An Approximation of Daily Rainfall by Using a Pixel Value Data Approach

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Abstract—The research aims to approximate the amount of daily rainfall by using a pixel value data approach. The daily rainfall maps from the Thailand Meteorological Department in period of time from January to December 2013 were the data used in this study. The results showed that this approach can approximate the amount of daily rainfall with RMSE=3.343.

Keywords—Daily rainfall, Image processing, Approximation, Pixel value data.

I. INTRODUCTION

RAIN is an important factor in hydrological, engineering and management of water resources. Rain is source of surface water and ground water which people can be use in life. The huge quantity of water can be cause problems i.e., too much water causes flood. Thus, water management is increasingly important, especially in Thailand. 47% of the areas is used in agriculture [1] which makes amounts of water an important factor. Therefore, if there is accurate rainfall information and a precise forecasting trend in advance then the water management will be more efficient.

For this reason, research about a rainfall by using the historical data has been used i.e., M. Kannan et al. forecasted rainfall by using a data mining technique [2] and L. R. Nayagam et al. introduced an empirical model for seasonal predictions of rainfall during the southwest monsoon [3]. In addition, researchers developed a new technique for forecasting rainfall from satellite data [4], [5]. Since the satellite cannot measure rainfall directly, an image processing technique will be used for analysis.

In Thailand, the daily rainfall data was collected throughout metrological stations in Thailand from 1951- present in the Thailand Metrological Department (TMD) database and they started to publish the data in 2010 on their website [6] in the form of a daily rainfall map, see Fig. 1. This study aims to approximate an amount of daily rainfall in Thailand from a daily rainfall map based on the pixel value data. This approximate data will present an amount of rainfall and it could be used in future research.

The rest of this paper is organized as follows: Firstly, in Section II, the data source and a methodology of pixel value index (PVI) image processing technique and image analysis are introduced. The results are illustrated in Section III. Finally, concluding remarks are provided in Section IV.

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II. METHODS

A. Data Source

The Thailand Meteorological Department presented the data of the amount of daily rainfall in the form of a rainfall map, in JPG format (Fig. 1). The image represents the amount of daily rainfall by using a color scale; see in the bottom right of Fig. 1, for example, 10 millimeters (mm) rainfall in the yellow areas and 1,200mm in the dark red areas. For this study, a daily rainfall map (image data) was downloaded from TMD's website and the historical data of the number of a daily rainfall were provided by TMD which cover the time period from January to December 2013.
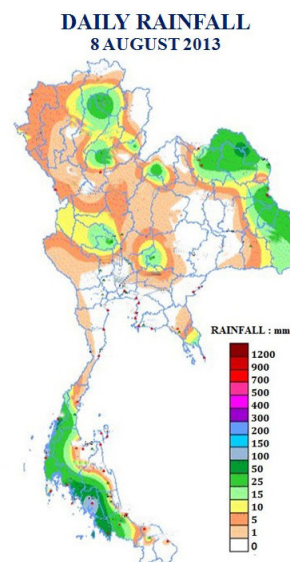

Fig. 1 A daily rainfall map in Thailand

B. Image Processing

The image are defined as a 2-dimensional function, $f(x, y)$ where x, y are spatial coordinate, the coordinate (x, y) is termed a pixel , and the amplitude of at any (x, y) is called the intensity level of the image at that point. When x, y are finite, we call the image is a digital image [4].

After downloading map from the TMD's website, the images were JPG-format, which is the name for one of the most widely used compression standards for images, and stored in the computer. The images were read and written into MATLAB and converted into a RGB format. The RGB image is a format for color images which represents an image with

three matrices of sizes matching the image format. Each matrix corresponds to one of the colors, red, green and blue colors give an instruction of how much of each these colors a certain pixel should be used [7].

For image processing applications, it is often useful to decouple the color information. The HSV format is often used by people who are selecting colors from a color wheel or palette, because it corresponds better than the RGB format does. The HSV (Hue, Saturation, Value) format is an image format that describes colors (hue) in terms of their shade (saturation or amount of gray) and their brightness (value or luminance). Hue is expressed as a number from 0 to 360 degrees representing hues of red (starts at 0), yellow (starts at 60), green (starts at 120), cyan (starts at 180), blue (starts at 240), and magenta (starts at 300). Saturation is the amount of gray (0% to 100%) in the color. Value (or Brightness) works in conjunction with saturation and describes the brightness or intensity of the color from 0% to 100% [7], [8]. As hue, saturation and value varies from 0 to 1.0 in MATLAB.
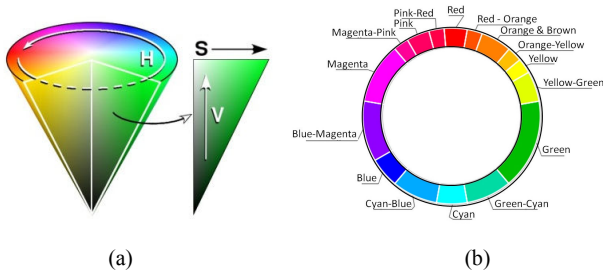

(a)   (b)

Fig. 2 (a) HSV cone (b) Hue ranges map

The MATLAB functions *rgb2hsv* and *hsv2rgb* can convert images between the RGB and HSV format [9]. A HSV image $f(x, y)$ is a 3D array of hue, saturation and value,

$$f(x,y) = \begin{bmatrix} f(1,1) & f(1,2) & \cdots & f(1,m) \\ f(2,1) & f(2,2) & \cdots & f(1,m) \\ \vdots & \vdots & \ddots & \vdots \\ f(n,1) & f(n,2) & \cdots & f(n,m) \end{bmatrix}_{n \times m \times 3} \quad (1)$$

with $f(x,y) \in A^3$ where $A = \{ z \in \mathbb{R} \mid 0 \le z \le 1 \}$ and $n \times m$ is a pixel number of image. Each element of the array was called pixel.

C. Image Analysis

Consider the color scale in Fig. 3 and check a hue, situation and value of each scale.

Define the amount of daily rainfall is function $g(f(x, y))$ where $f(x, y)$ is the HSV image function with $g(f(x, y)) \in \{0, 1, 5, 10, 15, 25, 50, 100, 150, 200\}$.

Function g is a transformation of f by consider a hue, saturation and value of any pixel, when hue value of any pixel is in the range of once color scale, the value of g (a pixel value) is equal to the value of that color scale (see Fig. 3), for

example, a hue range of a blue-magenta is value from 241° to 280° (0.6694 - 0.7778 in MATLAB) and once of pixel has a hue value in this range, g is equal 300.
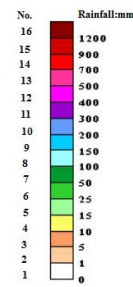

Fig. 3 Color scale

MATLAB was used to obtain the average of pixel value (APV) $\bar{g}$ which represent an approximate the amount of daily rainfall, which is by definition

$$\bar{g} = \frac{\sum_{j=1}^{m} \sum_{i=1}^{n} g(f(x_i, y_j))}{mn} \quad (2)$$

For comparative purpose, the root of mean square error (RMSE) was presented, which is by definition

$$RMSE = \sqrt{\frac{\sum_{k=1}^{N} (G_k - \bar{g}_k)^2}{N}} \quad (3)$$

where G is an observed rainfall value and N is number of data.

III. RESULTS AND DISCUSSIONS

Using a MATLAB functions *rgb2hsv*, a property of the color scale in Fig. 3 shown in Table I.

TABLE I
A PROPERTY OF COLOR SCALE

No. of color	range of Hue	Saturation	Value	A number of daily rainfall
1	0°	0	1	0
2	21°- 40°	0.3843	1	1
3	21°-40°	0.6118	1	5
4	51°-60°	0.6118	1	10
5	81°-140°	0.3765	0.9647	15
6	81°-140°	0.7670	0.8078	25
7	81°-140°	1	0.6118	50
8	170°-200°	0.3932	1	100
9	170°-200°	1	1	150
10	201°-220°	0.6157	1	200
11	281°-320°	1	0.8078	300
12	281° - 320°	1	1	400
13	321°- 330°	0.8078	1	500
14	355° - 10°	1	0.9961	700
15	355° - 10°	1	0.8392	900
16	355° - 10°	1	0.5490	1200

The image data covers the time period from January to December 2013 that it is about 323 image in total process and each image has 588×380 pixels. The pixel value was extracted on amount of daily rainfall. MATLAB obtain the APV which the property of a APV and the observed rainfall data value (ORV) from TMD were shown in Table II.

In Fig. 4 shows the APV as compared to ORV with RMSE equal 3.343.

TABLE II
A DESCRIPTION OF THE PIXEL VALUE AND THE OBSERVE RAINFALL VALUE

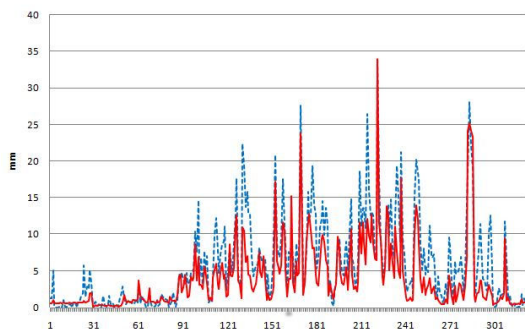|	N	Max	Min	Average
APV	323	33.949	0.089	3.866
ORV	323	33.813	0	5.849

Fig. 4 The association between the average pixel value of daily rainfall image (dot line) and the amount of daily rainfall (mm) in Thailand for TMD (solid line) with N=323 and RMSE=3.343

IV. CONCLUSION

The pixel value data approach is another method that can be used for approximating the amount daily rainfall form image data. The image processing technique was used to convert images in RGB to HSV format with MATLAB function. The value of each pixel is a transformation of an HSV function and the average of the pixel value is an approximate data. Since the value of color scale contains an integer value, the RMSE is too high when comparing the APV and OPV. In the future, this approximate data and technique should be modified to use for related research about rainfall.

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