coverage of the study area is 200 meter squares. The coordinate of the location is 350226.4623°E, 417404.1766°N in upper left and 350187.4097°E, 417679.9925°N in lower right.

This is an urban area and located near to the Middle Ring Highway. The topography of this study area is hilly and varies from one place to another. The features existing at this study area includes road networking, trees, shop buildings, single and double storey terrace houses, fences, facilities such as bus stands, public phones, lamp posts, electrical poles, drainage, manholes and overpass. Figure 1 shows the location of the study area.

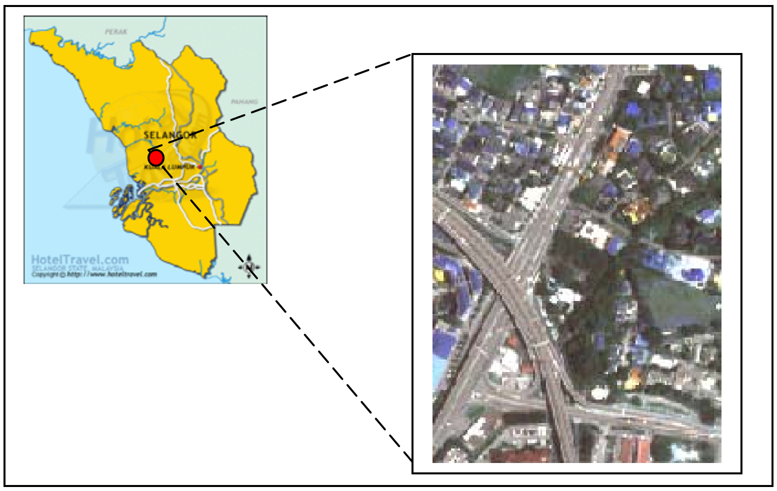

Figure 1: Location of the Study Area

The detail plan from conventional survey was used to evaluate the results of this study. Figure 2 represents the detail plan from conventional ground survey.

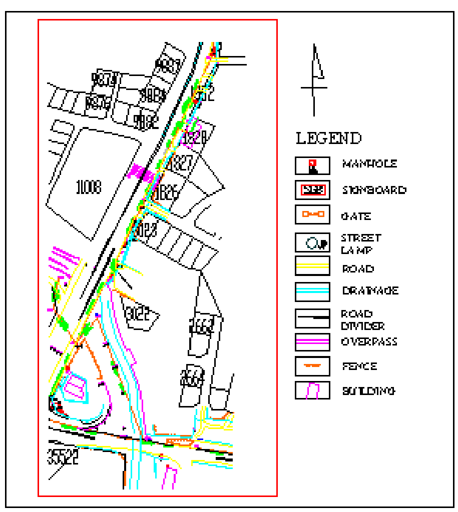

Figure 2: The Detail Plan from Conventional Ground Survey

5.0 METHODOLOGY

The methodology of this study was divided into three sections, which are pre-processing, processing and analysis. The pre-processing level covering an orientation model and epipolar resampling of aerial photograph while radiometric compression and orthorectification of Quickbird image. In the processing level, Digital Elevation Model (DEM) was generated from scanned aerial photograph and topographic features were extracted using visual interpretation technique, Edge Detector Filters, Canny Filter and Region Growing Segmentation. The analysis was carried out by computing the Root Mean Square Error (RMSE) and the reliable scale. Figure 3 represents the flow methodology in this project.

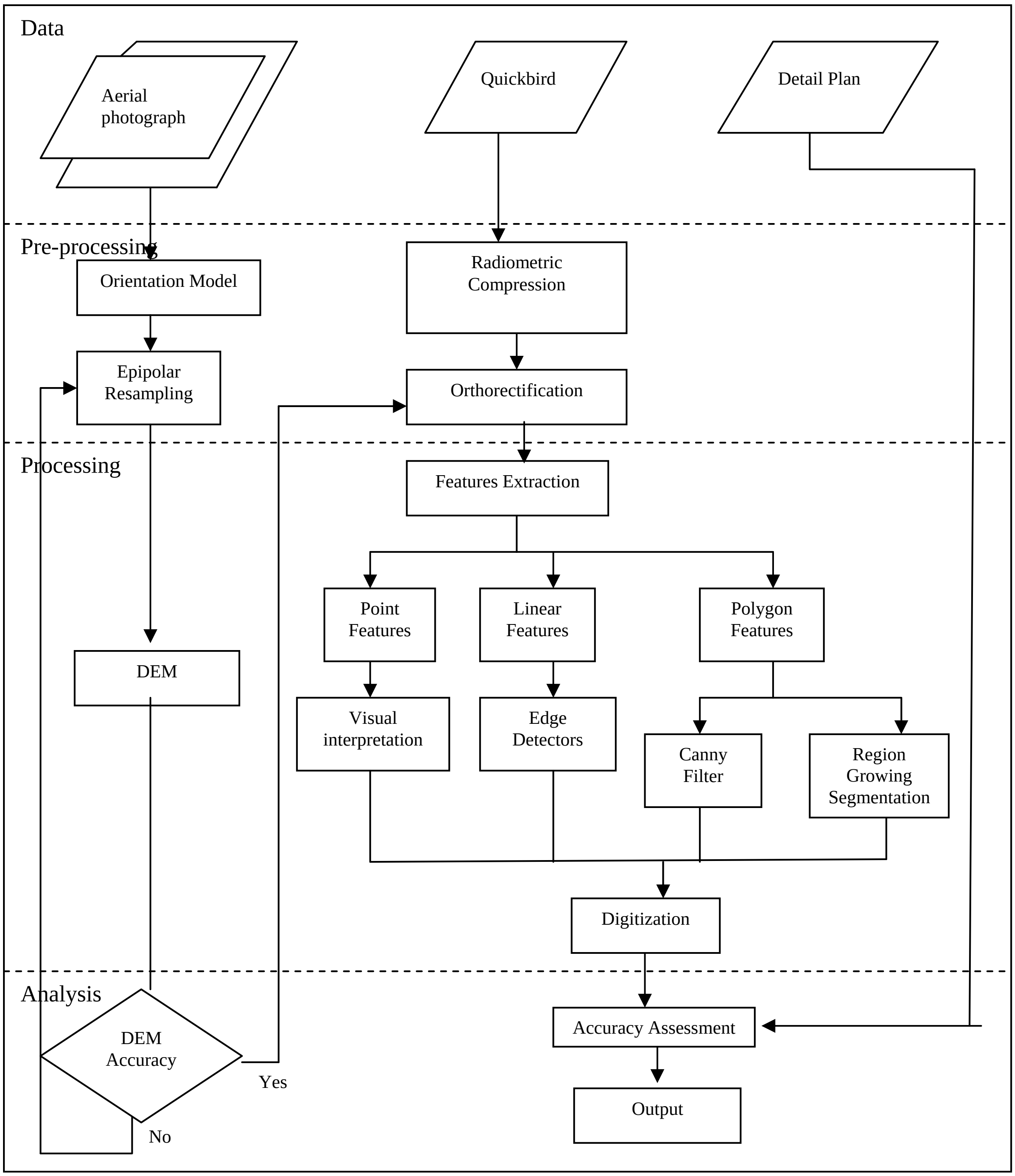

Figure 3: Flow of Methodology

In this study, the topographic features were divided into three types, which is point, linear and polygon features. Table 1 indicates the features with their types of categories.

Table 1: Types of Features

FEATURES	**TYPES**
Electrical Poles, Public Phone, Lamp Post	Point
Manhole	Point
Telekom box	Point
Sum box	Point
Culvert	Point
Signboard	Point
Hydrant	Point
Large tree	Point
Boulder	Point
Gate	Point
Building	Polygon/area
Lake, swamp and mine	Polygon/area
Road	Linear
Main pipe	Linear
Fence	Linear
Divider	Linear
Overpass	Linear

Visual interpretation technique was used to extract the point features from the Quickbird image while Canny Filter and Region Growing Segmentation were applied to extract the polygon features. Canny Filter is a combination of Smoothing Filter and Sobel Filter. In this study, the Gaussian Filters with window size 3, 5, 7 and 9 were used as a Smoothing Filter. In order to extract the linear features, Edge Detector Filters were applied. In this study, the Edge Detector Filters used were; Edge Detect and Laplacian with filter size 3, 5 and 7 and Non-directional Edge Detectors which is Prewitt, Roberts and Sobel. After the filtration, the image with the lowest standard deviation was selected to perform on screen digitizing. Additional information was used during the digitization of linear features where, the width of the road is taken into consideration. Table 2 shows the width of the roads in urban area.

Table 2: The Width of the Roads in Urban Area

	Main Road	**Brink Road**	**Back road**
Housing	66’	40’	20’
Industrial	100’	50’	30’
Low cost housing	66’	20’	15’

(Source: University of Science Malaysia, 2003)

6.0 RESULTS AND ANALYSIS

In order to extract the orthorectified Quickbird image, a DEM from aerial photograph was extracted. Figure 4 represents the Digital Elevation Model (DEM) while Figure 5 shows the orthorectified Quickbird image.

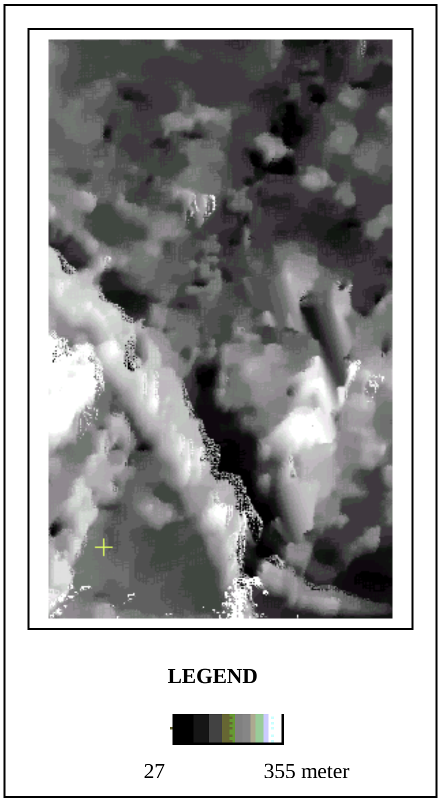

Figure 4: Digital Elevation Model (DEM)

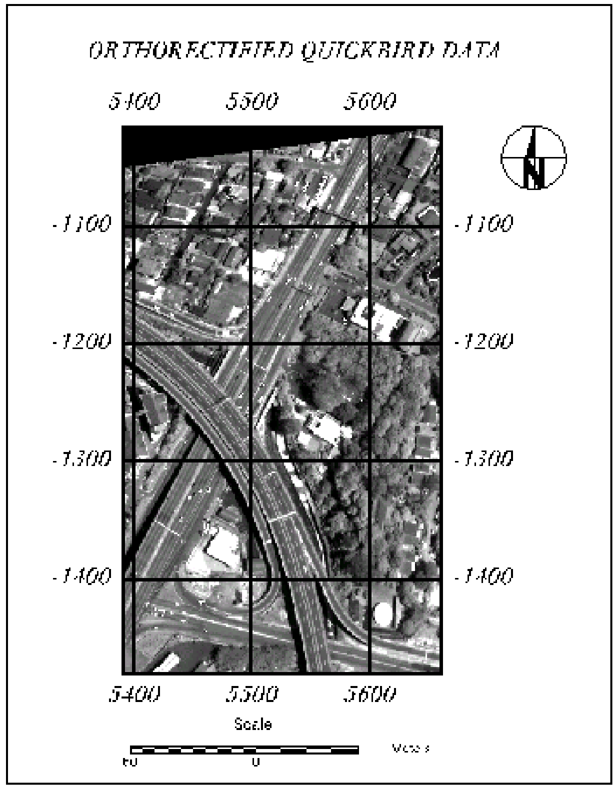

Figure 5: Orthorectified Quickbird Image

In this study, the accuracy of the DEM that generated from aerial photograph is 1.056 meters. It was proved that this approach is capable to generate a very dense array of elevation points in short periods of time in an unattended mode. Besides that, it gives a good capture of the overall surface of a ground scene and gives high quality results at high accuracies. There are several things that can contribute to the failure of the DEM extraction. Basically, the incorrect DEM due to the nature of the scene areas such as rivers, lakes and seas makes it extremely difficult to find a good match from the two images. During orthorectification, the Rational Function Model was used and the total error of rectification is 0.17 meters.

In order to extract the linear features and the polygon features, the Edge Detector Filters and Canny Filters were applied to the image. The image with the lowest standard deviation value was selected to be used in the next processing. Figure 6 and Figure 7 indicates the standard deviation of Edge Detector Filters and Canny Filters

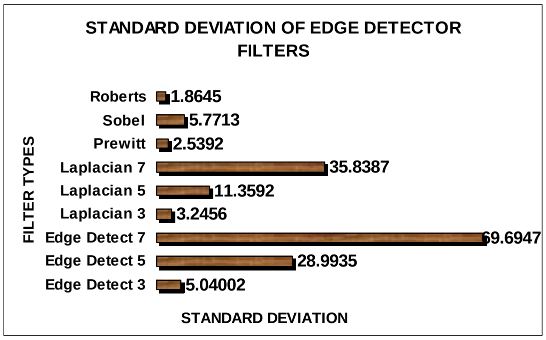

Figure 6: Standard Deviation of Edge Detector Filters

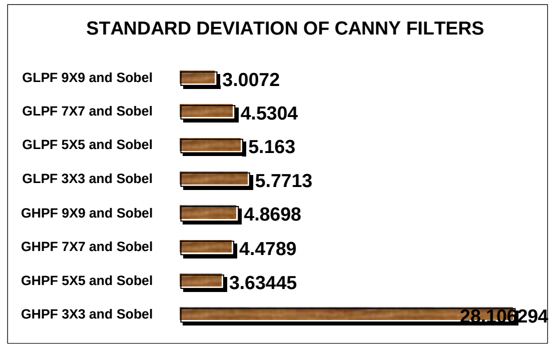

Figure 7: Standard Deviation of Canny Filters

In this study, the Roberts Filter was used to extract the linear features while Canny Filter's that produced from Gaussian Low Pass Filter with window size 9x9 and Sobel Filter was selected to extract the polygon features. Those images have the lowest standard deviation which is 1.8645 and 3. 00716. After the filtration process, on screen digitizing was performed. Figure 8 represents the digitization of linear features while Figure 9 represents the digitization of point features. In Figure 10, the digitization of the image that was applied to the Canny Filters is displayed while Figure 11 represents the results of Region Growing Segmentation in order to extract the polygon features.

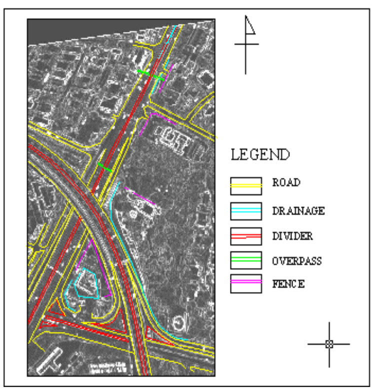

Figure 8: Digitization of Linear Features

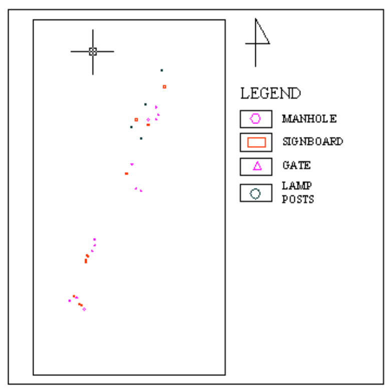

Figure 9: Digitization of Point Features.

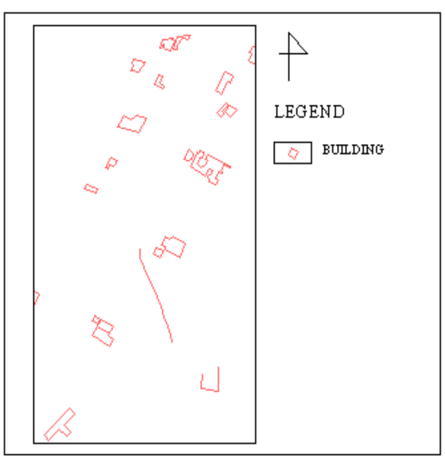

Figure 10: Digitization of Polygon Features Using Canny Filter

Figure 11: Digitization of Polygon Features Using Region Growing Segmentation

The evaluation of the results was carried out by comparing the coordinates of the extracted features with the detail plan that produced from the conventional ground measurement. Figure 12 represents the accuracy of the extracted features while Figure 13 represents the accuracy of the point features.

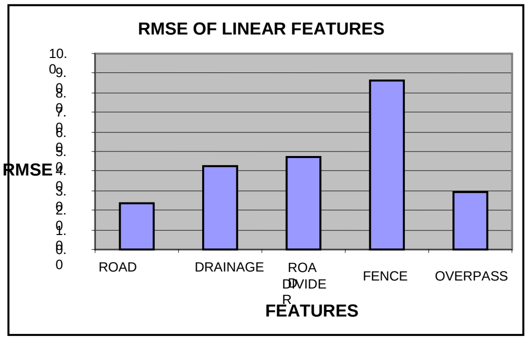

Figure 12: RMSE of Linear Features

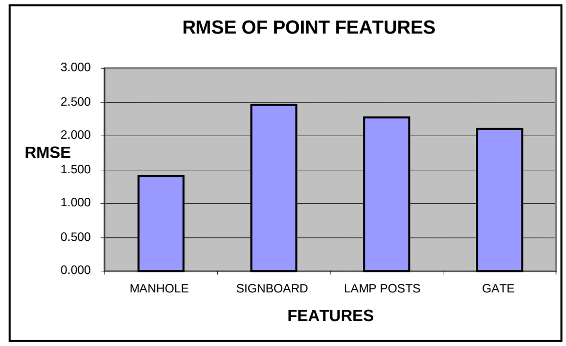

Figure 13: RMSE of Point Features

From the Figure 12, the road has the lowest RMSE with 2.371 meters while the fence has the highest RMSE with 8.643 meters. Roads were the clearest features and easily to be identified on the image. In this project, fences contribute the highest RMSE. Although it was clearly visible on the image, the exact location was hard to be identified. In addition, the shadow effect and the noise from trees caused discontinuity of this feature. It makes the identification of the fence become difficult.

From the Figure 13, the signboard contributes the highest RMSE followed by the lamp posts. These features were quite difficult to be identified from the Quickbird image. Lamp posts were identified by the shadow of the poles. These might caused inaccurate results because the exact location was difficult to identify. In point features extraction, the manholes contribute the smallest RMSE with 1.407 meters. Normally, the size of manhole is 0.61 meters. So, it was represented in a single pixel on the Quickbird image.

In order to extract the polygon features, two different techniques were used which are Canny Filter and Region Growing Segmentation. The only feature extracted was building. Figure 14 represents the RMSE of the extracted polygon features using Canny Filters and Region Growing Segmentation technique.

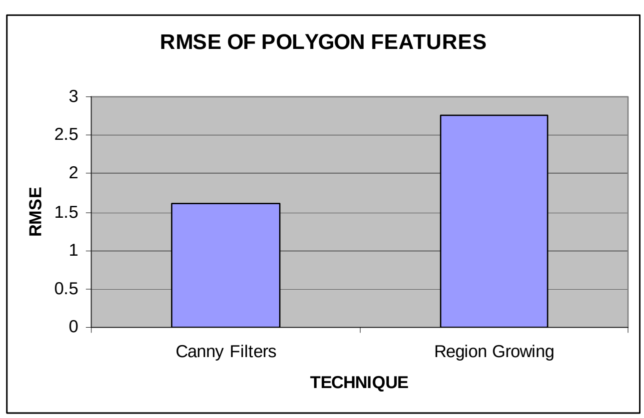

Figure 14: RMSE of Polygon Feature

The accuracy of the buildings that were extracted using Canny Filter is 1.6165 meters. The buildings were clearly represented in the filtered image and their edges were easily identified. At a certain part, the discontinuity of building edges arose. This was caused by the shadow effect from other features especially trees.

The accuracy of the buildings that were extracted from Region Growing Segmentation is 2.7615 meters. The error resulted by the noise on the image, which changed the pixels values of the building. Besides that, shadow effect from the neighboring features such as tree and lamp posts caused the pixels value changes. All of this enabled the segmentation processing. This proved that the polygon features is suitable to be extracted using Canny Filters and digitization because it has better accuracy. Although the Region Growing Segmentation is a faster technique, the accuracy failed to meet the accuracy requirement of the topographic detail mapping.

Figure 15 represents the topographic detail plan derived from Quickbird image.

Figure 15: Topographic Detail Plan Derived from Quickbird Image

In order to determine the accuracy of the topographic detail plan derived from the Quickbird image, the RMSE was computed. In this study, the accuracy of the detail plan is 3.1068 meters. This value can be categorized as moderate good. The reliable scale of this topographic detail plan was computed and it can be mathematically presented as

Photo scale = planimetric error / map error
= 3.1068 / 0.3
= 10.3559
= **1000 centimeter**

From the high resolution imagery, various value added of the digital products like geocode, photomaps and orthorectified photoproducts and Digital Terrain Model can be generated at desired map scales (up to 1: 2500) (Prasada et al., 2002). This has been proved in this project that the Quickbird satellite imagery is capable to be used for large scale mapping with scale up to 1:1000.

Three categories were created to analyze the contribution of Quickbird satellite data for topographic detail mapping. Table 3 indicates the categories and range of accuracy while Table 4 represents the features that are capable to be extracted from Quickbird image.

Table 3: Categories and the Range

CATEGORY	**RANGE (METER)**
Good	0 to 2.5
Moderate	2.6 to 5.0
Worst	More than 5.0

Table 4: Features that Capable to be extracted from Quickbird Image

FEATURES	**GOOD**	**MODERATE**	**WORST**	**UNDETECTABLE**
Roads	Yes			
Drain		Yes		
Roads divider		Yes		
Fence			Yes	
Overpass	Yes			
Manhole	Yes			
Signboard	Yes			
Lamp posts	Yes			
Gates	Yes			
Building	Yes			
Telecom Box				Yes
Sum box				Yes
Culvert				Yes
Hydrant				Yes
Boulder				Yes
Main pipe				Yes

The description of the features on the Quickbird image is shown in Table 5.

Table 5: Description of the Features on the Quickbird Image

FEATURES	DESCRIPTION
Roads	Road is the easiest features to be identified. The roads in side lanes 20 inches width can be delineated easily. No. of lanes are also detectable
Drainage	Difficult to identify because it is blocked by the other features. Identified as a linear feature with darker pixels.
Road dividers	Continuous linear feature. Located at the centre of main roads and highways.
Fence	Detectable as non continuous features because of the shadow.
Overpass	Easily to identify and clearly seen. Associated shadows were delineated
Manhole	Manhole is delineated in darker pixels. Represented by 1 or 2 pixels.
Signboard	Delineated in darker pixels. Represented by 3 or 4 pixels. Easier to identify differ from manhole.
Lamp posts	Detected as erected towers with shadows.
Gates	Detected based on the wall boundary and fence.
Building	Easily to identified. Size is varying and associated with well laid roads and sector pattern

7.0 CONCLUSION

In this study, the accuracy of extracted DEM is 1.056 meter, while the orthorectification of the Quickbird image accuracy's is 0.17 meters using Rational Function Model. It was identified that the stereo aerial photograph can be used to extract very accurate DEM.

The visual interpretation technique was used to extract the point features. This is because visual interpretation is the best technique and the best image processor of all and quickly detects and identify object (John, 2001). The best extracted point features is manhole with accuracy of 1.407 meters.

To extract the linear features, Non-directional Roberts Filter was used because it has the lowest standard deviation, which is 1.8645. The best extracted feature is road with accuracy of 2.371 meters. From this project, it was identified that fence is not capable to be extracted from Quickbird image because it has the worst accuracy, which is 8.643 meters.

The image that was filtered with Gaussian Low Pass Filter with window size 9 and Sobel Filter is the best technique to extract polygon features because it has the best accuracy, which is 1.6165 meters. The Region Growing Segmentation technique is not suitable to be used to extract polygon features because it falls in moderate category, with accuracy of 2.7615 meters.

In this project, the accuracy of the topographic detail plan derived from Quickbird image is 1.698 meters. It was seen that the digitized plan gave reasonable results. This leads to conclusion that Quickbird satellite data can be used as a data source for topographic detail mapping.

8.0 REFERENCE

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