The Outcomes of New Application for Controlling Hotspot Problem in Chiang Rai

Witoon Prommee, Nion Sirimongkonlertkul, Sarawut Pongleerata, and Vivarad Phonekeob

Abstract— *This paper studies the outcomes of new application on smart phones to solve hotspot 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 on installed 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 hotsport detector application on their smart phone, they will plan to control fire area and use google map in this application for surveying. In surveyed results, this application can show the number of hotspots, location of hotspots, land use map of burned area and 99 percent of detected hotspots are true fire. The top number of hotspots is to 322 in Mae Suai district. The average PM10 of Muean Chiang Rai station and Mae Sai station are to 128 µg/m^3 and 186.74 µg/m^3 which are more than the AQI standard (Air Quantity Index Standard, 120 µg/m^3) in April 2016. Moreover, the maximun PM10 is to 317 µg/m^3 at Mae Sai station.*

Keywords— **Smoke haze problem, MODIS, hotspot detector application, PM10, 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, a red area in Northern Thailand, where suffers the smork haze problem every year. The primary cause of this problem is the high numbers of hotspots in Chiang Rai, near provices inculding Chiang Mai , Nan, Phayao, Phrae, Mae Hong Son, Lampang, Lamphun, Uttaradit and shared borders inculding Myanmar and Laos forest areas. At the present, almost forest fires in Chaing Rai are caused by human activities.

Moderate Resolution Imaging Specrorodiometer (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 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 differenced Normalized Burned Ratio (dNBR) [3]. The hotspots presented radius of fire area is to 500 m or 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 accuracies of MOD13Q1 and MCD45A1 from MODIS datasets were 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 selected to the important database in researches. However, all papers focus on only fire model and they

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are not used in 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 dectect fire location, fire warning, and show google map for looking at burned area in Chaing Rai. Moreover, it is an active fire navigator which decreases travelling time to fire location. The outcomes of this application are experiment and result inculding hotspots surveying, the activities of the provincial officers, the relation of PM10 and the number of hotspots, and application accurracy. This application are tested in Chaing Rai province by protected areas regional office 15 between 1 January 2016 and 30 April 2016.

2. METHODOLOGY

2.1 The hotspot detector application

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

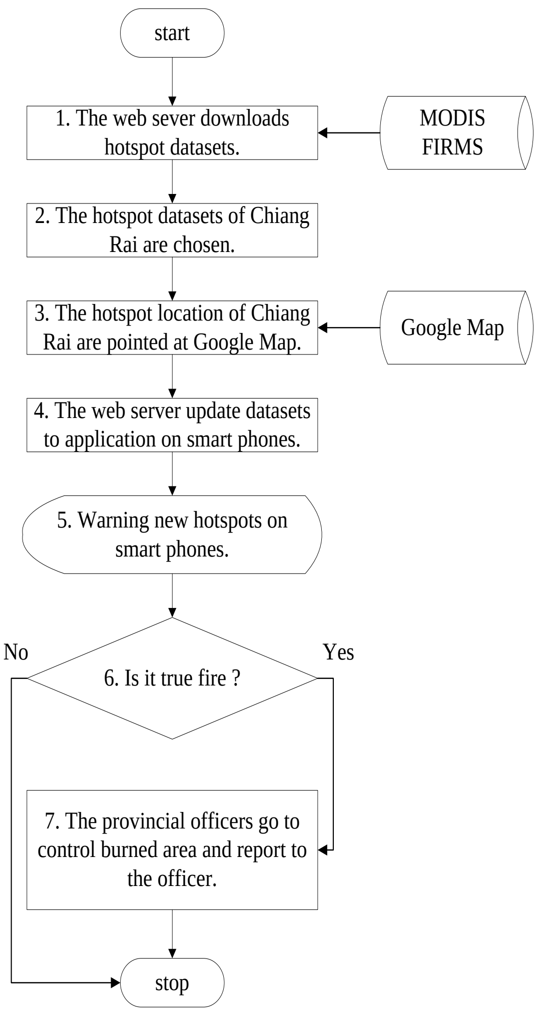

Fig.1. Flowchart of system.

Step 1: The web server download hotspot datasets of Southeast Asian from MODIS FIRMS every five minutes.

Step 2: The hotspot datasets of Chiang Rai 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 ia an agency under National Park, Wildlife and Plant Conservation Department , Ministry of Natural Resources and Enviroment 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 detector application on smart phones is the first research of this project.

3. STUDY AREA

Chiang Rai locates at 19^{o} 54$^{/}$ 30.89$^{//}$ N and 99^{o} 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. Chaing Rai has a tropical wet and dry climate (Winter). Temperature rises until April and the average temperature is to 37.90^{o} in Summer.

4. EXSPERIMENT AND RESULT

Protected areas regional office 15 has used the hotspot detector 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.

In Fig. 3, at 2:05 pm on 10 March 2016, hotspot 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 Pau 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. 4. Application and surveyed hotspots of 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.

Table1. 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
Summation	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 spots in Mae Suai, Mueang Chaing 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 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 spots in Wawi subdistrict where has large cron fields. The farmers uasully burn cron residue fields to clear land for preparing agricultural land agian.

Table2. 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 Chaing 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

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 PM10 which means that the dust in the air is less than ten micrometers of diameter (PM10) 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 station at Mueang Chaing Rai and Mae Sai where can measure PM10 between 1 January 2016 and 30 April 2016 shown in Fig. 7 and Fig. 8.

Table3. 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
Summation	323	322

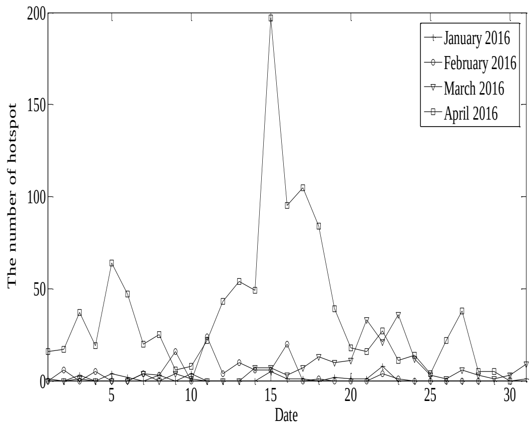

Fig. 6. The number of hotspots between 1 January 2016 and 30 April 2016 from the application.

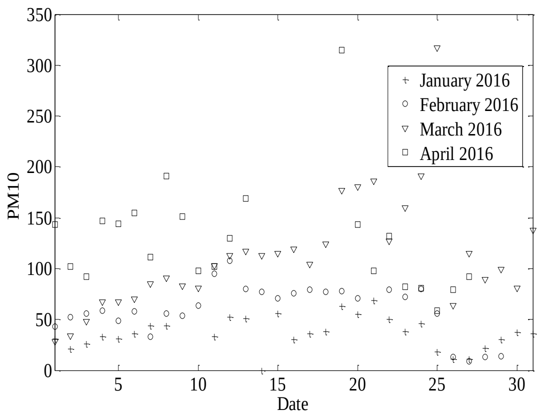

Fig. 7. PM101 between 1 January 2016 and 30 April 2016 at Mueang Chaing Rai station [10].

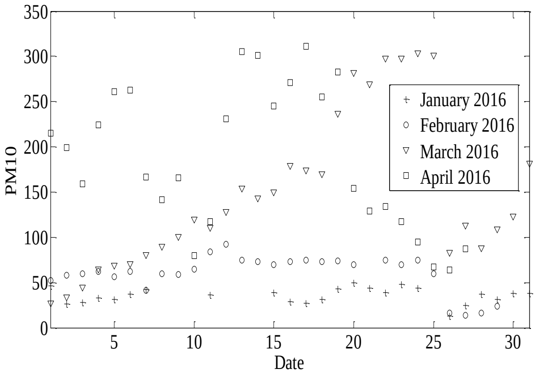

Fig.8. PM102 between 1 January 2016 and 30 April 2016 at Mae Sai station [10].

Table4. The statistic variances of PM10 and the number of hotspot between 1 January 2016 and 30 April 2016

Month		Min	Average	Max
January	$PM10_1$	11	37.42	69
	$PM10_2$	13	35.62	50
	hotspot	0	1.19	8
February	$PM10_1$	9	59.71	108
	$PM10_2$	14	60.14	92
	hotspot	0	3.92	24
March	$PM10_1$	28	112.45	317
	$PM10_2$	27	148.35	304
	hotspot	0	6.32	36
April	$PM10_1$	59	128	315
	$PM10_2$	64	186.74	311
	hotspot	0	36.90	197

The table 4 shows that the average PM10 is more than 120 µg/m^3 (Air Quantity Index Standard [11]) in March and April 2016. Moreover, PM10 varies following the number of hotspots directly, which has increased dramatically by 37.42 to 128 µg/m^3 at Mueang Chaing Rai station and 35.62 to 186.74 µg/m^3 at Mae Sai station for four months later. The average PM10 of Mae Sai is more than Mueang Chaing 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 PM10 is to 317 µg/m^3 at Mueang Chaing Rai station in March 2016 but the average PM10 at Mae Sai station (148.35 µg/m^3) is more than the average PM10 at Mueang Chaing Rai station. Fig. 9 shows the relation of PM10 violence and the number of hotspots. For instance, while the hotspots are happening, PM10 doesn't rise instantaneously until two days later between 15 April 2016 to 17 April 2016.

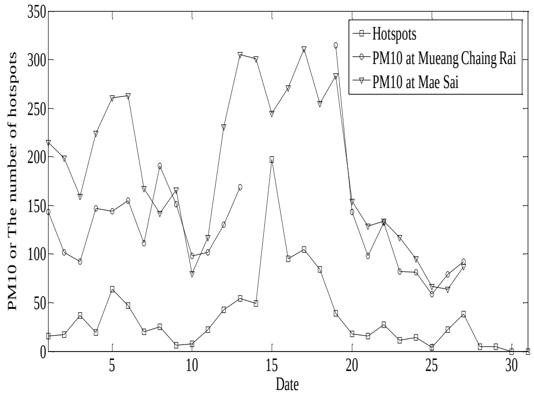

Fig. 9. PM10 and the number of hotspots in April 2016.

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

The researchers have proposed new application on the smart phones to be the important tool for finding hotspots location in big meeting of Chiang Rai shown in Fig.10. There are governor, district officers, soldiers, and polices who interest 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 citizen 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 detector application effectively helps the users to monitor and control fire area which causes the smoke haze problem. The hotspot dataset based on MODIS FIRMS of NASA and 99 percent of detected hotspots are true fire. To promote this application, the provincial officers make a network of anti-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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