IMAGINE AutoSync™ White Paper

Introduction

This document explains what to expect from IMAGINE AutoSync and how to adjust the underlying engine for optimal results. It also provides practical tips and hints, and describes the best strategies to handle difficult situations you may encounter.

This document will be updated periodically. Please refer to the IMAGINE AutoSync product page at our web site for the most recent version: http://gi.leica-geosystems.com/products/

Overview

Imagery always needs to be geometrically corrected to a map coordinate system to be useful. This is especially true for applications such as change detection, resolution merge (pan sharpening), mosaic, and even simple layer stacking. The geometric correction must be highly accurate, because misalignment of features at the same location could render the results useless. Additionally, many applications require the creation of a large database of georeferenced images.

The current process of manual point measurement can be prohibitively labor intensive for large applications, and it does not enforce sub-pixel level correlation between images due to the limitation of human visual interpretation. Block triangulation, although tying imagery together photogrametrically, does not enforce any correlation to already existing image layers.

IMAGINE AutoSync uses an automatic point matching algorithm to generate thousands of tie points, and produces a mathematical model to tie the images together. The resulting workflows significantly reduce or sometimes completely eliminate manual point collection. The output should be generally equal or better in accuracy in comparison to the current methodology.

Benefits

Some of the benefits of using IMAGINE AutoSync include:

- Automatic point matching algorithm for mass tie point generation.

- Automatic sensor detection (if sensor information is available).

- Streamlined wizard workflow that can handle a large number of similar images.

- Powerful workstation that provides an efficient environment and tools for tie point quality assessment, point measurement, preview of the output, and is useful in the organization of complex projects, and so on.

- Iterative model refinement and instantaneous rectification results in the workstation environment.

Constraints

As with any tool, poor data quality and/or inappropriate parameters can produce less than desirable results. As a user, you should be aware of the following:

- Default parameters are appropriate for most data, but may require adjustment to work well for more varied scenes.

- Data quality of the input images, reference image, and Digital Elevation Model (DEM) directly affects the final output results.

- User intervention may be required in some workflows to compensate for poor data quality, erroneous model selection, incorrect tie point measuring, and so on.

The more experienced you are with using IMAGINE AutoSync and the more knowledge you have about the data and workflow, the better the output will be using our software.

Data Preparation

The quality of your input data plays a crucial role in determining the accuracy of the output and extent of user intervention required. Additionally, the type of the input data largely determines which workflow to follow for optimal results. This section discusses various data you can use in IMAGINE AutoSync and how to best prepare the data. It also provides suggested remedies for potential problems.

Input Images

When using the edge matching workflow, you can use georeferenced or calibrated input images. In the georeferencing workflow, input images can be georeferenced, calibrated, or raw images. You can also use images that have map information but are not georeferenced to a particular projected coordinate system.

If you are using raw input images, you must first establish a footprint with the reference image before running automatic point measurement. This is a necessary step since raw images lack the map information to place the image at an approximate location to overlap with the reference image.

Another consideration when using raw imagery is the potential for matching problems between the uncorrected, vertically displaced mountainous regions in the raw image and an orthorectified reference image. This displacement can cause poor points to be generated from the automatic point measurement process. You can alleviate this problem by choosing an appropriate sensor model that allows for the specification of a DEM (DLT, RPC, or ROP) and using an accurate DEM. See the "Modeling" section for more details.

Sensor metadata can be very helpful in establishing models for rectification. For example, QuickBird images contain enough information to build a rigorous model. Generally, data that are rectified using a rigorous model and an accurate DEM produce the best results.

Reference Images

The reference image must be georeferenced and have projection information. For best results, the reference image should have a higher or spatial resolution equal to the input images. IMAGINE AutoSync has been tested with datasets that do not adhere to the above suggestion and at a factor of six difference, it was generally found that tie point editing was required to improve the solution.

Selecting Input and Reference Images

When selecting input and reference images to use, it is preferable to use images with maximum similarity. This largely improves the result of the automatic point measurement. If the images are too dissimilar, the results from the automatic point measurement process may be undesirable.

Some of the main factors that affect the similarities of images include the following:

Time of Capture

Time of capture, especially the season, could greatly alter the radiometric characteristics of the images. For example, a winter scene will not match well with a summer scene with high vegetation.

Resolution

Resolution is another factor that affects point matching results, because it creates a difference in the details of the two images. Avoid mixing input and reference images with a resolution difference larger than a factor of six.

Elevation Variation

Variation in the elevation could also cause a difference between the input and reference images. This is because the reference most likely will be an orthorectified image and therefore vertical displacement is minimal compared to the input. As a result, features that should be in the same location could be far apart when the input and reference images are attempted to be matched. To avoid this problem, you can select a model that will allow for the specification of a DEM.

Spectral Range of Selected Band

The automatic point matching process uses a single band of a multiband image to locate the tie point pairs. Consequently, it is important to make sure similar bands are selected from the input image and the reference image to achieve maximum similarity in radiometric characteristics. Selecting a band within the visible spectrum will produce the best results. Infrared and thermal bands should generally be avoided.

Sensor

The sensor used in capturing the image (Landsat, IKONOS, SPOT, and so on) affects the resolution and radiometric characteristics of the images. It also determines the mathematical models that can be used in the rectification. For example, the Rigorous Orbital Pushbroom sensor model can only be applied to sensors such as IRS, QuickBird, and so on. See the "Modeling" section for details on selecting an appropriate model.

Digital Elevation Model (DEM)

The availability of a high resolution Digital Elevation Model (DEM) can drastically impact the quality of rectification results, especially for mountainous areas. A DEM provides additional model-solving information in determining the location of features in the output. This could greatly reduce the negative impact of vertical displacement when matching input and reference images.

APM Engine

Automatic Point Measurement (APM) is a software tool that uses image-matching technology to automatically recognize and measure the corresponding image points between two raster images. In IMAGINE AutoSync, APM aims to deliver the coordinates of evenly distributed corresponding points between an input image and a reference image.

APM Strategy Parameters

APM works automatically to find the needed image points, but there are a set of parameters you can adjust in circumstances where the default settings fail to produce acceptable results. An Advanced Point Matching Strategy dialog is also provided for more control over the process. Please note that the defaults that appear in these dialogs can be set from IMAGINE properties under the IMAGINE AutoSync listing.

APM Strategy Tab

You can adjust APM parameters on the APM Strategy tab on the IMAGINE AutoSync Project Properties dialog in the workstation, or on the APM Strategy tab in the wizards.
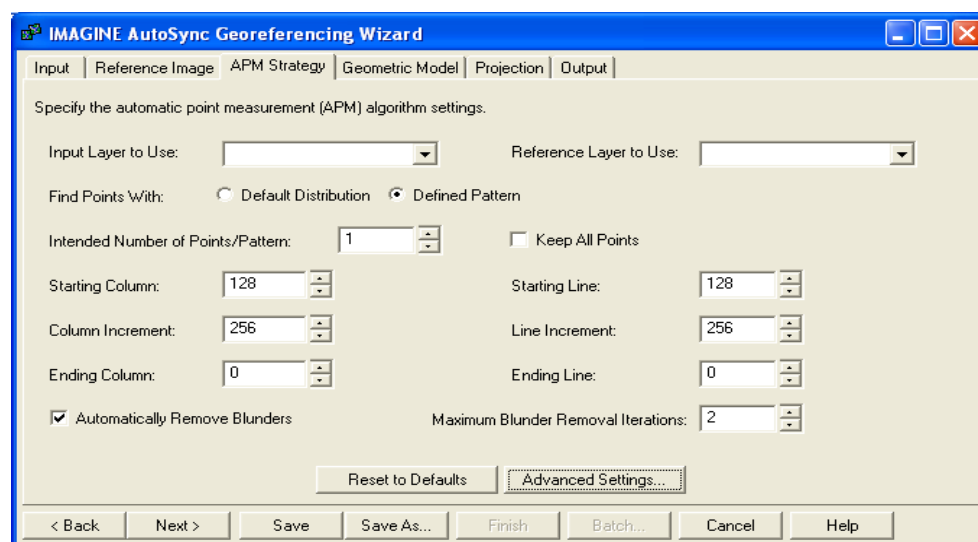
Input Layer to Use: Select the layer of the input image to use for APM. IMAGINE AutoSync automatically assigns a layer name for each layer in the input image, using the following format: Layer_1, Layer_2, and so on. Layer 1 refers to band one of the image. If you have multiple input images in your list and they contain a different number of bands, all possible bands will be listed. If you choose Layer_5 and one or more images only contain four bands, band 5 will be used on any images containing 5 bands, but band 4 or the next available band will be used on any images with fewer than 5 bands.

Reference Layer to Use: Select the layer of reference image to use for APM. IMAGINE AutoSync uses the actual reference layer names.
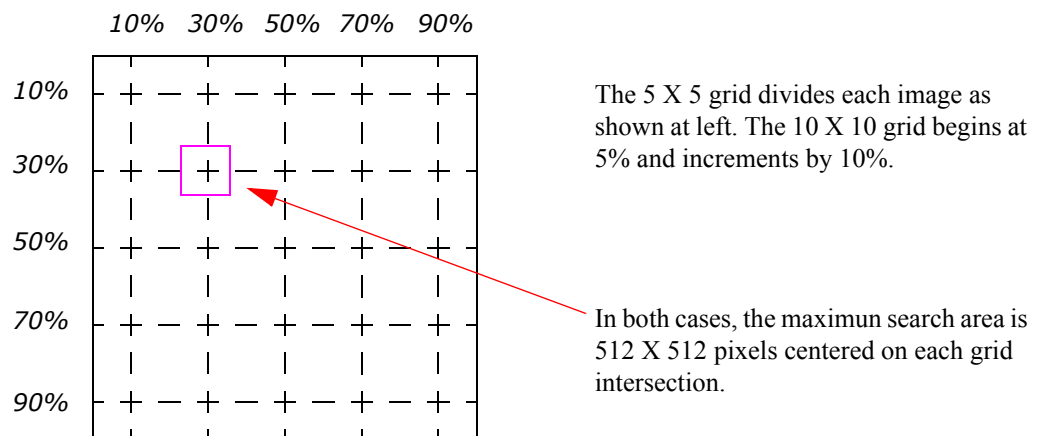
Try to select the layers of two images with same or similar spectrum. For example, if you use two color images, then try to choose the same green bands. The more similar the radiometric characteristics of two images are, the better APM results it can achieve. In case you are using images with different band widths (such as a black-white image and a multi-spectral image), you may still get good results, but you may also encounter less accurate matching points depending on the specific situation.

Find Points With: Select either the **Default Distribution** or **Defined Pattern** type of point distribution.

Default Distribution   APM superimposes a regularly spaced grid onto each image in an attempt to find matching points in a well distributed pattern. When you are attempting to collect fewer than 100 points, a 5 x 5 grid is used. If you want to collect 100 points or more, a 10 x 10 grid is used.

APM tries to collect matching points within an area of 512 X 512 pixels centered on the corresponding grid intersection of each image. If a matching point is not found within this area, APM moves to the next grid intersection. This optimizes the likelihood of finding well distributed points while minimizing search time on large images**.**

The 5 X 5 grid divides each image as shown at left. The 10 X 10 grid begins at 5% and increments by 10%.

In both cases, the maximun search area is 512 X 512 pixels centered on each grid intersection.

Default distribution is most appropriate for standard aerial photography and less so for the more varied possible inputs to IMAGINE AutoSync. For that reason, **Default Distribution** *is available as an option to those working with aerials, but the standard default setting for finding points is set to* **Defined Pattern** *in anticipation of a wider use of data.*

Defined Pattern   If you select **Defined Pattern**, the options **Starting Column**, **Starting Line**, **Column Increment**, **Line Increment, Ending Column,** and **Ending Line** become active. Using those options, you can define the exact placement of tie points throughout the images of the block. With this option, you can also define the intended number of points per pattern.

Intended Number of Points/Pattern (Image)   This section of the APM Strategy tab changes depending on whether you have selected **Default Distribution** or **Defined Pattern**, above. In the case of **Default Distribution**, enter the intended number of tie points generated for each image. The minimum is 9 and the maximum is 500. The default is 400. In the case of **Defined Pattern**, enter the intended number of tie points generated per pattern. The minimum number of points per pattern is 1 and the maximum is 8. The default is 1.

> *If you want to define a tie point pattern, select* **Defined Pattern**. *However, you should consider the overlap percentage when you define your own pattern and try to get each pattern location inside as much of the overlap as possible.*

Keep All Points   Select this checkbox to use all tie points generated regardless of accuracy or distribution. If this checkbox is active, the number of collected tie points will be greater than the intended number of points per image. You do not normally need to choose this option unless your images have low contrast, yielding few points without this option selected.

Starting Column, Starting Line: Define the starting location of tie points you want to find on the image in pixels. You will get better results if you define the starting location close to the upper-left corner of the overlap area on the higher resolution image. It is safe to define the location close to the upper-left corner of the image, but you may get bad results if it is close to the lower-right corner.

Column Increment, Line Increment: Define the increment in pixels for tie point locations along column and line direction. APM will try to find tie points around the image locations with these increments to the previous locations.

Ending Column, Ending Line: Define the last column and line for tie point collection. If you want to define them, they should not exceed the lower-right corner of the overlap area. If you leave them at the default of 0, 0, APM will automatically use the last column and last line of the overlap area.

Automatically Remove Blunders: Click this checkbox to remove blunders (wrong tie points) automatically from the APM generated tie points. Removing blunders is an iterative process based on a 3rd order polynomial model. When this option is selected, the points that do not fit well with the majority of tie points are considered blunders and are discarded. By default, this option is selected. You should deselect this option only if you suspect that it is removing correct tie points. For example, you should deselect this option when most of the APM tie points are wrong, or when there is a large difference in the terrain between the inputs and reference image.

Maximum Blunder Removal Iterations: This option becomes available when you choose to automatically remove blunders with the **Automatically Remove Blunders** option. The default is 2. In most cases, increasing this number means more iterations of the blunder removal algorithm will be run. As a result, more tie points will be considered as blunders and discarded.

Advanced Point Matching Strategy Dialog

On the Advanced Point Matching Strategy dialog in IMAGINE AutoSync, you can adjust the more advanced APM parameters to optimize automatic tie point collection.
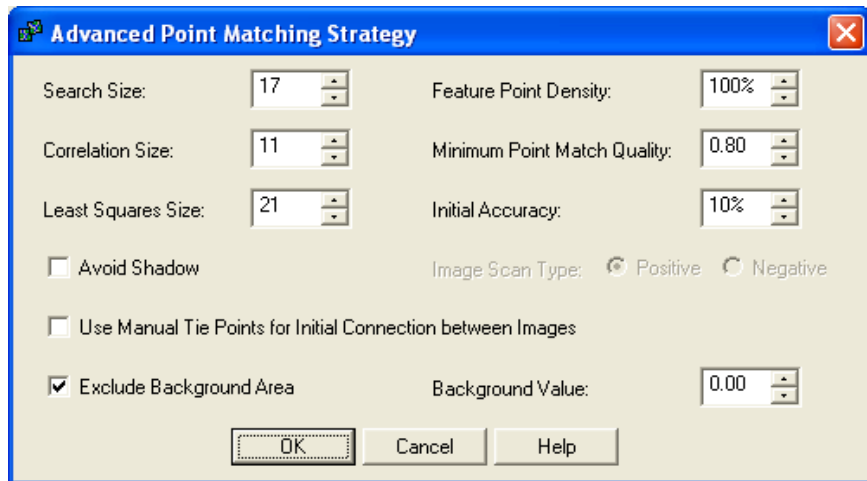
Search Size: Enter the window size in pixels to use for searching for corresponding points. IMAGINE AutoSync searches for the corresponding point within a square window defined by this parameter. The default value is 17 (a 17 x 17 pixel window). For flat areas, this value could be smaller, for steeper areas, it could be larger. A larger value could cause more computation time and more wrong points, but a smaller value could result in fewer matched points.

Feature Point Density: Defines the feature point density percentage based on an internal default. Increasing the value above 100% (for example, in poor contrast area) will get more feature points to get more matched points. Decreasing the value below 100% (for example, in an area with crowded details) will result in fewer feature points to accelerate the computation.

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*Normally, you do not need to adjust this parameter if you are using scanned aerial photos. However, if you select the "**Avoid Shadow**" option, you should set this parameter to a higher value (for example, 200%).*

Correlation Size: Enter the window size in pixels for cross-correlation. The default window size is 11 (11 x 11). A larger window size could cause a smaller correlation coefficient due to the geometric difference within the two correlation windows and, therefore, fewer matched points. A smaller window size could result in a larger correlation coefficient due to insufficient contents, therefore yielding more bad points.

Minimum Point Match Quality: Enter the limit for the cross correlation coefficient. The allowed value is between 0.6 and 0.99. The default value is 0.80. A larger limit results in fewer points accepted and less error. A smaller limit results in more correlated points but possibly more errors.

Least Squares Size: Enter the window size in pixels for least square matching. A larger window size could reduce the number of badly matched points, and could also reduce the number of good points. A smaller window size could increase the number of both bad and good points. The default is 21. You should increase this number for flatter areas and decrease the number for steeper areas. Setting the window size too small could result in insufficient contents in the window for the least square computation.

Initial Accuracy: Enter the relative accuracy of your initial values used by the automatic tie point generation process. Generally, a large value here increases the initial search area for possible corresponding points at the initial estimation phase. This value can be seen as the relative accuracy of the source you have chosen for your initial values (for example, initial map coordinates or relative terrain change). The default value is 10%. You should use initial values with an accuracy of 10% or better for the automatic tie point collection.

Avoid Shadow: When you select this checkbox, APM will try to avoid generating tie points in areas of shadow. Avoiding areas in shadow improves tie point accuracy. You should choose the type of images you are working with; negative or positive image scans.

You do not need to use this option unless shadows are very prominent in your images.

Image Scan Type: Positive   Select this option if you are working with a positive image (bare ground appears white in the image).

Image Scan Type: Negative   Select this option if you are working with a negative image (bare ground appears black in the image).

Use Manual Tie Points for Initial Connection between Images: Select this option if the manually measured tie points will be used as the initials for APM to find additional tie points automatically. Select this option when the initial map coordinates are very coarse, or when no map information is available for one or more of the images. If you try to rectify a raw image to another raw image, you should also select this option. You should manually collect a minimum of three points.

Exclude Background Area: Select this option if you want to exclude the background of the image. When you select this option, a bounding box excluding the background area will be calculated and used as the active image area for APM. The default starting column and starting row will move inside of this bounding box. If you manually changed the values in the **Starting Column** and **Starting Row**, then your new values will take precedence above the calculated bounding box.

Background Value: This option becomes available when you select the **Exclude Background Area** option. Enter the background value of the image. The default value is zero. If you do not know the background value, you can use the IMAGINE ImageInfo tool and review the pixel values of the image.

Ideal Situations for Good APM Performance

For the best APM results, try to ensure that the following conditions are met as much as possible. Not meeting one or more of these conditions does not necessarily mean that the APM results will be of poor quality.

- Use images with an overlap larger than 40%.

- Use images with the same or similar resolution or pixel size.

- Use images that were captured in the same season, at the same time of day (similar illumination conditions), and with similar weather situations with good visibility.

- Use images that were captured by the same or similar sensor.

- Select the same band or a similar band in the images for point matching to ensure similarity of radiometric characteristics.

- Use images that are properly orthorectified (if appropriate). This reduces the impact of vertical displacement and other distortions. Pay special attention to quality of orthorectification. A poorly orthorectified image produces bad results and is misleading in raising your expectation.

- Use images with relatively flat terrain. There is minimal vertical displacement and the radiometric characteristics are better preserved because they have not gone through extensive modification in a prior rectification process.

- Ensure good initial map information is available for the images. Images with less than 10% misalignment in the overlap region tend to yield better results. When there is no initial image map information, you need to perform an initial manual registration. You can do this by digitizing 3-4 high quality points that are evenly distributed and preferably placed close to the image corners.

- When using images with mountainous terrain, use an accurate DEM in order to remove the image displacement caused by the steep terrain change.

Situations to Avoid

These are some situations you should try to avoid, since any or a combination of the following conditions could result in poorly matched points.

> *If you are unable to improve any of the following conditions, refer to the "APM Trouble Shooting and Tips" section to learn about possible remedies by adjusting the APM parameters.*

- Using images with an overlap that is less than 256 x 256 pixels or with an overlap region that is too narrow. Since APM requires a sufficient region to deploy the matching strategy, an overlap less than 20% will not produce desirable results.

- Resolution differences (or pixel size difference) larger than 6 times. This is the threshold for any meaningful results.

- Using images with a drastic time difference can result in a poor match. For instance, a winter scene does not match well with a summer scene due to the change in vegetation. Images do not match well if they were captured too many years apart if there has been a high level of change.

- The band to match selection for inputs and reference should not differ too much in electromagnetic wavelength. For example, an infrared band might not match well with a blue band.

- Sensor characteristics between the images if too different can affect performance. For instance, a very high flying sensor does not match well with a low flying sensor. The band width used, sensor mechanism (pushbroom or discrete sensors) all could play a role in making the images distinct from each other.

- If using images with large, uncorrected terrain relief, the vertical displacement can drastically reduce the likelihood of successful APM results.

- Large scale, high-rise urban scenes do not match well due to the vertical displacement effect, which is difficult to orthorectify.

- Bad initial image registration. If misalignment in the overlap region is larger than 20%, or manually digitized points are unevenly distributed too far from image corners or of poor quality, results may be affected.

- Inappropriate placement of the starting point too close to the ending edge (lower-right corner) of overlap area. This will result in the overlap area not having enough search regions.

APM Trouble Shooting and Tips

Refer to this section if the APM results are not as expected. If APM results in a large RMSE, it may indicate bad APM results and/or inappropriate modeling. Examine the tie points carefully to ensure that the problem is from the APM results (many bad points, not enough points, and so on.) before applying the following steps to fine tune the APM parameters for improved results. If the APM points are correct but the output does not reflect the quality of the points, you most likely have chosen an inappropriate model.

Problem Diagnosis and Solutions

Sometimes you may not be able to rectify or improve any of the conditions. If that occurs, you can adjust the APM parameters by following the steps listed in the next section.

APM Parameter Tuning

When you need to adjust the APM parameters, first match your situation with one of the following, and then adjust the APM parameters accordingly.

Situation	Remedies
Many points, but many poor quality points	On the APM Strategy tab, change one or more of the following parameters: • Increase the **Minimum Point Match Quality** (> 0.9) • Increase the **Correlation Size** and **Least Squares Size** • Decrease the **Intended Number of Points**
Too few points, but good quality	On the APM Strategy tab, change one or more of the following parameters: • Increase the **Intended Number of Points** • Decrease the **Column Increment** and **Line Increment**

Situation	Remedies
Too few points, and poor quality	On the APM Strategy tab, change one or more of the following parameters: • Increase the **Search Size** • Decrease the **Correlation Size** • Decrease the **Least Squares Size** • Increase the **Intended Number of Points** *NOTE: Most likely, you have one or more undesirable conditions, such as a large misalignment. If the problem is a large misalignment, manually collect a few tie points and select the* **Use Manual tie points for initial connection between the images** *option under* **APM Strategy	Advanced Options**.
Too many points	On the APM Strategy tab, change one or more of the following parameters: • Decrease the **Intended Number of Points** • Increase the **Column Increment** and **Line Increment** • Increase the **Minimum Point Match Quality** (> 0.9) and increase the **Correlation Size** and **Least Squares Size** *NOTE: A large of number of points is unnecessary and slows down the APM processing. A large number of points does not necessarily improve the accuracy. Try to trim down the numbers and keep the best points.*

Edge Matching

The nature of APM is to avoid edges of images. Features on the edge, if no points were found, could be misaligned. For the edge matching workflow, it will typically align features towards the center of the overlap. If the next step of processing is mosaicking, a cutline down the center of the overlap will eliminate issues on the edge. To match the entire overlap, it may be necessary to manually collect points on the edge, especially on linear features, to obtain full alignment.

Modeling

This section provides a brief explanation of the various mathematical models available in IMAGINE AutoSync. You can apply these models to the input images in order to geometrically correct them. Understanding the model properties helps you select the model that will generate the most accurate results for your dataset.

Image to Image (2D) Transforms

An image-to-image transform can warp one image onto another without the use of an earth model (DEM). The fit will not be as good as a rigorous sensor model that requires a DEM because much of the distortion comes from the terrain.

Rubber Sheeting

Rubber sheeting is a two dimensional image-to-image transformation which is implemented as a piecewise transformation based on the triangles formed from the tie points. This has the property that the transformation is always perfect at the control points and there is always a well behaved transition from triangle to triangle. However, if an image has hilly or mountainous terrain, you will have to collect a large number of tie points. In effect, the tie points will be forming a model of the terrain surface. This can be impractical since the performance of rubber sheeting decreases as the number of points increases. Rubber sheeting is best used in an area of moderate relief when an actual sensor model and a DEM is not available.

Polynomial

A polynomial model is a two dimensional image-to-image transformation. The polynomial model is of the form:

$$X = \sum_n A_i x^i y^{(n-i)}$$

$$Y = \sum_n B_i x^i y^{(n-i)}$$

If the order is set to 1, then the result is an affine or linear transformation that is appropriate for cases where there is little or no terrain displacement and most of the image to image difference is in the form of scale, offset, and rotation. You can use higher orders in cases where there is slowly varying terrain effects with scale, offset, and terrain rotation. In both cases, it is assumed that the actual sensor model and DEM are not available.

Ground to Image (3D) Transforms

Every image is a mapping of three-dimensional (3D) coordinates into a two-dimensional (2D) plane. The ground-to-image transformation models this mapping using a DEM as the earth model.

Rigorous Orbital Pushbroom (ROP)

Many current satellite imaging systems use pushbroom sensors. This is a sensor that has a linear sensing array associated with an optical system. The whole system is moved forward by the orbital motion of the satellite. As it moves, the single line is pushed forward, scanning a whole image. The linear array can be thought of as a very narrow camera, which can be modeled with the same six parameters as a frame camera. Each line has a different set of six parameters. Because the orbit of the satellite is very stable and well known, the position (x, y, z) and orientation, omega, phi and kappa (ω, ϕ, κ) can be modeled as time varying parameters. The time is related to each line so these parameters can be computed give the line number in the image. In the case of the Rigorous Orbital Pushbroom (ROP), the parameters of the orbit model are refined using the tie points.

Satellites which are currently handled by the ROP model include:

- SPOT 5

- EROS 1A

- ASTER

- QuickBird

- OrbView

Approximate Sensor Models

It is possible to use mathematical approximations for many sensor models. These approximations do not directly model the sensor. Instead, they are based on mathematic formulas whose results are very close to the rigorous sensor model.

Rational Polynomial Coefficients (RPC)

Rational Polynomial Coefficients are (as the name implies) ratios of polynomials. These can model reasonably complex transformations and remain stable (high order polynomials tend to be unstable). Like a polynomial, a rational polynomial is described by an order and a set of coefficients for the numerator and denominator for the X and Y term. A rational polynomial is a 3D to 2D transformation in the sense that a ground x, y, and z are used along with the coefficients to compute the image row and column values.

The RPC coefficients are typically computed using a solved rigorous model. One reason to use RPCs is that you do not need to know the original rigorous model, so it is a good way to provide a common framework which is independent of the actual sensor used.

The following satellites' data and formats provide RPCs:

- IKONOS

- QuickBird

- OrbView

- NITF Data

The RPC values themselves cannot be computed from the tie points and ground points. However, existing RPC values can be refined to provide more accurate transforms.

Direct Linear Transform (DLT)

The Direct Linear Transform (DLT) is actually an RPC whose order is equal to one. The DLT is an excellent approximation for frame cameras, and when it is known that the data comes from a frame camera, you can use this without knowing the specifics of the frame camera. The DLT coefficients can be computed from the tie and 3D points.

Selecting a Model

You will get the best results when using a rigorous sensor model and an accurate DEM. Most of the satellite data are shipped with sensor model data (either parameters for the rigorous orbital pushbroom or RPCs) which IMAGINE AutoSync can read. If the model is unknown but a DEM is available, then it is a reasonable strategy to first try using a DLT. If the results from the DLT are not acceptable, the image may have been created using a pushbroom sensor. In this case, the pushbroom orbital parameters are unknown, so the next best candidate is to use one of the image-to-image (2D) transformations as described above.

Selecting a DEM/DTM

The quality and accuracy of the results will be directly tied to the quality of the DEM or DTM (Digital Terrain Model) used. A DTM usually does not include man-made structures such as buildings or bridges, so it can be expected that these features will have the most mismatch in the final results.

Modeling Trouble-Shooting and Tips

Refer to this section for additional modeling troubleshooting help and tips.

• The more rigorous the model, the better the result. Follow the list to make the best of the available information from the data. The recommended order of models from the most rigorous to the least is:

   1. Rigorous Orbital Pushbroom (ROP)

   2. Rational Polynomial Coefficients (RPC)

   3. Direct Linear Transform (DLT)

   4. Polynomial

   5. Rubber Sheeting

• The quality of the points is essential in determining the outcome of the image-to-image transformation models. Ideally they should be evenly distributed and closely matched. If a particular region has very few points, you may collect some points manually to compensate.

• If you determine that image to image (2D) transform is the best available model for the images, the following tips can help you decide whether to use an Affine, Polynomial, or Rubber Sheeting model.

Number of Tie Points	Appropriate Model
< 10	Affine
10–50	Polynomial (3rd Order)

Number of Tie Points	Appropriate Model
> 50	Polynomial or Rubber Sheeting *NOTE: When the density of points is satisfactory with an even distribution, use Rubber Sheeting. Otherwise, use the 3rd Order Polynomial.*

- Rubber sheeting models always have an RMSE of zero. Points would need to be manually reviewed in order to assess accuracy. When using the Linear or Non-Linear Rubber Sheeting model, you can first try using a Polynomial model for the data. Then use the RMSE as threshold to find and remove any mismatched points using the RMSE threshold selection tool in the IMAGINE AutoSync Workstation. The RMSE threshold selection tool will select all points that do not meet the specified value. By right clicking in the far left column on the CellArray, you can delete all selected points quickly eliminating the bad points. Finally, apply the Rubber Sheeting Model. Only the remaining points will be used, yielding better results.

- When results from using the Linear or Non-Linear Rubber Sheeting model show significant misalignment in a region, selectively collect some manual tie points in that area and resolve the model to correct the situation. This process can be very effective in correcting a situation where the overall model fits well, but is problematic in a small number of regions.

- Deleting points with an Error Mean + 2 x Standard Deviation, and resolving the model 3-4 times will drastically improve the overall error results. Repeating this process more than 3-4 times will have diminishing results. This is more applicable when using a rigorous model such as RPC, Orbital Pushbroom, or DLT. When using other models (Polynomial, Linear, or Non-Linear Rubber Sheeting, and so on.), this method may not be as beneficial.

- During the process of resolving the model, you can undo the last deletion of points if the model results are not what you expected.

IMAGINE AutoSync Tips and Hints

This section provides additional tips and hints for using IMAGINE AutoSync to generate the best results.

Interpreting Results

After careful data preparation, you can run APM and tie the images together through a mathematical model. Then you can review the results. This section explains how to correctly interpret the results, identify any problems, and how to resolve them.

Visual Inspection

Visual inspection in the workstation is the most reliable method to verify results. Use the Swipe tool on overlaying images to inspect them for proper alignment. A well-aligned set of images will swipe smoothly without sudden visual interruption, except where there are real changes (for example, new buildings) or shadows.

Tie Point Quality Analysis

Inspect selected areas and use the Zoom tool in the workstation to assess the quality. Also look for an uneven distribution of tie points. If this occurs, you may need to manually collect some points to compensate. An easy way to locate suspect points is to select points based on RMSE (for instance, RMSE > Error Mean + 2 x Standard Deviation). Then use the Drive To tool to locate the points quickly.

RMSE Analysis

RMSE is the cumulative result of point matching and modeling. A large RMSE could be caused by one or both. Inspect the tie points to determine whether the points are the culprit. Often times, the inappropriate use of a model is responsible for a large error value.

An example would be when the point quality is very good, yet the results show a large RMSE. Conversely, a small RMSE may not necessarily indicate good overall results. It could be an artifact of the model that is being used. For example, the Linear or Non-Linear Rubber Sheeting model by definition will produce a zero error because all tie points are meant to match exactly in the results while the regions surrounding the points may be distorted. Therefore, you should always perform a visual inspection along with analyzing the RMSE to ensure correct judgment of the error conditions.

Follow-up Actions

When your analysis of the results point to problems either in APM or modeling, refer to the proper sections of this white paper for specific tips for improvement:

- For better data preparation, refer to the "Data Preparation" section.

- For APM parameter tuning, refer to the "APM Engine" section.

- For a better model choice, refer to the "Modeling" section.

Using the IMAGINE AutoSync Workstation

This section provides some helpful tips when using the IMAGINE AutoSync workstation.

- Use the IMAGINE AutoSync Workstation for complex workflows that require more user intervention. The workstation provides more flexibility, tools for visual inspection of the results, and for manually collecting tie points.

- Set the color of the GCPs in the IMAGINE AutoSync preferences before running APM in the workstation. You will avoid having to select all of the GCPs individually generated by APM to change their color. Selecting a large number of GCPs (> 2000) can be very time-consuming.

- Use the **Preview Output** option on the Input Image context menu to view the results of the model before calibrating or resampling the imagery. While in the preview mode, you can continue to delete GCPs and resolve the model. Also, whenever you select Preview Output again, the model will be recomputed and the viewer updated appropriately. This avoids having to return to the Point Review mode.

- When both the input and reference image contain projection information and the two images are of different resolutions, click the Set Same Scale icon on the toolbar in the workstation to set the display scale of each image to be the same. During point review, it will be easier to find similar features between the two images.

- If large errors are produced when using imagery with no projection information, review the manually collected points to ensure they were collected over the same features. Low quality manual GCPs will produce low quality models.

- Using very low resolution elevation data with the rigorous models may result in a shearing affect in the output imagery. This is due to the difference in the resolution of the input image and the elevation data.

- It saves time to turn off the display of a large number of tie points in the Overview in the workstation.

Using the IMAGINE AutoSync Wizards

This section provides some helpful tips when using the IMAGINE AutoSync wizards.

- Use the Georeferencing or Edge Matching wizards when you want to be guided through a workflow.

- The wizard workflow can be labor-saving when the datasets are homogenous, large, and can be processed with the same settings of parameters and models.

- Do not mix different types of datasets where each dataset requires different settings in the same wizard workflow. Separate the datasets into different projects.

- Before batching large homogenous datasets with the wizard, try to run one dataset through the wizard and inspect the results in the workstation. Experiment with the settings of the workflow to find one that generates optimal output. Then batch the large datasets with the same settings.

- After you determine a good workflow, you can make batching easier by creating a template IMAGINE AutoSync .lap file with the proper settings but no images in the workstation. Then load the template .lap file in the wizard and add the large datasets.

IMAGINE AutoSync Workflows

IMAGINE AutoSync supports three main types of workflows. Use the workflow that is suitable to the nature of the data and your applications.

Georeferencing Workflow

Use the georeferencing workflow if you know that one input image is clearly of better accuracy, and both images are georeferenced. For example, use the georeferencing workflow if you have a database of high-accuracy images and you want to introduce another georeferenced image of lesser quality to the database.

Edge Matching Workflow

Use the edge matching workflow to bring the overlap area of image pairs into alignment. This workflow will modify both images due to the fact that the required shifts will be divided between the images. Edge matching may also be a good choice when the overlap area is small and it is undesirable to apply the same transform that is suitable for the overlap region to the entire image.

Raw Imagery Workflow

Use the raw images workflow when an image does not have georeferencing information available, or when it is unreliable. When the georeferencing information is unreliable, you should ignore the existing georeferencing information. With raw images, you need to manually collect at least three tie points that are evenly distributed, close to the image corners, and high quality.

General IMAGINE AutoSync Tips and Hints

Some miscellaneous tips and hints for using IMAGINE AutoSync include:

- If you calculate statistics on all imagery before using the image within IMAGINE AutoSync, this will improve the overall performance.

- IMAGINE AutoSync will recompute pyramids at the start of the APM process for any image that does not have 3 x 3 pyramids previously computed. ERDAS IMAGINE defaults to producing 2 x 2 pyramids. You can change the ERDAS IMAGINE Image File preferences to always produce 3 x 3 to save time.

- Work with local files whenever possible. Saving IMAGINE AutoSync project files that contain a large number of GCPs may be slow over a network.

- When resampling, ensure the output cell size is reasonable for the images. The IMAGINE AutoSync defaults may not be suitable for your application.

Summary

When properly used, IMAGINE AutoSync is a powerful tool for fast image rectification with a tremendous saving of manual labor. This is achieved by a streamlined workflow, user-friendly workstation environment, a state-of-the-art automatic point matching engine, and a wide selection of intelligent modeling methods.

The final output from IMAGINE AutoSync is the cumulative result of the workflow you select, the data quality, APM engine usage (parameter settings), and the model selected. To ensure the best results, you should make careful and judicious decisions on these factors, starting with the data preparation, and proceeding with the steps as outlined in the sections of this white paper.

As with any sophisticated system, using IMAGINE AutoSync requires that you have a basic understanding of the various components of the embedded technologies. The more knowledge you have with regard to the data and the internal working of IMAGINE AutoSync, the better your chance of success.

General Guidelines

Some general guidelines you should follow when using IMAGINE AutoSync include:

1. Start with careful data preparation to ensure that you obtain the best data available (refer to the "Data Preparation" section).

2. Ensure that you understand the parameters of the APM engine. Analyze the data to see how many ideal or undesirable scenarios the data may exhibit and try to rectify them. (refer to the "APM Engine" section).

3. Select the most accurate model for rectification and utilize the provided metadata. Understand the limitations of each model and troubleshoot accordingly (refer to the "Modeling" section).

4. Follow the tips and hints in the "IMAGINE AutoSync Tips and Hints" section. This will help you avoid frustration caused by improper use.

5. If your APM results are not as expected, analyze whether it is the result of bad tie points or improper choice of a sensor model (refer to the "Modeling" section). Then proceed to rectify the situation accordingly.

We are continually improving the technology in IMAGINE AutoSync to improve results and widen the scope of the product.

This document will be updated periodically. Please refer to the IMAGINE AutoSync product page at our web site for the most recent version:
http://gi.leica-geosystems.com/products