PROBLEMS AND PROSPECTS OF FIRE PREVENTION AND EXTINGUISHING

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FIRE DETECTION AND ELIMINATION METHODS AT AN EARLY DEVELOPMENT STAGE IN A PUBLIC BUILDING

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Abstract. The method of fire detection at an early stage and measures of it's elimination it in public buildings are described. An artificial intelligence system that combines heat, smoke sensors and image processing from cameras is presented. The technique has passed model studies and has shown its effectiveness.

Special attention is paid to data analysis algorithms that can reduce the probability of false positives and increase the reaction speed. The key stages of fire detection, threat classification and decision-making are considered. The results of testing in real conditions are also presented, demonstrating the high accuracy of the system. The prospects of integrating the technology with existing fire protection systems and its possible application in large public and administrative buildings are discussed.

Key words: fire safety, analysis, fire detection and elimination, monitoring system, artificial intelligence, automation

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Introduction

Ensuring fire safety in public buildings is one of the most urgent tasks today. A delay in fire detection can lead to serious consequences: deaths, property damage and environmental hazards.

Fire safety is an important element of ensuring the safety of both public and industrial facilities. In Russia its regulation is carried out in accordance with the Federal law of the Russian Federation dated July 22, 2008 No. 123-FL «Technical regulations on fire safety requirements». This law defines the basic principles and rules for ensuring fire safety, establishes the responsibilities of government agencies, organizations and citizens in this area, and regulates the procedure for conducting minimum fire safety and other measures aimed at preventing fires [1].

To solve these problems, it is necessary to develop comprehensive methods and systems capable of detecting signs of fire in time and immediately notifying operators and fire services.

The aim of this research is to develop a method for detecting and eliminating fires in public buildings at an early stage by combining various technologies and data processing methods.

Stages of fire detection and elimination

The development of a fire includes three stages, each of which has a certain importance in the process of spreading the fire. At the initial stage, a fire can be eliminated quickly and effectively if clear measures are developed in advance. The fire response algorithm at an early stage contains step-by-step instructions for employees, which allows them to respond quickly and safely to a threat [2].

The main signs of the early stage of the fire [3]:

– smoke;
– odor;
– temperature rise;
– noise;
– flames and sparks;
– changes in the environment;
– dimming lights.

Early detection of these signs allows for making timely actions aimed at fire elimination and minimizing of its consequences. The development of effective fire fighting techniques at the initial stage plays a key role in ensuring the safety of life and property. A fire can occur almost at any time, so it is extremely important to have a prepared action plan and respond quickly to prevent further losses. Effective actions in the first minutes of a fire can significantly reduce potential damage and save many lives [2].

The following components were used to build a fire detection and elimination system:

– the use of modern fire detection technologies such as heat and smoke sensors, as well as intelligent systems capable of analyzing environmental parameters [4];

– video surveillance cameras with image processing based on artificial intelligence (AI) (smoke and fire detection) [5];

– the use of automated fire extinguishing systems based on inert gases such as argon and nitrogen, which effectively suppress fire without harming people and equipment [6];

– analytical software for combining data from sensors and cameras for improvement of the fire detection accuracy [7].

The main focus was put on the use of highly sensitive sensors and early detection systems, including analysis of the concentration of combustion products, automatic start of gas fire extinguishing to prevent the spread of fire, as well as at the development of integrated monitoring systems that reduce the reaction time to a fire [8]. The stages of the methodology are presented in the table [9, 10]:

Table

Stages of the fire detection and elimination methodology at an early stage of its development in a public building

№	Stage	Actions taken
1.	Installation of a system of sensors and cameras at key points of a public building	Identification of the most vulnerable areas of the building (crowded areas, warehouses, technical areas)
		Installation of smoke, temperature, flame and gas analysis sensors to detect signs of fire
		Installation of surveillance cameras with highly sensitive sensors and night vision functions for continuous monitoring
		Integration of all devices into a singular network providing real-time data transmission

№	Stage	Actions taken
2.	Configuring AI algorithms for real-time image and data analysis (at this stage, machine learning and big data processing technologies are used)	Development of fire detection algorithms, including smoke, temperature changes, flame appearance and abnormal movements
		AI system training based on different fire scenarios to minimize false alarms
		Setting up an automatic threat classification system to determine the degree of risk and the scale of a potential fire
3.	Development of protocols for notifying operators and activating fire extinguishing systems (aimed at creating a clear system interaction scheme for all elements)	Prioritization of notifications (operators, security services, public notification systems)
		Alarm settings, including audio, visual, and text alerts in case of fire
		Automating the activation of fire extinguishing systems, such as water, foam or gas installations, taking into account the nature of the fire and the safety of people
		Integration of the system with local and centralized emergency response services
4.	Testing the system on fire simulators	Conducting simulations of various fire scenarios (for example, a fire in the kitchen, a short circuit in the control room, arson)
		Checking the correctness of sensors, cameras, and AI algorithms when detecting threats
		Evaluation of the system response time from the moment of fire detection to operator notification and activation of fire extinguishing systems
		Analyzing the received data and eliminating possible errors or delays in the system operation

These stages form an integrated approach to the development of effective methods for detecting and eliminating fires in the early stages of their development in public buildings [9].

As a result of testing the proposed methodology, the following data were obtained:

– the average fire detection time was 8 seconds. from the moment the first signs of fire appear;точность распознавания пожара на основе комбинированных данных достигла 97 %;

– the activation time of the automatic extinguishing systems was less than 15 seconds. After confirming the fire.

An example of the system's operation is shown in the figure: a reduction in response time compared to traditional systems is demonstrated.

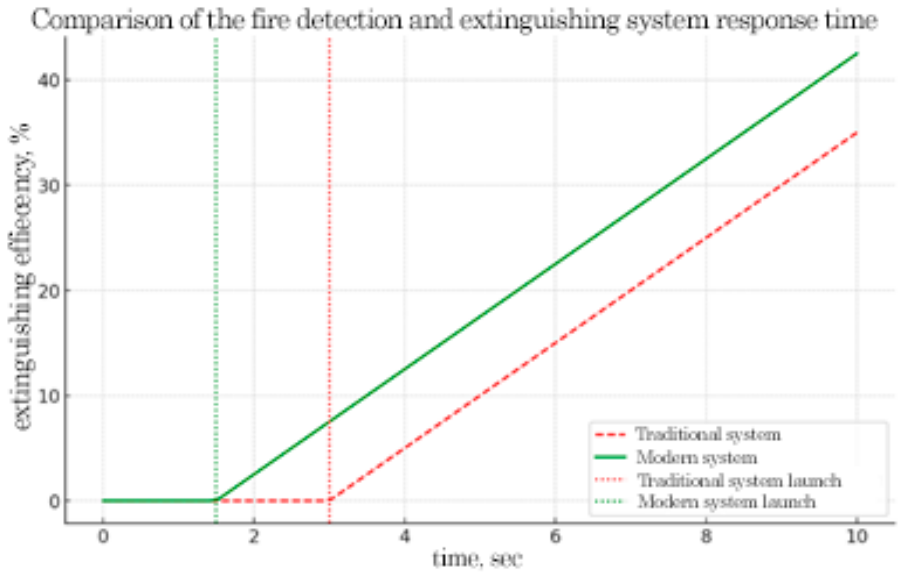

Fig. **Comparison of the response time of fire detection and elimination systems**

The modern system starts faster (after 1,5 seconds), while the traditional one reacts only after 3 seconds. Using a modern system allows you to eliminate the fire faster, minimizing possible losses.

Conclusion

Using a combined approach made it possible to minimize the number of false alarms due to the synergy of data from various sources. The greatest difficulty was related to the training of AI algorithms to work in conditions of smoke and low light conditions. Nevertheless, the developed system has shown its reliability and applicability in real conditions.

Thus, the presented method of fire detection and elimination at an early stage has proved its effectiveness. The use of intelligent systems can significantly reduce the risks and damage caused by fires in public buildings. In further studies, it is planned to adapt the system for use in residential buildings and industry.

List of sources

1. Technical regulations on fire safety requirements: Federal law of Russian Federation dated 22 July 2008 № 123-FL. Access from the information and legal portal «Garant».

2. EMERCOM of Russia. URL: https://mchs.gov.ru/ (reference date: 27.01.2025).

3. Ivanov A.A., Petrov V.V. Fire safety systems: modern approaches // Fire and emergency safety: materials of XVIII International scientific and practical conference Ivanovo, 2023. P. 9–12.

4. Gromov L.M. Fire safety of public buildings: practice and methodology. Novosibirsk: Science and practice, 2021. 300 p.

5. Ivanov A.P. Methods of early detection of fires in buildings and structures. Moscow: Academy of the State fire service of EMERCOM of Russia, 2020. 345 p.

6. Belyaev Yu.V. Innovative fire extinguishing technologies using gas systems. Moscow: Technopolis, 2021. 240 p.

7. Nikolaev S.T. Methodological approaches to the elimination of fires at the initial stage of their development. Voronezh: VGASU, 2020. 210 p.

8. ISO 7240-1. Fire detection and alarm systems. General requirements. URL: https://www.iso.org/standard/79791.html (date of reference: 25.01.2025).

9. Chernov D.A., Pavlova I.G. Fire safety of buildings: regulatory requirements and practical implementation. Nizhny Novgorod: NNGASU, 2022. 180 p.

10. Smith J., Doe J. Fire detection technologies in smart buildings // Journal of safety engineering. 2022. Vol. 14. № 11.

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