Fire ROS Calculator's Manual

Developed by:

Abdelrahman Abouali

Mathematical Model by:

Domingos Xavier Viegas

User's Guide

The program has a fully developed graphical user interface. By running the program, a single window will appear, on this window there are three main tabs on the top:

New Project; Which is used to start a new calculation of the ROS

Load Project; which is used in a case that you have an old project where you have calibrated the camera and so on, but you need to calculate other ROS for example or to get any of the provided results by the program.

Match images; which is just an assistant tool to equalize the size of some images to match another one, we will mention later on the cases when you will need use this tool.

Each tab of the three runs independently from the others. On the following, a detailed guide of how to use each one of them.

1. Starting New Project

On the New Project tab, you can find the window is divided to two panels, one for the inputs, and another for the results after calibrating the camera and detecting the fore front.

1.1. Inputs

There are six different groups of inputs you must make sure that you have provided them before starting the process of calibration and detection of the fore front. These groups will be discussed on the following:

1.1.1. Project Name; on the field where it's written Project Name you have to just provide a name for this run where all the results later will carry this name

1.1.2. Images; three groups of image must be provided:

Calibration images: which are images that were taken of the calibration object before starting the experiment.

Fire Front image: which is the taken images or frames during the propagation of the fire front over a surface.

Bed Surface Reference: which is the one image that were took while placing the calibration object over the surface where the fire will propagate. Look the pre calibration processing section for more details about how these images.

1.1.3. Size of the Checkboard Square; you need to provide the program here with the length of the one square of the checkboard (the calibration object) that was used for the calibration in mm.

1.1.4. Time Laps; which is the time lap between the frames or the images of the fire front that were taken during the fire propagation. You have to options, one is the constant time lap in a case you had a fixed time step between the frames and another if have variable time step between the frames, in that case you will have to enter the time between each two frames by clicking on “Add Laps”. In all cases the time is given in seconds.

1.1.5. Fuel Bed Geometry; here to you will need to provide the shape of the surface where the fire was propagating (the fuel bed). By choosing the shape of the bed the program will provide later a propagation counter map of the fire propagation enclosed inside a frame which is this shape of the bed. However, it’s not necessary to choose a shape you can just stick with the “Not Specified”. To choose a shape you have three options:

<u>Rectangular: </u>it will give a rectangular shape, however, you will have to draw one edge of this bed and provide the length of the other perpendicular edge of the rectangle.
To draw the edge, you can click on “Detect Bed Location” then you will have to choose one of the images to draw a line on it over the one of the bed edges. You can select either one of the fire front images or the calibration images as long as it’s an image from the same camera. After the image will open, you can click by the mouse where the edge is starting and drag the mouse while you are clicking to detect the other end of the edge. You can however edit the location of this line as you like by dragging its ends. After placing the line in the wanted position you will have to double click over the line to end the process of detecting this edge location.

<u>Triangular: </u>it will give a Triangular shape. You will need also to draw on edge of the triangle and provide the angle between the drawn edge and one of the other two edges and its length also. The drawing has the same process as for the rectangular shape. But you have to be careful with start and end of the drawn line, where the provided angle and length must be for the edge that will be joint with the drawn edge at its last detected point (the second end).

<u>Drawing the shape Manually: </u>by choosing this option you can draw manually any shape with straight edges. To draw the shape, click on “Draw Shape Manually”. You will to select an image also where you will draw the shape over it, then after it opens, you will have enter how many corners or edges does the shape has, then by right-clicking over the image and selection “Add Lines”, you will be enabled to draw the edges of the shape, then click “OK” when you finish placing the lines. Note that once you finished placing the first line you will be enabled to place the second one and so on, only after finishing placing all of them, you can edit their location before pressing “OK” to end the process.

1.1.6. Saving; by the checking the box of “Save frame images with drawn fire front line” the program will save a copy of the fire front images where the fire front lines that the user will draw later will be drawn over these images. The option is recommended in case the fuel bed has more than one surface, which means several runs of the program, so by this option the user use these saved images for the runs that for the other surfaces so he will know where he detected the fire front on the run before.
Finally, you will need to select a folder as a directory where all the results will be saved on.

1.1.7. Calibration and Detection of the fire front; after finishing entering all the inputs you can now click on "Calibrate and detect fire front", the program will do the calibration and then will ask you to start detecting the location of the fire front on each frame manually. The program will open the fire front images automatically one by one, the program will order them alphabetically by the name in ascending order, so the user must make sure before selecting the fire front images as an input that their names are ordered as the same as their timing order. The fire front can be detected by small line segments which will be defined by detecting the starting and ending points of these line segments. Every ending point will be also the starting point of the next line.

- To add a point; click left-mouse-click to determine a new point
- To delete the last point; press the "Backspace" key
- To finish the detection; click double clicks by the mouse at the last point to be detected, or simply you can press "Enter".

After finishing Entering all the inputs and detecting the fire front. The results options on the results panel will be enabled so the user can now get any results he likes. Also the program will give the considered number of calibration images, which is the number that the calibration has been made from the program sometimes will drop some of the inputted images automatically as the calibration object is not clear on them. The user must insure that the number of the considered calibration images is higher than 10, so accuracy of the results will be acceptable.

Once the user has finished the process of calibration and fire front detection, the program will save a file with extension: (*.mat). That file has all the necessary data to load the project and get any results later as it's explained on section 2.

1.2. Results

On the results panel, there are different options to get results that will help the user to understand more the fire behavior and its associated ROS's. On the following we will discuss the purpose of each option and how to use it.
Please notice that all the results that you will calculate from these options will be saved into an Excel sheet, and for some options not all the results that you suppose to get will be displayed on the program although it's saved into the excel sheet. <u>It's very important to press the bottom "Save Excel" before you exit or reset</u>, as the Excel sheet will be written at that moment, during the program run it's only on the computer memory.

1.2.1. Calculate Average ROS

We define the average rate of spread (ROS) of a fire along a prescribed direction as the slope of a linear fit of the function: *D(t)*, where *D* is the distance passed by the fire along a predefined direction during a time (t). We are following on this Viegas 2004. However, This simplification to calculate the average ROS is only acceptable if there are no consistent variations of the rate of spread (ROS) and it implies that the fire is spreading in a quasi-steady-state, which may not be valid in all cases (Viegas 2004). In case there is consistent variations we recommend to also "Calculate Dynamic ROS" option that's provided also on the program. Also for calculating the average ROS the program gives you the ability to add several lines where it will provide you the average ROS for each one of them and also the average of all of them, the user may use several adjacent lines to avoid local effects and variations on the fire spread behavior on that direction.

To measure the average ROS, you will have to place a line by left-mouse-clicking over the showed fire propagation contour map and select “Add Line”, then you can place the lines over the map after entering how many lines you would like to add. The user can detect also the area of interest by adding two frame ranks (from … to…) that user likes to calculate the ROS through them, which means determining the distances between these frames and calculating the ROS. Once the ROS’s were calculated the program saves an image on the results directory with the fire propagation map and the lines placed on it. Please notice the following:

- Note that once you finished placing a line you will be enabled to place the next one and so on, only after finishing placing all of them on the map, you can edit their location before pressing “Calculate ROS” to get their locations and calculate the ROS’s along them.
- The user must insure that the placed lines are intersection with the fire front lines, because in a case that it didn’t it will give a wrong value of the ROS. Also, it’s recommended to make more than one measurement on the same direction with changing slightly the position of the line.

1.2.2. Calculate Dynamic ROS

We define the dynamic ROS simply as the passed distance divided by the consumed time to pass it ($\Delta D / \Delta t$) along a predefine direction. Or it’s the slope of line joining two following points on the D(t) plot. So by calculating this ROS you will have the ROS that the fire translated with between two frames.

To measure the dynamic ROS, you will have to place a line by left-mouse-clicking over the showed fire propagation contour map and select “Add Line”. This line is where the ROS will be calculated along it. The user can detect the area of interest by determining the first and the last frame where the ROS will be calculated from the measured distances between the intersections of the determined fire front lines (frames) with the drawn line.

The obtained result here is the passed distances and the ROS that the fire passed them with it, along also with the average ROS. Once the ROS was calculated the program saves an image on the results directory with the fire propagation map and the line placed over it. Please notice also the same last mentioned points on the calculation of the average ROS about placing the line on the map and the intersections between the line and the fire front lines.

1.2.3. Measuring distances

By this option you can measure any distance over the fuel bed surface either by detecting it on the propagation map or from an image that the user would choose.

To measure the distance, you can just place a line or more depends on how many distances you like to measure. Adding the lines is with the same method that was explained for calculating the average ROS on section 1.2.1.

The obtained results from this option is the measured distances and the average of them in a case there were more than one.

1.2.4. Build the fire propagation map

From this option you can save the Fire propagation contour map with several options like showing or hiding the bed frame or changing the style of the line.
There is an option that you can determine the rank of the first frame on this map relatively to the whole experiment. This option can be used if there is more than one surface that the fire is propagating on, and as you will have to do a different program run for each surface. So, this option will make a consistence of the color and style of the fire front lines of the same time step on different surfaces.

1.2.5. Build iso-surface from ROS’s

This option allows the user to do 3D presentation of the fire ROS’s based on their X-Y location over the fire propagation surface, where the dynamic ROS will be on the Z axis. Then interpolating these values to build an iso-surface.
To get the iso-surface the user must add at least one line that the dynamic ROS will be calculated along it. However, it’s recommended to get a god presentation of the fire ROS values and their distribution over the surface to add first a convenient number of fire front images so that we will have a number of frames covering the whole surface with relatively small distances between the fire front lines. Also, to add as much lines as possible to cover also the whole surface so the 3D representation will have enough point to construct an iso-surface that presents the value of the fire ROS all over the surface.
For adding the lines, you can use the same method that on section 1.2.1., you can add more than one group of lines where every group will have different area of interest. Noticing that each group of lines must intersect with all the specified frames. After placing some group of line you will have to click “Add ROS’s” then repeat the past described way on section 1.2.1 again to place more lines and then click again “Add ROS’s”.
After finishing adding ROS’s values you can click on “Build iso-surface” button, that will present to you the iso-surface on the other axis. The user can show or hide each of the fire front lines, the bed frame and the points where the ROS were measured and the iso-surface was built from them.

1.2.6. Checking calibration Accuracy

You can check the accuracy of the calibration by checking the accuracy of a measured distance as the measuring distances is the main goal of the calibration and also the mina component on determining the ROS. So, the presented error here can be assumed as the error in all the obtained results during this run of the program or for this project.
To measure the error in some distance measurement you will have to select an image where you want to measure this distance form and then place a line over it with the same way that was shown in section 1.2.3. Then enter the real distance of that measurement and the program will give you the error. However, it’s recommended to take several measurements and take the average of them, as this error is including also the human error on putting the line exactly over the length that being measured.

2. Loading Project