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Merging Satellite Data in Order to Generating of Base Maps (Case Study: Isfehan - Iran)

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Abstract: *In recent decades, Remote sensing data becomes one of the basic information for generating of base maps and different applications in geomatics. In fact, it is providing very useful for a board range of environmental applications such as surveying, agriculture, geography, meteorology, hydrology, transportation, urban planning, control analysis, landscape planning and etc. Especially in order to generation base maps, the Satellites data has a great role and it is now widely applied on collecting and processing data. For reach to this purpose, we had been used Indian satellite imageries such as the IRS-P5 and the IRS-P6 satellite data which have been belonged to Indian Space Research Organization (ISRO). The P5 (Cartosat-I) satellite was launched on May 5, 2005 into circular sun synchronous orbit which it is equipped with two panchromatic cameras capable of simultaneous acquiring images of 2.5 meters spatial resolution. Also the IRS-P6 (Resourcesat-I) was launched on October 17, 2003 which has three sensor includes LISS III, LISS IV and AWIFS. The LISS IV sensor of this satellite has the spatial resolution 5.8 m with enhanced spectral resolution. It consists of three spectral bands in the green, red and near infrared regions of the electromagnetic spectrum. In this investigation we had been developed a method for generating of base maps in middle scale, such as 1:15000 ratio scale and an attempt has been made to evaluate the information content available with merging data consist of the IRS-P5 and MX mode image from IRS-P6 satellite imageries.*
The results have shown its capability in solving of generation base maps with IRS satellite data and we found that merging these data is very suitable for identification all of the features in the base maps in different categories.

Keywords: Base Maps, Merge Data, Remote Sensing, IRS Satellite Imagery

INTRODUCTION

The use of High resolution satellite images (HRSI) at 5 meters and better geometrical resolution has become a source of ongoing discussions since a number of years. Especially, in order to produce large scales map, these satellite imageries have a good potential and so the generation of base maps improve as well. In this investigation, we had been developed a method for generation of base maps in middle scale such as 1:15000 and 1:10000 ratio scales. For this purpose, we had been the IRS satellite imageries because the capabilities of these images are very suitable. Also, the Indian Space Research Organization (ISRO) successfully operates several Earth-resources satellites that gather data in the Visible and Near IR bands, beginning with IRS-1A in March of 1988. Our data for reach to generation the base maps, includes two kind satellite imageries from IRS series (Fraser, 1999).

The P5 (CARTOSAT-I) satellite images

Cartosat-1 satellite was built by the Indian Space Research Organization (ISRO) mainly for mapping. The satellite was launched into circular (altitude is 618 km) near-polar sun synchronous orbit on May 5, 2005. Cartosat-1 is equipped with two panchromatic cameras capable of simultaneous acquiring images of 2.5 meters spatial resolution. One camera is looking at +26 degrees forward while another looks at –5 degrees backward to acquire stereoscopic imagery with base to height ratio of 0.62. The time difference between acquiring of the stereo pair images is approximately 52 seconds. The imagery is supplied with Rational Polynomial Coefficients (RPC) and intended for image processing (Dowman & Tao, 2002). The location of P5 (Cartosat-I) satellite for preparing the stereo images is shown in figure 1.

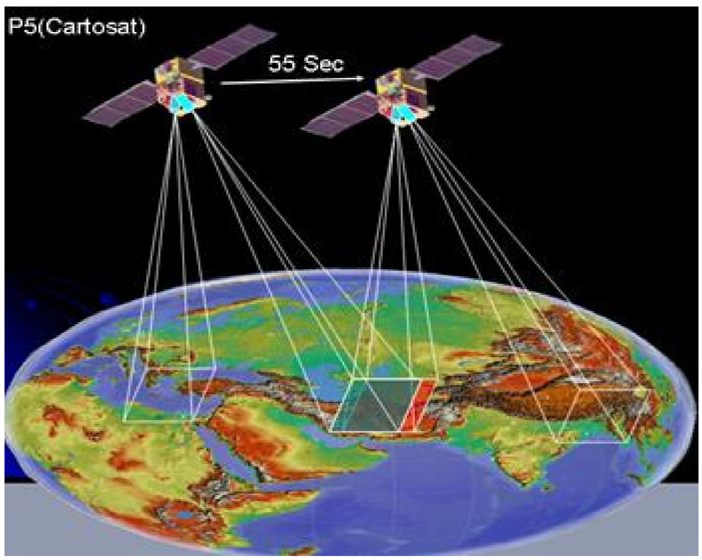

Figure 1: The location of P5 (Cartosat-I) satellite for preparing the stereo images

The P6 (RESOURCESAT-I) satellite images (Exactly LISS IV satellite imagery)

The P6 (RESOURCESAT-1) was launched on October 17, 2003 which has three sensors such as LISS-IV, LISS-III and AWIFS. The kind sensors of P6 (RESOURCESAT-I) satellite with another characteristic such as, revisit Cycle, Swath width, Spatial resolution and radiometric resolution is shown in table 1 (Lutes, 2006).

Table 1: The kind sensors of P6 (RESOURCESAT-I) satellite

Swath width	Spatial resolution	Radiometric resolution	No. of b Bands	Revisit Cycle	Kind of sensor
140 Km	23.5 m	7 Bit	4	24 days	LISS III LISS IV
70 Km	5.8 m	7 Bit	1	5-48 days	Mono-mode
23.9 Km	5.8 m	7 Bit	3	5-144 days	Mx-mode
700 Km	56 m	10 Bit	4	5 days	AWIFS

The LISS-IV (Linear Imaging Self-Scanner) sensor of this satellite has the spatial resolution 5.8 m with enhanced spectral resolution. It consists of three spectral bands in the green, red and near infrared regions of the electromagnetic spectrum (Fritz, 1999).

For performance our project to produce the base maps, we had been used the LISS-IV sensor images and then merge with IRS P5 (CARTOSAT-1) in order to improve spatial resolution with preservation the spectral resolution of these images (Navalgund, 2005).

Data set used

The case study for performing the suggested method to produce the base maps is located in Isfehan city of IRAN. The geographic extents for this area is:

Latitude from 32°, 36’ to 32°, 40' and longitude is from 51° 38' to 51° 43'.

The LISS IV image of the case study is shown in figure 2.

Figure 2: The part of MX-LISS IV from P6 (RESOURCESAT-I) satellite

Also the P5 (CARTOSAT-I) image of this case study is shown in figure 3.

Figure 3: The part of P5 (CARTOSAT-I) satellite image

Implementation of merging data

The higher resolution imagery is generally single band, while multispectral imagery generally has the lower resolutions; these techniques are often used to produce high resolution with multi spectral bands (Grodecki &

Dial, 2003). Resolution Merge offers three techniques: Brovey Transform, Multiplicative and Principal Component approaches. In this project we had been used the third approach (principal component) because the result with performing this method was better quality rather than another approaches. The result of merging P5 and MX-LISSIV of P6 satellite is shown in figure 4.

Figure 4: The merge of two data, P5 (CARTOSAT-I) satellite image with MX-LISS IV from P6

Map Design Software

The Remote sensing systems describe the data collection about any objects on the ground. In fact, they are raster system which has a great role in acquisition and processing data, but in order to produce base maps in different scales, we must have design software in vector structure. The view of the cartographic vector software is shown in figure 5.

After providing the merge data, the format of satellite imageries is converted to "Geo-Tiff" format. If we want to produce a map which we don't have any map in that area, we must have GCP points measured by GPS on the ground in order to orientation the merge data with the ground, else for updating the maps, we can use the older maps and get the GCP points from those maps.

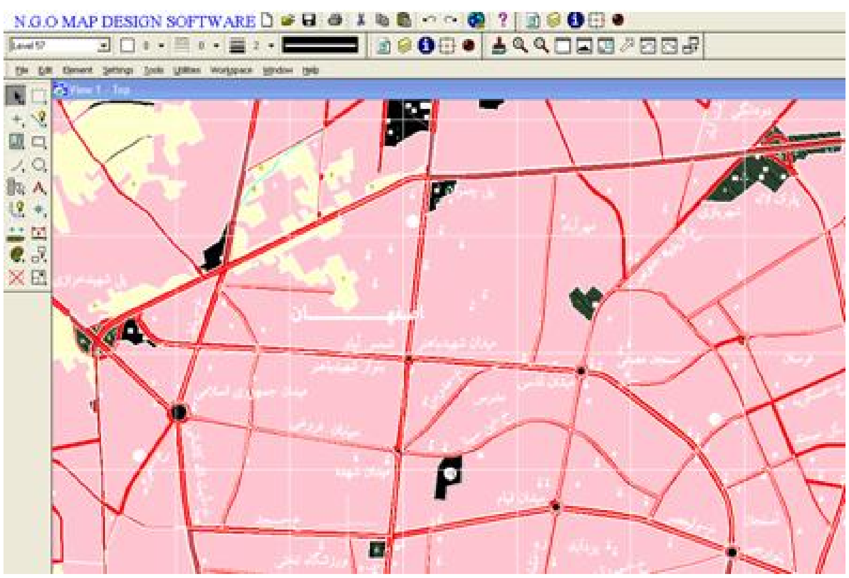

Figure 5: the view of the cartographic vector software

Also, all of the geographic objects available on base maps at the most common scales between 1/10 000 – 1/50 000 are available in our provided maps in 1/15000 ratio scale. These are in different types which shown in table 2.

Table 2: Geographic objects on our base maps

Type	Scale:1/15000
Communications	major roads and motorways, secondary roads, tracks, railways
Equipments	Power lines, Tunnels, Bridges, Sport fields
topography	Contours at 10 m major interval
Hydrology	Rivers and channels, Streams, Lakes and dams, Springs
Vegetation / land cover	Cultivated area, plantation, Grassland, Rocky areas
Artificial limits	Administrative boundaries, Cadastral boundaries and Several types of forest

The final provided map in 1:15000 ratio scale is shown in figure 6, but it is necessary to evaluate the horizontal and vertical accuracy assessment of the satellite imageries which used in generation of base maps. so nine well distributed GCP points were considered on a stereo pair of p5 images as the control points.

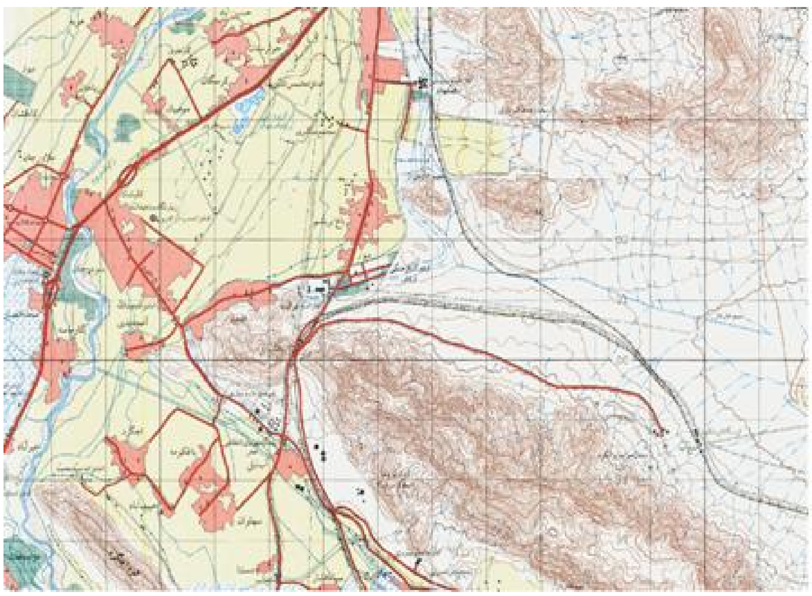

Figure 6: The final provided map in 1:15000 ratio scale

In Table 3 the accuracy of GCP's acquired from geodetic dual frequency GPS in relative mode are shown.

Table 3: The accuracy of GCP's acquired from dual frequency GPS in relative mode

Point		Sigmas(mm)		
No	NGO-Fardis	0.0	0.0	0.0
1	PA4011b	3.3	3.3	9.0
2	PA4012a	18.4	23.7	33.8
3	PA4013a	9.5	8.1	19.8
4	PA4014b	2.8	2.7	8.1
5	PA4015b	12.5	13.2	27.6

6	PA4016a	15.2	9.2	28.8
7	PA5014b	5.5	5.5	17.3
8	PA5015b	6.5	4.3	13.5
9	PA5016b	6.4	6.5	12.7

In the first step, we evaluate the horizontal and vertical accuracy assessment of these images on 8 check points with the contribution of a GCP point (figure 7). In the second step, we evaluate the horizontal and vertical accuracy assessment of these images on 7 check points with the contribution of 2 GCP points (figure 8). In the third step, we evaluate the horizontal and vertical accuracy assessment of these images on 6 check points with the contribution of 3 GCP points (figure 9). In the fourth step, we evaluate the horizontal and vertical accuracy assessment of these images on 5 check points with the contribution of 4 GCP points (figure 10). In the fifth step, we evaluate the horizontal and vertical accuracy assessment of these images on 4 check points with the contribution of 5 GCP points (figure 11). In the sixth step, we evaluate the horizontal and vertical accuracy assessment of these images on 3 check points with the contribution of 6 GCP points (figure 12). In the seventh step, we evaluate the horizontal and vertical accuracy assessment of these images on 2 check points with the contribution of 7 GCP points (figure 13). In the eighth step, we evaluate the horizontal and vertical accuracy assessment of these images on a check point with the contribution of 8 GCP points (figure 14).

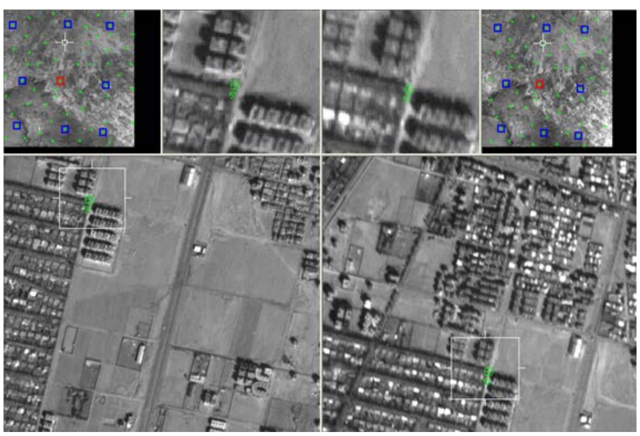

Figure 7: with the contribution of a GCP point

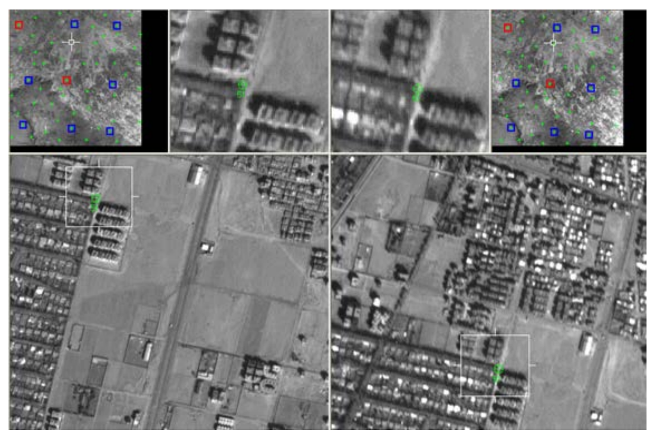

Figure 8: with the contribution of two GCP points

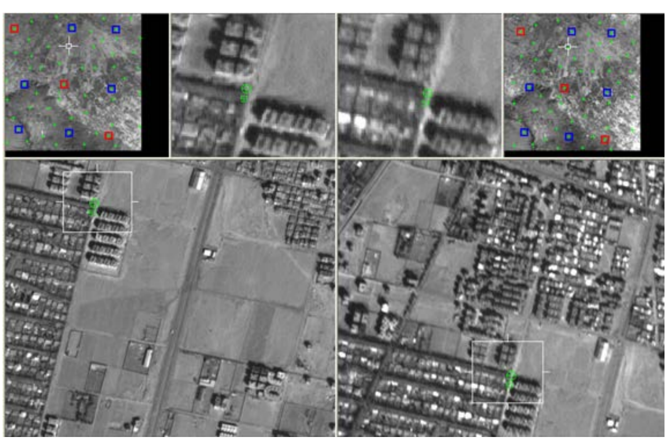

Figure 9: with the contribution of three GCP points

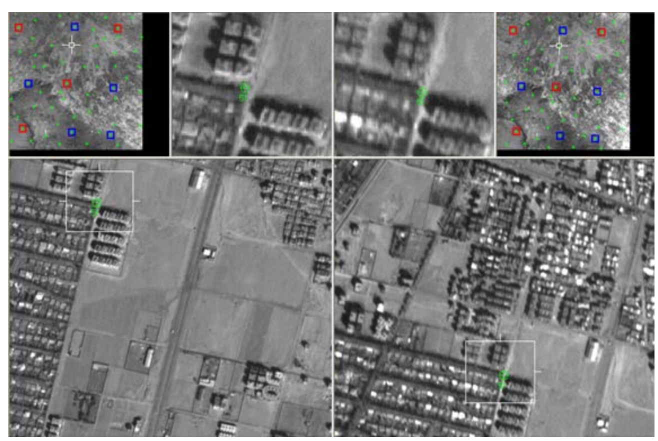

Figure 10: with the contribution of four GCP points

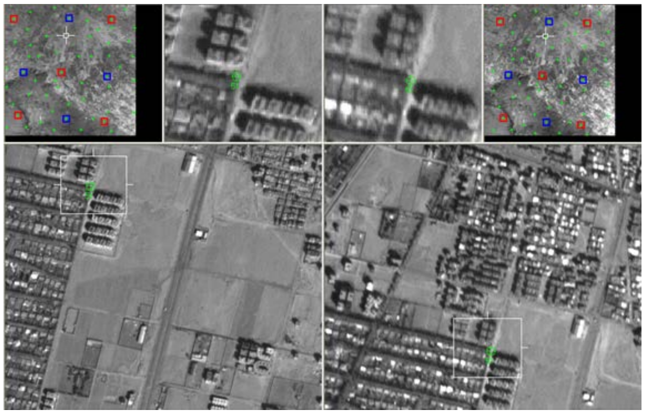

Figure 11: with the contribution of five GCP points

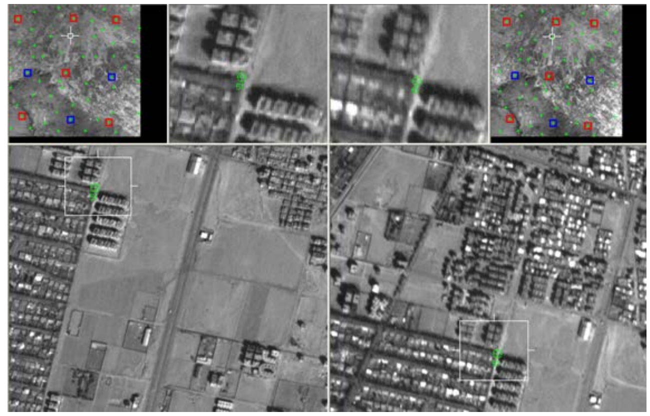

Figure 12: with the contribution of six GCP points

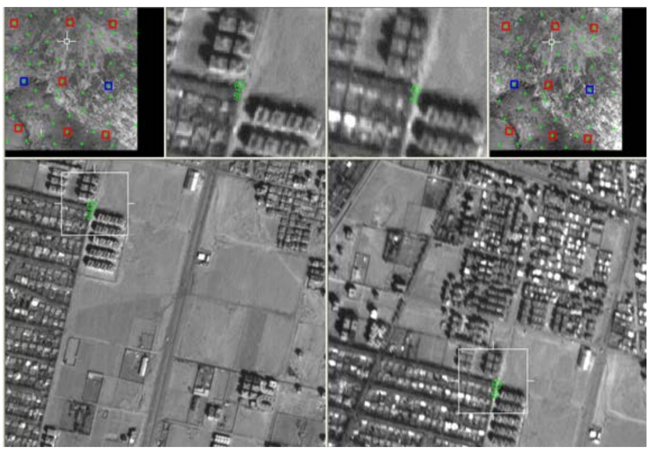

Figure 13: with the contribution of seven GCP points

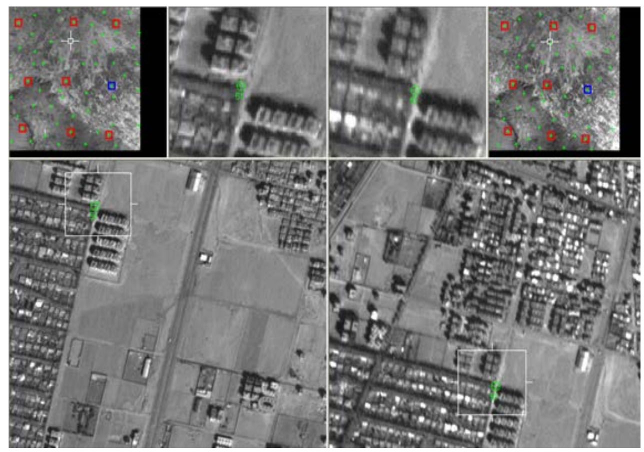

Figure 14: with the contribution of eight GCP points

Red colored point(s) is the GCP point(s) and the blue colored point(s) is the check point(s)

Also in each step, the RMSE on check points are calculated and the obtained amounts are given in following tables.

Table 4: Results with contribution a GCP point

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.00464235	0.00584815	-0.19568283
Check	2	3.51358041	-21.40766477	-3.16350278
Check	3	3.85560725	0.89290522	-8.26113400
Check	4	6.63525698	-7.49039292	-10.35887507
Check	5	4.49236646	-17.17915768	-2.07901746
Check	6	6.94341768	-8.37237224	-11.54060854
Check	7	4.57551709	-18.48161403	-2.52447674
Check	8	1.79747825	13.50922371	-4.35761848
Check	9	8.54889518	-21.54573070	-14.76587562

Also the total RMSE calculated on these check points are:
Ground X:5.4415(m), Ground Y:15.2836(m), Ground Z:8.4147(m)

Table 5: Results with contribution two GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.14071991	-0.81336465	-0.31419715
gcp	2	2.41867599	-14.72221467	-2.18257660
Check	3	3.59165651	2.48229885	-8.02180822
Check	4	6.63525698	-7.61200135	-10.38166037
Check	5	4.33564827	-16.21879118	-1.92921122
Check	6	7.08047927	-9.18711325	-11.65948787
Check	7	4.80760823	-19.89893876	-2.73177099
Check	8	2.13315545	-15.53426588	-4.65928485
Check	9	8.61819526	-21.96310098	-14.83737147

Also the total RMSE calculated on these check points are:
Ground X:5.7079(m), Ground Y:14.7900(m), Ground Z:8.9531(m)

Table 6: Results with contribution three GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	0.05222133	-0.58136414	-0.15600430
gcp	2	2.51617885	-14.98763021	-2.36806764
gcp	3	5.36840890	-13.67430482	-9.25527784
Check	4	2.66113132	4.91592004	-6.35436589
Check	5	5.90015734	-5.69467234	-9.09004719
Check	6	4.72421281	-17.25908458	-2.63888568
Check	7	7.08826442	-9.20489932	-11.66796294
Check	8	2.43013380	-13.53996850	1.56254365
Check	9	-1.16532445	-6.98190207	1.04767002

Also the total RMSE calculated on these check points are:
Ground X:4.5041(m), Ground Y:10.5773(m), Ground Z:6.7039(m)

Table 7: Results with contribution four GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.54408142	10.80845976	-1.10473597
gcp	2	-0.19292966	-0.82313607	-0.11123829
gcp	3	0.10085059	0.44380078	-0.15734633
gcp	4	-0.55662166	-2.32790636	-0.10541398
Check	5	-2.44445003	-4.33489362	-1.32847979
Check	6	-0.21507306	-10.73725470	-5.55459212
Check	7	0.28089930	-0.83308510	-3.68583660
Check	8	3.55146716	-10.08250927	-9.37893839
Check	9	-2.66124292	-1.71453885	3.80914416

Also the total RMSE calculated on these check points are:
Ground X:2.2714(m), Ground Y:6.9191(m), Ground Z:5.4531(m)

Table 8: Results with contribution five GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.08043212	12.81668914	0.77117498
gcp	2	0.20088009	-0.83801615	-0.58220534
gcp	3	-0.43385931	0.27118116	0.36513709

gcp	4	-0.17305951	0.50447177	0.24268870
gcp	5	0.28670391	-2.22775434	-0.97558282
Check	6	-2.09594057	-3.13128043	-0.36362014
Check	7	-0.80072838	-3.22196853	2.96677865
Check	8	-2.64083229	1.73300567	6.11543015
Check	9	-2.93731491	-2.09648815	0.24537065

Also the total RMSE calculated on these check points are:
Ground X:2.2713(m), Ground Y:2.6261(m), Ground Z:3.4057(m)

Table 9: Results with contribution six GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.14013732	12.85912845	0.76350209
gcp	2	0.38665953	-0.70498118	-0.60014600
gcp	3	-0.03002205	0.55923442	0.32758661
gcp	4	-0.16734636	0.50866957	0.24333071
gcp	5	0.51751404	-2.06305598	-0.99618708
gcp	6	-2.41967382	-1.72629566	0.19911976
Check	7	-2.23495053	-3.23081598	-0.35096590
Check	8	-2.39001491	-1.96233298	0.16726840
Check	9	-2.35236858	1.9385789	6.08393587

Also the total RMSE calculated on these check points are:
Ground X:2.3267(m), Ground Y:2.4527(m), Ground Z:3.5197(m)

Table 10: Results with contribution seven GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.22149752	12.79076299	0.54837713
gcp	2	0.26143830	-0.59683920	-0.25348534
gcp	3	0.09225463	0.46179976	0.01910172
gcp	4	0.29280764	0.11575878	-1.02574660
gcp	5	-1.72735156	1.42431030	4.43896371
gcp	6	1.03896577	-2.48271839	-2.32037316
gcp	7	-2.25024977	-1.86617940	-0.24550926
Check	8	-2.27185650	-3.20006711	-0.24984346
Check	9	-2.50813613	-1.06512447	4.63624654

Also the total RMSE calculated on these check points are:
Ground X:2.3929(m), Ground Y:2.3848(m), Ground Z:3.2831(m)

Table 11: Results with contribution eight GCP points

type	No.	Residual_x(m)	Residual_y(m)	Residual_z(m)
gcp	1	2.34441773	12.96391936	0.55827293
gcp	2	0.36463343	-0.45116312	-0.24362459
gcp	3	-0.01335284	0.31273610	0.01043295
gcp	4	-1.99839037	-2.81545817	-0.22875124
gcp	5	-0.49990628	0.40663747	-1.01074669
gcp	6	-1.76023819	1.37903502	4.43977541
gcp	7	0.91613553	-2.65615071	-2.33087423
gcp	8	-2.34149242	-1.99542814	-0.25491770

Check	9	-2.05085144	-2.83184615	-3.04922938

Also the total RMSE calculated on these check points are:
Ground X:2.0508(m), Ground Y:2.8318(m), Ground Z:3.0492(m)

Conclusion

In this investigation we had been developed a method for generating of base maps in 1:15000 ratio scale with the satellite imageries consist of the cartosat-1 (P5) and MX mode image from resourcesat-1 (P6) satellite imageries.
The result was shown that merging these data is very suitable for identification and delineation of linear and polygon features in city area and so, the level of classification improves as well. It is also found that more of the geographic features in a topographic base maps in difference categories such as Communications, Equipments, Hydrology, Vegetation, land use/ land cover and Artificial limits can be extracted with merging IRS P6 LISS IV data and IRS P5 product. Also the horizontal and vertical accuracy was evaluated and we found with consideration of 5 GCP points on the p5 satellite images, the suitable accuracy for generation of base maps in 1:15000 ratio scales was achieved, so use the more GCP points will not increase accuracy and just increase the processing time and lost money.

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