Automatic Airport Obstacle Detection System

KAMIYA Toshiyuki, KOIZUMI Hirokazu, KAWANO Minoru, SAWADA Shinji, SHIMAZU Hideo

Abstract

Correct identification of the terrain and buildings at the periphery of an airport is an important issue in aviation security. The ICAO (International Civil Aviation Organization) requests the authorities in charge of aviation administrations in all countries to collect electronic data on obstacles, including the geographic features and buildings adjacent to large-scale airports. NEC System Technologies, Ltd. has developed a system for the efficient extraction of obstacles around airports by using terrain and building height data obtained from the stereo processing of aerial photographs. This system is an application of the RealScape technology that has been used in checking changes in fixed assets.

Keywords

stereo processing, air traffic obstacle, aerial photo, DSM

1. Introduction

One of the most critical issues for aircraft aviation is to preserve the safety and security of daily travel. In order to ensure safe takeoff and landing of aircraft it is essential to ensure that specified areas around each airport are free of obstacles. In Japan, the Civil Aeronautics Acts define the height limitations for the area around an airport according to the distance from the airport. These are referred to as the "obstacle limitation surfaces." In 2004, the ICAO (International Civil Aviation Organization), which is an international organization for establishing standards, recommendations and guidelines related to the international operation of civil aircraft, issued recommendations for the participating countries. This was aimed at arranging the data on the terrain and obstacles adjacent to their airports, Electronic Terrain and Obstacle Data (eTOD) by conducting surveys, data collection and electronic management [1), 2)].

The arrangement of eTOD requires the correct survey and measurement of the terrain and buildings around each airport without any omissions; the comparison of results with the criteria given in the guidelines and the identification of obstacle types. In this paper, we introduce an air traffic obstacle extraction system to obtain the correct elevations of terrain and buildings based on stereo analysis of aerial photos that uses the RealScape system [3), 4)].

2. Airport Obstacles and Associated Issues

Aviation authorities in many countries restrict the elevations of buildings around their airports in order to secure the safety of takeoff and landing. In 2004, ICAO issued a recommendation on the eTOD data as the criterion to be observed commonly by countries worldwide. The eTOD defined in the recommendation is expected to be applicable for various purposes such as for the planning of flight paths and emergency avoidance paths as well as for the preservation of safety during aircraft takeoff and landing from or on an airport. At present, many countries have already started study and research into the data collection method or actual data collection and some of the Japanese airports have begun compilation of related databases. When investigating obstacles at the circumference of an airport, it is required to survey the area within a radius of 45 km around the airport with a height accuracy of 3.0 m and a horizontal resolution of 30 m, without omission. Nevertheless, as the traditional survey techniques often present difficulties in the accuracy of performing a thorough survey of such a large area, the need has been raised for a technique capable of achieving the required standard at low cost.

3. Airport Obstacle Extraction System

To meet the above issue, we have expanded the functions of

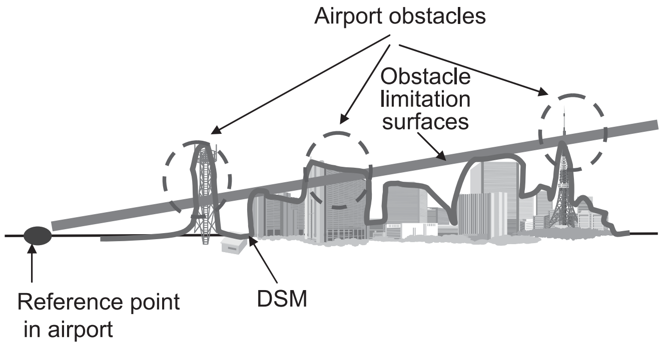


Fig. 1 Obstacle extraction using DSM and obstacle limitation surfaces.

the RealScape, software that we developed and commercialized for use in the fixed asset changes identification, and applied it to this application. Based on this expanded RealScape we have developed a new technique for extracting obstacles. The system with the new technique compares the high-accuracy, high-density numerical altitude model obtained from 3D analysis of aerial photos (DSM: Digital Surface Model) and the obstacle limitation surfaces [5]. **Fig. 1** shows a scheme of obstacle extraction based on comparison of DSM and the obstacle limitation surfaces.

3.1 Outline of Processing Method

This technique extracts obstacles in two process steps; 1) DSM calculation by stereo processing of aerial photos; 2) extraction and determination/confirmation of air traffic obstacles using DSM and the compilation of a database.

3.2 Design Policy

The target set in designing this technique was for compatibility of cost reduction and accuracy improvement via automated obstacle extraction. However, since the extraction of air traffic obstacles requires determination of the types of obstacles (tower, lightning rod, crane, etc.) and that omissions in obstacle extraction could lead to serious accidents, we decided not to apply complete automation but to apply it only in the extraction of obstacle candidates. In the subsequent steps, the inspection personnel confirm the candidate areas from stereo views of the original photos and determine the type of each obstacle after confirmation. **Fig. 2** shows the overall flow process.

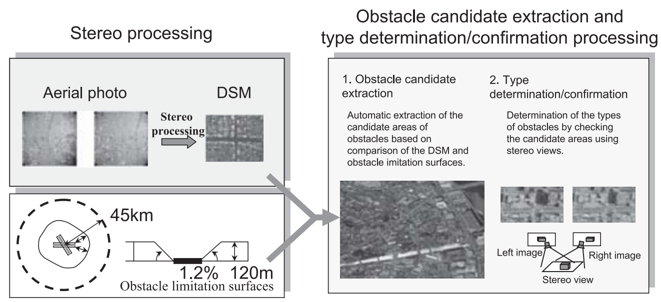


Fig. 2 Flow of air traffic obstacle extraction processing.

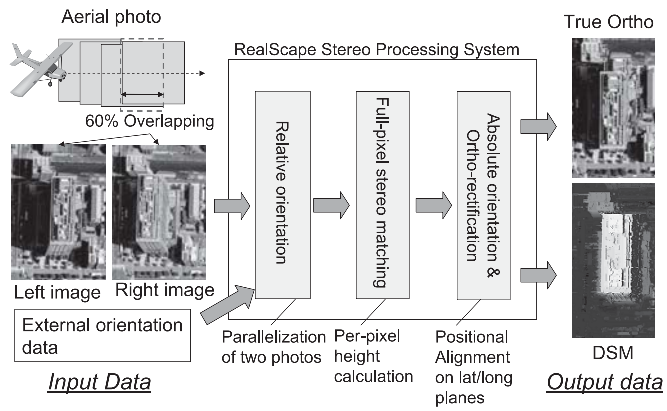


Fig. 3 Flow of stereo processing.

3.3 Stereo Processing

Fig. 3 shows the flow of stereo processing of RealScape. This technique utilizes aerial photos shot by flying multiple courses to cover the entire area around an airport without omission. These photos should be taken by overlapping about 60% of each frame with adjacent frames. RealScape identifies the corresponding positions in the area overlapped in the left/right adjacent images and obtains the DSM from the amount of deviation (parallax) between each pair of corresponding points. This process is based on similar principles to those of triangulation.

Since air traffic obstacles include small-scale structures such as a fence or lightning rod on the roof of a building, the aerial photos to be used are required to have high resolution. For instance, when an area within 45 km in all four directions from the airport is photographed with a resolution of 15 cm using a digital aerial photo camera (UltraCam/X), it is necessary to generate the DSM by processing about 2,400 sets of images, each having 14,430 × 9,420 pixels. RealScape is operated on

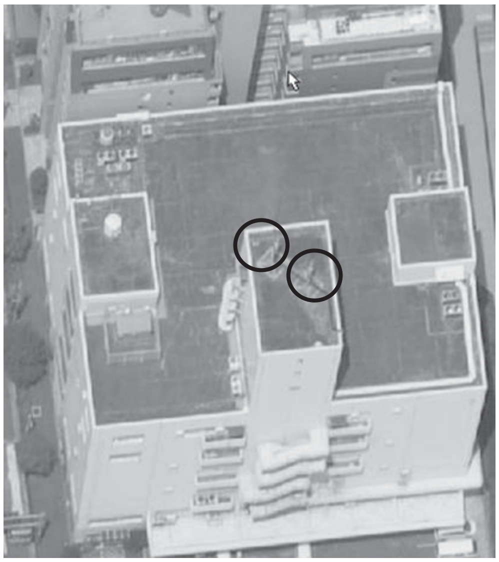


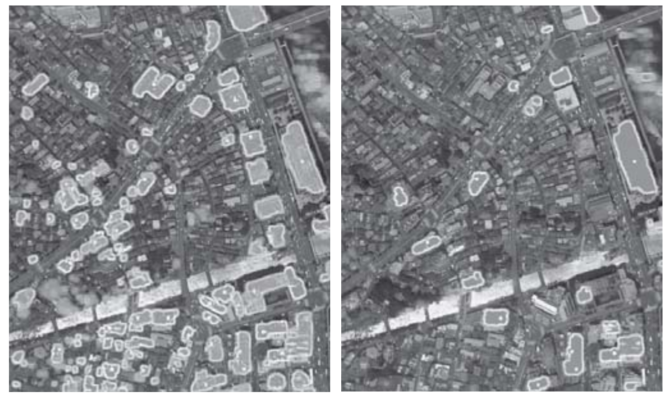
Fig. 4 Examples of lightning rods on a roof.

the client-server system which can be connected up to 48 client computers, so that it is capable of processing a large amount of stereo images at high speeds by means of the distributed execution of stereo image processing.

3.4 Obstacle Candidate Extraction and Type Determination/Confirmation Processing

The obstacle extraction is processed by comparing the DSM generated by RealScape for the target area with the heights of the obstacle limitation surfaces. In this process, the heights in DSM that exceed the restricted surfaces are detected as obstacles. In fact, however, small structures such as lightning rods and fences on the roofs of buildings are not always detected correctly on the DSM (**Fig. 4**). Therefore, the processing begins with the auto-extraction of obstacle candidates using obstacle limitation surface heights that are set lower than the actual obstacles by defining specific headroom. Processing then proceeds to the height confirmation and obstacle type determination by the inspection personnel who check the obstacle candidates in the aerial photos with stereo views.

This combination of automation and human confirmation reduces the manual labor and thereby enables accurate processing.



(a) Obstacle candidate buildings (b) Conclusively determined obstacles

Fig. 5 Obstacle extraction.

4. Test Results

To verify the effectiveness of this technique, we conducted obstacle extraction testing for an area at the periphery of a Japanese airport. **Fig. 5** (a) shows a result of extraction of candidate buildings (enclosed in white frames in the photo) in an area of about 500-meters square and Fig. 5(b) shows the final result after visual confirmation and type determination by the inspection personnel. It was verified that this technique can significantly reduce the labor requirement and can extract all of the buildings and projections in question within the target area.

5. Conclusion

In the above, we reported on a system that extracts obstacles on the periphery of airports by calculating the heights of adjacent terrain and buildings using 3D analysis of aerial photos. This technique is actually being applied already for obstacle removal at Japanese airports such as at the Tokyo International Airport (Haneda) and Osaka International Airport (Itami). The compilation of local electronic terrain/obstacle data is thus supported at low cost.

In the future, we intend to enhance the automation and accuracy of the system further and to prepare for its deployment in the overseas markets.

Automatic Airport Obstacle Detection System

References

1) ICAO, "ELECTRONIC TERRAIN AND OBSTACLE DATA", International Civil Aviation Organization (ICAO), Annex 15, Chapter 10, 2004
2) ICAO, "Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information", International Civil Aviation Organization (ICAO), Doc. 9881, 2004
3) KUNIEDA et al; "RealScape Series Fixed Assets Change Judgment System", NEC Technical Journal, Vol.1, No.1, pp.72-77, 2006
4) Koizumi et al; "Metropolitan Fixed Assets Change Judgment using Aerial Photographs", Proc. of the 21st Innovative Applications of Artificial Intelligence Conference 2009, pp.17-24, 2009.
5) Kamiya et al; "Airport Obstacle Extraction by Aerial Photograph Stereo Matching" Proc. of ASPRS/MAPPS 2009 Speciality Conference, 2009

Authors' Profiles

KAMIYA Toshiyuki
Manager, Research and Development
System Technology Laboratory
NEC System Technologies, Ltd.

KOIZUMI Hirokazu
Assistant Manager
System Technology Laboratory
NEC System Technologies, Ltd.

KAWANO Minoru
Assistant Manager
Innovative Service Solutions Division
Community and Medical Solutions Operations Unit

SAWADA Shinji
Manager
Innovative Service Solutions Division
Community and Medical Solutions Operations Unit

SHIMAZU Hideo
General Manager
System Technology Laboratory
NEC System Technologies, Ltd.