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Estimating Cabbage Production in Cameron Highlands, Malaysia Using IKONOS Data

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Abstract: The objective of the study is to map and count the individual cabbages at the early growth stage in Sg. Palas, Cameron Highland grown under a mix cropping system and estimate its production. With ground verification, an IKONOS 4 m multispectral imagery acquired on 25 February 2001 was digitally processed at an orthorectified level. A Digital Terrain Model (DTM) was developed and a scanned topographical map was overlaid with IKONOS data to precisely locate the attribute data and map the individual young growing cabbages. Using a supervised and unsupervised classification, less than and above 1.5 month-old cabbages were mapped and quantified. The algorithm and processing technique developed in this study can easily estimate a production of 25,000 cabbages/ha in Sg Palas area. Integrating the data with a Geographic Information System (GIS) may help Cameron Highland farmers to better market their cabbages in the future. The potential use of airborne hyperspectral imaging data such as UPM-TropAIR's AISA TropAIRMAP™ to map and predict the supply of cabbages should be the next step in precision farming revolution using remote sensing.
Keywords: Cabbage; Production; Market intelligence; High resolution; Satellite remote sensing

1. INTRODUCTION

Cameron Highlands in Malaysia has been the main cabbage production area in Malaysia. Way back in 2002, there was an over supply of cabbage production in Cameron Highlands. Estimating cabbage production in cameron Higlands, Malaysia has been a difficult task due to the mountainous nature of the area under study. On the basis of analysis of IKONOS satellite images materials, Kurbnov (2005) defined the problems of estimating condition of crops, contamination, density, drowning, identification of various crops and definition of areas they occupy and inventory of meadows, haymakings, pastures with an estimation of their condition and efficiency can find its solution with IKONOS datasets. The wonders of IKONOS imagery for agricultural applications in Japan has also been clearly highlighted by Chiharu and Eisaku (1999). Using a very high resolution IKONOS remote sensing satellite data, it is

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postulated as possible in monitoring the growing stage and estimating the area of agricultural crops in the Japanese cropping system. In addition, Vina et al. (2003) reported that the IKONOS imagery, in combination with ground-reference information has also been proven to be a useful tool for verification of conservation tillage practices in the United States. However, the use of IKONOS imagery in a Malaysian mixed cropping system is yet to be studied and tested. The result might be confused with the other vegetable crops within the study area. This might be due to the limitation of bands in the 4 m multispectral IKONOS imagery.

Papers dealing with the extraction of agricultural areas by means of structural features are mostly focused on the extraction of vineyards, orchards, or plantations. However, the structural characteristics exploited for the extraction of these objects also occur in cropland, namely straight parallel lines. In the case of cropland, these lines are visible structures caused by tilling. The spectrum of the techniques used in this context is wide and includes Hough (Ruiz et al., 2007), Fourier (Chanussot et al., 2005; and Ruiz et al., 2007) and Radon transforms (Chanussot et al., 2005), Gabor filtering (Delenne et al., 2008), variograms (Trias-Sanz, 2006 and Ruiz et al., 2007), and autocorrelation (Warner and Steinmaus, 2005). Another method for the classification of various types of vegetation distinguished by their spatial patterns in aerial images is presented by Delenne et al. (2008). They use a frequency analysis to estimate the row width and orientation and to detect the boundaries of vineyards. However, LeBris and Boldo (2007) first used a segmentation to extract homogenous regions before applying the algorithm of Trias-Sanz (2006). However, the approach of Trias-Sanz (2006) can be used to discriminate a large number of object classes by properly choosing the texton, but can give wrong results if the texton parameters are selected inappropriately. In contrast, this study focuses on the discrimination of only two object classes using structural information (cabbage and ages of cabbage).

Therefore, the objective of this paper is to assess the capability of IKONOS data in detecting, quantifying and mapping of young cabbages grown under a mixed cropping system. Once the individual cabbages can be counted, it is expected that the total cabbage production of the study area may easily be estimated.

2. MATERIALS AND METHODS

The study area (Long:101.38046478^0, Lat: 4.55092754^0) to (Long: 101.46630572^0, Lat: 4 6416771^0) is located in Sg. Palas, Cameron Highland, which is 219 km from Kuala Lumpur. The post processing visit to Cameron Highland was conducted from July 24-27, 2001. The objective of this visit was to conduct pre-ground verification of the cabbage area and its surrounding using IKONOS 4 m multispectral imagery and existing FAMA's data. (Fig. 1).

IKONOS data in R, G, B and NIR bands was captured on February 28, 2004 and saved in four separated multispectral files in GeoTIFF format. The separated files were then regrouped into one file using ERDAS Imagine software. Simillar algorithm and techniques developed for individual coconut counting in Mersing, Johor was used to extract and count the individual cabbages appeared in the imagery (Kamaruzaman, 2004). Digital Terrain Model (DTM) was generated based on the contour lines. ERDAS virtual GIS was used for 3D visualization and Flythrough. A scanned map was used as a guide to provide information such as name of a place, existing roads, rivers, etc.

The goal of this paper's approach is the verification of cabbages and their varying ages as objects of using 4 m multispectral IKONOS images. The images are orthorectified before processing starts. The verification is based on the results of a textural analysis and on structural and radiometric features. These features are jointly analysed in order to achieve a final assessment of each object according whether it conforms to the definition of its class in ATKIS or not. In this context, the different feature types distinguish different classes of objects. The textural features used by this approach can be used to separate a combined class 'cabbages', which comprises both young and old cabbages as objects, from other agricultural classes such as 'kamcam' or 'other vegetables'. A differentiation between too young ages of cabbages using the textural analysis is not possible due to the similar texture characteristic of these classes.

Selected digital mapping data was digitized from the scanned map. This information was useful in overlaying with IKONOS imagery as it could provide information on scanned map over the imagery. There were three major land cover classified using unsupervised classification, i.e, forest, vegetation and bare ground. Only the vegetation layer was required in the masking process to remove the pixels that were not involved in the classification (Fig. 2).

The segmentation process was used to merge regions that have similar radiometric properties and noise levels, but that are not separated by a significant edge. Hence, three criteria for merging similar segments were used. Two adjacent regions were merged, if the two mean grey level vectors were similar (more specifically: the difference between the two grey level vectors was statistically significant given the grey level covariance matrices), if the level of noise of the segments was similar, and if there was no significant grey level edge between the segments. If all criteria were fulfilled, these segments were merged, including the boundary pixels that formerly separated them. This analysis was repeated iteratively until no more segments can be merged. The merging order was given by the degree of similarity between the mean grey level vectors. The detail algorithm was outlined in Helmholz et al. (2008).

Unsupervised and supervised classification was then performed to separate the cabbage growing areas from other crops/vegetables. The output of the supervised classification showing three main crops, namely cabbage that was grown at 1.5 months and above, cabbage that was grown less than 1.5 months and other vegetation was shown in Fig. 3. The cabbage grown areas were verified and found reliable based on FAMA's record. The signatures from IKONOS imagery showed the area of cabbage in training area was not uniform due to the continuous and simultaneous cabbage plantation and harvesting activities. It was found that supervised classification using samples from training areas was more reliable than the unsupervised classification. The area that was classified as young cabbage has similar reflectance with other vegetation, while the result of supervised classification showed separation between young cabbage and non-cabbage areas (Fig. 4).

3. RESULTS AND DISCUSSION

Cabbage is a short-term cash crop that can be harvested within three months. The harvesting exercise is done by stages. As soon as the harvesting is done on the matured cabbage areas, the farmer started planting new cabbages on the same area. The time period between IKONOS data acquisition and the post-processing field visit was about five months. As a result, the data obtained from ground verification that can only be assumed reliable was the location of the cabbage area but not the non-cabbage/vegetable areas when the IKONOS imagery was captured. For instance, tomato or other vegetables may grow in the area that was grown by cabbage during the preliminary visit. For supervised classification, the attribute data that were recorded by FAMA’s staff during the capture of IKONOS data could improve the accuracy of mapping cabbage production under a mixed cropping system.

Supervised classification results indicated that there is a total production of 25,000 cabbages/ha for the whole of the study area. However, several factors need to be considered using this technique such as accurate land cover maps for masking, sufficient ground truth data for supervised classification and cloud-free IKONOS data. This is due to the fact that an IKONOS 4 m spatial resolution data does not permit to map the individual 20-30 cm diameter cabbages under a mixed cropping system in Cameron Highlands. Therefore, the algorithm that was used in estimating the individual coconut trees in Mersing is not appropriate to be used for individual counting of cabbages in Cameron Highlands.

4. CONCLUSION

In this paper, a method for counting, estimating and verification of cabbage production using IKONOS data has been presented. Despite IKONOS 4 m spatial resolution's capability of an individual cabbage counting which lead to about 25,000 cabbage/ha production estimate for the study area, IKONOS imagery was found not accurate enough and unsuitable as a tool for precision farming of cabbages in the Cameron Highlands. It therefore implies that for a short-term rotation cash crop like cabbage, the use of an airborne hyperspectral sensor such as that of UPM-TropAIR's AISA should be capable to operate under the cloud cover with a better spectral and spatial resolutions and minimum synchronized ground verification.

It is also hope to be able to detect other crop classes with different ages in future work. However, in this case, the image resolution would have to be adapted for the structural analysis, because the rows of crops only appear as parallel lines at a coarser resolution than 1 m. This future research would also have to determine the optimal scale for each object class. Furthermore, there is still room for improvement of the individual components of the approach, for instance the analysis of the histogram in the structural analysis or the automatic training of the parameters for the segmentation.

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FIGURES

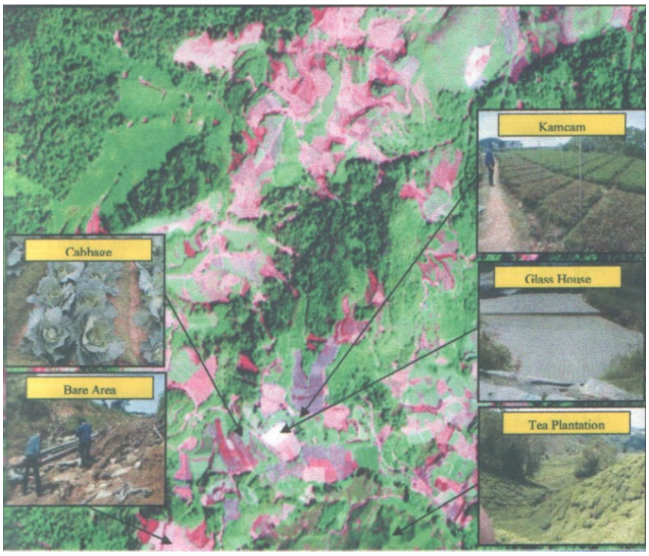

Fig.1: IKONOS imagery (Band 3,4,1) portrayed with ground verification data

Fig. 2: IKONOS imagery of vegetation area after masking process

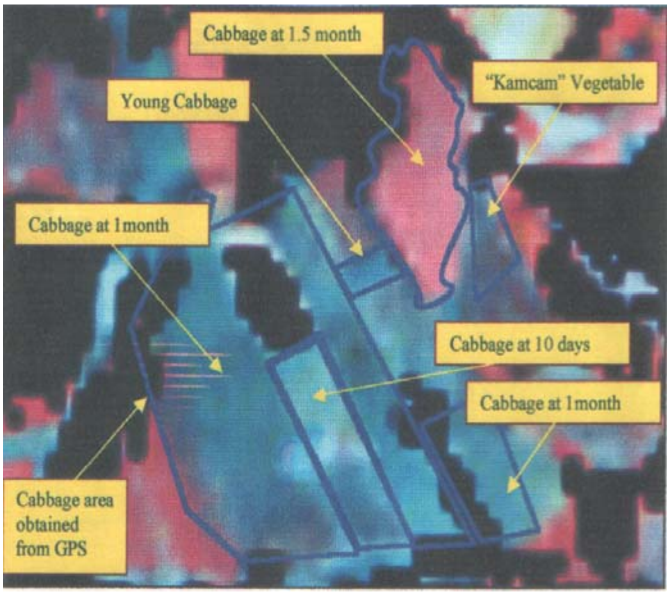

Fig.3: IKONOS imagery of cabbages using band 4, 3, 2 overlaid with ground data

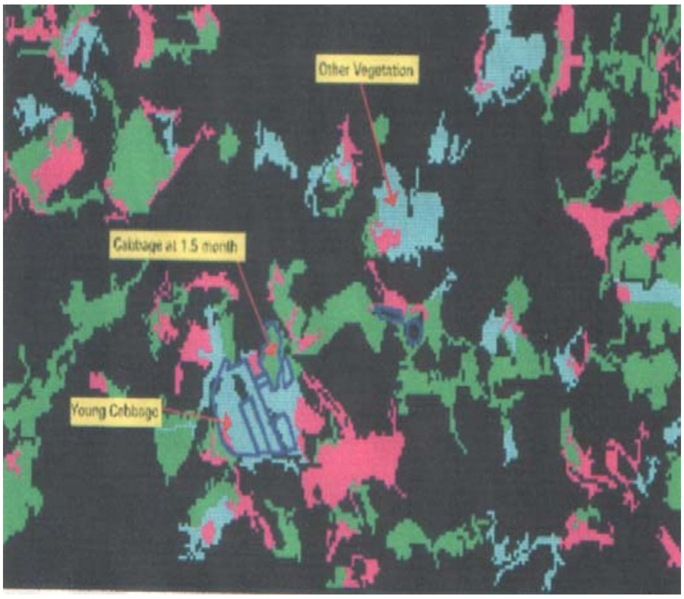

Fig.4: Supervised classification for cabbages and other vegetation