Fire ROS Calculator

Verification

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Introduction

This validate of the Fire ROS Calculator is based on comparing the average fire rate of spread (ROS) result from the program to a reference measurement and calculating the error. We have used the ROS quantity to do this validation as it's the main result from the program which is indeed validating the accuracy of the real distances measured from the fire images. On the following we will present the methodology and then the results.

Methodology

To validate the program, three fire propagation experiments where performed in the Forest Fire Research Laboratory of the University of Coimbra in Lousã (Portugal). A flat table with dimensions of 1m×1m where prepared with a uniform fuel bed composed by dead pine needles (*Pinus Pinaster*) with a load of 0.6 kg.m^{-2} (dry basis) (Fig. 1). A surface fire that is originated from a line along one of the table edges were developed in no-wind and no-slope conditions to insure as much as possible that it will develop a steady fire propagation.

The Reference Measurements

The reference measurement of the ROS was taken manually. The table is prepared with a set of lines (strings), the lines where spaced by 10 cm from each other and form the table edges, which give us 8 lines covering the whole table length (1 m) (Fig. 1). The time that was taken by the fire front to cross from a line to another where recorded. Knowing the distances d_k of the fire line position at a set of times t_k (k=1…n), we can determine the average ROS of the fire by calculating the slope of the linear fitting between the two data sets. (Fig. 2)

Fig. 1 The table where the tests were performed and the lines are appearing over the fuel bed

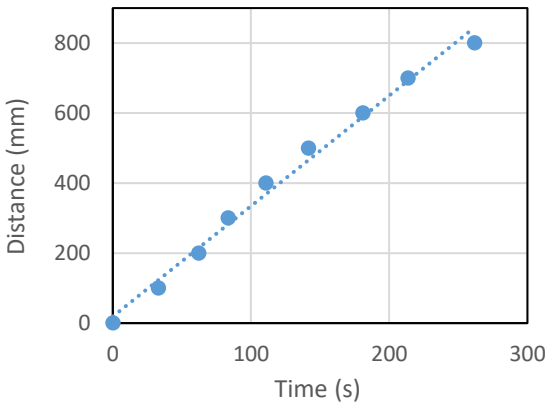

Fig. 2 The linear fitting between the distance and time data sets, where the slope of it is the fire ROS. Data is for test A

The Program Measurements

The fire where recorded with an IR camera, then several frames where acquired from the recording with a time lap between them of 30 s. The camera where calibrated following the same mentioned methodology in the Fire ROS Calculator Manual. The three tests have different calibrations where their parameters are stated in Table1.

Table1. Calibration parameters for the performed tests

Test	Camera Position	Table Position	Calibration Object
A	position 1	position 1	2×1m with 25 cm square size
B	position 1	position 2	2×1m with 25 cm square size
C	position 2	position 3	0.45×0.9m with 15 cm square size

The camera position 1 is random position at about 8 m high from the table, position 2 is also a random position at about 4 m high from the table (Fig. 4). This height is due to the camera zoom. The table position 1,2 and 3 are just random positions on the area under the camera. This randomness is added to evaluate the difference in errors with changing the calibration parameters.

On the analysis, the ROS of the fire where calculated using the "Average ROS" option where a three line where placed over the fire propagation map as shown on Fig. 3. The ROS is calculated along each of the three lines with same methodology of the linear fitting between the distance and time data sets.

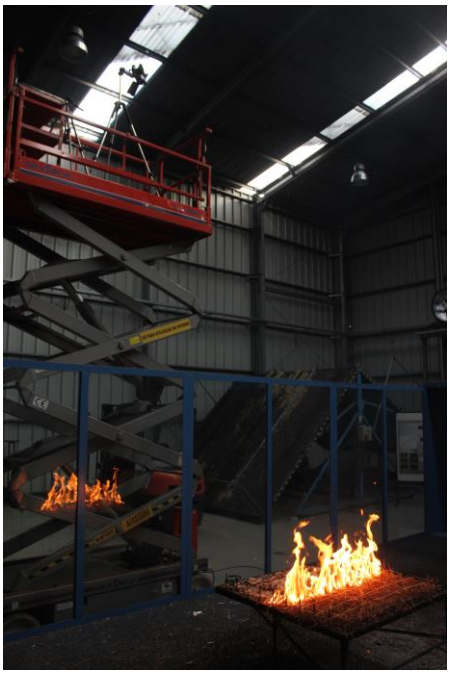

Fig. 4 position 2 of the IR camera placed over the red leather and ongoing test C over the table placed in position 3

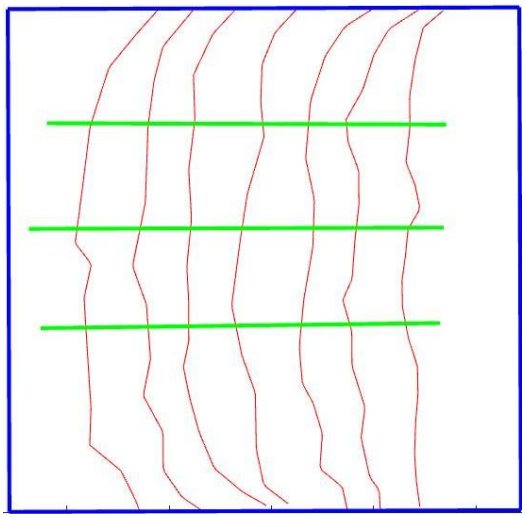

Fig. 3 the position of the three lines where the ROS was calculated along them for test C

Results

In Table2, the results of the calculated ROS along each line and for each test is presented along with the measured ROS reference and the error on each program results. The average of the values from the three lines is calculated also to represent the general average of the ROS that the fire traveled with along the table.

Table2. The ROS values form the reference measurement and the program measurements along with the errors

Test	**Test A**		**Test B**		**Test C**	
Reference ROS (mm/s)	3.15		3.61		3.64	
Quantity	ROS (mm/s)	Error (%)	ROS (mm/s)	Error (%)	ROS (mm/s)	Error (%)
Line 1	3.24	2.86	3.53	2.23	3.62	0.36
Line 2	3.29	4.36	3.60	0.27	3.48	4.24
Line 3	3.24	2.72	3.77	4.65	3.49	4.15
Average	3.26	3.31	3.63	0.72	3.53	2.92

The presented errors on Table2 are combination between two errors, the human error during measuring the reference value of the ROS as calculating the time have been made manually and of course the error from the calibration process.

Conclusion

From the presented results, we can assume an error margin of ±5% in the program results, as in all the calculated errors, the value didn't exceed that number. However, it's recommended to use several adjusted lines for purpose of calculating the average ROS along a direction since we saw from the results that it can reduce the error and give better presentation of the average ROS of the fire. Also, we recommend to use the option "Check Calibration Accuracy" on the program, where the user can determine the error on his results for each calibration the will be performed.