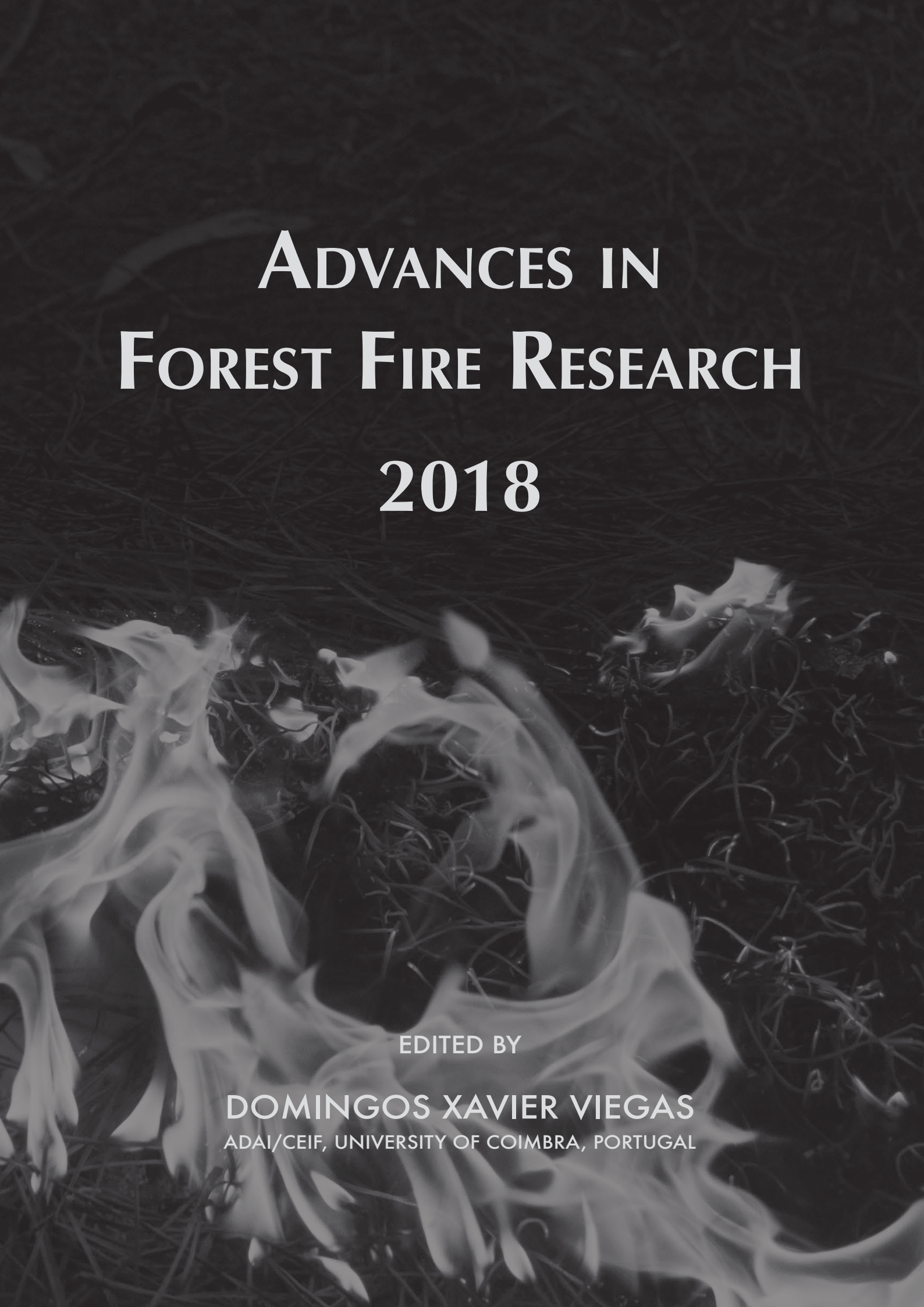
Advances in Forest Fire Research 2018



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System for personnel training in decision making of wildfires fighting

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Abstract

Wildfires (forest, peat, steppe, etc.) fighting is a complex and often dangerous process, connected with cooperation of many organizations and crews. Thus, suppression of a wildfire is a complicated process that requires a good organization. An important role in this process plays the qualitative training of personnel engaged in fighting the fire. In the process of extinguishing the fire crew of various organizations are involved: employees of Russian Aviation Forest Protection agency Avialesoohrana, crews of the Russian Ministry of Emergencies, members of voluntary fire crews created by municipalities. In accordance with the standard issued in Russia in 2018, a new working specialty - forest firefighter - has appeared. To such specialists are put quite high demands. They should not only be able to extinguish fires, but also have the skills of firefighting tactics, search engines, rescuers, psychologists, organizers and communication specialists.

Training of personnel in the techniques and tactics of combating wildfires is carried out in educational systems at various levels - from special education in the university to short-term courses for recruited employees of outside organizations. However, regardless of the educational institution level in which the training is conducted, members of firefighting crews should have basic knowledge of fire safety techniques, methods and tactics for wildfires combating.

As it known, one of the currently used effective forms of personnel training and professional development is interactive computer training systems that allow individual approach to the trainees both in material mastering and testing. A separate class of training systems are computer simulators widely used in various fields. Given the dynamic nature of the wildfire spread and the need to make operational decisions, training system should include the elements of a simulator – an imitation subsystem, which helps the trainee to observe the development of fire situation on the map, make decisions and evaluate their effectiveness.

In the work presented, an interactive simulation system FIREMAN, developed by the authors, is discussed. The system was designed to train the personnel on the basics of knowledge of wildfires and decision making to combat them. The structure of the system is described and an example of working system is given.

Keywords: wildfires simulation; personnel training; decision making, learning management system MOODLE

1. Introduction

Wildfires fighting is a complex and often dangerous process, connected with cooperation of many organizations and crews. Thus, suppression of a wildfire is a complicated process that requires a good organization (Davis, 1959, Deeming, 1972, Middlebon, 1977, Schetinski, 2002).

Wildfires cause huge economic and environmental damage to the countries and regions in which they occur, leading to the death of people. To support effective control of wildfires, a large number of information systems have been developed for simulation and prediction fire behavior (BehavePlus (Andrews, 2003), FARSITE (Finney, 1998), WFDS (Mell, 2007), etc.).

However, in addition to modeling directly the edge of the natural fire, there is a need to simulate various external influences on the fire for its localization and elimination. Such models can be actively used in the management of the fire situation, in particular, to solve the problem of effective

management of firefighting forces and facilities (European Forest Fire Information System, 2009, Russian information system of remote monitoring ISDM-Rosleskhoz , 2010), etc.

An important role in this process plays the qualitative training of personnel engaged in fighting the fire. In the process of extinguishing the fire crews of various organizations are involved: employees of Russian Aviation Forest Protection agency Avialesoohrana, crews of the Russian Ministry of Emergency Situations, members of voluntary fire crews created by municipalities.

In accordance with the standard issued in Russia in 2018, a new working specialty - forest firefighter - has appeared. To such specialists are put quite high demands. They should not only be able to extinguish fires, but also have the skills of firefighting tactics, search engines, rescuers, psychologists, organizers and communication specialists.

In fire extinguishing are involved, for example, fire jumpers, paratroopers, personnel of the fire and chemical stations. Forest firefighters can work in land groups, and in aviation units. These structures are under the jurisdiction of Avialesoohrana and are subordinated to Rosleskhoz. Professional standard unites these two spheres into one working profession.

According to the professional standard, forest fire extinguishers are divided into three classes. Firemen of the third class should be able to extinguish fires with the help of hand-held technical means (for example, a shovel or a fire extinguisher), the second - with the use of special equipment (including tractors for extinguishing forest fires). Firefighters of the first class, in addition, must have skills of organizers and be able to conduct search and rescue operations. Forest firefighters in special cases should be able to perform the functions of managers. It is impossible to find so many firefighters to provide each group with a leader.

According to the professional standard, forest firefighters should be able to correctly apply various means and methods of extinguishing, taking into account the characteristics of the terrain and fires, to choose safe places for creating strong points, to navigate in the forest. They should be able to act in extreme situations, adverse weather conditions, under the influence of stress factors.

The personnel training in the techniques and tactics of combating wildfires is carried out in educational systems at various levels - from special education in the universities (Matveev, 2002), where the course of forest pyrology is taught, to short-term courses for recruited employees of outside organizations. However, regardless of the level of the educational institution in which the training is conducted, members of firefighting crews should have basic knowledge of fire safety techniques, methods and tactics for wildfires combating.

As it known, one of the currently used effective forms of personnel training and professional development is interactive computer training systems that allow individual approach to the trainees both in material mastering and testing. A separate class of training systems are computer simulators widely used in various fields. Given the dynamic nature of the wildfire spread and the need to make operational decisions, training system should include the elements of a simulator – an imitation subsystem, which helps the trainee to observe the development of fire situation on the map, make decisions and evaluate their effectiveness.

In the work presented, the interactive simulation system FIREMAN, developed by the authors, is discussed. The system was designed to train the personnel in the basics of knowledge of wildfires and decision making to combat them.

2. Structure and functions of the fireman system

The system is a web-oriented software package based on learning management system (LMS) (MOODLE, 2010) and the TAIGA simulation program. Structure and components of the FIREMAN system are shown in Figure. 1.

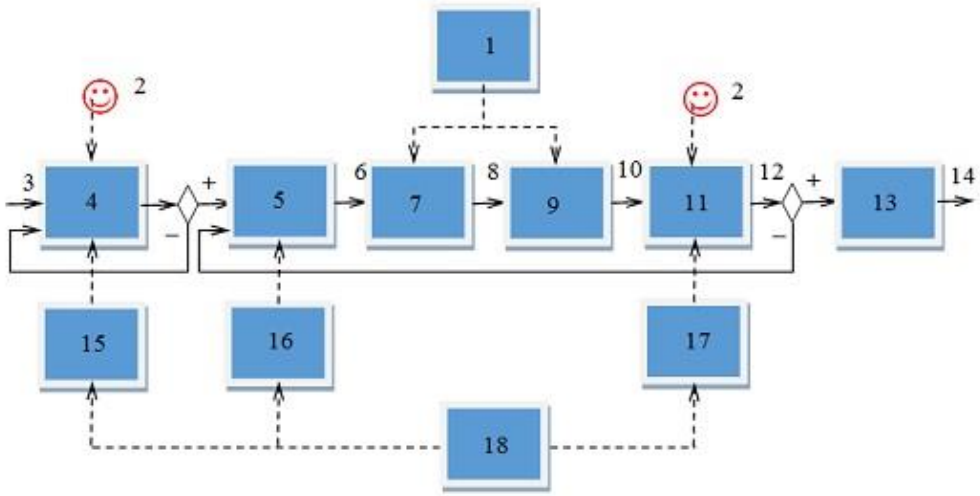

Figure 1 - The structure of the imitation training system FIREMAN. Legend: 1 – simulation program TAIGA; 2 – tutor; 3 - login to the system; 4 – preliminary training and testing; 5 - game scenario selection; 6 - scenario data; 7 - firefighting process simulation; 8 - system events; 9 - events protocol formation; 10 - events protocol; 11 - trainee's actions appraisal; 12 - trainee's actions assessment; 13 - training passage report formation; 14 - end of training; 15 – e-learning course on basics of firefighting and safety techniques; 16 - scenarios base; 17 - trainee's work appraisal rules; 18 – LMS Moodle.

2.1. Functions of LMS MOODLE:

- preliminary training and testing of trainees,
- assignment to a trainee the game scenario variant for the TAIGA simulator,
- receiving game events protocol from TAIGA,
- appraisal of trainee's decisions by tutor,
- formation an overall assessment of the trainee's work,
- formation the report with final grades.

2.2. Functions of the TAIGA program:

- demonstration of various scenarios for wildfire development and elimination;
- creation a game situation based on the initial data of the scenario: a map of the terrain with the indication of possible protection objects, characteristics of vegetable fuel materials, fire danger class, wind speed and direction, initial configuration of the fire, list of available firefighting forces and facilities;
- modeling the fire dynamics on basis of agent approach and displaying fire situation on the map of the terrain: fire spreading, action of fire-fighting forces and facilities (Dorrer, 2008, Yarovoy, 2016);
- messages generation on the fire dynamics: area passed by fire, length of the burning edge, distance to the object of protection - after a predetermined time interval;
- messages generation about the decisions made by a trainee: calling personnel and technical means, instructions for their movement, placing firemen along the edge of the fire, building fire protection bands, etc., time-bound;
- detection of catastrophic situations: objects of protection captured by fire, firefighters or equipment affected by fire, uncontrolled growth of fire area and length of a burning edge, etc.;
- events data transfer to MOODLE.

2.3. Functions of the tutor (or moderator):

- consultations and assistance to a trainee at the stage of preliminary training and supervision;

– appraisal of a trainee's actions when his work with the imitation program is over, formation of a report on the training completion.

Let us consider in more detail the components of the system.

3. Learning subsystem on the base of MOODLE

Learning Management System (LMS) MOODLE is today one of the most popular in the world and is used both in traditional educational process, and in personnel training. The acronym MOODLE is formed from the initial letters of the name Modular Object-Oriented Dynamic Learning Environment.

In the MOODLE system, you can create and store electronic learning materials and specify the sequence of their study. Electronic format allows you to use not only text, but also interactive resources of any format from an article in Wikipedia to a video on YouTube. To do this, the system provides a lot of tools: wiki, glossary, blogs, workshops, hyperlinks, files and much more. Thus, Moodle is designed to create quality distance courses and to organize an effective educational process.

Moodle can also be useful for automating of personnel training in basis of combating wildfires tactics. To solve such a problem, a distance course integrated with a computer simulator TAIGA was created.

The course consists of three main sections. The first section is called "Testing" and contains a block with input tests (Figure 2). Choice of the input test for a trainee is determined by tutor. An example of the input test is shown in the Figure 3. If the trainee correctly answered more than 90% of questions, a link to the computer simulator TAIGA, which is located in the second section of the course, becomes available to him. The second section is called "Interactive imitation system FIREMAN" (Figure 4).

4. Educational and training system Taiga

Educational and training system TAIGA developed by the authors can be used for training of various categories of trainees in educational and playful way in the basics of tactics to combat wildfires. TAIGA is a network geographic information system (GIS) with reference to the real terrain. The system has client-server architecture. To reduce the load on the network and better scalability, most calculations are performed on the client side that allows a user to distribute the load evenly between all devices. Server part is developed on PHP. The server contains a database that stores information about the simulation environment (real terrain). Client part is developed on JavaScript using a library of open source OpenLayers. This library is used to create maps based programming interface (API) and allows a user to create web-based interface for the maps display. This library can work with data from different map services, such as OpenStreetMap, Google, Yandex and others.

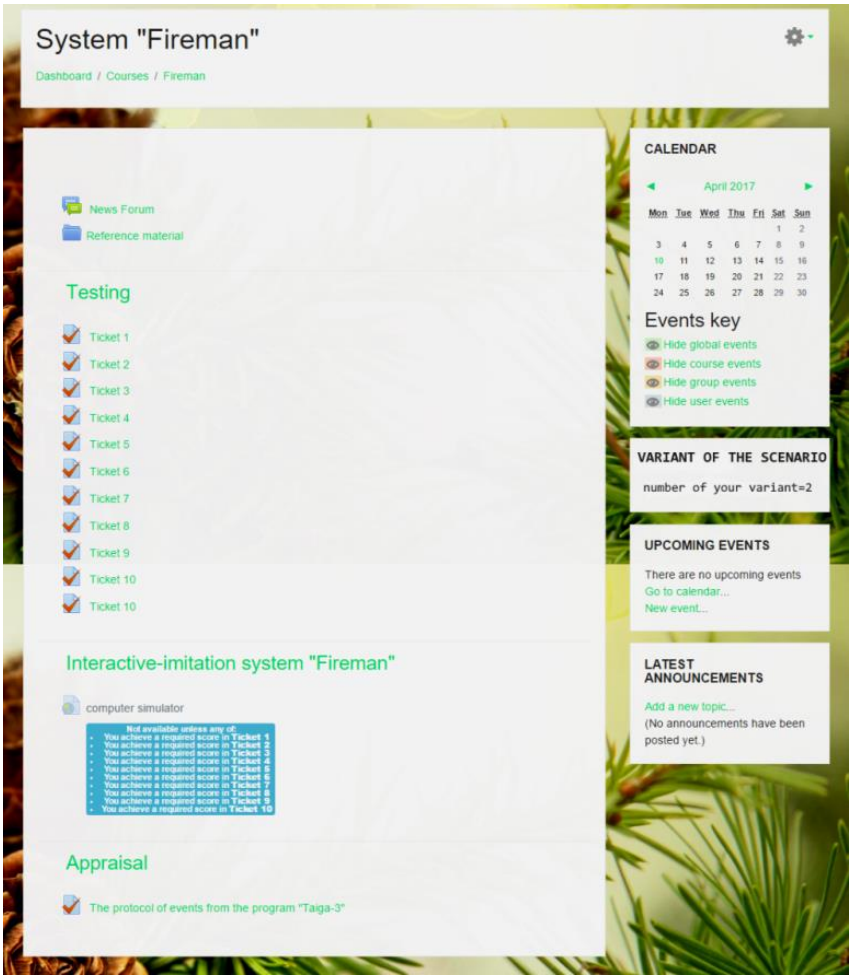

Figure 2 - Appearance of the Fireman Course Page

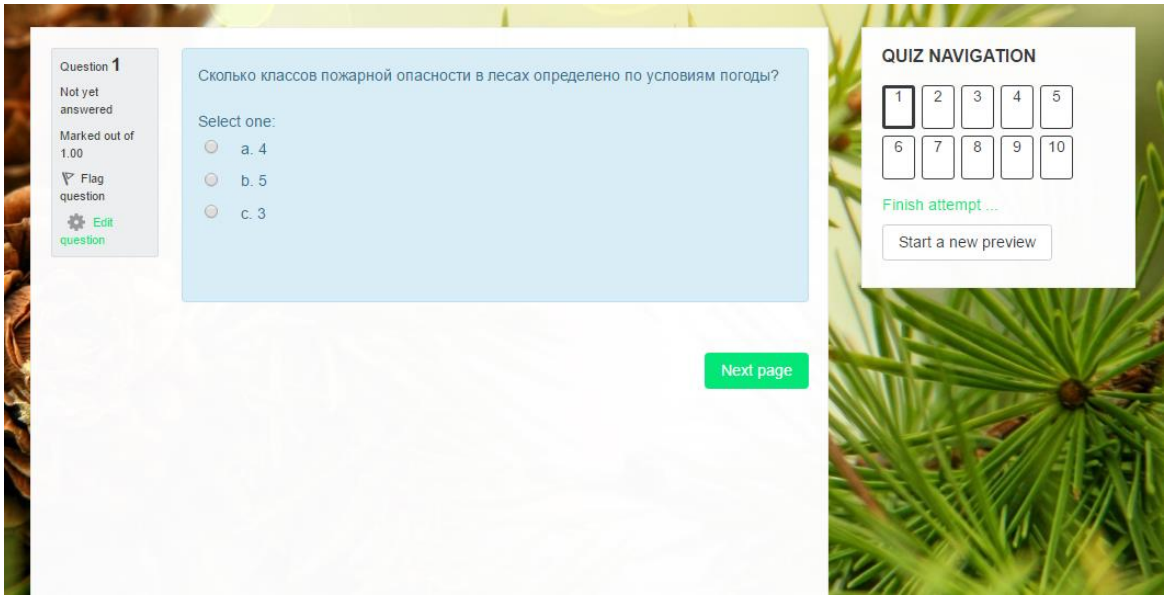

Figure 3 - Preliminary Test Example

The authors have developed an agent-based system containing two types of agents, designated A and B. Type A agents simulate the movement of the wave front. They can be in active and passive states. A-agent, which is in the active state, determines the motion of the process front. Agents of type

B (B agents) simulate the impact on agents of type A. They pursue a single goal - to translate all A-agents into a passive state. To do this, the B-agent moves through the simulation environment to the nearest A-agent and, approaching it, carries out a control action aimed at destroying it.

Figure 4 shows the localization menu, which is located on the right side of the system interface. This menu consists buttons, switches and text fields. On the left side of the system interface there is a map of the real terrain.

Figure 4 - User's menu of the Taiga system

5. An example of decision making

A simple example of wildfire fighting imitation is given below.

The environment settings of the fire simulation are the next.

- Polygon on the right-hand side of the figure, circled by a dashed line, represents a locality (protected object);
- area of the wildfire at the start is 0.22 ha;
- wind speed under the canopy is 2 m/s;
- wind direction from the north.
- fire danger class is four.
- aim of the game – to protect object from wildfire.

The place where the fire starts is appointed by the tutor. Initial fire contour is constructed automatically. In this example, the trainee decided to construct fire barriers to exclude the possibility of reaching by wildfire a protected area. Figures 5A - 5C shows the fire propagation dynamics. A

reader can see that the thickness of the fire barrier was not enough. The wildfire continued to spread and reached the settlement. Thus, simulation is over with the negative result.

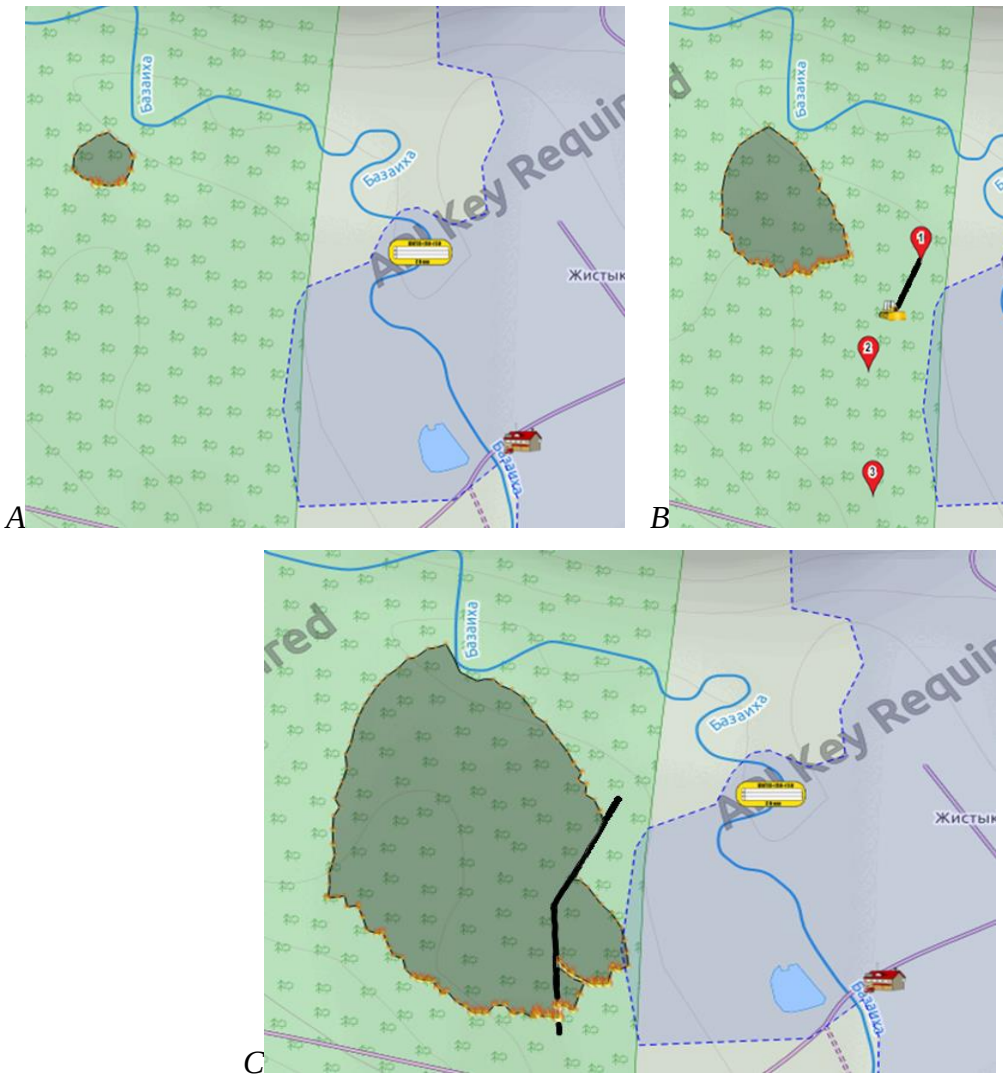

Figure 5 - Illustration of simulation process. Legend: A – start of the game, B – trainee desides to create a fire barrier and call a bulldoser, C- end of the simulation process, object was not protected

During the simulation process, an event log of the trainee's actions was generated. The fire situation protocol is presented below.

Time: 0 h, 0 m
Detected wildfire with area 0,22 ha;
Distance to the protection object 393 m;
Fire spread is 2,8 m/min;

Time: 0 h, 45 m
Trainee calls bulldozer D-533 for piercing the fire barrier;

Time: 1 h, 0 m
Area of wildfire 0,95 ha;
Distance to the protection object 281 m;
Fire spread is 3,19 m/min;

Time: 1 h, 25 m
Bulldozer D-533 began piercing the fire barrier width 0,5 m;

Time: 2 h, 0 m
Area of wildfire 1,995 ha;
Distance to the protection object 183 m;
Fire spread is 2,08 m/min;
Time: 2 h, 10 m
Bulldozer D-533 ended construction the fire barrier;
Time: 3 h, 0 m
Area of wildfire 3,413 ha;
Distance to the protection object 110 m;
Fire spread is 3,34 m/min;
Time: 4 h, 0 m
Area of wildfire 5,435 ha;
Distance to the protection object 50 m;
Fire spread is 2,42 m/min;
Time: 4 h, 40 m
Area of wildfire 6,995 ha;
Distance to the protection object 0 m;
Fire spread is 3,36 m/min;
Wildfire reached the protected object *(see Figure 5C)*

6. Conclusion

In the work presented the interactive imitation computer system FIREMAN is described. This system is intended for firefighting personnel training in basics of the wildfires struggle rules and tactics.

The system is a combine of popular e-learning system MOODLE and wildfire imitation system TAIGA developed by the authors. Such combination permits to obtain effective means for firefighters of different qualification levels training.

At the moment FIREMAN is tested in Reshetnev Siberian University of Science and Technologiy and in Siberian Fire and Rescue Academy.

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