CHAPTER: 17

A COMPARATIVE STUDY ON FOREST FIRE DETECTIONAPPLICATIONS

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ABSTRACT

Forests are regarded as one of the most valuable and necessary resources. Forest fire is one of the most common dangers in the woods. It has a significant negative impact on the forest and results in a significant financial loss. To protect natural resources as well as human safety and property. Early detection of forest fires can have a major effect on forest fire management. Various researchers have suggested a variety of forest fire detection techniques. There are a plethora of methods for detecting forest fires. A fire detection system for the use of an IR camera in UAV-based forest fire surveillance. The accuracy and reliability of forest fire detection are improved with this method. This paper is a review of the literature on forest fire detection.

Keyword: *Forest Fire Detection, UAV Based Forest Fire Surveillance*

INTRODUCTION

Forests are the keepers of the planet's ecological equilibrium. Forest fires have the potential to cause a slew of environmental hazards, wreaking havoc on the economy and putting human lives in jeopardy. Forest fire detection and monitoring has grown in importance as a means of conserving natural resources and ensuring human protection and property, and it is gaining worldwide attention. Because of the increasing number of large-scale forest fires around the world, automatic fire detection has become an effective technique for early fire detection. Unfortunately, forest fires are normally discovered after they have spread through a wide area of forest, rendering fire prevention and suppression very difficult, if not impossible.

The effect is catastrophic destruction and irreversible harm to the ecosystem and climate (Forest fires are responsible for 30% of CO_2 in the atmosphere), as well as irreversible ecological weakening. Long-term calamitous effects, such as impacts on local weather patterns and global warming, are among the many horrifying repercussions of forest fires. Forest fires are a concern since they usually happen in rural, unmanaged areas that are heavily forested, with trees, dry and dehydrating wood leaves, and other debris that act as a fuel source. These elements combine to create a highly flammable material that can be used to start a fire and later act as fuel.

Human activities such as smoking or barbecue parties can trigger fire ignition, as can natural factors such as high temperatures on a hot summer day or broken glass acting as a collective lens concentrating the sun's light on a small spot for an extended period of time, resulting in fire ignition. When a fire begins, flammable materials can easily feed the fire's central location, which grows larger and spreads quickly. The first stage of ignition is commonly referred to as the "surface fire" stage. This can lead to feeding on nearby tree sand, with the fire flame rising higher and higher, eventually becoming "crown fire." Typically, at this stage, the fire becomes sun controllable, and landscape damage can become excessive, lasting for an extended period of time depending on weather conditions and terrain. Every year, a vast area of forest is destroyed by fire. Early detection of a fire and monitoring of the potential danger will greatly reduce the response time, as well as the potential damage and firefighting costs. The following is a list of known rules: 1 cup of water in 1 minute, 100 liters in 2 minutes, 1,000 liters in 10 minutes.

The goal is to find the fire as quickly as possible, and pinpointing its exact location and telling fire units as soon as possible is critical. This is the flaw that the current invention aims to address at an early point, in order to improve or guarantee the possibility of putting it out before it grows out of control or causes serious harm. Authorities use a variety of identification and tracking technologies. Observers in the form of surveillance towers, satellite monitoring, and increasingly encouraged detection and monitoring systems based on optical camera sensors, as well as various forms of detection sensors or combinations of them, are among these. HIS document is an example of the desired layout for a PES Transactions/Journal paper. It contains information regarding desktop publishing format, type sizes, and typefaces. Style rules are provided that explains how to handle equations, units, figures, tables, abbreviations, and acronyms. Sections are also devoted to the preparation of acknowledgments, references, and authors' biographies.

RESEARCH PAPER RELATED TO FOREST FIRE DETECTION

Jorge Moragues, Ignacio Bosch, Luis Vergara - A scheme for automatic forest surveillance is defined in this paper. Although we concentrate on infrared image processing, we first present an absolute method for forest fire detection. Each pixel in an infrared image is associated with a pixel matrix, and each pixel is associated with a resolution cell, which is located using azimuth and range coordinates. First, estimate the complexity of automatic alarm detection in one resolution cell, likely to determine the presence of fire, until the energy level of the test pixel exceeds a certain threshold. If the noise's statistical distribution is well understood, the threshold can be used to satisfy a desired probability of false alarm (PFA), yielding a probability of detection (PD) that is proportional to the signal to noise ratio (SNR). Pixels by pixel, the captured images are processed. The newly developed scheme, which is based on infrared image processing, detects any fire danger early. The algorithms implement the fusion of various detectors that leverage different anticipated features of a real fire, such as tenacity and increase, with the aim of detecting the presence or absence of fire. Theoretical and functional stimulations are consistent with device monitoring related to false alarm probability.

The signal to noise ratio (SNR) is often used to measure the probability of detection (PD). Using a noise predictor, we can use these additional statistics regarding infrared background noise to increase the SNR. SNR can be improved by subtracting the approximate amount from the pixel under test. It's worth noting that increasing the SNR results in a higher PD for a given PFA. The scheme, which is based on infrared image processing, detects any fire hazard early. The proposed algorithms perform the fusion of various detectors that manipulate different predictable features of a real fire, such as determination and increase, in order to determine the presence or absence of fire. Theoretical and realistic simulations are provided to align the system's regulation with the likelihood of false alarm (PFA). The dependency of the probability of detection (PD) on the signal to noise ratio (SNR) is also calculated. [1,2]

J. Xiao, Jie Li, Junguo Zhang - Certain fire automatic detection, alarm, and control functions are needed in modern forest fire prevention facilities due to the characteristics of unexpected, stochastic forest fires, which make real-time monitoring difficult. A remote surveillance device based on a network video camera has proved to be a reliable technical support for real-time surveillance in recent years. This system includes a monitoring management command centre, wireless transmission, camera, lenses, console control, and power supply. The use of digital image processing to identify fires will significantly increase the technical content and level of automation of a fire detection system. The concept plan and practical implementation of developing a fire monitoring system based on digital image facts was conceived in light of the difficulty of monitoring forest fire. The device is based on a CCD camera that captures a continuous image. Applying a digital image processing algorithm to the configuration features, dynamic features, and color information of that interesting region of fire, and then recognizing the fire trigger based on the obtained features. The results of the experiment show that the device can correctly detect and confirm a fire. [3,4] C. Yuan - The identification of forest fires is the subject of this article and a system of monitoring using unmanned aerial vehicles (UAVs) is proposed. The second unit is a forest fire detection and tracking system focused on unmanned aerial vehicles (UAVs). The majority of early researches use videos to detect fire, and then researchers eventually use cameras to detect fire in real-world situations. Color, motion, and geometry are the three most common characteristics of fire used in vision-based fire detection. Image recognition algorithms are at the heart of a wide range of vision-based approaches. This paper conducts starter research on building up a progression of picture preparing calculations able to do viably distinguishing and observing backwoods fire to accomplish the objectives of programmed woodland fire recognition and following. The proposed method's basic concept is to use the Lab color model's channel "a" to extract fire pixels using chromatic features of fire. [5]

Wen-Bing Hang, Jim-wen peg - The identification of fire flames is a critical problem because it affects everyone's safety and property. Notwithstanding customary bright and infrared fire identifiers, molecule examining, temperature inspecting, and air straightforwardness observing are normally utilized fire identification strategies. However, the majority of these detectors have significant flaws. They need to be close to the flame to work. To meet the above prerequisites, another visual continuous fire location approach dependent on PC vision methods and chromatics hypothesis is proposed in this paper. To characterize fire highlights extricated from an assortment of fire pictures, the HSI shading model was picked. In light of the extricated fire attributes, the shading division technique is utilized to generally section areas with fire-like tones. The picture contrast measure and a developed chromatics-based shading veiling method are then used to reject false fire-like districts, for example, objects with indistinguishable fire tones or zones reflected from fire blazes.

They've contrived rules for lighter and more obscure settings. To prevent fire aliases, lower intensity and lower saturation pixels are removed after segmenting the fire area using HSI rules (fire like region). They also developed a metric for measuring the burning degree of fire flames, which includes no fire, small, medium, and large fires, based on binary counter difference images. They got both false positives and false negatives as a result of their work. However, changing the threshold value has little effect on the number of false positives and negatives. The experimental results show that with thirty frames per second, the proposed method can achieve a detection rate of around 97 percent. Furthermore, the method can identify fire flames in test videos within one second, which appears to be very encouraging. [6,7] Turgay, Hasan Demirel - In this paper, For flame pixel classification, a rule-based generic color model is proposed.

The proposed method constructs a standardized chrominance method for flame pixel classification using the yCbCr color space. In addition to translating the RGB and normalized Rgb rules to the YCbCr color space, new rules in the YCbCr color space are introduced to further mitigate the harmful effects of changing illumination and improve detection efficiency. The proposed system's flame pixel classification rates are compared to the previously implemented flame pixel classification model using new rules and a new standardized chrominance model. Except for the flame middle, this method segments the flame area. However, with a method that only classifies fix pixels based on color information, this proposed model gives a 99.0 percent right flame pixel classification rate. The rate of false alarms is 31.5 percent. This is a major advancement from other methods that have been used in the literature. [8]

J. Zhao, Z. Zhang, S. Han, Z. Yuan - Forest fire control, unlike other types of fire surveillance, has its own set of characteristics. The cameras are mounted on the tops of mountains, where the wind makes them unstable. The cameras' focal length may be adjusted, and the size of objects in captured images varies. The majority of the research papers focused on fire detection. All of them have posed significant challenges for vision-based fire detection, necessitating further research into the case of forest fire identification. This proposed forest fire detection algorithm takes into account both static and dynamic features. A support vector machine (SVM) was used, which was trained with static features derived from a Gaussian mixture model. Fire was successfully detected, but there were still false positives when red objects were present in the picture. [9]

T.Qiu ,Y.Yan, G.Lu - The viability of many edge-discovery techniques in recognizing fire edges has been tried. In spite of the way that these techniques are utilized to change a few boundaries. Edges extricated from non-insignificant pictures are hindered by fracture, implying that the edge bends are not associated; edge fragments are bogus edges that don't look like remarkable wonders in the picture. It is attractive to make an edge recognition framework for fire and fire picture preparing. [10]

D.Y. Chino, L.P. Avalhais, A.J. Traina - Emergency situations can result in financial losses, environmental disasters, or severe human life loss. Existing systems are based on ultraviolet and infrared sensors, and they typically use particle sampling to investigate the chemical properties of fire and smoke. This method uses visual features extracted from captured images to detect fire in images captured by camera without details. To address the aforementioned issues, we suggest a new method for detecting fire in still images that combines two techniques: pixel color classification and texture classification. The use of fire traces creates distinct textures that help distinguish between real fire and charred areas. Also with the details present in the images, a high degree of detection accuracy can be achieved. Bow Fire (Best of Both Worlds Fire Detection) is the paper's key contribution, a novel approach for detecting fire in still images. Our process, which combines color and texture information, proved to be successful in detecting true-positive fire regions in real-world images while excluding a large number of false positives. Our approach employs fewer parameters than previous studies, resulting in a more intuitive process for fine-tuning automatic detection. [11,12]

K.Angayarkkani, N. Radhakrishnan - Forest fires are a major environmental threat, wreaking havoc on economies and ecosystems while putting human lives in risk all over the world. The point of this paper is to introduce an Artificial Neural Network-based technique for recognizing woods fires in the timberland (ANN). The advanced pictures of the woods fire are changed over from RGB to XYZ shading space and afterward fragmented utilizing an-isotropic dispersion to isolate the fire regions. In the astute machine's engineering, the shading space estimations of the portioned fire locales are resolved utilizing a Radial Basis Function Neural Network. [13]

T.celik, H.demirel, H.ozkaramanli - A method for combining color information from fire with temporal changes in video sequences is proposed. To prevent the effect of shifting light, a number of laws use normalized values. Statistical analysis is performed in the rg, rb, and gb planes using this approach. In each plane, lines are used to define a triangular region that represents the pixel's region of interest. If a pixel falls within the triangular area of the rg, rb, and gb planes, it is designated as a fire pixel. The normalized RGB color space overcomes the effects of variance in illumination to some degree, and the YCbCr color space with separate illumination and chrominance achieves even further change. [14]

LITERATURE REVIEW

Sensor

Sensors are now used in nearly every fire detection system. The sensor's precision, reliability, and positional distributions decide the system's improvement. In open-air applications, large numbers of sensors are needed for high-accuracy fire detection systems. Sensors often need a continuous battery charge, which is impossible to achieve in a wide open area. If there is a near proximity to a burn, sensors sense it. This will result in sensor damage. For fire detection, camera monitoring, and wireless sensor networks, two types of sensor networks are now available. Sensors, digital cameras, image processing, and industrial computers have contributed to the creation of a modern technology framework for early detection and warning of forest fires using optical sensors. In terrestrial systems, various types of detection sensors may be used.

1. A video camera that can detect the visible spectrum of smoke during the day and a fire at night,
2. Infrared (IR) thermal imaging cameras, which monitor the flow of heat from a fire.
3. Infrared spectrometers to classify smoke's spectral characteristics

4. Light detection and ranging systems— LIDAR (light detection and range) systems that calculate laser rays reflected from smoke particles.

Regarding recognizing smoke and fire gleam, the different optical frameworks, which work as per different calculations concocted by the developers, all have a similar fundamental thought. To put it another way, the camera takes pictures. The handling unit tracks picture movement and decides the number of pixels contain smoke or fire gleam, at that point sends the outcomes to another calculation to choose whether or not a caution ought to be produced for the administrator.

Computer Vision Based Systems

Because in the rapid advancement of digital camera technology and video processing, these are replacing traditional fire detection systems. Three phases are used in computer vision systems.

1. Flame pixel classification.
2. Segmentation of moving object.
3. Analysis of the candidate region.

The yield of the fire pixel classifier, which makes significant zones on which the remainder of the framework works, decides the effectiveness of the fire discovery framework. Subsequently, an exceptionally exact fire pixel classifier with a low bogus identification rate and a high obvious recognition rate is required. A video flame detection algorithm that uses context subtraction and color analysis to classify candidate flame regions on the video frame and then uses a collection of fire extracted features, including color likelihood, to differentiate between fire and non-fire objects. While there are some algorithms that specifically deal with fire pixel classification, there are some that deal with spatial variation, temporal variation, spatial temporal variation, and contour variability of candidate blob regions. The description of fire pixels can be applied to both grayscale and color video sequences.

CCD Cameras

Low-cast CCD cameras are utilized to screen fires on long-range traveler planes. Non-picture highlights like dampness and temperature are joined with factual highlights like mean, standard deviation, and second request minutes in this cycle. To avoid false alarms, the technology can also be used in smoke detectors. The framework likewise incorporates a visual assessment work for the airplane team to affirm the presence or nonattendance of fire. A warm camera or a container slant zoom camera can be added to the unit. EYEfi does not currently provide automatic smoke detection, but expects to do so in the near future. Simply put, EYEfi can provide photos to fire departments if an operator detects smoke and uses EYEfi software to locate the smoke location on the ground using a GIS chart. For added precision, the device includes a weather station and a lightning detector.

UAV-Based System UAV-Based System

To address the impediments of customary strategies, more complex backwoods fire location approaches incorporating distant detecting procedures with different stages (like satellites, ground-based vehicles, and airplanes) are being created. As a result of the advancement of new technologies. Because of their fast mobility and upgraded work force wellbeing, there has been a flood sought after for automated airborne vehicles (UAVs) for woodland fire observation and identification. A commonplace UAV-based woodland fire observation framework is portrayed in the graph beneath. It consists of a group of unmanned aerial vehicles (UAVs), various types of onboard sensors, and a central ground station? The aim is to use UAVs to detect and monitor fires, forecast their spread, and provide real-time fire information to human firefighters, as well as to use UAVs to extinguish fires. The unit can direct fire checking (track down a likely fire and alarm firefighting work force), identification (track down a possible fire and caution firefighting staff), finding (process boundaries of the fire site, seriousness, and development), and guess (anticipate the fire's result) (forest the fire spread).

Figure 1: Schematic Illustration of the UAV Based Forest Fire Surveillance System.

Forest fire surveillance seeks to track the presence of fire before it occurs, while fire detection seeks to confirm if a specific fire is burning. The point of fire conclusion is to assemble however much data as could be expected about the fire. Fire visualization expects to track and conjecture fire spread dependent on continuous conditions, timberland vegetation design, and fire boundaries as valuable instruments for operational firefighting. Developing endeavors in late many years The development of

1) Frames for UAVs (fixed wing and revolving wing types) conveying the fundamental payload for fire recognition and observation is one of the essential exercises needed to finish the previously mentioned assignments with minimal measure of impedance from human administrators (far off detecting sensors for daytime, evening time, and every climate condition). 2) Remote sensing tools for fire detection and control; 3) For quick fire discovery, dynamic, and restriction, sensor combination and picture handling techniques are utilized. 4) Direction, route, and control (GNC) calculations for single and various automated ethereal vehicles (UAVs) for fire reconnaissance, identification, following, and forecast, just as fire smothering tasks; 5) UAV confinement, arrangement, and control strategies for ideal inclusion of fire territories for precise and quick fire discovery, expectation, and firefighting support/direction; 6) Before and after a fire is observed, autonomous and efficient route planning and re-planning techniques based on the fire growth situations; 7) Land station with satellite and remote correspondences, ground registering, perception for fire location, picture preparing, checking and determining with programmed alarm, and secure and proficient activity of UAV frameworks during the mission.

As can be appeared, quite possibly the most basic components in the UAV-based woods fire discovery framework is the PC vision-based fire location method. This is due to its various advantages, including the ability to track a wide variety of objects, provide intuitive and real-time images, and conveniently record data. Charge-coupled gadget (CCD) and infrared (IR) cameras, specifically, are generally mounted on UAVs. The innovation of a more proficient picture handling plan for fire location has gotten a ton of consideration. Shading and movement includes in CCD camera visual pictures are frequently utilized for fire identification. However, in some outdoor applications, the use of CCD cameras is generally thought to be insufficiently stable and reliable. The bogus alarm rate is in every case high in profoundly unique, non-organized backwoods conditions, the danger of smoke obstructing the fire, or the circumstance for analogs of fire, for example, rosy leaves influencing in the breeze and light reflections. In spite of the way that IR cameras are more costly than CCD cameras, they are frequently used to catch monochrome photos in both the day and the evening. Since IR pictures might be caught in low to no light, and smoke seems straightforward in IR pictures, IR cameras are generally used to catch monochrome pictures during the day and around evening time. The use of this effective approach is expected to minimize the number of false fire alarms and improve the forest fire detection system's adaptive capabilities in different environments.

Cascading

The accuracy of recognition is improved by using a cascade classifier. It is made up of several levels, each of which includes a powerful classifier. Those powerful classifiers are bypassed, and all of the features are divided into stages, each with a specific number of features. These stages are used to decide whether a given input sub window has fire features or not. If there are no fire features, the sub window is discarded and the process moves on to the next stage. Cascade detection is depicted schematically in Figure 2. Maybe than utilizing the entirety of the highlights in a window (over 6000), the highlights are separated into phases of classifiers, as found in Figure 2, for certain stages being stage 1 and stage 2. More often than not, the initial not many stages will just have a couple of capacities. In the event that the window comes up short, it is disposed of and the interaction is restarted with the second phase of highlights. A window or stage is known as a fire when it passes the entirety of the fire's qualities.

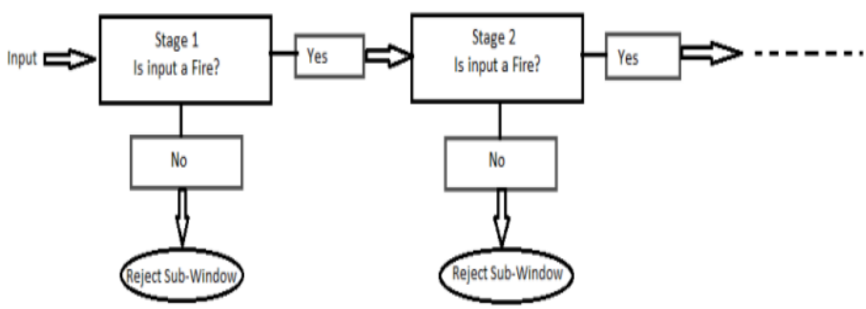


Figure 2: Schematic Description of cascade detection

System Design

We're using a Raspberry Pi 3 M0del B as a computing unit for this system's fire detection using image processing. It's the machine that does all of the code and image processing. The Raspberry Pi is connected to a USB camera, as seen in the block diagram Figure 6. The USB camera is the primary source of feedback for processing the live video that the USB camera captures. The machine continuously tracks the surroundings after processing the video using the Haar Cascade Classifier algorithm. If a fire breaks out in the vicinity, the webcam detects it and sends a fire warning to the user. If there is no fire in the scene, the video is continuously processed in the code until a fire is identified, at which point the only consumer receives a fire warning. The phases of the system are depicted in Figure 3 below.

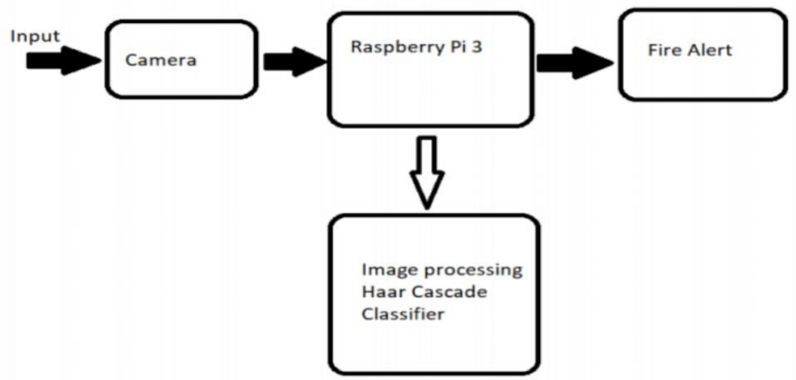


Figure 3: Block diagram

Algorithm

As previously mentioned, the first step is to train the classifier. Since training for the highly accurate classifier takes a long time and a lot of computing power, we only used a small number of images here. The caught outline from the webcam is changed to grayscale subsequent to preparing the fire course classifier. Since the frame taken by the webcam is in RGB color, it was converted to grayscale. Since RGB images have three color channels, converting the image to grayscale reduces the number of channels to only one, either black or white, making it easier to process. After that, the fire classifier is used with the built-in function detecMultiscale, which aids in the identification of image features and locations. Scale factor and minimum neighbor are examples of parameters that are moved. When it comes to detecting flames, these aspects are crucial. Since the scale factor allows re-scaling the size of an input frame to detect the fire when training the classifier, it is used to create a scale pyramid. The quality of an image is determined by another parameter, the min 24 neighbor factors, which are set to 7 for this thesis.

Flowchart

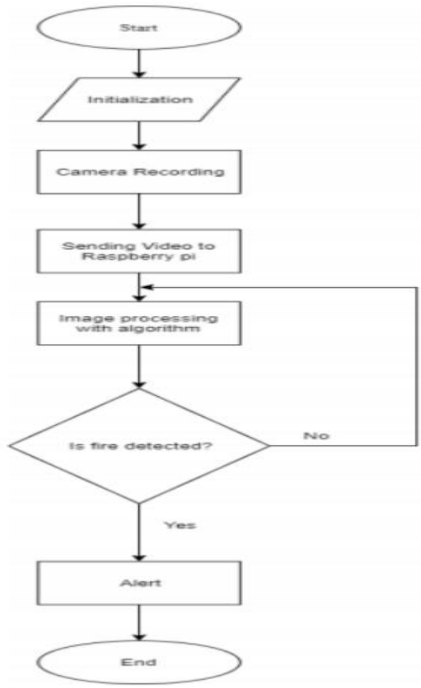


Figure 4: flowchart

Figure 4 is a flowchart of the device that depicts how it works. The video is first fed into the webcam, and then forwarded to the Raspberry Pi for processing. It will evaluate the picture that is accessible in the classifier using a cascade classifier. If a fire is detected, the code will run and a fire warning message will be displayed; if no fire is detected, the device will proceed and no fire alert will be displayed. Until a fire is detected in the target area, the device remains in the same loop.

Software Requirement

The application is written in Python, a high-level programming language that is simple to learn and use, and it makes use of the open CV library for all image processing systems. Also, since Python is preinstalled in the Raspberry Pi's operating system, the system here uses the Raspberry Pi as a central processing unit.

Python

Python is a high-level programming language that can be used for a variety of purposes. When opposed to other languages such as C, C++, and Java, the readability of code is improved with Python. The use of numerous syntaxes and the process for writing code is much too complicated and time-consuming to read. Python, on the other hand, has fewer lines of code. The main benefit of using Python is the code's simplicity and usability. Python now supports over 30 different libraries and frameworks, making it easier for developers to build and complete projects. NumPy is one of the libraries that are included in the system.

Matplotlib is a plotting library that can be utilized to assemble visual datasets just as factual information investigation. It's a critical library for working with multidimensional clusters. Python is broadly utilized in R&D due to its usability. In this day and age, Python is for the most part utilized for Machine Learning and Artificial Intelligence.

OpenCV

OpenCV is a free programming pack and AI library for continuous PC vision applications. Open CV is a cross-stage library that works with an assortment of programming dialects, including Python, Java, C++, and C. This library was created by Intel Corporation and is accessible free of charge under the open-source BSD permit. It's quite possibly the most broadly utilized libraries for video, picture, profound learning, AI, HCI, 2D, and 3D component tool compartments. The library contains in excess of 2500 calculations, including PC vision and AI calculations.

Some of the syntaxes that are used in the program are:

I. Import cv2 #used for importing the open CV library

II. Import NumPy as np # importing the NumPy array

III. Cv2.VideoCapture ()# used for capturing the video from the camera

IV. Cv2.cvtColor ()# used for converting an image from one color space to another

V. Gray = cv2.cvtColor (resized, cv2.C0L0R_BGR2GRAY) # used for converting RGB color to gray

VI. Fire = fire_detection.detectMultiscale (gray, 1.1, 7) # using fire classifier in which objects are loaded with the fire_detection.xml

Result

The thesis' main objective was to create a working prototype of a fire detection device. The fire was observed after the code was completed and mounted on the Raspberry Pi. Figure 6 depicts the detection of fire, while fire is not observed in Figure 5 due to the distance and scale of the flame. The flame in the device resembles a tiny led bulb, making it difficult to detect.

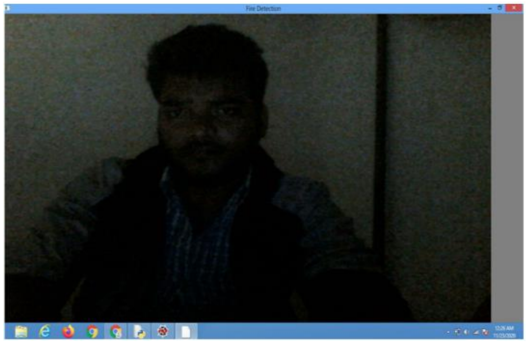


Figure 5: Fire not detected

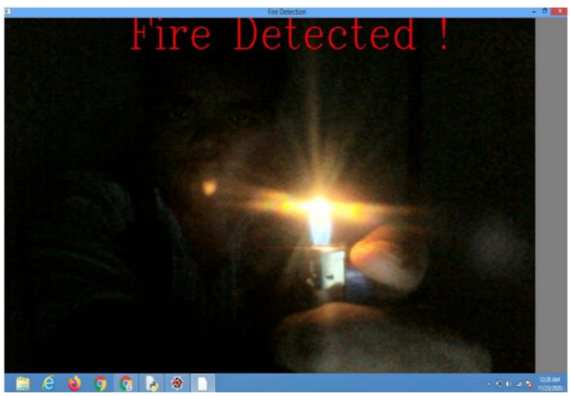
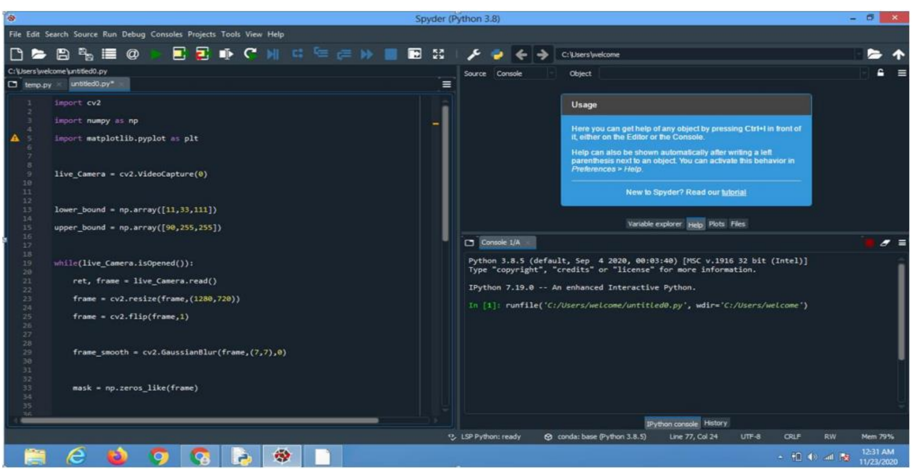


Figure 6: Fire detected



Finally, the result indicates that a fire has been observed. When the flame is observed, a red text written FIRE DETECTED appears in Figure 6. In fire, we can change the text in the rectangle box. The rectangle's size varies depending on the size of the flames. So, when coding, some threshold values for the rectangle were set in order to correctly detect the fire area. In the case of this project, the threshold value is given by setting the parameters for the scale factor value. 1. The scale factor is 1, and the min neighbor is 7. The scale factor is used to monitor the image pyramid during object detection. It will be difficult to classify the object if the scale factor is too large. As a result, it will be less precise, and if the scale factor value is less than, false detection will occur. Since the experiment was carried out in a room light setting, the scale factor was also adjusted to match the room light to obtain an accurate result.

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