Fire ROS Calculator

Manual

v. 2.1

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Introduction

This manual is made to guide the user throw the Fire ROS Calculator to gain the desired results and highlight some of the algorithms and models that have been used in the program’s code. The main objective of the Fire ROS Calculator is to measure the rate of spread of a fire spreading in a laboratory setting. The program calibrates a camera in a way that it obtains the real-world dimensions from the recorded images of a propagating fire (experiment). The program has some built-in tools to assist the user in a faster analysis. On this manual, the camera calibration process is presented first as it is the program’s main core and it requires the user to perform a calibration procedure before experimenting. Then secondly, we are presenting the user guide to perform an analysis and obtain the rate of spread of the fire and some other subordinated results. Finally, We are presenting the assisting tools will. The program’s interface constructs from five tabs on the top, the first tab is “New Session”, and it is used to perform a new analysis. The rest of the tabs are: Load Session, Match Images, Extract Frames and Camera Calibration, these are the assisting tools that will be discussed later.

Camera Calibration

The used calibration algorithm is the Computer Vision System Toolbox™ calibration algorithm which uses the camera model proposed by Jean-Yves Bouguet [1]. The model includes the pinhole camera model [2] and Lens distortion model [3]. The calibration algorithm uses a calibration object as a reference which is a checkerboard; this object will be captured by the camera in several positions. These captured digital (RGB) images of the calibration object are used by the algorithm to calculate the camera parameters (extrinsic, intrinsic and lens distortion parameters). These parameters can be obtained using the Camera Calibration tool. These parameters are for the camera itself, and the Camera Calibration tool allows the user to save them after being obtained for the first time. Please notice that you can use this saved camera parameters as long as you are using the same camera with the same lens.

In a case that the used camera in recording the fire propagation cannot take normal digital images (i.e. an IR camera has been used). The camera parameters cannot be obtained directly since the algorithm can detect the calibration object only on normal digital (RGB) images. There will be a need to use another digital camera with similar characteristics. The other camera is used to take photos of the calibration object and obtain the camera parameters, which is based on the assumption that the IR camera has the same parameters. However, to keep this assumption valid, the user must take into consideration the following:

- Place the digital camera as near as possible from the IR camera (or the camera that is being used to record the fire) and make sure that the two camera planes are parallel to each other (i.e. The difference in position can be corrected by transferring one of them along the three axes (x y z) without any rotation)
- Use a digital camera that has a zoom and lens diameter close to the IR camera as much as possible.

- If the digital camera zoom is adjustable, then adjust it to be slightly lower than the IR camera in a sense that the captured frame on the IR camera is within the digital camera frame.
- Before starting the analysis, the taken images of the calibration object from the digital camera must be cropped and rescaled to match the images that are extracted from the recording of the fire. The Fire ROS Calculator provides a tool (Match Images) to do that, and its guide is shown later in this manual. It is very recommended if the user is using a couple of cameras for the first time, to check the accuracy of the calibration using the Camera Calibration tool before starting the analysis.

The program needs two inputs to run (the New Session tab); First, the Obtained Camera Parameters of the used camera (the next section, the Camera Calibration tool, explains how to obtain it). Second, a Surface Reference Image (SRI), which is an image taken of the calibration object (the checkerboard) while it is placed over (parallel) the surface where the fire is propagating. Please notice that if the fire on the experiment is propagating over more than one flat surface, you need to capture this Surface Reference Image for each of them and perform an analysis (program run) for each of them also.

A pre-analysis procedure is required during experimenting so the program can obtain the Camera Parameters and calibrate it. The user needs to capture (photograph) the calibration object from 15 to 25 times while it is placed in a different random position each time on the space around the surface where the experiment is carried on. If the user is using the same camera, lens and calibration object size for a set of experiments, the user can perform this procedure to obtain the Camera Parameters only once and save it to be used for any other analysis later on. The Surface Reference image will need to be also captured during this pre-analysis procedure, and it will be captured every time the position of the camera has changed. (i.e. as long as neither the position of the camera or the position of the fire propagating surface have not changed the user does not need to capture the SRI for each performed test on this setting). For capturing the SRI, please notice the same mentioned considerations on capturing the calibration object on the next section.

The algorithm constructs a 2D plan from the Surface Reference Image (SRI), where each point (pixel) on the image over this surface can be translated to a point on the constructed 2D real-world dimensions' plan.

On the next section, we are discussing the calibration object and the procedure of capturing it by the camera along with some considerations.

The Calibration Object

The calibration object is a checkerboard pattern. It constructs from black and white squares which have the same size and distributed in a check pattern. This pattern is printed on a board and used to calibrate the camera. The user may find a group of checkerboard patterns with different sizes ready to be printed from here:

https://github.com/AAbouali/Fire_ROS_Calculator/raw/0f15eeef92f857431374cf3d4646c5384a713388/calibration%20objects.rar

Considerations for constructing the checkerboard, in a case the user wants to construct his own:

- The checkerboard must have an even number of squares along one side (e.g. X) and an odd number along the other side (Y) or vice versa.

- The checkerboard printout needs to be attached to a flat surface. Imperfections on the surface flatness can affect the accuracy of the calibration.
- Based on testing, it is recommended to blur or smudge the border corners of the checkerboard that are attached to the edges of the board or otherwise an error might happen in the detection process. However, the provided patterns by us have this smudginess (Fig. 1).
- The user may consider only half the width or the height of the squares which at the borders as the shown pattern in Fig. 2. However, this is only to reduce the total area as the far border corners are not detected.

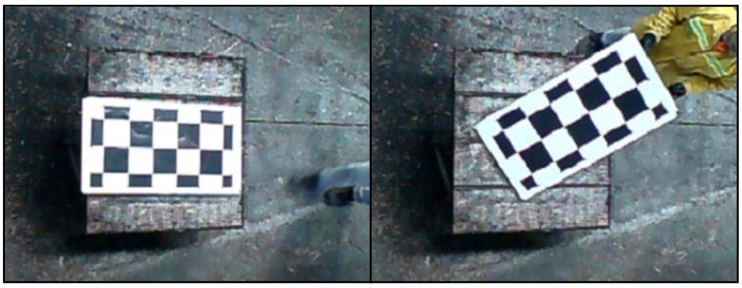


Fig. 2 Two different position where the calibration object where captured on. On the left, the board is place over the fire surface to get the Surface Reference Image. On the right, just a random position

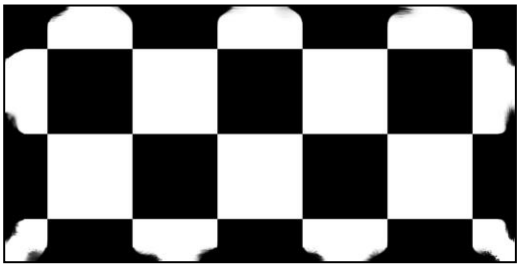


Fig. 1 Sample of the used checkerboard pattern to calibrate the camera

Considerations for Capturing the Calibration Object:

- Keep the object in focus, and don't change it (do not use autofocus).
- Do not change zoom settings between images.
- Use a proper calibration object size which fills about 20% to 80% of the frame. Otherwise, a not accurate calibration may be produced.
- Capture the images of the pattern at a distance roughly equal to the distance from your camera to the fuel bed surface. For example, if the fuel bed is at 2 meters, keep your pattern around 2 meters from the camera in all images.
- Place the checkerboard surface at an angle less than 45 degrees relative to the camera plane around the three axes.

Camera Calibration Tool

The Camera Calibration Tool has two objectives, Obtaining the camera parameters and check the accuracy of calibration.

<u>Obtaining the Camera Parameters:</u>

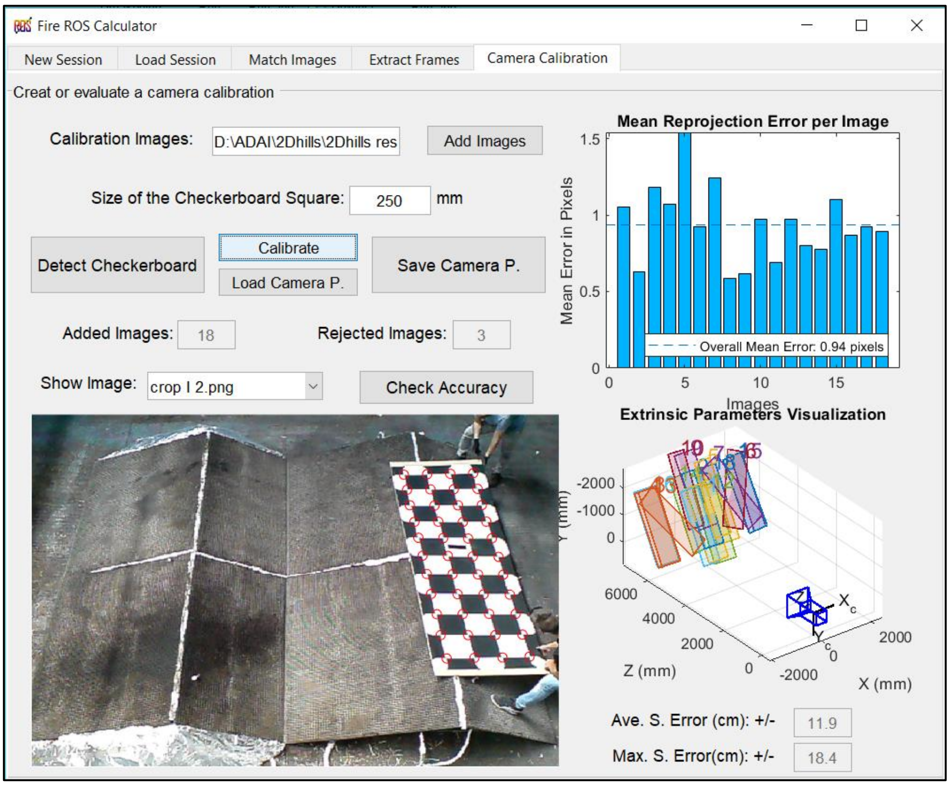
To obtain the camera parameters, it is required to have at least 4 images showing the calibration object in different random positions as mentioned previously. After having these calibration images, follow the following steps to obtain the camera parameters:

- Add the calibration images on the top
- Enter the size of one of the checkerboard's squares (the length of one edge of the square).
- Click on "Detect Checkerboard" button. After the program finishes detecting the checkerboard corners on the inputted images, the images will be displayed on the bottom with the corners

detection plotted over it. The program might reject some of the images if it is violating any of the mentioned considerations before for capturing the calibration object. However, The number of accepted and rejected images is displayed. The drop-down menu over the displayed image shows only the accepted images, and the user can change the selection to display another image. Notice that the algorithm detects only the inside corners on the board without its borders, that is why the smudginess has been added to the borders. The user might need in some cases to edit the calibration images by blurring or smudging the borders of the board in a case that the program has mistakenly detected some of these border corners.

- If the accepted images are over 3, the user can obtain the camera parameters by clicking over "Calibrate". After the program finishes the process, the mean reprojection errors and the extrinsic parameters will be displayed. The reprojection errors are the mean difference in pixel between the detected location of the corners and the calculated location by the algorithm. This error could be high for some images if the board was not flat and it is better to exclude this particular image and repeat the calibration process. The extrinsic parameters plot visualises the locations of the calibration object relative to the camera where the camera is at the origin. The user can rotate this plot for better display. Furthermore, the user may find a calculated standard error in the detection (the extrinsic parameters) on the down right corner. For more information about calculating this error, please refer to the MATALB web page
- Finally, click on "Save Camera P." To save this obtained camera parameters to use it later for analysis. It is recommended to save it in the default folder which opens by default when the user click save. The program display all the saved camera parameter files in this folder on the drop-down menu of the camera parameters selection on the New Session tab.

To check the accuracy of calibration, or precisely the accuracy of measuring the real-world dimensions, follow the following steps:



- First, the user needs to obtain the camera parameters following the previously shown steps, or load a saved one. Loading a saved one can be beneficially in a case that the user is checking less than 4 images of the calibration object taken from the same camera position (since it is not possible to obtain camera parameters with less than 4 images). Alternatively, the user has already the camera parameters of the used camera, and just want to check the accuracy of the detection of the current SRI.
- Select the surface reference image from the drop-down menu of the accepted images. The program considers whatever image selected on the drop-down menu as the SRI when the user clicks “Check Accuracy”.
- Finally, Click on “Check Accuracy”. A window will be displayed showing the SRI. The user needs to detect a distance on the image in which he knows its true value. This distance can be detected on the image by drawing a line between the two measuring points. To draw the line, right-click over the image and choose “Add Line”. Then enter the real distance of this line and click “Calculate Accuracy” where the percentage error in this measured distance will be displayed. The program calculates the percentage error according to the following equation:

$$error(\%) = abs\left(\frac{calculted\ Dist. - real\ Dist.}{real\ Dist.}\right) * 100 \qquad (Eq1)$$

The user may change the image that the distance is measured from (E.g. Selecting one of the IR images), but the user must be sure that the selected image has the same size and resolution as the SRI and has been captured from the same camera position.

User's Guide

We constructed the program interface of a single window with five tabs, which are:

New Session; which is used to start a new analysis.

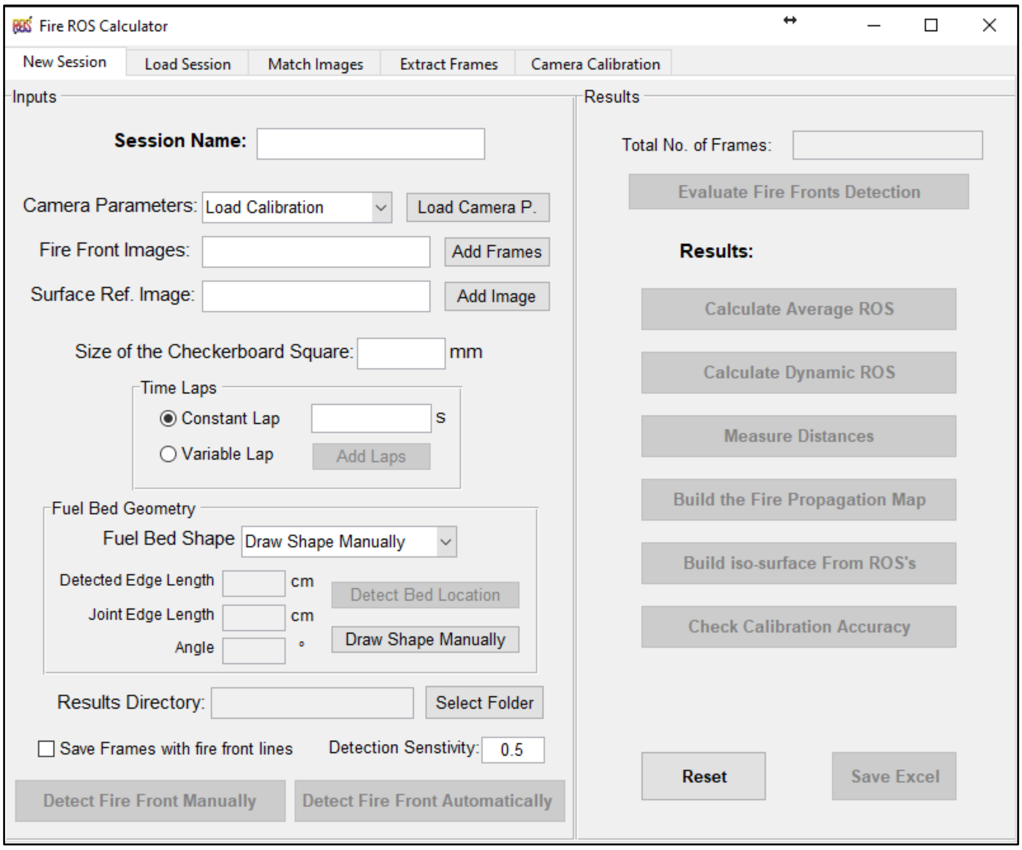
Load Session; which is used in a case that the user has an old analysis and needs to gain more results.

Match Images; an assistant tool to equalise the size and resolution of a group of images to match another one.

Extract Frames; an assistant tool to extract frames automatically from a video with a constant time step between them.

Calibrate Camera; a tool that obtains the camera parameters and to checks the accuracy of the calibration.

Each tab is a program that runs independently from the others. In the following, we present a detailed guide of how to use each of them except the Camera Calibration tool which we presented previously.



1. New Session (Analysis)

On the New Session tab, the window is divided into two panels, one for the inputs, and another for the results. The user must provide the inputs first and detects the fire front either using the automatic or the manual option; then the program will enable the user to obtain results.

1.1. Inputs

There are six groups of inputs must be provided before starting the process of detecting the fire front. These groups are:

1.1.1. Session Name

On the field where it is written “Session Name”, provide a name for this analysis.

1.1.2. Camera Parameters

The user could select a saved camera parameter file from the drop-down menu if there is any saved in the default folder, or he can select “Load Calibration” and choose the file. To create the camera parameters file for some camera, use the Camera Calibration Tool.

1.1.3. Images

<u>Fire Front images:</u> which is a series of images (frames) showing the propagation of the fire front over a surface with the time. The time step between them can be variable or fixed.

The program sorts the selected images by their names in ascending order, where the first image will have the zero-time reference. So, the user must check before selecting the fire front images as an input that their names are ordered as the same as their timing order. (e.g. 1,2,3, …)

<u>Surface Reference Image (SRI):</u> which is the image capturing the calibration object placed over the fire propagating surface.

Look the Camera Calibration part for more details about the SRI and the Camera Parameters

1.1.4. Size of the Checkerboard Square

In this field, enter the length of one square of the checkerboard (the calibration object) that was used to get the SRI in units of mm.

1.1.5. Time Laps

The time lap is the time between the images of the fire front (the frames) that are showing the fire propagation with time. Select an option, depending on the time lap between these frames if it was fixed or variable (changing from frame to another). If you have variable time steps between the frames, you need to enter the time between every two frames on the field that will appear by clicking on “Add Laps”. The times are given in seconds.

1.1.6. Fuel Bed Geometry

Here the user needs to provide the shape of the surface where the fire was propagating on (the fuel bed). The program considers the area within this shape as the region of interest (ROI) during the analysis. The user has two standard shape options which are the Rectangle and Triangle. If the shape is not one of them, the user needs to draw the shape manually.

On the following, a description is presented on how to detect the location of the shape on the image if it was one of the standard shapes or how to draw the shape if it is not:

Rectangular Shape

To detect the location of the rectangular area on the image, the user must draw one edge of the shape (the bed) and provides its length and the length of the perpendicular edge to it (the joint edge).

To draw the edge, click on “Detect Bed Location” then choose one of the fire front images or the surface reference image to draw a line over one of the bed edges. To draw the line, click with the mouse where the edge is starting and drag the mouse while holding to detect the other end of the edge. You can edit the location of the ends of the line by dragging them. After placing the line at the desired position, double-click over the line to end the process of detection or click “Enter”.

Triangular Shape

To detect the location of the triangular area on the image, the user must draw one edge of the bed and provides its length. Also, provides the length of another edge of the triangle (the joint edge) and the angle between the two edges. The drawing has the same procedure as for the rectangular shape, but attention must be taken with defining the ends of the drawn line, where the defined joint edge (its length and angle) is joining the drawn edge at its second defined end (last detected point).

Drawing the shape Manually

The user can draw manually any shape with straight edges using this option. To draw the shape, click on “Draw Shape Manually”. Then, select an image first which will be used for drawing the shape and provide the number of edges that the shape has. To draw the lines (the fuel bed’s edges), right-click over the image and select “Add Lines”, then draw them line by line. Note that once you finished placing a line of them, you will be enabled automatically to place the next one and so on, only after finishing placing all the lines, you can edit their location before pressing “OK” to end the process.

1.1.7. Saving the frames

By checking the box of “Save frames with fire front lines” the program will save a copy of the fire front images where the program plots the fire front lines over these images. The option is useful in a case the fire is propagating over more than one surface, which means several runs of the program, so by this option the user can use these saved images as the

"Fire Front Images" for the next run. That will clear where the fire front was detected in the previous run.

Finally, the user needs to select a folder as a directory where all the results will be saved in.

1.1.8. Detecting the fire fronts

Two methods are available to detect the fire front location on the frames, an automatic and a manual option. The program runs by selecting one of these two options after entering all the inputs.

<u>Manual Fire Front Detection</u>

After clicking, the program will open the fire front images automatically one after another, where the user must detect the fire front on each one of them. The fire front can be detected by drawing small line segments which are defined by detecting the starting and ending points of each line segment. Every ending point is considered the starting point of the next line automatically. The following points are some instructions to draw the lines:

- To add a point; left-click on the mouse to detect a new point location.
- To delete the last detected point; press the "Backspace" key.
- To finish the detection for the current frame; click double left-clicks by the mouse while detecting the last point, or just press "Enter".

<u>Automatic Fire Front Detection</u>

This method is based on an image processing algorithm that detects the fire front line on each frame automatically. The algorithm depends on the image colours where the burned area is usually brighter and on the history of the fire front location on the previous frames. The algorithm is designed for IR images only. The user might need to change the detection sensitivity which is a value between 0 and 1. Decreasing the detection sensitivity includes brighter areas within the detected burned area and vice versa. After the program finishes the detection, the user may check the detection on each frame by clicking on "Evaluate Fire Fronts Detection" on the right panel which using it is explained on the next point. However, this algorithm has a limitation, which it cannot detect two separate burned areas on the same ROI, in fact, when the algorithm detects two separate areas it calculates their area and considers only the bigger one. The program will send a warning to the user when it detects more than one burned area.

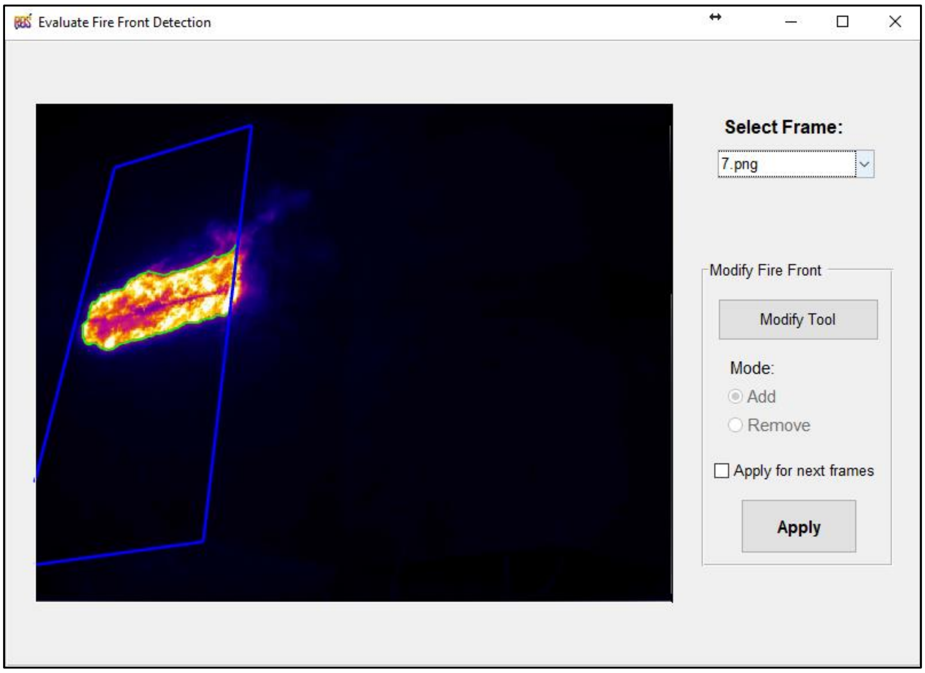
1.1.9. Evaluate the Fire Fronts Detection

This tool allows the user to evaluate the automatic detection of the fire front on each frame and modify it if needed. Select the frame from the drop-down menu to be displayed. Notice that the green line is the fire parameter or the fire front, the blue line is the ROI where the program is detecting the fire parameter only within it. To modify the fire parameter on the displayed frame, follow these steps:

- Click “Modify Tool”, go over the image and draw an area parameter by clicking and dragging. After drawing the area, its location can be changed by dragging it. The drawn area and the burned area must be intersecting.
- Choose a mode either Add or Remove. The Add mode will add the drawn area parameter to the burned area and redraw the overall fire parameter; the Remove mode will exclude the drawn area.
- Check the box “Apply for next frames” if you need to apply the same modification to all the following frames to the currently displayed one.
- Click “Apply” to execute the modification.

After entering all the inputs and detecting the fire front. The program will enable the results options on the right panel.

Once the program finishes the process of fire front detection, it will save a file with extension ‘*.mat’, this file has all the necessary data to load the session and get any other results later using the “load Session” tab.



1.2. Results

On the results panel, there are different options to measure the fire’s ROS or to represent it. In the following, we are discussing each of them.

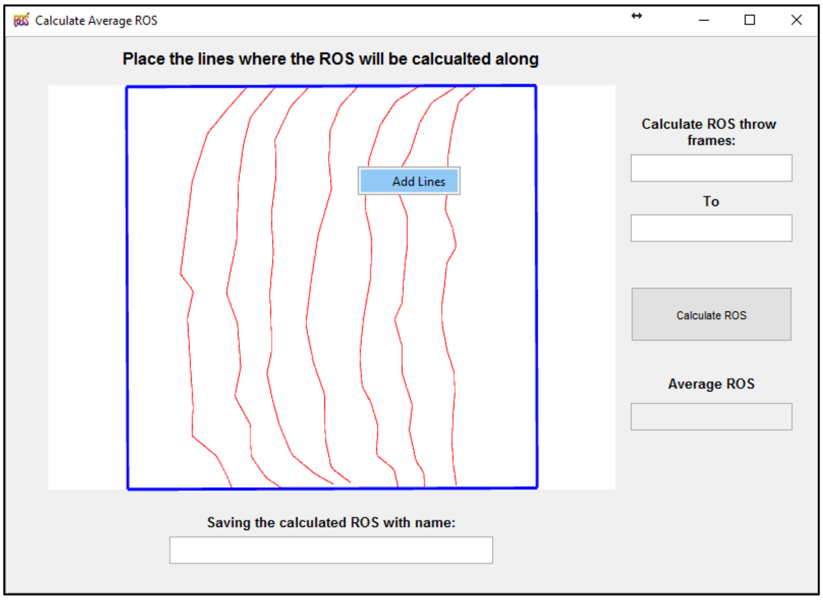
Please notice that all the output results during the session are saved on the temporary memory. After finishing the analysis, the user must save the results in an Excel sheet by clicking over “Save Excel” on the right down corner. <u>It is important to press the “Save Excel” button before exiting or resting,</u> otherwise or the gained results will be lost. The program also writes some information about the session and the inputted data to the excel sheet.

1.2.1. Calculate Average ROS

We define the average rate of spread (ROS) of 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 the predefined direction during a time (t). We are following on this Viegas 2004 [4]. 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) [4]. In case there are consistent variations, we recommend to use also the "Calculate Dynamic ROS" option to evaluate these variations. The slope is calculated where the passed distances are on the Y-axis and their corresponding times are on the X-axis. For calculating the average ROS of the fire in a general direction, the program gives you the ability to add several lines where it will calculate the average ROS along each one of them and the average of all of them. The user may use several adjacent lines to avoid local effects and variations in the fire spread behaviour along some direction.

To place the lines that the program will calculate the ROS along them, click a left-mouse-click over the presented 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 needs to define which frames will be considered in this calculation by adding two frame ranks (from "first line" to "last line"). These two frame ranks will change their colours to green on the contour map. Once the program calculates the ROS, it saves an image in the results directory that has the fire propagation map and the lines placed over it. Please notice the following:

- Once you finish placing a line you will be enabled to place the next one automatically and so on, only after finishing placing all of them on the map, you can edit their location before pressing "Calculate ROS". Changing the location can be done by dragging their ends on the map.
- The user must ensure that the placed lines are intersecting with all the considered fire front lines (frames) that were entered before. In a case that it did not intersect, the program will give an error.

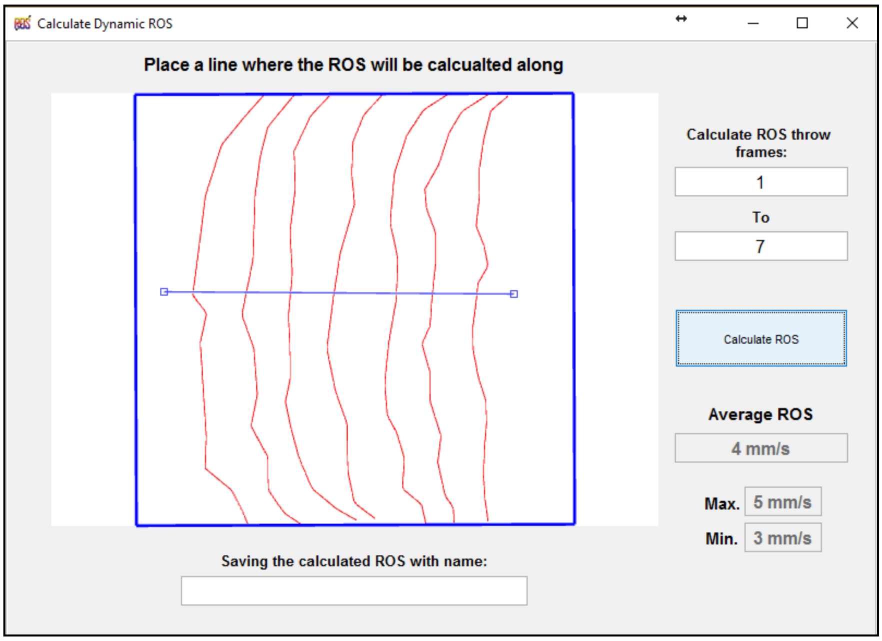


1.2.2. Calculate Dynamic ROS

We define the dynamic ROS as the passed distance from frame to another divided by the consumed time to pass it (ΔD/ Δt) along a predefined direction. Or in other terms, it is the slope of the line joining two following points on the D(t) plot. So, by calculating this ROS, the user will have the ROS that the fire has translated with between every two following frames.

To measure the dynamic ROS, place a line by left-mouse-clicking over the displayed fire propagation contour map and select "Add Line". This line is where the ROS is calculated along. As mentioned before on Calculating Average ROS, the user must enter the first and last frame ranks where this ROS will be calculated between.

For this option, the program provides the passed distances between the frames and the ROS that the fire translated with between them (the dynamic ROS), along also with the average ROS. However, on the GUI window, only the Average ROS, the maximum and the minimum achieved ROS's are presented. The detailed results can be found on the Excel sheet later.



1.2.3. Measuring distances

This option allows the user to measure any linear distance over the fuel bed surface either by detecting it on the contour map or from an image that the user would choose.

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

The obtained outputs from this option are the measured distances and the average of them in a case there was more than one.

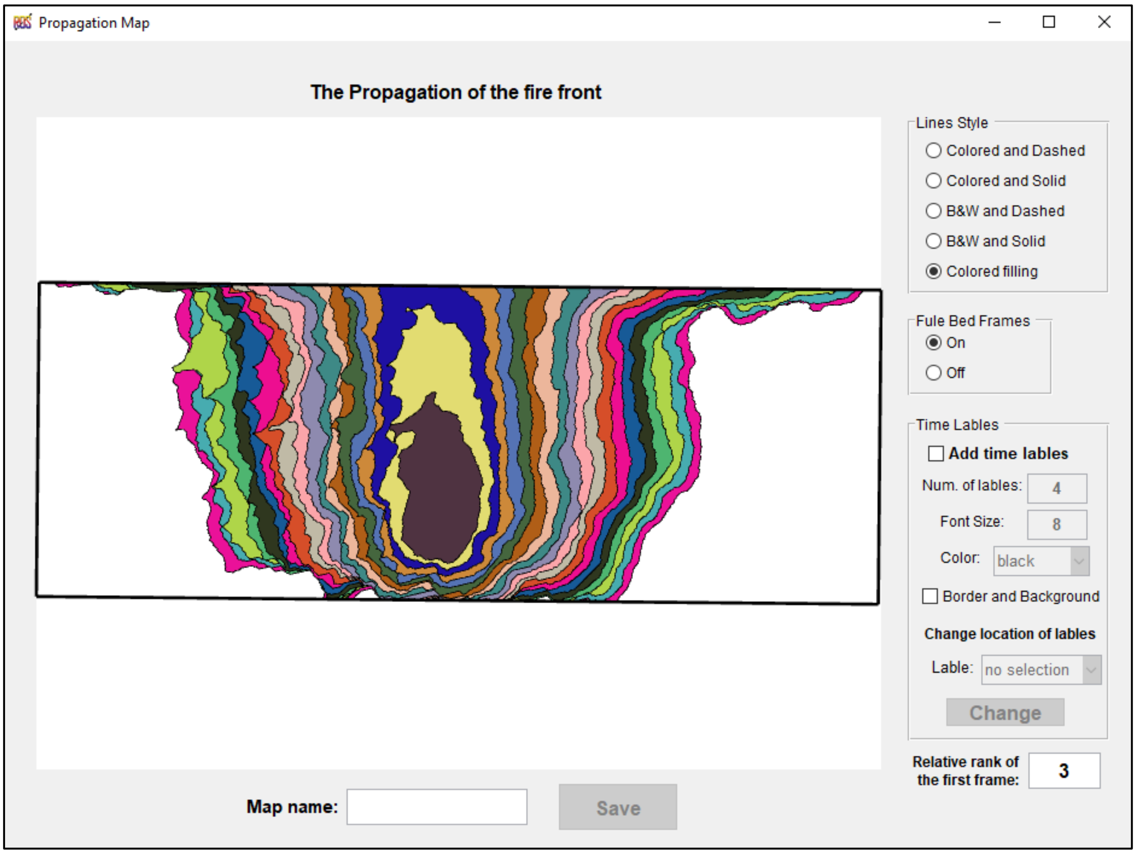
1.2.4. Build the fire propagation map

This tool helps the user to build a customised fire propagation contour map according to his needs. There are several options for the map's style. (e.g. showing or hiding the bed frame, changing the style of the lines and add time labels on the map)

If the experiment requires several program runs (more than one surface), there is an option to determine the rank of the first frame on the current map relative to the whole experiment. This makes consistency in the style of the map between the different runs. (i.e. the same colour for the same time step on all the generated maps).

The program places the time labels randomly over the fire perimeter. To change the location of the time label, select it from the drop-down menu Label and click "Change", notice that the fire parameter that the label is associated to will change its colour to red. Now choose its new location over that parameter by clicking on it.

After adjusting the map style, enter a name which it will be saved with and click Save. Please notice that if you saved two maps with the same name, the program overwrites it automatically.

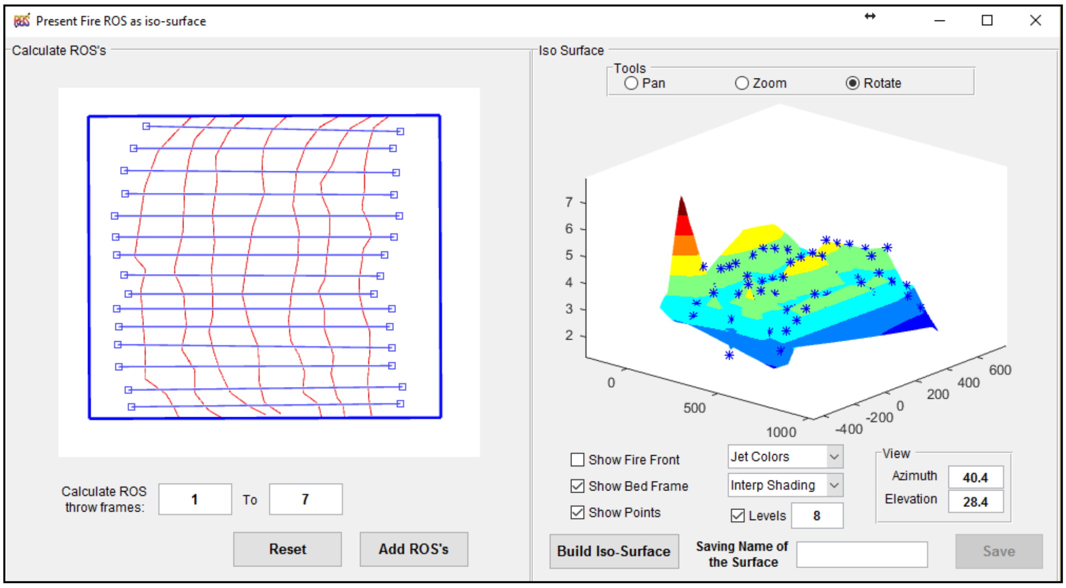


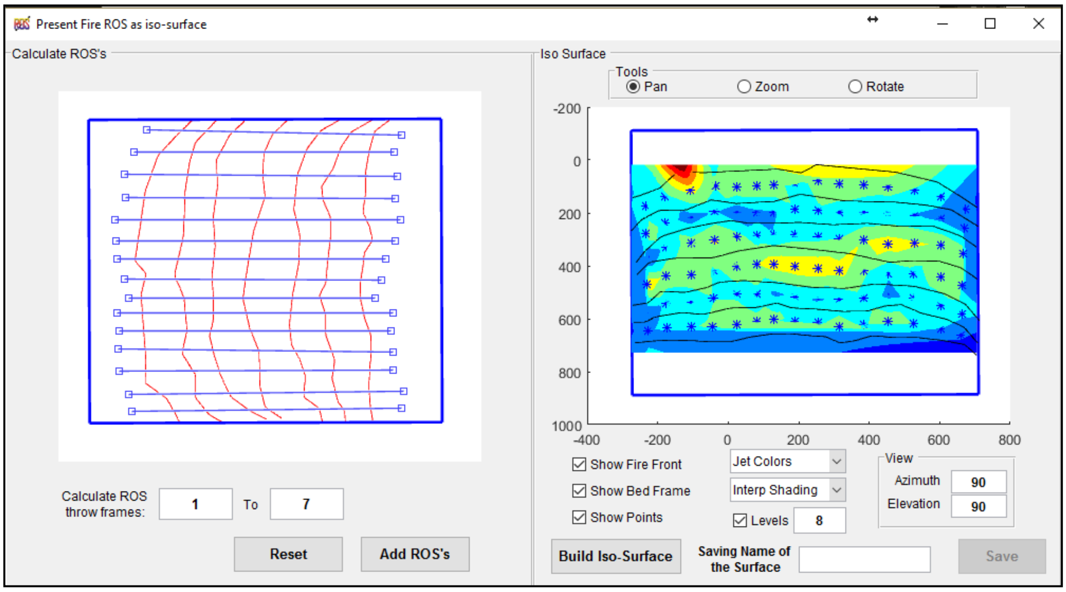
1.2.5. Build iso-surface from ROS's

This Tool allows the user to do a 3D presentation of the fire ROS's with their X-Y location over the fire surface, where the Z-axis represents the dynamic ROS. To get the iso-surface the user must add at least one line where the dynamic ROS will be calculated along it. However, to get a good presentation of the change on the fire ROS over the surface, it is recommended to use a convenient number of lines covering the whole surface, so the 3D representation will have enough values to interpolate and construct a good representing iso-surface.

To add the lines, use the same method that's mentioned in section 1.2.1. You can add more than one group of lines where every group will have a different range of frames. Notice that each group of lines must intersect with all the specified frames. After placing some group of lines, click "Add ROS's" before drawing another group of lines or constructing the iso-surface.

After finishing adding the ROS values (drawing all lines), click on "Build iso-surface" button. The user can change the style of the plot through several presented options.

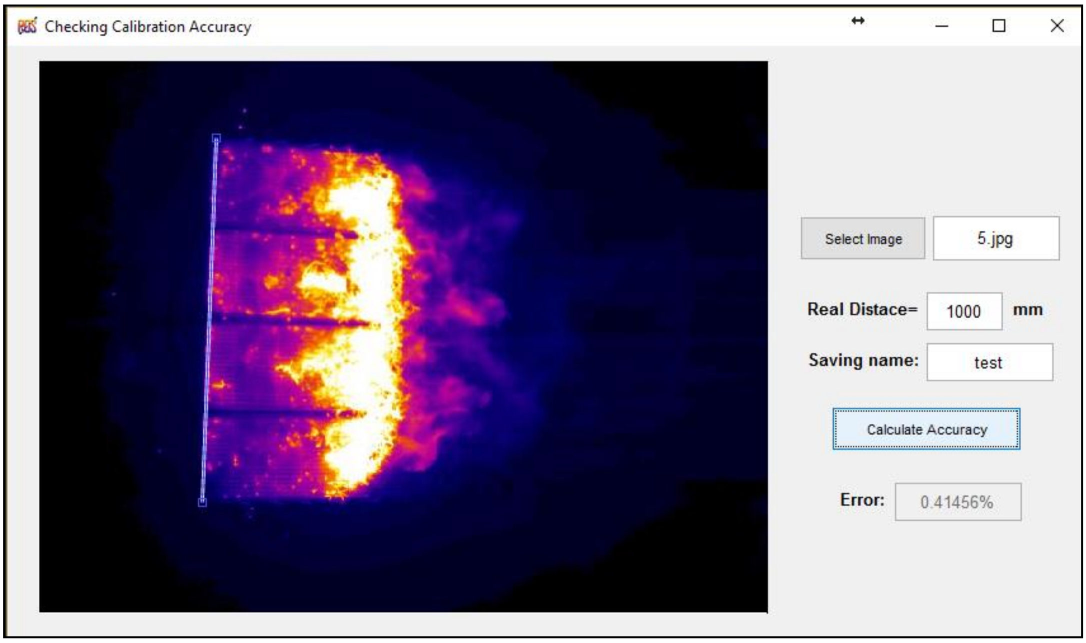




1.2.6. Checking Accuracy

The user can check the accuracy of the output results through this tool. The programs check the results by checking the accuracy of a measured distance as measuring the real-world distances is the primary key to obtain all the outputs. So, the presented error here can be assumed as the error in all the obtained results for this session.

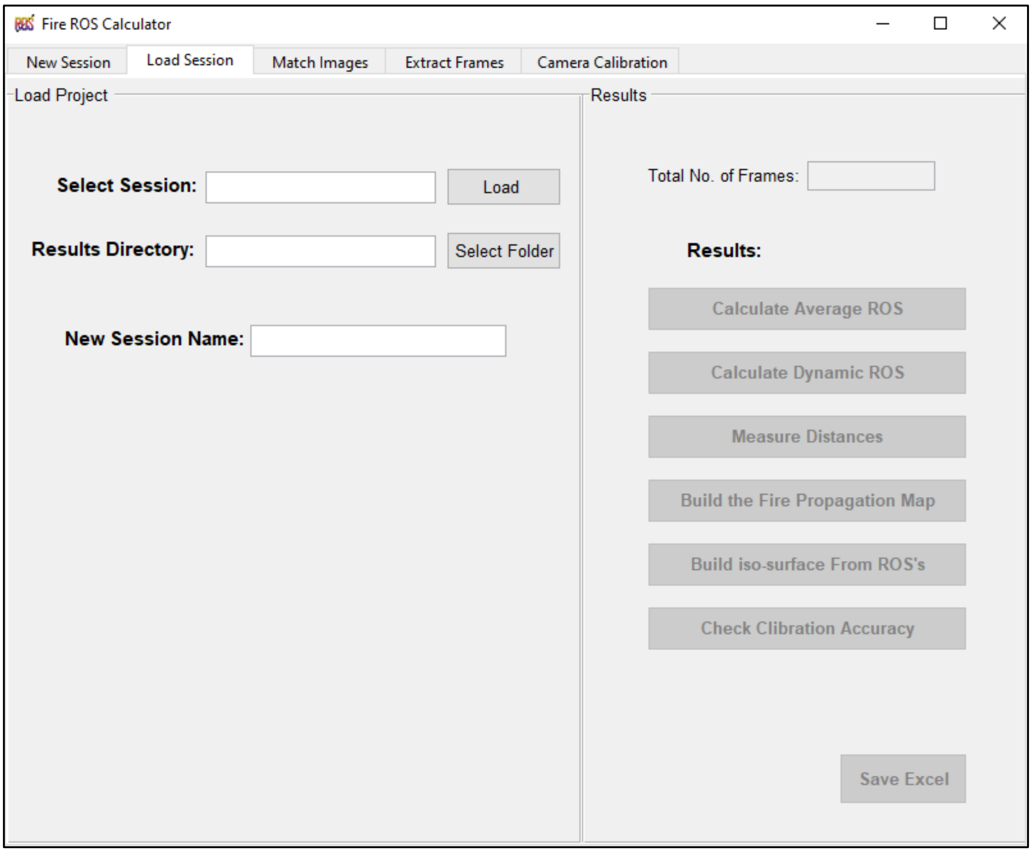
To measure the error in distance measurement, select an image where the distance will be measured from, then place a line over it with the same way that was shown in section 1.2.1. Enter the real distance of that measurement; then the program will give you the error calculated according to Eq1. However, it is recommended to take several measurements and take the average of them, as this error also includes the human error of placing the line exactly over the length that's being measured. Also, the error might change from direction to another.



2. Loading Session

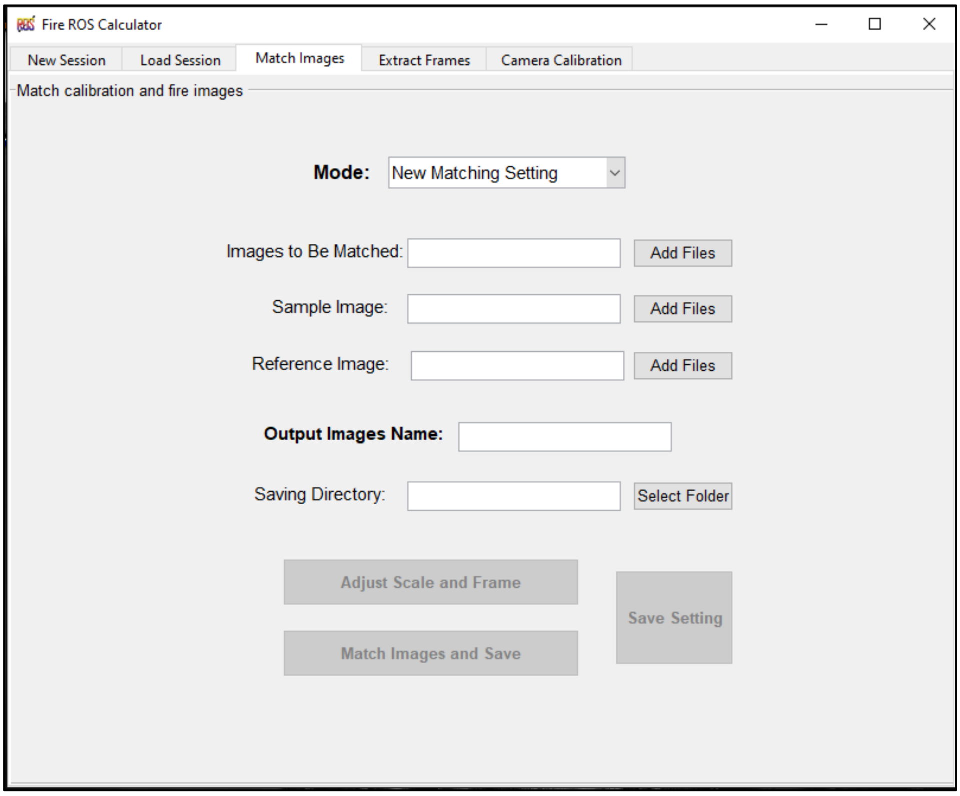
From this tool, the user can load an old session file (analysis), which is a file has the extension *.mat (a MATLAB Workspace), this file is generated automatically after performing the fire front detection. By loading the session file and choosing a directory and a name for the new results (the excel sheet name), the user will be able to obtain any of the result options that were mentioned before in section 1.2.

The program does not save the results in the session file neither on this tool or when the session file was created. Notice during saving any file, if the program found a file with the same name in the saving directory, it will overwrite it.



3. Match Images

This assisting tool is used to resize a group of images to match another inputted reference image. The tool is useful in a case that the fire images had a different size than the Surface Reference Image. Two options are available here, a New Matching Setting, where the user needs to define the resizing scale and the bounding frame or to Load a Matching Setting, where the user can apply the same resizing ratio that was saved before to another group of images without redefining them.



3.1. New Matching Setting

To match a group of Images to another Image (make them equal in the size and frame), add the Images (can be only one image) at “Images to be Matched” and add the image that you want to match them to it at “Reference Image”. At the “Sample Image” field, select one of the added images to be matched (the same image if it is only one). This sample image will be used to define the required scale and frame to match the images. Finally, enter a prefix name for the output images and their directory.

To Resize the images, the user must define a few points on the Sample Image and define the same location of these points on the other image (the Reference Image). Click on “Adjust Scale and Frame”, the Reference Image will be displayed, pinpoint two points on this image. Then the Sample Image will be displayed, pinpoint the same location of the two points on it. The two points must be pointed out as accurate as possible since it will affect the matching accuracy. (e.g. pinpoint two corners of the fuel bed appearing in both images). This Process will adjust the resolution of both images. Then, the program will open again the Reference Image where you need to pinpoint one point this time and pinpoint it also on the other image (The Sample Image). This process will define the image frame.

Now click on “Match images and Save” to execute the defined resizing process to the images and save them. The user may also save this matching setting where it can be used later to resize another group of images without repeating the process of defining the points.

3.2. Load a Matching setting

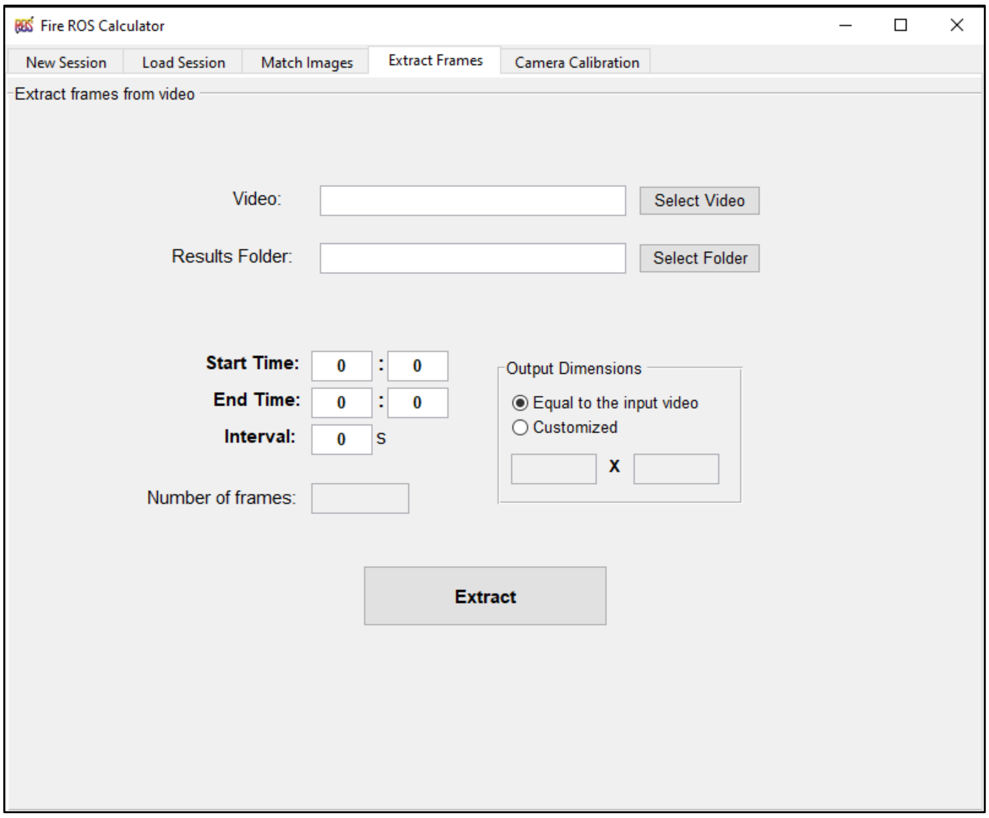
The user may use this option if there is a saved matching setting and wants to apply it to a group of images. Notice that the Images to be matched must have the same resolution and frames as the images that were used to create the Matching setting file to give the same desired output images.

To perform that, just add the images and enter a prefix name and a directory for the output images, then click on “Match images and Save”.

4. Extract Frames

The Extract Frames tool is helping the user to extract frames from an inputted video automatically with a constant time step between them. It was developed to obtain the frames that will be inputted on the analysis of the fire's ROS. However, it can be used for any purpose. The inputted video can have the format of .mp4, .mov or any format supported by Microsoft Media Foundation (.wmv, .avi, etc. …).

To extract frames from a video, select the video and a directory where the output images will be saved in. Then, enter the start and end times where the extraction will start and end in the format min:sec. The user must make sure that these times are within the video duration or the program will give an error. Enter the desired interval between the frames in seconds. The output number of frames will be displayed once you finish inputting all the time information and will be updated if you updated any of them. The user may also specify the resolution of the output images. After finish inputting the data, click on "Extract" to save the frames in the specified directory.



Compiling, Debugging and Feedback

We developed this program recently, and it is still under development. Please check that you have the latest version of the program where you can find it in the GitHub Repository: github.com/AAbouali/Fire_ROS_Calculator

The Fire ROS Calculator can be running from the MATLAB directly without the need to install it as a standalone application. To do that, download the source code from the GitHub Repository and change the MATLAB current workspace directory to be the directory of the source code. Then you may call the program by typing the function >> *Fire_ROS_Calculator* in the MATLAB's command window.

To compile your own version, you may type the following script on the MATLAB's command window, and MATLAB will compile the code and generate the installer, this after changing the MATLAB current workspace directory to be the directory of the source code.

>> *deploytool -package Fire_ROS_Calculator.prj*

This program has been tested and verified before publishing it; the user may find a verification report in the same repository. Although errors might happen, the developer asks you to please send the log file when an error happens to this email: abouali@adai.pt along with a brief description of the scenario when it happened. The log file can be found in the same directory that the program was launched from under the name "Fire_ROS_LogFile".

Verifying and Testing

We tested The Fire ROS Calculator, and verified its results against reference measurements. The verification process is presented in another document, "Fire ROS Calculator Verification". However, it was concluded that the Fire ROS Calculator's outputs have an error margin of ±5%. The user may run one of the verification cases (Case C), where the case inputs are included in the GitHub repository in a compressed file with the name "Case C Materials". The inputs are the Calibration Images, Camera Parameters file, Frame Images and the Surface Reference Image. We recommend in case that the user has compiled his version, to run the case and verify the outputs by comparing them to the reported reference measurement of the ROS in the Verification document. A guide to run the case is presented below:

- The user can find the already computed camera parameters file and use it to run the program on the "New Session" tab to calculate the fire's ROS. Another way, the user may use the included calibration images to compute the camera parameters using the "Camera Calibration" tool that was demonstrated earlier in this manual.
- On the "New Session" tab, Load the Camera Parameters file, the Frame Images and the Surface Reference Image. Then, enter the checkerboard square size which is 15 cm and the constant time lap which is 30 seconds. Next, detect the ROI (Fuel Bed Geometry), the User may use the rectangular option or draw the shape manually following the methodology demonstrated in section 1.1.6. Finally, check the box "Save Fames with fire front lines" if you want to produce images showing the detected fire front and then run the program by selecting the mode of detection either manual or automatic.

- After the program or the user in a case of manual detection finishes detecting the fire front. The list of output options will be enabled where the user may choose any of them to calculate for example the ROS or construct the propagation contour map.

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