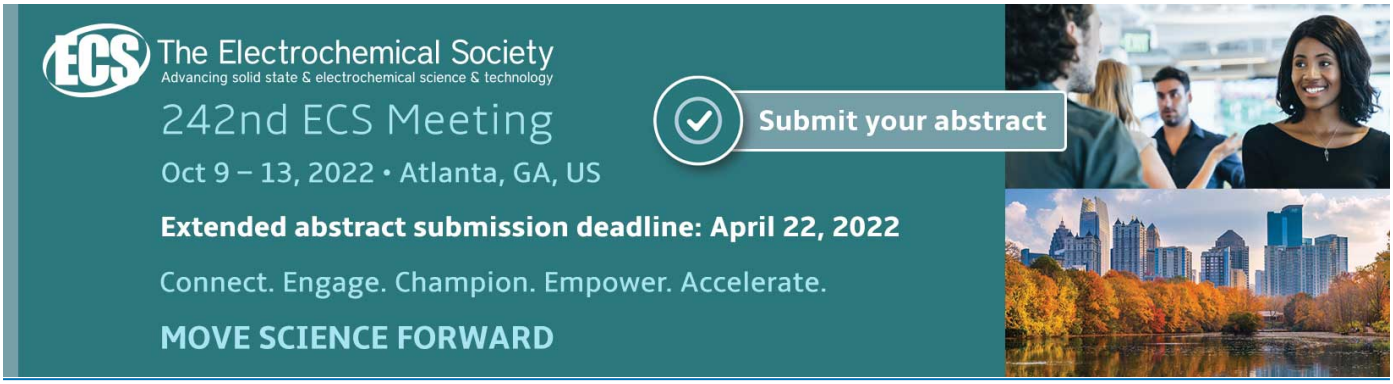
Prediction of hazardous fire factors and their impact on the ecology of the region



Prediction of hazardous fire factors and their impact on the ecology of the region

A Sh Arifzhanov, D K Muhamediyeva and U U Khasanov

Research Institute for the Development of Digital Technologies and Artificial Intelligence, Tashkent, Uzbekistan

E-mail: dilnoz134@rambler.ru

Abstract. Natural fires are a serious catastrophic phenomenon for the nature and population of our country and the world. The paper considers the forecast of the level of air pollution, which is possible based on calculating the dispersion of pollutants in the atmosphere and a comparative assessment of the magnitude of the impact with existing standards.

1. Introduction

Natural fires (forest, landscape) are a serious catastrophic phenomenon for the nature and population of our country and the world. Forest fires because serious material damage to the economy, claim human lives, affect the ecosystem and are a fundamental problem [1-3]. The fire damages forestry and agriculture, settlements. Hot, dry summers, gusty winds - all this contributes to the rapid spread of fire in the event of a fire. A significant part of fires during a fire hazardous period occurs in landscape fires [4]. Ignitions are classified according to the type of landscape in which the combustion occurred. There are three types of natural fires: forest, peat and steppe. Forest - dangerous for their location and secrecy. Often the forest thicket is inaccessible for specialized machines, and by the time the elimination begins, the fire is already spreading over a vast territory, making it difficult to extinguish it. Peat bogs - are the ignition of peat bogs, both drained and natural. Such fires usually occur in summer. Peat deposits burn out to the depth of the groundwater flow [5].

The method of extinguishing is selected based on the characteristics of the landscape, the extent of the boundaries of forest areas, the complexity of forecasting. The technique for extinguishing landscape fires includes subsections for each type of fire. However, there are some general methods of dealing with the fire element. Active methods are reduced to the elimination of fire at the initial stage. These include the impact on the edge of the flame and the creation of barriers to it. Overwhelming fire along the edge - the flame is knocked down by improvised means, stopping its advance. This method is widespread in the fight against steppe and forest grassland fires. Backfilling with soil - used only in sandy and sandy loam soils. Ditching in the path of fire - trenches are dug with plows and other specialized equipment. Annealing - in this situation, the fire is extinguished with oncoming fire. Annealing is started from the flame barriers towards the main fire, thereby destroying all flammable materials on the way of ignition. 35 Burning peat is extinguished mainly with water. Small foci are filled with water (sometimes with the addition of reagents) and dug up with a shovel with soil. Extensive flames are flooded with water. The most common method of eliminating steppe fires is considered to be counterfire, or annealing: from the fire line to the fire, they let fire. The flame burns out all the fuel in the path of the fire, and the ignition self-destructs.

2. Materials and methods

Forecast of the level of air pollution.

The management of fire investigation activities by the investigators of the State Fire Supervision Authority of the Fire Service at the initial stage is aimed at determining the location of the hearth and the cause of the fire. At the same time, the efficiency of decision-making in the investigation of a fire depends on the quality of information and analytical support, when, within the time established by the legislation, it is necessary to evaluate and choose a reliable and reasonable decision from a variety of possible versions about the circumstances of the occurrence and development of a fire. The existing model of information and analytical support in the investigation of fires uses the exclusion method, which involves the reasonable advancement of all possible options and their consistent exclusion. The best decision-making result is achieved with a larger number of developed options. Making the right choice of one or several of them becomes more and more difficult due to their large number. The process of evaluating and choosing alternatives is too laborious, but the possible benefit from finding all possible alternatives to an exhaustive level is met with time constraints for making a decision allotted by legislation to investigate a fire, which also reduces the quality of choosing and evaluating alternative versions. So, as a result of the assessment of the solutions put forward, the selection of alternative solutions on the scenarios of the occurrence and development of a fire is carried out with further verification in relation to the available versions. Consequently, an information model of the fire that has occurred is created and a conclusion about the location of the hearth and the cause of the fire is formulated.

At present, the models of information and analytical support in the investigation of fires have a high scientific level. However, in the conditions of the destruction of material traces by fire, fire-technical experts cannot come to an unambiguous conclusion about the mechanism and circumstances of the fire and, often, are forced to formulate a conclusion in a probabilistic form. This situation makes it difficult for the decision-maker to choose the option corresponding to the truth, does not allow diagnosing the nature of the causal relationships of violations of fire safety requirements and the dangerous consequences of a fire, which increases the likelihood of an error in decision-making when investigating fires. For example, when investigating a fire, the authorities do not identify and do not see the culprit in more than 60% of cases. The author of this study proposes a method that allows the decision maker to put forward and process the largest number of developed scenarios (versions according to the location of the source and the cause of the fire) and at the same time minimize labor intensity and keep within the time intervals allocated by law for the investigation of the fire. In order to implement the developed method, an algorithm is proposed for information-analytical decision-making support at the initial stage of fire investigation. Thus, the relevance of the work is due to the receipt of the target result - making a reliable decision in conditions of information uncertainty at the initial stage of the investigation of fires. The created system allows the decision-maker to also make decisions on the relationship between the identified violations to safety requirements and the nature of related events and circumstances: the occurrence of a combustion source in space and the cause of a fire in the time of the event. The currently formed models and algorithms, including those based on express assessment, do not affect the area of information and analytical support for the reconstruction of the process of the emergence and propagation of a fire.

3. Results and Discussion

Solving the problem of optimizing the structure of forces and means in a fire.

The paper proposes a mathematical model for calculating the rational number of operational fire and rescue units, fire extinguishing means and assigning them to the extinguishing areas, that is, the optimization of the structure of forces and means in a fire is formalized in the form of mutually influencing objects (subsystems) of a fire extinguishing control system with mobile means in a fire: where j - position - area, i - tactical unit of the subdivision - squad, N - total number of tactical units taking part in extinguishing the fire, distributed at extinguishing positions; M is the total number of positions occupied by the personnel of fire rescue units; number X is an array of system objects that

form a variety (*i, j*) of the composition of the fire extinguishing control system with predetermined values of extinguishing positions and tactical units; n and m are the maximum values of the admissible divisions of the values of *N* and *M*, set by the combinatorial analysis toolkit, taking into account the management methods of fire and rescue units [9-12].

Based on the above, we formalize the optimization problem of the effective placement of fire and rescue units at given positions when extinguishing a fire, taking into account the variety of *N* and *M* distributions depending on the extinguishing object:

$$\mathrm{R} = \sum_{i=1}^{n}\sum_{j=1}^{m} r_{ij}x_{ij} \to \max, \tag{1}$$

$$\begin{cases} \sum_{i=1}^{m} x_{ij} = N_j;\ j = \overline{1,n}; \\ \sum_{j=1}^{n} x_{ij} = M_i;\ i = \overline{1,m}; \\ x_{ij} > 0, i = \overline{1,m},\ j = \overline{1,n}. \end{cases} \tag{2}$$

We will consider the solution to this problem based on the ant e colony algorithm. It should be noted that this algorithm significantly speeds up the process of achieving an optimal solution.

The ant algorithm can be easily split into independently executable fragments. Moreover, in several different ways, the choice of which depends on the goal set, for example: reducing the execution time, increasing the accuracy of solutions, more adequate modeling of the behavior of ants, etc.

Most often, the creation of parallel algorithms is aimed at reducing the time for solving large-scale problems. Here we will consider an approach to the implementation of a parallel algorithm for optimizing an ant colony, aimed at achieving the most acceptable result in a single execution, using the example of an optimization problem. The essence of the algorithm boils down to the fact that the created ant colony is divided into *k* groups of *l* ants in each. Groups perform their tasks on a separate processor. The conditions of the problem are identical for all groups, i.e. in each, the algorithm for solving the optimization problem is worked out in its usual form, and as a result, the best solution is formed within the *g*-th group:

$$R_g = \sum_{i=1}^{n}\sum_{j=1}^{m} r_{ij}x_{ij}^{g} \to \max,\ g = \overline{1,k}. \tag{3}$$

The difference between this algorithm is the introduction of an additional procedure that, during a given number of attempts to find the optimal solution, a periodic global update of the pheromone matrix with the selection of the best solution found among all *k* groups. This update is taken into account at the next iteration within the group, and the edges of the graph are reinforced with a pheromone in accordance with it. Upon completion of all search attempts, the best route found in the end among the groups is selected, which is given as the final solution:

$$R = \max_{g=\overline{1,n}}\{R_g\}. \tag{4}$$

The algorithm, thus, provides not only intra-group, but inter-group global communication, which has a positive effect on improving the accuracy of the solution. Additionally, to speed up the work of groups, the algorithm uses the strategy of elite ants.

The computational experiment was carried out under the following specified conditions of the problem: $k = 80$, $l = 100$, the number of search attempts - 35. Global update of the best solution among the groups - every 5 iterations.

With an increase in the number of involved processors with a single execution of the algorithm, a more optimal solution to the problem is determined. At the same time, the running time of the program with the given parameters increases insignificantly, and is associated with an increase in the number of interprocessor exchanges.

Despite such positive dynamics, an inappropriate increase in the number of involved processors is not desirable. It is required to maintain a balance between the conditions / parameters of the task and the number of processors, since from a certain moment the algorithm will stop producing improved solutions, regardless of their number. In addition, the quality of the resulting solution is significantly influenced by the hardware and software platform of the computational range, on which the compilation and execution of the program is carried out. Including the quality of the pseudo-random number generator used.

4. Conclusion

Thus, wildfires are a serious catastrophic phenomenon for the nature and population of our country and the world. The work considered the forecast of the level of air pollution, which is possible on the basis of calculating the dispersion of pollutants in the atmosphere and a comparative assessment of the magnitude of the impact with existing standards. And also this article describes the process of using the algorithm of a bee colony, which is one of the heuristic methods for solving a problem of such complexity, which belongs to the group of multi-agent algorithms. Subsequently, to speed up the process of obtaining a global optimal solution, the technology of parallel computing should be used to solve the problem of optimizing the structure of forces and means in a fire. The solution of the problem and comparative analysis with neural networks showed that an increase in the number of points can complicate the process of achieving an optimal solution. In such cases, the use of the Hopfield network may not give sufficiently effective results, that is, it may take a lot of time and resources for calculations, and it is advisable to use multi-agent heuristic algorithms, such as the bee colony algorithm. In the theory of multi-agent systems, one agent can never provide a global solution; therefore, a set of agents is formed and effective relations are established between them. Solving combinatorial optimization problems using the bee colony algorithm and parallel computations can give good results in a situation where the number of points is very large.

References

[1] Belomutenko DV and Istochkina M V 2017 On the possibility of creating fire-retardant support strips using impregnations based on fire retardants. *Ecological and reclamation aspects of rational environmental management: materials of the International Scientific and Practical Conference Volgograd* **4** 406-412

[2] Belomutenko D V, Istochkina M V and Belomutenko S V 2019 Analysis of the influence of natural conditions on the burning of forest plantations and their protection from fires on the example of the Volgograd region. *Science and practice in solving strategic and tactical problems of sustainable development of Russia: collection of scientific articles based on the results of the national scientific and practical conference St. Petersburg* 109-110

[3] Yezhov K V and Belomutenko S V 2016 Features of extinguishing fires in the Volgograd region. *Strategic guidelines for innovative development of the agro-industrial complex in modern economic conditions: materials of the International scientific and practical conference Volgograd* 12-17

[4] Zarodova N A and Makovkina L N 2019 Legislation of the Russian Federation in the field of civil defense, protection of the population from emergencies of natural and technogenic character Science and youth. *New ideas and solutions: materials of the XIII international scientific-practical conference of young researchers Volgograd* 191-192

[5] Zozulya V M, Bespaly I K, Loginov F L and Mileev E B 1974 *Fire prevention in industry and agriculture: a textbook for fire-technical schools* (Moscow: Stroyizdat) 387

[6] Grishin A M and Filkov A I 2004 Geoinformation system for forecasting forest fire hazard.

Natural fires: occurrence, distribution, extinguishing and environmental consequences: m*aterials of the 5th international. conf Tomsk* 175–185
[7] Grishin A M, Dolgov A A and Tsimbalyuk A F 1997*Methodology for determining and calculating emissions of pollutants from forest fires* (Moscow: State Committee of the Russian Federation for Environmental Protection) 24
[8] Filkov A I, Sladkova T E and Gorina I A 2008 On the creation of electronic maps for forecasting forest fire hazard and a database for it. *Fires in forest ecosystems of Siberia: materials of the All-Russian conference with international participation Krasnoyarsk* 84–86
[9] Korolev G M and Okhramets T I 2003 On the question of the rate of spread of forest fires. *Natural fires: occurrence, distribution, extinguishing and environmental consequences*: *materials of the 5th Intern. conf Tomsk* 127
[10] Muxamediyeva D K 2019 *IOPConf.JournalofPhysics*: *Conf. Series* 1210
[11] Juraev Z Sh, Muhamediyeva D T and Sotvoldiev D M 2020 *IOP Conf. Journal of Physics: Conf.* Series **1546(1)** 012083
[12] Mukhamedieva D T 2020 *Journal of Physics: Conference* Series **1546(1)** 012091
[13] Kamilov M M, Khujaev O K and Egamberdiyev N A 2019 The method of applying the algorithm of calculating grades for finding similar diagnostics in medical information systems. *International Journal of Innovative Technology and Exploring Engineering* **8(6)** 722–724
[14] Egamberdiev N, Mukhamedieva D and Khasanov U 2020 Presentation of preferences in multi-criterional tasks of decision-making. *Journal of Physics: Conference Series, Ser.* **1441 012137** 1-8