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The Experience of Designing and Application of CAD Systems

(CADSM'2023)

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Department of Computer-Aided Design of

Lviv Polytechnic National University, UKRAINE

Department of Microelectronics and Computer Science of

Lodz University of Technology, POLAND

AGH University of Science and Technology, POLAND

The State University of Technology and Economics in Jaroslaw, POLAND

IEEE Poland Chapter of Electron Devices and Electronic Packaging

2023 IEEE 17th International Conference on the Experience of Designing and Application of CAD Systems (CADSM)

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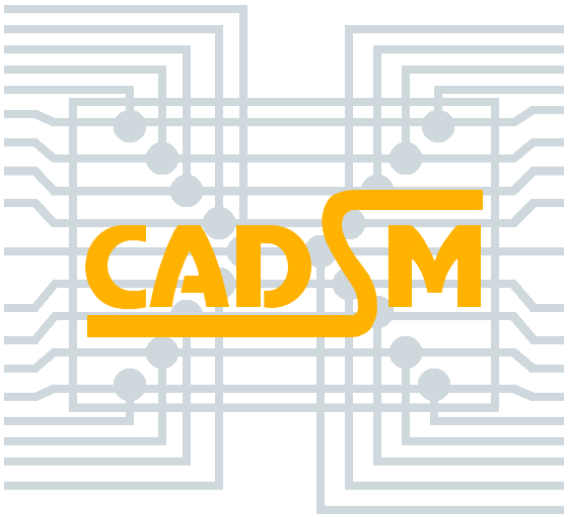

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Abstract* — Heat detectors are the best ones for detecting flame fires. Unlike other types of fire detectors, heat detectors can be used in polluted and aggressive environments. They are resistant to various interferences. However, heat detectors have the highest operation inertia. You can reduce the fires detection time by heat detectors using fuzzy logic mathematical apparatus. The heat detector based on fuzzy logic was developed and investigated in this article. For this purpose, a microcontroller based on the Arduino hardware was used. Heat detector responds to both fixed temperature and the speed of temperature rise. A new model of heat detector based on fuzzy zero-order Sugeno logic with two inputs in the MATLAB/Simulink package was developed. Research of the accuracy and adequacy of the obtained mode was done. In the course of research, it showed 100% accuracy and adequacy in relation to the developed model in the Fuzzy Logic Toolbox. In the Arduino software package, using the C programming language and the Arduino Mega 2560 board, a hardware implementation of the Sugeno zero-order fuzzy logic heat detector was implemented. Experimental studies have been carried out. The error of the result calculated by the Arduino did not exceed 2.5%. Execution time of one complete cycle of fuzzy block is 0.004 sec.

***Keywords* — fire detection system, heat detector, intelligent fire detector, fuzzy logic**

I. INTRODUCTION

To protect against fires, people have invented many ways and systems of fire protection. One of them is the fire detection system (FDS). According to the US National Fire Protection Association, the death rate per 1,000 fires in buildings is 55% lower with a working FDS than in buildings without a FDS or a non-operating FDS [1]. Therefore, it is very important that these systems are designed correctly and that the right equipment is chosen to save lives and property. Taking into account the significant damage from fires, time is a critical factor in detecting a fire. The ignition detection speed of FDS is influenced by various factors, for example: the selected type of fire detector (FD), the FD algorithm, the FD location, the type of fire, and so on. Fires can be smoldering or flaming. Smoldering fires are well detected by smoke detectors or gas detectors. Flame fires are well detected by heat or flame detectors.

Multi-sensor FD are considered to be the best. They detect both smoldering and flaming fires efficiently. However, the presence of smoke and/or infrared sensors makes it impossible to use them in polluted and aggressive environments, unlike heat detectors.

There are the following point heat detectors: rate of rise heat detector, fixed (statist) heat detector and for special applications detector [2]. The rate of rise heat detector is more efficient and sensitive than standard fixed heat detectors and detects fires at both slow and rapid temperature rises. Also, they are much better used when the ambient temperature is low.

Heat detectors are the simplest, not expensive, simple and cheap to maintain, very reliable, have good resistance to various interferences. In general, head detectors are more resistant to adverse environmental conditions compared to other types of FD. But they are considered the least sensitive and have the greatest inertia. However, there are a number of sites where flaming fires occur or where there is significant environmental pollution. For example, woodworking enterprises, elevators, mills, waste processing plants, etc. Then heat detectors are indispensable in use.

Disadvantages of FDs using information from only one sensitive element, including heat detectors, can be eliminated by developing algorithms based on fire detection methods by neural networks or fuzzy logic. Mathematical foundations of fuzzy logic are simpler than neural networks. They can be more easily implemented technically by means of microcontroller technology. These mathematical foundations make it possible to improve the technical characteristics of heat detectors: reduce their inertia, reduce the error of operation of the heat detectors from external interference and accurately detect fires.

Scientists are increasingly using hardware and computing platforms to study and debug the developed algorithms of heat detectors operation on the basis of fuzzy logic, for example, Arduino boards with Atmel ATmega328 or ATmega32U4 microcontrollers.

II. LITERATURE REVIEW

In the articles [3, 4] it is proposed to reduce the time of fires detection by heat detector due to the development of algorithms. Depending on temperature conditions of the environment, they change the value of static operating temperature and the speed of temperature increase at which the heat detector operates. However, the development of the FD algorithm is based on the use of clear logic. In this case, you cannot use expert judgment. Specific clear values are used. However, there may be cases when they may change.

In the articles [5, 6], the authors use an Arduino Uno board with different types of sensors to build a FDS. In the article [5], a smoke sensor is used to detect ignition. The system sends a fire or malfunction message via the GSM modem, turns on the fire pumps, gives alarms and turns off the power to the house. In the article [6], an IoT-based FDS using temperature and smoke sensors was proposed. After exceeding the threshold set values of controlled features, the microcontroller turns on the fan to remove smoke. At the same time, the Arduino sends information about the fire via the Wi-Fi module ESP8266. However, in the articles [5, 6]

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