Koh Chang Island Eco-Tourism Mapping by Balloon-born Remote Sensing Imagery System

Michiro Kusanagi[1], Jun Nogami[2], Tanapati Choomnoommanee[3], Teerawong Laosuwan[4], Eileen Penaflor[3], Niu Shulian[3], Yao Zuyan[3]

STAR Program Coordinator[1], Project Researcher[2], Master-Course Students[3], Doctorate Student[4]
Space Technology Applications and Research (STAR) Program,Asian Institute of Technology,
58 Moo 9, Km.42 Paholyothin Highway, Khlong Luang, Pathumthani 12120, Thailand
kusanagi@ait.ac.th

Abstract: Koh Chang Island is located near the east border of Thailand. The government of Thailand promotes the island as a model of eco-tourism spots. The Island undeveloped until recent years, is expected to change to major tourist attraction. “Digital Koh Chang project” has thus. The main objective of this project is to monitor the environment and land use status of the island and to support its sound development.

In March 2003, a field survey of this project was planned and field data were collected using both airborne and ground platforms and an ocean vessel. These data were combined with satellite data in the laboratory. This presentation is all balloon-born system field operation.

A 5-meter length balloon filled with Helium gas was used, whose payload consisted of two RGB standard color digital still cameras, two directional rotating servo motors, a camera mount cradle as well as signal transmitting and receiving components. A series of aerial high-resolution digital images were rather easily obtained using this inexpensive system, making it possible to monitor intended landscape features in a specific field.

Design of simple, low-cost and easily transportable flying platforms and local field surveys using them are useful for getting local ground truth data to calibrate satellite or airborne-based RS data. The design analysis to upgrade the system is further investigated.

Keywords: balloon, flying platform, field observation, directional control, eco-tourism, mapping, monitoring

1. Introduction

It is more than thirty years since the first artificial satellite of remote sensing was launched into orbit. Remote sensing, as a part of space technology, has achieved tremendous progress and has greatly contributed toward managing the earth’s natural resources, observing and predicting natural phenomena, and helping users to monitor and mitigate disasters. However, for very detailed remote sensing applications, satellite data may not be sufficient because of its limit in resolution and temporal availability. To overcome these problems, other platforms for land observation have been developed to get in-situ ground truth data which can calibrate and compensate satellite data and have become a complementary and important part of field observation technique.

Aerial photographs have come to play an ever-increasing role in the execution of cartographic mapping on various scales and in evaluation of natural resources of a region. Aerial photography requires the use of an airborne platform from which to expose the film. Airplanes, helicopters, and sky-sport flyers are usually employed as aerial photography platforms.

Another promising platform is the balloon. Balloon systems are cheap, transportable, and easy to use. In addition, they can be launched wherever and whenever the researchers want to conduct the experiment (Miyamoto et al., 2002 ; Nogami et al., 2002).

In a balloon system, the balloon is usually tethered to the ground and recovery is as simple as pulling the tether line to the ground. Due to safety reasons, though more expensive, helium gas is usually employed.

Another important part of a balloon system is the payload. It consists of critical components such as the camera, stable camera cradle, tracking, and communication subsystems. An onboard or flight computer is also necessary to control every functionality of the payload (Meehan, 2002). The camera cradle can be attached to servos to allow the camera to pan and tilt. The communication subsystem, obviously, is for sending signals from ground control to the payload and vice versa. Technically, the payload is the most complicated part of a balloon system and that requires more man- hours to complete.

Balloon aerial photography must be conducted in a calm or very light wind condition. Any more wind pushes the tethered regular-type balloon to the side and downward. However, the airship-like shaped kite-balloon that we utilized in this project have added weathercock stability through the lift component as well as drag component, both of which are controlled by pulling and releasing the sling attached at a tail. This simple mechanism can make the system more stable and add weathercock stability.

In this study, a kite-balloon system was employed to survey an area in Khlong Phrao, Koh Chang Island. The area was selected due to its accessibility, appropriateness for coastal survey, and for some practical reasons.

Major points were considered prior to this survey. These include the following:

1. To design a suitable and stable camera mount or cradle
2. To design an operation control equipment for payload
3. To test the functionality of the system by test launch
4. To conduct a field survey using the tested system.

2. System Description

2.1. Kite-balloon

The kite-balloon used in this study is made of thin polyethylene material. Dimensions are about 2 meters in width and 5 meters in length. Helium gas was used to inflate the balloon. The kite-balloon cruising altitude is approximately 100m with the payload suspended beneath it. The major force components acting on this kite-balloon are described in Figure1.

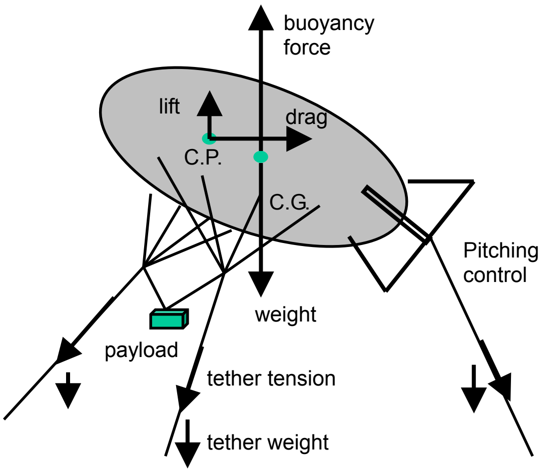

Figure 1. Major force components of Kite-balloon

2.2. Payload, cameras and directional mount

Payload
The payload consists of common and inexpensive commercially available digital camera, directional rotating motor (servo), and signal transmitting and receiving components. Cameras took pictures at fixed interval of 30 seconds in RGB mode. The two digital cameras were mounted on a triangular cradle (as shown in Figure 2). Such position enables to capture patched areas of opposite sides along the survey path. The servomotor, which is remotely controlled, controls the camera cradle positioning in order to get appropriate or target areas. The video transmitter and its receiving unit are used to monitor areas on ground that within the camera view. On the main board are batteries that can supply adequate electric power for the motor and the transmitter.

Radio remote control
Radio remote control was selected to take pictures without bringing cameras down every time. We applied 3 channels FM radio system by using 2 channels for pitch (up and down) and yaw (left and right) control.

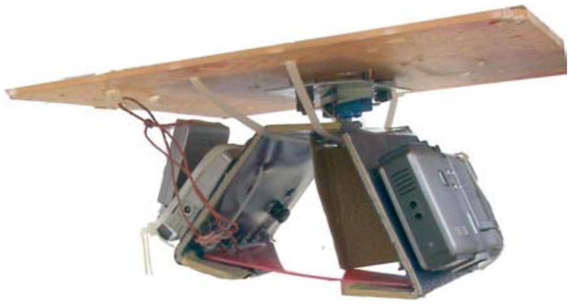

Figure 2. Photograph of the camera mount cradle

Servo Actuator
Camera movement was controlled by the motion of servo, which is controlled from the ground through a radio receiver. Original design of the camera cradle would utilize two servomotors for controlling the pitch and yaw movements, however, due to time limitations such plan was not attained. Final design employed only one of the two available motors.

2.3. Real time data acquisition

The data from the camera can be conveyed to ground controller in real time by VDO transmitter. The process is as follows: first, the data from the camera is sent to the transmitter through AV line. Then the transmitter sends these data to the monitor on the ground (for this system, the distance between transmitter and receiver should not exceed 1000 meters). Finally the controller acquires the real time data from the camera. This information will be the basis if camera position should be changed or not.

3. Results and lessons learned

The group working on the balloon system, perhaps, experienced the most number of obstacles during the entire study. Insufficient information about the island beforehand, limited time, and weather conditions are among the reasons of those problems. This experiment is conducted in the STAR Program course “Aerospace Technology”. We think that the educational significance through this field study and design of platform would be plentiful.

Some of the pictures taken are shown in Figure 3.

4. System Improvement

For further research mission might focus on overcoming of the major disadvantages, e.g. stability control and intentionally cardinal imaging.

Gyro-mounted IMU that can sense the attitude of platform in real-time would improve the flight stability using feedback control of tether system in pitch, yaw and roll plane.

Continuous monitoring of specific target on the ground irrelevant to the attitude of kite-balloon is also considered for further research. Feedback control of camera orientation vector by servomotor has to be made using the accurate position data obtained from hybrid GPS/INS navigation system and the accurate attitude data obtained from IMU-gyro.

Low-cost but stabilized kite-balloon system in higher-altitude would be possible by utilizing two, three or multi-stage tethers.

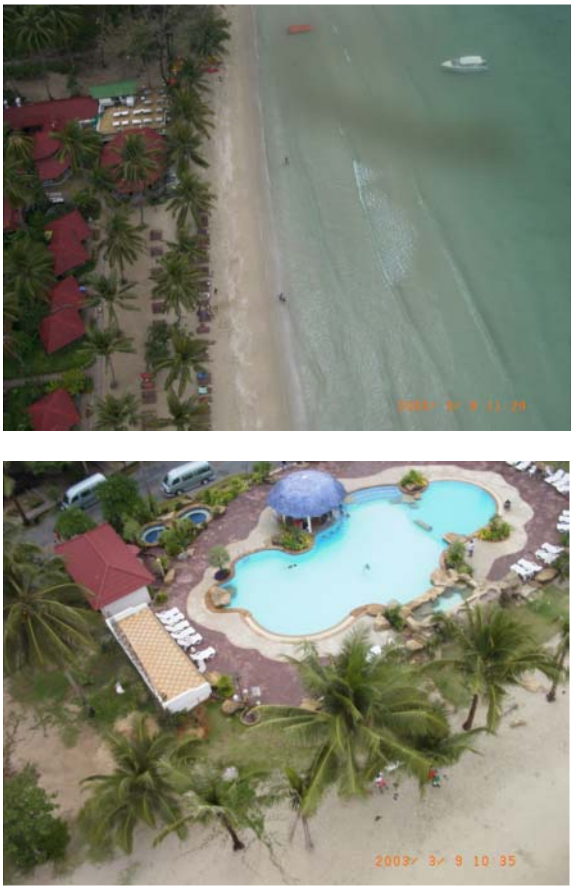

Figure 3. Kite-balloon-based aerial photographs

5. Conclusion

Eco-tourism resorts of Koh Chang Island in Thailand can be mapped using the developed balloon-borne mapping system. Two RGB standard color Digital still cameras were set up and mounted onto a directional control unit as a balloon payload. Chronologically subsequent photos reveal adequacy that satisfy the photographic work. This system presents the potential to better operational experiences in management of eco-tourism resources.

As a result, main advantages of this developed balloon-borne mapping system are seen to be:

- Large scale and high resolution digital images taken by mounted cameras are easily acquired, making it possible to monitor intended landscape features in a specified field.
- The prototype of directional control unit, comprising vertical and horizontal rotating component, wireless transmitter/receiver and remote controller, is the newly constructive solution for omni-directional mapping.
- The use of commercially available digital cameras is the key characteristic of this type of simple, light, easy-to-use and inexpensive system.
- In combination with wireless communication technique, ground-based monitor facilitates the synchronic control during ground features mapping according to purpose of survey.
- Operational flexibility of balloon-borne mapping system is applicable to other projects or fields, especially real-time disaster monitoring or inspection of dangerous areas.

As well as of disadvantages, some restrains which probably suspects to threat usefulness and accuracy of the system are proposed.

- Relatively high frequency oscillations due to air turbulence are not negligible and need to be suppressed using vibration-isolation mechanics.
- Activities for attainment of fine imagery rely extensively on weather conditions, wind velocity, rain extent, sunshine intensity for example.

On the basis of current mapping survey, further research mission might focus on the possible improvement of relevant advantages and overcoming of the major disadvantages, such as stability balance control under the severe weather condition and intentionally cardinal imaging.

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