Forest Fire Simulation User’s Manual

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Terms of Use

Forest Fire Simulation software was developed by NTUA/ChemEng and is distributed to CALCHAS Project (Grant Agreement NUMBER LIFE08 ENV/GR/000558) partners as part of Action 4, namely Development of forest fire evolution simulator.

1. In principle the software package is to be used for the needs of the CALCHAS project. Any use by third parties outside of the CALCHAS consortium and for purposes outside the CALCHAS project framework without the permission of CALCHAS consortium is not allowed.

2. The software source code is held by NTUA/ChemEng.

3. NTUA/ChemEng do not undertake any responsibility for further developments of the Forest Fire Simulation software package.

4. NTUA/ChemEng personnel are willing to provide further help instructions and interact with the CALCHAS’s partners on the use of the Forest Fire Simulation software package. Our research staff could provide further clarifications to questions submitted through emails.

Contact persons: Professor Chris T. Kiranoudis (kyr@chemeng.ntua.gr).

5. CALCHAS partners are kindly requested to include the appropriate acknowledgement statements to NTUA/ChemEng in every document issued on the basis of output of the Forest Fire Simulation software package.

6. CALCHAS partners are kindly requested to contact the research staff of NTUA/ChemEng in due time, and consider the incorporation of the most relevant research person(s) of our University to scientific publications, if the latter are based solely or partly on the outputs of the Forest Fire Simulation software package.
Forest Fire Modelling

Background

The software tool that predicts forest fire front propagation is based on a mathematical model that was developed by the NTUA team in order to achieve precise computational evaluation of the fire marching contour under the influence of the various terrain and meteorological parameters that affect fire spread and direction. The model was based on a two fold reasoning; a discrete contour propagation model for estimating fire front expansion and a fuzzy-neural system for the estimation of fire spread as a function of terrain characteristics, vegetation type and density and meteorological conditions. The model takes into consideration various operational issues in order to account for real-world instances and crisis situations such as: multiple ignition points and in particular their spatial distribution and their temporal appearance; recalculation of the marching front based on point and/or line and/or polygon shape of the fire boundary; temporal variation of the factors affecting fire spread; variable terrain characteristics modelled as a 3D raster grid. Model details can be found in the manuscripts listed at the end of this session.

Relevant Papers


Application Information
System

One of the main deliverables of CALCHAS project is the deployment of a forest fire simulation software (Information System). The System Platform provides with operations that involve collecting, overlapping, manipulating and visualizing a large volume of data derived from the analysis of a possible forest fire ignition, its potential spreading and the related consequences. It can be used as a tool for the coordination of the involved agencies or services (System Users as Decision Makers) that must take into account the necessary measures for the defence against a disaster of such a nature, and also the exact place, timing and way of realization of these measures. The development of the Information System was based on the following steps: identification of user needs; development of functional specifications; determination of the system architecture; system implementation; evaluation /validation. It is necessary that the simulation system developed support the following decisions: assessment of incident consequences and incident evolution; support decision on the construction of an appropriate emergency plan; identification and notification of required response steps; make the decision maker determine the appropriate response actions and the required resources as well as make decisions on dispatching and monitoring of the responses.

All data necessary for the calculations provided by the Information System resources are retrieved from the database repository where the System Software Service is installed and started. Any kind of updating such data is automatically represented in the cartographic system as long as such an update takes place in the system repository and the Software Service restarts. Moreover, the system database is supplied with spatial coordinates of points of interest (such as meteorological stations). The connection between these two operational units of the system is made through the XML protocol.

The main assistant tool that has been developed for the simulation calculations is the Forest Fire Simulation Software Service (FFSSS), which performs the necessary numerical calculations that would quantify the extent of the consequences of a forest fire. The forest fire simulator is a powerful tool for control and decision making since it combines in real time, the available spatial characteristics with all other critical information that can change the conditions of maintaining or spreading a forest fire, and
contributes to the decision of taking the most proper measures for the direct confronting of such situations. The user interactively specifies the type and the characteristics of the fire scenarios through the system user interface. The simulator has its own library of mathematical models and a solver to evaluate the exact geographical region where the consequences are more intense for the population, so that immediate actions can be taken. It runs as a MS Windows Service Application and it has multitasked parallel architecture to support demand for calculations from many concurrent users.

In all, the Information System with the above described structure and tools, can automatically calculate the consequences of a particular forest fire. Being continuously supplied with data from the database it executes the proper calculations regarding direct or indirect consequences of a fire. Moreover, it is supporting the decision maker to make the appropriate course of actions that would enable the less possible harm on population, depending on the severity of the specific incident.
Running the Software

The software tool is developed in the form of a web-based application. Its main purpose is to forecast the fire progress based on real-time information regarding the morphology of the area and current meteorological conditions. The URL of the simulation tool is the following:

http://calchas.eu-project-sites.com/

and is currently available for the partners of CALCHAS project and for the end users participating in its training community. Access to the system is guarded by a username/password login page as such as the one of Figure 1. Each time a user logs to the system, a session data structure is kept for him at the server’s repository protected by a unique GuID (automatically created and stored). In such a way, the system will not be confused if login is made by the same computer, or a separate tab of the same browser or computers of the same IP address.

![Calchas System Input Dialog](image)

**Figure 1.** Login page to the software.

All browsers are supported (WebKit browsers such as Mozilla Firefox, Google Chrome, Apple Safari and Microsoft Internet Explorer). No specific browser is set as default by the development team and effort was given to have the same look and feel actions in the user interface for all browsers.

Safe login to the system leads to a two-fold view page that consists of two panes (Figure 2); the left pane is the navigation pane where the user interface controls are placed; the right pane is a V3 Google Maps API Map. The map is fully featured (map, terrain, satellite, labels) and all relevant controls are supported.
The User Interface controls and their usability are described in detail in the following section.

**USER CONTROLS**

This is the complete list of System User controls of the User Interface and their usability. Most controls are used for the off-line simulations.

**WIND SPEED (m/s)**

Textbox where the wind speed is provided in m/s. Default value is 5 m/s.

**WIND SPEED DIRECTION**

Combobox where the wind direction is provided. The user can select from a collection of 16 string values (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW). Default value is N (North Wind)

**TEMPERATURE (deg C)**

Textbox where the wind temperature is provided in degrees Centigrade. Default value is 25 deg C.
HUMIDITY (%)

Textbox where the wind relative humidity is provided in %. Default value is 60 %.

TIME SPAN (min)

Textbox where the desired time span for the calculations is provided (both for on-line and off-line use) in minutes. Default value is 60 minutes (1 hour).

TOTAL TIME SPAN (min)

A read-only textbox where the total simulation time so far is kept. Each time a new simulation is performed the Total Time Span value of the previous textbox is added to this value. Total time span is given in minutes.

BUTTONS

This is the complete list of System User buttons of the User Interface and their usability. Their usage is closely related to drawing aspects of the ignition areas and simulation itself.

INITIALIZE ALL

Remove all ignition points / shapes, initialize data structures and perform a new simulation (on-line, off-line or combination).

SEED POINTS

Invokes the mode of drawing ignition points. When this mode is set, ignition points can be drawn by simply clicking the map area of the forest site (Figure 2).

REMOVE LAST POINT

Removes the last ignition point inserted.

SEED POLYGONS

Invokes the mode of drawing ignition polygons. When this mode is set, ignition polygons can be drawn by simply clicking the map area of the forest site point by point so that a polygon is drawn (Figure 3).

REMOVE LAST SEGMENT

Removes the last point of the polygon inserted. In the case where this point is the last, it will not be removed. Instead, the user can use the REMOVE LAST SHAPE button to remove the entire shape.
Figure 2. Ignition Points

**REMOVE LAST SHAPE**

Removes the last inserted polygon shape. The shape is acknowledged as such where the use closes it.

**CLOSE SHAPE**

All inserted polygon points are wrapped into a polygon.
SIMULATE

Perform an estimation of the new forest fire front based on input provided by the user in the pane controls (off-line simulation).

Figure 4. Simulation

Figure 5. Data from Meteorological Stations
DATA FROM STATIONS

Data are retrieved from the database and presented in the map. Wind arrows can be used to show the wind direction as map markers. Information is provided in the relevant info control of the marker (Figure 5).

SIMULATE STATION DATA

Perform an estimation of the new forest fire front based on meteorological conditions provided by the meteorological station grid (on-line simulation). The data are used in such a way that calculations on the front are performed from the data related to the closest station. In this way, more than one meteorological station can be used for a single front calculation.

SIMULATE HISTORICAL STATION DATA

Perform an estimation of the new forest fire front based on meteorological conditions provided by the meteorological station grid from historical data (off-line simulation). The information retrieved by the database is average values of all meteorological conditions from previous years. The system averages these values for times that belong to a time window of hours and days before and after the current time point for all years stored in the database.

LOGOUT

Logs out the System User
Case Studies

The Login Page of the System gives access to a System User to perform simulations. Each username/password combination, if valid, will invoke a different site as a case study. Only one site is supported for each username/password combination for security reasons. The tool presently caters for two forest sites (that are mapped in the Figure 6) namely:

1. Troodos Mountain, Cyprus (left)
2. Grammos Mountain, Northern Greece (right)

but apparently, the design and software architecture allows the inclusion of several other sites provided that necessary data are embedded in the core of simulation mechanism.

Figure 6. CALCHAS Forest Sites
We will now give a complete tour of the tool by giving an example of a 3 hour fire front prediction in Troodos.

**Step 1.** Suppose that the ignition points are as in Figure 7 (an already formed front and two new ignition points)

![Figure 7. Forest Fire in Troodos I](image)

**Step 2.** Simulate using current meteorological conditions for 1 hour

![Figure 8. Forest Fire in Troodos II](image)

**Step 3.** Use meteorological predictions (from the Meteo Service) and simulate for another 2 hours off-line.

![Figure 9. Forest Fire in Troodos III](image)
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