

# APPLICATIONS OF MULTI-MODE AIRBORNE DIGITAL CAMERA SYSTEM IN WENCHUAN EARTHQUAKE AND QINGDAO ALGAE DISASTER MONITORING

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**KEY WORDS:** airborne remote sensing, disaster monitoring, Wenchuan earthquake, Qingdao algae, dammed lake, sailing competition

**ABSTRACT:** Remote sensing is the quicker responding technique when natural hazards were happened. The timely airborne images are the most important information for the headquarters to planning the succor mission. Multi-mode Airborne Digital Camera (MADC) system is a novel airborne digital camera developed by Institute of Remote Sensing Applications of Chinese Academy of Sciences. This system could acquire high quality images through three modes of wide field, multi-spectral (hyper-spectral) and stereo conformation. The basic components and its technical parameters of MADC are proposed in this paper. The applications of MADC were expanded in Wenchuan earthquake and Qingdao algae bloom. Some analytical methods and information extraction technologies are proposed, and some typical analysis and imaging results are given too. Some suggestions for the design and configuration of MADC are discussed at the end of this paper.

When natural hazard is happened, the responsibility of the remote sensing staff is to capture and interpret the images of the disaster area, and to report the results to the headquarters for planning the succor mission. All the works should be done quickly and efficiently because of the disaster's devastation and suddenness. For the fast response, there are three requirements for aerial remote sensing. Firstly, the time to prepare the airborne devices should be shorter and shorter. And the suitable devices and flight platform should be selected according to the different disaster and location. Secondly, the staff and the devices should reach the disaster area as soon as possible by plane or train or other vehicles. Finally, the processes of image processing and information extraction should be simplified with an acceptable precision.

MADC system is a novel airborne digital camera, which could acquire high quality images through three modes of wide field, multi-spectral (hyper-spectral) and stereo conformation. MADC played a very important role in the disaster monitoring of Wenchuan earthquake and Qingdao algae. Especially, the distribution map of dammed lakes in Jianjiang River was provided to the front line headquarters, and the dynamic changes of algae distribution was monitored in the Qingdao's Olympic sailing venue.

## 1. INTRODUCTION OF MADC SYSTEM

MADC system was developed by Institute of Remote Sensing Applications of Chinese Academy of Sciences from 2003. We proposed the design of multi-mode and large area array digital camera in 2003 (Fang Juonyong, 2003), and used one year to develop MADC system. Several

airborne experiments have been done with different modes and aviation parameters to test the stability of MADC (Fang Junyong, 2005, Wei Zheng, 2005). The main parts of MADC are four large array CCD cameras, and the system could capture wide field, multi-spectral and stereo images through different mechanical interface. The assembly diagram of MADC with wide field is shown in figure 1. MADC can choose different mode for different application purpose to capture images of remote sensing and other assistant data. The basic technical specifications are listed as Table 1.

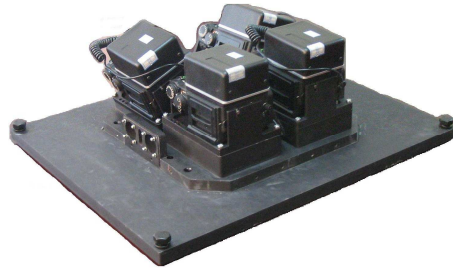


Figure 1. The assembly diagram of MADC with wide field mode

Table 1: Basic technical specifications of MADC

|  |                         |
|--|-------------------------|
| <b>General parameters</b>                            |                         |
| Single CCD pixel count                               | 4096 x 4096             |
| Pixel size   | 9 $\mu$ m               |
| Analog-to-digital conversion                         | 12bits                  |
| Shutter speed  | 1/4000-32s              |
| Frame rate per second (minimum inter-image interval) | 0.3 frames (3 seconds)  |
| <b>Wide field mode</b>                               |                         |
| Focal length   | 80mm                    |
| Field of view, cross track (along track)             | 72° (26°)               |
| Panchromatic image size                              | 12000 x 4000 pixels     |
| <b>Multi-spectral mode</b>                           |                         |
| Color (multi-spectral capability)                    | 4 channels, visual, NIR |
| Filter Bandwidth                                     | 50-100 nm, or 20-30nm   |
| Color image size                                     | 4,096 x 4,096 pixels    |
| Field of view, cross track (along track)             | 26° (26°) or 42° (42°)  |
| Focal length   | 80 mm or 45mm           |
| <b>Stereo imaging mode</b>                           |                         |
| Image size   | 4,096 x 4,096 pixels    |
| Focal length   | 80 mm or 45mm           |
| Stereo angle   | 23° or 43°              |

Many flight experiments were carried out with the prototype of MADC from 2005. MADC system finished all the aerial experiments in the typical regions, such as, Beijing, Sinkiang, Guizhou, Shandong, Guangdong, etc. It could capture the low and high resolving power image data on the different plane from low speed to high speed at different altitude. The adaptable flight platform includes Helicopter, transport plane (Y-12 and Y-5B), Citation II, and UAV. After

those aerial experiments, MADC system could realize the expected functions and capture the multi-mode aerial images. The pre-processing and analyses of the images got in the experiments demonstrate that the system matched the anticipative design purpose.

## 2. GENERAL DESCRIPTION OF MADC'S APPLICATIONS IN WENCHUAN AND QINGDAO

Wenchuan Earthquake was happened on May 12, 2008. We arrived at Hanzhong with MADC system on May 15, 2008, and arrived at Mianyang, which is near from Wenchuan, on May 21, 2008. Because of the airspace control and bad weather, it is very difficult to takeoff, so every flight chance is very hard-won for remote sensing. MADC system was assembled in wide-field mode to reduce the number of flight lines, thus it could capture images of large area in the least time. For capturing the color images, an additional color digital camera with 24mm lens was mounted with MADC system.

The rivers have been destructed by the massive earthquake and subsequent aftershocks, such as Minjiang River, Jianjiang River, Mianyuanhe River and Shitingjiang River. The landslides caused the interruption of communication and formed many dammed lakes with great danger along the rivers. One important aim is to master the status of the rivers at first time by airborne remote sensing, especially to get the information of the landslide along the rivers and dammed lakes formed when a series of landslides blocked the overflow. So the designed flight lines were along the river. Several flights were executed by MADC mounted on the M-17 helicopter at 400m~800m altitude, and the total flight time was about 8 hours. Thousands of images are acquired and processed. The mosaic images and analytical results played a very important role in the water-control of dammed lakes.

During June and July of 2008, an algae outbreak invaded the Olympic sailing venue in Qingdao, northeastern China. MADC system was redeployed to monitor the dynamic changing of algae from July 2. The multi-spectral mode was used to capture images especially with IR band because of the obviously characters in IR band of algae. For capturing the color images, an additional color digital camera with 24mm lens was also mounted with the IR digital camera. A POS (Position and Orientation System) was used to provide the flight parameters and altitude.

The algae would be an issue if the waters were not cleaned up in August, and the Olympic Sailing Competition would be affected. The aim is to extract the location and area of algae in time. So the designed flight lines covered a large area, which includes the Olympic sailing venue. Many flights were executed by MADC mounted on the Y-12 transport plane at 400m~3000m altitude, and the total flight time was about 70 hours. Thousands of images are acquired and processed. The algae distribution charts of every flight day are submitted to the headquarters. The mosaic images and analytical results played a very important role in the cleanup of algae.

## 3 THE WORK FLOW OF RIVER INVESTIGATION AND SOME TYPICAL IMAGES WITH ANALYSIS

### 3.1 The Work Flow of the Aerial Remote Sensing for Wenchuan Earthquake

The total work contains the following important steps, aerial image collecting, image processing, image interpretation, thematic mapping and analysis. The images were collected by MADC system on the platform of helicopter. The processing of the images contained image convertor, color adjustment, image mosaic and image geometric correction. The aim of color adjustment is to enhance the image and improve the details on the image. The image mosaic is realized by the software AutoPano and the geo-correction by the software ENVI and EARDAS according the relief map. The interpretation is to get the location and size of the landslide and dammed lake along the river. At last, the status and damage of the landslides and dammed lakes are evaluated and reported to the Headquarters for Earthquake Disaster Mitigation for decision. The work flow chart is shown in figure 2.

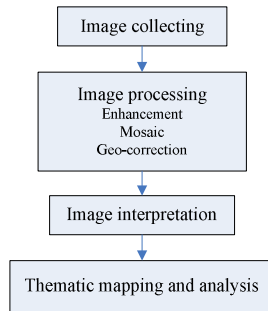


Figure 2. The work flow of the aerial remote sensing in the investigation of rivers destructed by the earthquake

### 3.2 Some Typical Images and its Analysis

#### (1) The mosaic image of Jianjiang River and images of Tangjiashan dammed lake

The images along Jianjiang River were acquired on may 22, 2008 and the mosaic image of the middle part of Jianjiang River is shown in figure 3, which have become very dangerous because of the landslide along the river and the dammed lakes formed when rubble from a massive landslide set off by the deadly May 12th earthquake blocked the flow of the River. Several landslides created a series of dammed lakes along the river, which increasing the risk of bursting and threatening thousands of people downstream. The Tangjiashan dammed lake named by the nearby mountain Tangjiashan is the largest one of them and is about 3.2 kilometers away from the seat of Beichuan County which worst devastated by the earthquake. It is inaccessible by road and can only be reached by foot or air. The detail information of dammed lakes got from aerial remote sensing is a great help to the evaluation and solution of the damage. Figure 4 presents the image submerged town Xuanping and image of Tangjiashan landslide and dam. From the image we can get the length of the Tangjiashan dam is about 800 meters, the width is about 610 meters, the height of the dam top is about 124 meters.

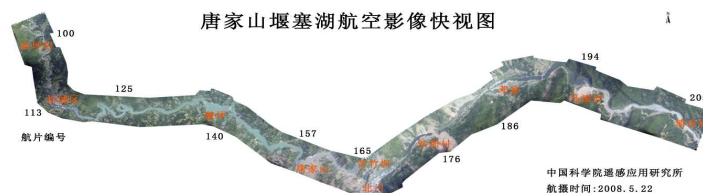


Figure 3. The mosaic image of Jianjiang River

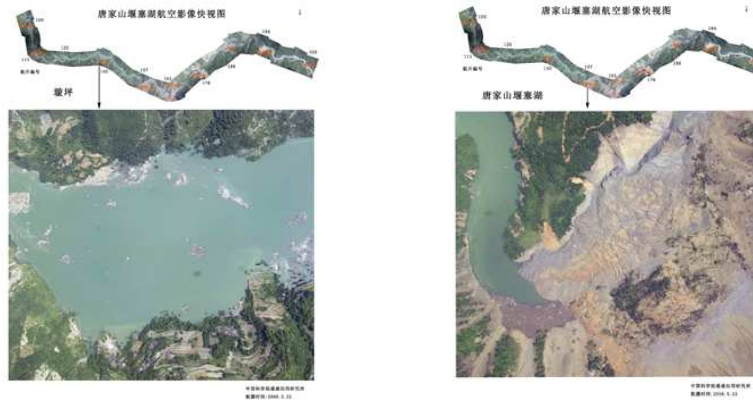


Figure 4. The image of Tangjiashan dammed lake  
 ( left: the submerged town Xuanping, right: Tangjiashan landslide and dam)

(2) The image of damaged hydropower station and bridge on Minjiang River

Minjiang River is one of the worst damaged river by the earthquake, the landslide is normal along the river and the road is destroyed, which caused great difficulty to deal with the emergency. A damaged hydropower station and a damaged bridge on Minjiang River are shown in the figure 5. The investigation of the landslide, damaged road and bridge along the river gave detailed in-time and necessary information for emergency rescue and road recovery.

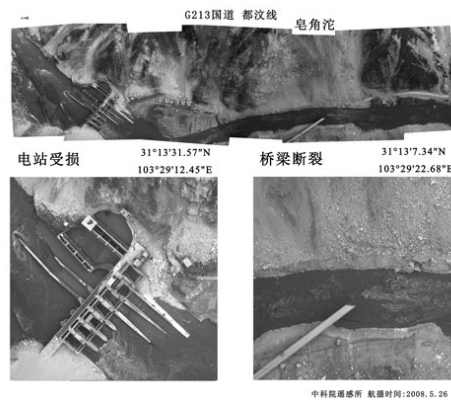


Figure5. The image of damaged hydropower station and bridge on Minjiang river

4 THE WORK FLOW, KEY TECHNIQUES AND SOME TYPICAL IMAGES FOR ALGAE MONITORING

4.1 The Work Flow and Key Techniques for Algae Monitoring

The key work is how to realize the automatic extraction of the algae information quickly. We set up an effective work flow and the automatic extracting method considering the characteristic of the color image of MADC. The in-time and accurate information of algae distribution provide great valuable and useful information for algae clearing and forecasting.

The aerial remote sensing work flow of algae monitoring by color images is shown in figure 6 which contain four main steps, image collecting, image processing, algae information extraction and thematic mapping.

Image collecting is carried out in any feasible day by MADC with POS on the plane platform. The processing for image mainly contains POS extraction, image converting (data format converting by Photoshop), and image ortho-rectification and ortho-image mosaic. After mosaic image finished, the algae information extraction is the key work which need more understanding of the characteristics of the image. We set up some index from the characteristic of the image for distinguish the algae from the sea water, avoiding the negative effect of the noise (CCD effect), wave (mirror reflection) and imaging mode (dark edge), realized the accurate and automatic extraction of algae by decision tree method. The pixels in the image are classed into two classes, algae and the others, then convert the class image to vector file for information integration and mapping in ArcGIS. The last step is making of thematic map and the statistic analysis of algae information with GIS software.

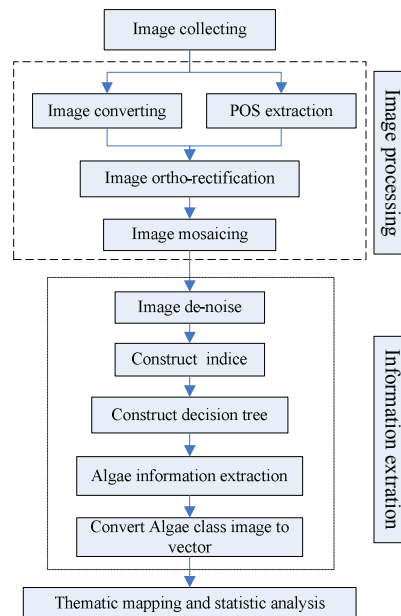


Figure 6. The work flow of algae monitoring by color images

The key technique for algae remote sensing monitoring is the ortho-rectification of the images, the construction of indices and decision tree, which are necessary to the automatic and quick extraction for algae information extraction.

For the IR image, the contrast between algae and water is more obvious than the color image, but the algae just can be manually interpreted because it just has one band. When the quality of color image is not good in bad weather, IR image is a good choice.

#### 4.2 Some Typical Images and Monitor Results

An IR image is shown in figure 7. Figure 8 presents a color image, the algae are obvious, and the white or green color is algae. Do algae extraction method to the mosaic image, get the class image, convert the class image into vector file for thematic mapping, the result of July 6,2008 is shown in figure 9, presenting the distributing of algae .

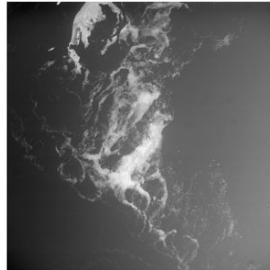


Figure 7.Example of IR image



Figure 8.Example of color image



Figure 9. The thematic map of July 6, 2008

## 5. SUGGESTIONS FOR MADC SYSTEM

The ability of capturing data is enhanced by MADC system which can obtain aerial images in three modes, so it is very convenient for many kinds of applications. But there are some improving suggestions when MADC is applied for disaster monitoring.

Only some helicopters have a window for remote sensing, so MADC is not suitable for helicopter because of its mounting style. MADC should provide a modified version which could be mounted in the podded cabin of the helicopters. The integrated level should be improved for a more compact and lighter airborne device.

The current image processing software is not suitable for the urgent response. The basic requirement is the fastest processing, and the final results should be delivered to the headquarters as soon as possible. So the fast mosaic arithmetic and information extraction method should be developed for disaster monitoring.

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