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To the Issue of Development and Implementing of the Information-Analytical System of Forecasting of Fire-Dangerous Situation in a University Admission Committee

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Abstract: The study deals with the task of monitoring and forecasting of occurrence and evolution of fire-dangerous situation in a university admission committee based on the apparatus of neural networks and production computations. A structural-functional system organization is proposed that allows early detection of fire-dangerous situation or initial stage of a fire.

Key words: Fire-dangerous situation, fire, university admission committee, situation assessment, production system, neural network

INTRODUCTION

Relevance of the study the essence of the proposed approach: Premises of a university including admission committee, present one of bigger types of Dfficult Tchnical Ojects (DTO) that have high fire risk by virtue of high density of office and other equipment indoors, large amount of printed products as well as worn out electric networks and cables. Such objects, in general have extended infrastructure, unique geometric shapes which is important for understanding the process of development of a fire as a system (GRF., 2012). The most important support of the objects is fire safety of electric networks and cables under load.

However, the causes of more than 30% of fire situations, occurring in DTO of the mentioned type are electric network and cables defects and/or breach of operation conditions (Sazonov *et al*., 2013, 2015). A significant amount of fires occurs as a result of failure of office equipment, energy demanding machines (copiers, coffeemakers, heaters, etc.) and electric networks. Heating and spark effects of electric current create supportive environment for firing of flammable materials in office space.

Overloads, short failures, high resistance in electric networks, electric arc or sparking are causes of fires. The reason of overload in an electric network is connecting excessive amount of consumer. In event of overload wire, insulation cripples and fractures which leads to firing of insulation or flammable materials, smoldering and combustion of cable winding (Sazonov *et al*., 2013, 2015; Emelyanov *et al*., 2014). The main reasons of short failure are lack of regular inspection of insulation, contact of bare wire and conductive objects, influence of chemically active materials, dust and humidity on wires, incorrect installation, etc.

Thereby, rational organization and automation of solving tasks of recognition, assessment and forecasting of fire risks are possible only on the basis of creating perspective information-analytical models with modular design that perform constant control of the most important physical and chemical factors, fully consider structural-logical and statistical properties of fire risks.

The essence of the proposed approach to forecasting of a fire-dangerous situation: Existing automatic tools of monitoring current Fire-Dangerous Situation (FDS) react to the fact of combustion occurrence and the subsequent fire. It means that these tools treat a fire as an external destructive event, not a system that has conditions, causes, stages of evolution and propagation. In other words, modern control tools are responsible for the task of identification of FDS (Titenko *et al*., 2013). The issues of forecasting and early detection of a possible fire are generally not implemented by such control tools. Considering this difficult situation, the functions of monitoring and forecasting of FDS are among the top-priority activities of IT departments of fire protection services.

Forecasting of FDS means defining conditions and quantitative assessment (probability) of occurrence and evolution of a fire-dangerous situation based on analysis of historical and current data about the state of the controlled object including:

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- Parameters of the controlled environment (temperature, amperage in the electric network, load power, generated heat of electric wires, etc.)
- Indicators of FDS (gases, generated during smoldering, firing and fire propagation, sparking, etc.)

Forecasting is possible on the basis of the solution of the task of monitoring of FDS, i.e., gathering, analyzing and preprocessing data (parameters of environment and indicators of fire-dangerous situations) about conditions of FDS and external environment (the controlled environment) (Egorov *et al*., 2013). Monitoring of FDS is a system of regularly performed measurements and observations of the state of the controlled environment, including indicators of FDS in order to detect deviations from standard parameters and to subsequently detect trends of their alterations. Tools of forecasting are designed for quantitative analysis of historical and current data for making a decision on the prediction of a fire. Considering the duality of the problems to be solved, tools of monitoring and forecasting should be considered as a complex, parameters of the environment (physical variables) and indicators of FDS (chemical variables) as an interconnected set of variables describing different conditions of a fire as a system: standard, unstable, critical edge (smoldering), fire-dangerous, pyrolysis.

A particular task of gathering and initial analysis of data about FDS is made through the measurements and analysis of physical and chemical factors:

- Amperage
- Conductor temperature
- Concentration of carbon monoxide (1 m^3)
- Concentration of carbon dioxide (1 m^3)
- Concentration of hydrogen (1 m^3)
- Concentration of aromatic hydrocarbon (1 m^3)

The combination of these factors (parameters and indicators) and their accumulation in a database makes it possible to formalize the processes of forecasting and recognition of a fire and to use a mathematical apparatus and computer tools for statistical and intellectual analysis of time series of controlled factors. Intellectual analysis of time series is performed using neural networks for adaptive detection of significant trends in fire-dangerous situations. This is the essence of the approach and the proposed information-analytical system of forecasting a fire-dangerous situation.

MATERIALS AND METHODS

The structural-functional organization of the information-analytical system of monitoring and forecasting of a fire-dangerous situation: In order to implement the considered functions, the following structure of the Information-Analytical System (IAS) for forecasting a fire-dangerous situation is proposed. IAS is a component-oriented system of interaction of allocated levels gathering the measurement information, its preprocessing, aggregation, storage and transmission to the upper levels for implementing computational functions of building the forecast of fire-dangerous situation development (Fig. 1).

At the uppermost level of IAS (level 0-not shown) is an automated workstation of the fire safety administrator-an administrator who monitors the state of DBMS and technical tools of measurement and data gathering and records it to the database (MS SQL Server).

Measuring, data gathering and transmission devises (level I) are designed for regular data collection from a large number of measuring devices, execution of measurements and initial computations and data transfer to the next level. In order to obtain data on

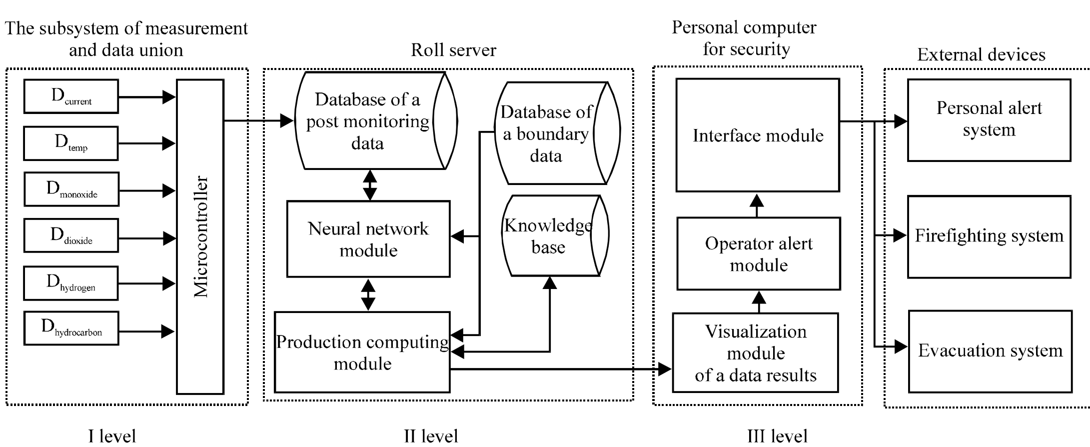

Fig. 1: The structure of IAS of monitoring and forecasting of a fire-dangerous situation

FDS it is supposed to use commercially available devices of domestic and Foreign production equipped with counting-pulse digital and analog outputs as well as a controller ADAM5510/TCP programmed for the mentioned above operations.

The polling server (level II) is a software-hardware complex which is intended for interaction with the controller and processing of historical and current data (time series of physical and chemical factors) in order to identify significant trends in FDS and determine the state of a fire as a controlled environment. The novelty of the technical solutions lies in the dynamic nature of processing of heterogeneous data that have an individual rate of change. In order to do this, a window of a variable length is used to select segments from the original time series which are subsequently, aggregated and the resulting synthetic series are further processed.

At the level III organizational and calculation tasks of the processes of monitoring and forecasting of FDS are being solved. For the reasonableness in decision making the visualization of the results of monitoring of an array of physical and chemical factors and states is constantly performed. On the basis of the performed calculations and the forecast the commands for reporting to LPR and interaction with external executive systems are formed (fire-alarm system of the company, territorial MCHS system 112. etc).

RESULTS AND DISCUSSION

The approximate evaluation of comparison of costs for the use of the system of forecasting and damage from a fire by the example of a typical university admission committee office: The most important economic and time indicator of the effectiveness of fire protection service actions is the time of prompt response (from the moment of reporting a fire to its isolation and suppression). Its reduction directly affects the consequences of a fire (a decrease in the number of deaths, injuries as well as a decrease in material damage). Studies show that in order to reduce the number of death in fires by about 4 thousand people per year it is necessary to shorten the average time of reporting a fire and response to a fire by 15 min from the current one. Reduction of the time of isolation and suppression of a fire by 1 min allows to reduce the damage by 300 rubles per 1 m^2. In turn, the proposed IAS keeps round-the-clock control of the fire danger of electric networks of office and other types of objects for various purposes.

Implementation of IAS of monitoring of DTO will allow to reduce the average time of reporting a fire or even to prevent it which in turn will result in a decrease in the number of casualties and a decrease in material damage.

Assume that the estimated cost of developing and implementing IAS in a typical admission committee office of 100 m^2 is 180, 000 rubles of which the cost of IAS itself is 80, 000 rubles including a processing server and a network of sensors, the cost of installation and configuration is 30, 000, the cost of software development is 70, 000 rubles. In turn, based on the average cost of a fire of 300 rubles per 1 min per 1 m^2, the damage from a full-scale fire in a typical admission committee office of 100 m^2 is 30, 000 rubles per 1 min.

Therefore, a conditional assessment of effectiveness of IAS from preventing a full-scale fire (100% coverage) of 1 min duration can be estimated in minimal number of prevented fires in a typical office 6 fires. Figure 1 is given for the worst case with an "instantaneous" rate of spread of fire as a continuous environment and 100% damage to material values that have fallen into a fire zone. Naturally, such calculation should consider a geometry of an office rates of fire as a continuous environment and a certain proportion of damage to material values. Nevertheless, for the IAS at an average fire frequency in a typical admission committee office of 1.7 years for its worst case the payback period of the system can be estimated at 9.2 years.

CONCLUSION

An information-analytical system of monitoring and forecasting of FDS that allows to predict a fire before its occurrence has been designed. This IAS can be adapted to existing software systems. It has a modular structure and a standard network architecture which simplifies the task of complex automation of fire-dangerous situation control. The research is performed within grant of the President of the Russian Federation MK-968.2018.8

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