

# Accuracy Analysis on the Automatic Registration of Multi-Source Remote Sensing Images Based on the Software of ERDAS Imagine

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## ABSTRACT

The automatic registration of multi-source remote sensing images (RSI) is a research hotspot of remote sensing image preprocessing currently. A special automatic image registration module named the Image Autosync has been embedded into the ERDAS IMAGINE software of version 9.0 and above. The registration accuracies of the module verified for the remote sensing images obtained from different platforms or their different spatial resolution. Four tested registration experiments are discussed in this article to analyze the accuracy differences based on the remote sensing data which have different spatial resolution. The impact factors inducing the differences of registration accuracy are also analyzed.

**Keywords:** Multi-Source Remote Sensing Images; Automatic Registration; Image Autosync; Registration Accuracy

## 1. Introduction

With the development of remote sensing technology, more and more remote sensing images are being produced. These images are obtained in different time phases, resolutions, wave range and by different sensors. The remote sensing and artificial intelligent technologies make the fusing and comprehensive utilization of different-source remote sensing images possible. Nevertheless, one of the key problems is how to realize the images match automatically. Some institutions and scholars, in China and abroad, have made abundant research on remote sensing image automatic registration. Some researchers created the relevant algorithm on different types of data design. In 1998, Zuxun Zhang *et al.* put forward a rapid full-automatic method for the registration of remote sensing images with different resolutions and from different sensors. The main content of the method in this article is to use multi-stage image probability relaxation integrated matching technology. The high resolution image was taken as a reference image, and the reporter also makes full use of high-resolution-image information to improve the accuracy of registration. However, this method requires the spectral characteristics of the selected images shouldn't be in much difference. Le Yu *et al.* [1] adopted the coarse-to-fine method to register

the remote sensing images. The method is described here. Firstly, the Sift operator was used to extract feature points of images for coarse registration. Secondly, the method of adaptive-feature extraction based on Harris operator was then adopted to make the feature points distribute uniformly. Finally, the TIN etc., multiple technologies were used to realize the image fine registration [2,3]. However, this method is directly based on the maximum residual information when making the coarse deletion. The method of deleting coarse has been proven not robust sufficiently. The ERDAS IMAGINE software has also been made research in multi-source remote sensing image registration. In version 9.0 and above version, an extra special remote sensing Image automatic registration module—Image Autosync module, was added in. This module could realize the automatic registration of the multi-source remote sensing images. The registration efficiency and accuracy are greatly improved. Nevertheless, in this module, the accuracy of remote sensing image registration is different for images with different resolution and in different platforms. The lower the resolution, the lower the registration accuracy is.

The registration test and precision analysis of remote sensing images with different time, different regions and different resolution are reported in this article based on

the previous research. The Image Autosync module of Image Autosync is validated in the registration of remote sensing data although there are still some multiple problems in Accuracy differences. The brief analysis of the causes of problems is given.

## 2. Multi-Source Remote Sensing Image Registration

Multi-source remote sensing image registration is superimposing [4] of two or more remote sensing images which have different wave band, different time phase, different angles of view or different sensor within the same area or the same target. The main purpose of image registration is to achieve two or more remote sensing images with the geometric position consistency through decreasing or eliminating the geometric deformation caused by the imaging-condition differences between pre-registration images and the reference images. Multi-source remote sensing image automatic registration is a key step of remote sensing image preprocessing, and is also the basis to realize remote sensing image analysis of the same target or area, comprehensive and comparative processing. It plays a quite important role in processing the remote sensing image.

## 3. Image Autosync Module

Image Autosync is an added module in the ERDAS IMAGINE 9.0, which provides an automatic image registration tools to ensure the users in various technical levels to complete professional registration work easily. The module mainly includes image edge matching and geographic reference image registration functions. The first workflow is to input two or more images with potential difference, such as HJ images and TM images. Thousands of homonymy points in their overlap region are produced to obtain high-precision registration of remote sensing image. This method can not only change the existed registration accuracy in the geographic-reference image, but also realize rapid registration from the original image to image based on geographic reference. The second workflow is the edge matching, which apply the partial model to the overlap part of the image. This submodule Autosync Workstation in the Image Autosync module is mainly used to complete registration of remote sensing image with different sensors, different time phases, different resolutions, and make a detailed contrastive analysis with their registration accuracy.

### 3.1. Autosync Workstation Automatic-Registration Theory

In the ERDAS IMAGINE 9.0 and above versions, the automatic-registration module with the tool APM (Automatic Point Measurement) to automatically match the

control point. In Image Autosync, APM is a software tool to automatically identify the control points consistent when input two different grid images—input image and the reference image. The basic theory of APM automatically matching the control point is that use pyramid data structure to match level by level. When APM began to run, firstly, it establishes respectively a  $3 \times 3$  image pyramid data structure for the input image and the reference image, which is a group of image sequence generated from low to high resolution. Began to match with the lowest level resolution, the APM will then find the matching point and mapping it to the search area of the last layer, and improve a layer of resolution of the two images, match in the search area, improve the resolution until in accordance with the original image resolution. The matching points of the two images are obtained [5].

### 3.2. Autosync Workstation Registration Process

It's very convenient for ERDAS IMAGINE to realize the automatic registration. The user only need to input the pre-registration IMAGE and the reference IMAGE, and choose feature points extracted options, IMAGE corrected option and IMAGE resampling options in different options, and finally we can get the images which splice of reference IMAGE after registration and pre-registration IMAGE. The concrete realization steps as shown in **Figure 1**.

Under the working environment of Autosync Workstation, a reference image and one or more pre-registration images are needed to be input. In order to achieve higher registration accuracy, the overlap of the images should be at least 20% [6]. As the reference image and pre-registration images sometimes come from different sensors, different time phases and different resolutions, the shear in advance may needs, so that the two images could be overlapped more.

After inputting the reference image and pre-registration image, the parameters of APM are required to be set. In APM, the option of advanced Point Matching Strategy—Use Manual TiePoints for Initial Connection between Images, and its default is not ticked. In order to ensure the accuracy of registration, here, this option is chosen, and four control points in the four corner areas of the image are chosen. In the APM parameter of senior control point matching strategy, there is a Minimum Point Match Quality. The parameter value ranges from 0.60 to 0.99. The smaller this value, the more the matching points will be, but the more the wrong matching points are. On the contrary, the higher the value the less the matching points are, but the less the wrong matching points are. The value is set according to the specific conditions of the two images. Typically, the value is a few bigger in plain region of the image, and the value is

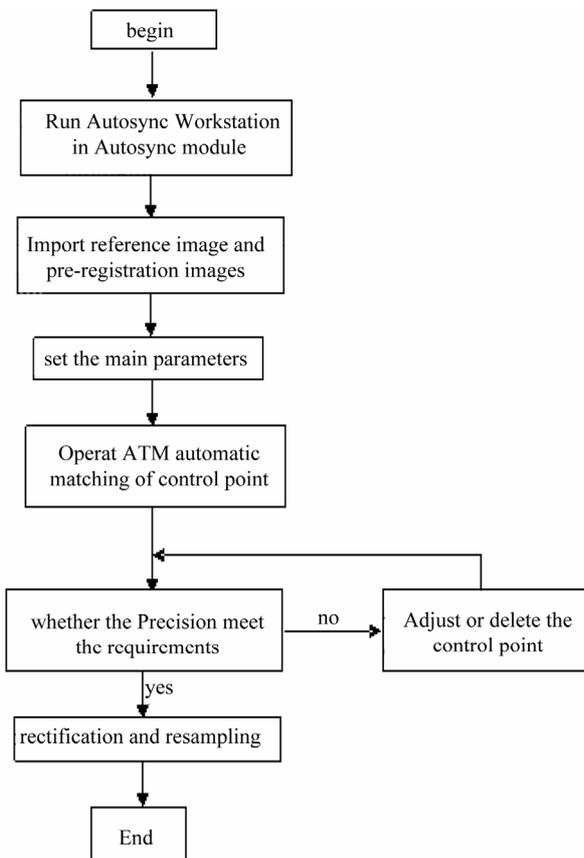


Figure 1. Registration process.

smaller in mountainous area of the image or when image quality is poor [7].

### 3.3. Accuracy Control and Resampling

Image registration accuracy is usually measured by RMS error (root mean square). The following is calculation formula:

$$RMS = \sqrt{(X' - X)^2 + (Y' - Y)^2} \quad (1)$$

$X$  and  $Y$  represents the original coordinates in Formula (1), and  $X'$  and  $Y'$  represents coordinates after conversion. The total RMS error is determined by the residual. Residual is the distance between the original coordinate and inverse transform coordinates on one direction. Residual  $X$  is the distance between original  $X$  coordinates and conversion  $X'$  coordinates, so as residual  $Y$ , total RMS error shows as follow:

$$T = \sqrt{\frac{1}{n} \sum_{i=1}^n XG_i^2 + \frac{1}{n} \sum_{i=1}^n YG_i^2} \quad (2)$$

In Formula (2),  $T$  represents total RMS error,  $n$  represents the number of GCP point,  $XG_i$  represents the  $X$  residual of  $GCP_i$ ,  $YG_i$  represents the  $Y$  residual of  $GCP_i$ .

Through the GCP tools in Autosync Workstation, the RMS error and total RMS error of GCP points can be seen. If the RMS error doesn't reach the requirements of precision, (some) low quality control points will be deleted to reach the accuracy [8].

After the RMS reached the accuracy, the pre-registration image will be matched and sampled. Due to more points extracted automatically, usually, the Polynomial (Polynomial transformation) is used to realize registration. In this paper, three Polynomial transformations were chosen [9]. In the resampling, bilinear interpolation method is selected. The combination of the above two transformation mode can not only reach the registration accuracy requirement also can improve the speed of registration. After the resampling, we can analyze the stability of ERDAS IMAGINE automatic registration for multi-source remote sensing data registration through the local amplification of prominent feature and total RMS [10].

## 4. Image Autosync Registration Test

In order to analyze the impact factors to precision for the multi-source sensor image registration, the data and the way of combinations in the test are as follows: 30 m resolution, HJ data of Jiangsu and HJ data; 30 m resolution, TM data of Tibet and TM data; 30 m resolution, HJ data of Jiangsu and TM data and 0.41 m resolution Geo-eye data of Hainan area and 0.1 m resolution unmanned aerial vehicle (uav) data. This paper uses the above data to realize the automatic Image registration through the ERDAS IMAGINE, and analyze the accuracy of registration results from the vision and the root mean square.

### 4.1. Automatic Registration Test

In the four tests, the cubic polynomial is used for registration and the method of bilinear interpolation is used for image resampling.

#### Test 1: HJ data and HJ data registration test

Loading data and automatically extracting rear interface of control point which is shown in Figure 2.

#### Accuracy analysis

Some typical points were selected from the report of ERDAS automatic registration, shown in Table 1. This table includes the minimum and the maximum error of the registration points and maximum matched and minimum matched point.

1) Visual effect analysis. As shown in Figure 3, it is the local enlarged view after two HJ star image spliced.

2) The RMS error analysis. From self-generated report of ERDAS, the root mean square error is 1.182 after HJ star image registration.

#### Test 2: TM data and TM data registration test

Loading data and the distribution of feature point after

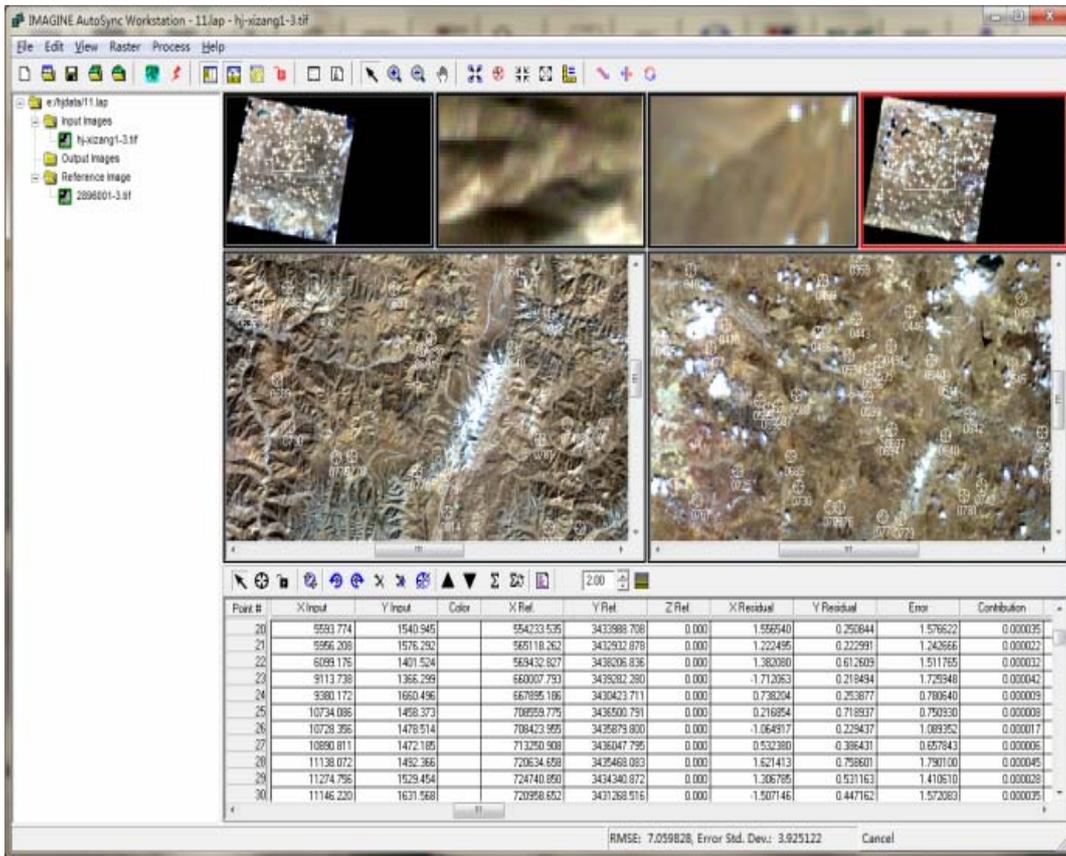


Figure 2. HJ automatically extract feature point.

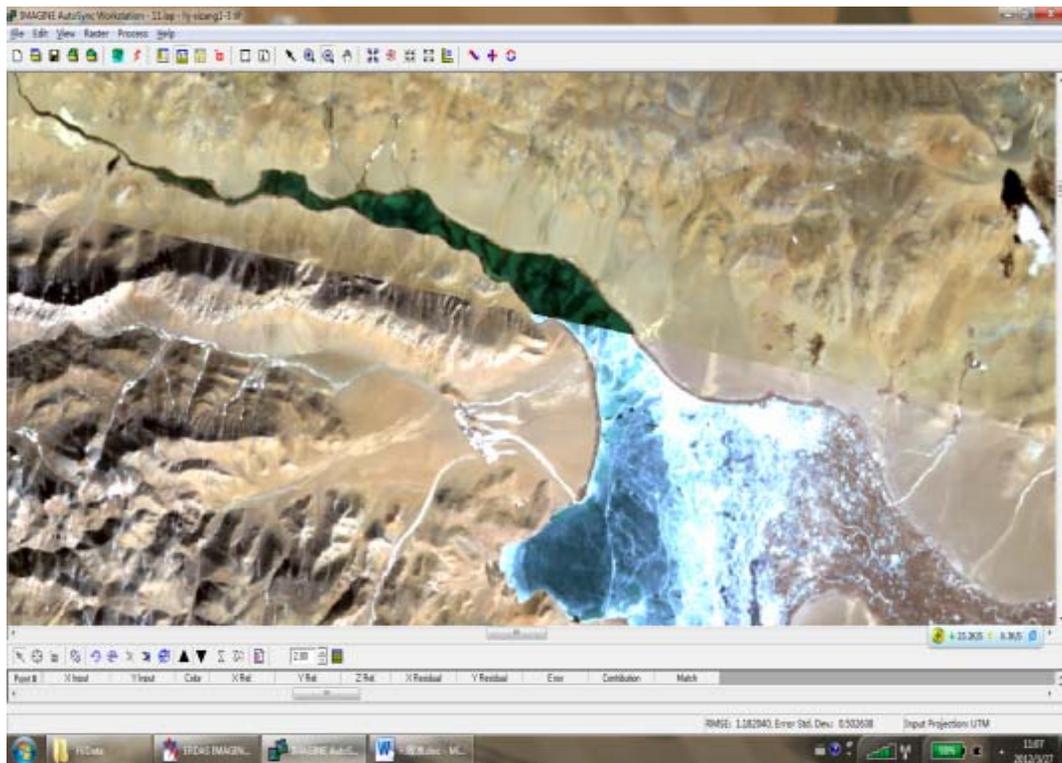


Figure 3. Local enlarged view and its distribution.

**Table 1. Environment star image registration.**

Point ID	X Input	Y Input	X Ref	Y Ref	X Residual	Y Residual	Error	Match
0170	13460.451	2195.385	790342.177	3414217.719	2.2019	1.2808	2.547	0.86
0618	1765.198	6210.755	439195.634	3293807.475	-0.2925	0.0585	0.298	0.93
1076	4739.070	9743.559	527912.958	3187954.892	0.8373	1.2257	1.482	0.98
0454	8755.150	4974.081	648934.394	3330851.733	0.8600	-1.0767	1.378	0.85

extraction is shown in **Figure 4**.

#### Accuracy analysis

Select some typical points from the report of ERDAS automatic registration, shown in **Table 2**. This table includes the minimum error and the maximum error of the registration points and maximum matched and minimum matched point.

1) Visual effect analysis. As shown in **Figure 5**, it is the local enlarged view of linear features joint selected after two TM images spliced.

2) The RMS error analysis. From self-generated report of ERDAS, the root mean square error is 0.183 after TM image registration.

#### Test 3: HJ data and TM data test

The reference image we selected is HJ data of 30 m resolution the in the test, and pre-registration image is TM image of 30 m resolution. The test data loading and feature points extracting is shown in **Figure 6**.

1) Visual effect analysis. As shown in **Figure 7**, it is the local enlarged view of linear features joint selected after TM and HJ images spliced.

2) The RMS error analysis. From self-generated report of ERDAS, the root mean square error is 4.499 after TM and HJ image registration.

#### Test 4: Geoeye and unmanned aerial vehicle (UAV) data

This test used two images with different sensors and different resolution to test. The test data were Geoeye data of 0.41m resolution and UAV image of 0.1 m resolution. The test data loading and feature point distribution is shown in **Figure 8**.

#### Accuracy analysis

Select some typical points from the report of ERDAS automatic registration, shown in **Table 3**. This table includes the minimum error and the maximum error of the registration points and maximum matched and minimum matched point.

1) Visual effect analysis, as shown in **Figure 9**, it is the partial enlarged view of linear features joint selected after Geoeye and uav images spliced.

2) The RMS error analysis, from self-generated report of ERDAS, the root mean square error is 14.396 after Geoeye and uav images registration.

## 4.2. Results of Test

From the tests above we can find that for different images, the registration accuracy of image Autosync automatic registration module is quite different. For image of the same sensor and resolution, the registration precision is higher and lower for image of different sensors and resolutions. For image of different platforms and resolutions, after registration, the accuracy is worst. The detailed comparison is shown in **Table 4**.

## 5. Conclusions

The conclusion can be obtained from the analysis, by using Image Autosync to register multi-source remote sensing Image and through analyzing the registration precision and registration efficiency of each experiment (this paper does not involve the time), that automatic registration accuracy of homologous data is the highest, registration accuracy of different source but the same resolution image take second place, and registration accuracy of different source different resolution image is the worst. The reasons for the differences of registration precision mainly include the following:

1) The quality of image affects the registration accuracy directly. The HJ image and TM image are both 30 m resolution, but their respective registration accuracy is discriminating, this mainly because imaging quality of the TM images is better.

2) The registration accuracy of the same sensor images is higher than different sensor precision, which is mainly caused by imaging time and point of view with the different sensors. Even if the same target in different sensor image can also present inconformity scales. Image Autosync realizes automatic registration only once, if realizes the thoughts of secondary registration from coarse to refined, it will improve their registration accuracy as to the registration of different source remote sensing data.

3) From the tests above, we can find different sources for remote sensing data, the bigger the gap between the resolution, the worse the registration accuracy. It mainly because the bigger the gap between the resolution, the actual distance gap of each pixel resolution representative will be bigger, so the precision of the feature points extracted can be reduced, and finally results in a lower

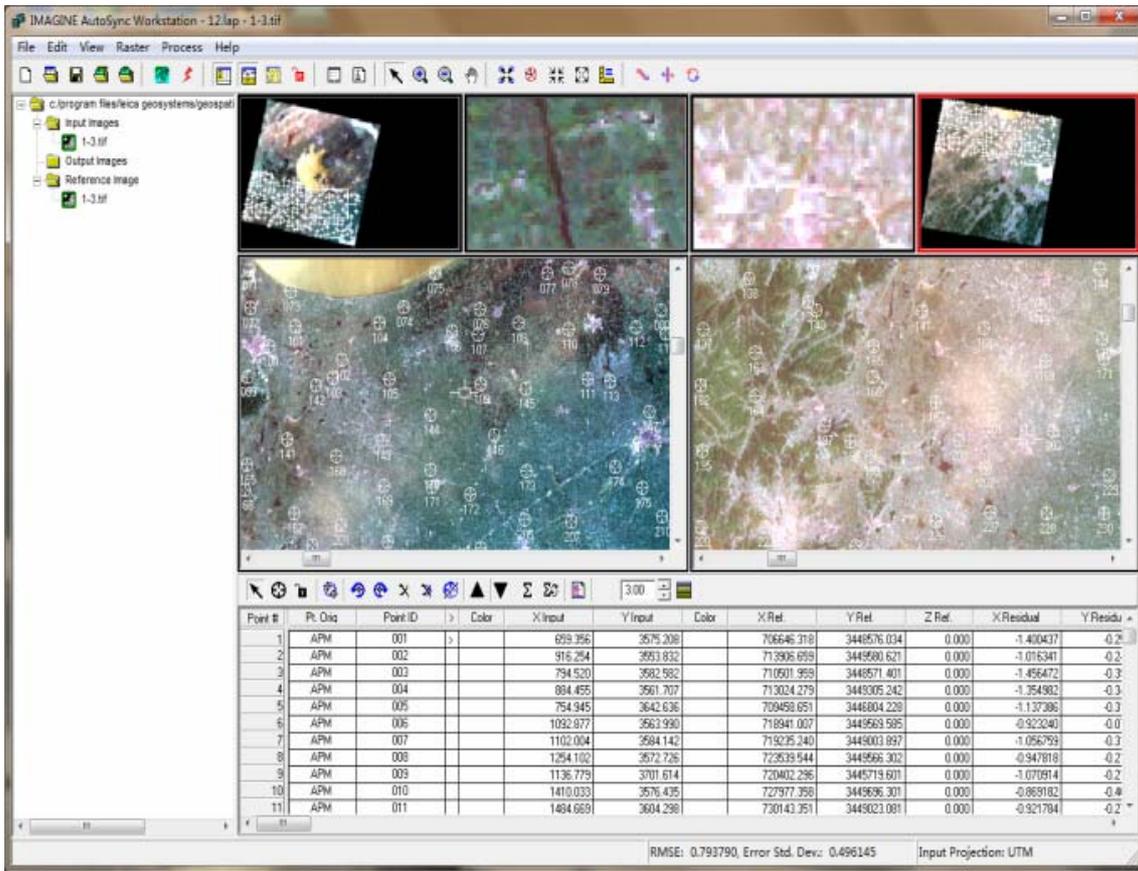


Figure 4. TM automatically extract feature points.

Table 2. TM image registration.

Point ID	X Input	Y Input	X Ref	Y Ref	X Residual	Y Residual	Error	Match
0921	762.893	8182.871	389711.396	3789837.392	0.1389	-0.0412	0.144	0.95
1071	6525.201	9179.280	562593.925	3759741.767	-0.8837	-0.1380	0.894	0.91
702	1349.308	6233.846	407356.245	3848286.181	-0.2781	0.1009	0.242	0.98
1004	8551.452	8543.257	623398.652	3778732.473	-0.9855	-0.3103	1.033	0.90



Figure 5. Local enlarged view and its distribution.



Figure 6. TM and HJ automatically extract feature.



Figure 7. Local enlarged view points and its distribution.

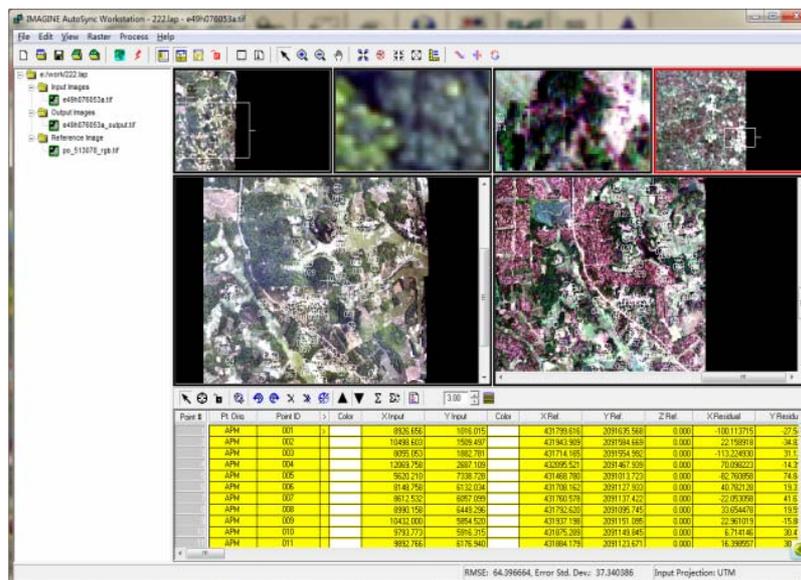
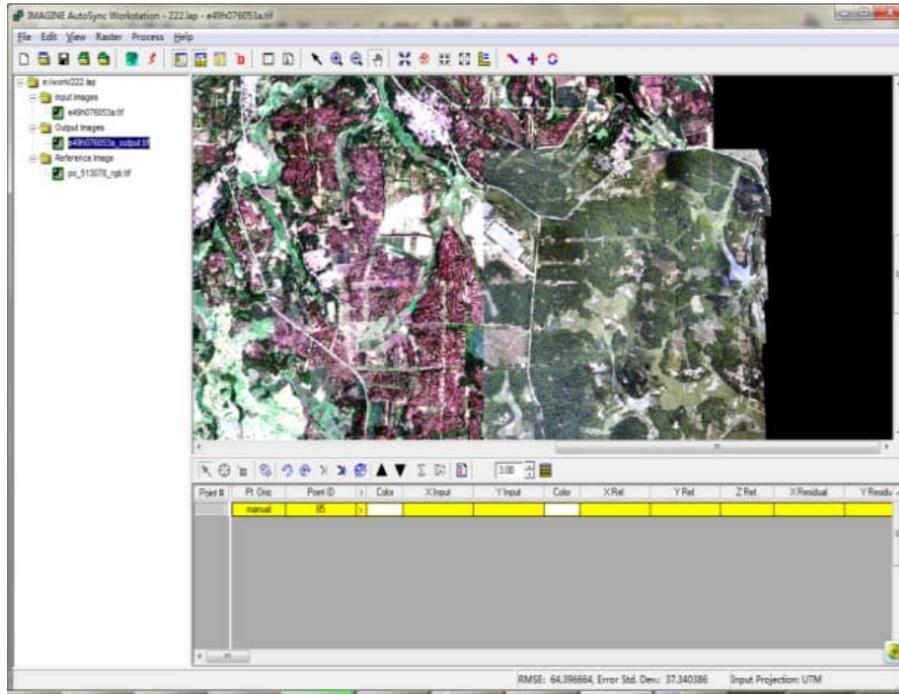


Figure 8. Geosy and uav data automatically.

**Table 3. Geoeye and uav image registration.**

Point ID	X Input	Y Input	X Ref	Y Ref	X Residual	Y Residual	Error	Match
1117	4016.492	10255.045	506175.615	3172630.283	1.0148	1.4828	1.796	0.90
0700	1171.399	6942.921	421362.106	3271907.255	-2.4059	1.6105	2.8952	0.85
0942	7873.0258	8855.9667	621979.248	3214500.820	1.7200	-0.8870	1.935	0.92
0696	11103.737	6641.040	719241.269	3280949.062	-1.7690	0.8966	1.983	0.83

**Figure 9. Partial enlarged view of extracted feature points.****Table 4. Automatic-registration-accuracy comparison of multi-source remote sensing data.**

Registration Image	TM and TM Image	HJ and HJ Image	HJ and TM Image	Geoeye and UAV Image
RMS Error	0.183	1.182	4.499	14.396

registration precision.

## 6. Acknowledgements

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