ORTHOMETRIC PROCESSING OF VERY HIGH SPATIAL RESOLUTION FRAME
IMAGERY USING DISTRIBUTED TECHNIQUES

U.S. Army Corps of Engineers, Engineer Research and Development Center
Topographic Engineering Center
Alexandria, VA, 22315

X. Sun, D. Florence
Flight Landata Incorporated
Lawrence, MA, 01843

ABSTRACT

Very high spatial resolution frame imagery (pixel areas << 1.0 m²) is becoming readily available from a
number of government-owned and commercial sensors. These systems have and will be mounted on a variety of
rotary and fixed-wing aircraft, and because of their small size, are ideally suited as organic sensors for Unmanned
Aerial Vehicle (UAV) platforms. Because of the relatively small ground coverage of these systems, a
large number of individual frames must be quickly and accurately georegistered to cover a typical area of
interest. In a test conducted at Yuma, AZ during February 2004, a total of 88 frames of stereo imagery
with 0.01 m² spatial resolution were used to cover approximately 4 km along a roadway. Using a recently
developed distributed processing system, the 88 frames
were mosaicked and georegistered to meter level accuracy in less than 52 minutes. Incorporating state-of
the-art hardware, the same number of frames could be
used to cover more than 20 km on the ground, providing
a valuable data source to multiple applications including
targeting, route reconnaissance, and improvised explosive device (IED) detection.

1. INTRODUCTION

Products derived from very high spatial resolution
imagery have a multitude of tactical applications which
allow the battlefield to be viewed in greater clarity, a key
requirement of the Future Force. These applications
include stereo vision, site mapping, battlefield
reconnaissance, targeting, and improvised explosive
device (IED) detection. However, a critical step in
effectively utilizing this data are the accurate
georegistration of the imagery to a pertinent ground
coordinate system.

To satisfy the particular objective of creating
orthometrically accurate mosaics in near-real-time, a
distributed, photogrammetric pre-processing technique
was developed. The most laborious and time-consuming
task associated with orthoregistration is the selection of
tie points (image to image) and ground control points
(image to geographic coordinates). The selection of
control points using traditional techniques can take hours
or days for even a moderate number of individual
images. However, because the determination of tie
points between two (or more) overlapping frames can be
considered independent from other sets of overlapping
frames, an automated parallel or distributed approach
can be used.

2. METHODS

As part of this effort, an existing hardware and
software suite was quickly modified by the Corps and
Flight Landata Inc. as a proof-of-concept for the
identification of IEDs using high spatial resolution
change detection (pixel area = 0.01 m²). The sensor
system consisted of four 1392 x 1040, 10 bit,
progressive scan cameras filtered to blue, green, red, and
near-infrared bandpasses. Imagery was collected via a
Piper Cherokee 6 at 1500 feet above ground level to
achieve the required spatial resolution from the 25 mm
focal length lenses. The sensor position during exposure
was determined using Wide Area Augmentation System
(WAAS) GPS. Sensor orientation was derived from
onboard accelerometers and fiber optic gyro. Overlap
between individual frames was approximately 80
percent.

The developed processing technique computes an
initial frame exposure position and orientation of all
frames collected. Each combination of overlapping
frames (up to a total of 6 frames per tie point) is then
packaged and parsed by a root machine to the individual
processors. The individual processors calculate a user
defined, or software suggested number of tie points, and
return the completed points to the root machine. Results
from the individual processors are tabulated and
translated into sensor model support files. The above
steps are repeated using a preexisting registered source
to determine ground control points. Potential reference
sources include, but are not limited to, IKONOS,
Quickbird, controlled image base (CIB), U.S. Geological
Survey (USGS) digital orthophoto quarter quads
(DOQQs), and National Assets. Tabulated tie and
ground control points are then processed through a co-
Orthometric Processing of Very High Spatial Resolution Frame Imagery using Distributed Techniques

Approved for public release, distribution unlimited

See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2004 in Orlando, Florida., The original document contains color images.
linearity-based bundle block adjustment (Slama, 1980) using commercial-off-the-shelf (COTS) software to determine an accurate position and orientation of each frame exposure station. Construction of image-based end products, such as high spatial resolution stereo models, digital terrain models, and mosaics is then straightforward.

3. RESULTS

For the 88 frames of the Yuma imagery, 1343 tie and ground control points were calculated in approximately seven minutes using a dedicated 32-node processing system. Bundle adjustment and mosaic construction using the COTS software package SOCET SET took an additional 45 minutes. A USGS DOQQ was used as the geographic reference source. Final spatial accuracy (elliptical error) of the bundle adjustment was 2.5 m. Data were collected on two subsequent dates (Feb. 11 and Feb. 12) to demonstrate the change detection concept. An example of the 0.01 m² spatial resolution image mosaic is shown in Figure 1.

Manual comparisons between imagery collected on subsequent days over the Yuma site showed these data could successfully locate IED-like items. Pixel level co-registration between the two days allowed an analyst to locate changes with minimal user fatigue. An example of a simulated IED found through change detection is shown in Figure 2. The Feb. 11 imagery (before IED placement) is shown on the left side of Figure 2, the Feb. 12 imagery (after IED placement) on the right. Changes between the two dates are obvious. The break in the curb on Feb. 11 has been filled in by a bright material, and a “drag” line leading away from the curb is readily apparent. Six additional items of similar size were found throughout the 4 km roadway.

4. CONCLUSIONS

Results from numerical simulations and actual imagery demonstrates the capability to georegister long, high spatial resolution flightlines quickly and accurately. Imagery collected during February 2004 test in Yuma show that the concept of change detection was successful in locating simulated IED devices in the field. While the identification of IEDs at Yuma was performed manually, the ability to co-register two sets of imagery acquired at different times accurately will make it possible to effectively use digital or automated change detection routines. Further hardware and software improvements will enable future systems to produce products over larger areas in less time, providing a valuable data source to multiple tactical and civil applications.

4. REFERENCES


Figure 1. True color mosaic of Yuma roadway from Feb. 11, 2004.

Figure 2. Before (Feb. 11) and after (Feb 12.) placement of a simulated IED device.