An Industrial Waste Monitoring System Based On the Use of Satellite Images

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Abstract

The many uses of space technology have found applications in various fields that affect our lifestyles and they have thereby tended to become more or less essential components of our every day lives. This trend has aroused attention as a new growth area in satellite based earth observations that are aimed at improvements in personal safety from a national perspective. This paper introduces the satellite technologies associated with earth observations that are being applied to industrial waste monitoring. It also discusses a recently deployed industrial waste monitoring system. We intend that these technologies will contribute to a wider promotion of the use and application of satellite imaging systems that have previously been limited to use by a small number of specialists.

Keywords

satellite image, industrial waste, illegal dump, monitoring, remote sensing, cloud computing, SaaS

1. Introduction

As was discussed in "Space System Businesses - Vision and Roadmap," the use of space based technology has been contributing to various aspects of our lives such as in weather forecasting and for broadcasting and communications and it is now becoming an indispensable feature of our every day lives. However, its use is still insufficiently adopted in the field of earth observations (remote sensing) such as in agriculture, fisheries, civil engineering, urban planning, disaster countermeasures and prevention and topographical observations etc. Nevertheless, since it clearly offers a potential means for enhancing life styles by making them safer and more comfortable, it is attracting public attention as a new and growing field in the business enterprise domain.

One of the current examples of the use of data acquired from earth observations is an Internet site showing views that combine various satellite images and aerial photographs. However, the observation dates of the satellite image data used in such services are often unknown and sometimes tend to be rather out of date. In addition, it is also said that the variances in time and accuracy between images make these services unsuitable for earth observations that require high accuracy. Up to the present, there has been no mechanism that makes it possible to obtain satellite data of the known observation timing of a required location, to apply necessary image processing to such data and to then store it in a database by adding relevant information. This would enable people who need such satellite image data to readily obtain it at a low price and at the requisite timing.

When we consider the social needs for the use of satellite image data, an urgent need may be found in the field of local government. The departments of local government are currently spending a large amount of time and labor in monitoring industrial waste issues and they will be sure to find satellite imaging data a convenient means of improving surveillance levels for investigating and preventing illegal dumping, etc.

At NEC, we have been developing an industrial waste monitoring system that makes use of the satellite images of the ALOS (Advanced Land Observation Satellite), which is regarded as an earth observation satellite of the foremost class.

The satellite images obtained via the ALOS are relatively low-priced compared to past satellite images, so the resulting expansion of the possibility of the use of satellite images by local communities is attracting attention. Below, we introduce our "industrial waste monitoring system" using satellite images.

2. Outline of Satellite Imaging

2.1 Outline of ALOS

The ALOS is an earth observation satellite launched by the Japan Aerospace Exploration Agency (JAXA) in 2006. It orbits the earth in a 46-day period at an altitude of about 700 km and observes the ground surface vertically. If weather permits, it can observe a specific area for up to eight times per year. Observation is possible with a resolution of 2.5 meters (a precision that enables the location of roads and the presence/absence of buildings) over a broad area of 35 km × 35 km per image.

The satellite images obtained with the ALOS include a 2.5-meter resolution monochrome image called a "PRISM image" as shown in **Photo 1** that is used mainly in the creation of stereoscopic images, and a 10-meter resolution color image called the "AVNIR-2 image" as shown in **Photo 2** that is used in the creation of land-cover or land-usage classification maps. As these are hard to read visually in their original forms, they are merged with an actual map in order to create a 2.5-meter resolution color image called a "pan-sharpened image" as shown in **Photo 3** (hereafter and for convenience the term "satellite image" will refer to the pan-sharpened image).

2.2 Compilation of an ALOS Satellite Image

As the satellite images observed via the ALOS are distorted due to the fact that the Earth is spherical as well as being affected by variable topographic altitudes, they cannot be projected onto planar map data. The satellite image data is therefore compiled into planar satellite images by adopting the following steps.

(1) A common reference point is determined on both the PRISM image and on the map data (maps published by the Geographical Survey Institute or other organizations).

(2) With respect to the reference point, the distortions of the

Photo 2 Color, low-resolution AVNIR-2 image.

Photo 1 Monochrome, high-resolution PRISM image (Near Morioka JR Station).

Photo 3 Pan-sharpened image compiled from Photos 1 and 2.

PRISM and AVNIR-2 images are corrected by means of applying orthographic projections.

(3) Optimum color adjustments are applied to the PRISM and AVNIR-2 images.

(4) The PRISM and AVNIR-2 images are superimposed so that their reference points are matched.

(5) Steps (3) and (4) are repeated until an optimum image is obtained.

Since the skill and expertise in reference point setting and color adjustments tend to vary between operators, the above method is accompanied by the issue of difficulty in maintaining a satisfactory quality among the created images. At NEC, we are solving this problem by standardizing the operating procedure so that optimum quality can be maintained even when a large number of images are compiled.

3. Efforts for Industrial Waste Monitoring System

NEC has accumulated a wide range of expertise related to the prevention and containment of illegal dumping and of the inappropriate treatment of industrial wastes from the practical utilization of satellite images. This has been achieved via the ALOS with technical guidance for satellite image use by Emeritus Professor Ryuzo Yokoyama of Iwate University, who is currently working at the Center for Regional Collaboration in Research and Education, Iwate University. The result is the Industrial Waste Monitoring System based on the use of satellite images that is introduced in the present paper.

The typical image used for image analysis in a monitoring system may be a mechanism that compares multiple satellite images automatically and extracts differences for analysis. In fact, however, it is said that the practical implementation of such a mechanism is difficult because the contexts of the satellite images vary greatly depending on the season as shown in **Photo 4** and **Photo 5** .

At NEC, we are designing an industrial monitoring system based on the expertise in industrial waste monitoring that we have accumulated up to the present. The images may thereby be read visually by local government officials in charge of industrial waste monitoring who have detailed knowledge of the imaged locations and have much experience in their particular job. The operations of such persons resemble those of physicians who read X-ray image data and use the results to support their diagnoses. In other words, the system is designed to improve the monitoring effects based on the fusion of expert human knowledge and satellite images.

Photo 4 Satellite image observed in springtime.

Photo 5 Satellite image observed in the fall.

4. Outline of the Industrial Waste Monitoring System

The industrial waste monitoring system features a server database of satellite images and associated information (map information, industrial waste treatment facility information, etc.) and the user can browse the stored information via the Internet as shown in **Fig. 1** . The system utilizes cloud computing and the service is provided as SaaS (Software as a Service) for which the user does not have to possess a server or any in-house applications.

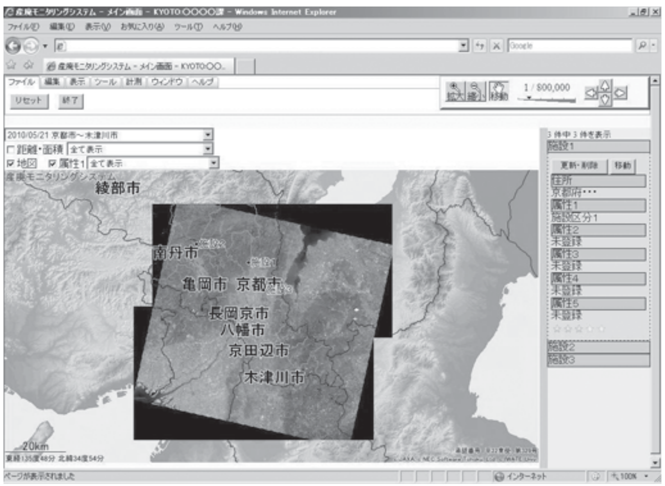

Fig. 1 Main window of the industrial waste monitoring system.

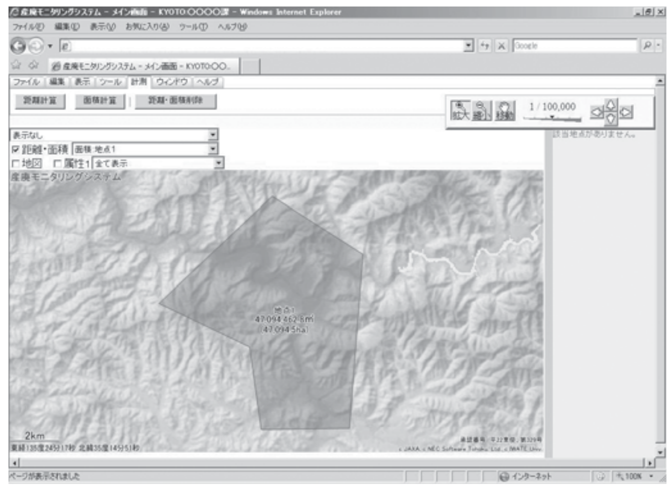

Fig. 3 Measurement of area of a designated region and its display at window center.

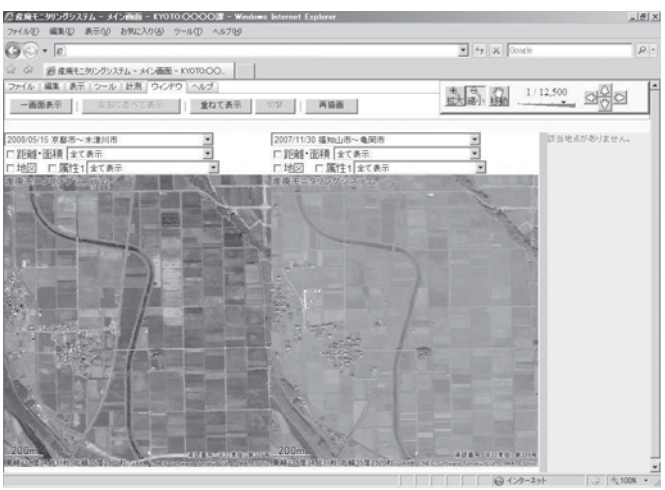

Fig. 2 Window showing a comparison of satellite images captured at different seasons.

A user who monitors industrial wastes can identify the changes visually over time by arranging multiple satellite images captured at different times side by side as shown in **Fig. 2** or by superimposing satellite images and switching the displayed image by successively pressing a button.

The basic functions available with the industrial waste monitoring system include inquiries regarding satellite images via the database, enlargement and reduction of image sizes and by repositioning across locations.

Distance and area calculations are also available as auxiliary functions for use in comparisons of changes over time. With regard to the area calculation, the user designates multiple points and the system displays the area of the polygon connecting them in hectares or square kilometers as in **Fig. 3** . The information on the selected regions and the calculated results are saved so that they may be recalled later without a need for re-calculation.

5. Toward Commercialization

The industrial waste monitoring system is currently being verified by the industrial waste monitoring departments of 12 Japanese prefectures under the industrial waste monitoring model project of the Ministry of the Environment. The system is highly evaluated for its capability of looking down upon a broad area from directly above, the ease of comparison of changes over time and the ease of inquiry using maps and facility information. Various other impressions and opinions have also been collected and are supporting our efforts. These include the enhancement and improvement of functions such as high-resolution image capturing and volume calculations/displays. We are therefore aiming at commercialization before the end of FY2011.

Since the industrial waste monitoring system contains many useful functions, it can also be applied over a wide range of monitoring functions other than for industrial waste monitoring, such as in archaeological site management and forestry improvements etc. Currently, we are conducting studies for its application in other fields by sharing information with local government departments that are responsible for operations other than industrial waste monitoring.

6. Conclusion

In this paper, we introduced our recently developed industrial waste monitoring system.

The promotion of the use of space based technology in the field of earth observation (remote sensing) is expected to improve the safety and comfort aspects of people's lifestyles. For this purpose, NEC intends to advance commercialization of the service introduced here and to promote its use over wider fields.

In closing this paper, we would like to express our gratitude to Emeritus Professor Ryuzo Yokoyama of Iwate University and the staff of the Laboratory for Remote Sensing Application of the Center for Regional Collaboration in Research and Education, Iwate University.

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