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An Interpolation of Accumulated Rainfall System Using Image Processing Technology

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ABSTRACT
An accumulated rainfall map presents the amount and distribution of rainfall in terms of time periods and areas. The map is useful in the process of quantitative analysis to monitor a water situation in Thailand as well as to suggest risks of flood in the future. The rainfall data sets are collected through Telemetering system installed cover all Thailand. The received data from the Telemetering system will be processed along with other spatial based values and then displayed through images on the rainfall accumulation map. The objective of this system development is to create an interpolation of rainfall accumulation system applying image processing technique. The rainfall data sets getting from the Telemetering system are interpolated with the yearly, monthly, weekly accumulated data and other specific periods and represented in various boundaries levels such as Thailand, region, province, basin, or sub-basin. Moreover, the other data sets such as humidity, air pressure, and temperature from Telemetering system are interpolated as well. The system is displayed images following the user's requests. The system should finally serves the user instantly in real time without the limitation of areas and time periods.
Keywords: Accumulated Rainfall Map, Inverse Distance Weighted, Interpolation, Image

I. INTRODUCTION

Over the past several years, Thailand experienced many severe flood and extreme drought events. Therefore, the monitoring system have been designed the concept and developed to watch the accumulated rainfall and warn when there is a heavy amount of precipitation in any areas. The accumulated rainfall represents the temporally distributed rainfall amounts. In this work, the rainfall amounts are collected through observation and measurements from multiple instruments such as the manual rain gauges and the electronic telemetering rain gauges with wireless or GPRS data transmission in real-time. Telemetering rain gauges are located cover all Thailand nationwide. These accumulated rainfall values can be interpolated to create distributed rainfall map. The interpolated rainfall accumulation represents the temporal amount and distribution of rainfall in areas.

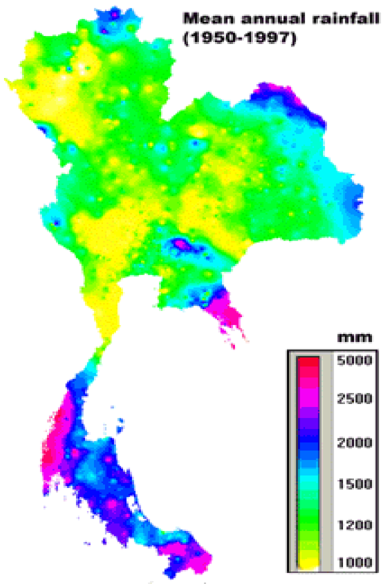

Figure 1. The Example of rainfall accumulation map in period of 1950-1997.

The accumulated rainfall map image is useful because it can be used to analyze the rainfall trend and water situation in Thailand. The rainfall map displays inundation trend, therefore it is also used to make decision for water management. The accumulated rainfall map image can be used to consider the change of rainfall occurrence and the distribution of spatial and temporal rainfall. In addition, it can be compared with the past rainfall map for finding the weather pattern which is useful for water management in agriculture such as water reserve planning, preparation for the uncertainty of precipitation although the rain delay, rain off season, or more than normal or less than normal rainfall for crop planning in each area. In disaster prevention, the accumulated rainfall maps are used for the efficient inundation and drought occurrence assessments in each area.

The interpolation of the accumulated rainfall map images creation is consist of the large datasets of rainfall amounts, spatial data cover all Thailand. In the software system, the periods of time and areas are defined for ease of management and image production. In another, the interpolation of the accumulated rainfall map images are manually generated a specific event; the irregular periods and areas. Therefore, to provide a convenient and fast rainfall map images creation, the image processing system of interpolation of accumulated rainfall maps was developed. The rainfall datasets from rain gauges are calculated to obtain the weekly, monthly, yearly accumulated rainfall, or other specific periods. Then, these rainfall accumulations are processed together with spatial data or locations to interpolate and display the country, region, basin map images, or other specific sub areas. The system is on-line and displayed images following the user's requests. The system should finally serves the user instantly in real time without the limitation of areas and time periods.
The remaining of this paper is organized as follows: Section 2 presents the general background information about the system. Section 3 proposes the process of the accumulated rainfall interpolation. In section 4, the result and discussion are explained. Finally, section 5 is the conclusion.

II. BACKGROUND

2.1 Data

The data used in this system consist of two data sets: the rainfall amounts from telemetering and spatial boundaries data. The detail of each data set is concluded in Table 1.

Table1. The details of data sets used in the system.

Data type	Field	Remark
Telemetering	Name and position	To refer the rainfall position in each area
Rainfall amount, humidity, air pressure, temperature	Daily accumulated rain, hourly humidity, hourly air pressure, hourly temperature	The 24-hour rainfall accumulation of each Telemetering station, The hourly humidity, air pressure, and temperature of each Telemetering station
Boundary	Spatial boundary in spatial database	The province, amphoe, tambon, basin, and sub-basin boundaries of Thailand

2.2 Inverse Distance Weighting method

Inverse Distance Weighting or IDW is a method for interpolation with a known set of points. The general form of finding an interpolated value at a given point using IDW is an interpolating function represented in (1).

$$F(x,y)=\sum_{i=1}^{n} w_i f_i$$

with F(x,y) is the given point, n is the number of neighbor points, f_i is the rainfall accumulation of station i and w_i is weight that can be calculated in (2).

$$w_i=\frac{h_i^{-p}}{\sum_{j=1}^{n} h_j^{-p}}$$

with p is the weighting power which equals 2 in this work, h_i is the distance between station i and the given point that can be calculated by (3).

$$h_i=\sqrt{(x-x_i)^2+(y-y_i)^2}$$

with (x, y) is a coordinate of the given point and (x_i, y_i) is a coordinate of station i.

III. THE SYSTEM PROCESS

The processes of rainfall interpolation system are represented in Figure 2. The first step is the getting the information of image displaying from users via webpage. The users can select and specify each parameter on the system webpage. The first parameter is the request areas such as Thailand, province, amphoe, tambon, region, basin, or sub-basin boundaries. The second parameter is the time period of rainfall accumulation such as daily, weekly, monthly, or yearly rainfall. In the next step of system process, the parameters are sent and checked the existing images in cache storage before the interpolation of rainfall accumulation process started.

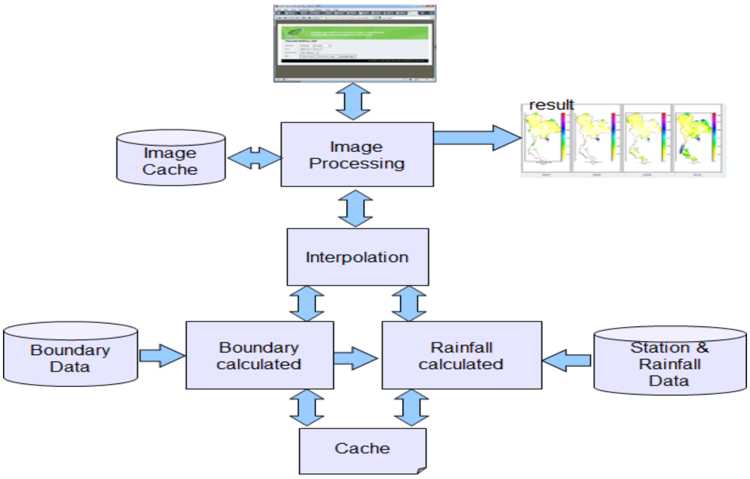

Figure 2. A Process of the interpolation of rainfall accumulation system.

In the third step, the request areas from users are sent to query and retrieve data from a collection in Spatial Database. The spatial boundaries data received in the third step are converted to the simplify polygon features for fast processing. Then, the polygons are the one data set of input data of the interpolation process. The Inverse Distance Weighting or IDW method is applied for rainfall interpolation in this system. These existing polygons are stored in cache for the fast returned values in the next operation. In the next step of interpolation process, the determined time period parameter is used to query the rainfall amounts from Telemetering stations within the specific boundaries. The number of data is calculated that it has enough for interpolation processing. Finally, these rainfall amounts are processed in daily, weekly, yearly rainfall accumulations, or other specific time periods. These obtained rainfall accumulations are also stored in cache for the fast returned values in the next operation. The determined spatial boundaries and rainfall accumulations of each Telemetering station are calculated together by applying the Inverse Distance Weighting method for generating rainfall accumulation map images represented in Figure 3. These generated map images are sent to display on webpage and collected into system cache for the next calling operation.

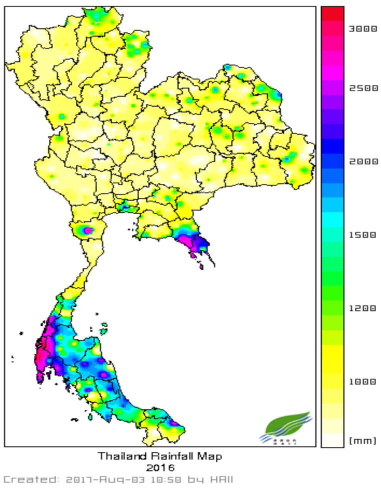

Figure 3. An example of the production of accumulated rainfall interpolation map using Inverse Distance Weighting.

IV. RESULT AND DISCUSSION

This image processing system of rainfall interpolation is designed to operate on World Wide Web. Therefore, users can select and specify the boundaries and the time periods on the system webpage. The processed image outputs are also displayed on the system webpage represented in Figure 4. These image outputs can be used for situation analysis as the example shown in Figure 5. Figure 5 shows the weekly rainfall accumulation maps of Thailand in period of September 2017 that the last map or the week of 27 August – 2 September 2017 map shows the maximum amounts of rainfall being on the North, Northeast, and East regions of Thailand.

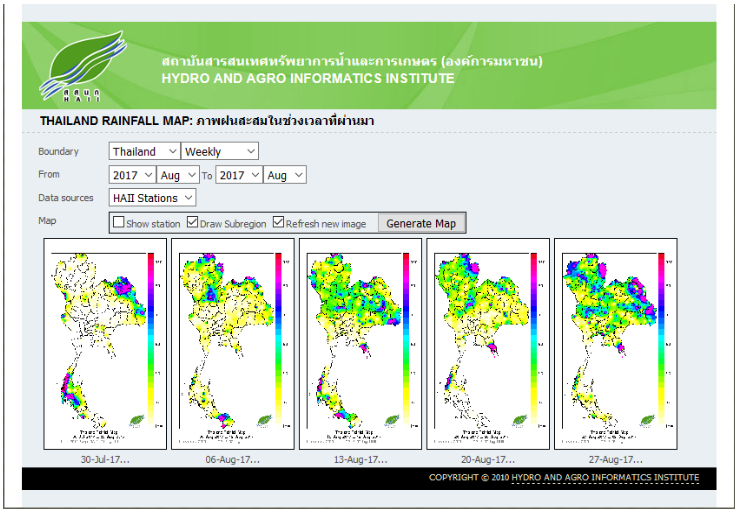

Figure 4. The interpolation of rainfall accumulation system webpage.

The regular speed of this system operation is time-consuming because of the large number of selected boundaries, the complexity of boundaries, and the large number of rainfall data. The previous mentioned issues have the large impact on speed of image creation processing. Therefore, the data sets are adjusted for reducing processing times but the sufficient resolution is very important for using these data sets. In this process of work, the image is produced using time around 15-30 seconds that it is optimal speed in sufficient resolution.

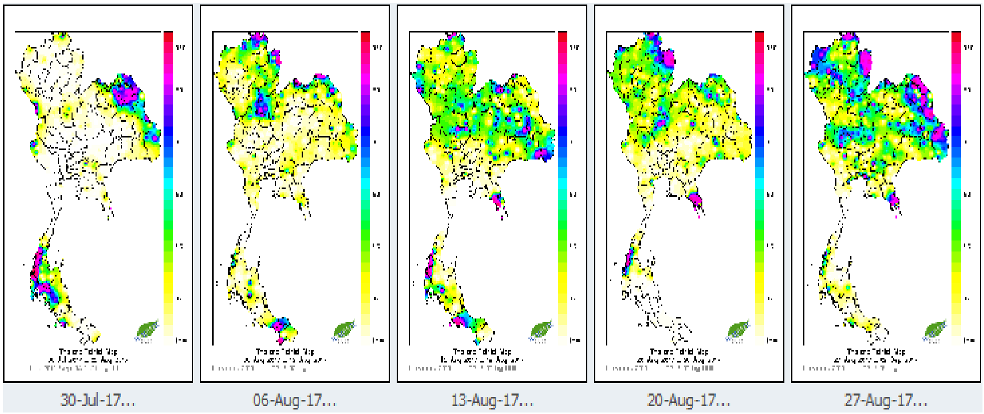

Figure 5. The example of weekly rainfall accumulation maps of Thailand in August 2017 period.

Another thing to consider is rainfall data cleansing from telemetering station. Due to the rainfall data from telemetering station is unstable and missing, it is therefore necessary to have the appropriate cleansing criteria to get a station that represents information in each area. In this system, telemetering stations that pass the criteria must have the data more than 50% of specific time periods. It can be combined to calculate the accumulated rainfall for the production of rainfall accumulation maps. In addition, the humidity, air pressure, and temperature which are the data sets also getting from Telemetering system are produced the interpolation map images every hour as well. They are shown in Figure 6.

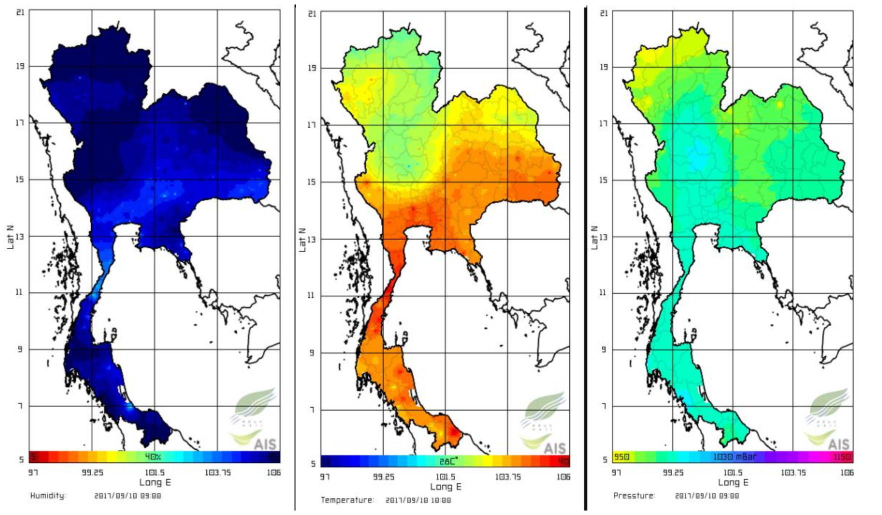

Figure 6. The example of hourly humidity, air pressure, and temperature interpolated maps.

Moreover, the animation of hourly accumulated rainfall interpolation was produced to monitor and record the movement of rainfall direction when there was some tropical storm which influenced on Thailand as shown in Figure 7.

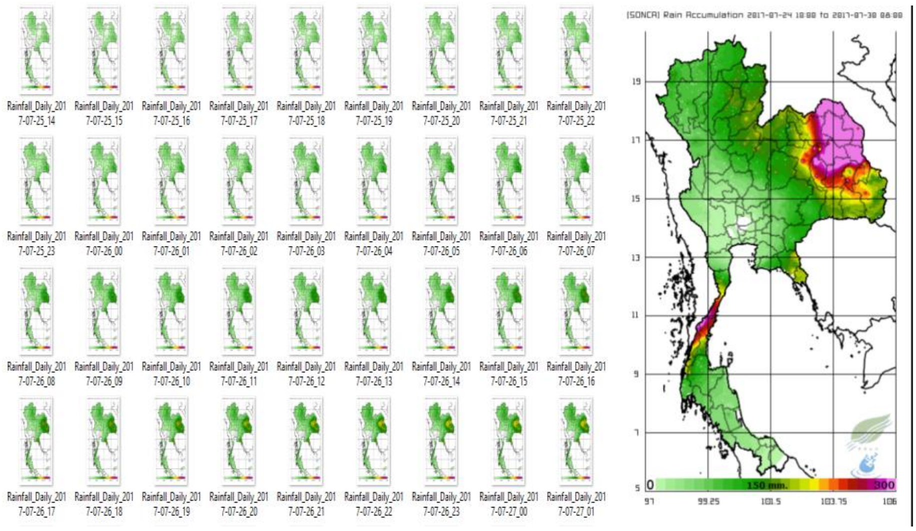

Figure 7. The series of hourly accumulated rainfall interpolation when SONCA happened and its animation.

V. CONCLUSION

This system was designed and developed to apply the image processing technology with the data sets that are telemetering rainfall data and the spatial boundary data for generating the set of rainfall accumulation map images. The users can select and specify the boundary areas and time periods as they requires. The system user interface was developed to be in webpage format which is easy to access information. These rainfall accumulation, hourly humidity, hourly air pressure, and hourly temperature maps can be used in the analysis and consideration of the related situations. Due to the images creation in this system is time-consuming, it is therefore necessary to develop the caching system for storing the images that have been produced in the past.

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