**Industry-specific intelligent fire management system**

**LITERATURE SURVEY**

This section discusses different AI techniques and other fire detection methods used in the past to mitigate risks of fire by early detection and reduce false warnings, but our main focus is ANFIS technology. Efforts were made for early fire detection and risk mitigation. Diverse technologies developed by researchers have been used such as fuzzy logic, neural networks, video-based techniques, Image Processing color-based fire detection methods, etc. Early Fire detection always has been an important research Topic for researchers. The idea of using multiple sensors was proposed by Faisal et al. [[2](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B2-sensors-19-03150)]. The proposed wireless sensor network (WSN) consists of different sensors that share a single wireless network and used GSM. The proposed system results were tested in a smart home to reduce false warnings. Elias et al. also provided a solution using wireless sensor network that was embedded in a micro-controller board for fire hazard detection and fire monitoring purpose [[3](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B3-sensors-19-03150)].

Hamdy et al. Built a “Smart Forest Fire Early Detection Sensory System (SFFEDSS)”, by combining the wireless sensor networks and artificial neural networks for the detection of forest fire [[4](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B4-sensors-19-03150)].

Yu et al. [[5](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B5-sensors-19-03150)] collected the sensor readings for smoke intensity, humidity, temperature to use it in fire detection using Feed-forward neural network approach. The disadvantage of a Feed-forward approach is it demands high processing at the node level resulting in a large amount of power consumption which reduces the lifespan of the node. Also, cluster head destruction in the fire badly affects the robustness of the system.

A system presented by Vikshant et al. works for detection of forest fire by combining wireless sensor networks (WSNS) [[6](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B6-sensors-19-03150),[7](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B7-sensors-19-03150),[8](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B8-sensors-19-03150),[9](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B9-sensors-19-03150)] with fuzzy logic. Multi-sensors technology is used for detecting fire chances and early fire detection. Information gathered from different sensors such as heat, humidity and CO density light, will be sent on the cluster head using event detection mechanisms. Multiple sensors used to detect fire probability and direction are embedded in each node to reduce the false alarm rate and improve the efficiency [[10](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B10-sensors-19-03150)]. A simple way to detect fire developed by Muralidharan et al. using Multiple sensors with the implementation of fuzzy logic and presented the obtained results in MATLAB [[11](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B11-sensors-19-03150)].

In 2017, Yu-Liang Hsu. [[12](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B12-sensors-19-03150)] developed a multi-sensor data fusion technology with artificial intelligence, wearable intelligent technology, and sensor fusion technology that can control home appliances and locate the position of home residents. It works in indoor environments. Similarly, a system was developed by Mirjana et al. which used an IoT concept for determining true fire presence according to the situation [[10](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B10-sensors-19-03150)].

Robert et al. introduced a system using Arduino microcontroller and fuzzy logic technology in search of fire detection in automobile and to reduce its damage due to fire. Different sensors like temperature sensors, smoke sensors, and flame sensors were used. This system was tested on an average-sized car with 2 kg cylinder mounted behind the passenger’s rear seats [[13](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B13-sensors-19-03150)].

J Olivares-Mercado [[14](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B14-sensors-19-03150)] proposed a method of early fire detection by analyzing visual smoke characteristics such as color, dynamic texture, gray tones, etc. The system was tested using standard videos containing smoke.

JH Park. [[15](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B15-sensors-19-03150)] proposed an early fire detection system for smart cities with a multifunctional artificial intelligence framework. The artificial intelligent framework includes an adaptive fuzzy algorithm, machine learning algorithms and Direct-MQTT based on SDN.

In this paper, ANFIS technology is used to design a fire detection control system and reduce false alarms. ANFIS technology has been used in mobile robot navigation [[16](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B16-sensors-19-03150)], healthcare monitoring systems [[17](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B17-sensors-19-03150)], air conditioning control [[18](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B18-sensors-19-03150)], flood susceptibility modeling [[19](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B19-sensors-19-03150)], and many other applications. In recent times, fiberoptic sensors were used for structural fire engineering [[20](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B20-sensors-19-03150)], however, there is a need for true fire identification. IoT is successfully being used to achieve accuracy and efficiency in modern smart systems and has provided positive results as well [[21](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B21-sensors-19-03150),[22](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B22-sensors-19-03150),[23](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B23-sensors-19-03150),[24](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6679255/#B24-sensors-19-03150)]. This success of IoT was the motivation to design the proposed a smart and intelligent system for fire monitoring

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