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A YOLO based Technique for Early Forest Fire Detection

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Abstract: Forest fires, wildfires and bushfires are a global environmental problem that causes serious damage each year. The most significant factors in the fight against forest fires involve earliest possible detection of the fire, flame or smoke event, proper classification of the fire and rapid response from the fire departments. In this paper, we developed an automatic early warning system that incorporates multiple sensors and state of the art deep learning algorithm which has a minimum number of false positives and give a good accuracy in real time data and in the lowest cost possible to our drone to monitor forest fire as early as possible and report it to the concerned authority. The drones will be equipped with sensors, Raspberry pi 3, neural stick, APM 2.5, GPS, Wifi. The neural stick will be used for real time image processing using our state-of-the-art deep learning model. And as soon as forest fire is detected the UAV will send an alert message to the concerned authority on the mobile App along with location coordinates of the fire, image and the amount of area in which forest is spread using a mesh messaging. So that immediate action will be taken to stop it from spreading and causing loss of millions of lives and money. Using both deep learning and infrared cameras to monitor the forest and surrounding area, we will take advantage of recent advances in multi-sensor surveillance technologies. This innovative technique helps the forest department to detect fire in first 12 hours of its initialization , which is the most effective time to control the fire.

Keywords: WildFire, Forest fire, Early Detection, Images data, Deep Learning, Survival Analysis, Supervised Learning, CNN

I. INTRODUCTION

Forest fires are responsible for massive global damage every year. In spite of being classified as a “natural phenomenon” by the International Union for Conservation of Nature (IUCN) Report “Global Review of Forest Fire 2000” [1], 90% of wildfires are caused by human activity. Wildfires lead to significant forest loss (6–14 million hectares of forest per annum) and contribute to 30% of atmospheric CO[2].

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This gives rise to massive loss of life, global warming, destruction of various environmental, entertainment and essential resources. There is an urgent need to elicit a widespread, international response to forest fires.

The recent, unprecedented forest fires in the Amazon and Australia were responsible for huge damage to the ecosystem, exacerbation of air pollution and death of almost 480 million wildlife[3]. Even though it could have been easily prevented by the authorities, due to lack of proper surveillance and human negligence it worsened. Wildfires are the main cause of the devastation of major sites of archaeological and cultural importance, particularly in the Mediterranean region. These places, highly cherished through the generations, usually lie near areas of vegetation or forests. Increasing seasonal temperatures, due to global warming, have been leading to more and more self-ignited forest fires, which are exacerbated by dry vegetation and strong winds. Arson, human carelessness and lightning strikes are some other causes.

The places with extreme weather conditions, such as storms and floods, are high risk. Ancient Olympia was gravely threatened by a rapid wildfire in the summer of 2007[4]. The fire reached an overlooking hill and it was thankfully restrained before it entered the main site, but it managed to reach a historic hilltop above the main stadium. The surrounding forest was destroyed. In addition to taking precautionary measures early action in reporting and restraining forest fires is the only way to curb losses to the human population in terms of monetary as well as heritage and culture. Fire surveillance focuses primarily on early detection and containment of said fires as they are much easier to restrain when their ignition location is known [5]. An IoT based fire detection system should be capable of raising early fire alerts and also be able to collect location and spread data. [13]. This system could be used by the fire department to reach and appropriately localize the fire before it reaches critical places. Most commercial surveillance systems fail to utilize the maximum applications offered by current technologies due to lack of integration. Visible range cameras set up on high watch towers are used by the majority of these systems. A few use the more expensive infrared cameras while a few others might use wireless temperature sensor networks with real-time feedback for early fire detection and monitoring. All above approaches have their own pros and cons. Therefore, with this project we aim to build an automated early forest fire detection system that makes use of sensors to monitor extreme weather conditions that cause wildfires in places of archaeological and historical importance surrounded by forests.

A. Motivation

Wildfires cause permanent harm to the environment and pose a threat to residents’ lives.

The burnt area in the USA, in 2015 was twice of what it was in 1990 according to the National Interagency Fire Centre (NIFC) [6]. Recent wildfires in Amazon Rainforest and in Australia (reported by CNN) are responsible more than 40 deaths and 50 missing, more than 480 million dead animals and evacuation of more than 200,000 local residents [3]. Wildfires are estimated to happen over 220,000 times worldwide and burn over 6 million hectares of land Therefore, there is an urgent need of automatic and prompt detection of forest fires. This motivates to build an automatic early alert system that uses integration of various sensors with state of the art machine learning algorithm which has a minimum number of false positives and give a good accuracy in real time data and in the lowest cost possible to our drone to monitor forest fires as early as possible and report it to the concerned authority

B. Our Contributions

- Proposed a machine/deep learning algorithm for detection for wildfire in real time.
- A drone is created with a camera and raspberry pie mounted and an on-board computer (neural stick) on it for real time video analysis
- A cross platform native mobile application for the authorities to get notification which also finds the nearest fire-fighting station from the detected region of forest fire

II. RELATED WORK

Forests are an important component of conserving nature's balance. The forests cover about a third of the earth's surface and are home to two-thirds of the terrestrial species on the planet. Wildwoods are the source of biodiversity on our planet. Unfortunately, wildfires destroyed hundreds of thousands of hectares of forest annually, and hundreds of billions of dollars are spent on extinguishing those enormous and destructive fires. While forest fires help to create new forests, it is hard to guarantee that unrestrained, uncontrolled and unmanaged fires do not spread to locales that endanger the ecological system and human life. A wildfire has become a natural hazard which is serious. So early forest fire prevention is crucial and reduces its risk. This concern has been the topic of research for many decades. There are a number of solutions and fixes developed to tackle this problem. One way of preventing forest fires is by developing early fire detection systems in the forest. Tremendous efforts were made to monitor, detect and quickly and effectively extinguish the fire before it gets out of control. Conventional methods of forest fire monitoring and detection use humans to unremittingly monitor and screen the forests. However, this method needs a higher cost and is not hazardous for people monitoring the forest. Remote sensing mechanisms have lately become one of the most efficient forest-monitoring techniques. Earth orbiting satellites, UAVs and even air-floating devices have been used to recognize and identify wildfires. Satellite images collected by two primary satellites launched for wildfire detection, the advanced high-resolution radiometer (AVHRR)[7] was launched in 1998 and the moderate resolution imaging spectro-radiometer (MODIS), was launched in 1999,[7] were used. Needless to say, these satellites would provide images of the regions of the Earth once a couple of days, which is a long period of time for fire scanning; in addition, weather conditions can adversely affect the quality of satellite imagery [7]. Jain sun et al [8] presented Deep Residual Learning method for image recognition on COCO object detection algorithm. The experiment was performed and the proposed work shows an improvement of 28%. James Wong et al. [9] proposed various methods of deep learning to classify the seven main human emotions: rage, disgust, terror, joy, sorrow, disappointment and neutrality. Facial expression dataset from kaggle was used. The experiment was performed and results proved that the proposed approach performed well with 76% accuracy. Liang Xu et al. [10] proposed Deep Convolutional Neural Network for fire detection. The wildfire scanning and detection is performed in a cascaded form, i.e. the entire image is first examined by the global image level classifier, and if flame is found, then a fine- grained patch classifier is used to determine the precise location of the flame patch. The fire patch detector obtains identification precision of 97 percent and 90 percent on teaching and trial data sets respectively. Toreyin et al [11] to detect fire and flame, use motion and color clue features combined with Edge blurring and flicker features. Zhang et al.[12] suggested two deep Convolutional Neural Network(CNN) joined together to detect fire in images of the forest. In the above approach, firstly, a global picture classifier tests the entire image; after which, if a fire is detected in any area, another classifier is used to identify the specific position of the fire in that picture.

III. PROPOSED WORK

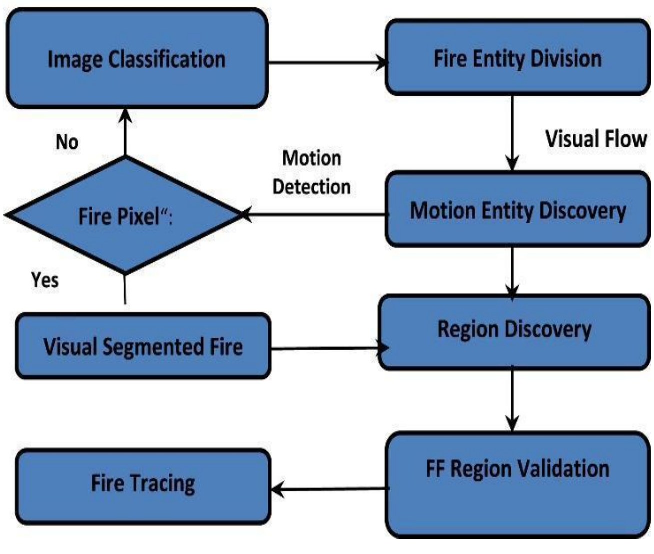

Fig.1. System Architecture

Figure 1 described the proposed system architecture. The burning substances are primarily identified as sceptical flame regions using a division strategy based on histograms to expel the non-fire structures and results are verified by a deep learning model. The outdated-style optical flow strategy is then linked to classify moving objects in the candidate flame areas for disposing of static non-fire entities. Additionally, the movement vectors dictated by the optical flow are examined to reduce the false positive rates triggered by hot moving components.

Afterwards, the converged applicant fire spots of visual and IR images are spotted; a credible affirmation of flame in the convergence regions relies on such pixels. At last, once the flame areas have been confirmed, mass counter-strategy is followed by fire zones.

A. Convolutional Neural Network

Problems and applications with computer vision such as object recognition and location, image segmentation, super-resolution, labelling, indexing and retrieval, Deep CNN have shown promising results. This universal popularity is attributed to their hierarchical layout, which learns very powerful elements from the unprocessed data automatically A traditional Deep CNN design is made up of three well-knots:

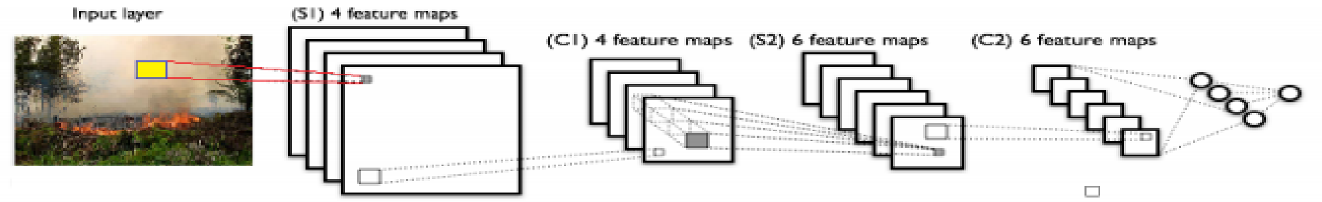

Fig.2. Structure of CNN

1) A convolutional layer, in which particular feature maps are produced when added to specific kernels to the input data, is the foundation of the YOLO algorithm.

2) A max pooling layer used to select optimum activation using a restricted neighbourhood of feature maps obtained from the previous convolutional layer; the objective of this layer is to achieve invariance of translation and a decrease in dimensionality to a certain degree.

3) A fully interconnected architecture of model inputs the high-level data knowledge and builds its global representation. This layer fits multiple stacks of convolutional and max pooling structures, ultimately resulting in a representation of the input data at a high level.

Such layers are constructed in a hierarchical structure, so the output of one layer serves as the input data of the subsequent layer. During the training process, the weights of all neurons in convolutional kernels and thoroughly attached layers are balanced and learnt. s These weights in the model represent characteristics of the input training data, and can also identify the goals. Figure 2 lays out the CNN structure.

B. Working

1. We use a drone equipped with a high-resolution camera, a microprocessor (Raspberry Pi) and ArduPilot Mega (APM) for controlling the drone, essentially a flight controller.
2. There is a barometer, Humidity sensor, Global Positioning Sensor (GPS), IMU, and compass. GPS and compass sensors are used in navigation systems in the UAV. The barometer analyses the air pressure which would be used as the reference for maintaining UAV height. The IMU is composed of accelerometer and gyroscope sensors used to approximate the position of the UAV.
3. The Raspberry Pi, which acts as a microprocessor, processes the data from both the high-resolution camera and GPS. The Raspberry Pi sends data to the cloud server for digital access and in real time.
4. From the previously available data we will predict the region and time, when forest fire will happen.
5. For auto-piloted drones we decided to choose APM 2.5. We can manually select the region where we want our drone to move continuously in a dedicated region.
6. We embed our yolov3 model in a neural stick, as soon as the image is captured it is processed and passed to CNN which will check for forest fire. And if detected more than a confidence level it will send a notification.
7. The resultant of processed data is sent to the authority concerned, using raspberry pi, using various internet protocols

The complete working is shown in Figure 3.

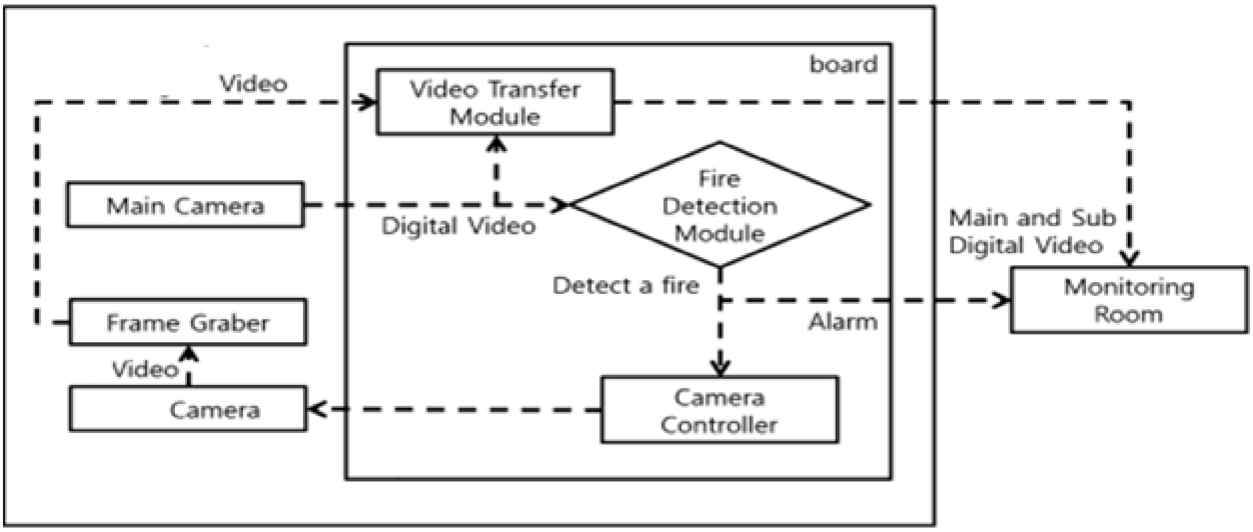

Fig. 3. Working of Proposed Work

IV. EXPERIMENTAL ANALYSIS

A. Experimental Setup

Table 1 describes the hardware and software requirements used in the proposed framework.

TABLE 1: H/W and S/W Requirements

Hardware Interfaces	Drone kit APM 2.5
	Raspberry Pi 4
	Neural Stick
	Camera
	Node MCU
	Smoke Sensor
	IMST IC880A
Software Interfaces	Flutter SDK
	HTML and JS
	PHP
Tools Used	Python 3
	Tensorflow (version2)
	OpenCV
	Keras
	Numpy
	Matplotlib
	Scikit Learn
	Matlab
	Raspberry Pi4

B. Performance Parameters

Three parameters are used to check the performance of the proposed framework.

Sensitivity: Sensitivity is a calculation of the proportion of positive real cases expected to be positive (or true positive)

$$Sensitivity = \frac{True\ Positive\ (TP)}{TP + False\ Positive\ (FP)} \quad (1)$$

Specificity: Specificity is described as the percentage of actual negatives that have been forecast as negative (or true negative).

$$Specificity = \frac{True\ Negative\ (TN)}{TN + FP} \quad (2)$$

Accuracy: Accuracy is the percentage of observations that our analysis got correct. Formally, the concept of accuracy is as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + False\ Negative} \quad (3)$$

C. Results

D. For results, we trained our model on more than 5000+ images to predict fire. The working of the prototype is shown in Figure 4.

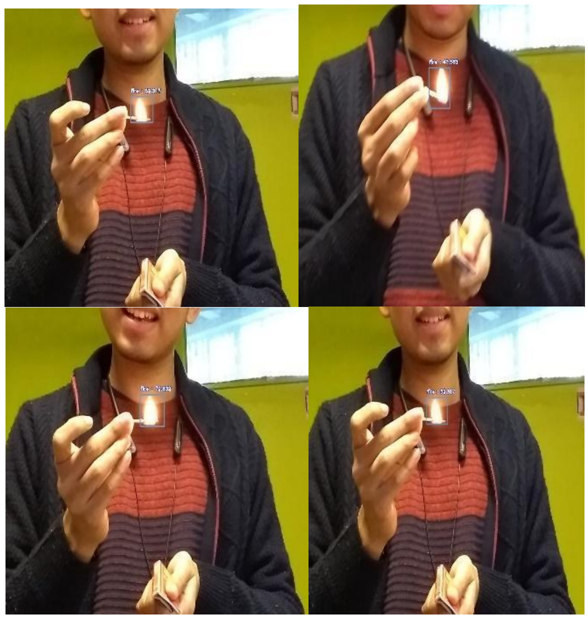

Fig. 4. Working of Prototype

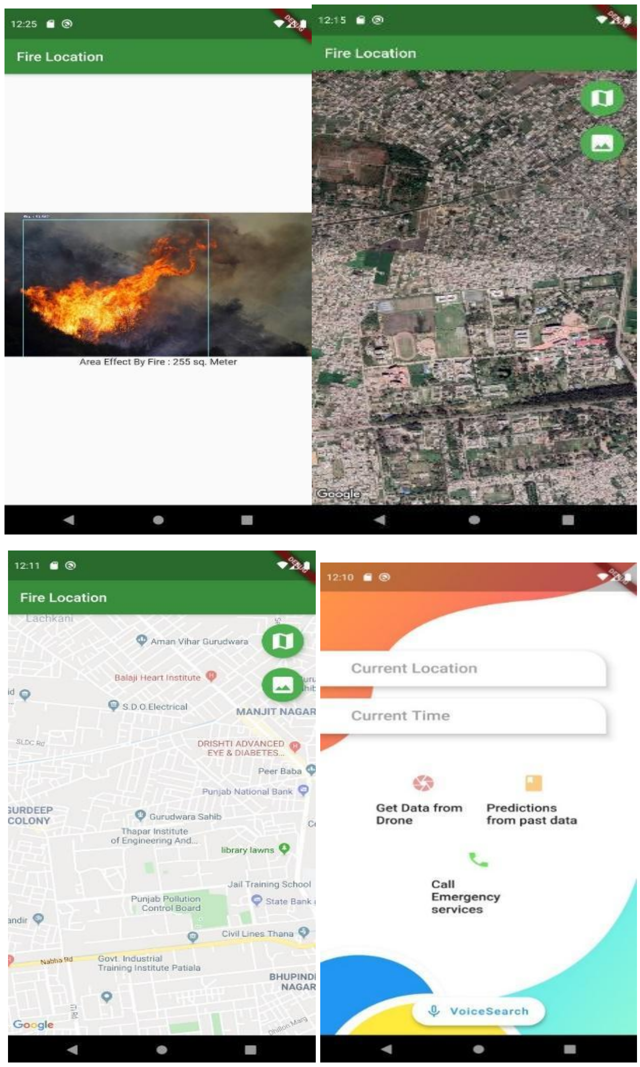

Fig. 5. Mobile APP

In the present work, YOLO based forest fire detection system is working with an accuracy of 90%. The sensitivity and specificity for present research is 92% and 90% respectively. A basic structure of the mobile app and web interface is shown in Figure 5. We have researched and deeply analysed more than 20+ research papers to find the faults in the prediction method. We can update the authorities via Short Message Service by using the present system. We tested our model on our videos from social media. We have created a web page which uses NASA satellite data for the prediction of vulnerable states in India towards forest fire. Continuous monitoring of areas which are highly vulnerable to forest or bush fire is performed. It saved human labour effort and intelligence from doing repeated and endless tasks. We have developed a system which can monitor areas where human survival is next to impossible. It can also be used to detect survivors, if any in an avalanche or an air plane crash with minor changes in the code. We have developed a system in such a way that it can decrease the response time of various forest fire departments. Early detection of bush fire is performed to prevent any large-scale destruction. Lastly, we used technology as a whistle blower to alarm concerned authorities and prevent massive environmental mislaying.

V. CONCLUSIONS

The technology used by us to locate a forest or a bush fire is based on the concept of deep learning and YOLO algorithm. This deep learning model is deployed on a Raspberry-Pi with neural stick on a UAV which help in detection of fire .We have been able to test the code in our nearby surroundings and have successfully inferred the results which are quite accurate. Considering this first step done, we now aim to make an android, ios and web application where we would deploy the technology used above in the forest fire detection system. All in all, this application will help the forest departments of various vastly spread forests in early detection of forest fire and will ease the work of those departments which are endlessly monitoring the fire prone forest round the globe.

REFERENCES

1. "International union for conservation of nature", [online]. Available: https://portals.iucn.org/library/sites/library/files/documents/2019-007-En.pdf, last accessed 2019/08/09.
2. S. Kaushik, "Forest fire disaster management". New Delhi: National Institute of Disaster Management, Ministry of Home Affairs, Government of India, 2014.
3. "Australia fires kill half a billion animals as crisis mounts, [online]Available: https://www.cnbc.com/2020/01/03/australia-fires-nearly-half-a-billion-animals-killed-as-crisis-mounts.html, last accessed 2020/02/17.
4. N. Grammalidis, E. Çetin, "August. A multi-sensor network for the protection of cultural heritage", In IEEE, 2011, pp. 889-893. [Dig. 19th European Signal Processing Conference, Spain].
5. K. Dimitropoulos, K. Köse, N. Grammalidis, and A.E. Çetin,, "Fire detection and 3D fire propagation estimation for the protection of cultural heritage areas", International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2010, 38(8), pp.620-625.
6. Y. Zhao, J. Ma, X. Li, and J. Zhang, "Saliency detection and deep learning-based wildfire identification in UAV imagery", Sensors, 2018, 18(3), p.712.
7. A.A. Alkhatib," A review on forest fire detection techniques", International Journal of Distributed Sensor Networks, 2014,10(3), p.597368.
8. K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition", In Proceedings of the IEEE conference on computer vision and pattern recognition, 2016, pp. 770-778.
9. A. Savoiu, and J. Wong, "Recognizing facial expressions using deep learning", 2017.
10. Q. Zhang, J. Xu, L. Xu, and H. Guo, "Deep convolutional neural networks for forest fire detection", In 2016 International Forum on Management, Education and Information Technology Application. Atlantis Press, 2016.
11. F. Yuan, "An integrated fire detection and suppression system based on widely available video surveillance". Machine Vision and Applications, 2010, 21(6), pp.941-948.
12. A. Namozov, and Cho, "An efficient deep learning algorithm for fire and smoke detection with limited data", Advances in Electrical and Computer Engineering, 2018, 18(4), pp.121-129.
13. A. Dhillon, A. Singh, "Machine Learning in Healthcare Data Analysis: A Survey", Journal of Biology and Today's World, 2019, 8(2), pp. 1-10.

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