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Fire Detection By Real time Video Analysis Using OpenCV

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Abstract
We propose a system to detect fire visually through any visual data source, for instance- CCTVs, Web Cams and other preinstalled cameras. The main advantage of this system is how we need not install any new hardware for the same. It will work on pre-existing hardware networks using our software application. Fire detection is a major threat to urban lives and the increasingly harrowing cases of wildfires have made it a huge threat to our society as well as our environment. We aim to propose a system that would help combat and control fires to such an extent so as to actually make a difference.

Keywords: Fire Detection, Python, Open-CV, Fire control and monitoring

1. INTRODUCTION

For as long as we can remember, fire is something that has always been very hard for us humans to control. We have been using controlled fires for much more than a millennium in order to shape the civilization around us. But, ever so often; be it through the wild fires or those caused through human folly, we are made aware of the horrors that it can cause.

Uncontrolled fires can wreak absolute havoc and can even cause numerous fatalities. For such a formidable opponent, we have done little to nothing to combat it. As you will see through this paper, none of the existing systems have been effective in controlling or monitoring fire in the slightest.

In this paper, we propose a system to detect fire visually through any visual data source, for instance- CCTVs, Web Cams and other preinstalled cameras. The main advantage of this system is how we need not install any new hardware for the same. It will work on pre-existing hardware networks using our software application. Fire detection is a major threat to urban lives and the increasingly harrowing cases of wildfires have made it a huge threat to our society as well as our environment. We aim to propose a system that would help combat and control fires to such an extent so as to actually make a difference.

Also, because detection is done in real time, it can not only be used as a fire monitoring system but can work excellently to help control and combat fires. With recorded footages of fire saved after an incident, it provides a greater possibility to analyze, detect and sometimes even correct the causes of the fire breakout.

There are a few existing systems, but their efficiency is questionable at best. The most difficult part is to differentiate actual fires from false positives. False positive is a huge concern when it comes to fire detection and to counter that we propose to use HSV algorithm instead of the regular RGB algorithm.

We aim to collect visual data from live sources or in other words, monitor live data for any fire -like footages. If found, the camera starts recording the footage and sends the recorded footage along with the sound alarm to the nearest designated authority.

2. EXISTING SYSTEM

The proposed system uses Convolutional Neural networks or CNNs as proposed in [1]. In [1], they propose to use special type of neural networks that make early fir detection more effective. Although this is better than the earlier methods of fire detection, the enormous amounts of time that it requires and the heavy resources that it consumes has made this system highly inefficient and hence has hardly

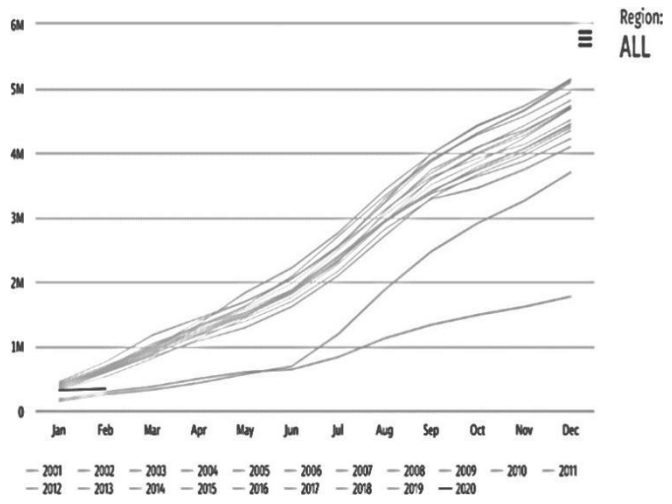
been implemented in the real world yet. The existing system is so heavily dependent on advanced technical concepts like machine learning that grasping the idea of it has become at least slightly more difficult.
The existing system also requires more time and monetary cost which are both highly valued. The existing systems all use RGB color algorithms and the architecture diagram is more complicated. It also makes use of proximity sensors and thermostats which are quite expensive to use in large scale. It suggests to use networks like RESTNET 50 and VGG16.

3. LITERATURE REVIEW

Apart from [1], we reviewed seven different papers, to get a better understanding of the actual system an also to detect and correctly identifies the flaws in the current system.
The [2] makes use of Visual C++ and Open-CV to identify fires. It mostly deals with outdoor fires. The outdoor fires or wildfires tend to display more movements according to the wind and are usually of high intensity. They use the YUV color model instead of the RGB in [2]. [2] also makes use of BLOB architecture, where in suspected footages of the screen supposedly depicting fire is converted to a blob and the size of this BLOB determines the fire.
[3] makes use of foreground Image accumulation and optical flow techniques. Each accumulated frame is proposed differently and in two instances to detect smoke and actual fire. These are the tell tales signs of an actual fire. Physical movement detection is used to determine the fire.
[4-10] proposes a false alarm rejection rate which hikes up its actual success rate of 92.7%. This system is implemented in C++and Open-CV. The next model proposed in [5] is inexpensive and practical but sadly also not feasible at all. The outdated BLOB architecture is left behind for a newer more modern Block-based algorithm that performs much better practically. They work up a technique called background subtraction using Adaptive Median Algorithm. [6] use Multi Expert System [MES] for different classifiers. With an efficiency rate of 83.87% it primarily focuses on fire detection through surveillance cameras.
Researching these different papers has helped us come to a conclusion that the best image processing model would be to use HSV algorithms as they produced the highest success rate. Also, it has led us to believe that instead of MATLAB, Open- CV and Python would be our best software choices to achieve accuracy and efficiency with the least amount of resources[11],[12]..

4. STASTICAL DATA ANALYSIS

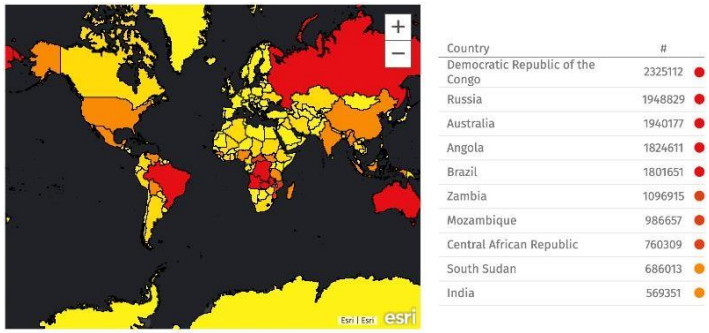
In this section, we have gathered data from various sources that shows trends in fire alerts over different periods of times.



Graph 2:Fire alerts seasonal progressions

The above graph shows the seasonal progression of fire around the world from 2001 till February of 2020. From the above graph it is abundantly clear that through the years, there has hardly been any change in the occurrences of fire around the world.

Each line in the above graph represents the seasonal progression of a whole year starting from January through December. With over twenty years of data, our hypothesis of fire breakouts being extremely consistent has been established quite successfully. There have been only two years that act as the exception to the rule, all others seem to follow the established hypothesis.

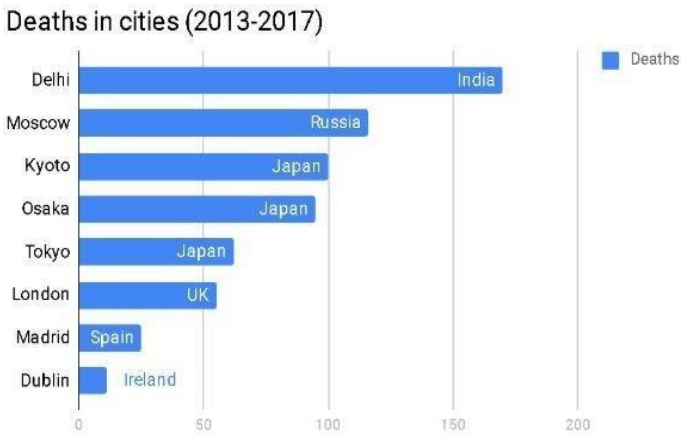


Graph 3: Greatest number of Fire Alerts by Province

The above graph depicts the greatest numbers of fire alerts by province from 3rd February 2019 till 2nd February 2020. As you can see, Democratic Republic of the Congo has had the greatest number of fires in the given time period with 2,325,112. While comparatively, India has had 569,351 fire alerts in the given time frame.

These fires also cause a lot of damages to property as well as life. The fatalities that occur in the cities due to preventable fires is particularly alarming.

The below graph depicts the number of deaths that occur in a city due to fire breakouts all around the world. Analyzing the three graph it is clear that India has a huge issue with fire casualties that could be very well prevented if there was some kind of monitoring system to at least provide a bit of a control over the system [13].



Graph 1:Number.of Fatalities across cities

India has a huge issue with deaths related to fire. Delhi has the highest death rate due to fire in the whole world with more than 150 casualties succumbing to their injuries in the capital. This shows the

extremely poor city management standards that are upheld in the city. With the advent of our new proposed system, fire management and control will become not only easy, but also quite cheap. The already pre-installed city-wide CCTV cameras could simply be connected to a server and then the whole city will come under real time Fire detection and Monitoring.

Solutions like these need to be implemented as soon as possible because of the increase in number of deaths due to fire, this past year .

4. PROPOSED SYSTEM

The proposed system aims to remove all the inefficiencies of the existing system all the while being more cost and resource effective.

After thoroughly reviewing the existing system, conducting a literature review and also extensively analyzing various statistical reports, we can safely conclude that Fire is an alarming issue that has been consistent for the past 20 years despite the gigantic leaps that we have taken in technology that could have been used to control and minimize the destruction caused by it. There has been little progress in the field which should have had a lot more progress by now.

The proposed system aims to change that.

We aim to collect visual data from live sources or in other words, monitor live data for any fire -like footages. If found, the camera starts recording the footage and sends the recorded footage along with the sound alarm to the nearest designated authority.

Also, because detection is done in real time, it can not only be used as a fire monitoring system but can work excellently to help control and combat fires. With recorded footages of fire saved after an incident, it provides a greater possibility to analyze, detect and sometimes even correct the causes of the fire breakout.

5. SOFTWARE SPECIFICATIONS

We used Python as our programming language due to the vast libraries that it has to offer. It is portable and dynamic. It is very flexible and has a powerful ecosystem of packages that can be easily manipulated to create a wide variety of functions. We used Anaconda navigator as a user-friendly GUI . The wide variety of Python libraries that were used include Numpy, Pandas, SKlearn, Open-CV and Seaborn amongst others. Open-CV is basically used to process the visual data that is gathered.

6. KEY MODULES USED

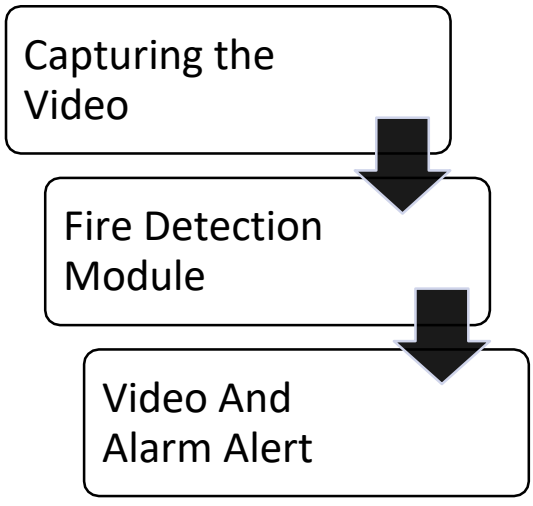


Figure 1: Modules Used

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As seen from above figure, we have three basic modules-

I. Capturing the Video- This refers to collection or gathering of visual data through any pre-installed cameras.

II. Fire detection Module- This covers the different algorithms required to detect fire.

III. Video and Alarm Alert- This Module deals with passing sound alert as well as the recorded tape of the fire detected to the nearest authorities.

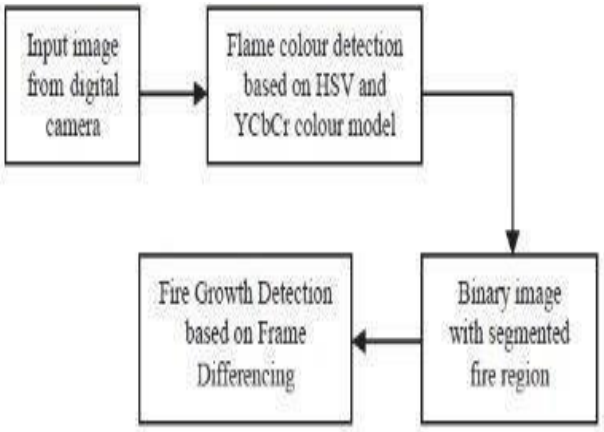

Figure 2: Architecture Diagram

The first and foremost step is to get input from the digital camera. Then, Flame colors are detected based on HSV Model. The noteworthy point here is that only flames, which are moving erratically enough are actually captured so as to reduce the number of false alarms that are possible.

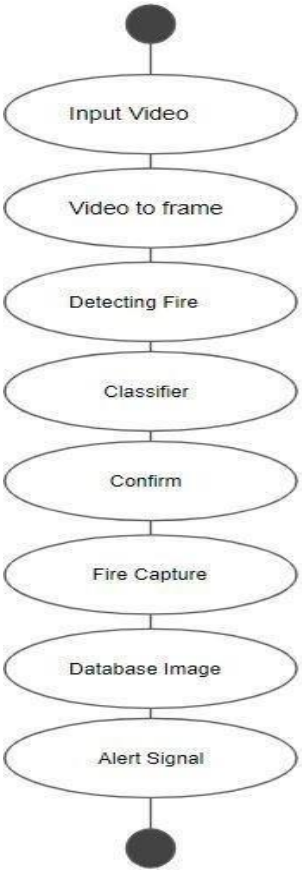

Figure 3: Activity Flow Diagram

6. FIRE DETECTION MODULE

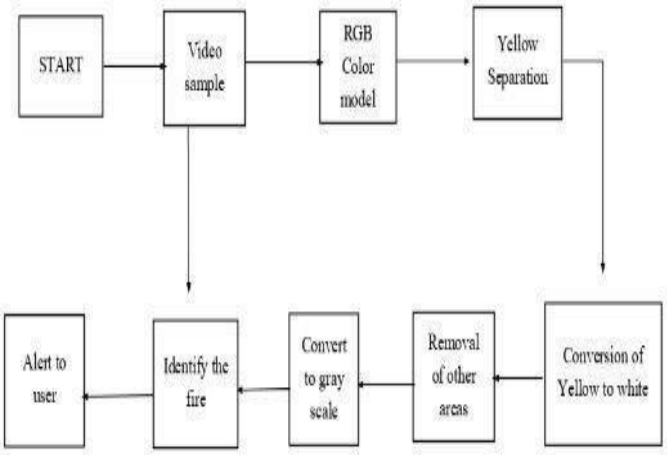

Figure 4: Fire Detection

For better fire detection, our model converts the captured images/video from RGB Model to HSV model.

HSV Model

The HSV algorithm includes HUE and Saturation which are similar to the functioning of the human eye which processes the color resulting in the image processing algorithm along with the physiological factor. The Value component represents the intensity of color that is decoupled from the color information of the represented image.
The mathematical logic of the conversion is explained below:

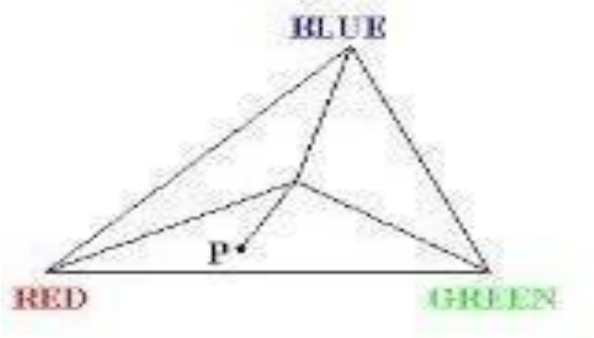

Figure 5:RGB Model

The Hue of the point P is the measured angle between the line connecting P to the triangle center.
The saturation of the point is the distance between P and the triangle center.
The intensity of the point is represented as height on a line perpendicular to the triangle and passing through its center. The gray scale points situated out on the same line, and the conversion formula is as follows:

Equation 1: Hue

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right\}$$

Equation 2:Saturation

$$S = 1 - \frac{3}{R+G+B}[\min(R,G,B)]$$

Equation 3:Value

$$V = \frac{1}{3}(R+G+B)$$

After conversion, the segmentation of fire region from a video frame is the first requirement for the fire detection algorithm.

6. ADVANTAGES

- Does not require expensive sensor systems.
- Much more efficient in image processing
- Uses pre-installed cameras so is easier to implement
- Can be used by Governments to ensure fire safety.
- Far less no. of false alarms.

CONCLUSION

With the alarming issue that fire has become, we need to combat it with equally robust techniques. Our proposed system is one such monitoring technique that will be easy yet equally effective to implement. With the usage of the HSV algorithm instead of the older RGB, the system has become even more efficient and hence can positively make differences in the real-world scenarios.

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