DESIGNING AND MANUFACTURING MONITORING STATION FOR EARLY DETECTION AND TRANSMITTING FOREST FIRE INFORMATION

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SUMMARY

This paper represents designing results of forest fire monitoring equipment developed by researchers from Vietnam National University of Forestry. The function of equipment is to automatically detect forest fire and to transmit this information to forest owners and managers. The system used fire detection algorithm from IP camera and applied geospatial technology to manage forest fire, early detect hotspot and transmits information for forest fire fighting. The system includes 01 IP camera connected to the Internet via 3G signal, 01 software for controlling and analyzing data. To evaluate the possibility of fire detection and the accuracy of the information transmitted by the model, the authors conducted a control forest fire at different spatial location and levels of fire intensity. This is an automatic system for early detection of forest fires with high precision, replacing manually monitoring in forest management. It helps to prevent forest fires spreading and minimizing the damage caused by forest fires.

Keywords: Forest fire, forest fire detection, geospatial technology, image processing, IP camera.

I. INTRODUCTION

Forest fires, also known as wild fires, are uncontrolled fires occurring in wild areas and cause significant damage to natural and human resources. This is a universal problem that both confronts and confounds many countries. In fact that, forest fires were only observed when it was spread out over a large area, leading to difficulties in controlling and preventing and even impossible. Such forest fire not only destroy large amount of natural resources, but also destroys wildlife and their natural habitat, wreaks general havoc on ecosystems (a huge amount of smoke and CO_2 in the air) and creates environmental pollution (30% CO_2 in the air comes from forest fire).

According to Forest Protection Department, by 31th December 2014, Vietnam had over 13.8 million hectares forest area (natural forest and plantation forest covered 10.6 and 3.2 million hectares respectively). In which, over 50% was the forest area of high fire risk, mainly included pine, melaleuca, bamboo, acacia, eucalyptus, dipterocarpace and young natural regeneration forest.

In recent years, forest forest prevention in Vietnam has been focused on applying geospatial technology (remote sensing, GIS GPS) in fire forecasting. Results and practical applications confirmed that this is an effective method for early forest fire detection with high accuracy, quickly updated information of forecasts in term of temporal and spatial. However, using satellite image for early forest fire detection is suitable for mountainous area which is difficult to travel and for minimizing the damage of the large forest fire. MODIS satellite provides 4 images every each day, in many cases forest fire might be detected after 6 hours (not including image processing), then it does not meet timely for forest fire fighting in dry season. In valuable forests such as economic values, historical sites, conservation areas which are inflammable in dry season, a system of watchtowers has been built by forest owners and forest fire could be detected by human with binoculars.

To contribute solving those problems, the authors develop early forest fire detection and information transmission system from ground

observation stations. This system integrates geospatial and information technology to process real-time forest fire information in the server and sent to other connected devices. The system includes the hardware and software which automatic detect fire and transmit data to users.

II. MATERIAL AND METHODOLOGY

2.1. Image receiver: IP Camera

An IP camera not only captures sequences of images, but also has its own processor, memory and operating system. It allows to load programs to process the captured information without the need of additional computer equipment. The number of frame captured in a second depend on different camera, normally it get 20 frames in one second. IP cameras can also be connected to form networks, making a video surveillance system more reliable. Generally the information provided by IP camera is encoded data in several formats, such as JPEG and MJPEG.

Basically, MJPEC is the series of JPEG images were captured continuously. Therefore, JPEG and MJPEG are the same. To detect objects, IP camera analyses a series of frame in a large enough of time, but it must ensure the timeliness for each different task and objects.

Another reason for using IP camera is the quality of images captured from IP camera is always guaranteed without interference from signal transmission. For normal cameras, the signal transmission by coaxial cable to the receiver, although placed in an environment with less interference, the signal transmitted to the receiver still affected by the material of the cable, so the image quality photos cannot be guaranteed for image analysis to detect objects, especially forest fires.

2.2. Algorithm of Images processing to detect forest fire

Normally, IP camera uses two basic protocols to access the images that captured from the sensor network: protocol *http* (Hyper Text Transfer Protocol) and *rtsp* (Real Time Streaming Protocol). These protocols allow access data from IP camera in two formats: protocol *http* allows assess and retrieve directly JPEG images; protocol *rtsp* using H.246 codec, thus received signals need a decoder to obtain JPEG images. Depending on each different IP camera, we use different protocols.

Images are captured from camera would be sort by time and then put in image processor. After that model detects fire through the sign of smoke or fire or both of these according to the flowchart:

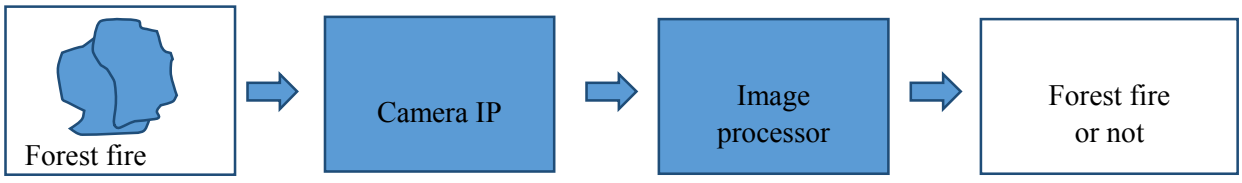


Figure 1. The flowchart of image processor to detect smoke and fire

Captured images from IP camera usually have relatively large resolution. The minimum resolution is 1280 x 720 pixels. If we analyze image directly, it take a long time, however, the accuracy is high. By contrast if we reduce the size and then analysis, it might be quickly and low quality as well. For forest fire detection, it is not required to be high speed but high accuracy. Therefore, obtained image will be retained quality to analysis.

This paper does not create a new algorithm for images processor, it integrates some being applied algorithms to detect forest fire with high confident level of warming information

(Leonardo Millan-Garcia, Gabriel Sanchez-Perez, Mariko Nakano, Karina Toscano-Medina, Hector Perez-Meana and Luis Rojas-Cardenas, 2012; Turgay Çelik, Hüseyin Özkaramanlı, and Hasan Demirel, 2007):

IP camera module provides DCT blocks of 8 × 8 coefficients of each frame. Then the DCT (Discrete Cosine Transform) inter-transformation is applied to all blocks of 8 × 8 coefficients of each frame to get DCT blocks of 4 × 4 coefficients. Using the DC values of each DCT blocks to get the smoke region candidates and discard non-smoke region. After that, a series of new images with movement region is obtained and tagged as fire. If there is no fame is obtained, image is classified as non-fire.

III. RESULTS AND DISCUSSION

3.1. Structure and operation of forest fire monitoring

3.1.1. Structure of system

Each camera was established as diagram below:

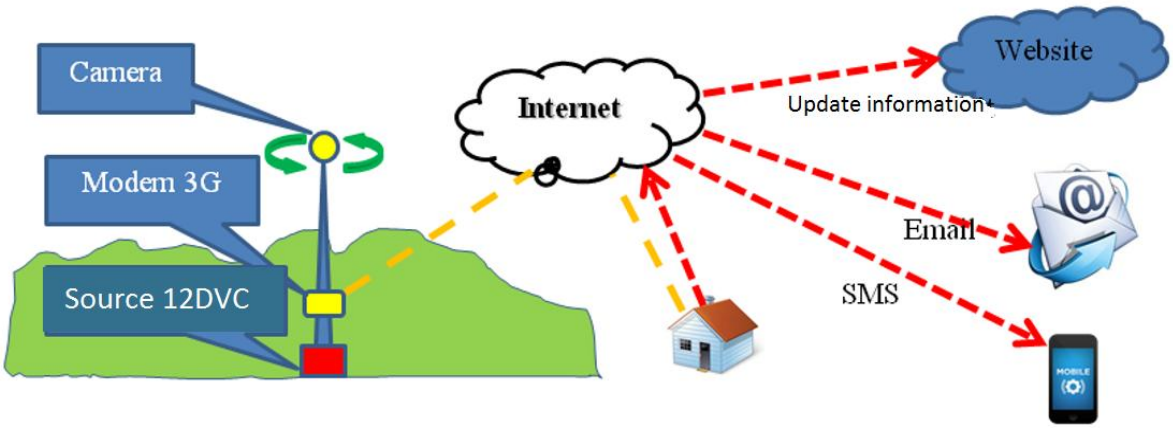


Figure 2. The structure diagram of ground monitoring station

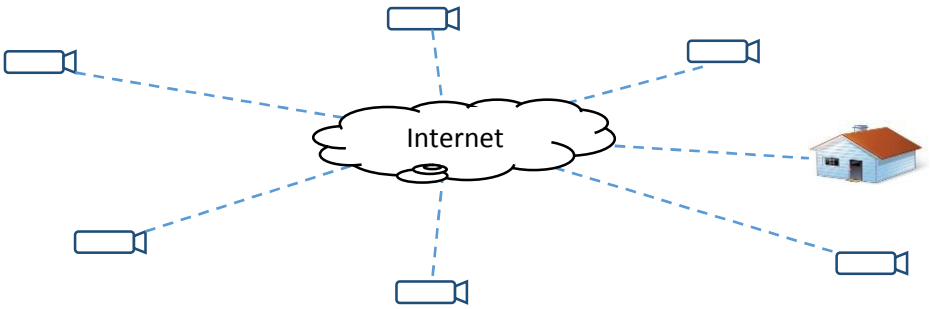


Figure 3. IP Camera connect with center via internet

3.1.2. The operation of fire detection system

Each station includes 01 IP camera connected internet through 3G signal to transmit observation signal to the center. This signal is an image that was captured from camera. After a predetermined period of time in server, the software will automatically access to station to retrieve images to analyze. Software in server arranges the time to access to station according to a defined cycle that ensure all images is collected. The more stations the more complication in operation in the system.

Each captured images will be analyzed, processed to detect smoke and flame by some algorithms. To detect fire, system will identify the exact location which is an area or plot of fire occurrence. Location of fire is identified through the coordinate of monitoring location, two observation angles which system captured

images. Querying the forest map installed monitoring station, software will determine exactly fire occurred in the forest area or not, and the exactly forest plot if fire occurs.

Time for analyzing an image is about 0.3 second. Time for loading an image depend on the connection speed of 3G network in each station. However, due to relative low) image resolution (280 x 720 Pixel- up space of about 140 Kb, loading image is not taking too long time.

The software is designed to automatically acquire images from the camera via the Internet, 60 seconds was set in software to acquire image. Captured image will be stored in hard drivers. After specific interval time, the images will be deleted automatically (time storage is depending on the number of IP camera and the capacity of computer hard disk). The capacity of recoded images is about 140Kb/ image, therefor, in one day, one camera will record 1440 images, equivalent to 197Mb of hard drive storage.

The flow chart of image processing in software:

A. Daytime

B. Nighttime

Figure 4. Captured image in software from IP camera

Detecting forest fire is based on data analysis from IP camera by algorithms to detect smoke and flame. When detected an abnormality (flame, smoke) the system will send a message and sound at the same time to manager. The manager can confirm the warning by looking at images in website to make an appropriate treatment.

Software loads images and processes data continuously via the Internet. Software can connect to unlimited cameras in many different positions. Captured images are analyzed to determine the location of fire. If a fire occurs, the system will automatic warn by audio and send the email or text message to preinstalled phone number.

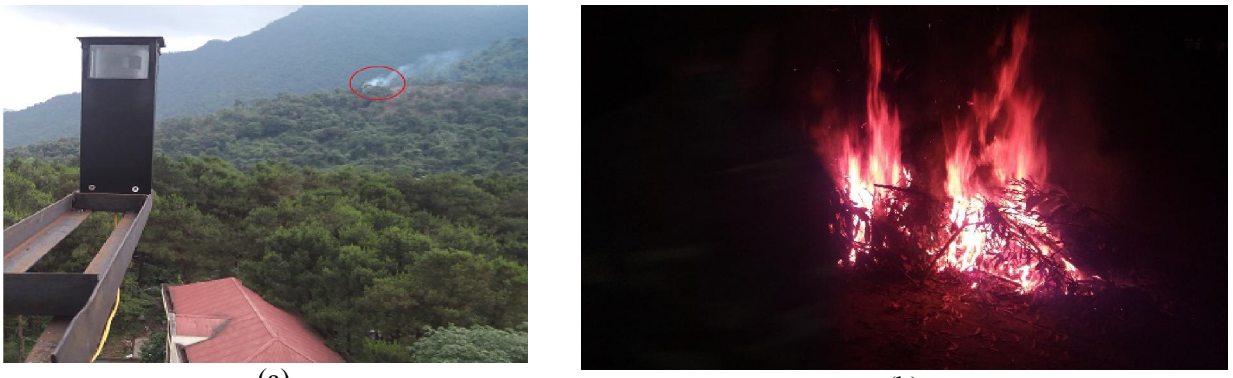
3.2. Assessment of the performance of forest fire detection system

To assess the ability to detect smoke, flame and assess the accuracy of the information transmitted by the system for early forest fires detection from the ground monitoring stations,

the authors conducted 33 controlled burns, including 32 burning in daytime and 1 burning in nighttime in U Minh Thuong National park, Ba Vi National park, Soc Son Forestry Centre, Vietnam National University of Forestry (figure 5 and 6).

(a) (b)

Figure 5. a) A controlled burning in reality, b) captured image form device in monitoring station at U Minh Thuong National park



(a) (b)

Figure 6. a) A controlled burning at Ba Vi National park, b) A controlled burning in nighttime

Results of detecting forest fires from controlled burning:

In total of 33 cases of controlled burning, system was not detected 5 cases. Because forest canopy is higher than the view of IP camera (2 cases); view from camera at 5000 m is in the line of horizontal view (2 cases); a remained case was cause of frog.

For camera was setup in 11 m to 13 m height, it can be easy to detect fire in distance maximum 4 km equivalent area approximately 5024 ha.

The results from controlled burning in nighttime indicated that an fire area of 2-4 m^2, flame was continue until the camera captured the second image, system detected the fire based on algorithm of color and expansion direction of flame.

3.3. System of alarming and transmitting forest fire information

If forest fires are confirmed, system will send information automatically to installed email or phone number for managers to extinguish the fire. This process takes 15 - 20 minutes since the fires occurred. In compared with the fire detected by satellite images It takes about 2 hours or required forest rangers at the watchtower 24/24 hours.

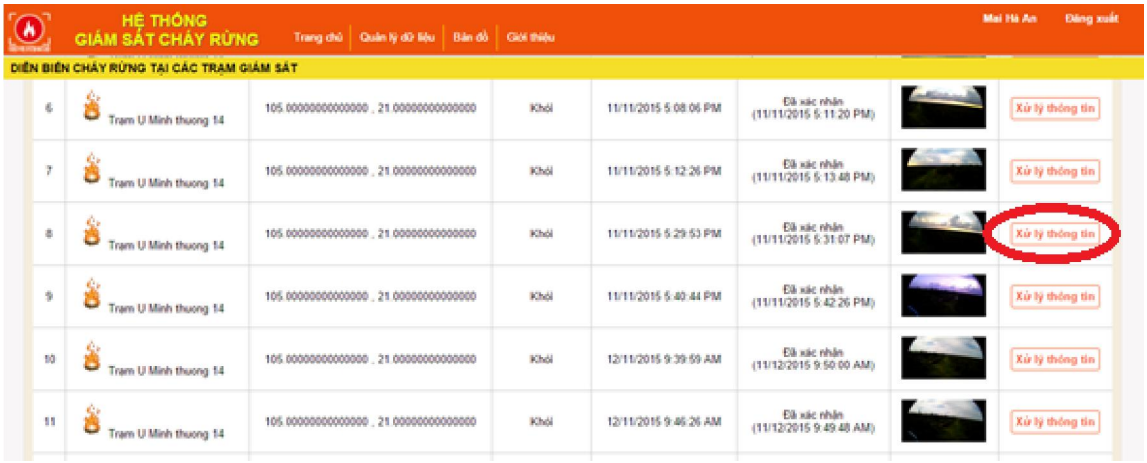


Figure 7. Processing information from detected fire

When administrator processes (figure 7) detected fires by click the button of "processing information", system will report information for processing, based on real local condition, people who directly process information will decide to choose within 4 options:

Process: After extinguishing the fires.

Confirm: When make sure that the fire is real, the system will send alerts by emails or SMS to all installed phone numbers and email address.

Cancel: When detected fire is unreal.

Close: Come back to the alerting fires list.

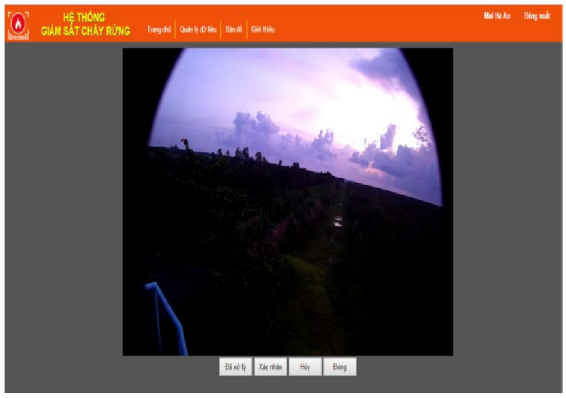


Figure 8. Captured imaged sent to email of manager

Confirmed information about the fire will be sent to email, SMS. It allows to update fire points to website that was designed to connect with Google Earth and Google Map (fig. 9). Fire points are denoted on the map by red dots. When users click on red dots, system will provide the shortest way from fire point to fire station in order to organize optimal solutions.

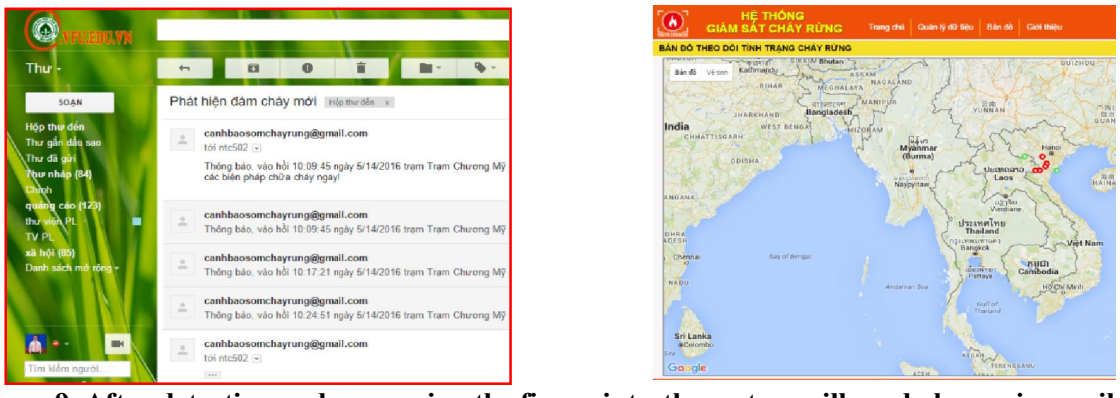


Figure 9. After detecting and processing the fire points, the system will send alarm via email and show all the fire points on the map

IV. CONCLUSIONS

With controlled burning of 2 - 4 m^2 and observation distance of this system to fire up to 4 km, if smoke can get through the canopy, system will detect forest fire in 8 minutes right after beginning; and system analysis and transmits information to stakeholders simultaneously.

Under the bad condition with fog, cloud (especially in North region) or installed location is blocked by the height of surround object, the system cannot work efficiently.

Ground station of forest fire monitoring system is active 24/24 hours. In the daytime, system can detect fires through signal such as smoke; in the nighttime, it can detect fires through flame picture.

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NGHIÊN CỨU THIẾT KẾ VÀ CHẾ TẠO THIẾT BỊ GIÁM SÁT NHẰM PHÁT HIỆN SỚM VÀ TRUYỀN TIN CHÁY RỪNG

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TÓM TẮT

Bài báo trình bày kết quả chế tạo thiết bị giám sát hệ thống lửa rừng của nhóm nghiên cứu từ Trường Đại học Lâm nghiệp. Thiết bị có chức năng tự động phát hiện cháy rừng và truyền tin cháy rừng tới chủ rừng và các cấp quản lý. Hệ thống sử dụng thuật toán phát hiện cháy sớm từ Camera IP, đồng thời ứng dụng công nghệ không gian địa lý tích hợp công nghệ thông tin trong quản lý lửa rừng, phát hiện sớm các điểm cháy rừng, xử lý thông tin và truyền tin phục vụ công tác chỉ huy chữa cháy rừng. Hệ thống bao gồm 01 camera IP được kết nối với Internet thông qua tín hiệu 3G, 01 chương trình điều khiển và phân tích dữ liệu. Để đánh giá khả năng phát hiện và độ chính xác của thông tin truyền đi của mô hình, nhóm tác giả đã thử nghiệm đốt có kiểm soát các "điểm cháy rừng", các điểm cháy rừng này được thực hiện ở các vị trí không gian khác nhau, với cường độ cháy khác nhau. Đây là hệ thống phát hiện sớm cháy rừng tự động có độ chính xác cao, thay thế cho việc quan trắc bằng thủ công trong quản lý rừng, kịp thời ngăn ngừa những đám cháy rừng có thể lan rộng và giảm thiểu tối đa những thiệt hại do cháy rừng gây ra.

Từ khóa: Camera IP, cháy rừng, công nghệ không gian địa lý, phát hiện cháy rừng, phân tích ảnh.

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