JUDUL: OIL PALM TREE CROWNS DELINEATION AND ENUMERATION USING SATELLITE IMAGES

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OIL PALM TREE CROWNS DELINEATION AND ENUMERATION USING SATELLITE IMAGES

CHAI SOO SEE

A thesis submitted in fulfillment of the requirement for the degree of Master of Science in Information Technology

FACULTY OF INFORMATION TECHNOLOGY UNIVERSITY MALAYSIA SARAWAK 2003
DECLARATION

No portion of the work referred to in this report has been submitted in support of an application for another degree or qualification of this or any other university or institution of higher learning.

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DEDICATION

To my beloved dad and mum, my dear sister and brother,

your love, faith, support and encouragements

are my greatest inspirations.
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ABSTRACT

Manual interpretation of medium and high spatial resolution aerial imagery for forestry has evolved during the 20th century. For this type of application, manual delineation and enumeration of the tree crowns on the aerial images are the main activities required. At late of that century, a new research branch which aims at fully or partly replace human image interpreter by a “seeing computer” was born. For this new research branch, the application of image processing techniques in delineating the tree crowns on the images is being greatly surveyed and a lot of delineation techniques had emerged. The launching of IKONOS satellite, which provides very high spatial resolution to the user, has opened up another option of the input data, that benefits the users in a lot of aspects, for this type of applications.

This research has utilized the resolution of the IKONOS satellite image for oil palm tree crowns delineation and enumeration purpose in replace of aerial images, which was once a favorite and common input data for this application. With this type of source image, this research has determined the use of smoothed curvature for better delineation of the oil palm tree crowns from the image.

The use of Principal Component Analysis (PCA), which utilizes the eigenvalue and eigenvector, incorporate with the mean evolve point, of the detected points to detect the oil palm tree crowns. For these detected points, the research proposes the use of distance analysis to eliminate the redundant points detected and also to re-detect those points, which are omitted. The determination of the accepted and rejected will be next analyzed using the circle drawing method. This will eliminate points which are too far from the middle of the tree crowns. The whole process is termed as Statistical Analysis method.

A prototype of the proposed model is successfully designed and developed. With human operator being used as the supervision tool incorporate with the supervision of object descriptions, the result of enumeration from the proposed model is compared with the result of the manual delineation. The average enumeration accuracy is 92.10%, with the percentage of correctly spotted tree crowns being 84.08%.

Several recommendations are also suggested for the future work at the end of the thesis.
ABSTRAK


Kajian ini telah memanfaatkan penggunaan imej beresolusi tinggi dari satelit IKONOS untuk tujuan pembatasan dan enumerasi pokok kelapa sawit. Penyelidikan ini telah menggantikan penggunaan foto udara yang merupakan satu jenis data input yang biasa digunakan bagi aplikasi jenis ini. Dengan penggunaan sumber imej jenis ini, kajian ini telah menentukan penggunaan 'smoothed curvature' bagi tujuan pembatasan pokok, terutamanya pokok kelapa sawit dari imej.


Satu prototaip bagi modul yang telah dicadangkan telah berjaya dibangunkan. Dengan penggunaan diskripst objek, keputusan penghitungan secara manual dengan modul cadangan akan dibandingkan. Purata kejaitan penghitungan adalah 92.10% dengan nombor pokok yang didapati betul sebanyak 84.08%.

Beberapa cadangan penyelidikan telah dicadangkan di bahagian terakhir tesis ini.
CHAPTER 1: INTRODUCTION

This chapter serves as the introduction of the overall of the research. The evolution of the technology, which leads to the use of remote sensing techniques in forestry and agriculture applications, will be briefly explained. Furthermore, this chapter will lead to the understanding of the purposes and the significance of the research being carried out. With the scope of the research being stated, this chapter will also explain the methodology being taken in approaching the solution of the research problems. At the end of this chapter, an overview of this thesis organization is presented.

1.1 Background

Manned satellites were launched to certain orbits in the space to measures object properties on the Earth's surface. This information is produced in the form of images termed satellite images. Satellite images capture electromagnetic radiation emitted or reflected by different features visible to the sensor. These features include natural components like lakes, rivers, forest, oceans, mountains, as well as man-made objects like buildings, bridges, roads and agricultural crops.

The usage of satellite images is getting more and more important as a source of information nowadays. These images have been utilized in diverse fields like environmental study, weather forecasting, defense system, image processing and Geographic Information System (GIS). To fully utilize this technology, a lot of studies and researches have been done to identify features on satellite images.

With the increase of availability, affordability and spatial resolution of satellite images, various research activities and studies have been carried out to produce efficient and automatic techniques to identify the features on satellite images. This technique is very useful for human in various fields. For example, in forest planning, forest inventory is one of its essential parts. By forest inventory, it means the process of obtaining information about the forest stands, which includes information like:

- trees age
- stem number
- average height
- average diameter
- species type, etc

This kind of information is normally found by measurements conducted in the forest using a classic method described within the field of forest measurements. However, instead of measuring the information directly, this information can be found by extracting information from satellite images.

Among the five forest stands information mentioned above, getting the stem number from satellite images has been a favorite area of research and the accuracy of this result
Chapter One

is getting better since the spatial resolution of the satellite image is getting higher. Getting the stem number is an important activity especially for plantation owner. For example for oil palm plantation, the oil palm plantation owners will have a genuine interest in knowing the number of trees in their plantation for the fact that they need to monitor the production and assess the value of the plantation. In the buying and selling of oil palm plantation, the interested parties evaluate the plantation not only by the size, but the quantity of palm on the plantation. By knowing the actual number of palm, they can better estimate and assess the production rate of this plantation (Hui, Liew et al., 2000).

1.1.1 Remote Sensing

Remote sensing is broadly defined as collecting and interpreting information about a target without being in physical contact with the object. The two common platforms for remote sensing observations are aircrafts and satellites. The images produced are valuable as they present a repetitive and consistent view of the Earth, which helps human in monitoring the Earth system and also the human activities on the Earth. Some of the applications using this technology are:

- Environment monitoring and assessment (forest fire, earthquake prediction)
- Agriculture (crop condition, species analysis)
- Global change detection and monitoring (global warming, deforestation)
- Mapping (land use, land cover)
- Security (defense system in a country)

Aerial image is the original data of remote sensing application before manned satellite was launched. Aerial photos have been used for surveying and planning operations since the late 1940's. In forestry, the visual interpretation of aerial photos quickly replaced the fieldwork-intensive line method as a tool for forest mapping (Ilvessalo 1950, Nyyssönen 1955, Poso 1965). Since then the main use of aerial photos has been the mapping of forests in connection with forest management planning.

The launching of the first Landsat Multispectral Scanner System (MSS) in 1972 had opened a new era for remote sensing. Subsequently, for different purpose and usage, a lot of satellites have been successfully launched to space to help human in obtaining useful information and the spatial resolution of these satellite images is getting higher.
### Table 1.1: Overview of some satellites

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launch</th>
<th>Optical / Radar</th>
<th>Pan / Multi</th>
<th>Resolution (meters)</th>
<th>Swath (KM)</th>
<th>Revisit (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPOT 1/2/3</td>
<td>1986/90/93</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>10 60</td>
<td>20 60</td>
<td>1-4</td>
</tr>
<tr>
<td>SPOT 4</td>
<td>1998</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>10 60</td>
<td>20 60</td>
<td>1-4</td>
</tr>
<tr>
<td>Landsat 5</td>
<td>1984</td>
<td>Optical</td>
<td>Multispectral</td>
<td>30 185</td>
<td>80 185</td>
<td>16</td>
</tr>
<tr>
<td>LandSat 7</td>
<td>1999</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>15 185</td>
<td>30 185</td>
<td>16</td>
</tr>
<tr>
<td>IRS IC/D</td>
<td>95/97</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>5.8 70</td>
<td>23 150</td>
<td>5</td>
</tr>
<tr>
<td>RADARSAT</td>
<td>95</td>
<td>Radar</td>
<td>N/A</td>
<td>8-100</td>
<td>188 810</td>
<td>3-5</td>
</tr>
<tr>
<td>ERS-1/2</td>
<td>91/94</td>
<td>Radar</td>
<td>N/A</td>
<td>30-50</td>
<td>100-500</td>
<td>3-35</td>
</tr>
<tr>
<td>IKONOS</td>
<td>1999</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>1 11</td>
<td>4 11</td>
<td>3.5-5</td>
</tr>
<tr>
<td>QuickBird</td>
<td>1999</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>0.82 22</td>
<td>3.28 22</td>
<td>1.5-4</td>
</tr>
<tr>
<td>SPIN-2</td>
<td>Periodic</td>
<td>TK-350</td>
<td>Panchromatic</td>
<td>10 200</td>
<td>2 180</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KVR-1000</td>
<td>Panchromatic</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Cameras)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OrbView 2</td>
<td>1997</td>
<td>Optical</td>
<td>Multispectral</td>
<td>1.1 km 2800</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>OrbView 3</td>
<td>1999</td>
<td>Optical</td>
<td>Panchromatic Multispectral</td>
<td>1 8</td>
<td>4 8</td>
<td>3</td>
</tr>
</tbody>
</table>

#### 1.2 Image Data

For remote sensing applications, choices of input data range from aerial images to satellite images. In this section, the discussion of the benefits of using satellite imagery, in term of the use of IKONOS satellite images in the oil palm tree enumeration application, versus aerial imagery will be presented. This will continue with presenting the considerations of the suitability of the image to be used for this research purpose.

#### 1.2.1 Satellite Imagery (IKONOS) Vs. Aerial Imagery

Aerial image has been used as a main data source for most of the forestry applications which requires very high spatial resolution. The successful launching of IKONOS has changed this situation as IKONOS satellite can acquire imagery up to 1-meter resolution. The use of IKONOS satellite images provides a lot of advantages to the users compare to aerial images. This advantages are listed as below:
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a. Fast
In the time that a pilot needs to take to preflight his aircraft, IKONOS satellite image can map an entire plantation. As satellites are in constant orbits, they revisit the same place after a constant period. So, user of satellite image can get the image of their project area very fast.

b. Inexpensive
If the project area is wide, then satellite image is less expensive compare to aerial images. From Table 1.1 above, it can be seen that the swath of IKONOS satellite is 11km². For oil palm plantation, it can range from 40 hectares to as large as 75,000 hectares (Hui, Liew et al., 2000). So, using IKONOS satellite images will be less expensive compare to aerial images as coverage of the plantation is a requirement.

c. Accurate
Using satellite images, there is no worry whether the cartographer made a mistake when taking the image, as there is no human (pilot) involvement in the creation of raw satellite images.

d. Digital
IKONOS satellite images are digital. This means that there is no need for expensive data conversion, scanning or digitizing. These images are also ortho-rectified, aligned and georeferenced (Childs, 2001). With minimum preparation, the images can be used for the image processing. Moreover, imagery is guaranteed to be 80% cloud-free or better (SpaceImaging, 2000).

e. Up-to-date
IKONOS can collect and process about 600 images of an 11 km² area per day as well as revisit any location every 1.5 to three days. So, the satellite images show up-to-date information. This is a great advantage if information of the health of a huge plantation, which is needed to be taken frequently, is required.

Aerial images offer a suitable data source if the project area is small. If mapping of ground features smaller than 1-meter square is needed, then aerial images are more suitable than satellite images. For oil palm plantation, the object of interest, which is the oil palm tree crown is around 1-meter square, so, IKONOS satellite images, which offers very high spatial resolution images, and with the benefits that are listed above, it is a suitable data source for this application.

1.2.2 Image Source

With the advantages of the satellite images in term of the oil palm tree enumeration application, over aerial images, satellite image has been chosen as the source of input data for this research. Image resolution can be defined as the smallest area that the satellite sensors can distinguish from areas around it on the image (Canadian Avalanche Association, 2002). For tree crown delineation and enumeration application, which