RICE PHENOLOGY MONITORING IN THAILAND USING TIME SERIES MODIS IMAGERY

Boonyasith KHOBKHUN, Akara PRAYOTE, Preesan RAKWATIN, and Natasha DEJDUMRONG

Department of Computer and Information Science, Faculty of Applied Science
King Mongkut's University of technology North Bangkok
1518 Pibulsongkram Road, Bangsue, Bangkok 10800
Tel:+66 (2) 913 2500; Fax +66 (2) 587 4350

Geo-Informatics and Space Technology Development Agency (Public organization),
120 Government Complex (Building B) ChaengWattana Road, Laksi District, Bangkok 10210, Thailand;
Tel:+66 (2) 141 4672; Fax.+66 (2) 143 9594 to 5

Computer Engineering Department, Faculty of Engineering
King Mongkut's University of technology Thonburi, Witsawawattana Building, 10th-11th Floor
126 PrachaUthit Road, Bang Mot, ThungKhru, Bangkok 10140
Tel: +66 (2) 470 9083, +66 (2) 470 9085 and +66 (2) 470 9382

E-mail: boat_boonyasith44@hotmail.com, akarap@gmail.com, preesan@gistda.or.th, natasha@cpe.kmutt.ac.th

KEY WORDS: Rice crop phenology, Terra MODIS

Abstract: At present, rice is important to Thailand where the country's rice exports is among the top of the world. Thailand has an area that is suitable for extensive farming. Management on planting acreage and insurance policy will help Thai farmers to have a better living. Data about the area is important for government policy makers to plan for agriculture. This results in increased performance in the volume of output for export and increased ability to compete on the world market ensuring good lives of the farmers. This paper attempts to map rice area in Thailand using MODIS time-series Normalized Difference Vegetation Index (NDVI) data (16 days composite) from the initial planting period until harvest. The area consists of difference and volume of enough water to make rice more than one crop cycle, graph of time series is follow the implantation. Data processing to filter out interference of NDVI time series will be used to smooth out the data. It method can be used to detect and to identify areas of cultivation by planting patterns and detection accuracy can be assessed when compared with the data obtained from the survey data and related statistics. Phenology data on the cultivation of these crops will facilitate the management of the area and to pay compensation for agricultural produce caused by natural disasters, for each area, and for age of the plant which will be offset by the price difference.

1. INTRODUCTION

Rice is the staple food of the Thai people. It is rich in nutritional value. Rice is very important in Thai culture. Rice also plays an important role in Thai economy because Thailand has high volume of exports, Thai rice is known around the world especially, the "jasmine rice", a breed of long grain rice for its taste and fragrance. Rice crop cycle is 5–6 months; most are planted in the rainy season. That is called single crop cycle per year. Since Thailand has two patterns of rice cultivation, namely, season rice and out of season rice, the latter has shorter growing period. Rice can be grown throughout the country, depending on the availability of water. Therefore, areas with irrigation have higher potential.

Change detection and classification of agricultural produce can be achieved by the use of remote sensing, which is the monitoring of the situation of the agricultural areas with satellite imageries. It is possible to distinguish difference crops on the field. It can also be used to evaluate agricultural production as well. Principles of remote sensing systems; the use of reflection of the wave and the energy released by the object can be used for such application. The data appear as a digital number, derived from sensors mounted on aircraft or on satellites. Each orbiting track covers a wide area. The data in the form of signal spectrum, when analyzed and interpreted in the form of a map, can be used as numerical data, table or chart.

In satellite remote sensing, tools used to monitor changes in vegetation is Moderate Resolution Imaging Spectrometer (MODIS). In this study, changes in vegetation were measured using Normalized Difference Vegetation Index (NDVI) to study the dynamics of crop phenology, or seasonal crop **(José M. et al., 2011)**, of the study area to monitor surface changing. They are presented in the form of time series curves which MODIS NDVI time series is popular for mapping large crop **(ZHANG Shengwei et al., 2011)**. It can be used to describe the current state of the area, and distribution of the crop, as well as any vegetation changing.

This study aims to monitor the phenology of rice in Thailand, and to determine the areas of crop models with NDVI from 16 day MODIS data. The results of the study are useful to development of crop management

systems, setting of Thai rice prices and insurance systems, which will affect planning and rice growing farmers, ultimately leading to better living standards for the farmers.

2. STUDY AREA AND DATA

2.1 Study area

Since rice farming in Thailand spreads all over the country, this study chose an area in central part of the country, as shown in Figure 1 as a study area where it has good irrigation system, there are several major rivers to make form of agriculture that range. This area is in the river plains interspersed with hills, suited to agricultural activities. The study area is located on the tropical grasslands, near the equator, with moderate rainfall, and occasional drought. Rainy season is during May to October to make enough water to grow for rice. In dry season, irrigation systems are support to cultivation that makes the area is suitable for cultivation **(D. Kamthonkiat et al., 2005; Lv Tingting. and Liu Chuang., 2010)**. The climate in the area, the lower part of the area is wetter than the upper part of the area. Due to the influence of sea breezes.

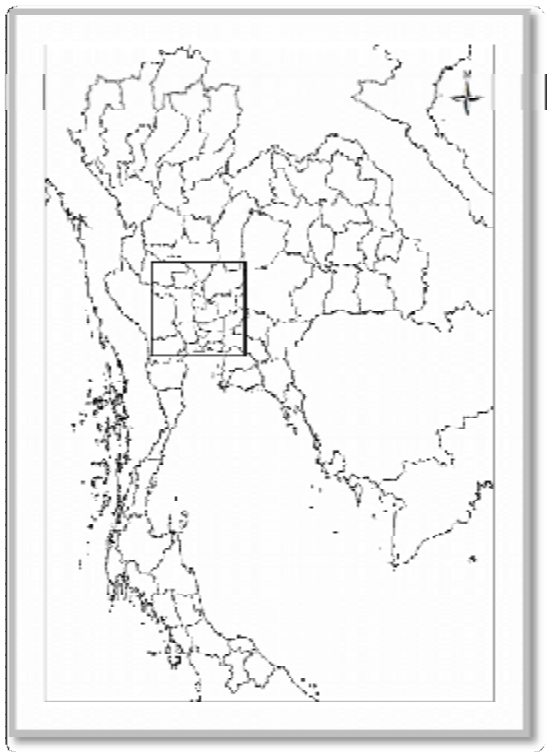

Figure 1 study area

2.2 Data

In this study, MOD13Q1 (Vegetation Indices) was used which is all about the vegetation index of the 16 days cycle at resolution of 250 meters by using index difference vegetation and NDVI. The imagery covered an eleven-year time series, from 2000 to 2010 for made to the phenology of the plant cover. In particular, the area planted with rice. Time series data which is the normalized difference vegetation index of to be used in the analysis area **(M. BOSCHETTI et al., 2008)**. The MOD13Q1 is tile product, tool of mosaic and reprojection is "MODIS Reprojection Tool 4.1" to mosaic tile product and re-projected into Universal Transverse Mercator (UTM) Thailand is in zone 47-48. This tool can extract NDVI bands for MODIS data for analyze.

3. METHODS

The MODIS time-series by Normalized Difference Vegetation Index (NDVI) data (16 days composite) have noise from inclement weather and clouds to effect the reflection of false light. The NDVI time series data of that pixel will have signal abnormalities. It is not the fact and affect the data analysis. Solution for use the time series to filtering noise signal **(Yves Julien. and José A. Sobrino., 2010)** to obtain the time series of the NDVI accuracy by phenology of vegetation covering the area.

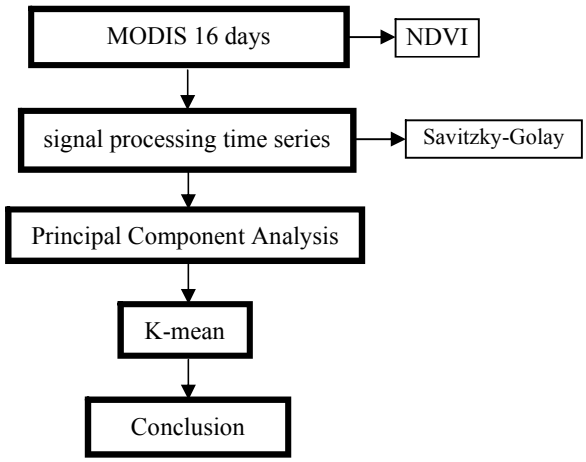

Figure 2 Flowchart of the step of research

3.1 Savitzky-Golay filter

Savitzky-Golay filter was first proposed for smoothing which is the time by Least Square Polynomial Fitting **(Savitzky and Golay, 1964)** is a filter to move the window to cover the series, where each pixel smoothing is obtained by calculating the values of the polynomial and designed to preserve the form of the signal. This is the basis of the filtered signal. It will make a new NDVI time-series to be in a satisfactory form.

3.2 Principal Component Analysis : PCA

Principal Component Analysis (PCA) is a powerful tool for data analysis. To reduce the dimension of the data used to monitor phenology to the information needed to creating a matrix of covariance of the image data to calculate eigen value and eigen vector. The result will be eigen value and eigen vector which correspond to item with each other. To select the data to be used to sort the data in descending order and to choose data which have key elements, makes it possible to eliminate information that is not critical to analysis. The data is obtained from NDVI which has been smoothed. This analysis will be a key component in urban areas, planted areas, water areas, forest areas and mountain areas **(R. Lasaponara., 2006)**.

3.3 K-mean

Median K (K-mean) is one of the analytical techniques in cluster analysis, which is a technique used to identify and monitored with the same information in the same group. K is the average group and the number of cycles of each kind of information will be included in one of the groups. Each group will have input in the center and the distance to the center for find the distance between two points using the Euclidian Distance to calculate the new application of the average of all the objects in the group. The data can be organized quickly.

4. RESULTS AND DISCUSSION

Monitoring of MODIS time series class is associated with the appearance of the area, characteristics of plants, nature of agriculture. This allows the data to influence the nature of agriculture is going to be accurate because of the overwhelming influence of surface reflection and other factors, the weather is also a factor that will affect the time series data. Need to manipulate data before the analysis. The results are the most accurate.

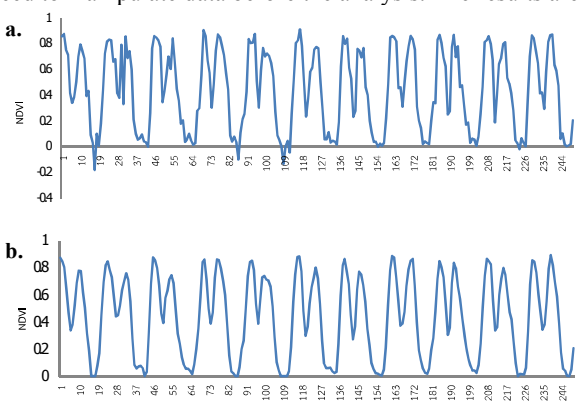

Figure 3 Characteristic of the signal in the time domain of the NDVI time series data

4.1 Filtering time-series NDVI data by Savitzky Golay

Filtered NDVI time series data by Savitzky-Golay. The filter can filter noise of clouds and climate which is not conducive to retention. The noise filter must be removed prior to data analysis. The format of the signal in one pixel of the signal would look like in Figure 3a, and after the interference filter, the results are shown in Figure 3b as a graph that has the appearance of smooth curve vesus time. It can be used to analyze the data **(Jin Chen., Per. Jonsson., et al., 2004)**. Savitzky-Golay filter can calculate with equation

$$Y_j^* = \sum_{i=-n}^{i=n} C_i Y_{j+1}$$

where Y is original NDVI value
Y_j^* is new NDVI value for jth
C_i is coefficient for ith for filter ($C_i=1/(2n+1)$)
n is number of smoothing windows

After filtering the data signal will be smoother. The smoothness will depend on the number of windows using filters. Which must be chosen to fit the data, because the window is too large will cause the amplitude of graph is dropping **(Per Johnson and Lars Eklundh., 2004)**.

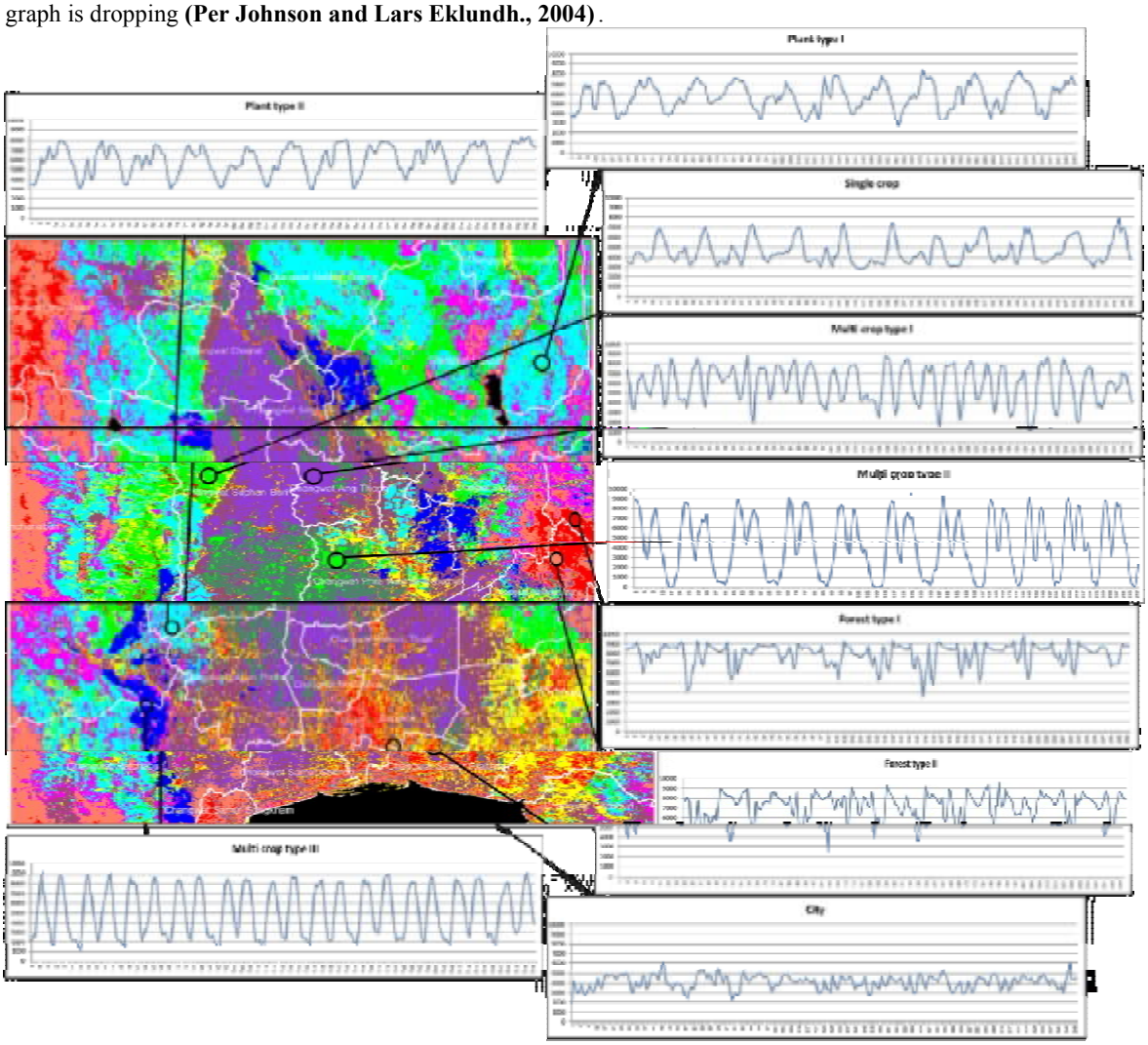

Figure 4 Area grouping based on NDVI

4.2 Classification area

After filtering signal with Savitzky-Golay filter. The signal of time-series is smoother, the acquired image data goes through a separate processing to demonstrate the characteristics of the different areas in the study area by means of the image data to the rest of the information needed to divide the area by the analysis component (PCA),

which makes the rest of the information is necessary for the divided by the area of the signal in the same manner and to identify areas with a color space that can be divided into groups. The results are shown in Figure 4, which will be noted that in each area has a signal that varies according to land use by agricultural activities. Divided by the area of water in urban areas, mountainous areas of rice fields and with other types of farming in Figure 4 is the variation of the signal varies.

5. CONCLUSION

The results of research by NDVI time series indicated that the areas in the study area have some form of agricultural activity with a lot of varieties. The study area covers an area around the farm. Farm land, park, hilly area, water, etc. all exhibit difference signal that is expressed in different forms. This study contents on the area planted with rice by single crop planting and multi crop pattern where signal varies. When the area is planted with multi crop, it showed different patterns that is altogether there cases : two crops per year, two to three crops per year and three crops per year depending on the natural topography of the multi crop planting area in the river basin. This is also influenced by the use of fertilizers, which are widely used in this area. The results of this study were investigating the crop compared with the data from the land use map by Land Development Department, Ministry of Agriculture and Cooperatives.

6. ACKNOWLEDGEMENTS

The author wish to thank Asst. Professor Dr. Teerasit Kasetkasem, Dr.Nattapong Puttanapong for advice on agricultural development as well as the personnel of the Geo-Informatics and Space Technology Development Agency (Public Organization) to provide advice and useful information for this study.

REFERENCES

D. Kamthonkiat., K.Honda., et al., 2005. Discrimination of irrigated and rainfed rice in a tropical agricultural system using SPOT VEGETATION NDVI and rainfall data. International Journal of Remote Sensing, 26, pp. 2527-2547.

Jin Chen., Per. Jonsson., et al., 2004. A simple method for reconstructing a high-quality NDVI time-series data set based on the Savitzky–Golay filter. Remote Sensing of Environment, 91, pp. 332-344.

José M. Peña-Barragán., Moffatt K. Ngugi., et al., 2011. Object-based crop identification using multiple vegetation indices textural features and crop phenology. Remote Sensing of Environment, 115, pp. 1301-1316.

Lv Tingting. and Liu Chuang., 2010. Study on extraction of crop information using time-series MODIS data in the Chao Phraya Basin of Thailand. Advances in Space Research, 45, pp. 775–784.

M. BOSCHETTI., D. STROPPIANA., et al., 2009. Multi-year monitoring of rice crop phenology through time series analysis of MODIS images. International Journal of Remote Sensing, 30, pp. 4643-4662.

Per Jonsson. & Lars Eklundh., 2004. TIMESAT - a program for analyzing time-series of satellite sensor data. Computer & Geoscience, 30, pp. 833-845.

R. Lasaponara., 2006. On the use of principal component analysis (PCA) for evaluating interannual vegetation anomalies from SPOT/VEGETATION NDVI temporal series. Ecological modeling, 194, pp. 429-434.

Savitzky, A. & Golay, M.J.E., 1964. Smoothing and differentiation of data by simple least squares procedures. Analytical Chemistry, 36, pp. 1627-1639.

Yves Julien. & José A. Sobrino., 2010. Comparison of cloud-reconstruction methods for time series of composite NDVI data. Remote Sensing of Environment, 114, pp. 618-625.

ZHANG Shengwei., LEI. Yuping., et al., 2011. Crop Classification Using MODIS NDVI Data Denoised by Wavelet: A Case Study in Hebei Plain, China. Chin. Geogra. Sci, 21, pp. 322-333.