

OPTIMIZATION OF GROUND CONTROL POINT (GCP) AND INDEPENDENT CONTROL POINT (ICP) ON ORTHORECTIFICATION OF HIGH RESOLUTION SATELLITE IMAGERY

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Abstract. In the rapidly evolving technology era, various survey methods have been widely used one of them by remote sensing using satellite. It is known that the satellite image recording process is covered by rides (satellites) moving over the Earth's surface at hundreds of kilometers, causing satellite imagery to have geometric distortion. To reduce the effect of geometric distortion of objects on the image, geometric correction by orthorectification is done. Pleiades is a satellite of high resolution satellite image producer made by Airbus Defense & Space company. The resulting satellite imagery has a 0.5 meter spatial resolution. As a reference for the more detailed space utilization activities of space utilization arranged in the Regional Spatial Plans, Detailed Spatial Plans was created with the 1: 5000 scale map which has been governed by the Geospatial Information Agency. In the process of orthorectifying satellite imagery for this 1: 5000 scale map, ground control or Ground Control Point (GCP) is used for geometric correction and Digital Elevation Model (DEM) data. In this research, the optimal number of GCP usage for orthorectification process in Rational Function method is 21 GCP using 2nd order polynomial

Keywords : Orthorectification, Satellite Imagery, GCP, Rational Function, Polynomial.

I. INTRODUCTION

As a reference for more detailed space utilization activities of spatial activities regulated in the Spatial Plan, a Detailed Spatial Plan with a 1: 5.000 scale map has been prepared by the Geospatial Information Agency (BIG). Used on a scale of 1: 5,000, because on a scale map greater than or equal to 1: 5000, in addition to blocks, will also be drawn other elements such as channels and fences.

Pleiades is a satellite of high resolution satellite image producer made by Airbus Defense & Space company. The Pleiades satellite produces satellite imagery data in two modes, namely the panchromatic mode and the multispectral mode. Satellite images in the panchromatic mode have a spatial resolution of 0.5 meters with a band number of 1 band (panchromatic), while satellite images in multispectral mode have a spatial resolution of 2 meters with a band number of 4 bands (VNIR - Visible Near Infra Red). This satellite image has good specifications, so it is often used in survey planning and making thematic maps [4]. This

satellite image is great for 1: 5.000 scale map with the required horizontal precision of 0.5-2.5m [1].

In the process of orthorectifying this satellite image, a ground control point or Ground Control Point (GCP) is used for geometric correction of x and y positions. This GCP has an important role to correct data and improve the overall image. The accuracy of ground control points depends on the type of GPS used and the number of point samples on the location and the time taken. For 1: 5,000 scale mapmaking, a static geodetic GPS receiver of static method with 30-45 minute observation [1] was used. For the addition of z position information, Digital Elevation Model (DEM) data was added. DEM was a digital data describing the geometry of the earth's surface shape or parts thereof which comprises the set of coordinate points of the sampling result from the surface of the earth with the algorithm defining the surface using the coordinate set. For 1: 5.000 scale mapmaking, DEM can be used with 5-10 meter vertical accuracy [1].

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reached, it returns to the orthorectification process using the next GCP model (GCP used increases). Sixth, When the Mean Square Error (RMSE) GCP value meets the ≤ 2.5 meter requirement, the image has been orthorectified. Then tested the geometric accuracy of the image with ICP coordinates. When the Mean Square Error (RMSE) ICP value does not meet ≤ 2.5 meters (map scale 1: 5000), then return to orthorectification process using the next GCP model (GCP used increases).

Seventh, When the Mean Square Error (RMSE) ICP value meets the ≤ 2.5 meter requirement, the image has been orthorectified and can be used in scale of 1: 5000

Eight, If there is an unused image model (due to the use of the previous model), an orthorectification process remains to be performed. This step used to increase the number of GCP analyzes used with the maximum scale of maps that can be generated.

Then, Analysis of the effect of the number of GCPs with RMSE values done by looking at the RMSE GCP and ICP values displayed in image processing software. This value is related to how large the map scale can be made from the orthorectification image of the various given GCP variations. Planymetric precision analysis is divided into 3 parts order 1, 2, and 3 and each order is divided into classes 1, 2, and 3. Classification of GCP numbers with geometrically generated image scales divided to 3 classes 1, 2, and 3.

Analysis of image distance accuracy done by calculating the distance between GCP from the outermost side and comparing the results with the distance measurement results in the image. The resulting distance difference can be used to determine the RMSE value. T-Test Statistics test is used to find the distance error value allowed for the 1: 5000 scale map. In this research, 3 sample of the best orthorectification image distance from each polynomial order is used. Image analysis of orthorectified results is performed on 1 image with the best accuracy. Includes pixel analysis, analysis of aquatic objects, transformation analysis, and analysis of high objects. From the analysis, it can be determined how many points of GCP at what order orthorectification needed for optimization of 1: 5 scale scale map.

IV. RESULTS AND DISCUSSION

IV.1. RMSE Results Orthorectification

The Placement of GCP Point were located to represent terrain condition in order to increase the accuracy of RMSe. The process of orthorectification using the Rational Function method has 3 choices of polynomial order. 1st order (Nearest Neighbors) requires at least 7 GCP, 2nd Order (Bilinear Interpolation) requires a minimum of 19 GCP, and 3rd order (Cubic Convolution) requires a minimum of 39 GCP. Here is the distribution of 74 point measurement field.

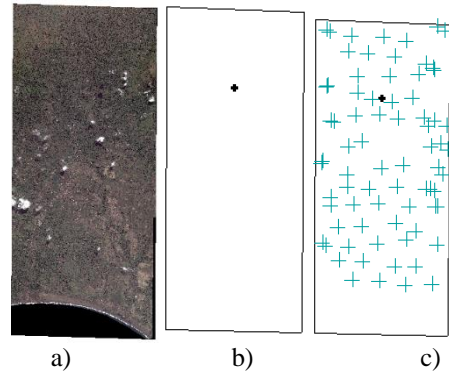


Figure 1 a). High Resolution Image b). Image Area c). Output Measurement Point



Figure 2. Graph of RMS Error GCP and ICP value of Orde 1 (in meters)

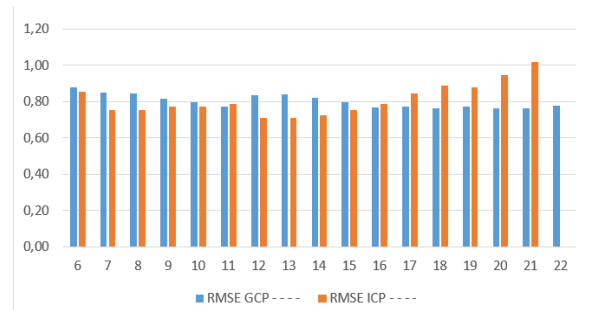


Figure 3. Graph of RMS Error GCP and ICP value of Orde 2 (in meters)

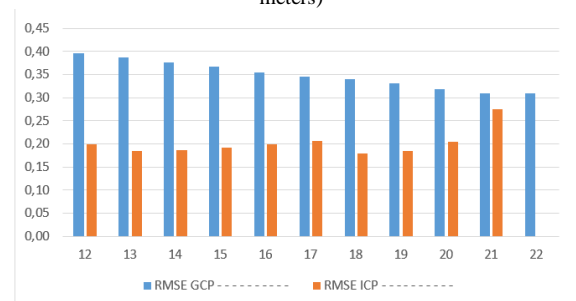


Figure 4. Graph of RMS Error GCP and ICP value of Orde 3 (in meters)

IV.2. Analysis of Distance Accuracy and Test of T-Test Statistics

In this approach, the distance analysis will only be performed on the best model of each order, ie at 1st order with the use of 9 GCP, 2nd Order with the use of 21 GCP, 3rd order with the use of 41 GCP.

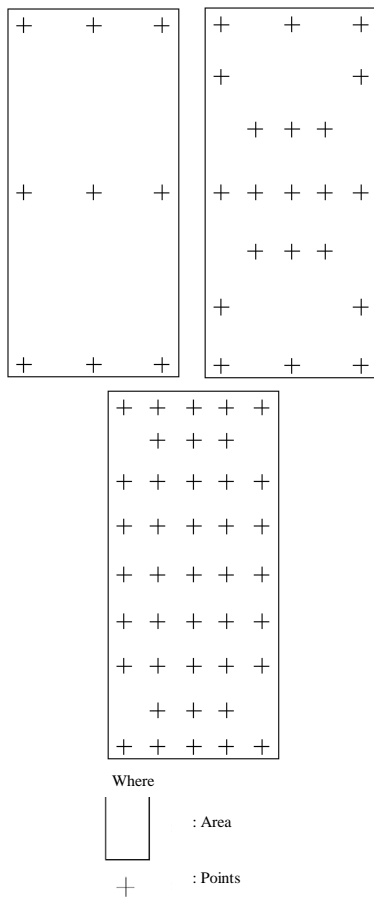


Figure 5. Point Distribution Point 9 GCP, 21 GCP, 41 GCP

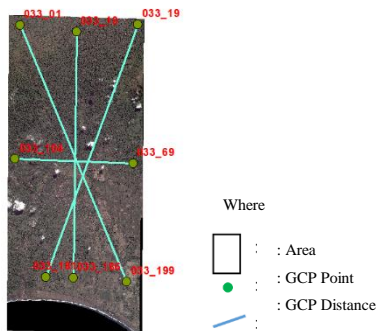


Figure 6. Sample Distance on distance accuracy test

If used $\alpha = 5\%$ and degrees of freedom 2 ($n = 3$), then obtained:

$t_{\gamma, 1 / 2\alpha} = t_{1, 0.05} = 4,303$ (from the student t-test table). With two-sided test method is calculated:

$$X1 = \mu - ((t1, 0.05 * \sigma_x) / \sqrt{2}) = \mu - ((4,303 * 0.25) / \sqrt{2}) = \mu - 0.761$$

$$X2 = \mu + ((t1, 0.05 * \sigma_x) / \sqrt{2}) = \mu + ((4,303 * 0.25) / \sqrt{2}) = \mu + 0.761$$

If we use $\alpha = 10\%$ and degrees of freedom 2 ($n = 3$), then we get:

$t_{\gamma, 1 / 2\alpha} = t_{2, 0.05} = 2,290$ (from the student t-test table). With two-sided test method is calculated:

$$X1 = \mu - ((t1, 0.05 * \sigma_x) / \sqrt{2}) = \mu - ((2,290 * 0.25) / \sqrt{2}) = \mu - 0,516$$

$$X2 = \mu + ((t1, 0.05 * \sigma_x) / \sqrt{2}) = \mu + ((2,290 * 0.25) / \sqrt{2}) = \mu + 0,516$$

Here is a sample test of distance from west of image (point 033_104) to east position of image (point 033_69) at $\alpha = 5\%$ and $\alpha = 10\%$

Table 9 Test Results of t-test on Sample Distance west (point 033_104) to east (point 033_69) at $\alpha = 5\%$

Order	x	X1	X2	Result
1 st	18963.818	18962.217	18963.738	Accepted
2 nd	18963.329	18962.217	18963.738	Rejected
3 rd	18962.874	18962.217	18963.738	Rejected

Table 10 Results of t-test on Western Distance Samples (point 033_104) to East (point 033_69) at $\alpha = 10\%$

Order	x	X1	X2	Result
1 st	18963.818	18962.461	18963.493	Rejected
2 nd	18963.329	18962.461	18963.493	Accepted
3 rd	18962.874	18962.461	18963.493	Accepted

From the calculations of 1st order, 2nd order, and 3rd order with $\alpha = 5\%$, there is 1 result that is beyond the measure which means H_0 is rejected (H_a accepted) on the test of the west-to-east distance sample in 1st order. From the calculations of 1st order, 2nd order, and 3rd order with $\alpha = 10\%$, there is 1 result which is beyond measure which means H_0 is rejected (H_a accepted) on testing of west to east sample in 1st order.

It can be concluded that although the best model for 1: 5000 scale map is available on 3rd order with 41 GCP usage, but for optimal quantity GCP use 2nd order with 21 GCP.

IV.3. Pixel Image Analysis Result Ortorektifikasi

In pixel image analysis ortorektifikasi results done on 2nd order with the use of GCP as much as 21 point order 2, which in the previous explanation found that the 2nd order with polynomial order 2 is the optimal model in the scale map 1: 5000. The following changes pixel size after the orthorectification process obtained from 5 sample point.

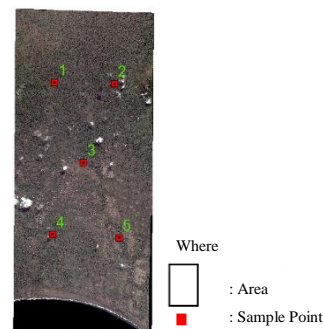


Figure 7. Sample Points Distribution

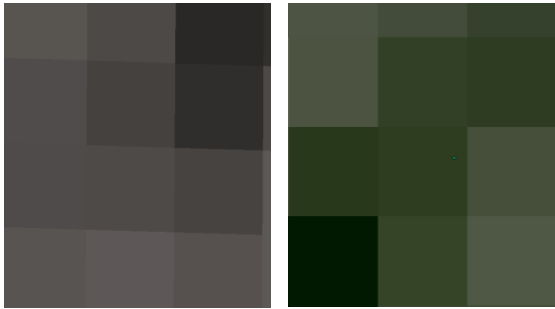


Figure 8 Differences of the Pixel Before and After Pixel Form

V. CONCLUSION

The conclusion from this research are :

- a. In orthorectification process, so that RMSE GCP value $\leq 2.5\text{m}$ can be used amount of GCP as much as 8 GCP with polynomial of orde
- b. In the process of orthorectification the addition of excessive amount of GCP does not alter the scale of the resulting map significantly. For order 1 orthorectification process, optimal GCP used is 9 GCP, 2nd order is 21 GCP, and order 3 is 41 GCP
- c. Relation It is found that the order of polynomials used with the resulting image scale is in order 1 can be used for 1: 3000 - 1: 11000 scale map creation, order 2 can be used for 1: 1500 - 1: 5000 scale map creation, order 3 can be used to map scale $\leq 1: 1500$. The scale varies depending on the accuracy class of the map used
- d. Although the best model in geometric accuracy is found in 3rd order with the use of GCP as much as 41 points and using the order of polynomial 3. But for the scale map 1: 5000, simply use model 7 with the use of 21 GCP with the order polynomial 2.

References

- [1] Geospatial Information Agency. 2015. Mapping Aspect for Detailed Spatial Plans. Cibinong
- [2] K. D. R. Ma, and R. X. Li. 2003. "Rational Functions and Potential for Rigorous Sensor Model Recovery". American : Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University, Columbus, OH 43210 (li.282@osu.edu).
- [3] Tao, C.V., and Y. Hu, 2001a. 3-D reconstruction algorithms based on the rational function model, Proceedings of ISPRS Joint Workshop "High Resolution Mapping from Space" 2001, 19–21 September Hanover, Germany, unpaginated CD-ROM
- [4] Tempfli, K. 1991. DTM and differential modelling. In : Proceedings ISPRS and OEEPE joint workshop on updating digital data by photogrammetric method. Oxford, England

- [5] Th. Toutin a, R. Chénier, Y. Carbonneau. 2002. "3D Models for High Resolution Images: Examples with Quickbird, Ikonos And Eros". Canada : Canada Centre for Remote Sensing.
- [6] Turker, M. and A. O. Ok. Tanpa Tahun. "Comparison Of Different Mathematical Models On The Accuracy Of The Orthorectification Of Aster Imagery". Ankara, Turkey: Hacettepe University.
- [7] Whiteside, A. 1997. Recommended Standard Image Geometry Models, OpenGIS Web Site, URL : <http://www.opengis.org/ipt/9702tf/UniversalImage/TaskForce.ppt>