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A Survey on Forest Combustion Recognition Techniques

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ABSTRACT
Forests are the main natural resources that provide various direct & indirect benefits and play an important role in the life of a human being on the earth. It is the duty of human to save the earth from vanishing of the forests and also from the major hazards that take place, to save the wild animals, to support human living and to protect rare species of the planet from being dead. A forest fire has a huge and serious impact on the environment. They also affect the future for decades. Artificial Intelligence techniques are used to visualize/recognize forest fires through the numerous images that are captured and fed as input to the model. Forest fires can be detected or prevented by training machines with suitable algorithms for fire detection and alarming. This paper highlights different forest fire detection techniques employed in the literature from past ten years concluding the future steps to be taken by the researchers to avoid forest fires.

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I. INTRODUCTION

Forests play a crucial role in our daily life. In the past, early humans were dependent on the forests for their needs such as food, clothing, and shelter. Forest prevents soil erosion. The roots of their trees tie up their soil particles together and prevent the soil from being washed [1]. Trees help to balance the climate of a place. They take water from their roots, and then they open some of it as water vapour. In this process, they manage to keep the surroundings cool. Trees are very responsible for bringing the rain by saving the water vapour content of the atmosphere [2]. Forest fires represent a real threat to human lives, ecological systems, and infrastructure [3].Forest fires are always caused in one of two ways naturally or human caused. Natural fires are started by lightening with a very small percentage started by spontaneous combustion of dry fuel such as sawdust and leaves. On the other hand, human caused fires can be due to any number of reasons. A fire needs three things: fuel, oxygen, and heat. Sometimes, fires occur naturally, ignited by heat from the sun or a lightning strike. However, most wildfires are because of human carelessness, such as arson, campfires, discarding lit cigarettes, not burning debris properly, and playing with matches or fireworks. We need to recognize forest fires and help the natural cycle of wood growth and replenishment [4]. Artificial intelligence and machine learning have found many ways to enter many fields of research and technology. Traditionally artificial intelligence deals with making programs and performing tasks that need human intelligence and this is done by automating the human part in decision making. Machine learning has recently become the most popular field of artificial intelligence, mostly due to the availability of digitized data, also known as big data. Machine learning algorithms or data are used on a set of training data and aim to give output that can be used as a part of an intelligent algorithm. Forest fire monitoring and observations are important tasks of forest management where forest owners want to prevent and minimize the damages caused by forest fires. The design and development of an intelligent system are nowadays unimaginable without employing some sort of machine learning. Machine learning techniques consist of training a model on collecting data and using the model in analysis, prediction, and decision making. While the development of a mathematical model and evaluating it on data collected at the usage time is a traditional approach, nowadays data are needed in both parts of design and evaluation. The modern approach improves the accuracy of detection and simplifies the maintenance of the system.

II. SURVEY ON FOREST COMBUSTION RECOGNITION TECHNIQUES

Forest is source of living for human beings. Forests provide ecological balance and help human, animals and birds lead comfortable life. They play vital role as they provide us air to breathe, food to eat , shelter to live , fuel to run our vehicles, cook our food, and means of living for the tribal people in and around the forest area. As forests play great role in human living these days India witnessed great amount of forest fires in 2020.Analysing the reasons for forest fires and research aimed towards better forest Combustion recognition techniques employing various technological advancements is another solution to reduce the disaster. The literature showcased many techniques in the areas of data mining, Artificial intelligence, Deep learning, image processing and Machine Leaning.

Zang et.al [5] in their work deployed multiple monitors with various viewpoints, in contrast to traditional models that recognize images from a particular single source. This model avoids false alarms. In this method, a graph neural network model is proposed that works on the similarity between multi-view images. It improves the accuracy of forest fire recognition. A dataset of images of forest fire is provided as input, this model extracts important features of the image that differentiates the forest from other things or substances. Image segmentation is done with the help of the HSV (Hue, Saturation and Value) model. It recognizes fires by identifying the hue, saturation, and value of colour. So all the pixels with fire are highlighted and we can know clearly that it is a forest fire. To distinguish forest fire image 3 steps are needed to be followed, 1. Image collection. 2. Fire recognition. 3. Screening the cropped images.

Sakr, George et.al [6] in their work presented an effective forest fire detection method using AI. Forest fires are a fundamental part of many ecosystems such as boreal forests, temperate forests, Mediterranean ecosystems, etc. Forest fire prediction, prevention, and management measures have become more important. Nowadays for forest fire danger prediction systems represent an essential tool to predict forest fire risks, they support the forest fire monitoring and extinction phase, assist the fire control planning and resource allocation and a system for automatic recognition of fire smoke using artificial neural networks applied to advanced high-resolution radiometer. The idea was to build a fire spread simulator and to land at good decision policies. Any forecast mechanism bases its prediction on continuous observation of several specific features. In this paper, the aim is to reduce the number of monitoring features and to eliminate unwanted data and to strengthen required weather prediction mechanisms. In the simplest form, SVM (Support Vector Machine) uses a linear hyper plane to create a classifier with a maximal margin. In other cases, where the data is not linearly separable, the SVM maps the data into a higher-dimensional space called the feature space. The weather data provided by the Lebanese Agricultural Research Institute (LARI) cover the Lebanese territory. Each day of weather data from LARI corresponds to a specific number of fires that are extracted from the fire list. The number of fires over the nine years is used to create the four scales of danger on which the prediction takes place. The relationship between the weather parameters of today and the fires in the upcoming days is monitored through SVM. The paper presented a forest fire risk prediction mechanism, based only on meteorological data and independent of any weather prediction mechanism The results demonstrate the ability to predict forest fire risk with a limited amount of data and has shown that support vector machines can be used for a two-class prediction of fire risk with very high accuracy of up to 96%.

Seric et.al [7] discussed the advantages of using machine learning and artificial intelligence techniques in forest fire observers. The system architecture describes three main parts, i.e., the data is analyzed by network observer that checks the validity of system parts and data available from sensors, phenomenon observer for detection of scenario taking place in the environment that is monitored, and system observer for analysis of system usefulness and identification of future improvement of the system. In all of these three parts, ML/AI techniques are used. Detecting forest fires from a single or series of digital images has led many scientists to work on applying image processing and computer vision techniques in the search for algorithms to detect fire or smoke. In these researches, scientists aim their focus on the exactness and correctness of proposed algorithms. Besides the exactness and correctness detection algorithm, it must involve mechanisms for observation of vital parts and automatic recovery in case of failure. Artificial Intelligent forest fire monitoring and surveillance system are software systems supporting cameras mounted on pillars to monitor locations in the forest. Some tasks, followed by a software system are 1. Collecting data from the monitoring locations 2. Analyzing the validity of data collected from the monitoring location 3. Data processing in search for visible signs of smoke and fire 4. data archiving 5. Presenting the results of the processing to the users via a web interface.

Alkhitib et.al [8] discussed that forest fire Detection is the Forest defender of the earth's ecological balance. Forest fire’s cause irreparable

damage to the environment and that atmosphere of 30% Co2 comes from forest fires. These forest fires are a great menace to ecologically healthy grown forests and the protection of the environment. There are some most frequently used fire detection techniques are1. Controlled burning 2. Watch towers 3. Infrared 4. Spotter planes 5. Water tankers 6. Optical smoke detection. In Australia the fire does not harm any humans or properties it is left to burn until it dies alone. This paper, highlights about fire suppression and detection Techniques, Satellite-Based Systems, Optical sensors, Digital cameras, Wireless sensor networks. Millions of hectares of forest are destroyed by fire every year. Areas destroyed by these fires are larger and produce more carbon monoxide than the overall automobile traffic. In fire suppression and detection techniques, they discussed the most frequently used fire detection techniques. In satellites based system's earth-orbiting satellites and even air floating division have been employed for observation and detection of a forest fire. An optical sensor and digital camera surveillance and wireless sensor network are also employed. There are several detections and monitoring systems used by authorities. These include observers in the form of patrols or monitoring towers, aerial and satellite monitoring are increasingly promoted. Detection and monitoring systems based on optical camera sensors and different types of detection sensors or their combination are used to detect forest fires.

Mahmoud et.al [9] discussed that accurate forest fire detection algorithms remain a challenging issue because some of the objects have the same features like fire, that may result in a high false alarm rate. These forest fire detection algorithms remain a challenging issue. This paper presents a new image processing forest fire detection method, which consists of four stages. First, a background subtraction algorithm is applied to detect moving regions. Secondly, candidate fire regions are determined using CIEL colour space. Thirdly, special wavelet analysis is used to differentiate between actual fire and fire-like objects, because candidate regions may contain moving fire-like objects. Finally, a support vector machine is used to classify the region of interest as either real fire or non-fire. Forest fires warn to human lives, environmental systems, and infrastructure. The objects have the same features with a fire detection method containing four stages, Background subtraction algorithm is applied to detect moving regions, Candidate fire regions are determined using CIE Lab colour space, and special wavelet analysis is used to differentiate b/w control fire and fire objects, Support vector machine is used to classify the region of interest to either real fire or non-fire image processing. In this, background subtraction and special wavelet analysis methods are employed. The forest fire detection method achieved a good detection rate (93.46%) and a low false alarm rate (689%) in fire likes objects. The future work and the method's accuracy could be improved by extracting more fire features and increasing the training data set.

Abid et.al [10] presented a comprehensive type of survey based on machine learning algorithms on forest fire prediction and detection systems. Forest fires are breaking out so frequently nowadays. Forest fires are causing major environmental damage. Every year, millions of hectares are being hit in several parts of the world and there is a threat to fauna and flora species whose lives are being affected because of forest fire consequences. Detection has become an old method in terms of an emergency, considering this they have implemented wireless sensor networks (WSNs) and unmanned aerial vehicles (UAVs) these are proposed because these consists of automatic detection of forest fires. Almost all types of machine learning methods are exploited for these issues so we have to follow the trend which is towards the integration of artificial intelligence. In other work different machine learning models were introduced for the identification of burned forest areas (MLP, SVM, RBFN) were investigated and have been detected and collected 7920 burned forest areas between 2009 and 2018. The report results consist of a success rate between 53.02% 62.89% and the global accuracy 65%. So MLP is chosen as the best model in machine learning algorithms. In our country, the month of April may be the time when forest fires take place in various parts of the country, this is due to dry soil caused by a weak monsoon this will happen in extremely prone areas which lead to forest fires in India that takes up to 26.2% of forest to fire which is 1,72,374 sq km. The main reason for the forest fire is human activities. Global climate change leads to pollution and it leads to rising instances of fires. Extreme heat and dryness created by rubbing of branches are also possible causes and lack of soil moisture also becomes a key factor for forest fires. In the year 2019 satellite information was also being given when a major part of the fire is being spotted in forests.

Hariyawan et.al [11] Proposed a new method for forest fire detection. To solve this problem a new type of detection system is presented: A wireless sensor network (WNS). This sensor consists of a transmitter/receiver, microcontroller, and three sensor measurements of gasoline. Methane, CO, and CO2 are used as the main indicator for the early detection of forest fires. RF modules in a shown area are 310m at 230m and

90m at 19,200 bps. In terms of current technological developments, some sustainable programs require a system to analyze and be capable of monitoring indications of forest fires. Currently, wireless technologies can send data without using wires. This technology has become one of the best developments of applied technology that can support forest fire conservation programs. A wireless sensor network (WSN) is a computed, communication, and measurement process that provides administration capabilities to a device for observation, treatment for events, phenomena, and environment using wireless technologies. WSN technologies provide the foundation to conduct experiments on the environment. Overall human activities and actions require monitoring WSN systems employing sensors based on temperature, pressure, humidity, position, optic, radiation, movement, and vibration. Each node of WSN systems generally consists of communication, sensing, power, and processing. The main part of the wireless sensor network is system processing which can affect energy consumption. Some of the processors are Microcontroller, Digital signal processors, Application-specific IC, and Field programmable gate arrays. To detect forest fires they perform measurements of temperature, flame, gas, oil, co2, Co, and methane from the burning peat. In this way, the wireless sensor network (WSN) is working to detect the forest fire beforehand to avoid massive damage which could affect the whole ecosystem.

Yan, Xiaofei, et.al [12] discussed that Human observation is a traditional method to detect forest fire, risky conditions suddenly pulls people back when a fire occurs. The various human observations of forests fires like novel sensing technologies such as cameras, infrared detectors, satellite-based remote sensing, wireless sensor networks, etc. (WSN), etc. The monitoring variation of smoke or fire in the forest by using Machine Vision Method (MVM) are available in literature survey. Some disturbances by the landscape, smoke produced from industries, weather conditions, and social activities may deflect the accuracy of machine vision-based systems. We have an alternative technique for fire and forest and post-fire recovery by satellite-based remote sensing. This Remote sensing method normally scans the image by using satellites at an interval of one or two days. In recent times a satellite operated by the Japan Meteorological Agency has a special feature where it can detect fire hotspots within 10 minutes, and also write data over the entire hemisphere. This is the example that is acceptable for real-time forest fire detection, although a wide area of around 0.1 hectares with a location error of about one kilometer takes one pixel of remote sensing-based images that contains fire or smoke at the beginning stage of fire occurrence. Nowadays monitoring of forest fire using Wireless Sensor Network (WSN) is an alternative technique that is becoming more and more popular for real-time applications Modules that can collect humidity, air pressure, wind direction and speed, temperature, smoke, gas concentration, and some solar-powered nodes integrated with sensors are integrated inside WSN. This data is communicated, stored, and processed with control centres through the nodes of wireless networks. If in case there is any occurrence of fire the control centres will automatically detect those hotspot areas. Sensors can be monitored in both dynamic and static parameters, which are very useful for detecting and eradicating forest fires. Some previous studies of forest fires say that to maintain high accuracy and efficiency; we should monitor air temperature and smoke density, etc. An artificial Neural Network (ANN) is defined as a mathematical model designed in such a way that it can perform every work as the human brain does. Generalization capability, self-organization, and adaptive learning are the features of Artificial Neural networks (ANN). It is considered to be a good classifier because it deducts smoke and flaming phases with high accuracy according to the sensor measured data. Both training and testing phases of (ANN) were performed using the mat lab tool, which has excellent processing of numerical models and large data sets.

Barmpoutis et.al [13] observed that to detect fires in the forest we have many technologies. In this paper, optical remote sensing techniques are used. Terrestrial System: A terrestrial system is a very early detection system that consists of individual sensors or a network of ground sensors. Those sensors are used are handled carefully and are placed to achieve adequate visibility. The sensors used in watchtowers, which are used to monitor high-risk detection and also used for verification and localization of reported fires. Different types of cameras used for the detection of forest fires like Optical cameras and IR cameras that can capture data ranging from low to ultra-high resolution. Optical cameras that provide colour information. IR cameras that provide Thermal Radiation. Unmanned Aerial Vehicles: A terrestrial imaging system can be able to detect both flame and smoke but it is very much impossible to view promptly. By using UAVs we can have broader and more accurate perceptions. It can also be used for detecting many symptoms like fire and smoke using Geostationary Satellites and by using Cubesats. Finally, this paper concludes that we can have a detailed comparison between

three categories of fire detection in terms of Accuracy, covered Area, and response time.

Hanamaraddi et.al [14] discussed forest fire detection by using Image Processing. Forests can purify water, stabilize soil, cycle nutrients, moderate climate, and store carbon. Nowadays, due to forest fires, the ecological balance is disturbed so many people are facing many health problems. By using Image processing for forest fire detection through YCbCr colour model, adopted and rule-based colour model due to its less complexity and effectiveness. By using Image Processing we can identify the quality of fires by the colours. We can detect the fire quantity as high or low. The output of Image Processing is either an image or a set of characteristics or parameters which was related to that image. In Image Processing, the input was taken as a 2D signal and then applied to standard techniques. A colour model is a mathematical model that describes the colours that which describes as tuples. 1. CMYK color model 2. RGB colour model 3. YCbCr colour model The Identification of Forest Fire Based on Digital Image Processing: In this, forest fire by using the Image Processing functionality is easily detected based on continuous image sampling by a CCD camera. Configuration characteristics, dynamic characteristics, and colour information from the Image Processing algorithm. The source of the fire can be easily identified by its characteristics. In this paper, the uses of YCbCr colour spaces separating luminance from chrominance is discussed.

Basu, M.Trinath, et.al [15] have found that in a survey 80%of losses are due to forest fires. If the fire was identified, action can be taken to reduce or prevent forest fire and to maintain ecology. The work has assembled a fire finder by Node MCU which is an interface with a temperature sensor, a smoke sensor, and a signal. The temperature sensor detects the warmth and the smoke sensor detects any smoke produced because of fire. Whenever a fire is activated it consumes adjacent and produces smoke from candlelight or oil light which was used by a family. When warm force is high, then the alerts go on. When a bell or an alert goes on then the temperature smoke level decreases. Additionally LCD is interfaced to the Node MCU board with the assistance of IoT innovation. When LCD recognizes smoke or fire, then it alarms the client about the fire through the Ethernet. The wireless sensors can easily detect early wildfire.

III. CONCLUSION

This paper gives an insight into possible ways that were implemented for Forest Combustion Recognition using techniques like image processing, temporal variation, wireless sensors, spatial data, CNN, ANN, and swim techniques. Application and performance of forest fire detection techniques depend upon the size of forest, type of forest: sparse or dense, area located and many other parameters. In the near future there will be more advanced techniques based on remote sensing that may lead to forest fire detection and automatic fire control methods can be employed to reduce fires using AI and ML.

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