UDC 681.5.015 (045)

**[1]V. M. Syneglazov,**
**[2]V. L. Kupriyanchyk**

# COMPUTER-AIDED DESIGN OF INFORMATION FIRE MONITORING SYSTEM

National Aviation University, Kyiv, Ukraine
E-mails: [1]svm@nau.edu.ua, [2]v.kupriyanchyk@yandex.ua

***Abstract*—*Information fire monitoring system is proposed. Description of structure and algorithmic software of the offered system is given.***

**Index terms**—Evacuation; optimal evacuation route.

## I. INTRODUCTION

According to the results of research in the first half of 2014 that was made by the specialists of the Ukrainian scientific-research Institute of civil protection monitoring of fires and the consequences from them on the basis of the accounting data received from local authorities SSES of Ukraine in regions and Kyiv there was registered 30236 fire, representing an increase of 3.5 % over the same period of 2013.

The number of deaths due to fires decreased by 3.2 % and amounted to 1197 against 1237. The number of injuries in fires increased by 3.0 % and amounted to 798 against 775.

Material losses caused by fires, amounted to 2 billion 15 million 3 thousand UAH, of which direct losses are 587 million 32 thousand UAH, and side - 1 billion 427 million 971 thousand UAH.

During the reporting period in Ukraine on an average day there were 167 fires, which killed 7 and injured 4 people, a fire destroyed or damaged 70 buildings and 13 units of vehicles; daily financial losses from fires amounted to 11.1 million UAH.

On trade and warehouse buildings, the number of fires increased by 20.9 %. In general, on these objects appeared 521 fires. Direct losses amounted to 54 million 562 thousand UAH. (+58,7 %). Incidental damages to these facilities amounted to 100 million 856 thousand UAH (+73,3 %).

Due to fires in industrial buildings, 2 people died (for 6 months of 2013 – 1 person). The largest percentage of fires in industrial facilities noted in the Khmelnytsk region (2.9 % of their total number in the region). The average in Ukraine is 1,7 %. [1]

A serious problem in high-rise buildings is fire safety. Experience of high-rise construction in neighboring countries forces us to approach to the design of sprinkler systems in high rise buildings so that each apartment (room) in this house was equipped with a fire alarm system, that the house had its own autonomous fire extinguishing system, emergency elevators [2].

One of the main means of protection against the damaging effects of fire is timely evacuation and dispersal of site personnel from hazardous areas.

Researches have shown that the majority of people during evacuation (up to 90 %) able to adequately assess the situation and reasonable actions, but, experiencing fear and infecting with it each other, can panic.

The movement of people is considered as an important functional process, typical for buildings of any purpose.

In case of fire there is a real threat to the health and lives of people. Therefore, the evacuation process begins almost simultaneously and has a clear focus. As a result of such simultaneous and directional movement and due to the limited bandwidth of emergency routes and exits s a higher density of human flows can be created, there are physical effort on the part of individuals who are evacuated, which significantly reduces the speed.

Solving the problems of detection and alerts in case of fire on objects with mass stay of people at the present stage requires constant improvement. Therefore, the task of construction of information fire monitoring system is very important.

## II. PROBLEM STATEMENT

The task of work consists in construction of information fire monitoring system, which corresponds to the following requirements.

1. To detect fire in time.
2. To provide information into data base (DB), where are data about all premises (the class of premise, measurements, the characteristic of equipment and materials).
3. The system must rate the fire by the number of sensors which worked.
4. Based on the created 3-D models of premises begin to predict the spread of fire in time and location of the hearth fire.
5. To estimate the number of people in each room.

6. To calculate the optimal evacuation route for each time period of evacuation considering the spread of fire.

7. To implement information for people by audio and visual signals.

## III. REVIEW OF EXCISTING SYSTEMS OF SIMULATION OF EVACUATION

Fire safety demands of people, with rare exceptions, organization of their safe evacuation. The criteria for safe evacuation of people – timeliness and zero interference – now are checked on the basis of calculations using certain models of human flow (or wider – evacuation models implemented in the executive algorithms for computers.

For today, in the world there are a few dozen models that use different methods of presentation of the internal environment of the building (exact or rough network), simulation of the movement of people (individual, group / streaming), in different ways take into account the psychological aspects of human behavior (actions when receiving a signal about a fire, route selection, the impact of dangerous factors of fire).

*Cities Evatek.* This software package can be used for different types of buildings. The algorithm is implemented according to GOST 12.1.004–91.

Type of model: partial model of behavior / movement model. By default, only motion is simulated. Users can define several different profiles, roles for agents and their behavior scenarios:

– calculating of evacuation time of people based on individual characteristics of the movement of people in the flow based on Russian standards of human speed from density of people in a rectangular area around the person;

– input the source data to calculate using a graphical editor, the ability to import geometry from DXF files;

– displaying the density map, passed and current ways of agents;

– the ability to play and record the results of the calculation;

– 2D/3D visualization of movement modes;

– report generation, including raw data, the simulation results, graphs, maximum and medium density at time, the percentage of used outputs;

– export report issued in DOC-format file.

*Cities FlowTek*. This software package can be used for different types of buildings. The algorithm is implemented according to GOST 12.1.004–91.

Type of model: movement model.

The main characteristics of the system:

– input the source data to calculate using integrated graphics editor based on scanned building plans;

– support of parameterization;

– work with a single project file in the program complex Cities to calculate the fire risk;

– the ability to create several scenarios of evacuation;

– displaying the map of calculated areas and evacuation routes;

– 2D/3D motion animation of human flows with the possibility of stepping through revision;

– revision of the basic parameters for a given settlement area;

– report generation, including raw data, table of calculated evacuation time from each room, table of time for exit from floors, table of areas with a delay of motion, summary table of evacuation time for all scenarios, maps of calculate areas, the image of evacuation routes.

*Evacnet 4.* This software package can be used for different types of buildings, such as offices, stadiums, high-rise buildings, hotels, restaurants and schools.

Main task of model is the optimization of evacuation from the building. This means that the evacuation time from the building is minimized.

Type of model: movement model.

The structure of model: network model.

The behavior of agents: no.

*BuildingExodus.* The purpose of this system is the simulation evacuation of large number of people from different types of buildings. In BuildingEXODUS an attempt to consider "people-people, people-fire and interaction of people." The model consists of six submodels, some of them interact with each other for information transfer about the process of evacuation, simulation, data about agents, movement, behavior, toxicity danger and geometry.

*Simulex.* This is evacuation model with the possibility of simulation of a large number of people from buildings with complex geometric architecture.

Type of model: partial model of behavior. This is based on the distance between agents, which determines their speed. In addition, the model allows to realize overtaking, turning, sideways and backward movement.

The structure of model: "regular grid." Plan of floor and net part on cells the sizes of 0,2 × 0,2 m. The model contains an algorithm that calculates the distance from each block to each output. And the received data are displayed on the map.

The behavior of agents: implicit behavior. The movement of agents: fluctuation in speed of movement, steps aside and deformation of the body,

overtaking etc., is based on the results of many video surveillance and analysis of individual movements, and a number of additional results of scientific researchers.

*PedGo*. Simulates moving crowd, imitates the evacuation of people from buildings, ships, aircraft and other types of public transport.

Type of model: Movement/partial model behavior.

The structure of model: "small grid," which divides the floor of 0.4 × 0.4 m and represents the space occupied by the person. Walls, furniture and other obstacles are presented in the cells.

The behavior of agents: implicit behavior. Before calculations the model offers to specify certain characteristics for agents, such as: the delay before the evacuation, patience, reaction, omissions, power. This set of parameters is used for the characteristic behavior. Two of these parameters, the delay time and power, are stochastic [3].

## IV. THE STRUCTURE OF THE PROPOSED SYSTEM

The structure of the proposed system is shown in the block diagram (Fig. 1).

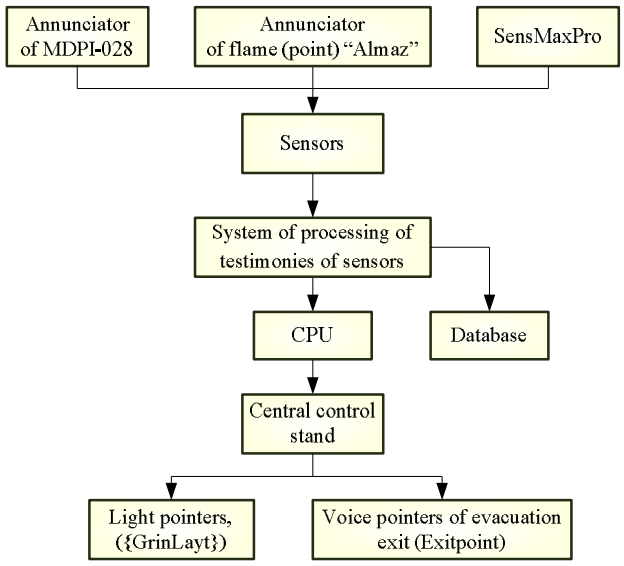


Fig. 1. Structure of the system of fire supervision

In general, the sequence of operation of the system can be described as follows. The system of processing of testimonies of sensors (SPTS) monitors the state of all apartments, analyzing the testimony of present sensors real-time (input/output, flame, smoke). Information from SPTS served in the database (DB), which contains information about:

– the type of premises;

– coordinates of the placement of premises;

– materials.

Based on the information from the DB the Central processing unit (CPU) selects the evacuation model, proper algorithm [4] and calculates the optimal evacuation route. The calculations are carried out using the methods and formulas that are available in the CPU.

Next, the CPU gives a command on central control stand (CCS) about beginning of evacuation. For the conclusion of information about the way of evacuation it is necessary to give information about the accessible sensors of notification of people to CPU.

Based on this information, the CPU sends signals to the sensors of notification of people and shows the best evacuation routes.

## V. CHOICE OF COMPLEX OF HARDWARE'S

In the system it is suggested to use next hardware.

1. Annunciator of MDPI-028.

The thermal maximally differential fire annunciator MDPI-028 is intended for the exposure of fire after the change of ambient temperature in an apartment in two ways:

– after achievement of threshold value a temperature;

– after speed of change of temperature.

2. The fire detector of flame (point) "ALMAZ."

The detector is intended for the detection in enclosed spaces of buildings and structures flames from fires, that accompanied by ultraviolet radiation (UV) in the wavelength range from 220 to 280 nm. The response time of the detector upon detection of the fire – 3 sec.

The maximum detection range of the fire is 80 m, the angle is 90°.

3. Light pointer of series of "GrinLayt."

The light pointer of series of «GrinLayt» is executed on the basis of acrylic transparent plate on which the inflicted inscriptions or icons are typographically printed. Illuminating from beneath of image is carried out by the line of ultra-bright light-emitting diodes, located in a metallic corps.

In the nomenclature of pointers there are models which work from 12 V and 24 V direct-current and from a network 220 V an alternating current.

4. Voice pointers of evacuation output ExitPoint.

Pointers ExitPoint are used as auxiliary devices in the fire alarm system and accelerate the process of evacuation of people in the building. ExitPoint have a nominal voltage of 24 V and are designed for a stabilized power supply.

5. System of count of visitors SensMax Pro – Automatic people counter.

This system is designed to count visitors in shops, restaurants, cafes, shopping malls and other complexes of the premises. SensMax Pro consists of wireless people counters, collector with automatic collection and transmission of data, analytical

software. The inputs and outputs of the premises are equipped with wireless counters of people which record every visitor who enters or leaves the room. Statistical data from the counter people is read by the collector in silent mode every 10 minutes and transmitted to the central database via the local network or the Internet.

## CONCLUSION

1. The necessity of building the information system fire monitoring, which would release people from public buildings high-rise buildings in case of fire is substantiated.
2. The information system which provides the decision of next tasks is offered, namely:
– fire detection;
– making decision in relation to evacuation of people from buildings;
– information support and notification.
3. Complex of hardwares is determined.

## REFERENCES

[1] DRandSFE "UkrCPR" Analysis of array of accounting cards of fires (POG_STAT) for 6 months in 2014. (in Ukrainian).

[2] Shostachuk, D. M.; Shostachuk, A. M. "The integrated security system of people staying in high-rise structures: a systematic approach." Bulletin of Zhytomyr State Technological University no. 3 (54). (in Ukrainian).

[3] Kutsenko, S. C. Overview of software systems for calculating the time of evacuation of people from buildings and structures. (in Ukrainian).

[4] Kormen, T.; Leyzerson, C.; Ryvest, R. Algorithms: design and analysis. Moscow: MCNV, 2002. 378 p. (in Russian).

Received 20 August 2014.

**Sineglazov Viktor.** Doctor of Engineering. Professor.
Aviation Computer-Integrated Complexes Department, National Aviation University, Kyiv, Ukraine.
Education: Kiev Polytechnic Institute, Kyiv, Ukraine (1973).
Research area: Air Navigation, Air Traffic Control, Identification of Complex Systems, Wind/solar power plant.
Publications: more than 450 papers.
E-mail: svm@nau.edu.ua

**Kupriyanchyk Volodymyr**. Student.
Education: National Aviation University, Kyiv, Ukraine.
Research interests: systems and process control, computer-aided design, fire monitoring systems.
Publications: 0.
E-mail: v.kupriyanchyk@yandex.ua

**В. М. Синєглазов, В. Л. Купріянчик. Автоматизоване проектування інформаційної системи пожежного спостереження**
Запропоновано інформаційну систему пожежного спостереження. Надано опис структури та алгоритмічного забезпечення системи. Запропоновано комплекс технічних засобів.
**Ключові слова:** евакуація; оптимальний маршрут евакуації.

**Синєглазов Віктор Михайлович.** Доктор технічних наук. Професор.
Кафедра авіаційних комп'ютерно-інтегрованих комплексів, Національний авіаційний університет, Київ, Україна.
Освіта: Київський політехнічний інститут, Київ, Україна (1973).
Напрям наукової діяльності: аеронавігація, управління повітряним рухом, ідентифікація складних систем, вітроенергетичні установки.
Кількість публікацій: більше 450 наукових робіт.
E-mail: svm@nau.edu.ua

**Купріянчик Володимир Леонідович**. Студент.
Освіта: Національний авіаційний університет, Київ, Україна.
Напрямок наукової діяльності: системи та процеси керування, системи автоматизованого проектування, системи пожежного спостереження.
Кількість публікації: 0.
E-mail: v.kupriyanchyk@yandex.ua

**В. М. Синеглазов, В. Л. Куприянчик. Автоматизированное проектирование информационной системы пожарного наблюдения**
Предложена информационная система пожарного наблюдения. Представлено описание структуры и алгоритмического обеспечения системы. Предложен комплекс технических средств.
**Ключевые слова:** эвакуация; оптимальный маршрут эвакуации.

**Синеглазов Виктор Михайлович.** Доктор технических наук. Профессор.
Кафедра авиационных компьютерно-интегрированных комплексов, Национальный авиационный университет, Киев, Украина.
Образование: Киевский политехнический институт, Киев, Украина (1973).
Направление научной деятельности: аэронавигация, управления воздушным движением, идентификация сложных систем, ветроэнергетические установки.
Количество публикаций: более 450 научных работ.
E-mail: svm@nau.edu.ua

**Куприянчик Владимир Леонидович.** Студент.
Образование: Национальный авиационный университет, Киев, Украина
Направление научной деятельности: системы и процессы управления, системы автоматизированного проектирования, системы пожарного наблюдения.
Количество публикаций: 0.
E-mail: v.kupriyanchyk@yandex.ua