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SMOKE AND FIRE DETECTION USING CONVOLUTIONAL NEURAL NETWORKS

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Abstract - Fire outbreaks are a typical occurrence all throughout the world, and the harm they bring to both nature and humans is enormous. In comparison to classic sensor-based fire detection systems, vision-based fire detection systems have lately gained favor. However, the image processing technique's detection method is time-consuming. I introduced a fire detection technique based on Convolutional Neural Networks for high-accuracy fire picture identification that is compatible with training using datasets. Number of images in the datasets taken for fire and smoke are 1102 and 12631 respectively. Totally, there are 13733 images. These images are rendered from video containing fire and some of those from internet. These images are resized and reshaped to convert as training dataset using Data Augmentation. The model is trained by applying convolution, activation functions and max pooling operation. By using different batch sizes and epoch values, the model is trained. The accuracy of model is 94%. Thus, I am getting with a high accuracy and high detection rate.

***Key Words*:** CNN, Keras, Tensorflow, Python, Data augmentation

1.INTRODUCTION

The work of fire detection is critical for people's safety. To prevent fire-related harm, several fire detection systems have been created. Various technical solutions are available. Most of them are sensor-based and confined to indoor use. They use ionization to detect the presence of particles created by smoke and fire, which needs close contact to the flames. As a result, they can't be used in big, enclosed spaces. Furthermore, they are unable to offer information such as the initial fire location, smoke propagation direction, fire size, fire development rate, and so on. Video fire detection systems are used to overcome such constraints.

Because of the rapid advancements in digital camera technology and video processing techniques, computer vision-based systems are increasingly being used to replace traditional fire detection methods. Video-based fire detection systems are ideal for detecting fire in wide, open areas. These technologies may also be used to evaluate fire behavior and conduct three-dimensional fire localization. Furthermore, closed-circuit television surveillance systems are now placed in a variety of locations to monitor both the inside and outside of buildings. In this case, it would be preferable to build a video fire detection system that could make use of current technology while avoiding additional costs.

Since the 1990s, researchers have been working on this topic. In the literature, there exist a number of video-based fire and flame detection algorithms. The bulk of these algorithms are concerned with the color and form of smoke and flames, as Ill as their temporal behavior. Following that, the purpose is to create a rule-based approach or a multi-dimensional feature vector that can be fed into a traditional classification algorithm such as SVM, Neural Network, Ada boost, and so on. As a result, traditional video fire detection systems deal with the issue by relying on expert knowledge to construct appropriate feature extractors. The rule-based models and exclusionary features must be created by professionals. Using a learning algorithm to extract the important characteristics rather than an expert to design them is an alternative solution to this challenge. Such traits may be learned by deep learning algorithms to identify fire and smoke in video. Convolutional Neural Networks are a type of deep learning that can extract picture topological features.

As a result, our strategy is conceptually quite straightforward. As a strong fire/smoke frame detector, I employ a Convolutional Neural Network. Without the requirement for a feature extraction stage, the CNN works directly on raw RGB frames. From the training data, the CNN automatically learns a set of visual attributes.

The remainder of the paper is laid out as follows. The next section examines related work. Convolutional neural networks are briefly discussed in Section III. The suggested CNN architecture is described in Section IV. Section V contains the experimental data and performance analyses. Section VI finishes this study by discussing the constraints.

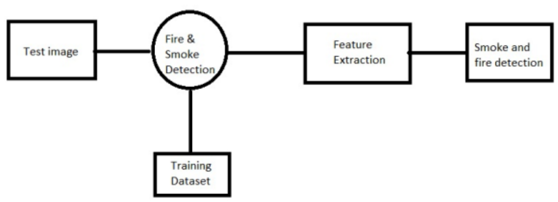

Figure 1: Overview of Smoke & Fire detection

2. RELATED WORKS

[1]INFORMATION-GUIDED FLAME DETECTION BASED ON FASTER R-CNN
CHENYU CHAOXIA, WEIWEI SHANG, AND FEI ZHANG
2020

Due to the diversity of the shape and texture of flame, and interference objects that are similar to flame in color, detecting the position of flame from images is a difficult task. To enable generic object detection methods to achieve better performance in flame detection tasks, a color-guided anchoring strategy is proposed that uses color features of the flame to limit the location of the anchor. To solve the problem of high false alarm rate when directly using generic object detection methods in flame detection, a global information-guided flame detection method is proposed; this strategy uses a parallel network to generate image global information. I use these two methods to improve Faster R-CNN (Regions with Convolutional Neural Network features) to perform the fire detection process in a guided manner. Experiments on the Bonfire dataset show that our method improved detection speed by 10.1% compared with the original Faster R-CNN. In addition, the false alarm rate has decreased by 21.5%, and the overall accuracy of detection has increased by 9.3%. Experiments on PascalVOC and Corsician datasets further demonstrate the robustness of the proposed methods.

[2]DEEP LEARNING ALGORITHM FOR FIRE DETECTION
MUHAMMAD IQBAL, CASI SETIANINGSIH, BUDHI IRWANA
2021

Based on data from ayobandung.com, the Bandung City Fire and Disaster Management Office (DiskarPB) handled 199 fires in 2019. Of these, as many as 121 cases of building fires, 69 bush or grass fires, and the rest are handling fires outside the city of Bandung. As a result of these fires, it is estimated to result in losses of IDR 44,363,700,000. However, with the blackout carried out by officers, Diskar PB managed to save material worth IDR 810,790,534,400. According to them, the obvious dominant cause is human negligence, starting from the stove and then electricity. The speed with which people are aware of fires and reporting fire incidents also affects. The time for making this report is precious for Diskar PB officers. So it is crucial to get information as soon as possible before the fire spreads more. For indoor fire detection, a system is designed with sensors and cameras. This system will detect in real-time if there is smoke or fire, the system will notify the user by telegram. This fire system uses the Backpropagation and Convolutional Neural Networks (CNN) method used to carry out object recognition and fire patterns. This system can improve safety in fire prevention. The fire detection system created has an accuracy rate of 95% for the Backpropagation method. Meanwhile, CNN has an accuracy rate of 97%.

[3]USING OBJECT DETECTION METHODS FOR REAL TIME FOREST FIRE DETECTION
SHIXIAO WU, LIBING ZHANG
2019

In this paper, I focus on three problems that surround forest fire detection, real-time, early fire detection, and false detection. For the first time, I use classical objective detection methods to detect forest fire: Faster R-CNN, YOLO (tiny-yolo-voc, tiny-yolo-voc1, yolo-voc.2.0, and yolov3), and SSD, among them SSD has better real-time property, higher detection accuracy and early fire detection ability. I make the fire and smoke benchmark, utilize the new added smoke class and fire area changes to minimize the wrong detection. Meanwhile, I adjust YOLO's tiny-yolo-voc structure and propose a new structure tiny-yolo-voc1, the experiment proves that this improves the fire detection accuracy rate. This paper is very practical for forest safety and real time forest monitor.

[4]REAL-TIME FIRE DETECTION METHOD COMBINING ADABOOST, CNN
OLEKSII MAKSYMIV, TARAS RAK, DMYTRO PELESHKO
2020
This paper presents a novel algorithm for detection of certain types of emergencies relating to fire, smoke and explosions by processing the data recorded from the camera monitoring, based on a cascaded approach. First, the combination of Adaboost and Local binary pattern (LBP) are used for getting Region of Interest (ROI) and reducing time complexity. Next, to alleviate common problems of the vulnerable such as false positives, I propose to use Convolutional Neural Network (CNN). The final experimental results showed that the accuracy rate of this method for emergency detection could reach 95.2%.

3. PROPOSED SYSTEM

Majority of the research since the last decade is focused on traditional features extraction methods for flame detection. The major issue with such methods is their time-consuming process of features engineering and their low performance for flame detection. Such methods also generate a high number of false alarms especially in surveillance with shadows, varying lightings, and fire-colored objects. To cope with such issues, I extensively studied and explored deep learning architectures for early flame detection. Motivated by the recent improvements in embedded processing capabilities and potential of deep features.

● I investigated numerous CNNs to improve the flame detection accuracy and minimize the false warnings rate.

● It increases the accuracy of the trained model I use the Data Augmentation technique.

●Data Augmentation leads to replicating the amount of data available for training.

3.1 MERITS OF PROPOSED SYSTEM

●Will increase the rate of quality of detection.

●Enhance the Quality of the trained data. By using data augmentation, the trained model can able to detect fire and smoke outbreaks more accurately.

●The technique has many advantages such as early fire detection, high accuracy, flexible system installation, and the capability to effectively detect fires in large spaces and complex building structures.

3.2 MODULES DESCRIPTION

There are two phases of modules used in the project. They are the training phase and the testing phase.

TRAINING PHASE:

In the training phase the data sets which are collected from the internet are being trained using CNN to create a trained model. The data set images are fetched from the Kaggle website for the training purpose. Number of images in the datasets taken for fire and smoke are 1102 and 12631 respectively. Some of the example data sets are provided below.

Figure 2: fire data set

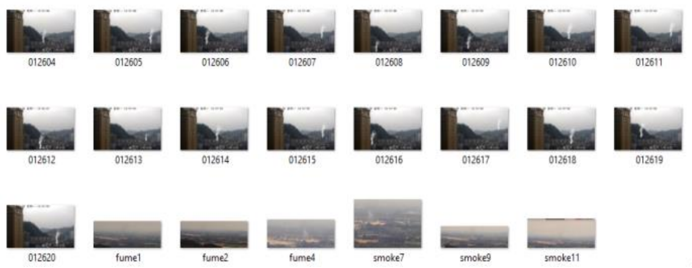

Figure 3: smoke data set

TESTING MODULE:

Number of images in the datasets taken for fire and smoke are 1102 and 12631 respectively. Totally, there are 13733 images. These images are rendered from video containing fire and some of those from internet.

By using different batch sizes and epoch values, the model is trained. The accuracy of model is 94%.Thus, I am getting with a high accuracy and high detection rate.

```
test_image=image.load_img(image_for_testing,target_size=(224,224))
test_image=image.img_to_array(test_image)
test_image=test_image/255
test_image=np.expand_dims(test_image,axis=0)
result = (cnn.predict(test_image) > 0.5).astype("int32")

Catagories=['Fire','Smoke']

image_show=PIL.Image.open(image_for_testing)
plt.imshow(image_show)

plt.title(Catagories[int(result[0][0])])
plt.show()
```

Figure 4: fire detection

4. ARCHITECTURAL AND DATA FLOW DIAGRAM

4.1 SYSTEM ARCHITECTURE

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development.

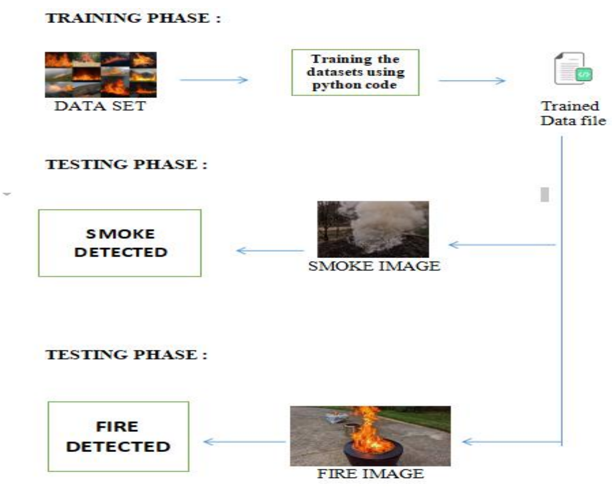

Figure 5: System Architecture

4.2 DATAFLOW DIAGRAM

A data flow Diagram is a graphical representation of the “flow” of data through an information system, modeling its process aspects. A DFD is often used as a preliminary step to create an overview of the system without going into great detail, which can later be elaborated.

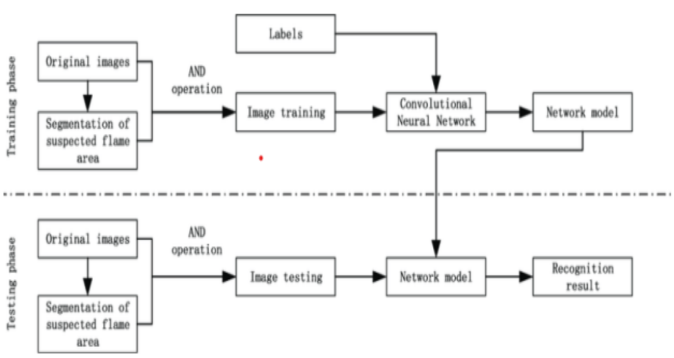

Figure 6: Data flow Diagram

4.3 OTHER DIAGRAM

4.3.1 USE CASE DIAGRAM

Use case diagram is a graphic depiction of the interactions among the elements of a system. Use cases will specify the expected behavior, and the exact method of making It happened. Use cases once specified can be denoted both textual and visual representation.

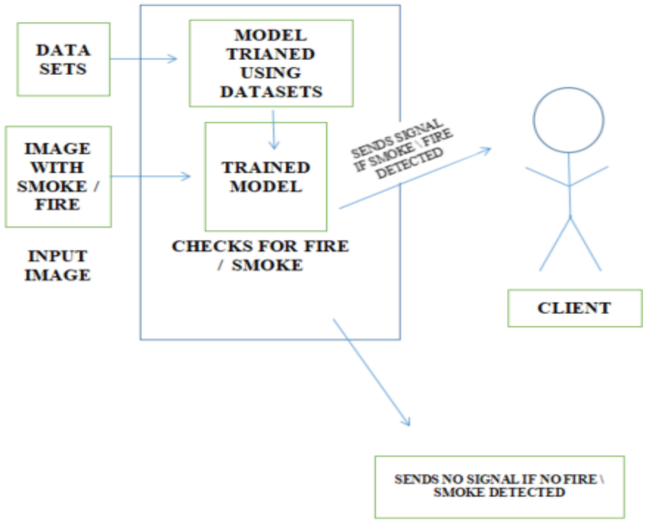

Figure 7: Use Case Diagram

5. RESULTS AND OBSERVATIONS

The system worked well efficient in different scenarios.

5.1 DATASET FROM KAGGLE

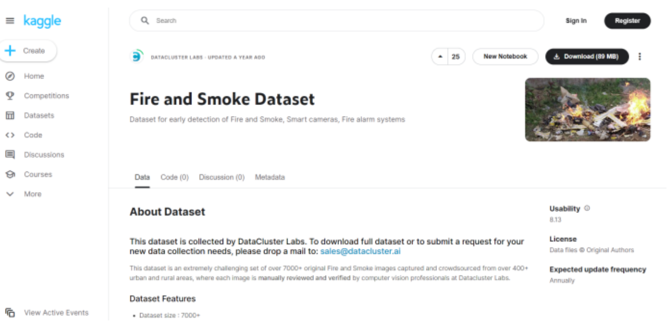

Figure 8: Smoke and Fire Datasets

5.2 DATASET COLLECTION

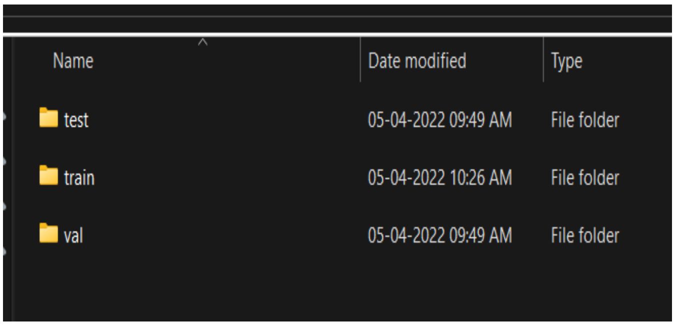

Figure 9: Datasets screen

5.4 TRAINING MODULE

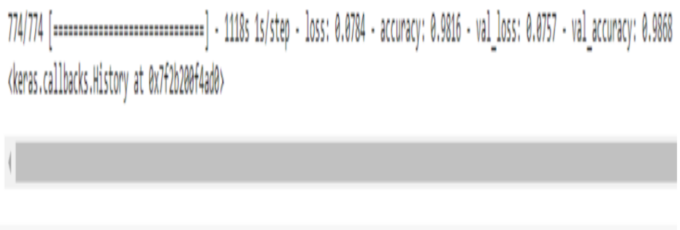

Figure 10: Training Module Screen

5.5 TRAINED MODULE

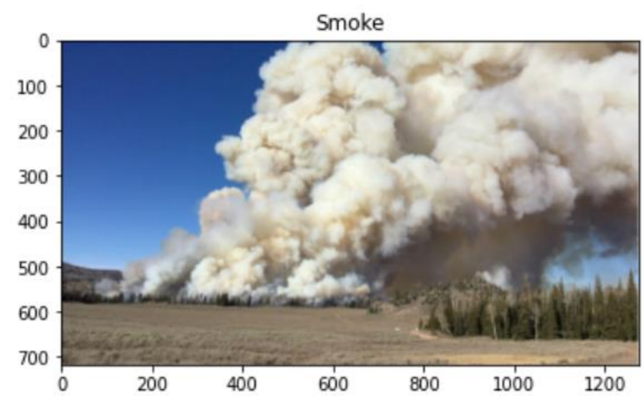

Figure 11: Smoke deducted

Figure 12: fire deducted

6. CONCLUSION

A vision-based technique for fire and smoke detection was given in this research. The suggested technique employs a convolutional neural network-based deep learning approach (CNN).The confusion matrix and ROC curves show that the detection stage has a high overall accuracy. I demonstrated that scanning the feature map instead of the whole original picture during the detection test reduced the time cost by a factor of 6 to 60.

As a result, the motion information of fire and smoke may be encoded, reducing the time cost significantly. Furthermore, I must increase our training set in order to improve the identification and localization of smoke and fire on video. Because of his shape and texture, smoke is more difficult to detect and locate.Our model can only identify red fire; to detect other colors of fire, I must expand our training set to include additional fire colors such as blue, etc... I also intend to test our algorithm against traditional approaches on a wider range of video fire pictures, including varied materials, sources, and ventilations.

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