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Remote Sensing and Unmanned Aerial Device for Early Forest Fire Detection

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ABSTRACT
2016 was a record breaking year in terms of forest fire incidents in South East Asia. The fires were devastating as it caused a lot of damages. In fact, all over the world, 2016 has been an unusual year because it has extended the fire season everywhere, including South East Asia. Causes of fire ranged from natural disasters, the El Nino phenomenon, to man-made fires like slash and burn farming and arson. There is a need to know what is really the most common causes of forest fires in South East Asia. This information would help in designing early, real-time and fast detection and response to fires that would break-up in forests and bushes so that early fire eradication can be done. The scalable characteristic of fires makes it essential that forest fires have to be detected early to stop it from expanding. The information is also important in order to develop a prototype of a system which will be based on the characteristics and vulnerability of forests in South East Asia. A thorough study of the causes of forest and bush fires and its mechanisms of occurrence and expansion will be done and will be the information needed to design and implement a prototype to detect fires early. The prototype will be utilizing a combination of remote sensing and unmanned aerial device (i.e. drones) that would immediately send information that would facilitate immediate action to eradicate the fire.

Keywords: *Unmanned Aerial Device, early fire prevention, forest fire, drone, remote sensing, ZigBee*

INTRODUCTION
Fires, both man-made and natural, contribute to forest loss. Fire is the oldest method used to clear land for farming and other uses, and it is still widely used in many countries. This is a concern not only because of the added threat to biodiversity and other natural systems, but deforestation—especially by fire—is also a key emitter of carbon dioxide.

Wildfires are a natural occurrence and serve important ecosystem functions. Forest landscapes are dynamic and change in response to variations in climate and to disturbances from natural sources, such as fires caused by lightning strikes. Many tree species have evolved to take advantage of fire, and periodic burns can contribute to overall forest health. Fires typically move through burning lower branches and clearing dead wood from the forest floor which kick-starts regeneration by providing ideal growing conditions. It also improves floor habitat for many species that prefer relatively open spaces.

Forests are the protectors of earth's ecological balance. Unfortunately, forest fires usually are noticed only when they have already spread over a large area, so that controlling and managing them is difficult and at times even impossible. The result is devastating loss and irreparable damage to the environment and atmosphere (30% of carbon dioxide (CO2) in the atmosphere comes from forest fires), in addition to irreparable damage to the ecology (huge amounts of smoke and carbon dioxide (CO2) in the atmosphere). Among other terrible consequences of forest fires are long-term disastrous effects such as impacts on local

weather patterns, global warming, and extinction of rare species of the flora and fauna.

According to figures obtained by Euro news (Harris 2017), the number of forest fires in the EU has more than doubled in 2017, affecting an area twice the size of Luxembourg. As of 2017 count, 1,671 fires were recorded, showing a big rise from the 639 annual average over the previous eight years. The culprit, according to experts, is the rise of climate change, which extended the usual wildfire season and as a result increased the frequency of blazes.

This year also saw Portugal, Italy and Croatia having hit with forest fires because of high temperatures in the summer and the absence of rainfall. A major blaze in June 2017 in Portugal resulted to 64 casualties. Global warming was a factor in this deadly fire since the wildfire season was extended from two to five months this year (Euronews, 2017).

In the United States, authorities considered 2017 as the worst dry conditions and extreme heat are causing widespread forest fires. In August 2017, dozens of wildfires were identified through Terra satellite image.

Research indicates that human-caused climate change has already had a significant increase on the overall number and size of fires. The amount of land burned in the US since 1984 was double what would have been expected without the effects of climate change in that period. And wildfire season has become about two and a half months longer since 1970 (a trend that's expected to continue).

Besides driving climate change, human activity plays a more direct role in fire season, too – 84% of wildfires are started by people, according to one recent study. A massive blaze in Oregon was allegedly started by teenagers who threw firecrackers into the dry forest. It covers 37,500 acres and is currently only 13% contained (Loria 2017).

Forest fires in Indonesia have resulted in a smoky haze blanketing the South East Asian region for months. Both the haze and the controversy around it have intensified in recent years. But what causes it, and what makes it such a contentious issue? What's causing the haze? Every year Indonesia sees agriculture fires in Riau province in East Sumatra, South Sumatra, and parts of Kalimantan on Indonesian Borneo (BBCNews 2015). The fires are said to be caused by corporations as well as small-scale farmers who use the slash-and-burn method to clear vegetation for palm oil, pulp and paper plantations. The fires often spin out of control and spread into protected forested areas. The problem has accelerated in recent years as more land has been cleared for expanding plantations for the lucrative palm oil trade. The burnt land also becomes drier, which makes it more likely to catch fire the next time there are slash-and-burn clearings. These lands become vulnerable spots for new fires.

In South East Asia, it was identified that Sarawak had the most fire alerts on the first 3 quarters of 2017. Accordingly, there were 860 fire alerts in this state. Sabah is the next in the list with 241 fire alerts, then Pahang with 54, Terengganu with 37, and Selangor with 26 (thestar.com.my 2017). These numbers, however, are just 30% of 2016 fires. That year was record breaking in the number of fire incidents due to the "el nino" phenomenon experienced that year.

For 2017, out of the more than a thousand of fires in South East Asia, there is a need to know the common causes as information to be able to detect early any incidents of fire thus preventing further damage to life and property. This study proposes a prototype for a system that would detect fire at early stages.

OBJECTIVES OF THE RESEARCH

The objective is to detect the fire as fast as possible and its exact location and early notification to the fire units is vital. This is the deficiency that the present invention attempts to remedy, by means of early stage, so as to enhance or ensure the chance to put it out before it has grown beyond control or causes any significant damage.

This study embarks on the following objectives:

1. To investigate the main causes for the forest fire.
2. To detect forest fire at the very early stage and notify the decision makers.
3. To develop a prototype of automated forest fire prevention system using remote sensing and unmanned aerial device.

Currently, insufficient resources (money and manpower) are allocated to fire prevention activities such as ignition reduction, hydrological management and regulation enforcement, as compared to suppression efforts. This unbalanced fire management

focus results in larger uncontrollable fires due to a lack of prevention and preparation across the landscape. Agencies and companies should try to focus 80% of their resources on prevention and preparedness activities.

REVIEW OF PREVIOUS WORK

In view of the destructive nature and spontaneity of forest fires, a mechanism for immediate response by all relevant agencies was put in place to reduce the negative impacts such as loss of property and environmental degradation. In 1998, the Government of South East Asia directed the National Disaster Coordinating Committee to include forest fires under its jurisdiction in addition to its existing responsibilities for flood, urban fires and industrial and other natural disasters. This was followed with a draft Standard Operating Procedure (SOP) for forest and plantation fires that will be implemented as soon as possible. The SOP was formulated in line with the South East Asian National Haze Action Plan, which is a component of the ASEAN Regional Haze Action Plan. Among others, the draft SOP provides guidelines relating to the responsibilities of various government agencies and chains of command in response to large-scale forest fires.

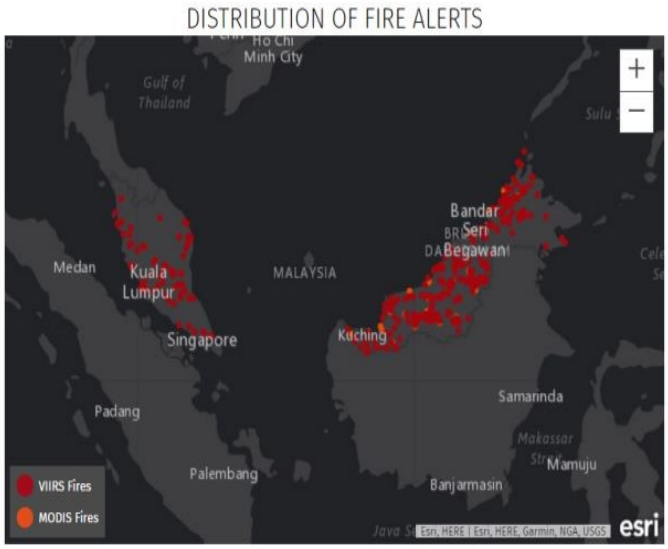

Figure 1: South East Asia Fire Alerts 2017
(source: http:www.thestar.com.my)

There are researches done on early detection of forest or bush fires and this section has selected the most related one to review.

A. Early detection of forest fires

The importance of early detection for forest fires can never be emphasized because fires are scalable by nature and the earlier it is detected, the easier it would be put off and ensures the avoidance of damage to nature, life and property.

A study by Yi et al. (2004) was able to develop and apply the Early Warning and Monitoring System for Forest and Grassland Fires (EWMS/FGF). This system was used in China to more efficiently manage fires. This research used GIS and remote sensing techniques. Information dissemination is in the form of easy to understand reports with charts and matrices. The system developed is early fire detection, near real time fire monitoring, post-fire damage assessment and rapid information dissemination through internet.

Abdullah et al. (2017) used a wireless sensor network in early detection of forest fires. The paper was done in connection to the Advanced Fire Fighting (AF3) Project which is under the 7th Framework Programme (FP7), the European Unions Research and Innovation funding programme. The project is called Low Power Wireless Ground Sensor Network (LPWGSN), which was developed with a near-real time environmental monitoring capabilities. It deals with the early detection aspect and in monitoring fire progress. The system has been tested in trials where real-life fire fighting situations were present. The results of the trials show that was fully functional throughout the trials and even withstood the extinguishing activity in other tests such as pellet and drop water tests. Due to the ease of use and robustness, the network was also used to monitor the environment during the pellet drop tests as well as collect wind data to help validate one of their partners' wind models.

B. Wireless monitoring systems for fire detection

The Low Power Wireless Ground Sensor Network (LPWGSN) developed by Abdullah et al (2017) is a wireless sensor composed of intelligent ZigBee mesh networking (with a XBEE-Digimesh radio transceiver module). The ground sensor nodes operate in clusters composed of Master and Sub Nodes. The Master nodes' role is as gateways that allow the upload of data to the remote server. There is a redundancy that is built in to ensure that the data collected by the sub nodes is efficiently uploaded to the nearest functional Master. Telemetry data between sub nodes and master node includes all sensor readings, battery level, geographical position, etc.

ZigBee is also the wireless technology employed by Wang et al (2010) in the forest fire monitoring system that they have developed. ZigBee is coupled with

GPRS communication technology. In this system, ZigBee network collects the information in the forest environment then is transmitted to a server through internet via FTP server and public network IP. The GPRS network controls the communication through coordinator mode. The monitoring center gets the information which are used for decision support for experts and system forest fire managers.

C. Unmanned Aerial Devices

Unmanned Aerial Technology (UAT) are known under various different names and acronyms, such as "Unmanned Aerial Systems" (UAS), "Unmanned Aerial Vehicle" (UAV), "aerial robot" or simply "drone," which is the most popular term being used today (Colomina and Molina 2014).

Chamata (2017) stated that UAT are technologies that has become very essential in a lot of applications such as fire-fighting, explorations, search and rescue, and other similar activities. Drones are utilized today because of their capability of which is they are able to fly at different angles over areas which manned vehicles cannot reach.

PROPOSED WORK

Methodology

This work proposes a novel approach of using remote sensing and digital image processing. The main objective is to prevent the fire from erupting and subside it at the very early stage. It will also avoid unnecessary effort due to irrelevant transmission of information. Hence, all the factors that contribute to forest fire incidence are studied and each factor will be studied in depth so as to device strategies to curb forest fires. These factors have been considered in the proposed work.

The study will employ historical data analysis, observation and prototype development as methods to complete the project. It would involve work with remote sensing devices to identify anomalies in the forest area environment, communication through wireless networks, then which would trigger launching of a drone towards the area of anomaly. The drone will take and transmit video or real-time pictures of the area. If the anomaly turns out to be an incidence of fire, then the drone can apply initial fire retardant to the area. The information transmitted by the drone is also utilized for further decision making on the said incident.

System Description

The system is being developed to detect forest fires as early as possible, identify its exact location and be able to get early notification to the central command station which houses the server.

The flowchart at Fig. 1 shows the flow of the proposed system. First, notifications will be sent by the sensor network through ZigBee wireless communication which will be received by the control station. This signal will trigger the launching of an unmanned aerial device (i.e. drone) which will go to the area where the sensor signal came from. The drone will take video or real-time photographs of the area. If the images show an anomaly, fire retardant will be sprayed over the area. Control station will also be prompted for any further action that they will decide on to control the fire in that area.

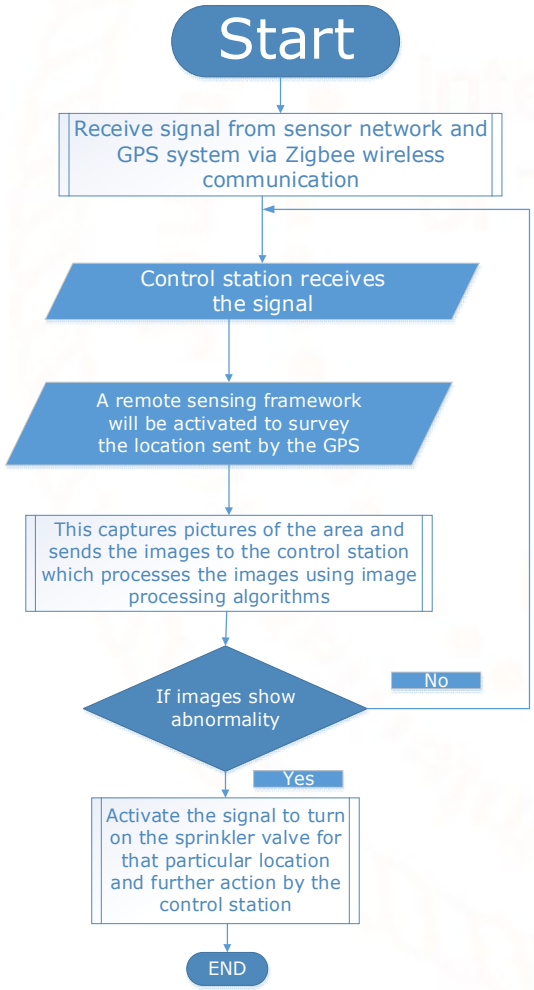

Fig.1 System Flowchart

CONCLUSIONS

There is no denying that forest fires are a big problem in Southeast Asia. This has caused a lot of damage on life and property, as well as in the environment and even the atmosphere. In Southeast Asia, we have

honed in to slash-and-burn farming as the most common cause of forest fire which has devastated a lot of areas in Indonesia and has caused damages also in the surrounding countries like Malaysia, Singapore, Thailand and Brunei. Using technology to prevent forest fires have become the mission of many scientists and researchers because of this.

This study is a combination of technologies to come up with a useful system that would detect forest fires early and be able to do something about it before it expands. The use of remote sensing, wireless networks, and unmanned aerial device to gather essential information that would identify the start of a forest fire is a system that would help in preventing incidents of forest fires in Southeast Asia.

Recommendation for further research is the possibility of increasing the load of the aerial device to enable it to carry more fire retardants to make it more efficient and effective in putting off startup of forest fires. More research should be done to balance the management of forest fires, so that more research should be made in preventing forest fire rather than managing the fire when it has already erupted and expanded.

REFERENCES

1. Abdullah, S., Bertalan, S,, Masar, S., Coskun, A. and Kale, I, (2017) A Wireless Sensor Network for Early Forest Fire Detection and Monitoring as a Decision Factor in the Context of a Complex Integrated Emergency Response System. IEEE. 978-1-5386-2816-4/17.
2. BBC News. (2015). *What causes South East Asia's haze?*. [online] Available at: http://www.bbc.com/news/world-asia-34265922 [Accessed 11 Jan. 2018]. Grassland Fires by Remote Sensing Data. IEEE. 0-7803-8742-2/04.
3. Chamata, J. (2017) *A Proposal for the Adoption of Unmanned Aerial Technology in Malaysia.* 4th Borneo Research Education Conference, BREC 2016, 17th-18th August 2016, University Technology MARA Sarawak, Malaysia.
4. Colomina I., Molina P. (2014) *Unmanned aerial systems for photogrammetry and remote sensing: A review.* ISPRS Journal of Photogrammetry and Remote Sensing, *Volume 92, June 2014, Pages 79-97*
5. Harris, C. (2017). *Climate change blamed as EU's forest fires more than double*. [online] Available at: http://www.euronews.com/2017/10/16/how-europe-s-wildfires-have-more-than-trebled-in-2017 [Accessed 11 Jan. 2018].
6. Loria, K. (2017). *Nearly 2 million acres of land are burning across the US in one of the worst fire seasons we've ever seen*. [online] Business Insider Malaysia. Available at: http://www.businessinsider.my/wildfire-season-western-us-2017-9/?r=US&IR=T [Accessed 11 Jan. 2018].
7. Thestar.com.my. (2017). *Sarawak has most forest and land fires in Malaysia - Nation | The Star Online*. [online] Available at: https://www.thestar.com.my/news/nation/2017/08/06/sarawak-has-most-forest-and-land-fires-in-malaysia/ [Accessed 14 Dec. 2017].
8. Wang, G., Zhang, J., Li, W., Cui, D, Jing, Y. (2010) A Forest Fire Monitoring System Based on GPRS and ZigBee Wireless Sensor Network. IEEE. 978-1-4244-5046-6.
9. Yi, Z., Shirong C., Weiqi Z., Litao W. (2004) Early Warning and Monitoring System for Forest and Grassland Fires by Remote Sensing Data. IEEE. 0-7803-8742-2/04.
10. Zhu, Y., Xie, L. and Yuan, T. (2012) Monitoring System for Forest Fire Based on Wireless Sensor Network, Proceedings of the 10thWorld Congress on Intelligent Control and Automation, July 6-8, 2012, Beijing, China.