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SMART AND GREEN FIRE DETECTION SYSTEM WITH IMAGE PROCESSING

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ABSTRACT: Risk of fire is a major yet not considered are of disaster management. The urban as well as rural areas face this issue and it leads to loss of lives as well as property at higher scales. In India, most of the cities have poor fire mishap facilities available. The fire accidents either are at small scale or large scale. Sometimes these small-scale fires lead to large scale ones as quick measures and fast alerts were not made. Need for quick and proper fire detection system formulation is needed to be made. This was the motivation behind the given analysis made and the system developed. The system uses three major operations. Flame and smoke sensor sense the fire. Image processing is achieved through Pi B+ model, applying background subtraction to the images and segmenting them using machine learning techniques and finding the accuracy and efficiency using confusion matrix for the detected scenarios. Buzzer is provided to intimate the people around of the accident which has occurred. The USB camera captures the most recent image through video frames taken and sends it to the fire department via email. SMS alert and Location is sent to the registered numbers. Call alert is made using wireless network techniques. Thereby giving notification alerts at a faster pace to enable the people to take corrective actions as soon as possible. The system is powered with solar panels which makes it more eco-friendly and can be used in cases of power breakdowns and emergency cases.

KEYWORDS: Fire detection, sensors, image processing, alerts, Background Subtraction, segmentation techniques.

I. INTRODUCTION

Communities and its residents face various challenges when a fire breaks in. Around the world, though frequent fire accidents occur but the wellbeing measures taken are often ineffective thus lead to more mishaps and loss [1]. In country like India, rural areas if face a fire accident, it spreads quite quickly due to different reasons such as thatched roofs, improper stove burnouts. In urban areas it can be due to gas cylinder explosion, unattended appliances left open, short-circuiting etc. In rural areas most of it is due to the financial incompetence of safety measures provided [2]. There the life is at stake for sure but the stashes and food reserves also effect the economic condition of the area and country as a whole if a fire breaks in. Thus, there is a need for improving the financial stability but to do so such systems can be installed to make a good surveillance as well as detection possible.

The fire accidents do not just affect the rural or urban dwellings but it has bad results in forests and on wildlife. One such example is of the Amazon forest fire that broke and effected almost 906 hectares of the forest. Forests have been the major source of life sustaining oxygen [3]. Thus, effective measures are to be taken to prevent losing more of these wildlife and forests to wildfires. There have been various solutions to the disasters that occur but very few focuses in this domain of study. Mitigation techniques can be many but the analysis and detection is the major step to that mitigation. A quick detection with better efficiency is required leading to the analysis of this research study [4].

This research analysis makes use of sensors as well as the image processing algorithms to detect small- and large-scale fires. The sensors used for this initial study are flame and smoke sensors. Flame sensor works on the photodiode sensors which detect IR light and thus detecting the fire if it crosses certain threshold [5]. Smoke sensors work with the concentration of smoke in the range it has been set at. It also uses threshold values to take the decision and send signals to the image processing module [6]. Only when the sensors confirm the presence of fire the camera is turned ON and the video frames are analyzed. It is the part where different algorithms come into picture and perform processing and analysis of the scale and true fire alerts. If the fire is detected then the notification alerts are sent to the fire department and the owner and concerned authorities. The system is eco-friendly and makes use of solar energy to power in cases of power outages [7].

The existing systems have used similar approaches yet more elaborative approach is the objective to this research. The existing systems have less accuracy in terms of the results provided at the end. The motivation for this analysis lies in issues concerning fire in rural areas leading to huge losses in goods and lives [8]. The analysis is made using the confusion matrix to calculate the efficiency and predictive accuracy of the research. The return on investment is taken as a basis for this prediction and thus compared with different paper works. The major objective is to provide cost efficient and compact system which can be installed anywhere. The economically feasibility of the system is also considered. Eco-friendly and always available system is the aim of this research. Quick and fast analysis with better performance and least use of power is the goal of this analysis.

II. LITERATURE SURVEY

Norsuzila Yaacob, Muhammad Salihin Ahmad Azmil, Suzi SerojaSarnin, Khairul Nizam Tahar, proposed a framework where smoke sensors and camera was used to detect fire [9]. The remote observation was carried out and the data from smoke sensor was sent for detection of fire in the area. This analysis helped the firemen in pinpointing the area and take care of the residents. This system though uses the smoke and camera for sensing, it does not provide accurate results and the cameras need to be monitored 24/7 for taking care of causalities. Also, false alarms are the major issue. The analysis taken from this survey was to use sensors and camera for remote monitoring.

Rosni Abu Kassim, Md Saifudaullah Bin Bahrudin had proposed an alerting system which made use of Arduino uno microcontroller and Raspberry pi microprocessor [10]. The alerting system had the ability to send the alerts remotely to a web page whenever a smoke was detected nearby. The image of the site was shown on the webpage. The drawback is that the internet facility if not available makes the system unusable. Also, the power consumed by the system is large as the site was monitored continuously. The analysis taken from this survey was to use Raspberry pi to send images.

The research done by Ajay Mudgil, Mahendra Gupta, Sarita Gupta and Prashant Bhardwaj used the RF receiver which received the transmitted information [11]. This information was then sent to MCU. It basically calculated the area affected by fire and the amount of fire extinguishers required to doze the fire. The site of affected area was shown on the webpage and the address was sent to the site. The Google maps were used. GSM was used to pinpoint the location. The drawback of this analysis was that the GSM does not provide exact or correct location thus can cause more issues. The idea taken from this analysis was to provide calling service form GSM.

The framework proposed by PanomkhawnRiyamongkol, JareeratSeebamrungsat and Suphachai Praising was depended upon the light investigation and discovery [12]. They made use of HSV and YCbCr models for shading. These models gave different and distinct yellow, orange and splendorcolors by encompassing the light. The development of Fire was examined and outlined using these contrasts. But the user was not able to get any alerts in case of this analysis. The survey analysis for this idea was to make use of HSV algorithms to provide better representation of real-world images.

The system proposed by G P Hancke, K B Deve and B J Silva deployed smoke and temperature sensors in the research [13]. SMS was sent using GSM module also the location was sent via in-built GPS of GSM. LM35 and MQ-2 sensors were used to detect fire. But the system was prone to more false alarms and therefore the efficiency was low. The survey led to this research conclusion to make use of sensors but using Raspberry Pi's in-built GPS for the location pinpointing.

A framework was proposed to make the fire detectable and estimating a more concise model. When the scene changes continuously thus making it difficult to detect. Heuristic edge detection technique was used to capture better images for recognition. The framework created images similar to the shading in fire to detect the same. Still the images were difficult to detect. This system was researched by Sung-Hwan Jung and other authors [14]. This survey helped in this analysis in a way of avoiding the frame errors due to the algorithms used.RicardusAnggiPramunendar and his team gave a framework research which made it possible to use multi-color features and visual sensing like background subtraction and frame segmentation techniques [15]. The error rate of the system was higher than expected. This framework was taken for the analysis of this research taking into account the background subtraction and other techniques.

III. DESIGN AND IMPLEMENTATION

The architecture of the system is shown in the Figure 1. This system has four modules which in turn contain smaller submodules. The user of the are owners, fire department and the forest officials. The user registers his

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mobile number during the installation with the system. The owner in contacted via this number when the fire breaks. Solar power is given to the Arduino in cases of power breakdowns.

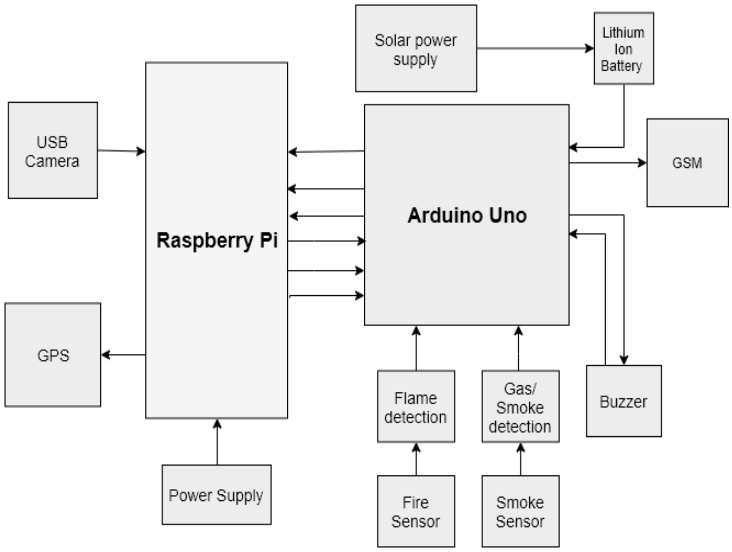

Figure 1.Architecture of the System

A separate power supply has been connected to the modules. Lithium batteries gets charged via solar panels. This can also be charge from external power supply. The GSM module interfaced with Arduino Uno board sends an SMS every time the system detects fire. It then calls the registered user. Raspberry pi performs image processing and runs different operations through algorithms. From color detection to segmentation of video frames, everything is performed by the Pi. The USB camera captures videos.

This happens only when both the sensors, i.e. flame and smoke sensors, confirm the presence of fire. The buzzer turns ON in the first stage of detection and then the serial data is shared between the microcontroller (Arduino) and microprocessor (Raspberry Pi). If the fire is detected then the camera turns ON and the frames are captured. These are then segmented and the most recent image is sent to the fire department via mail. The owner is alerted through Call. The SMS with the location is sent to the registered number. This system not only easy to understand and work with but it is eco-friendly and efficient in dire cases. The sensory network is commercially feasible is cost effective.

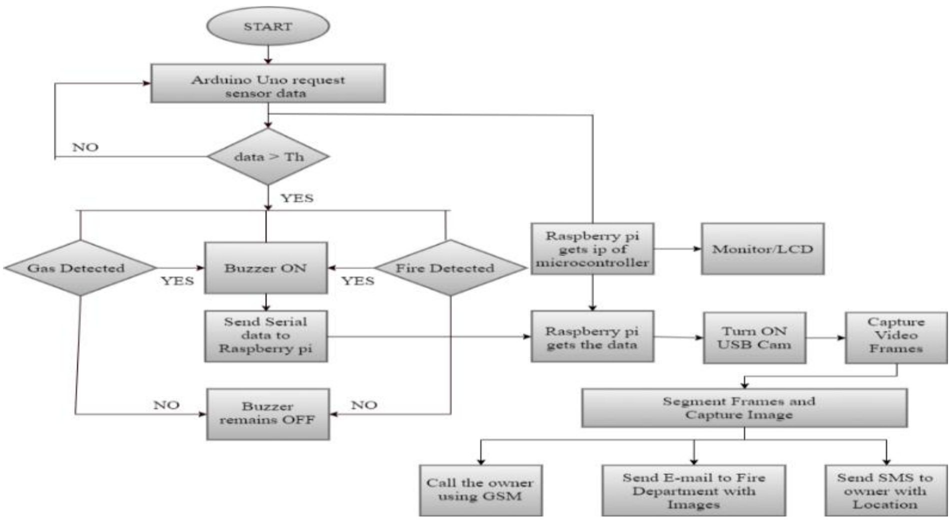

Figure 2. Flowchart for the system

The flowchart of the system is depicted in the Figure2. This figure explains the working and depicts the work flow of entire system.

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3.1 Sensors for Fire Detection

The sensors are interfaced with the Arduino uno board and thus form the Sensory module of the project.

A. Arduino Uno and its IDE (Software)

Arduino uno is a microcontroller which was initially designed for school kids to work on projects. As it was easy to work with, the Arduino uno became more and more widely used and now it is used in almost all kinds of IOT projects. The board not only contains microcontroller but has a space of Flash memory of 32kb, SRAM of 2kb and EEPROM of 1kb. In the given proposed system this board is used for connecting sensors and storing their codes in its memory. Arduino uno has ATMega328 chip for processing [16].

The IDE for Arduino is a commercial software open to all. The software comes with two in-built functions. These functions enclose the code to be written on the chip. Setup() and loop() are the functions. The setup() contains the code for declaring and defining variables and pins of the board. The loop() contains the code which is executed repeatedly, thus helping the sensors and other components to check for events periodically.

B. Solar Power Supply

The solar panels make the supply module in the project. The energy efficient and eco-friendly part of the project lies with the solar power supply. The solar panels have silicon cells which convert the solar energy into electrical form. The reason behind providing solar power to the system is to provide functioning of the system at situations such as power shortages [17]. This panel is connected to the power booster which has a facility of charging. This in turn is connected to a rechargeable Lithium-ion cell. This battery powers the Arduino uno and thus makes it eco-friendly.[17]. This panel is connected to the power booster which has a facility of charging. This in turn is connected to a rechargeable Lithium-ion cell. This battery powers the Arduino uno and thus makes it eco-friendly.

C. Flame Sensor

The main idea for using a flame is to detect the flame/fire. This is a sensor which detects the fire or radiation. The sensor has circuitry which helps in increasing the sensitivity of the sensor. This sensor has three pins for interfacing it with the Arduino uno board, namely VCC, GND and D0. The digital output pin is interfaced with pin 5 of uno. The power and ground pins are interfaced with the power supply i.e. voltage regulator which in turn connects the +5 Volt and Ground pins of Arduino uno board [18]. The flame sensor detects the existence of a fire through photodiodes present in the sensor. These receive the IR light. The sensor contains OP-Amp which checks if there is any change in the voltage. If it detects any fire or flame nearby within the range it has been set to sense the fire then the output pin D0 provides 0Volts i.e. LOW value. If the fire is not detected then the D0 pin gives 5Volts i.e. High value.

D. Smoke Sensor

MQ6 sensor is used to detect the strength of gas/smoke in the surrounding area. It detects the concentration in the vicinity, according to the range defined for it. Smoke sensor similar to flame sensor has potentiometer on its board which helps in changing the sensitivity as and when required. The sensor has 4 working pins namely, A0, D0, GND and VCC. In case of D0 pin, the pin is interfaced with Arduino uno's A5. The VCC and GND are interfaced with the power supply. The sensor senses smoke during fire accidents and the Analog value is sent to the Arduino, there it is compared with the threshold value defined. This analysis makes it possible to confirm the presence of fire and thus it combines the overall serial data and sends it to the raspberry pi.

The sensors interfaced with Arduino uno and their working can be explained in the form of a flowchart as shown in the Figure 3 below.

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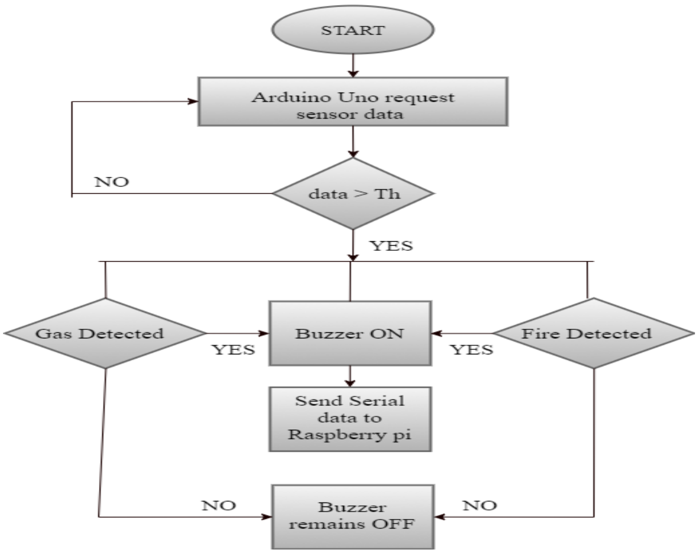

Figure 3. Workflow of Arduino

3.2 Pre- Processing of the Image

This research contains a smart part as an image processing module which receives the serial data from the Arduino uno which triggers some actions.

A. Raspberry Pi

Pi is a mini-computer. The Raspberry pi used in the project for various actions that need to be performed. This microprocessor that has around forty pins and twenty-seven GPIO pins. An in-built Bluetooth has been provided on the board. The board can be connected via USB ports provided. In the project/proposed system we are using Raspberry Pi B+ and here it has various purposes as given below:

1. The serial data from the Arduino uno, that is the confirmation of the presence of fire in the vicinity is received by the Pi and which triggers to an action of turning ON the webcam.
2. The webcam captures video frames from where the image is taken. This image is sent to the concerned authorities via mail server [19].
3. The SMS is sent to the registered number along with the location of the area which has been affected. For the coding, we have used python which is an easy to work with raspberry pi. The python version 3.8 has been used for this purpose. Raspberry pi requires a separate monitor for working with it. The codes used help in working with various machine learning techniques. These techniques are applied on the frames captured and thus helps in distinguishing the real and fake frames. The system uses color detection algorithms, background subtraction algorithm, Sobel edge detection and HSV.

B. USB Camera

The USB camera is put in all those locations which need to monitored and which need surveillance. In this system the USB camera which has been used is from Quantum company. It can capture 30 Mega Pixels of frames. In the system it is used for taking images of fire. The camera is attached to Pi via the USB ports given. Video frames are captured and sent to the pi which then processes it according to the algorithms given. The images captured are converted from RGB to HSV [20]. Then background subtraction is run. At end the segmentation techniques are used over those images.

C. RGB

RGB is a color space. It a concept about making use of three main colors, R-Red, G-Green and B-Blue, which mixed together make up different colors. The main application of this concept can be seen in computer graphics. It is also seen that RGB can be represented as a cube in a 3-D space of Cartesian plane [21].

The advantage of RGB is that it can be transformed into more readable and analyzable format. It can be transformed by using different linear and non-linear transformations. This is when color detection algorithm comes into picture. The input taken from the USB camera is read by Pi. The algorithm then creates the R, G, B bands for the video frames captured. It then computes the graphs for the R, G, B and the colors provided to it in the algorithm to detect. A histogram is sketched. Then the images are converted to grey scale. After this the colors required to be detected are found and then the image is given for later algorithms to work on. Removing noise is done by median-filter. This algorithm executes continuously for each video frame that the USB camera captures during the fire accidents.

D. HSV

H-Hue, S-Saturation, V-Value, represents a color space different from RGB. It is seen that HSV is better than RGB form when we are working on three-dimensional space. HSV is the main for used in this project. The RGB space is transformed into HSV. HSV is basically designed on cylindrical coordinates [22]. It is a finer way of representing human view images compared to RGB. It describes the color sensation in the images. The space ranges from 0 to 1. It is obtained from RGB conversion through a nonlinear transformation formula as given below:

$$\theta = \cos^{-1} \frac{\frac{1}{2}[(Red-Green)+(Red-Blue)}{[(Red-Green)^2+(Red-Blue)(Green-Blue)]^{\frac{1}{2}}} \tag{1}$$

Where,

Hue is θ when Blue is less than or equal Green and is 360° when Blue is greater than Green.

Value is equal to the maximum of $(Red, Green, Blue)$.

Saturation is equal to the difference between value and minimum of Red, Green and Blue divided by the value.

This space uses color detection algorithm. A Gaussian model is created which makes it more precise to detect and identify a fire [23]. This technique makes all possible. The image from RGB is taken by the algorithm the edge of the fire is detected and divided. The Gaussian model is blended and a polygon shape encloses the edge detected image. The fire is identified among the highlights and comparative studies are conducted thereby making use of decision trees to identify the fire. One such example is of Markov's model which made use of GM, DBFIR. This framework uses a set of local locations for the testing purpose.

Color detection algorithm used is given as:

Step 1: Get an Input Image from the camera.

Step 2: Create RGB bands.

Step 3: Computing, plotting RGB, for the histogram.

Step 4: Convert input to grey-scale.

Step 5: Track R, O and Y objects in world, subtracting the R, O and Y parts from the converted image.

Step 6: Noise is removed using median-filter.

Step 7: Grey-scale is transformed to Black-white image.

Step 8: Taking out all pixels lesser than 300px.

Step 9: Select all the connected segments from the image.

Step 10: Find centroid, bounding boxes and area. Then, Rectangular boxes are applied for R, O and Y color.

Step 11: Stop

E. Sobel Edge

Sobel Edge is yet another technique of detecting the edge in the images. This technique is used to analyze the growth of fire. In this system is used to determine the boundaries of fire in the image and thus helping in transformation of the image from RGB to HSV. This algorithm contains a particular condition which checks the intensity of a fire using different ranges. Masking can be used to get better and accurate results while working with Sobel edge detection technique. Mask used in this system is given in the formula (2)

$$M_x = \begin{matrix} -2 & -1 & -2 \\ 0 & 0 & 0 \\ 2 & 1 & 2 \end{matrix} \quad \text{and} \quad M_y = \begin{matrix} -2 & 0 & 2 \\ -1 & 0 & 1 \\ -2 & 0 & 2 \end{matrix} \tag{2}$$

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F. Subtracting the Background

The next step after detection of edge is to subtract the background from the image. This technique is applied to find objects apart from the main object in an image. The main idea behind is to identify that particular condition which is to be considered as the background image. It compares the frames with background that was received before to find the existence of fire [24]. For confirming the presence of fire, this is applied on dual frames which are obtained at same position at different timestamps. The background models received have quite a stable situation. Foreground image detection is calculated by using the formula (3).

$$Result(x, y) = Image(x, y) - Background(x, y) \tag{3}$$

Where,

$Result(x, y)$ - The result obtained from BS technique.

$Image(x, y)$ - Image used for finding the location of the fire.

$Background(x, y)$ - Image considered.

$Result$ is the pixel value which varies [25]. In case of frames it is important to use difference in the frames. The given formula (4) is used for frame difference.

$$| frame_k - frame_{k-1} | > Threshold \tag{4}$$

Where,

$frame_k$ – Input frame.

$frame_{k-1}$ - Frame where fire is not present.

G. Segmentation Techniques

Segmentation, the last step is applied to break images which detect fire against the ones in which there is no fire. Color range is specified to be used for ROI. The formula for the same is given in the formulas (5-7).

$$Distance(X, M) = \|X - M\| \tag{5}$$

$$= \left\{(X, M)^t (X - M)^{\frac{1}{2}}\right\} \tag{6}$$

$$= [(X_{Red} - M_{Red})^2 + (X_{Green} - M_{Green})^2 + (X_{Blue} - M_{Bluw})^2]^{\frac{1}{2}} \tag{7}$$

The video frames form the decision tree of true positives and true negatives. The false positives and false negatives were also observed during the analysis during its earlier stages [26]. Using these predictions, a confusion matrix had been designed. This matrix called as confusion matrix is created. The E- efficiency and A- accuracy can be calculated using the given formulas (8-9):

$$Efficiency = \left(\frac{NTP+NTN}{NTP+NTN+NFP+NFN}\right) \times 100 \tag{8}$$

$$Accuracy = \frac{NTP}{NTP+NTN} \tag{9}$$

Where,

NTP - No. of frames, algorithm detected fire correctly.

NFN - No. of frames, algorithm failed to detect.

NTN - No. of frames algorithm does not detected fire when not present.

NFP - No. of frames, algorithm detects fire when not present.

IV. RESULTS AND DISCUSSIONS

An important part of the system is to alert and notify to the concerned authorities and people when a fire breaks in. This system has four ways of alerting.

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4.1 Buzzer alert

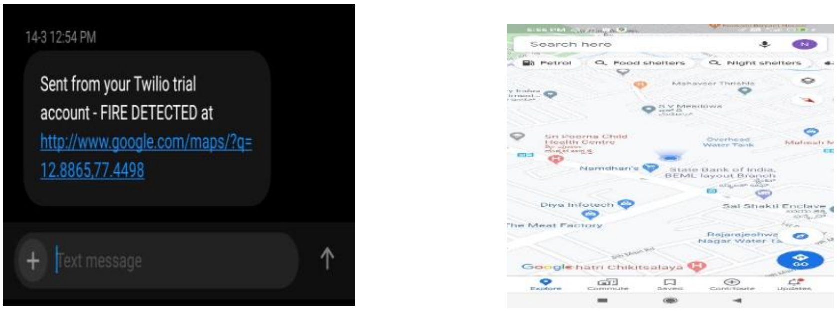
The buzzer is a small alerting device which buzzes when a particular event occurs, here in this project it is the fire hazard. When a certain threshold crosses the sensors direct buzzer to buzz. It thus by making sound notifies the people in the surrounding area, they can be neighbors or forest officials or even the owner himself.

4.2 *GSM900A*

Calls are made using GSM module. It is a WSN module which makes use of AT commands for processing and uses wireless networks to connect to the nearest sink and make calls similar to a mobile phone. In this system it is used to make calls to the registered mobile number. Here in this case it is the number of the owner. Thus, when a fire breaks in the Arduino connected to this module senses the fire through its sensory module and then directs the GSM module to make a quick alert call to the number registered [27].

4.3 Location and SMS

The SMS alert is done by sending an SMS using Twilio application available online. The SMS sent consists of the Alert of a fire being detected and the location from a google API named Google Maps. The code in Raspberry pi does the job. Figure 4 depicts the output of this notification alert.



(a) **(b)**

Figure 4. (a) SMS alert (b) location sent to user

4.4 Sending mails to Fire Department

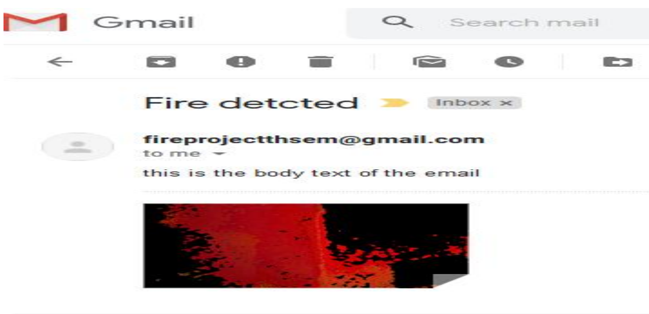


Figure 5. Fire department receives email

The Raspberry pi is coded with a code which can send email via Twilio application to the authorities' mail server. Email id of the fire department is registered in the code written into Pi. The Pi sends the image obtained after the segmentation techniques to the email as an attachment. The initial performance analysis has been applied to few video frames which were taken by the Webcam. These frames were compared with the use of algorithms mentioned. The video frames were then attached and sent to the fire department via mail.

Color detection showed some histograms to be found. These were the bands which were detected during the color detection algorithm. The Figure 6 shows the color detection of an input image. The color variation is shown here.

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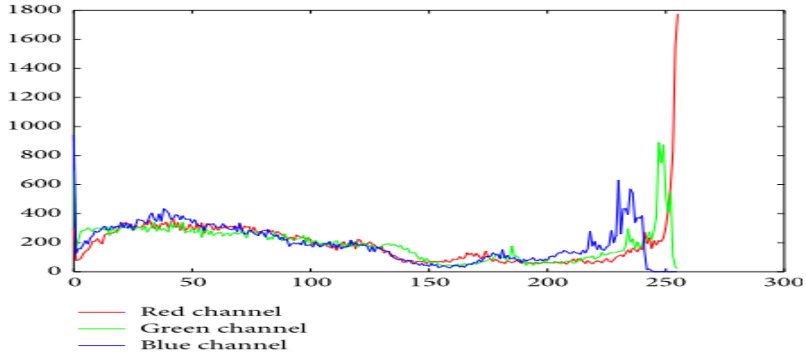


Figure 6. RGB graph for fire detection

The statistical analysis for the given graph has been performed which lead to the detection of red color in the given frame. The Table 1 represents the values statistically derived from the graph.

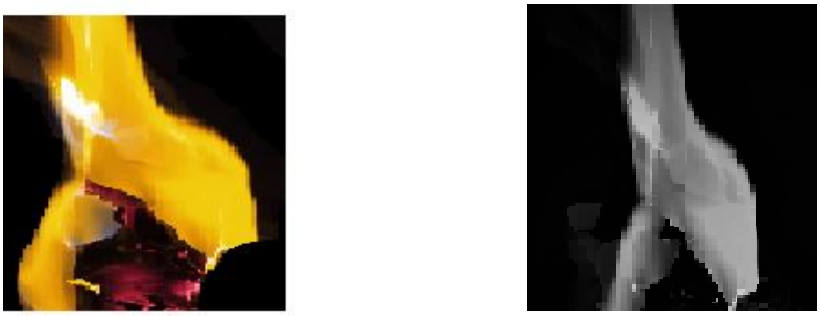
Table 1. Statistical Analysis for RGB

Color	Timestamp(milliseconds)	Highest Color Frequency (Hz)
Red (R)	255	1800
Blue (B)	225	600
Green (G)	245	800

The background subtraction techniques are applied to the images during image processing. The Figure 7 (a) and (b) shows the original image and the image after applying background subtraction respectively.Figure 8 (a) and (b) depicts the original image and the image after background subtraction respectively.

(a) **(b)**

Figure 7. Small-scale fire (a) Original image (b) Image after background subtraction



(a) **(b)**

Figure 8. Large-scale fire (a) Original image (b) Image after background subtraction

The final images which are sent to the authorities are shown in Figure 9 (b) and Figure 10 (b) for small and large scale fire respectively.

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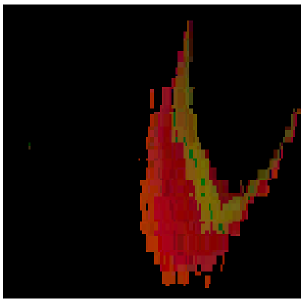

(a) **(b)**

Figure 9. Small Scale fire (a) Original image (b) Final image after applying all image processing techniques


(a) **(b)**

Figure 10. Large-Scale fire (a) Original image (b) Final image after applying all image processing techniques

About 20 test cases have been considered for this research and analysis. In the end the algorithm's accuracy and efficiency is calculated. Table 2 given below considers few observed cases.

Table2. Test Cases

Dataset Used	Presence of Human Expert	Result Detected by Algorithm	Miscalculatedby Algorithm
TC 1	Present	NTP	NFN
TC2	Present	NTP	NFN
TC3	Present	NTP	NFN
TC4	Present	NFP	NTN
TC5	Present	NTP	NTN
TC6	Present	NTP	NFN
TC7	Present	NTP	NFN
TC8	Present	NTP	NFN
TC9	Present	NTP	NFN
TC10	Present	NFP	NFN
TC11	Absent	NFP	NFN
TC12	Absent	NTP	NFN

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TC13	Absent	NTP	NFN
TC14	Absent	NTP	NFN
TC15	Absent	NFP	NFN
TC16	Absent	NTP	NFN
TC17	Absent	NFP	NFN
TC18	Absent	NFP	NTN
TC19	Absent	NTP	NFN
TC20	Absent	NTP	NFN

The final efficiency and accuracy of the system has been calculated using formula (8) and (9) which gives the system efficiency as 85% and accuracy as 94% which is comparatively more and better than KumarguruPoobalan and his team's analysis which gave about 80.64% efficiency and 93% accuracy. Final system snapshot is given in Figure 11.

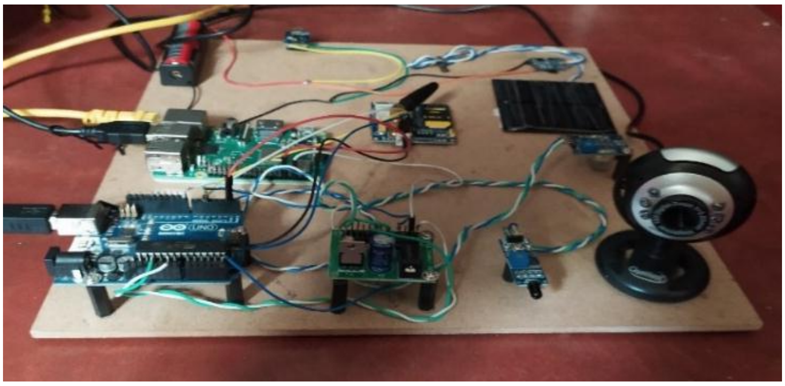

Figure 11. Final image of proposed system

V. CONCLUSION

A smart fire detection system has been successfully been completed. The system is green under the qualities it exhibits as we have powered it via solar panels. The image processing makes it more accurate and reduces the false alarms. The fire detection efficiency is increased. The algorithm's ability to predict are high. Power supplied through solar panels make it available at all times. The system is 85% efficient and 94.11% accurate. The fire is detected in levels. The sensors first perform checking for smoke or fire and only if detected, the webcam takes the images and performs required operation. In future the efficiency and accuracy will be increased. Considering more frames and data, and highly sensitive sensors for the system can make a vast difference. These are the future scope of the system proposed.

VI. REFERENCES

[1]. Ning Ma, J.,2013. Research and thinking about problems of rural fire control work under the "Three Rural" policy. Journal of Chinese Polices Armed Police Force Academy29(2), p. 343-345.

[2]. http://www.beyondcarlton.org/fire-safety-rural-areas-india-anyone-care/.

[3]. https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Regional-risks/Rural-areas.

[4]. https://en.wikipedia.org/wiki/2019_Amazon_rainforest_wildfires.

[5]. https://circuitdigest.com/microcontroller-projects/arduino-flame-sensor-interfacing.

[6]. https://create.arduino.cc/projecthub/Aritro/smoke-detection-using-mq-2-gas-sensor-79c54a.

[7]. https://www.instructables.com/id/SOLAR-POWERED-ARDUINO-WEATHER-STATION/..

[8]. https://www.donegalgroup.com/learning-center/fire-prevention-and-safety-information/common-causes-of-fires-and-ways-to-prevent-them.

[9]. Muhammad Salihin Ahmad Azmil, NorsuzilaYa'acob, Khairul Nizam Tahar, Suzi SerojaSarnin, "Wireless Fire Detection Monitoring System for Fire and Rescue Application",ISBN: 978-1-4799-8249-3, IEEE 11th International Colloquium on Signal Processing & its Applications (CSPA2015) , Kuala Lumpur, Malaysia

ISSN- 2394-5125 VOL 7, ISSUE 14, 2020

[10]. Md Saifudaullah Bin Bahrudin, Rosni Abu Kassim, ‘‘Development of Fire Alarm System using RaspberryPi and Arduino Uno’’ International Conference on Electrical, Electronics and System Engineering, ISBN: 978-1-4799-3178-1, 2013, IEEE.
[11]. Sarita Gupta, Ajay Mudgil, Prashant Bhardwaj, MahendraGupta, “Design and Development of Automatic Fire Alert System”, 8th International Conference on Computational Intelligence and Communication Networks, ISBN: 978-1-5090-1144-5,2016, IEEE DOI 10.1109/CICN.2016.130.
[12]. Jareerat Seebamrungsat, Suphachai Praising and Panomkhawn Riyamongkol, “Fire Detection in the Buildings Using Image Processing”,Third ICT International Student Project Conference (ICT-ISPC2014), ISBN: 978-1-4799-5573-2, 2014, IEEE 2019.
[13]. K B Deve, G P Hancke and B J Silva, “Design of a smart fire detection system”, ISBN: 978-1-5090-3474-1, 2016, IEEE.
[14]. Bo-Ho Cho, Jong-WookBae, and Sung-Hwan Jung, “Image Processing-based Fire Detection System using Statistic Color Model” ,2008 IEEE.
[15]. Guruh Fajar Shidik, Fajrian Nur Adnan, Catur Supriyanto, Ricardus Anggi Pramunendar, Pulung Nurtantio Andono, “Multi Color Feature, Background Subtraction and Time Frame Selection for Fire Detection”, International Conference on Robotics, Biomimetics, Intelligent Computational Systems, ISBN: 978-1-4799-1208-7/13, IEEE.
[16]. https://www.arduino.cc/en/Guide/ArduinoUno.
[17]. https://www.instructables.com/id/SOLAR-POWERED-ARDUINO-WEATHER-STATION.
[18]. https://www.electronicshub.org/arduino-flame-sensor-interface/.
[19]. https://www.raspberrypi.org/documentation/usage/webcams/.
[20]. Kumarguru Poobalan and Siau-Chuin Liew, “Fire detection algorithm using image processing techniques”, Proceeding of the 3rd International Conference on Artificial Intelligence and Computer Science (AICS2015), Penang, MALAYSIA. (e-ISBN 978-967-0792-06-4), pp 160-168.
[21]. Ahmad AA Alkhatib, Smart and Low Cost Technique for Forest Fire Detection using Wireless Sensor Network, International Journal of Computer Applications *Volume 81 – No.11, November 2013.*
[22]. Ming Zhao Jiajun Bu Chun Chen, “Robust background subtraction in HSV color space”, Proceedings of SPIE MSAV, vol. 1.
[23]. https://www.fullstackpython.com/blog/send-mms-picture-messages-python.html.
[24]. https://www.sciencedirect.com/book/9780128023990/methods-and-techniques-for-fire-detection.
[25]. Ahmad AA Alkhatib, Smart and Low Cost Technique for Forest Fire Detection using Wireless Sensor Network, International Journal of Computer Applications (0975 – 8887) *Volume 81 – No.11, November 2013.*
[26]. https://www.sciencedirect.com/science/article/pii/S1877705816001132.
[27]. https://www.cookinghacks.com/index.php/documentation/tutorials/gprs-gsm-quadband-module-arduino-raspberry-pi-tutorial-sim-9