Abstract—The successful operation of FORMOSAT-2, which was launched on May 21, 2004, proved the concept that the temporal resolution of a remote sensing system can be much improved by deploying a high spatial resolution sensor in a daily revisit orbit, and each accessible scene can be systematically observed from the same angle under similar illumination conditions. These characteristics make FORMOSAT-2 an ideal satellite for site surveillance. The unique orbit and the arrangement of the charge-coupled device lines onboard FORMOSAT-2, however, also raise new challenges in image processing. This paper describes a fast and automatic system that is able to process a large amount of FORMOSAT-2 daily revisit imagery for the purpose of site surveillance. The system is comprised of several modules, including level-2 product generation, band-to-band coregistration, a spectral preserved pan-sharpening technique, and multitemporal imagery matching. Two examples processed by the system are given to demonstrate the applicability of FORMOSAT-2 daily revisit imagery for site surveillance. The experiences of operating FORMOSAT-2 for more than one and a half years are summarized, and the advantages and disadvantages of a daily revisit orbit are discussed. Experience obtained from this paper would benefit the system design and image processing of future satellite missions with similar specifications, such as the Pléiades HR scheduled to be launched in 2008.

Index Terms—Coregistration, daily revisit, FORMOSAT-2, georeferencing, pan-sharpen, Pléiades HR, site surveillance.

I. INTRODUCTION

REMOTE sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [1]. The performance of a remote sensing system is determined by its spatial, temporal, spectral, and radiometric resolutions [2]. Up until now, most of the efforts in the development of remote sensing systems have focused on increasing the spatial resolution. For example, the SPOT series has gone from 10 m (SPOT-4) to 2.5 m (SPOT-5), while the IKONOS series and the EROS series have all proposed to go to 50 cm. Another attempt is to enhance the spectral resolution by deploying a hyperspectral sensor in the orbit, such as the spaceborne Hyperion sensor with 242 wavebands ranging from 350 to 2500 nm, onboard the Earth Observing 1 satellite launched in November 2000. These existing observation systems, while capable of increasing spatial or spectral resolution, are all limited in temporal resolution.

From the consideration of site surveillance, however, temporal resolution is a critical characteristic that might override other desirable qualities. Observation systems operated in the near-polar orbit with broader swaths, such as the NOAA series and the Moderate Resolution Imaging Spectroradiometer, are able to achieve the temporal resolution of one or two days. But their spatial resolutions are not sufficient for site surveillance. An ideal remote sensing system for site surveillance should enable us to monitor dynamic phenomena at both the highest spatial resolution and the highest temporal frequency. Another important consideration is the viewing angle and illumination condition. The inconsistency in geometric shapes of the same object and its shadows among various images can be avoided by keeping the same viewing angles and illumination conditions. The multitemporal imagery obtained from such a system, therefore, can be automatically matched and compared with each other to a high extent of accuracy. Such an ideal system of site surveillance, however, has never been available until the successful operation of FORMOSAT-2 launched on May 21, 2004. As will be explained later, FORMOSAT-2 is able to observe specific areas with high temporal resolution at the expense of reducing global coverage.

FORMOSAT-2 is the second satellite that is owned and operated by the National Space Organization (NSPO) of Taiwan. Based on the cooperative agreement between the Disaster Prevention Research Center (DPRC) of the National Cheng Kung University and NSPO, DPRC serves as the first image application and distribution center (IADC) in the world that receives, processes, and archives FORMOSAT-2 imagery on a daily basis. After more than one and a half years of operation, DPRC has successfully applied FORMOSAT-2 imagery to disaster preparedness, rescue, and environment monitoring, such as in the aftermath the South Asia tsunami [3]. DPRC has also demonstrated the potential of FORMOSAT-2 daily revisit imagery in site surveillance [4]. However, it has also been found that the unique orbit and the arrangement of the charge-coupled device (CCD) lines onboard FORMOSAT-2 raise new challenges in image processing, such as the problem of band-to-band misregistrations of FORMOSAT-2 imagery.

To fully exploit the advantages of daily revisit imagery in site surveillance and meet the operational requirement of an IADC, an automatic FORMOSAT-2 image processing system (F2 AIPS) has been developed and implemented at DPRC.

This paper first reviews the specifications of the remote sensing instrument (RSI) onboard FORMOSAT-2 and the characteristics of the daily revisit orbit. The description of
each module of the F2 AIPS is then given, including level-2 product generation, band-to-band coregistration, spectral preserved pan-sharpening technique, and multitemporal imagery matching. The daily revisit images of the Kaohsiung area taken by FORMOSAT-2 on July 2–4, 2004, are processed by F2 AIPS and given as examples. The results demonstrate that the subtle changes that occurred in a small area can be automatically identified from the entire region of observation with comparatively higher accuracy. The advantages and disadvantages of daily revisit orbit are discussed. Experience obtained from this paper would benefit the system design and image processing of future satellite missions with similar specifications, such as the Pléiades HR scheduled to be launched in 2008.

II. FORMOSAT-2

A. RSI

The RSI onboard FORMOSAT-2 was built by EADS Astrium SAS, France, which makes the FORMOSAT-2 imagery available for 2-m resolution in panchromatic (PAN) and 8-m resolution in four multispectral (MS) bands from visible to near-infrared with scene coverage of 24 × 24 km. Table I gives the spectral range of each band. FORMOSAT-2 is able to point to ±45° along track and ±45° across track. The high agility of the platform and the high temporal resolution of the sensor, as well as the innovative orbit and operational concepts, have been imitated by the Pléiades HR, the next French Earth observation system [5]. The Pléiades HR is basically a constellation of two satellites that are very similar to FORMOSAT-2 except for an improved spatial resolution of 70 cm.

The RSI is comprised of a monolithic linear CCD array with 12 000 pixels for PAN band and quad-linear CCD arrays with 3000 pixels for each MS band. Thanks to a high electrooptical performance as well as mechanical stability and geometrical specifications, these CCD arrays meet the high accuracy imaging requirements for Earth observation systems [6], [7]. There is no need to employ time delay and integration techniques to sum up the charges collected over several CCD elements or to enlarge the integration time by a permanent rotation of the satellite during imaging. The individual MS CCD lines are shifted against the PAN CCD line combination in the sampling direction in the focal plane, as illustrated in Fig. 1(a). Such an arrangement makes the PAN CCD line and each of the MS CCD lines scan the ground sequentially with a slight time lag rather than simultaneously. As a result, FORMOSAT-2 is able to take a much longer strip of image along its moving direction compared to the images taken by other high spatial resolution sensors. However, the side effect of band-to-band misregistration is also significant and visually obvious in the FORMOSAT-2 image. Taking the Earth’s rotation and orbital instability into account, this effect is even more serious when the satellite is operating in large angle ranges along and/or across track directions [3].

B. Daily Revisit Orbit

In a broad sense, the daily revisit orbit of FORMOSAT-2 is a special case of exactly repeating the sun-synchronous orbit with a period of one day. Rees [8] provides a detailed derivation of a simple condition that must be fulfilled by this type of orbit, i.e.,

$$\frac{P_n}{P_E'} = \frac{n_1}{n_2}$$

(1)

where $P_n$ is the nodal period, $P_E'$ is one solar day of 24 h, $n_1$ determines the time interval between successive opportunities to observe a given location, and $n_2$ governs the density of the subsatellite tracks on the Earth’s surface. In the case of FORMOSAT-2, to achieve daily revisit orbit ($n_1 = 1$) under the given condition of 14 subsatellite tracks ($n_2 = 14$), $P_n$ needs to be set at a value of 102.86 min. This is attained by placing FORMOSAT-2 at an altitude of 891 km with an inclination of 98.99°.

The exactly repeating orbit is not a brand new idea, but FORMOSAT-2 is the first satellite with a high spatial resolution sensor placed in a daily revisit orbit. FORMOSAT-2 is able to capture any scene in its coverage area each day. In the mean time, each accessible scene can be systematically observed from the same angle under similar illumination conditions. Fig. 1(b) shows the accessible areas and the ground track of FORMOSAT-2 orbits with ±45° viewing angle across track (side looking). As denoted outside the shaded area, FORMOSAT-2 has to make a slight reduction of the coverage area in low latitudes to achieve the daily revisit orbit. These gaps can be filled by placing a duplicate of FORMOSAT-2 in the identical orbit but overpassing the center of each gap. This is exactly what the Pléiades HR proposes to do by deploying a constellation of two satellites.

Although the accessible area of the current FORMOSAT-2 orbit is limited in low latitude, this limitation can be removed by manipulating FORMOSAT-2 at a large viewing angle across the track. In the event of the South Asia tsunami in 2004, for example, NSPO made an attempt to increase the viewing angle to as high as ±53° and demonstrated that all areas can be imaged with a slight sacrifice in spatial resolution [3]. However, since the swath of FORMOSAT-2 imagery (24 km) is much less than the width of the assessable area during one overpass (more than 1500 km), only about 1.6% of the accessible areas denoted in the shaded region in Fig. 1(b) is able to enjoy the continuous acquisition of images everyday. But if necessary, FORMOSAT-2

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral range (μm)</th>
<th>Spatial resolution (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>0.45–0.52</td>
<td>8</td>
</tr>
<tr>
<td>B2</td>
<td>0.52–0.60</td>
<td>8</td>
</tr>
<tr>
<td>B3</td>
<td>0.63–0.69</td>
<td>8</td>
</tr>
<tr>
<td>B4</td>
<td>0.76–0.90</td>
<td>8</td>
</tr>
<tr>
<td>PAN</td>
<td>0.45–0.90</td>
<td>2</td>
</tr>
</tbody>
</table>

Fig. 1. (a) Illustration of the arrangement of CCD arrays in the focal plane, (b) Accessible areas and ground track of FORMOSAT-2 orbits with ±45° viewing angle across track (side looking). Courtesy of the NSPO.
can be programmed to take daily images of the same site within its accessible area.

III. AUTOMATIC FORMOSAT-2 IMAGE PROCESSING SYSTEM

A. Level-2 Product Generation

To assist the IADC in processing the substantial amount of FORMOSAT-2 imagery on a daily basis, NSPO and Tatung System Technologies Inc. developed the FORMOSAT-2 terminal for level-1 A and level-2 products generation [9], [10]. The raw data of FORMOSAT-2 images received by the NSPO ground station are transmitted to DPRC via Taiwan’s Advanced Research and Education Network every morning. The raw data are then processed to the level-1 A product by applying the basic radiometric calibration and to the level-2 product by projecting the raw image onto a spheroid using the ephemeris data onboard to correct the satellite orbit and altitude. The geometric performance can be further tuned-up, and the in-tratelescope and intertelescope registrations can be conducted.

B. Band-to-Band Coregistration

For applications in site surveillance, the pan-sharpened image that integrates a lower spatial resolution MS image with a higher spatial resolution PAN image is preferred because both spectral and spatial information can be retained and represented in one single image. The accurate band-to-band coregistration is a prerequisite to generate a pan-sharpened image of high quality. This prerequisite, as aforementioned, has been a major problem of image processing ever since the launch of FORMOSAT-2.

Band-to-band misregistration is not a unique problem for FORMOSAT-2. Other sensors installed with multiple telescopes are expected to have the same problem to a certain extent. For example, a similar problem was also reported for Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) onboard Terra (EOS-AM1). Since the spectral range, spatial resolution, and imaging system are all quite different for the three subsystems of ASTER, namely VNIR, SWIR, and TIR, Iwasaki et al. [12] and Iwasaki and Fujisada [13] successfully developed a series of procedures to coregister ASTER imagery step-by-step. During the preflight test period, the data collected from the collimator were used to establish the preliminary geometric database. The database contains a set of line-of-sight vectors and the cross-track pointing axis vectors that are both expressed toward the navigation base reference. During the initial checkout period, a fine tune-up displacement can be found. Even with such a demanding computation, the FNCC technique with the intention of meeting the requirement of generating a good pan-sharpened image for applications in site surveillance can be selected to be as high as 51 × 51 pixels to improve the correlation, and the size of the searching window can be set to several times the size of the subscene for comparison.

Authorized licensed use limited to: National Cheng Kung University. Downloaded on August 3, 2009 at 05:11 from IEEE Xplore. Restrictions apply.
Fig. 2. Example of the misregistration between the FORMOSAT-2 (a) PAN and (b) MS bands in one standard scene (12 × 12 km). The red cross symbol points to the center of each subscene (51 × 51 pixels) on the PAN image, while the blue cross symbol indicates the central position of the corresponding subscene on the MS imager. (c)–(g) Five regions denoted by green boxes are further enlarged for illustration. This pair of image was taken on December 1, 2005, in the catchment area of the Shihmen Reservoir located in the northern part of Taiwan.
The red cross symbol points to the center of each subscene (51 × 51 pixels) on the PAN image, while the blue cross symbol indicates the central position of the corresponding subscene on the MS image. Five regions denoted by green boxes are further enlarged in Fig. 2(c)–(g) for illustration. Note that Fig. 2(a) and (b) is cut from the original PAN and MS images, and the central parts of both images are coregistered with each other. Therefore, region 5 [Fig. 2(g)] is well coregistered. The other four regions adjacent to the corners of the original images, however, exhibit heterogeneous and nonnegligible misregistrations. By applying the FNCC technique, the F2 AIPS is able to establish a total of 14,036 correlated subscenes. Note that subscenes with either low DN values or low variances are not taken into account in the processing.

Another issue is to reject the error-prone correlations. Apart from removing subscenes with lower correlations, Iwasaki and Fujisada [13] used a coarse GTOPO30 DEM to calculate the a priori information of image displacement and then reject those subscenes with higher deviations of displacement. Since their approach requires a higher accuracy in geolocation that is not valid for FORMOSAT-2 level-2 product, we follow their concept to examine the displacement of each subscene but rely everything on the information of correlated subscenes that are established by the FNCC technique. Thanks to the characteristics that the distribution of these subscenes is so dense and most of them bear a pretty high value of correlation, we may reasonably assume that the displacement for each subscene is close to the displacement interpolated from its neighbor subscenes. If the deviation of displacement is larger than a threshold, we may reject that subscene and replace the displacement by the interpolated value. In the case of Fig. 2, a total of 864 subscenes with suspicious displacements are ruled out. Finally, the triangulation method is employed to warp the slave image against the master image based on a total of 13,172 correlated subscenes to achieve an accurate band-to-band coregistration and generate a pan-sharpened image of high quality. The percentage of the successful number for this correlation is as high as 93.84%. The pan-sharpened images with and without the correction of band-to-band misregistration in regions 1 and 3 [Fig. 2(c) and (e)] are further enlarged in Fig. 3 for illustration. Two regions are circled in Fig. 3 to highlight the differences.

C. Spectral Preserved Pan-Sharpening

The general approaches of pan-sharpening, such as the IHS transform [17] and Brovey transform [18], are widely used. These approaches, however, cannot avoid distorting the image’s spectral properties. To improve the spatial details and yet preserve the spectral properties, it is necessary to develop a new approach that is able to produce color composites with sharper spatial details and high spectral fidelity. Thanks to the specific spectral ranges of the FORMOSAT-2 PAN and MS, the summation of the MS bands is a low-resolution replica of the high-resolution PAN band image, except for a small gap between MS bands 3 and 4. Based on the principle of the published smoothing filter-based intensity modulation (SFIM) technique [19], Liu et al. [3] proposed a new technique, namely spectral summation intensity modulation (SSIM), to improve the spatial details and yet preserve the spectral properties.

To illustrate the differences in the image’s spectral properties that resulted from various sensors and various pan-sharpening techniques, the images of Song-He Community taken by SPOT-5, FORMOSAT-2, and an unmanned helicopter are compared in Fig. 4. Due to the geological composition and the topography, the Song-He Community is always under threat of landslide and debris flow during the rainy season. Fig. 4(a) was taken in 2003 by SPOT-5 with a spatial resolution of 2.5 m. This was achieved by staggering its dual HRS sensors. Since the HRS sensor does not have a blue band, the color image presented in Fig. 4(a) is actually a “simulated natural color” rather than a “true natural color.” Note that all the color information for the buildings is lost in the image. After Typhoon Mindulle hit on July 2, 2004, a devastating debris flow ravaged the Song-He Community and caused severe damage to property and loss of lives. FORMOSAT-2 took the image of Song-He Community right after the disaster. The SSIM technique was employed to generate the pan-sharpened images as shown in Fig. 4(b). Fig. 4(c) shows the image of the same area taken from an unmanned helicopter flying at low altitude. Visually comparing these images demonstrates that FORMOSAT-2 indeed provides a more realistic and colorful image. In addition, the SSIM pan-sharpened image [Fig. 4(b)] possesses a high fidelity to the original spectral properties when compared with the high spatial resolution image taken by the unmanned helicopter flying at low altitude [Fig. 4(c)].

D. Multitemporal Imagery Matching

With a certain amount of GCP, the digital topography model (DTM) of the imaging area, and the detailed attitude of the sensor, a rigorous orthorectification can be made to generate the orthoimages from the raw images taken from the satellite.
Fig. 4. Images of Song-He Community. (a) Simulated true color image with 2.5-m resolution taken by SPOT-5 in 2003. (b) SSIM pan-sharpened image with 2-m resolution taken by FORMOSAT-2 in July 2004. (c) High spatial resolution image taken by the unmanned helicopter flying at low altitude.

For most of the regions in the world, however, the information of GCPs and DTM is usually restricted or not available. For example, in the Taiwan area, the spatial resolution of DTM available is 40 m, which is not compatible with the high spatial resolution of FORMOSAT-2 imagery. In addition, the number and accuracy of existing GCPs are not sufficient for the requirement of rigorous orthorectification. Most
importantly, the rigorous processing of orthorectification is time consuming. It would not be a practical approach for continuously monitoring a small site.

By contrast, multitemporal images taken from FORMOSAT-2 can be automatically matched with each other to a high degree of accuracy without the need for rigorous orthorectification. Therefore, they are ideal for site surveillance. One set of FORMOSAT-2 daily revisit imagery taken in the Kaohsiung area of Taiwan from July 2–4, 2005, is shown in Fig. 5 as an example. As described earlier, the FNCC band-to-band coregistration and the SSIM pan-sharpening technique are first applied to each pair of PAN and MS images taken on the same day, as shown in Fig. 5(a), (b), and (c), respectively. The color composite of red (PAN band of July 2), green (PAN band of July 3), and blue (PAN band of July 4) is shown in Fig. 5(d). Although the conditions of weather and cloud cover were quite different on those three days, the geometric shape and shadow of the same object, as well as its relief displacement caused by terrain, are all very similar in every image. As a result, the multitemporal images taken from FORMOSAT-2 are highly correlated, and the FNCC technique can be employed again to match all images against one master image.

There are two challenges for multitemporal images matching. First, the areas covered by clouds cannot be correlated, while the areas in shadow need to be enhanced to establish as much correlation as possible. Second, the dynamic changes on the ground need to be ruled out from the background to avoid establishing a wrong correlation. Thanks to the FNCC technique and the characteristic of similarity among the FORMOSAT-2 multitemporal imagery, a comprehensive amount of correlated scenes can be established. Even after ruling out some of the suspicious correlations, the matching of multitemporal images is still able to achieve good accuracy. The two regions denoted by red boxes, including the Kaohsiung International Airport and Kaohsiung Harbor, are enlarged and further discussed in Figs. 6 and 7.

IV. RESULTS AND DISCUSSIONS

The most straightforward approach to site surveillance is to compare the continuous observations at the same location and discriminate the subtle changes. This belongs to the category of change detection. A variety of change detection techniques have recently been summarized and reviewed by Lu et al. [20]. After comparing the main characteristics, advantages, disadvantages, and key factors affecting the change detection results of a total of 31 methods, they recommended the single-band image differentiating method for digital change detection of change/nonchange information. They also concluded that one of the prerequisites of change detection is the precise geometrical registration between multitemporal images. The impact of misregistration on change detection has been emphasized in other studies [21], [22]. Townshend et al. [21] quantitatively evaluated the errors caused by misregistration and concluded that the coregistration should be less than one pixel for most of the purposes of change detection. As illustrated in Figs. 6 and 7, the matched multitemporal imagery generated from F2 AIPS meets the requirement very well.

A color composite can be made by specifying the PAN images taken on each of the three days as red, green, and blue band, respectively [Figs. 6(d) and 7(d)]. This is a common approach to highlight the changes among the images acquired at three different times. Generally speaking, the precise geometrical registration between multitemporal images makes the color composite a grayscale monotone, except for those areas contaminated by clouds, hazes, or shadows. Those areas can be easily recognized by the monotone of one primary color in a comparatively large area. Even in those areas, the change/nonchange and on/off events send clear alarms via three primary or complementary colors. This color composite gives the information of where and when the change has occurred, which guides the image interpreters to locate the change in the corresponding SSIM pan-sharpened image [Figs. 6(a)–(c) and 7(a)–(c)]. By comparing the spectral information of that particular object/phenomenon to the spectral library, the image interpreters are able to identify what the change is to a much higher extent of accuracy. Since FORMOSAT-2 can continuously provide daily revisit images, and the entire process is fully automatic through the F2 AIPS, the image interpreters can easily establish a comprehensive database of the same site without the tedious and substantial amount of work required for image processing. This gives the image interpreters more capacity to concentrate on investigating why and how these changes are caused.

Fig. 6 shows an example of site surveillance at Kaohsiung International Airport. Whether it is the arrival/departure of airplanes at the terminal or the operation of shuttles and maintenance/service vehicles, the dynamic changes in this area are vividly illustrated by these daily images. Note that the image of this region taken on the third day (July 4) falls completely in a cloud shadow [Fig. 6(c)]. However, all features in this image can be enhanced by the processing of 99% linear stretching, and the color composite [Fig. 6(d)] is still able to give a faithful description of the changes over the three days. For large-scale objects, such as airplanes, it is straightforward to identify these objects by comparing their size and feature with the existing database. For small objects of merely several pixels, such as the shuttles and maintenance/service vehicles, the object can be located in the corresponding SSIM pan-sharpened image, and the object can be identified by comparing its spectrum to the spectral library. Fig. 7 shows another example of site surveillance at Kaohsiung Harbor. Note that many large-scale objects are changing in this area everyday, such as cranes, containers, and ships in the docks. Since the size of the cross-section for multitemporal image matching can be set as high as 51 × 51 pixels, and all suspicious pairs of correlated scenes have been ruled out, the changes of these large-scale objects can be faithfully identified and delineated in the color composite [Fig. 7(d)]. Likewise, the spectral information of any change can be provided from the corresponding SSIM pan-sharpened image, and the entire process is automatic.

One factor in the success of this paper is the fact that the vegetation cover usually does not change much in a few days. This ensures the establishment of correlations among the daily revisit images taken by FORMOSAT-2. It is still possible to discriminate those subtle changes from the multitemporal images, such as the growth or decay of vegetation in a few days. The premise is an accurate radiometric calibration and a reliable atmospheric correction. This work has been planned by NSPO. Once a sound approach for radiometric calibration
Fig. 6. One example of site surveillance at Kaohsiung International Airport using daily revisit imagery taken by FORMOSAT-2 on (a) July 2, 2005, (b) July 3, 2005, and (c) July 4, 2005. (d) Color composite of red (PAN band of July 2), green (PAN band of July 3), and blue (PAN band of July 4).

Fig. 7. One example of site surveillance at Kaohsiung Harbor using daily revisit imagery taken by FORMOSAT-2 on (a) July 2, 2005, (b) July 3, 2005, and (c) July 4, 2005. (d) Color composite of red (PAN band of July 2), green (PAN band of July 3), and blue (PAN band of July 4).
and atmospheric correction is developed and implemented, the FORMOSAT-2 daily revisit imagery can be further applied to study subtle changes in vegetation over a much smaller time scale.

After running the IADC for more than one and a half years, we found that the user’s expectation and the operational concept of FORMOSAT-2 are still confined to the usage of medium spatial resolution images with a larger swath. As a result, achieving the largest coverage is still the major consideration in operations. Although FORMOSAT-2 is able to repeat the same orbit everyday, not many occasions or places actually enjoy the continuous acquisition of images. Even in Taiwan, the average period of image acquisition at the same site in 2005 was every seven to ten days [4]. There are currently several commercial satellites operating at general sun-synchronous orbits with a larger swath, and FORMOSAT-2 should serve as an important complement to the existing satellites. Therefore, the operation of FORMOSAT-2 should use its advantages of both high temporal and spatial resolutions for applications such as site surveillance.

V. CONCLUSION

The innovative characteristic of sun-synchronous and daily revisit orbit makes FORMOSAT-2 an ideal satellite for site surveillance. The unique orbit and the arrangement of the CCD lines onboard FORMOSAT-2, however, have also raised new challenges in image processing. The F2 AIPS described in this paper enables us to automatically generate a set of multitemporal images with high spectral fidelity at high spatial resolution. Furthermore, all images can be automatically matched with each other to a high degree of accuracy. Therefore, they are ideal for the analysis of change detection. The sequential three-day images taken near Kaohsiung International Airport and Kaohsiung Harbor on July 2–4, 2005, demonstrate the advantages of the daily revisit orbit and F2 AIPS for site surveillance.

As the spatial and temporal resolutions of the remote sensing systems are increasing, the approach developed for site surveillance is a practical way to automatically gather a large amount of data, process the data for change detection, and screen the data for information. The high agility, high temporal resolution, and innovative orbit of FORMOSAT-2 have been followed by the Pléiades HR [5]. Experience obtained from this paper will benefit the system design and image processing of future satellite missions.

REFERENCES


