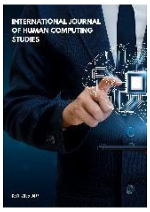

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Analysis of Real-Time Video for the Detection of Fire Using OpenCV

M. Gandhi*, S. Manikandan, B. Vaidianathan

Dhaanish Ahmed College of Engineering, Chennai, Tamil Nadu, India

* Correspondence: gandhi@dhaanishcollege.in

Abstract: Because of the wide range of colours and textures present in visual landscapes, fire detection is a challenging undertaking. To get over this issue, several fire image categorization methods have been suggested; nevertheless, the majority of these systems depend on rule-based methods or characteristics that are manually created. Develop and propose an innovative technique for fire picture detection using deep convolution neural networks. Adaptive piece-wise linear units are utilised in the network's hidden layers in place of conventional rectified linear units or tangent functions. In addition, we will generate a fresh, compact dataset of fire photos to use for model training and evaluation. Increasing the amount of training images available through the use of conventional data augmentation methods and generative adversarial networks helps alleviate the overfitting issue that arises from training the network on a small dataset. In this study, we compare and contrast two methods for measuring the geometrical features of wildland fires: one that uses image processing to identify colours, and the other that uses Mk2ethods. Presented here are two novel rules and two novel detection methods that make use of an intelligent combination of the rules; their respective performances are then evaluated. About 270 million non-fire pixels and 200 million fire pixels taken from 500 wild terrain photos taken under different imaging conditions are used to run the benchmark. Color and presence of fire are used to classify pixels as fire, whereas average intensity of the associated image is used to classify pixels as non-fire. Because of this, the future of Metrologic systems for detecting fires in unstructured environments looks bright thanks to this technology.

Keywords: Fire Detection from Real-Time, Video Using Opencv, Data Augmentation Techniques, Adversarial Networks, Network Algorithm.

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Introduction

Fire detection has become more important as a technology because long-lasting fires pose a threat to human safety and health. Electronic cameras are the basis of the present detection technology, which typically relies on pressure and heat cameras. On the other hand, there's a major problem with those methods: they're conditionally dependent [4]. In the event of a genuine fire, it might lead to significant casualties if the cameras are malfunctioning or improperly set up [5-12]. The installation of electronic surveillance cameras is being done to address these issues. As a result, computer vision-based fire detection systems for these devices are in high demand. A variety of cameras are included in these gadgets. When compared to more conventional detection techniques, these kinds of systems have a number of clear benefits [16]. When compared to more conventional approaches, this form of detection has several advantages, such as a lower overall cost and a significantly easier deployment process. Second, a vision camera-based fire detection system can monitor a vast area depending on the camera used, and it does not require any type of conditions to activate the camera. As a result, the response time of the system is faster than any other traditional detection methods. The main advantage of this system is that it may record the fire's origin in video or still format, which can be utilised to diversify fire detection methods [17-22]. We present an algorithm in this research that takes fire colour and edge data and merges them. Then, a parameter is generated to extract the essential data from the photos in order to detect and identify the fire, using the combined findings of both methods [23-27].

When it comes to big events and strategically located locations like woods, substations, railway tunnels, and warehouses, fire monitoring and prevention has traditionally been a major concern from the outside. The repercussions will be catastrophic once these areas catch fire. Most current fire detection systems rely on the sensitive detection of heat, gas, and flames [28-37]. Fire detectors and similar sensors are advantageous due to their extensive use, low cost, extended service life, excellent anti-interference ability, quick reaction, and high sensitivity. However, in an open-space setting, for various reasons (such as high altitudes, vast spaces, and air mobility), the signals conveying heat, gas, and fire can quickly dissipate, leaving only a weak signal when it reaches the detector. This, in turn, reduces the accuracy of the detectors' ability to detect heat, gas, and fire, makes it easy to delay the optimal time to sound the alarm, and increases the likelihood of fire disasters. It is very difficult, if not impossible, to use the Fire sensor to detect fires in open areas such as forests [38-42].

So, alternative methods of fire monitoring are required in a large-space setting. As technologies like computer vision, digital image processing, and pattern recognition have advanced, researchers have begun to focus on developing video-based fire detection systems to address the limitations of older methods. This dissertation proposes an alternative to the conventional detector image processing for the purpose of gathering, analysing, and processing images of massive fire scenes [43-49]. At last, it accomplishes its goal of detecting and recognising fires in real-time. There are two primary subfields within fire monitoring: fire detection and flame detection. Combustion causes fire to take on both visually striking and functionally significant physical traits. Among the many threats to people and their possessions, fire ranks high. Many people rely on point-type thermal and fire detectors to keep large-scale fires and fire damage to a minimum. However, these devices are sensitive to environmental factors and easily malfunction or damaged if not utilised properly [50-55].

The developments in computer vision and image processing, video-based fire detection has recently become a popular technique. It offers several benefits over older approaches, including a wider detection area and faster response times. Fire detection gives a more advanced fire range than flame detection since fire is the leading symbol of fire. Several algorithms have been suggested for fire detection in recent years. One of these algorithms involves breaking a video stream into 32×32 pixel blocks, then extracting features using discrete cosine transform and wavelet transform. Then, a support vector machine is employed to detect fire based on the video's colour, wavelet coefficients, motion orientation, and a histogram of oriented gradients and other feature vectors for each candidate block [56-61]. To further refine the process, two trained random forests are used to determine if a candidate block is fire-related, in conjunction with histograms of local binary pattern and local binary pattern variance pyramids. Lastly, a trained neural network classifier is employed to distinguish between fire and non-fire extracted shape-invariant features on multiscale partitions [62-71].

This is followed by the proposal of a staircase searching technique based dual threshold algorithm for video fire detection. There have been many improvements and years of work in fire detection, however there are still many issues. There are essentially two stages to the conventional approaches of fire detection or classification: The first step is to extract features from the input fire images; these elements could include colour, texture, form, irregularity, flutter, or frequency [72-79]. The second step is to train a classifier to use these features to determine if an image contains fire. Thus, the efficacy of these approaches is dependent on the reasonableness of the manual features; nonetheless, people frequently depend on their own experiences when making feature selections, which can be a blind, laborious, and complicated process. While there are ways that have shown promising results, it's important to note that these manual features are tailored to certain data sets. Applying the same features to other datasets may not yield the desired outcomes [80-85].

Objective

1. Video or image fire detection is the primary focus of this effort.
2. The goal is to spot ironic patterns in photographs that don't match up.
3. Develop a model that outperforms the suggested baseline in terms of accurately classifying newly-authored documents.
4. Achieving our detection aim is dependent on obtaining high-quality data, which is one of our essential sub-goals.
5. Staying away from duplicate fire photos in my data
6. Identifying fire photos solely
7. As a result of meticulously checking each picture for signs of fire.

Literature Review

Recently, there has been a lot of buzz in the computer vision community about using video analysis to spot fires. To distinguish between fire and non-fire frames, traditional algorithms rely solely on feature vectors and rule-based models. Depending on the type of fire seen, these characteristics are hard to pin down. The result is a high number of false alarms and a low rate of detection. An alternative to relying on a human expert to construct these attributes is to train a learning algorithm to do so automatically. The author of this research suggests using a CNN to detect fires in videos. It has been demonstrated that object classification is an area where convolutional neural networks excel. This network is capable of extracting features and classifying them all inside its own design. The suggested method outperforms several relevant traditional video fire detection approaches in terms of classification performance when tested on real-world video sequences. The results show great promise for the use of CNN to identify fires in videos [1].

By analysing the data acquired from the camera monitoring using a cascaded technique, Maksymiv et al., [2] introduce a new algorithm for identifying specific types of fire, smoke, and explosive crises. The first step in obtaining a ROI and reducing time complexity is to utilise Adaboost in conjunction with a local binary pattern (LBP). The author next suggested a Convolutional Neural Network as a solution to prevalent vulnerability issues, such as false positives (CNN). The end trial results demonstrated that this strategy could achieve an accuracy rate of 95.2% for emergency detection.

In order to identify fires, Hu et al., [3] suggests a deep learning-based approach. The three deep learning networks utilised in the proposal were VGG-16, AlexNet, and GoogLeNet. The network is trained to distinguish between three distinct states—normal, smoke, and flame—based on the image input from a closed-circuit television (CCTV) camera. The three locations where fire events were recorded are mountains, high-rise buildings, and residential regions. The photographs utilised in the datasets are from these three areas. All three network models achieved above 90% accuracy in fire detection classification, according to the experimental results.

Problem statement

Among the many issues plaguing nations in the third world, including those in asia, africa, and the americas, is the frequent occurrence of wildfires and the inadequate response by fire departments. The level of fire risk has altered because most of these countries are utilising innovative approaches to increase their capabilities. There is a lack of data on fire breakouts and losses, and collecting information is already a challenge in many countries. Finding a fire picture is the crux of the matter because it will provide the anticipated results.

Modules Description

Fire Video Frame Extraction: This module does all of the necessary video data processing for the system to function. Reading the video data and extracting picture frames from the video is its primary function in the system. It records the frame and sends it to the email address we provided in the event that a fire is detected. It is capable of distinguishing between genuine and fake fires. It does not sound an alarm or send an email alerting the user to the occurrence of a fire if it detects a false alarm.

Module for Converting Colors: The video's processing of raw video data might use various formats or setups. In order for the system to function, all of the data must be consistent in terms of format and configuration. This module facilitates subsequent processing of video data by converting it to RGB format.

An essential part of the system is the fire detector module. Pixel and frame analysis, two fundamental techniques for distinguishing between background and non-fire pixels, are the focus here. It is possible to further break this module down into its component parts by adding a classifier and two analysis parts [86-92].

The alarm module's main function is to sound an alert in the event that the frame in question is in danger of fire. In the last frame that the classifier component submits, this module keeps an eye out for pixels that indicate fire. As soon as a possible fire frame is identified, an alert is activated to indicate the existence of fire [93-99].

Materials and Methods

The technique here is machine learning, of which computer vision is a branch. Features that are similar to Haar-like features that are used in digital images for object recognition. The 'Integral Image' concept is employed by the Haar classifier to quicken the computation of the detector's features. The learning algorithm is built upon Boost. As a means of producing highly efficient classifiers, it reduces an extensive set of characteristics to a more manageable number. Combining more complex classifiers to form a "cascade" discards the image's non-face components, directing more computation towards promising object-like regions.

Once the classifier receives the enormous quantity of image data utilised for training, the initial step is to extract "Haar features" from every single one of them. If a picture has a relevant feature, one can use a convolution kernel called Haar Features to find it [100-111].

Nearly 180,000 features might be computed using Viola Jones's proposed method, "Integral Images," with a base window size of 24x24. Think about the difficulty of calculating the pixel difference for each characteristic separately. To address this computationally intensive procedure, the concept of the Integral Image was created. If you want to know how many pixels are inside a rectangle, you need to know the values of its four corners. This is because of the integral image [112-117].

Viola Jones did more than one thing to ensure the algorithm ran quickly; she employed a "cascade of classifiers" technique. The cascade classifier essentially uses a series of powerful classifiers at each stage. This is useful since it eliminates the need to apply all window characteristics at once. Instead, it breaks the attributes down into smaller windows, and the classifier evaluates if each window has a face. Assuming the opposite is true, the sub-window and everything in it are eliminated [118-123]. The sub-window moves on to stage 2 of feature application after passing the classifier. In Figure 1.

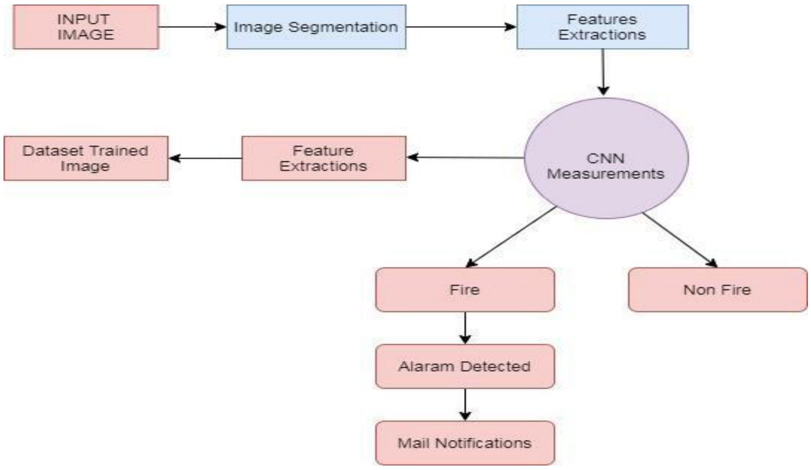

Figure 1: Data Flow Diagram

First, we create an image dataset. Then, we extract its features. Based on these features, we determine whether the image contains fire or not [124-129].

Here we are taking a movie or image and using image segmentation to split it up into individual frames. The following step is feature extraction, following segmentation. Once fire or non-fire is detected, we extract the feature from the pictures or video (Figure 2).

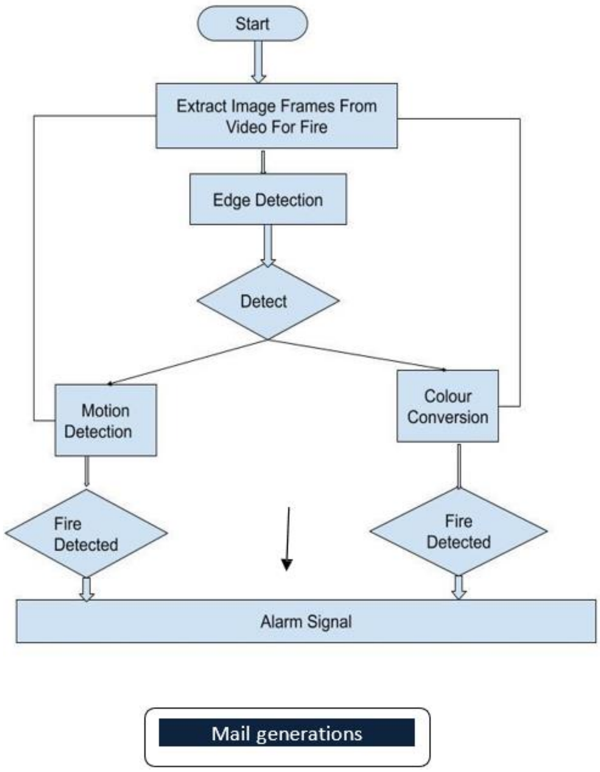

Figure 2: Flowchart Diagram

Results and Discussion
Software Description:

Python: Python is a robust programming language that is easy to learn. It uses object-oriented programming in a straightforward but effective manner and offers efficient high-level data structures. Python is a great language for scripting and fast application development on most platforms because of its interpreted nature, dynamic typing, and beautiful syntax [130-138]. You may get the Python interpreter and its huge standard library from the Python website. You can get them in binary or source form for all the main systems. And you can distribute them freely. You may find a plethora of free third-party Python modules, programmes, and utilities on the same site, along with their distributions and links to extra documentation. Additional data types and functions written in C or C++ can be quickly and simply added to the Python interpreter (or other languages callable from C). For programmes that need to be customised, Python is also a good choice for extension languages.

Deep Learning: A subset of the larger discipline known as Artificial Intelligence, deep structured learning (also known as hierarchical learning) is one of several machine learning techniques. In order to extract and transform features, deep learning algorithms require many layers of nonlinear processing units. The output from one layer is used as input by the next layer. When applied to domains like bioinformatics, computer vision, audio recognition, social network filtering, machine translation, and natural language processing, deep neural networks, deep belief networks, and recurrent neural networks have achieved results that are on par with, or even better than, those of human specialists. Feature extraction and transformation are performed using a family of machine learning algorithms known as deep learning, which employs multiple layers of nonlinear processing units. Algorithms and networks for deep learning that rely on learning features or representations of data at several levels without supervision.

Opencv-Python: If you're having trouble with computer vision, try using OpenCV-Python, a collection of Python bindings. The general-purpose programming language Python, created by Guido van Rossum, gained immense popularity due to its easy-to-understand syntax and high degree of code readability. The coder can convey their ideas with fewer lines of code while maintaining readability.

Keras: A Python interface for artificial neural networks is provided by the open-source software package known as Keras. Keras is a library that the TensorFlow library uses as an interface. Keras used to work with a bunch of different backends, such PlaidML, Microsoft Cognitive Toolkit, Theano, and TensorFlow. That was until version 2.3. Only TensorFlow is compatible with version 2.4. It prioritises ease of use, modularity, and extensibility in its design to facilitate rapid experimentation with deep neural networks. It was created by François Chollet, an engineer at Google, and is a component of the ONEIROS (Open-ended Neuro-Electronic Intelligent Robot Operating System) project. The XCeption model for deep neural networks was also written by Chollet.

To simplify the process of developing code for deep neural networks and to facilitate the work with both text and image data, Keras includes several implementations of regularly used neural network building blocks such layers, objectives, activation functions, optimizers, and a plethora of other tools [139-144]. There is a Slack channel and an issues page on GitHub where the community may go to get help with the programming. Keras may be used with classic neural networks as well as convolutional and recurrent ones. Dropout, batch normalisation, and pooling are some of the other typical utility layers that it offers.

Tensor Flow: The machine learning library known as TensorFlow is freely available and open-source. Although it has many potential applications, its primary focus is on deep neural network training and inference. TensorFlow is a library for symbolic mathematics that uses dataflow and differentiable programming as its foundation. Google employs it for both internal research and external production. For internal Google use, the Google Brain team built TensorFlow. In 2015, it was made available to the public under the Apache License 2.0. TensorFlow is the next-generation technology developed by Google Brain. The release date of version 1.0.0 was February 11, 2017. Although TensorFlow's standard implementation only supports a single device, it is capable of running on several CPUs and GPUs (with optional CUDA and SYCL extensions for general-purpose computing on graphics processing units). You can use TensorFlow on 64-bit Windows, macOS, Linux, and mobile platforms like iOS and Android. Computation may be easily deployed across several platforms (CPUs, GPUs, TPUs), including desktops, clusters of servers, mobile devices, and edge devices, thanks to its flexible architecture. Stateful dataflow graphs are the building blocks of TensorFlow calculations. A tensor is a multidimensional data array, and the actions that these neural networks execute on them are the inspiration for the name TensorFlow. Jeff Dean said at the 2016 Google I/O Conference that out of 1,500 GitHub repositories mentioning TensorFlow, just five were from Google.

Convolutional Neural Network(CNN)

Among the many types of neural networks used for picture recognition and classification, convolutional neural networks stand out. Convolutional neural networks find extensive use in many domains, including scene labelling, object detection, face recognition, and many more. Convolutional neural networks (CNNs) use pre-processed images to identify and categorise objects, such as dogs, cats, lions, tigers, etc. Depending on the image's resolution, the computer interprets it as a series of pixels. How it appears will depend on the image's resolution; h* w* d stands for height, w for width, and d for dimension. The matrix's 6*6*3 array represents an RGB image, whereas the 4*4*1 array represents a grayscale image. Convolutional neural networks (CNNs) employ a series of convolutional, pooling, fully connected, and filtering layers for each input image (Also known as kernels). This will be followed by a probabilistic item classification using the Soft-max function.

Restnet50: ResNet, which stands for Residual Networks, is a foundational classic neural network in computer vision. The 2015 ImageNet competition was won by this model. The main achievement of ResNet was its ability to successfully train very deep neural networks with 150+ layers. The issue of vanishing gradients made training extremely deep neural networks challenging before ResNet. Compared to ResNet 152's 152 layers, VGG's 19 Inception layers, GoogleNet's 22, and AlexNet's eight, the model that won ImageNet 2012 and seemed to start the focus on deep learning only had eight convolutional layers. This blog post will teach you how to code a ResNet-50, a condensed version of ResNet 152 that is commonly used as a foundational model for transfer learning.

Gmail Generation Model: Producing the plain text of an email, which is represented by an object structure called a message object, is a typical task. In order to send your message through the smtplib or nntplib modules, or to print it out on the console, you'll have to do this. The Generator class is responsible for taking a message object structure and turning it into a plain text document. Similar to the email, once again. In the parser module, you can create your own generator from the ground up if you want to go beyond what the included one can do.

When you use the generator on the application's Message object, though, it can seem different since the programme uses defaults. The BytesGenerator class allows one to produce bytes as a result. If the message object structure contains bytes that are not ASCII, the flatten() method of this generator will return the original bytes. It should be possible to use BytesGenerator to parse and flatten any communication that complies with the standards.

Revolution of Depth: Nevertheless, adding more layers to a network will not increase its depth. The infamous vanishing gradient problem makes deep networks challenging to train; as the gradient is back-propagated to older layers, it could become incredibly small due to repetitive multiplication. Consequently, the network's performance becomes saturated or even begins to degrade quickly as it goes deeper. With the use of real-time computer vision techniques built using the OpenCV package, the primary objective of this study is to automatically detect fire in a video frame. Current security systems, including commonplace industrial or personal video cameras, must be compatible with the suggested approach. The camera must remain stationary in order for the solution to be applied. From the perspective of computer vision and image processing, the mentioned issue is the identification of objects that are constantly changing in appearance using colour and motion characteristics. The backdrop detection method effectively segments moving objects in video sequences, even while static cameras are used. It uses rule-based colour detection to identify potential areas of foreground items that resemble flames.

Conclusion

In order to find candidate regions, a Faster R-CNN network that has been trained for fire detection was utilised. Linear Dynamical Systems (LDS) can be used to validate fire zones that have been spotted. Our datasets should be expanded with the help of photographs so that we can evaluate how effective the proposed methodology is. For the purpose of detecting fires in video sequences, the proposed method should be expanded to include dynamic textures. For the purpose of distinguishing between fire-colored objects and actual fire, we utilised VLAD encoding, which not only enhances efficiency but also dramatically reduces the number of detection errors. The findings demonstrate that the suggested method maintains high true positive rates while simultaneously reducing the number of false positives that are caused by items with a fire-colored appearance by a significant amount.

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