Fire ROS Calculator

Verification Package

v. 2.0

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Introduction

This verification package for the Fire ROS Calculator is based on comparing the resultant average fire rate of spread (ROS) from the program to a reference measurement and calculating the error. We have used the ROS quantity to do this verification as it's the main output from the program and it verifies the accuracy of the calculated real-world distances. In the following we will present the methodology and then the results.

Methodology

To validate the program, three experiments were performed in the Forest Fire Research Laboratory of the University of Coimbra in Lousã (Portugal). A flat table with dimensions of 1m×1m was prepared with a uniform fuel bed composed of dead pine needles (*Pinus Pinaster*) with a load of 0.6 kg.m-2 (dry basis) (Fig. 2). A surface fire that was originated from a line along one of the table's edges was developed in no-wind and no-slope conditions. This consideration was taken to ensure a steady propagation as much as possible, which will exclude the dynamic effects that may develop in the presence of a slope and/or a wind condition, these dynamic effects may vary from experiment to another which is not convenient on our verification.

<u>The Reference Measurements</u>

The reference measurement of the ROS was taken manually. The table is prepared with a set of lines (strings), the lines were spaced by 10 cm from each other. The time that was taken by the fire front to cross from a line to another was recorded. Knowing the distances travelled by the fire line (d_k) during 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. 1), following on this Viegas (2004) [1], which is also the same methodology that's the program is using to calculate the ROS.

Fig. 2 The table where the tests were performed and the lines are appearing over the fuel bed

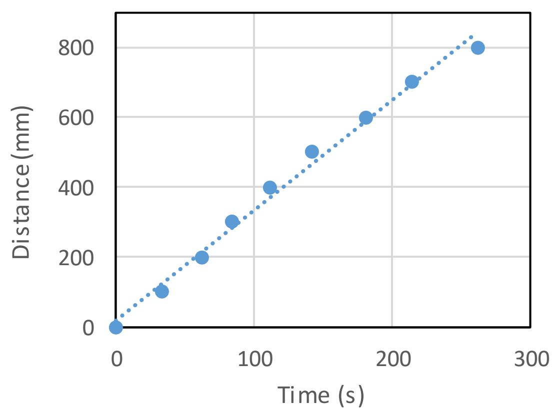

Fig. 1 The linear fitting between the distance and time data sets, where the slope of it is the fire ROS. Data is for test A

The Program's Measurements

The fire was recorded with an IR camera, then several frames were acquired from the recording with a time lap of 30 seconds between them. The camera was calibrated following the same mentioned methodology in the Fire ROS Calculator Manual. The three tests have different calibrations and camera positions as shown in Table1. (i.e. the camera parameters have been computed for each test)

Table1. The performed tests' parameters

Test	Position	Calibration Object
A	8 m altitude from the table (42 mm lens)	2×1m with 25 cm square size
B	4 m altitude from the table (19 mm lens)	2×1m with 25 cm square size
C	4 m altitude from the table (19 mm lens)	0.45×0.9m with 15 cm square size

In this combination of tests, we used two different camera lenses, one with a wide angle zoom and another with a higher zoom. Also, two calibration objects with different sizes were used.

In the analysis, the average ROS of the fire was calculated using the "Calculate Average ROS" option in the program. To calculate the average ROS, three lines were considered and they are placed as shown on Fig. 4. To determine the location of the fire front, the Manual fire front detection option was used. However, the Automatic detection was considered also for test C.

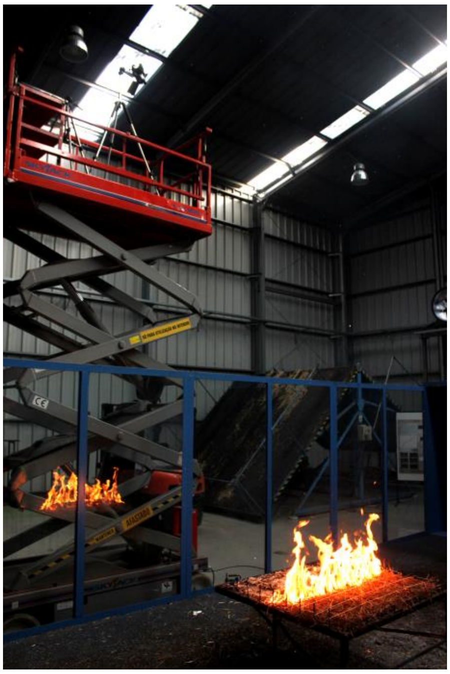

Fig. 3 Image taken during one of the tests showing the camera placed over the red platform. The Image is from test C

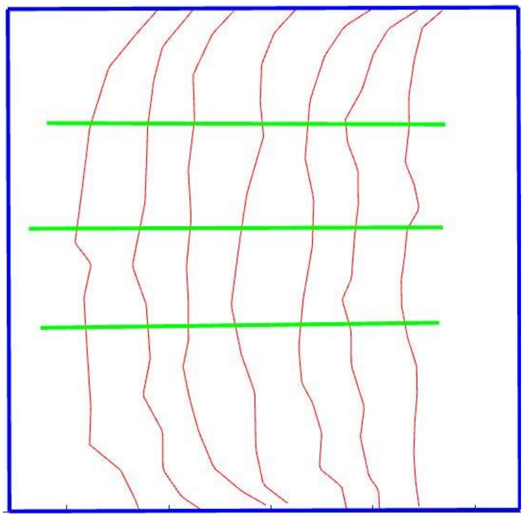

Fig. 4 the position of the three lines where the ROS was calculated along them for test C

Results

In Table2, the results of the calculated ROS along each line and for each test are presented along with the reference ROS (the measured one). The error on each result is presented also. The average of the ROS values from the three lines is calculated also to describe the overall ROS that the fire has traveled with over the table, the comparison between this average value and the measured ROS is more accurate in dead as the measure ROS is describing also the overall ROS and not the ROS along a specific line. The Automatic Detection result for Test C is reported also.

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

Test	Test A		Test B		Test C		Test C (Auto Detection)	
Reference ROS (mm/s)	3.15		3.61		3.64		3.64	
Quantity	ROS (mm/s)	Error (%)	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	3.57	1.91
Line 2	3.29	4.36	3.60	0.27	3.48	4.24	3.46	4.94
Line 3	3.24	2.72	3.77	4.65	3.49	4.15	3.58	1.71
Average	3.26	3.31	3.63	0.72	3.53	2.92	3.54	2.85

The presented errors on Table2 are combined errors, which are 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 and the fire front detection. We can notice from the reported results for the auto fire front detection for test C, that the average error is almost the same. However, we can't deduce from these results that the auto detection is changing the accuracy compared to the manual detection because the lines where the ROS's were calculated along weren't placed exactly on the same positions. In Fig 5, the auto detection of the fire front is demonstrated for the frames of test C.

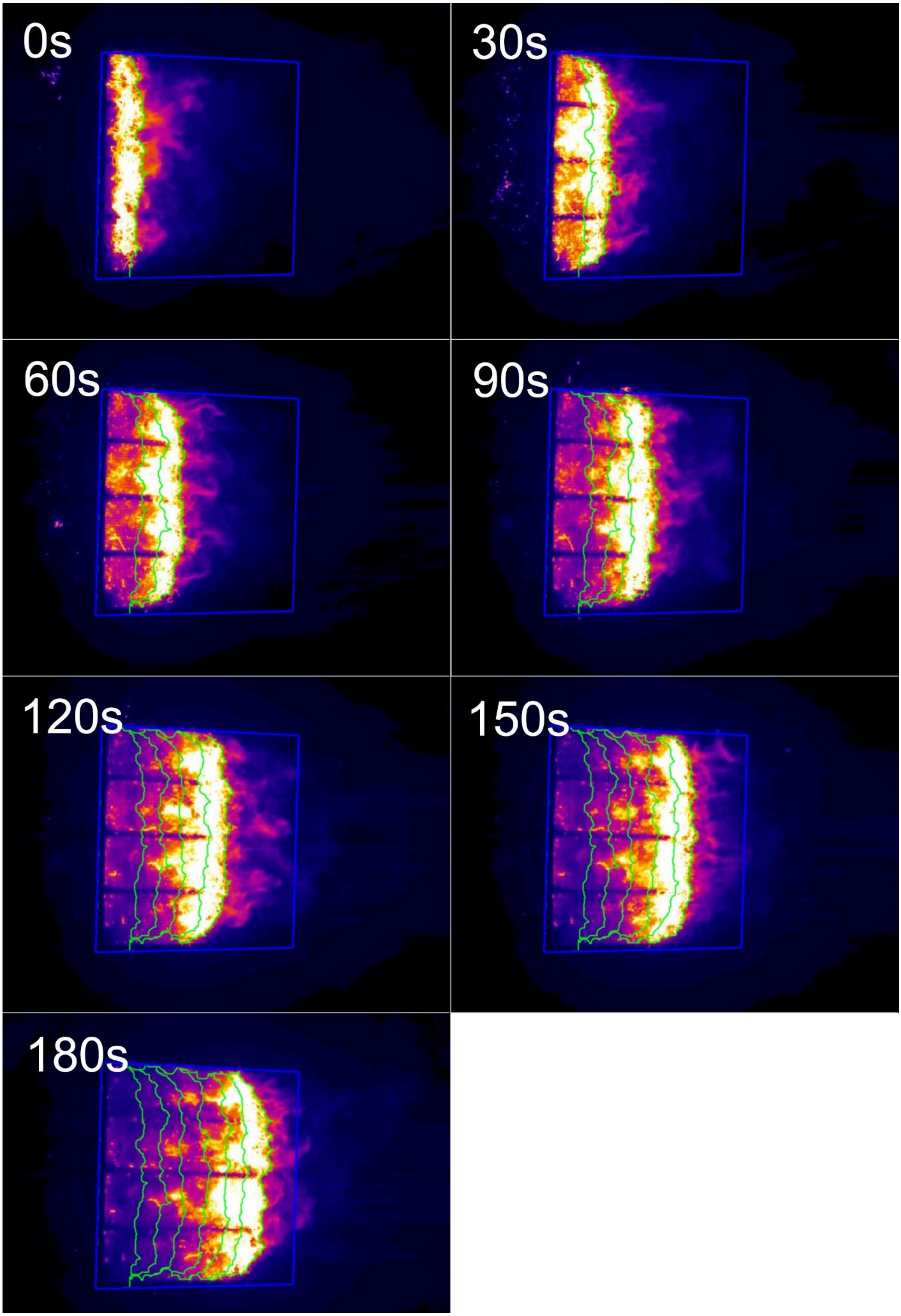

Fig. 5 Sequence of Images showing the program's automatic detection of the fire front for test C, the used detection sensitivity was 0.6.

Conclusion

From the presented results, we can determine an error margin of ±5% for the program's results, where all the calculated errors in this verification package didn't exceed that number. However, it's recommended to use several adjusted lines for calculating the average ROS on some direction as it gives better definition for average ROS on that direction. Also, we recommend to check the accuracy on the produced results using the "Check Accuracy" option. The user may try to reanalyze Test C where its frames and Surface Reference Image is available on the GitHub repository.

References

[1] Viegas, Domingos X. (2004). "Slope and Wind Effects on Fire Propagation." International Journal of Wildland Fire 13 (2): 143–56. doi:10.1071/WF03046.