The Outcomes of New Application for Controlling Smoke Haze Problem in Chiang Rai

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Abstract— *This paper studies the outcomes of new application on smart phones to solve smoke haze problem in Chiang Rai. In this application, there are three main parts including web server,android application, and users. For the web server, the automatic filter program downloads the hotspot data of only Chiang Rai every five minutes from the Earth Science Data and Information System (ESDIS) of NASA. After that, the web server updates the new hotspot data in the application installed on smart phones. This proposed application is tested between 1 January 2016 and 30 April 2016 by Protected areas regional office 15 of National Park, Wildlife and Plant Conservation Department. If the users receive warning voice from the hotspot monitoring application on their smart phone, they will plan to control fire area in this application for surveying. In surveyed results, this application can show the number of hotspots, geographic location of hotspots, land use map of burned area and 99 percent of detected hotspots are true fire. The top number of hotspots is 322 in Mae Suai district. The average PM_{10} of Muean Chiang Rai and Mae Sai stations are to 128 $\mu g/m^3$ and 186.74 $\mu g/m^3$ which are higher than the normal AQI (Air Quantity Index of the United States Environment Protection Agency (EPA), 120 $\mu g/m^3$) in April 2016. Moreover, the maximun PM_{10} is to 317 $\mu g/m^3$ at Mae Sai station. The moderate-resolution imaging spectroradiometer (MODIS) is used to study hotspots in Chiang Rai.*

Keywords— **Smoke haze problem, MODIS, hotspot monitoring application, Chiang Rai.**

1. INTRODUCTION

Forest fire is a part of natural and has positive feedbacks including feedbacks including the vegetation natural succession and soil properties. In the other hand, if fire intensity is too high, it will give negative feedbacks including smoke haze problem, greenhouse gas emission, global warming, water lacking, and wild animals become extinct [1]. Chiang Rai province, an area in Northern Thailand, where suffers the smoke haze problem every year. The primary cause of this problem is the high numbers of hotspots in Chiang Rai, near provinces including Chiang Mai, Nan, Phayao, Phrae, Mae Hong Son, Lampang, Lamphun, Uttaradit and shared borders including Myanmar and Laos forest areas. At the present, almost forest fires in Chiang Rai are caused by human activities.

The MODIS active fire hotspots have been widely used to study wildfire on the global map. The hotspot datasets acquire from MODIS sensor of Terra and Aqua satellites. Terra passes the equator of earth around 10:30 AM and 10:30 PM. And Aqua passes the equator around 1:30 PM and 1:30 AM. As a result, MODIS active fire hotspot datasets are generally able to download 4 times per day. There are many strategies of forest fire prevention and management using MODIS datasets including regionally adaptable differenced Normalized Burned Ratio (dNBR)-based algorithm for burned area mapping [3], predicting forest fire by artificial neural networks [4], mapping spatial and temporal patterns of Mediterranean wildfires [5], monitoring deforestation in Neotropical dry forest [6], global burned area mapping [7], and satellite-based automated burned area detection [8]. For example, MODIS data was used to map burned area which based on dNBR [3]. The hotspot presented an area of fire area is more than 1 km^2. MODIS imagery and artificial neural networks (ANNs) are used to predict forest fire in Brazilian Amazon [4]. The monthly number of hotspot and indicator of fires were input of ANNs to calculate the risk of fire. MODIS fire products are used to map the fires spatial and temporal patterns of Mediterranean wildfires [5]. The MOD13Q1 is the 250 m MODIS product based mapping fire with accuracies above 80 %. The detection of vegetation fires used MODIS active fires datasets to monitor the number of fires and fire density in Neotropical dry forest [6]. They operated at a 1 km^2 resolution using MODIS datasets from Terra and Aqua. Global burned area algorithm was developed to detect burned area from ENVISAT-MERIS imagery and MODIS active fire data [7]. This algorithm made thermal, Near Infrared Reflectance values (NIR), and visible information to be indicators for detecting burned pixels. The study of burned area detection in Brazilian savanna was based on the use of MODIS burned area product (ACD45A1) [8]. It cloud detect burned medium and large size areas which were more than 0.5 km^2.

From ref [3] to ref [8], MODIS hotspot datasets are the important hotspots database for active fire. However, all papers focus on only fire model and they are not used in

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the real condition to lead to activities.

In this paper, we propose new application for controlling hotspot problem. The MODIS hotspot datasets are transferred to easy platform on smart phone. The users can use this application to detect fire location, fire warning, and show google map for surveying at burned area in Chiang Rai. Moreover, it is an active fire navigator which decreases travelling time to fire location. The outcomes of this application are experiment and result including hotspots surveying, the activities of the provincial officers, the relation of PM_{10} and the number of hotspots, and application accuracy. This application was tested in Chiang Rai province by protected areas regional office 15 between 1 January 2016 and 30 April 2016.

2. METHODOLOGY

2.1 The hotspot monitoring application

The processes of the hotspot monitoring application can be described in seven steps as follows:

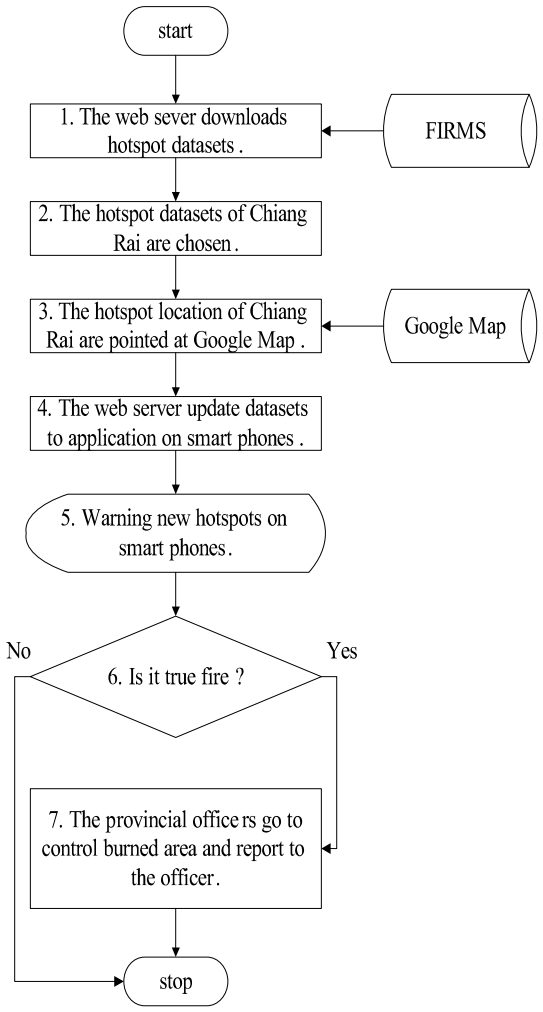

Fig.1. Flowchart of system

Step 1: The web server download hotspot datasets of Southeast Asian from the Fire Information for Resource Management System (FIRMS) which distributes Near Real – Time active fire data from MODIS.

Step 2: The hotspot datasets of Chiang Rai including date, time, location and percent's fire confident, are chosen by the filter program of the web server.

Step 3: The hotspot location of Chiang Rai are pointed at Google Map.

Step 4: The web server update new hotspots to the application on installed smart phones.

Step 5: The smart phones display warning message to users.

Step 6: The land use map of active fire area is considered. If it is true active fire, go to step 7. Otherwise, go to stop.

Step 7: The protected areas regional officer 15 go to control active fire area and report this event back to the office.

2.2 The users: Protected areas regional office 15 of National Park, Wildlife and Plant Conservation Department

Protected areas regional office 15 is an agency under National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment acting as follows:

1) Prepare a management plan in the area of conservation in accordance with the plans and policies of the Department of National Parks, Wildlife and Plant Conservation.

2) Work on the management of forest resources, forest management, conservation of nature reserves and other protected wildlife including National Park Watershed conservation area, handling wildfire prevention, suppression of encroachment in protected areas and control of legal timber and under other related laws.

3) Operational support on education and research for the conservation and restoration of natural resources, biodiversity, and ecotourism including community activities in protected areas.

4) Support the work of other agencies involved or assigned.

Fig. 2. A memorandum of understanding between protected areas regional office 15 and Rajamangala University of Technology Lanna Chiang Rai on 1 December 2015.

Rajamangala University of Technology Lanna Chiang Rai had made a memorandum of understanding (MOU) with protected areas regional office 15 in the project title "Cooperative research in smoke haze problem" on 1 December 2015. The hotspot monitoring application on smart phones is the first research of this project.

3. STUDY AREA

Chiang Rai locates at 19º 54/ 30.89// N and 99º 49/ 57// E. It is subdivided into 18 districts (Amphoe). The districts are further subdivided into 124 subdistricts (Tambon) and 1,751 villages (Muban). Chiang Rai area size is about 11,577.56 square kilometers and cover land use including concession, conserved forest, agricultural land reform office, agricultural land, highway, and community area. Chiang Rai has a tropical wet and dry climate (winter). Temperature rises until April and the average temperature is to 37.90ºC in summer.

4. EXPERIMENT AND RESULT

Protected areas regional office 15 has used the hotspot monitoring application on smart phones to survey and control active fire area for four months. In this event, the smoke haze problem of Chiang Rai annually happens in January, February, March, and April.

Fig. 3. Application and surveyed hotspots of wildfire.

Fig. 4. Application and surveyed hotspots of house roof.

In Fig. 3, at 2:05 PM on 10 March 2016, hotspot geographic location is at UTM 603855E 2203247N where is in Takaupeung subdistrict of Mae Chan district. The application alerts hotspots on fire fighter's smart phone (red shirt) of protected areas regional office 15. They use map function of this application to plan for controlling fire on agricultural land.

At 11:10 am on 8 March 2016 shown in Fig 4, hotspot location is at UTM 576953E 2176736N where is in Pa Ngio subdistrict of Wiang Pa Pao district. The application alerts hotspots on fire fighter's smart phone of protected areas regional office 15. This hotspot is near industry. From the survey, it was found that the hotspot was occurred because of heat emitted from the house roof.

Fig. 5. Hotpot location on the application.

In Fig 5, this application can show land use of burned area which is very useful to slove slow managment problem and check the possibility of true fire hotspots.

Table 1. Surveyed results of the number of hotspots on landuse between 1 January 2016 and 30 April 2016

Land use	The number of hotspots	
	Application	Surveyed results
Concession	458	458
Conserved forest	800	793
Agricultural land Reform Office	42	40
Agricultural land	58	58
Highway	64	64
Community Area	28	28
Total	1,450	1,441

Table 1 shows the number of hotspots on different landuse of Chiang Rai between 1 January 2016 and 30 April 2016. It can clearly be seen that the large numbers of hotspots are at 793 and 458 points in conserved forest and concession respectively. Furthermore, almost hotspots are true fire. However, there are ten points of hotspots come from heat of rock and house roof in the area of conserved forest and agricultural land reform office.

Table 2 shows the number of hotspots on different districts of Chiang Rai between 1 January 2016 and 30 April 2016. The top five number of hotspots are to 332,

235, 169, 147, and 101 hotspots in Mae Suai, Mueang Chiang Rai, Wiang Pa Pao, Mae Fa Luang, and Wiang Kaen respectively. Their almost area is big forest where risks to be burned by wildfire.

Table 2. Surveyed results of Chiang Rai districts between 1 January 2016 and 30 April 2016

Districts (Amphoe)	The number of hotspots	
	Surveyed results	Percent
Mae Suai	322	22.35
Mueang Chiang Rai	235	16.31
Wiang Pa Pao	169	11.73
Mae Fa Luang	147	10.21
Wiang Kaen	101	7.01
Thoeng	80	5.55
Chiang Khong	61	4.23
Mae Chan	61	4.23
Phaya Mengrai	60	4.16
Chiang Saen	47	3.26
Doi Luang	40	2.77
Phan	32	2.22
Khun Tan	27	1.87
Wiang Chiang Rung	19	1.32
Mae Lao	16	1.11
Wiang Chai	14	0.97
Pa Daet	7	0.49
Mae Sai	3	0.21

Table 3. Surveyed results of Mae Suai subdistricts between 1 January 2016 and 30 April 2016

Subdistricts (Tambon)	The number of hotspots	
	Application	Surveyed results
Wawi	105	104
Tha Ko	58	58
Pa Daet	53	52
Si Thoi	23	24
Mae Suai	18	19
Chedi Luang	9	9
Mae Phrink	2	2
Total	323	322

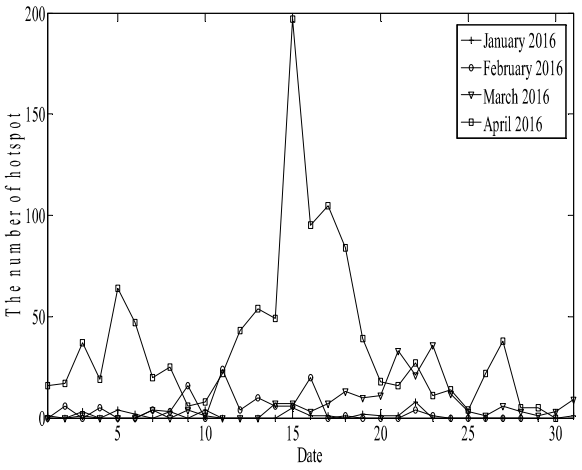

Fig. 6. The number of hotspots between 1 January 2016 and 30 April 2016 from the proposed application.

Table 3 shows the number of hotspots in Mae Suai between 1 January 2016 and 30 April 2016. The top number of hotspots is to 104 hotspots in Wawi subdistrict where has large cron fields. The farmers uasully burn cron residue fields to clear land for preparing agricultural land again.

In Fig.6, the graph shows the number of hotspots between 1 January 2016 and 30 April 2016. The number of hotspots in April has risen considerably and is more than January, Febuary, and March. The maximun number of hotspots is to 197 on 15 April 2016 which is Songkran holiday. Another indicator of the smoke haze violence is PM_{10} which means that the dust in the air is less than ten micrometers of diameter (PM_{10}) and is so small that it can get into the lungs, potentially causing serious health problems. Ten micrometers are smaller than the width of a single human hair.

There are two stations at Mueang Chiang Rai ($PM_{10,1}$) and Mae Sai ($PM_{10,2}$) where can measure PM_{10} between 1 January 2016 and 30 April 2016 shown in Fig. 7 and Fig. 8.

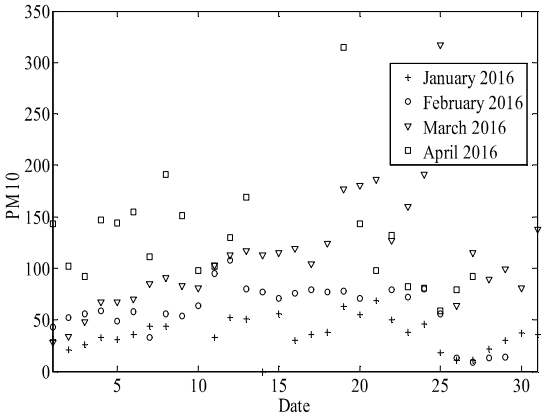

Fig. 7. $PM_{10,1}$ between 1 January 2016 and 30 April 2016 at Mueang Chiang Rai station [10].

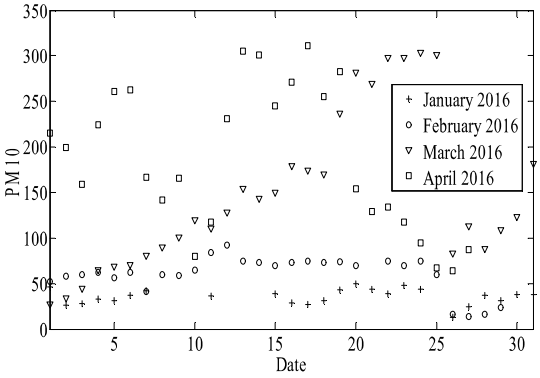

Fig. 8. $PM_{10,2}$ between 1 January 2016 and 30 April 2016 at Mae Sai station [10].

Table 4. The statistic variances of PM_{10} and the number of hotspot between 1 January 2016 and 30 April 2016

Month		Min	Average	Max
January	$PM_{10,1}$	11	37.42	69
	$PM_{10,2}$	13	35.62	50
	hotspot	0	1.19	8
February	$PM_{10,1}$	9	59.71	108
	$PM_{10,2}$	14	60.14	92
	hotspot	0	3.92	24
March	$PM_{10,1}$	28	112.45	317
	$PM_{10,2}$	27	148.35	304
	hotspot	0	6.32	36
April	$PM_{10,1}$	59	128	315
	$PM_{10,2}$	64	186.74	311
	hotspot	0	36.90	197

The table 4 shows that the average PM_{10} is higher than 120 µg/m3 (Air Quantity Index Standard [11]) in March and April 2016. Moreover, PM_{10} varies following the number of hotspots directly, which has increased dramatically by 37.42 to 128 µg/m^3 at Mueang Chiang Rai station and 35.62 to 186.74 µg/m^3 at Mae Sai station for four months later. The average PM_{10} of Mae Sai is higher than Mueang Chiang Rai in February, March, and April. Although, the total number of hotspots is to 3 spots. This result indicates that there are external factors including wind direction, geography, and wildfire near borders.

Although the maximum PM_{10} is 317 µg/m^3 at Mueang Chiang Rai station in March 2016 but the average PM_{10} at Mae Sai station (148.35 µg/m^3) is higher than the average PM_{10} at Mueang Chiang Rai station. Fig. 9 shows the relation of PM_{10} violence and the number of hotspots. For instance, while the hotspots are happening, PM_{10} doesn't rise instantaneously until two days later between 15 April 2016 to 17 April 2016.

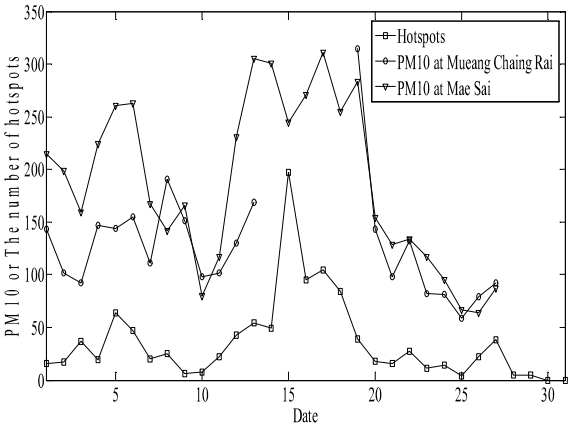

Fig. 9. PM_{10} and the number of hotspots in April 2016

Fig. 10. The networks including government and people of wildfire prevention.

The researchers have proposed new application on the smart phones to be the important tool for allocating hotspots location in big meeting of Chiang Rai shown in Fig.10. There are governor, district officers, military and police officer who have interested in this application to control hotspot problem in Chiang Rai. Moreover, the citizen can this application to protection their area themselves.

Finally, the outcomes of this application make a network which composes of governor and people to prevent and control wildfire area. The action of this network can refer at www.hotspotforestfire.com. Moreover, this application is a hotspot navigator to decrease time of travelling to fire location. As a result, fire fighters of protected areas regional office 15 can control fire and decrease burned area size effectively.

5. CONCLUSION

In this paper, the proposed hotspot monitoring application effectively helps the users to monitor and control fire area which causes the smoke haze problem. The hotspot dataset based on FIRMS of NASA and 99 percent of detected hotspots are true fire. To promote this

application, the provincial officers make a network of monitoring active forest fire to protect human caused fire. Chiang Rai is selected to use this application for solving the smoke haze problem and decrease burned area between 1 January 2016 and 30 April 2016 as wildfire season. These results indicate that not only internal hotspots but also external factors including wind direction, geography, and near external hotpots lead to smoke violence. The outcomes of this application with Chiang Mai, Nan, Phayao, Phrae, Mae Hong Son, Lampang, Lamphun and Uttaradit remain to be investigated.

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