Evaluation ofa Formalized Model for Classification of Emergency Situations

Vera Titova and IelizavetaGnatchuk

Khmelnitsky National University, Khmelnitsky, Ukraine

sobaka2032@rambler.ru

Abstract. Formalization of conditions that characterize the problem of classification of emergency situations is considered in this paper.This formalization is the basis for the Formalized Model of the emergency situations classificationproblem. Intelligent methods are used to solve this problem. These methods are also the basis for the development of the Neural Network Model for emergency situation classification. In this paper wedevelop the structure of the model and determine the number of network layers, the types of neurons and its membership functions. Using the Neural Network Model as decision support for the dispatchers of emergency services makes it possible to improve the quality of emergency situations classification.

Keywords: formalization of conditions, fuzzy neural networks, emergency situations, problem of classification of emergency situations, Formalized Model, Neural Network Model.

1 Introduction

The dispatchers of emergency services have often to deal with emergency situations in their everyday professional activity and make decisions to eliminate such situations.

Nowadays, there are many geoinformation systems for emergency services that help dispatchers in their work [1, 2].However, most of these systems just visualize the information about the situation; displaythe locations of forces and resources at dispatcher's disposal; simulate the situation. The decision to eliminate the situation is entirely madeby the dispatcher, who makes it based on visual informationavailable.

Events that characterize any emergency situation can changeduring the time neededfor the dispatcher to make a decision. Moreover, various situations differ by the type of event and the set of possible decisions.

The more possible decisions and events characterize the situation, the more resources and time will be neededfor the dispatcher for making the final decision to eliminate this situation.

Based on these facts, we can conclude that the dispatcher of emergency services is the decision maker. And in his or her professional activity he or she needs a decision support, which targets at situation elimination rather than at information visualization. Therefore, providing of such decision support for the dispatcher of emergency services is an urgent scientific problem.

2 Problem formulation

A primary problem that the dispatcher should solve to make a decision is the problemof emergency situation classification.

Emergency situation is violation of normal living conditions and human activities on the similar or territory caused by accidents, natural disasters, epidemic, epizootic or epiphytotic processes, large fire, using the weapons of mass destruction that resulted or can result in human casualtiesand material losses. Any emergency situation is characterized by the lethal casualties, asignificant deterioration of living conditions, the significant deterioration of people‘s health, economic losses [3].

The decision to eliminate any emergency situation includes the forces and resources necessary to minimize the human casualties, material losses and restore the normal living conditions.

To make a decision the dispatcher has to analyze the available information and assign the situation to one of the known classes. The quality of the decision depends on its correct classification.

Emergency situations that can occur on the territory of Ukraine are classified by the nature of occurrence and by the level of possible consequences [3].

By the nature of occurrencean emergency situation can be [3]:

- technogenic;
- natural;
- social and socio-political;
- military.

By the level of possible consequences an emergency situation can be [3]:

- national;
- regional;
- local;
- building or property.

Any situation is characterized by two parameters: the place of occurrence and conditions. The conditions of the situation are theevents that are inherent to this situation. The place of the situation is the geographical location on the country map.

Events directly influencethe situation class as they determine its nature. Geographical location does not influence the situation classdirectly, but there are several parameters that characterize the situation place and can have influence on the situation class. The first parameter is the situation area.It determines which area is covered by the situation at the time of receivingthe information about it.

The second parameter is the danger of the situation place. It means the presence of buildings that can worsen the situation. For example, a nuclear power plant, a military arsenal, etc.

The thirdparameter is the number of peopleat the situation place.The more people are at the situation place, the more can be injured or die.

Another parameter that influences the nature of the situation and its possible consequences is the time elapsed from beginning of the situation to receiving the information about it.The later information of the situation isreceived, the more dangerous consequences the situation will have and the more time and resources will be needed to fix it.

The problem of classifying emergency situations is characterized by the following attributes:

- a human is the source of information about it, so that the input data can be inaccurate, incorrect, contradictory or subjective;
- there is athe large number of hidden relationships between the input and output data;
- the input data can be changed during solvingthe problem;
- the solution of the problem cannot be reduced to mathematical calculations.

Thus, emergency situations classification is a poorly formalized problem [4], which complicates its solving. The formalization of this problemenables to simplify its solution.

3 Formalized Model of emergency situations classification

To develop the formalized model, we introduce the following indexes:

- I_1 – the number of peopleat the situation place. The more people are at the situation place, the higher is the index value;
- I_2 – the danger of the situation place. The larger isthe number of dangerous buildings at the situation place, the higher is the index value;
- I_3 – the situation area. The larger is the area covered by the situation, the higher is the index value;
- E – the set of events that characterize the situation, $E=[e_1, e_2, e_3 .. e_i]$, i – the number of all possible events that can be the cause of an emergency situation. We have identifiedthe following subsets in this set: $E_1=[e^1_1, e^1_2, .. e^1_a]$ – the subset of events that characterize the technogenic emergency situation; $E_2=[e^2_1, e^2_2, .. e^2_b]$ – the subset of events that characterize the natural emergency situation; $E_3=[e^3_1, e^3_2, .. e^3_c]$ – the subset of events that characterize the social and socio-political emergency situation; $E_4=[e^4_1, e^4_2, .. e^4_d]$ – the subset of events that characterize the military emergency situation; $E_5=[e^5_1, e^5_2, .. e^5_f]$ – the subset of events that characterize the emergency situation at the national level; $E_6 =[e^6_1, e^6_2, .. e^6_g]$ – the subset of events that characterize the emergency situation at the regional level; $E_7=[e^7_1, e^7_2, .. e^7_h]$ – the subset of events that characterize the emergency situation at the local level; $E_8=[e^8_1, e^8_2, .. e^8_j]$ – the subset of events that characterize the emergency situation at the building or property;
- T – time elapsed from the beginning of the situation to receivingthe information about it;
- S – the set of emergency situations classes; s_1 – atechnogenic emergency situation; s_2 – a natural emergency situation; s_3 – asocial or socio-political emergency situation; s_4 – amilitary emergency situation; s_5 – a emergency situation at the national level; s_6 – a emergency situation at the regional level; s_7 – a emergency situation at the local level; s_8 – a emergency situation at the building or property.

Any situation belongs to one of the classes s_1 .. s_4 and to one of the classes s_5 .. s_8. For example, the situation that belongs to s_1 and s_7 is atechnogenic emergency situation at the local level.

Taking into account the dependencies between the input parameters and the situation classes, we obtained the following equations:

$$s_1=f_1(e^1{}_1, e^1{}_2, .. e^1{}_a, T) \tag{11}$$

$$s_2=f_2(e^2{}_1, e^2{}_2, .. e^2{}_b, T) \tag{12}$$

$$s_3=f_3(e^3{}_1, e^3{}_2, .. e^3{}_c, T) \tag{13}$$

$$s_4=f_4(e^4{}_1, e^4{}_2, .. e^4{}_d, T) \tag{14}$$

$$s_5=f_5(e^5{}_1, e^5{}_2, .. e^5{}_f, T, I_1, I_2, I_3) \tag{15}$$

$$s_6=f_6(e^6{}_1, e^6{}_2, .. e^6{}_g, T, I_1, I_2, I_3) \tag{16}$$

$$s_7=f_7(e^7{}_1, e^7{}_2, .. e^7{}_h, T, I_1, I_2, I_3) \tag{17}$$

$$s_8=f_8(e^8{}_1, e^8{}_2, .. e^8{}_j, T, I_1, I_2, I_3) \tag{18}$$,

where f1..f8 are conversions that have be performed on input data to classify a situation.

The analysis of the subject area displays that five events are enough to classify a situation. Therefore, we introduce a set $E`= [e`_1, e`_2, e`_3, e`_4, e`_5]$, where $e`_1..e`_5$ are the events characterizing the situation that is classified.

Also, the following conclusions are madefrom the analysis of the subject area:

- the situation belongs to the class s_1 if it is characterized by events from the corresponding set E_1. This means the situation belongs to the class s_1 if $E` \subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \not\subset E_4$;
- the situation belongs to the class s_2 if it is characterized by events from the corresponding set E_2. This means the situation belongs to the class s_2 if $E` \subset E_2$, $E` \not\subset E_1$, $E` \not\subset E_3$, $E` \not\subset E_4$;
- the situation belongs to the class s_3 if it is characterized by events from the corresponding set E_3. This means the situation belongs to the class s_3 if $E` \subset E_3$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_4$;
- the situation belongs to the class s_4 if it is characterized by events from the corresponding set E_4. This means the situation belongs to the class s_4 if $E` \subset E_4$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$;
- the situation belongs to the class s_5 if it is characterized by events from the corresponding set E_5, if the situation place is characterized by the large number of people, the high danger,the large areaand also if a lot of timehas passed since the beginning of the situation. This means the situation belongs to the class s_5 if $E` \subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $E` \not\subset E_8, I_1, I_2, I_3, T \rightarrow \max$;
- the situation belongs to the class s_6 if it is characterized by events from the corresponding set E_6, if the situation place is characterized by thesmall number of people, the low danger, the large area and also if a lot of timehas passed since the beginning of the situation. This means the situation belongs to the class s_6 if $E` \subset E_6$, $E` \not\subset E_5$, $E` \not\subset E_7$, $E` \not\subset E_8, T, I_3 \rightarrow \max, I_1, I_2 \rightarrow \min$;

- the situation belongs to the class s_7 if it is characterized by events from the corresponding set E_7, if the situation placeis characterized by thesmall number of people, the low danger, the small area and also if a lot of timehas passed since the beginning of the situation. This means the situation belongs to the class s_7 if $E` \subset E_7$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_8$, $T \to \max, I_1, I_2, I_3 \to \min$;
- the situation belongs to the class s_8 if it is characterized by events from the corresponding set E_8, if the situation placeis characterized by thesmall number of people, the low danger, the small area and also if alittle of timehas passed since the beginning of the situation. This means the situation belongs to the class s_8 if $E` \subset E_8$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $I_1, I_2, I_3, T \to \min$.

As a result we have a system of rules with denoting s – the situation to be classified:

$s=f_1(e^1_1, e^1_2, .. e^1_a, T) + f_5(e^5_1, e^5_2, .. e^5_f, T, I_1, I_2, I_3)$, if $E` \subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $E` \not\subset E_8$, $I_1, I_2, I_3, T \to \max$;

$s=f_1(e^1_1, e^1_2, .. e^1_a, T) + f_6(e^6_1, e^6_2, .. e^6_g, T, I_1, I_2, I_3)$, if $E` \subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_6$, $E` \not\subset E_5$, $E` \not\subset E_7$, $E` \not\subset E_8$, $T, I_3 \to \max, I_1, I_2 \to \min$;

$s=f_1(e^1_1, e^1_2, .. e^1_a, T) + f_7(e^7_1, e^7_2, .. e^7_f, T, I_1, I_2, I_3)$, if $E` \subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_7$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_8$, $T \to \max, I_1, I_2, I_3 \to \min$;

$s=f_1(e^1_1, e^1_2, .. e^1_a, T) + f_8(e^8_1, e^8_2, .. e^8_j, T, I_1, I_2, I_3)$, if $E` \subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_8$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $I_1, I_2, I_3, T \to \min$;

$s=f_2(e^2_1, e^2_2, .. e^2_b, T) + f_5(e^5_1, e^5_2, .. e^5_f, T, I_1, I_2, I_3)$, if $E` \subset E_2$, $E` \not\subset E_1$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $E` \not\subset E_8$, $I_1, I_2, I_3, T \to \max$;

$s=f_2(e^2_1, e^2_2, .. e^2_b, T) + f_6(e^6_1, e^6_2, .. e^6_g, T, I_1, I_2, I_3)$, if $E` \subset E_2$, $E` \not\subset E_1$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_6$, $E` \not\subset E_5$, $E` \not\subset E_7$, $E` \not\subset E_8$, $T, I_3 \to \max, I_1, I_2 \to \min$;

$s=f_2(e^2_1, e^2_2, .. e^2_b, T) + f_7(e^7_1, e^7_2, .. e^7_f, T, I_1, I_2, I_3)$, if $E` \subset E_2$, $E` \not\subset E_1$, $E` \not\subset E_3$, $E` \not\subset E_4$,$E` \subset E_7$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_8$, $T \to \max, I_1, I_2, I_3 \to \min$;

$s=f_2(e^2_1, e^2_2, .. e^2_b, T) + f_8(e^8_1, e^8_2, .. e^8_j, T, I_1, I_2, I_3)$, if $E_2 \neq \{\}$, $E` \subset E_2$, $E` \not\subset E_1$, $E` \not\subset E_3$, $E` \not\subset E_4$, $E` \subset E_8$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $I_1, I_2, I_3, T \to \min$;

$s=f_3(e^3_1, e^3_2, .. e^3_c, T) + f_5(e^5_1, e^5_2, .. e^5_f, T, I_1, I_2, I_3)$, if $E` \subset E_3$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_4$, $E` \subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $E` \not\subset E_8$, $I_1, I_2, I_3, T \to \max$;

$s=f_3(e^3_1, e^3_2, .. e^3_c, T) + f_6(e^6_1, e^6_2, .. e^6_g, T, I_1, I_2, I_3)$, if $E` \subset E_3$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_4$, $E` \subset E_6$, $E` \not\subset E_5$, $E` \not\subset E_7$, $E` \not\subset E_8$, $T, I_3 \to \max, I_1, I_2 \to \min$;

$s=f_3(e^3_1, e^3_2, .. e^3_c, T) + f_7(e^7_1, e^7_2, .. e^7_f, T, I_1, I_2, I_3)$, if $E` \subset E_3$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_4$, $E` \subset E_7$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_8$, $T \to \max, I_1, I_2, I_3 \to \min$;

$s=f_3(e^3_1, e^3_2, .. e^3_c, T) + f_8(e^8_1, e^8_2, .. e^8_j, T, I_1, I_2, I_3)$, if $E` \subset$ $E` \subset E_3$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_4$, $E_8$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $I_1, I_2, I_3, T \to \min$;

$s=f_4(e^4{}_1, e^4{}_2, .. e^4{}_d, T) + f_5(e^5{}_1, e^5{}_2, .. e^5{}_f, T, I_1, I_2, I_3)$, if $E` \subset E_4$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $E` \not\subset E_8$, $I_1, I_2, I_3, T \to \max$;

$s=f_4(e^4{}_1, e^4{}_2, .. e^4{}_d, T) + f_6(e^6{}_1, e^6{}_2, .. e^6{}_g, T, I_1, I_2, I_3)$, if $E` \subset E_4$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \subset E_6$, $E` \not\subset E_5$, $E` \not\subset E_7$, $E` \not\subset E_8$, $T, I_3 \to \max, I_1, I_2 \to \min$;

$s=f_4(e^4{}_1, e^4{}_2, .. e^4{}_d, T) + f_7(e^7{}_1, e^7{}_2, .. e^7{}_f, T, I_1, I_2, I_3)$, if $E` \subset E_4$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \subset E_7$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_8$, $T \to \max, I_1, I_2, I_3 \to \min$;

$s=f_4(e^4{}_1, e^4{}_2, .. e^4{}_d, T) + f_8(e^8{}_1, e^8{}_2, .. e^8{}_j, T, I_1, I_2, I_3)$, if $E` \subset E_4$, $E` \not\subset E_1$, $E` \not\subset E_2$, $E` \not\subset E_3$, $E` \subset E_8$, $E` \not\subset E_5$, $E` \not\subset E_6$, $E` \not\subset E_7$, $I_1, I_2, I_3, T \to \min$;

This system is our proposed Formalized Model of emergency situation classification. Analyzing the model, we conclude:

- the problem of emergency situations classification is characterized by a large number of possible decisions and a large number of closely related characteristics. Thus, it is difficult to solve by the exhaustive search of all decisions available;
- this problem cannot be solved by algebraic methods because its solution cannot be reduced to numerical calculations;
- with some input data, the situation does not correspond to any rule completely. It can belongs to several classes with different membership degrees, which makes the classification fuzzy.

Given the conclusions above, we propose to solve this problem by methods of artificial intelligence, for example, hybrid neural network [5,6].This approach has the following advantages [6]:

- its training is carried out using neural network learning algorithms, which have advantages in processing unreliable data;
- all conclusions are made on the basis of fuzzy logic, in the function and expression of which it is easy to transform the system of rules of the Formalized Model of emergency situation classification;
- hybrid neural networks, as expert systems, enable to add expert information to the learning process and explain the results of solving problems, which enables to trace or alter decision making process.

4 Neural Network Model of emergency situations classification

Given the relations and interactions of the Information Model, itis determined that input data vector consists of 9 elements. So, the Neural Network Model has 9 inputs: I1 – the number of people at the situation place; I2 – the danger of the situation place; I3 – the situation area; T – time elapsed from the beginning of the situation to the receiving the information about it; e1 .. e5 – events that characterize the situation.

I1 and I2 take values in the range [0..3], where 0 – no people/ no danger, 1 – a few people/ low danger, 2 – moderate number of people/ medium danger, 3 – many people/ high danger. I3 takes values in the range [0..10], where 0 – minimal area that can be covered by the situation within the building or property, 10 – maximal area that can be covered by the situation within several regions. T takes values in the range

[0..3], where 0 – the situation began less than 2 hours ago, 1 – the situation began 2-12 hours ago, 2 – the situation began 12-24 hours ago, 3 – the situation began over 24 hours ago. e1..e5 take values in the range [1..100], 100 – the maximum number of possible events. An event number is determined by the facts of the event. For example, 22 – fire, 1 – earthquake, 25 – building collapse, etc.

The number of model outputs is two. The first output determines the emergency situation class by nature. It takes values in the range [0..1], where the values in the range [0..0.35] correspond to naturalemergency situations, the values in the range [0.2..0.55] representtechnogenicemergency situations, the values in the range [0.4..0.75] describemilitary emergency situations, the values in the range [0.6..1] are attached to social or socio-political emergency situations.

The second output determines the emergency situation class by the level of possible consequences. It takes values in the range [0..1], where the values in the range [0..0.35] represent to emergency situations at the building or property, the values in the range [0.2..0.55] describe emergency situations at the local level, the values in the range [0.4..0.75] are attached to emergency situations at the regional level, the values in the range [0.6..1] cover emergency situations at the national level.

The Neural Network Model of emergency situation classification is displayed in Fig. 1. It consists of three layers of neurons. The neurons of the first layer determine the matching degree of input variables to fuzzy membership functions as illustrated in [7, Fig. 4-7]. The neurons of the second layer determine the degree of truth of each of the system rules described above. The neurons of the third layer determine the emergency situation class.

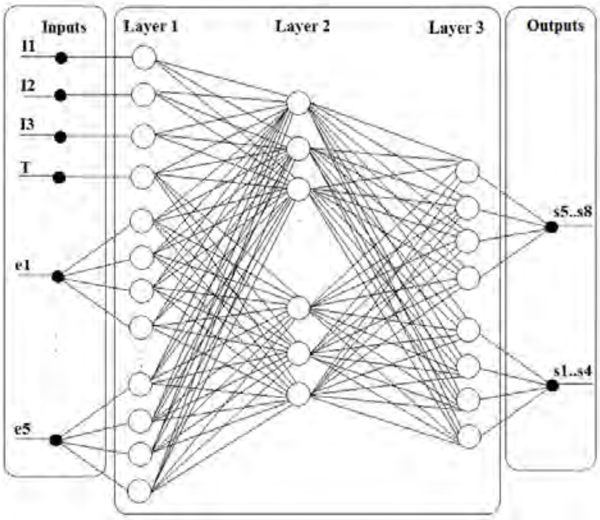

Fig. 1. Neural Network Model of emergency situations classification

5 Evaluating the accuracy and adequacy of the Formalized Model

The Neural Network Model of emergency situations classification isimplemented using the software package Fuzzy Logic Toolbox of Matlab. The implementation of the model is given in [7].

The model is tested on the following set of input values, (Table 1, columns I_1-I_3, T, e_1-e_5), where the number of test sets was 20. The columns R_1, R_2 (Table 1) display the actual results of the model operation, R_1 determines the class by nature, R_2 determines the class by the level of possible consequences. The columns $R`_1$, $R`_2$ (Table 1) display the expected results corresponding to the incoming sets, $R`_1$ determines the class by nature, $R`_2$ determines the class by the level of possible consequences.

Table 1. Results of Neural Network Model application

No.	I_1	I_2	I_3	T	e_1	e_2	e_3	e_4	e_5	R_1	R_2	R_1`	R_2`
1	0	0	0	3	25	-	-	-	-	0.15	0.55	0.15	0.45
2	1	3	0	1	25	-	-	-	-	0.25	0.55	0.25	0.45
3	2	3	1	0	25	-	-	-	-	0.25	0.15	0.25	0.15
4	3	1	6	0	1	-	-	-	-	0.25	0.55	0.25	0.55
5	3	1	6	1	1	-	-	-	-	0.25	0.55	0.25	0.55
6	3	1	6	2	1	-	-	-	-	0.85	0.55	0.85	0.55
7	3	1	6	3	1	-	-	-	-	0.85	0.75	0.85	0.75
8	3	1	6	0	1	34	35	39	40	0.35	0.55	0.35	0.55
9	3	1	6	1	1	34	35	39	40	0.35	0.55	0.35	0.55
10	3	1	6	2	1	34	35	39	40	0.85	<u>0.85</u>	0.85	0.75
11	3	1	6	3	1	34	35	39	40	0.85	<u>0.85</u>	0.85	0.75
12	1	3	1	0	36	-	-	-	-	0.35	0.25	0.35	0.25
13	2	3	1	1	36	-	-	-	-	0.35	0.25	0.35	0.35
14	1	3	1	2	36	-	-	-	-	0.35	0.55	0.35	0.55
15	2	3	1	3	36	-	-	-	-	0.85	<u>0.85</u>	0.85	0.75
16	3	2	3	0	35	39	20	-	-	0.35	0.35	0.35	0.35
17	3	2	3	1	35	39	20	-	-	0.35	0.35	0.35	0.35
18	3	2	3	2	35	39	20	-	-	0.85	0.45	0.85	0.45
19	3	2	3	3	35	39	20	-	-	<u>0.85</u>	0.45	0.75	0.45
20	3	0	3	0	35	39	20	-	-	0.35	0.35	0.35	0.35
21	3	0	3	1	35	39	20	-	-	0.35	0.35	0.35	0.35
22	3	0	3	2	35	39	20	-	-	0.35	0.45	0.35	0.45
23	3	0	3	3	35	39	20	-	-	0.85	0.45	0.85	0.45
24	2	2	3	0	75	-	-	-	-	0.85	0.35	0.85	0.35
25	2	2	3	1	75	-	-	-	-	0.85	0.35	0.85	0.35
26	2	2	3	2	75	-	-	-	-	<u>0.85</u>	0.35	0.75	0.45
27	2	2	3	3	75	-	-	-	-	0.55	0.45	0.55	0.45
28	2	0	0	0	25	-	-	-	-	0.15	0.15	0.15	0.15
29	2	1	0	1	25	-	-	-	-	0.25	0.15	0.25	0.15
30	2	2	0	2	25	-	-	-	-	0.25	0.25	0.25	0.25

Input values and expected results are determined as follows:

- **situation №1:** fire in an uninhabited area, the area of firebeing small andthe starting time of the fire being unknown. So, I_1=0, I_2=0, I_3=0, T=3, e_1=25. The analysis of situation classification statistics enables us to conclude that situation isa natural emergency situation at the local level. $R`_1 \in [0..0.35]$, $R`_2 \in [0.2..0.55]$.

- **situation №2:** fire near to a nuclear power plant, area of fire being small andthe starting time of the fire being less than 12 hours. So, I_1=1, I_2=3, I_3=0, T=1, e_1=25. The analysis of situation classification statistics leads to conclusion that situation can be viewed asatechnogenic emergency situationat the regional level, $R`_1 \in [0.2..0.55]$, $R`_2 \in [0.4..0.75]$.
- **situation №3:** an earthquake in a densely inhabited area, the area covering the region, the starting time of the earthquakebeing less than 2 hours. So, I_1=3, I_2=1, I_3=6, T=0, e_1=1. An earthquake can generate mudslides (e_i=5), building collapsing (e_i=34), power network accidents (e_i=35), gas pipeline accidents (e_i=40), water pipeline accidents (e_i=39), etc. This can lead to panic, robbery, looting as time increases. Thus, the analysis of situation classification statistics enables us to conclude that situation be classifies as atechnogenic or thesocial emergency situation of the regional level, $R`_1 \in [0,2..0.55]$ or $R`_1 \in [0.6..1]$, $R`_2 \in [0.4..0.75]$.

Actual results falling into a wrong interval are marked with a dash (Table 1). From the analysis of actual results, we conclude that the accuracy of the mathematical model is 94% for the class by nature and 90% for the class by the level of possible consequences. This error appears acceptable [8].

The adequacy of the model iscalculated by the absolute error.It is 0.1 for the class by nature and 0.3 for the class by the level of possible consequences, which is also acceptable [8].

The accuracy and adequacy evaluation performed enables us to conclude that the Formalized Model developed isapplicable to solvingthe problem.

6 Conclusions

The problem of emergency situation classification solved by a dispatcher of emergency services after receiving the information about the beginning of the situation is considered.

We come to conclusion that this problem is poorly formalized, and, therefore it is impractical to apply mathematical methods to solve it.

The Formalized Model of the emergency situation classification is developed on the basis of the analysis of relations and interactions between the parameters characterizing the situation and its possible classes.

The class of any emergency situation depends on the events, the area of the situation location, the danger of the situation location and the time that elapsed from the situation beginning. These parameters were the basis for the Formalized Model represented by a system of rules.

After the analysis of the Formalized Model we propose to use hybrid neural network for solving of the problem of emergency situation classification.The novelty of this approach and its advantages over other methods consist in the fact that such networks not only use standard algorithms for training neural networks, but they can acquire new knowledge and are logically transparent to the user.

Hybrid neural network is implemented in the Matlab environment. The results of its applicationenable us to conclude that developed model is appropriate for the problem consideration.

The model above can serve as a basis for the development of a decision support system for the dispatchers of emergency services.

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