Using AI with IoT to prevent forest fires

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Abstract:
The research project shows that road networks play an important role in a number of geographic applications, such as mapping, infrastructure planning, and traffic routing software. Automatic and semi-automatic road network extraction techniques have significantly increased the extraction rate of road networks. The performance of road detection is severely affected by noise or low frequency. Road edge detection images play an important role in detecting the direction of the road and the specific location of obstacles, size, and speed of obstacles on the road. In this paper, several road detection techniques are theoretically analyzed, and a new road detection method using median filter is proposed. By comparing it with some well-known techniques, it is found that there are many gaps in the techniques presented so far. By comparing the proposed algorithm with the proposed one, it is proved that the proposed algorithm does not introduce artifacts in the old techniques.
Keywords: Actuator systems, Internet of Things, Internet of Everything, Edge computing, Deep learning.

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Introductions:

Recent years have been marked by climate change with pronounced periodicity of abundant winter rainfall concentrated in a few hours and days, with long periods of drought especially in the summer season. In addition, more and more policies are available to solve global pollution Problems Two approaches can be used: preventive and a reactive In the first case, there are numerous examples in the literature of the Internet of Things intervenes in many settings in industry [١], smart cities [٢] and mobility [٣]. Suddenly climate change and the use of pesticides are weakening the balance of biodiversity with impacts on the spread of tree diseases that can encourage the expansion of forests, the use of artificial intelligence (AI)-based systems makes it possible to detect the occurrence of plant diseases, providing crowdsourcing tools to inexperienced people for the early determination of tree diseases [٤].

In the short and medium term, a reactive approach and forest monitoring should be employed to allow timely prevention and intervention. Under the European Copernicus project, the European Forest Fire Information System (EFFIS) [٥] collects and analyses satellite images. According to data collected since the beginning of ٢٠٢٢, more than ٦٠٠,٠٠٠ hectares of forests have been burned in the European Union alone. Wildfires are one of the greatest threats to ecosystems, animal species and human life, as well as a source of enormous economic and social damage. Furthermore, due to fires, the previous balance is undermined by additional risks arising from other natural events such as landslides and avalanches. Early detection therefore plays a very important role. Currently, this task is entrusted to operators who are stationed in the area of interest and are suitably positioned in strategic locations. It is obvious that the use of a land cover-based system through human presence over large areas entails several constraints that can be adequately met.For example, in recent years the surveillance system has been supplemented by the installation of video cameras in strategic locations and remote control at surveillance centers.

Although the introduction of cameras may facilitate human monitoring and control activities, the presence of data operators [٦]. Recently, hybrid surveillance techniques have been introduced, with scenario monitoring by cameras and the use of artificial intelligence (AI) tools that partially replace the human operator. Technically, the development of high-performance digital cameras, increasingly combined with advanced image processing techniques and the use of machine learning (ML) algorithms, has made it possible to create fire detection systems based entirely on image processing. The principle of operation consists in evaluating the changes in the pixel values of images obtained at different moments in time. The use of ML techniques makes it possible to determine the potential risk situation [٧]. In addition, ML-based models require additional considerations that affect the consumption. There are also system speed and the generation of false alarms, as well as the need for high computational capabilities of the devices involved.

In the recent literature, there are several works on urban air quality monitoring [٨], [٩] and the creation of low-cost tools totypes [١٠] are the inspiration for the proposed work on monitoring large areas in rural environments. In this work, a fire browser system is proposed through several sensors to obtain real-time data: temperature, humidity, atmospheric pressure, CO٢, CO, ethanol, ammonia and other gases that can complement the sensor system. In the proposed system, environmental information is transmitted via digital mobile radio from nodes to a social Internet of Things platform called Lysis (DMR), where it will be analyzed and correlated through a Convolutional Neural Network (CNN) with the aim of early fire detection by smart applications.

In recent years, smart applications have been widely studied to support sustainable environments and improve human living conditions. In this context, a smart solution based on the social Internet of Things paradigm is proposed for real-time monitoring and detection of potential forest fires. The paper is organized as follows: In section two, an overview of the state of the art is presented. The system architecture and design of the proposed fire extinguishing system are explained in section three. The system implementation, scenarios and results are discussed in section four. Finally, the conclusion is stated in section five.

Related works:

There are several solutions for detecting and managing forest fires in the literature. Specifically, the works can be divided into two general categories: those that use image processing and those that use sensors to analyze environmental parameters.

Several methods are used to capture images as input by the detection system. In [۱۱], the authors propose a work in which satellite images are processed based on severity levels to identify fire-affected areas (hot spots). Hierarchical clustering algorithms are used to identify these areas and the direction of fire spread. Fire ID - Image analysis is based on the analysis of RGB pixel values. In [۱۲], the authors process multi-temporal satellite images obtained from MODIS sensors and employ artificial neural networks (ANN) to identify high-risk forest fire areas. In this work, examples of areas where forest fires are identified were selected for training, validation and testing. ANNs show promising results in terms of fire prediction. Speed and accuracy.

With the recent advances in unmanned aerial vehicles (UAVs), real-time surveillance for military and civilian applications using these devices is becoming increasingly popular. In [۱۳], a forest fire monitoring and detection system has been designed using a UAV equipped with sensors and cameras. Algorithms based on image comparison, infrared detection, and correlation of the acquired data (e.g., temperature) are used to monitor forest fires. In [۱٤], an early fire detection system based on the use of UAVs is presented. The paper presents networks of UAVs through which thermal images are acquired, RGB, and position and distance data, useful in the fire mitigation phase. For processing data from multiple sources, deep learning-based computer vision and traditional algorithms have been developed and used.

analysis on image acquisitions, a system based on devices placed locally in the scenario of interest is proposed [۱٥]. The proposed acquisition system essentially consists of two devices: a raspberry Pi Zero W and a PiCamera V۲ module. The produced images are processed and analyzed using Matlab. In [۱٦], an IoT platform based on a Raspberry Pi microcontroller equipped with a smoke sensor and camera is proposed. The proposed detection system relies on color and motion information to minimize false detections. This information is processed together with that of the smoke sensor. When a fire is detected, the device sends an SMS to the monitoring station via GSM.

In general, systems that rely on image processing have advantages in terms of fire detection accuracy, but at the same time they have several disadvantages: hardware system implementation and maintenance costs and high computing capacity required. For these reasons, several works in the literature use approaches based on the use of sensors that analyze environmental parameters. In [۱۷], the author proposes a method that can improve the accuracy of fire detection performance in evergreen and temperate forests by detecting temperature and atmospheric carbon dioxide levels.

The proposed automatic fire detection system in [۱۸] includes two sensors: the MQ-۲ smoke sensor with very high sensitivity to propane, methane, LPG, smoke, alcohol, carbon monoxide and hydrogen; the fire sensor in the proposed work, these sensors are installed on slave nodes that acquire environmental values of the area they are located in and then send this information to the leader nodes via RF. After receiving, the leader node analyzes the data and transmits the presence of fire to the control station via GSM. In [۱۹] a monitoring system based on a WSN consisting of multiple sensor devices, a solar charging mechanism and a wireless transmission module is proposed. The device collects environmental information about temperature, humidity, smoke and methane every ۱٥ minutes and then sends it to the base station where it is stored, processed, and analyzed and then, if necessary, contacts the civil defense.

I System Architecture:

A. Dmr hardware system

This section describes in detail the components used to make Dmr nodes and the Dmr gateway. The Dmr no deconsists of a board to which sensors, a charge controller, rechargeable batteries, and a small solar panel are connected, making the individual node totally energy autonomous. The transmission standard is Dmr , according to the standard currently used by civil defense .

• the ٤FmYsf Nxdn Ds tar P۲٥ Dmr module is the heart of the fire detection node. The node manages the main smoke detection sensors and sends them in VHF/UHF to the Dmr gateway. In addition, the node is powered through rechargeable batteries connected to a charge controller and a suitably sized solar panel. This node is based on a Raspberry Pi Zero ۲W+ and a transmission module compatible with the Dmr standard.

• The BME٦٨٨ ٤-in-١ Quality Breakout Sensor (Gas, Temperature, Pressure, Humidity) has updated features as a gas scanner that can respond to volatile organic compounds (VOCs), volatile sulfur compounds (VSCs), and the presence of carbon monoxide and hydrogen in indoor or outdoor air.

• a solar panel (١٠W ٦V ١٧٠٠mA ٢٦٠x١٤٠x٢,٥mm) with USB Charge for Outdoor Working support was appropriately sized to support the energy needs of the node throughout the day, charging the ٣٥٠٠mAh - ١٠A١٨٦٥٠ batteries.

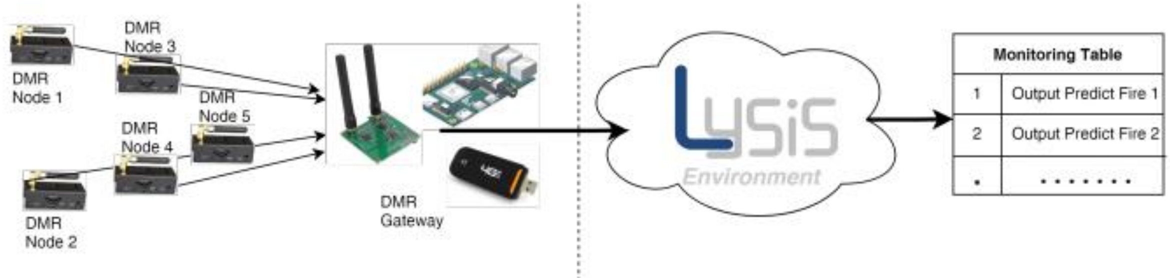

Fig. ١: General view of the DMR system with Lysis platform for real time monitoring and alert.

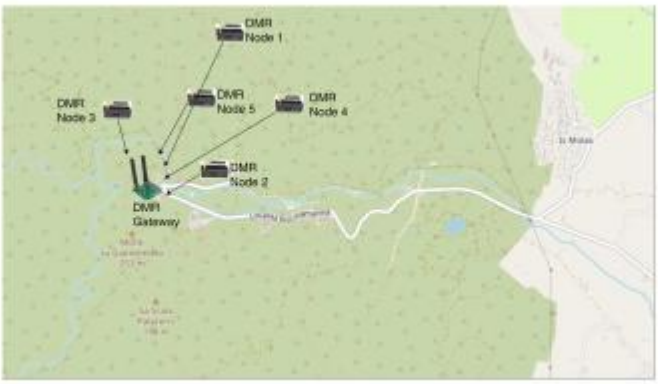

Fig. ٢: The scenario employed for preliminary testing with ٥DMR nodes and DMR gateway within an area of ٥ km ٢ .

The DMR gateway is based on a Bewinter Hotspot Duplex MMDVM module, a high-performance ٣٢-bit ARM MMDVM processor, a hotspot module from DMR, P-٢٥, D-Star and System Fusion for Raspberry Pi with SMA antenna. The shield is based on a Raspberry Pi ٤, which is connected to the cloud via a ٤G LTE network. Thesystem shown in Fig. ١ is designed to work com-pletely autonomously without any special human interven-tion, restarting all processes in case of temporary power source failure.

B. Software architecture

The proposed system consists of ٥ DMR nodes operating independently of each other. Each node is equipped with sensors to detect forest fire smoke and other useful parameters for studying dynamics such as temperature, humidity, atmospheric pressure, UV index. The nodes are mostly in deep sleep mode to preserve batteries and limit power consumption. They wake up every ٥ minutes to acquire sensor data, perform packet processing, and finally perform wireless DMR transmission of the acquired information.

The DMR data gateway collects information from all DMR nodes and transmits the data to a social IoT (SIoT) platform called Lysis using a ٤G LTE network. Lysis is a SIoT platform designed for distributed IoT applications involving socially connected objects [٢٠]. Objects can establish social relationships in an autonomous manner with respect to their owners with the advantages of improved network scalability and information discovery efficiency [٢٠]. The overall architecture of the Lysis platform is based on four.

functional levels:

١) the lower level is made up of the “things” in the real world;

٢) the virtualization level, which interfaces directly with the real world and is made up of Social Virtual Objects (SVOs);

٣) the level of aggregation is responsible for composing different SVOs to set up entities with augmented func-tionalities called micro engines (MEs);

٤) the last level is the application level in which user-oriented macro services are deployed.

To use the Lysis architecture, virtual layer elements (SVOs) representing DMR nodes were designed and implemented. Each DMR node has its own SVO with which it communicates to send and record information about smoke levels and other useful parameters. An artificial intelligence algorithm was developed in Lysis to determine fire cases through training performed in the field by simulating fire and smoke propagation, as described in the next section. Lysis collects sensor data and processes it by continuously comparing it with previous stored data of vai nodes with social relationships to allow for further identification of dangerous situations. Outliers are mathematically processed to avoid false positives and generate alarm situations.

Systemimplementation:

The scenario employed for the preliminary tests has been depicted in Fig. ٢. The identified region is located in Sardinia (Italy) in the mountainous area "Pixina Manna" locality at ٤٥٠ meters above sea level. The area has several elevation profiles typical of the region and is characterized by "maquis" type vegetation. The nodes were placed as in the figure, on tree trunks at a height of ٥ meters above the ground. The arrangement of the nodes allows the detection of fire smoke from any direction. The tests were conducted on a "mistral" type wind day with west/northwest (WNW) direction. The smoke source was positioned WNW with respect to the.

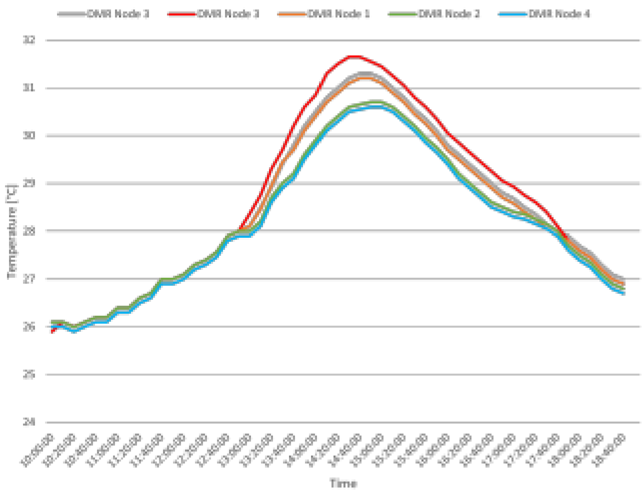

Fig. ٣: Trend of temperatures detected by the various DMRnodes due to the presence of a fire with W-NW origin.

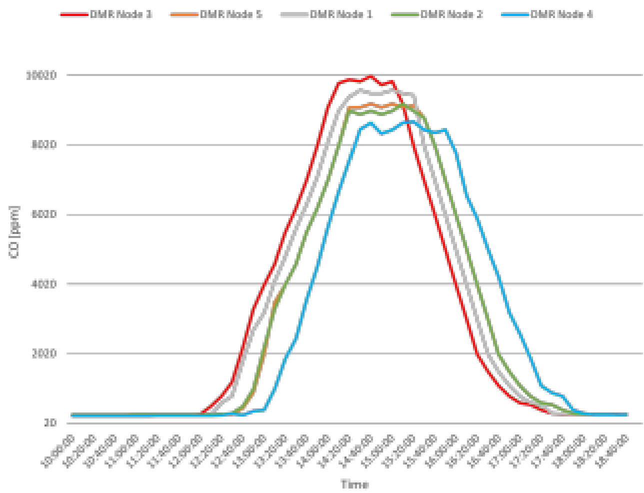

Fig. ٤: Trend of CO detected by the various DMR nodes due to the presence of a fire with W-NW origin.

The proposed scenario is such that nodes ٣, ١ and ٥ are the first to be involved in smoke detection. Detections are then reported by nodes ٢ and ٤. The detection timeline plays an important role in determining the direction of origin of the fire front. Typically, the first nodes to notice smoke are the nodes closest to the fire, so they are crucial for identifying the direction of the fire and implementing appropriate countermeasures.

Results:

The hardware/software system was tested in a real-world scenario.A real-world scenario where DMRnodes periodically transmit sensor data to the gateway.The DMR gateway transmits the data to the cloud in real time where it is processed and graphically displayed. The smoke emission locations are artificially generated from burning organic materials such as brushwood. The DMR nodes detected the temperature increase and the CO increase simultaneously while acquiring the values. As we can understand in Figure ٣, the manipulation process of the ٥ DMR nodes shows an overlap in the first part of the graph, in the time range from ١٠:٠٠ AM to ١:١٠ PM. The BME٦٨٨ sensors [٢١] were tested in the laboratory in a controlled environment before being placed in an outdoor environment, without showing any other deviations.

Compared to what was declared by the manufacturer. At ١:٠٠ PM, the fire source was activated in the WNW position relative to the ٥-node DMR system located in Figure ٢. The experiments were conducted on a day with a mistral wind in the same direction as the fire source. This aspect was very important in assessing the worst-case scenario in an emergency situation. The system quickly returned responses by detecting not only the temperature increase due to the presence of hot air from the fire, but also the temperature difference detected by the DMR nodes. In fact, the nodes closest to the source (i.e., ٣, ١, and ٥) were the first nodes to detect the temperature increase. Similarly, the remaining nodes that are further from the source also "noticed" that there was an external heat source influencing the normal daily temperature trend. The greater the distance between the nodes, the lower the temperature increase, as shown for DMR nodes ٢ and ٤ compared to nodes ٣, ١, and ٥. The second point to discuss concerns the peaks of the individual curves. The shorter the distance between the DMR node and the fire front, the shorter the time it takes for the curve to reach its maximum temperature peak. More distant nodes reach the peak with some delay. Therefore, the longer the distance between the fire front and the DMR node, the longer the response time and the lower the peak temperature modulus detected. At ٢:٣٠ PM the fire source was extinguished and the curves decreased and overlapped asymptotically due to natural conditions and no additional external source to influence the trends. The trend of CO detected by the individual DMR sensors is shown in Figure ٤. The characteristic aspects of these curves are mainly related to the amplitude modulus and the delay in detecting a change in CO concentration. An important point to consider is that the greater the distance between the fire source and the DMR node, the lower the concentration detected by the DMR due to the lack of significant smoke amplification. Due to the greater distance from the smoke source, nodes ٢ and ٤ measure lower concentrations than nodes ٣, ١ and ٥. Similarly, due to the low wind intensity, nodes further from the smoke source detect concentrations with a delay compared to the closest nodes. In Figure ٤, it can be seen that the nodes shift to the right as they move away from the fire source. Together with the temperature readings, the CO data was processed for early detection of the criticality of the fire by determining its propagation speed, direction and direction. These aspects enable the detection station to save significant time in launching rescue vehicles and all the necessary policies to fight and extinguish the forest fire in the shortest possible time.

Conclusion

In this work, geo-electronic noses were developed based on innovative sensors that detect changes in air components that lead to the presence and development of fires in forests. The communication system is based on the DMR standard, which integrates the functionality of the proposed system with the DMR standard in civil defense.The experiments performed showed faster detection of forest fires compared to studies in the literature. The values detected by the different DMR nodes in the SIoT Lysis platform are interpreted through artificial intelligence algorithms, eliminating false positives. The system is able to calculate the direction and speed of the fire front. The system has been tested and trained in real open space.A scenario that demonstrates its effectiveness.

Table١. Plan implementation schedule: Schedule: Specify by hatching the squares.

Steps of implementation	Activity	Implementation time (months)												Activity percentage
		١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢	
First	Research writing													١٥
Second	Writing the research according to the regulations													١٠
Thidm	Review previous topics													١٥
Fourth	Preparation of research equipment													١٥
Fifth	Testing of research equipment													٥
Sixth	Testing and installation of sensors, equipment software													١٠
SEventh	Software testing and fun													١٠
Eighth	System implementation and use													١٠

Study outputs:

• Final report of the research project in one copy with a CD in PDF-Word format

•Ten-page article report

• Also, the results of this project will lead to the preparation and publication of articles in foreign journals and conferences, scientific-research journals and domestic conferences.

Information about the project results:

• It should be noted that the project results respond to the need for new technology that can inform the audience when a fire starts.

• Related higher education institutions, both governmental and non-governmental, can use the project results

• If approved and willing, the government or private organizations that will cooperate with this project include:

Table٢: Organization Approval

No	Organization name	Type and amount of cooperation	Name of person in charge and signature
١	Organization name is Optional	Yaer and month	Ferst name . Last name
٢	...	...	...
٣	...	...	...

Reference:

[١].H. Fujii, S. Managi, and S. Kaneko, “Decomposition analysis of air pollution abatement in china: empirical study for ten industrial sectorsfrom ١٩٩٨ to ٢٠٠٩,” Journal of Cleaner Production, vol. ٥٩, pp. ٢٢–٣١,٢٠١٣.

[٢]. A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, “Internetof things for smart cities,” IEEE Internet of Things journal, vol. ١,no. ١, pp. ٢٢–٣٢, ٢٠١٤.

[٣].F. Callegati, G. Delnevo, A. Melis, S. Mirri, M. Prandini, and P. Sa-lomoni, “I want to ride my bicycle: A microservice-based use casefor a maas architecture,” in ٢٠١٧ IEEE Symposium on Computers andCommunications (ISCC). IEEE, ٢٠١٧, pp. ١٨–٢٢.

[٤].C. Ceccarini, G. Delnevo, and C. Prandi, “Frugar: Exploiting deeplearning and crowdsourcing for frugal gardening,” in Proceedings ofthe ١st Workshop on Experiences with the Design and Implementation of Frugal Smart Objects, ٢٠٢٠, pp. ٧–١١.

[٥].EFFIS,“EuropeanForestFireInformationSystem(EFFIS).”[Online].Available:[٢]

[٦]. D. Stipaničev, L. Šerić, M. Braović, D. Krstinić, T. Jakovčević,M. Štula, M. Bugarić, and J. Maras, “Vision based wildfire and natural risk observers,” in ٢٠١٢ ٣rd International Conference on ImageProcessing Theory, Tools and Applications (IPTA), ٢٠١٢, pp. ٣٧–٤٢

[٧] A. Jha, S. Vedak, K. Mundada, R. Walnuskar, U. Chopade, and A. Iyer,“Early fire detection using deep learning,” in ٢٠٢١ InternationalConference on Artificial Intelligence and Machine Vision (AIMV),٢٠٢١, pp. ١–٦.

[٨] P. Chiavassa, F. Gandino, and E. Giusto, “An investigation on duty-cycle for particulate matter monitoring with light-scattering sensors,”in ٢٠٢١ ٦th International Conference on Smart and Sustainable Tech-nologies (SpliTech), ٢٠٢١, pp. ١–٦.

[٩] B. Montrucchio, E. Giusto, M. G. Vakili, S. Quer, R. Ferrero, and C. Fornaro, “A densely-deployed, high sampling rate, open-source air pollution monitoring wsn,” IEEE Transactions on Vehicular Technol-ogy, vol. ٦٩, no. ١٢, pp. ١٥ ٧٨٦–١٥ ٧٩٩, ٢٠٢٠.

[١٠] G. R. Espinosa, B. Montrucchio, E. Giusto, and M. Rebaudengo, “Low-cost pm sensor behaviour based on duty-cycle analysis,” in ٢٠٢١ ٢٦thIEEE International Conference on Emerging Technologies and FactoryAutomation (ETFA), ٢٠٢١, pp. ١–٨.

[١١] D. T.L. and V. M.N., “Analysis of wild fire behaviour in wild con-servation area using image data mining,” in ٢٠١٥ IEEE InternationalConference on Electrical, Computer and Communication Technologies(ICECCT), ٢٠١٥, pp. ١–٣.

[١٢] E. E. Maeda, A. R. Formaggio, Y. E. Shimabukuro, G. F. B. Arcoverde,and M. C. Hansen, “Predicting forest fire in the brazilian amazon usingmodis imagery and artificial neural networks,” International Journalof Applied Earth Observation and Geoinformation, vol. ١١, no. ٤, pp.٢٦٥–٢٧٢, ٢٠٠٩. [Online]. Available:[٣]

[٢] https://effis.jrc.ec.europa.eu/

[٣] https://www.sciencedirect.com/science/article/pii/S٠٣٠٣٢٤٣٤٠٩٠٠٠٢٣٣.

[١٣] W. Liu, Y. Yang, and J. Hao, "Design and research of a new energy-saving uav for forest fire detection," in ٢٠٢٢ IEEE ٢nd InternationalConference on Electronic Technology, Communication and Information(ICETCI), ٢٠٢٢, pp. ١٣٠٣–١٣١٦..

[١٤] S. Li, L. Qiao, Y. Zhang, and J. Yan, "An early forest fire detectionsystem based on dji m٣٠٠ drone and h٢٠t camera," in ٢٠٢٢ Interna-tional Conference on Unmanned Aircraft Systems (ICUAS), ٢٠٢٢, pp.٩٣٢–٩٣٧.

[١٥] N. Ya'acob, M. Najib, N. Tajudin, A. Yusof, and M. Kassim, "Imageprocessing based forest fire detection using infrared camera," Journalof Physics: Conference Series, vol. ١٧٦٨, p. ٠١٢٠١٤, ٠١ ٢٠٢١.

[١٦] R. D. Aachal Ramteke, Rohini Pochhi, "Iot based forest fire detectionsystem using raspberry pi and gsm," International Journal of AdvancedResearch in Science, Communication and Technology, ٢٠٢١.

[١٧] P. R. Reddy and P. Kalyanasundaram, "Novel detection of forest fireusing temperature and carbon dioxide sensors with improved accuracyin comparison between two different zones," in ٢٠٢٢ ٣rd InternationalConference on Intelligent Engineering and Management (ICIEM),

٢٠٢٢, pp. ٥٢٤–٥٢٧.

[١٨] U. Dampage, B. Lumini, W. Ridma, K. Kinshawa, and J. Bathiya,"Forest fire detection system using wireless sensor networks andmachine learning." Sci Rep., ٢٠٢٢.

[١٩] M. Owayjan, G. Freiha, R. Achkar, E. Abdo, and S. Mallah, "Firoxio:Forest fire detection and alerting system," in MELECON ٢٠١٤ - ٢٠١٤١٧th IEEE Mediterranean Electrotechnical Conference, ٢٠١٤, pp. ١٧٧–١٨١.

[٢٠] R. Girau, S. Martis, and L. Atzori, "Lysis: a platform for iot distributedapplications over socially connected objects," IEEE Internet of ThingsJournal, vol. PP, no. ٩٩, pp. ١–١, ٢٠١٦.\

[٢١]. BOSH.(٢٠٢٢)GasSensorBME٦٨٨.[On-line].Available:[٤]

[٤] https://www.bosch-sensortec.com/products/environmental-sensors/gas-sensors/bme٦٨٨/"