Real Time Precision Location

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Abstract

Airborne sensors provide a valuable source of imagery by virtue of the location of the deployed platform. However, obtaining precise and rapid information from such imagery has been difficult due to the enormous amount of post processing required by existing software and hardware to extract the geo-location for targets of interest. Commercially available software packages running on high-level computer systems generally take several minutes and typically hours of human intervention to provide credible target location.

This paper describes a method of locating every pixel and every target of interest in an image to within a few meters as the images are acquired and some of the additional benefits that would result from such processing on low cost PC computers and in real or near real time.

Problem

Several things are required to accurately reference and aerial image:

1. The geolocation of the sensor platform at the time the image was captured.

2. The pointing angle of the sensor at the time the image was captured.

3. A sufficiently detailed 3D model of the terrain.

Of these the most difficult to obtain with sufficient accuracy is the second, particularly in small platforms. INS units are available, but tend to be expensive, bulky and may only provide sufficient accuracy after some form of post processing, making them unsuitable for a real-time application.

Solution

An option exists in software that could eliminate the need for pointing angle information and is described in this paper. This option would create tie points between overlapping images and by occasionally pointing the sensor at known locations at any time during the mission the targets would be accurately referenced by the tie points. This is currently done in the photogrammetry community with a technique known as block adjustment. A block of overlapping images is joined by tie points; a few ground control points are located (minimum of three for the entire block); and the geolocations and pointing angles for individual images are then derived mathematically.

If such a technique could be accelerated in hardware to run in real time, and particularly in an embedded or hands-off mode, it would make available a host of advantages. The remainder of this paper outlines a method for doing such acceleration and describes some of the advantages that would result.

Method

Consider the image in Figure 1. A target is identified in the image (in this case the missile launcher just left of center) and is marked with the red crosshairs. The GPS and IMU of the sensor platform and existing software could locate this target to within some rather wide degree of accuracy as indicated by the large accuracy circle around the target.

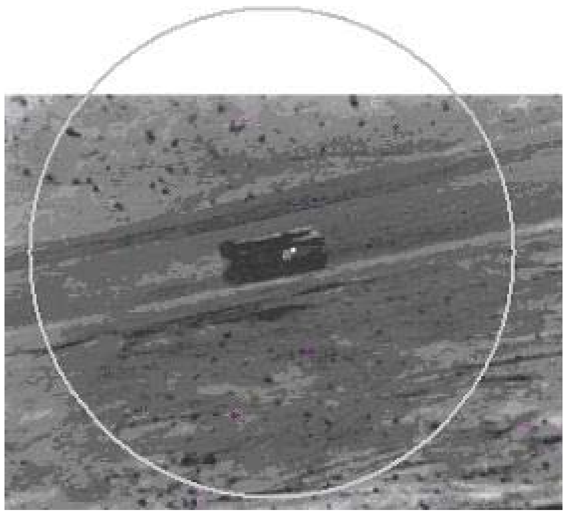

Figure 1. Low Accuracy

Now if we point the camera to a previously known and established ground location or by inputting a precise target location (in this case a road intersection) from another platform the software will use that to refine the location of our original target as shown in Figure 2 below.

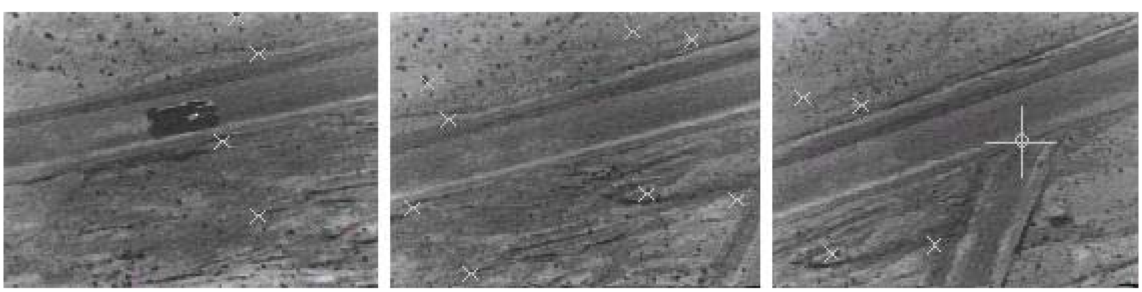

Figure 2. Tying Target to Known Location

This improves our accuracy greatly as shown by the tight red circle of Figure 3. With the use of automatically generated tie points we can extend that accuracy improvement as shown back to the target image

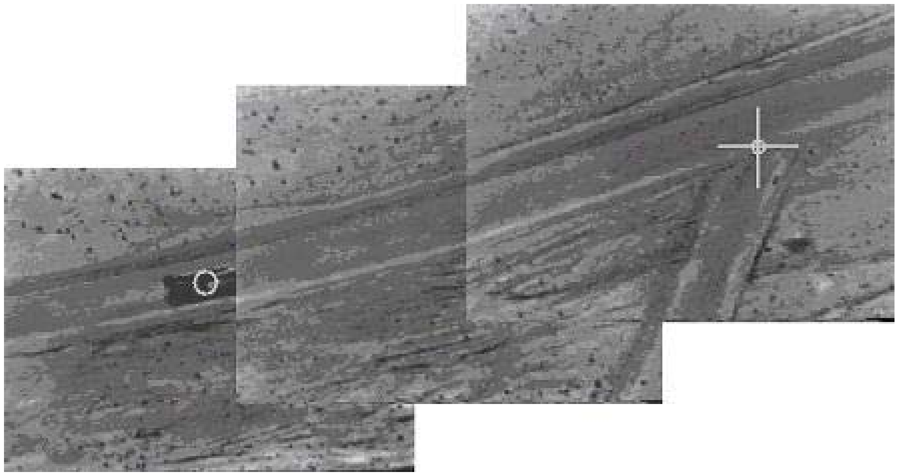

Figure 3. Mosaiced Enhanced Accuracy

Of course, the accuracy will drop off as the number of frames between the target and reference frames increases. If the two are many frames apart the accuracy may drop to an unacceptable level. This decrease in accuracy is shown as ever increasing circle diameters in Figure 4.

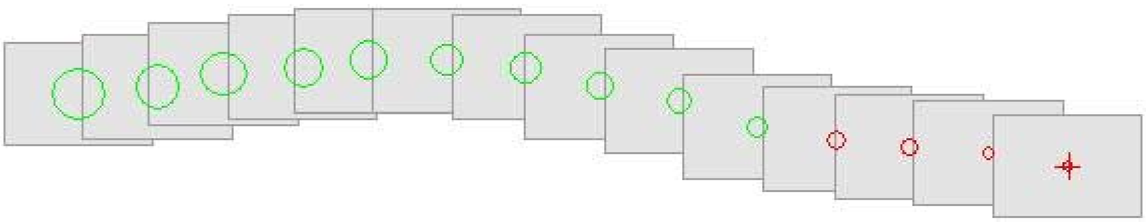

Figure 4. Accuracy Drop-Off

To remedy this growing inaccuracy we simply need to point the sensor at another known reference point somewhere on the other side of the target. This will tighten the accuracy of all the frames in between. (See Figure 5.)

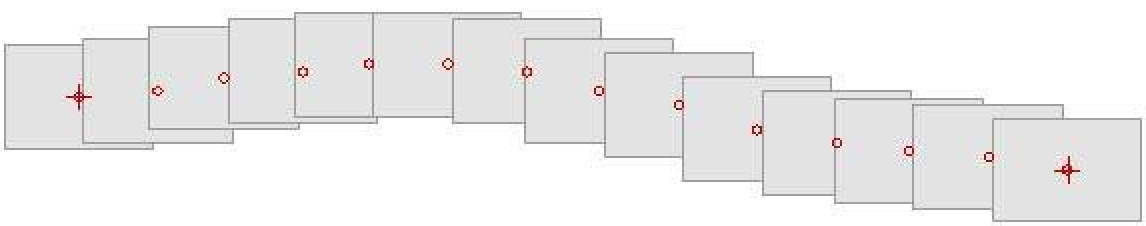

Figure 5. Accuracy Maintained with Multiple Marked Points

Proposed System

A system to accomplish what is described above is possible with COTS technology in an offline, post-processing mode. The challenge, however, and the place where such a system increases greatly in value is to perform it all in real time and ultimately on platform. Cardio Logic has developed an algorithm that not only makes this possible with a single plug-in card to COTS PC hardware, but can also be implemented in an ASIC for on-platform applications with very tight weight and power budgets.

A block diagram is shown in Figure 6 . The system would take as input the following

- Unprocessed images from the sensor
- A predetermined list of ground control points and their coordinates
- Real time location of the sensor platform from GPS
- Real time pointing angle of sensor from an Inertial Measurement Unit (IMU)
- A terrain model
- Control inputs would consist of:
- A freeze/save frame signal to mark and save frames with either targets or ground control points
- Cursor position for marking ground control points in the image
- The system would produce as output:
- Orthorectified frames
- Geolocation readout of cursor position
- Accuracy circle calculation and overlay

Note that GPS, IMU and terrain inputs are optional. The motivations for including them, if available, would be, 1) improved accuracy, and 2) faster recovery after losing tie point continuity (flying through a cloud, for example).

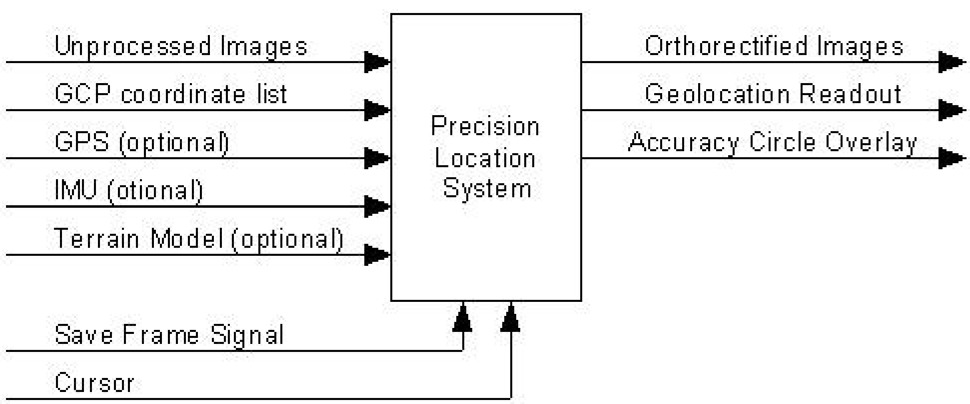

Figure 6. Block Diagram

System memory would be minimized by saving only frames with targets or ground control points. In between frames, once tie points are extracted, would be discarded and only tie point information preserved.

Features

Besides providing the fastest and most accurate pinpointing of any observed target, this system would offer other advantages as well.

First, the accuracy circle as described would give an operator an immediate knowledge of the accuracy of any target location readouts. The accuracy is based upon several factors--number and proximity of ground control points, availability and accuracy of GPS and IMU data, and accuracy and resolution of the terrain model--all of which would be reflected in the size of the accuracy circle. Moreover, the size of the circle would inform an operator when more ground control points are required.

Second, being able to orthorectify images in real time would make it possible to mosaic them in real time. By pivoting a narrow view sensor back and forth an entire area of operation could be assembled and continually updated. This would allow a relatively low cost, low altitude sensor to image an area with the same resolution as a high resolution, high altitude sensor.

Finally, with sufficiently recognizable ground control points, that is, points such as road intersections that can be reliably detected with pattern recognition algorithms, the whole orthorectification and mosaicing process could be performed with no human intervention.

Conclusions

Targeting accuracy of aerial imagery can be significantly improved by making use of previously determined ground control points in the vicinity using standard photogrammetric techniques. Using Cardio Logic algorithm this improved accuracy, orthorectification and mosaicing could all be done in real time and on platform.