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The Rainfall Detection and Color Classification of Radar Images Using Machine Learning

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***Abstract*—** *The product of weather radar image is the colors indicating the rainfall intensities under the radar radius. The weather radar images can be analyzed by estimating the rain rate from the colors displayed on the radar images. In this paper, the K-Means Clustering algorithm and the image processing technique are applied for rainfall detection and color classification on radar images. In addition, the average rainfall amount in interest areas is estimated by using the relationship between radar reflectivity value and rain rate*.

***Keywords*—** *Image processing: K-Means Clustering: Rainfall: Radar reflectivity: Rainfall intensity*.

I. INTRODUCTION

Currently the water situations which are the flood events can be analyzed and monitored from multiple data sources. One of the important data sources is the weather radar. The weather radar shows where it is currently raining and can estimate the rainfall intensities. The weather radars calculate the rainfall intensities by using a relationship between the reflectivity (*Z*) and rainfall rate (*R*), called the *Z*-*R* relation [4].

The radar images used in this study have been the products of Thai Meteorological Department and Department of Drainage and Sewerage Bangkok Metropolitan Administration in Thailand. An advantage of data from radar is that we know the rain covers the area of radar radius distance or a large area.

In this work, the machine learning method was applied in radar image colors classification. The different colors indicate the intensity of rainfall. Green and light green indicate drizzle, yellow a medium intensity, and red and magenta indicate heavy rain [8]. The K-Means algorithm and K Clusters which are the machine learning methods were applied to analyze the colors and calculate the intensity of rainfall in the areas of Thailand.

The remaining of this paper is organized as follows: Section 2 describes the background knowledge related to this work. Section 3 explains the algorithm of color classification of the radar images. In section 4, the results of rainfall detection and color classification are explained. The future work will be mentioned a bit in section 5. Finally, this work is concluded in section 6.

II. BACKGROUND

The data type used in this work is the weather radar images covering areas in Thailand and K Mean and K Cluster which are the machine learning methods described in this section.

A. Weather Radar Images

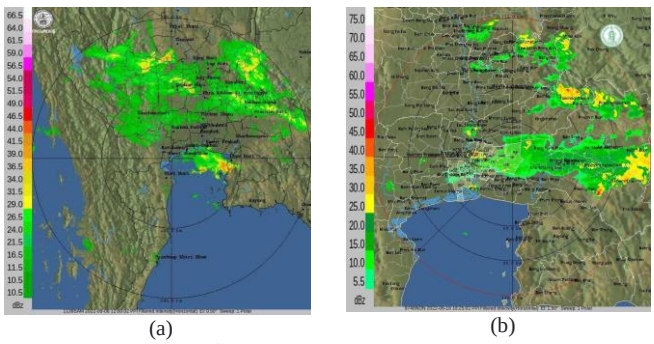
Weather radar is an instrument that sends out the radio waves into the atmosphere to find precipitation. If the signal encounters any precipitation, it is reflected back to the radar tower. The radar tower product is a display of reflectivity measured in dBZ (decibels) [7]. The reflectivity is the amount of transmitted power returned to the radar receiver after encountering precipitation. This work applies which identifies rain and determines the rainfall intensity. It can provide spatial and temporal rainfall data.

The results of weather radar are displayed as a color image. The colors can indicate the intensity of rainfall and also apply to indicate the amount of rainfall. The colors in a radar image range from green for drizzle, to red or magenta for a heavy rain. The color scale for different levels of reflectivity as follows [8]:

- magenta: 65 dBZ (extremely heavy rain)
- red: 50 dBZ (heavy rain)
- yellow: 35 dBZ (moderate rain)
- green: 10 dBZ (light rain)

dBZ values can be converted to rainfall rates (R) in millimeters per hour using the Marshall-Palmer formula.

The radar images used in this work have been the products of Thai Meteorological Department and Department of Drainage and Sewerage Bangkok Metropolitan Administration in Thailand shown in Fig. 1.



(a) (b)

Fig. 1. (a) An example of Thai Meteorological Department and Department radar image, (b) an example of Sewerage Bangkok Metropolitan Administration in Thailand.

B. K-Means Clustering Method

K-Means Clustering is an unsupervised machine learning algorithm that is used to solve the clustering problems [2]. This algorithm groups the unlabeled dataset into different clusters. It clusters the data into different groups and discovers the categories of groups in the unlabeled dataset on its own without

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any training dataset. The K-means Clustering algorithm mainly operates two tasks as follows [2]:

- Determines the best value for k center points or centroids.
- Assigns each data point to its closest centroid. Those data points which are near to the particular centroid, then create a cluster.

Fig. 2 Illustrates the working of the K-Means Clustering Algorithm.

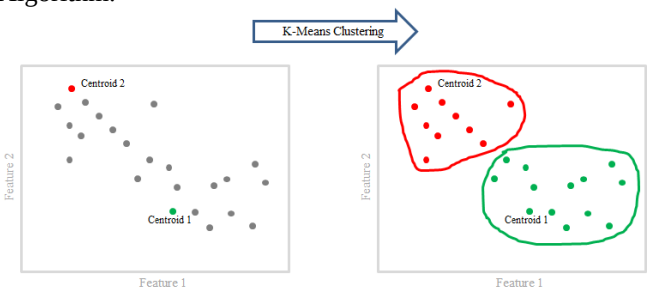

Fig. 2. The working flow of K-Means Clustering Algorithm.

C. Radar Reflectivity

Rainfall intensity is measured using a relationship between the reflectivity factor (Z in mm^6/m^3) and its precipitation intensity (R in mm/hr). The rainfall rate R can be related to the reflectivity factor Z by (1) [1].

$$Z = aR^b \tag{1}$$

where a and b are constants and R is the rainfall rate in mm/hr. The reflectivity factor Z is dependent on the size and number of rain drops per unit volume of space and has the units of mm^6/m^3. For this work, a and b are constants from the Marshall and Palmer equations [3] where a=200 and b=1.6, so we can get

$$Z = 200R^{1.6},$$

$$R = \left(\frac{10^{(dBZ/10)}}{200}\right)^{\frac{5}{8}}$$

III. Methodology

This section explains the method and algorithm that the radar images colors are identified and classified with the K-Means Clustering algorithm and image processing method to find the average rainfall amount.

A. K-Means Clustering Algorithms

The working steps of the K-Means Clustering algorithm applied to classify the rainfall colors in radar images are explained in the following steps [6]:

Step 1: Select the number of K to decide the number of clusters. In this work, the number K is the number of different colors which are the meaning of rainfall intensities in radar images.

Step 2: Select centroids which are the color codes in this work.

Step 3: Assign each data point which is the color codes, in this case, detected in the radar images to their closest centroids, which will be formed to be the clusters.

Step 4: Calculate the variance and place a new centroid of each cluster.

Step 5: Repeat the third step that means reassigning each data point to the new closest centroid of each cluster.

Step 6: If any reassignment occurs, then go to the fourth step else go to the end process and then the model is ready.

B. Colors Classification Implementation in Radar Images

Step 1: Get the radar images. The sample image shown in Fig. 3 is used in this work [6].

Fig. 3. An example of a radar image used for input data.

Step 2: Apply the K Means algorithm and identify k clusters that will be the colors indicated the rainfall intensities. In this step, the outputs are the RBG encoding of colors which are the k clusters.

Step 3: Split the images into smaller squares. Fig. 4 shows the sample smaller images which are 14th-17th slides from 10x10 squares. There are multiple colors in each square.

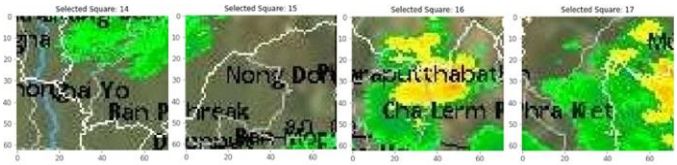

Fig. 4. The splitting images which are 14th-17th squares.

Step 4: Identify the location of each square and calculate the percentage of colors in that square. Fig. 5 shows the summary of colors percentage in each square. That means this work can tell us where there is heavy rain, moderate rain, light rain, or no rain.

Square Number	#12a51f	#66dc73	#efdf15	#cbf356	#489f39	#09d211	#32dc40
14	4.903340120543712	4.754736258662848	6.570492575046735	5.914512012395017	3.9097763583327856	5.662009821167505	4.668941251609808
15	4.0783288598766285	4.925999409824257	6.962353198497974	6.578562196132556	3.4724088126625685	4.695998212502863	4.037294675879441
16	4.805817636864768	4.909103284578627	8.228973649508974	7.173666353028325	3.7093148687025006	5.866755456291522	4.772010741707362
17	5.309506637648208	5.245633554529112	8.746255457330175	7.502829250812427	3.7108070588629807	6.851737466574943	5.434217639177906

Fig. 5. The sample of summary of colors percentage in each splitting image.

IV. Result

The result obtained in this work is the average rainfall amount (mm.) from the radar image in a period of 1 hour. The rainfall amount can be analyzed and calculated from the Z-R relationship equation or (1). The results combined with the colors percentages of each splitting image. Therefore, the total average rainfall is obtained from the sum of average values of all images.

V. Conclusion

This work is the detection of the rainfall intensities in radar images. The colors indicated the rainfall intensities in the radar images are detected and classified by using K-Means Clustering

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algorithm which is Machine Learning method. These rainfall intensities have been converted to the rainfall amount by the Z-R relationship equation and using Marshall Palmer Relation.

VI. Future Work

The work can be extended to multiple sites of radar locations, and also applied to the province boundaries in Thailand.

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