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# CropCam UAV for Land Use/Land Cover Mapping over Penang Island, Malaysia

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## ABSTRACT

The problem of difficulty in obtaining cloud-free scene at the equatorial region from satellite platforms can be overcome by using airborne imagery as an attempt for introducing an economical method of remote sensing data; which only requires a digital camera to provide near time data. Forty three digital images were captured using a high resolution digital camera model pentax optio A40 (12 megapixels)at a selected location in the same day in Penang Island from a low-altitude flying autopilot aircraft (CropCam) to generate land use/land cover (LULC) map of the test area. The CropCam was flown at an average altitude of 320 meters over the ground while capturing images which were taken during two flying missions for the duration of approximately 15 and 20 minutes respectively. The CropCam was equipped with a digital camera as a sensor to capture the GPS points based digital images according to the present time to ensure the mosaic of the digital images. Forty one images were used in providing a mosaic image of a bigger coverage of area (full panorama). Training samples were collected simultaneously when the CropCam captured the images by using hand held GPS. Supervised classification techniques, such as the maximum likelihood, minimum-to-distance, and parallelepiped were applied to the panoramic image to generate LULC map for the study area. It was found that the maximum likelihood classifier produce superior results and achieved a high degree of accuracy. The results indicated that the CropCam equipped with a high resolution digital camera can be useful and suitable tool for the tropical region, and this technique could reduce the cost and time of acquiring images for LULC mapping.

**Keywords: CropCam, LULC, supervise classification, digital camera**

## INTRODUCTION

The increasing availability of remote sensing images, acquired periodically by satellite or airborne sensors on the same geographical area, makes it extremely interesting to devolve the monitoring systems which is capable of automatically producing and regularly updating land use/land cover (LULC) maps of the consider site (Bruzzone *et al*., 2002). Remote sensing technique has the ability to represent LULC categories by means of classification process. With the availability of multispectral remotely sensed data in digital form and the development in digital processing, remote sensing supplies a new prospective for LULC analysis (Weng, 2001). Remote sensing applications for agriculture and forestry often require images with a high temporal resolution (Grenzdoreff and Zuer, 2007); this is difficult and /or costly obtain, either by satellite imagery or conventional airborne data. Therefore, unmanned UAV equipped with GPS and digital camera, so called CropCam, has become the focus of our research as a development technique to collecting the data. Most researchers have examined the use of conventional aircrafts or satellite system to collect such imagery (Lim *et al*., 2009; Saleh, 2009). Unfortunately, both have limited ability to provide accurate and

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concurrent imagery in LULC mapping. Thus, alternative methods of acquiring imagery need to be evaluated. Our objective is to evaluate high resolution imagery using a variety of applications involving LULC mapping. The sensor used in this study was a 12.0 megapixel digital camera model Pentax optio A40 that enables the CropCam to acquire colour imagery with a 9.0 cm spatial resolution from the height of 320 meters above the ground. Supervised classification of remote sensing images had been widely used as a powerful means to extract various kinds of information concerning earth environment. The ability to acquire imagery at relatively low altitude (e.g. 200-640 m above the ground), afford UAVs the ability to acquire imagery below the majority of atmospheric conditions, such as cloud cover, that often plague other remote sensing systems. Atmospheric conditions such fog and haze can have an effect on UAV based systems, but to a lesser degree than other platforms that may have acquisitions heights of 10 to 100's of kilometers above the earth's surface (Tan *et al*., 2009). Another great advantage of a UAV based aerial imagery system is the ability to be quickly deployed and have imagery available almost concurrent. A part of this, the fact that some UAVs can hand lunched and skid landed in relatively small locations; eliminate the need for takeoff and landing strips, which may be at a significant distance from the emergency site. The main purpose of this study are to do LULC mapping using CropCam unmanned Aerial Vehicle (UAV) and digital camera to make a quick decision about the specific area can be made after processing the data.

## STUDY AREA AND DATA ACQUISITIONS

The flying field site over Penang Island, Malaysia was chosen as the study area. The study area is balik pulua located between altitude 5° 39' N to 5° 41' N and longitude 100° 20' E to 100° 24' E (*Fig. 1*).

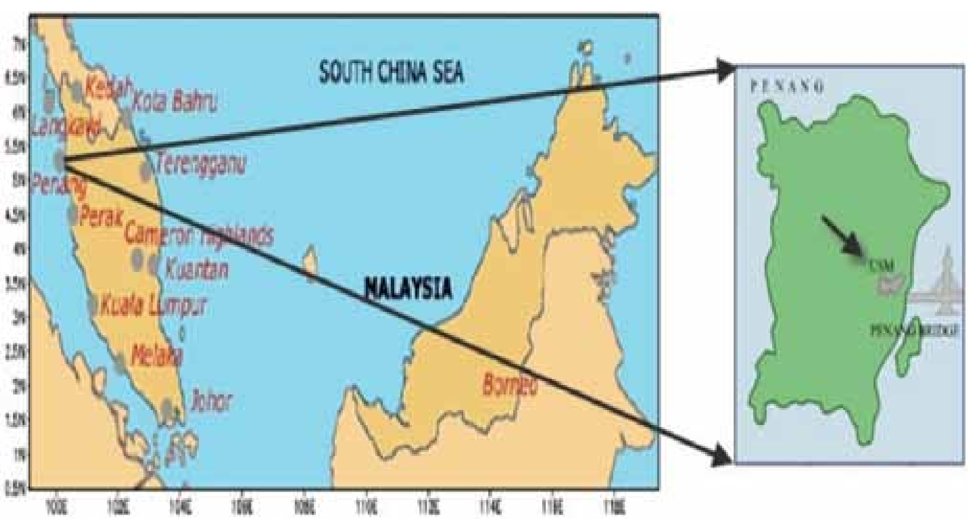


*Fig. 1: The geographical features of the study area*

A digital camera (*Fig. 2*) was used to capture RGB digital images from CropCam UAV (*Fig. 3*) at an altitude of 320 meters above the ground. The images were captured between 4 p.m. and 6 p.m. on the 9th January 2009. The images were acquired at approximately 60% overlapped and 30% sidelapped and covering around 900 meters square of the ground while flying over our area which had been chosen due to the fact that it is an open area without any near obstacle that can hinder safe

CropCam takeoff and landing. The images were taken under a suitable condition which was during a sunny day with a normal wind speed at approximately 5 knot/hour to ensure the flight stability and the camera's capability to capture accurate images; all images were taken also during two flight missions in one day for duration 15 and 20 minute respectively and with average CropCam speed at 60 m/sec during flying.


*Fig. 2: Digital Camera- Pentax optio A40 (Pentax optio, 2009)*

*Fig. 3: CropCam Unmanned Aerial Vehicle (UAV)*

## REMOTE PLATFORM AND SENSOR

In this study, the CropCam was flown above the study area at an average of altitude of 320 meters during image acquisitions. The technical specifications for the CropCam platform are shown in Table 1.

The CropCam is a revolutionary mini agriculture plane that could change the way to manage the crops, fields, or any part of the agriculture operation by providing high resolution GPS based digital images for precision agriculture. CropCam is a radio controlled model glider which can be easily assembled and hand lunched, it can be fitted with a miniature autopilot, digital camera, Trimble GPS, and software that can provide images on demand. The CropCam was able to fly automatically from the moment it takes off and lands. It also provides high resolution GPS based images on demand.

TABLE 1
The technical specifications for the CropCam [8]

| | |
|---|---|
| length | 4 feet |
| Wing pan | 8 feet |
| Weight | 6 pounds |
| Engine | 0.15 cu in/Axi Brushless |
| Fuel tank | 6 oz/lithium polymer batteries |
| Altitude | (400-2200) feet in Canada (can be adjusted to meet our application) |
| Flight duration | 20 minutes |
| Camera | Pentax digital optio A40 |

CropCam can be lunched using hands from a corner of the field and the powerful miniature autopilot and GPS did the navigate in a pattern over the field. Both the CropCam and the digital camera perform automatically to take GPS based digital imageries, each individual image is GPS based with latitude, longitude, and latitude (Pentax optio, 2009).

## METHODOLOGY

Forty four digital imageries of the flying site were selected for LULC classification, sample of the images were shown in (*Fig. 4*). The images were acquired in three visible bands (red, green, and blue). The size of each raw high spatial resolution image was 4000 pixels by 3000 lines. Forty one images were mosaiced together to produce a bigger coverage area (*Fig. 5*). The mosaic image was separated in to three bands (RGB) for multispecialty analysis using PTGui Pro8.1.3 software. The PTGui is panoramic stitching software originally developed as a graphical user interface for

*Fig. 4: Sample of raw images used in this study*

panorama tools. PTGui currently a full featured photo stitching application (CropCam, 2008). A total of 20 training samples were collected simultaneously when the CropCam was capturing the images using hand held GPS and were used to register the mosaic image into an established geographic coordinate system UTM (*Fig. 6*).

*Fig. 5: The mosaic image used for land cover/land use*

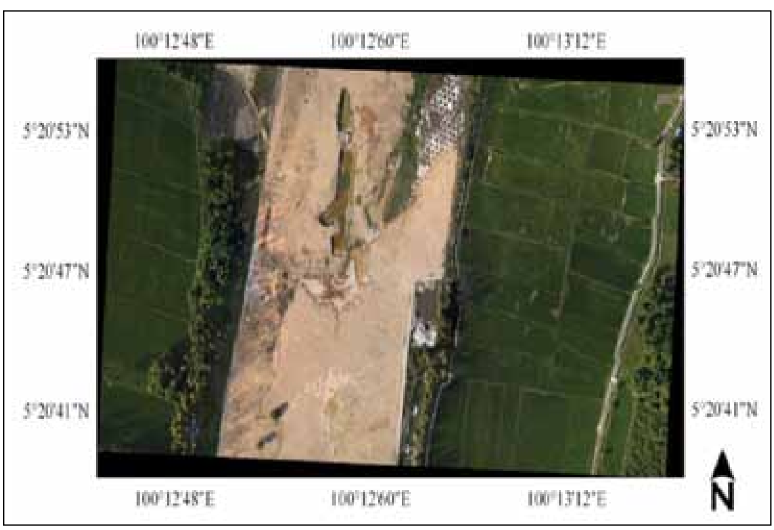


*Fig.6: The geocoded mosaic image used for land cover/land use classification*

All the images were taken in absolutely clear sky on the 9th January 2009.All image-processing tasks were carried out using PCI Geomatica version 10.3 digital image processing software.

Supervised classifications were operated in three basic steps: training, classification and accuracy assessment. The aim of the classification is to categorize all of pixels in the digital image into LULC classes in the ground. Training samples are needed for supervised classification; selection of training areas in this study was based on the colour image. The areas were established using polygons. There are delineated by spectrally homogeneous sub area, which have, given class name. Many researches choose the maximum likelihood classifier in their studies (PTGui, 2009; Saura and Miguel-Ayanze, 2002; Donoghue and Mironnet, 2002). In this study the mosaic image was classified into four classes .Once the training sites and classes were assigned, the full panorama image was classified using three upervised classification algorithms which are Maximum Likelihood, Minimum-to-Distend, and Parallelepiped. Accuracy assessment was made to the image after classified .among the various methods of accuracy assessment discussed in remote sensing literatures, three measures of accuracy were selected and tested in this study, namely overall accuracy, kappa coefficient, and error matrix (Thiemann and Kaufmann, 2002).

## DATA ANALYSIS AND RESULTS DISCUSSION

A total of 100 training samples were randomly generated in this study. The three supervised classifiers performed to the mosaic image after registered in UTM coordinate system. The image was classified into four legends which are trees/vegetation, water, soil field and urban. Overall accuracy and kappa coefficient results of the three classification methods are shown in Table 2 and error matrix results are shown in Table 3.

The overall accuracy is expressed as a percentage of the test pixels successfully assigned to correct legends. Based on the findings Maximum Likelihood classifier produced the highest degree of accuracy with overall accuracy 90.02% and kappa coefficient 0.81, Minimum-to-Distend gave overall accuracy 79.46% with kappa coefficient 0.562 and Parallelepiped classifier result was the lowest in overall accuracy of 31.29% and kappa coefficient 0.14.A classified image using Maximum Likelihood classifier is shown in (*Fig. 7*).

TABLE 2
The overall classification accuracy and Kappa coefficient

| Classification method | Overall classification accuracy (%) | Kappa coefficient |
|---|---|---|
| Maximum likelihood | 90.02 | 0.81 |
| Minimum distance to mean | 79.46 | 0.562 |
| Parallelepiped | 31.29 | 0.14 |

TABLE 3
The confusion matrix results

| Classified data | Reference data | | | | |
|---|---|---|---|---|---|
| | V | W | S | U | Total |
| V | 52 | 3 | 4 | 0 | 59 |
| W | 4 | 2 | 6 | 1 | 13 |
| S | 0 | 1 | 19 | 6 | 26 |
| U | 0 | 0 | 0 | 2 | 2 |
| Total | 56 | 6 | 29 | 9 | 100 |

Class: V: tress Vegetation; W: Water; S: Soil filed; U: Urban

The results show a good agreement between the image and the ground. During supervised classification processing we had some misplacing pixels or mixed pixels between the four classes this is happened because we using limited channels (RGB) specially when we was classified the trees and other vegetation.

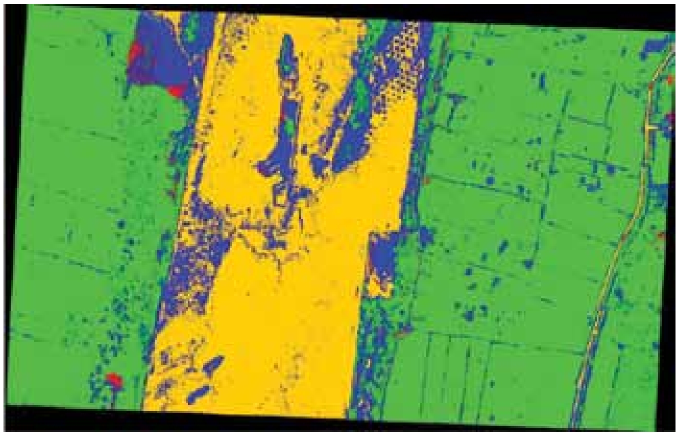

*Fig. 7: The classified image obtained using Maximum likelihood classifier (Green = Trees/ vegetation, Blue = Water, yellow = Soil field, red = Urban and black = unprocessed area)*

## CONCLUSION

From the classified map, Maximum Likelihood method gives a good result for LULC mapping. This analysis has demonstrated that the capability of the digital camera with high spatial resolution to capture images from a low elevation attached to a CropCam can give more accurate results and consider low cost compare with others remote sensing data collected from satellite or manned airborne. This study showed that the normal digital can provides an alternative way to capture useful data for LULC mapping. The study showed also that the CropCam UAV as an ideal and new remote sensing system for collecting data, this includes that the fact that it can be transported and deployed easily. The study confirmed that using CropCam system can give high resolution and real time images for accurate further processing and at a relatively low cost.

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