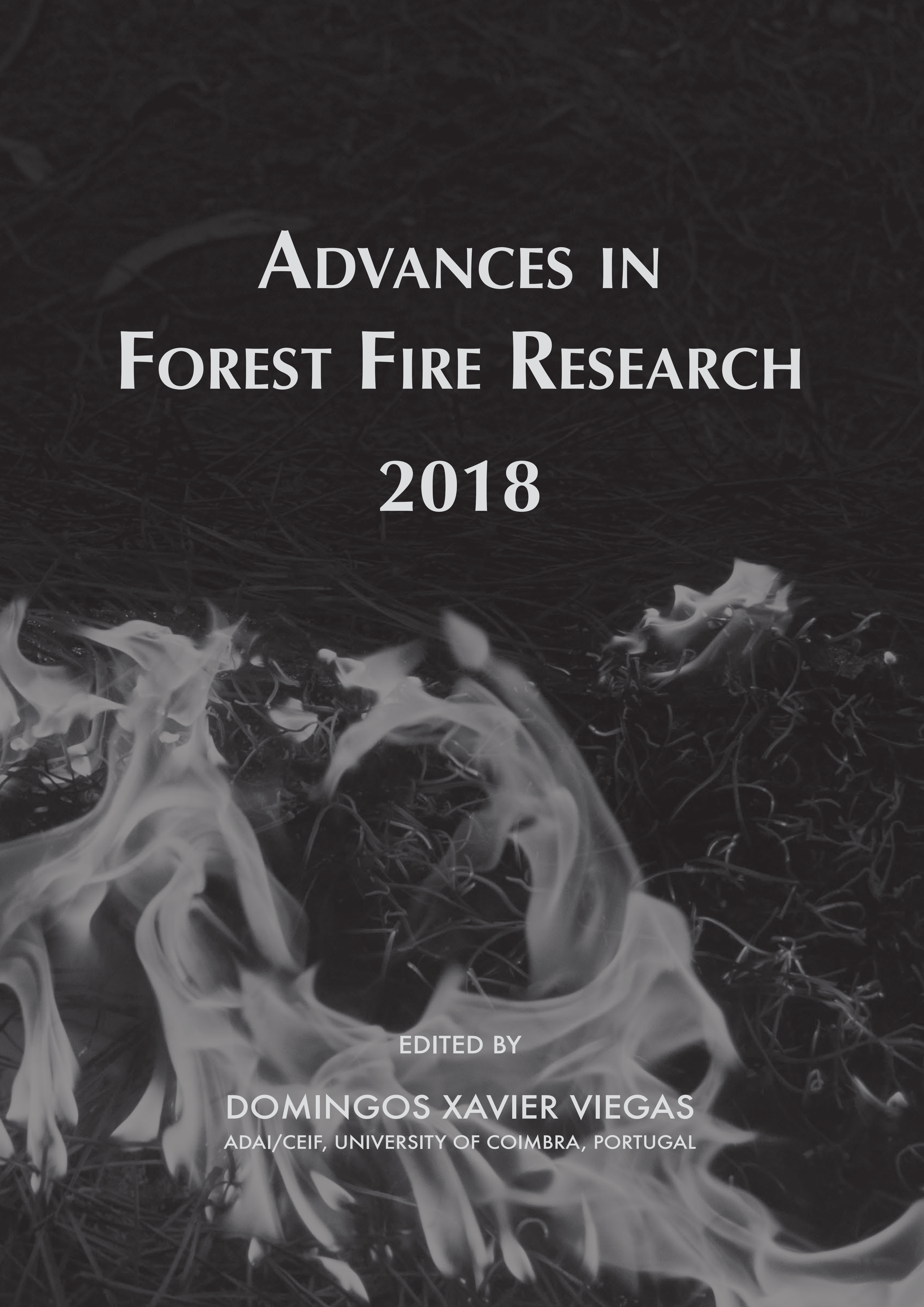

Advances in Forest Fire Research 2018

EDITED BY

DOMINGOS XAVIER VIEGAS
ADAI/CEIF, UNIVERSITY OF COIMBRA, PORTUGAL

https://doi.org/10.14195/978-989-26-16-506_184

Short contribution – Decision Support Systems and Tools

Management of an infrared imaging system for wildfire monitoring

Christian Mata*; Mario M. Valero[1], Elsa Pastor, Eulàlia Planas
Center for Technological Risk Studies, Universitat Politècnica de Catalunya – BarcelonaTech. c/Eduard Maristany, 10-14(EEBE),08019 Barcelona, Spain, {christian.mata@upc.edu}*

Abstract

In this work, we present our system architecture developed to manage and pre- and post-process TIR (thermal infrared) imagery for wildfire applications. It is mainly composed of an acquisition module, a pre-processing unit and a GUI graphical interface for post-processing analysis. Specific data-acquisition software was developed to overcome the limitations of the applications provided by camera manufacturers. This data acquisition module was complemented with a pre-processing unit to deal with those videos already recorded using manufacturers' software. This pre-processing unit converts stored IR raw files (which are unreadable) into a standard format that allows an overall thermal analysis. Our system can handle video formats used by two of the most important IR camera providers, i.e. Optris and FLIR. Finally, a graphical interface application provides the user with a user-friendly menu to detect fire edge position at desired time steps (i.e. automated perimeter tracking), to calculate rate of spread maps and interact with the data-driven forecasting module. This system makes two important contributions. First, it constitutes a common framework that ensures coherence in the treatment of IR data, no matter how it was obtained. Additionally, it incorporates the image processing algorithms in which we have been working for the past years, making them easy-to-use and facilitating the analysis of their results.

Keywords: infrared imaging system, GUI graphical interface, wildfire monitoring

1. Introduction

Technological innovations are being increasingly developed in recent years by the wildfire research community to provide managers with fire monitoring and simulation tools. During the past five years, we have been developing an integrated system for tactical monitoring and data-driven spread forecasting, with the aim of making available an affordable and fully automated tool for tactical wildfire decision-making. Infrared imagery- based fire edge detection and inverse modelling short-term fire spread prediction algorithms have already been published elsewhere (Rios et al. 2016, Valero et al, 2017, Rios et al., 2018 and Valero et al, 2018). Those are the core elements composing our system, envisaged to couple meaningful automated wildfire monitoring with accurate fire spread forecasting.

Concretely, we can summarize the purpose conducted along two different lines. Firstly, the fire spread simulator published in (Rios et al. 2014, Rios et al. 2016). Secondly, the observed isochrones needed for calibration, which had been provided manually, can now be detected automatically using thermal aerial infrared (TIR) imaging and the algorithms presented in (Valero et al. 2017b, Valero et al. 2018). In this sense, the fact of using TIR imagery as the only source of optical data reduces the system complexity, weight and cost in comparison with hyperspectral imagers. However, an acquisition system and pre-processing stage with a high quality management is required in order to perform the post-processing analysis.

In this work, a system architecture developed to acquire, manage and pre- and post-process TIR imagery is presented. An acquisition module, a pre-processing unit and a GUI graphical interface for post-processing analysis mainly compose this architecture. The importance to record and store IR raw files (e.g. .RAVI) are input in the pre-processing unit. Specific software has been developed and implemented to convert these original (and unreadable) data into a standard format that allows an overall thermal analysis. Finally, a graphical interface application provides the user with a user-friendly menu to detect fire edge position at desired time steps (i.e. automated perimeter tracking), to calculate rate of spread maps and interact with the data-driven forecasting module.

2. Management of the Infrared Imaging System Architecture

2.1. Acquisition

Data acquisition hardware consists in an affordable computer programmed to obtain IR data from an IR camera. Specific software was developed to acquire IR data from Optris cameras. Optris produces some of the smallest and most affordable IR cameras available at present, but their software is totally opaque and it has critical limitations. The main idea is to develop a generic software to be adapted tom other common IR imaging systems. An overview of data management in the image acquisition and pre-processing module is depicted in Figure 1. The data acquisition module is defined as following: acquisition device, camera control platform, supported operating systems and export data system (using different data formats).

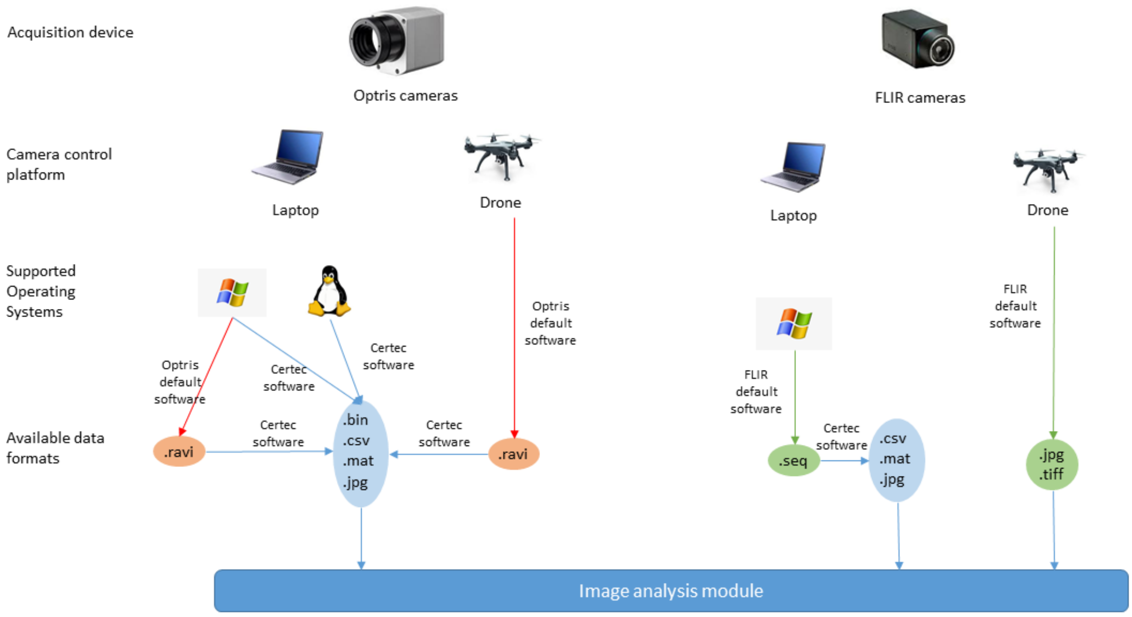

Figure 1 - Overview of data management in the image acquisition and pre-processing module

One of the advantages of this acquisition system is the integration of different IR cameras such as Optris PI and FLIR into the software. Furthermore, this software could be adapted to other cameras if needed in the future. The fact of using TIR imagery as the only source of optical data reduces the system complexity, weight and cost in comparison with other commercial systems. Moreover, this software was implemented in different versions depending of the supported operating systems such as Microsoft and Linux products. After the acquisition, the main problematic step is to export the record data into an easy format to be post-processed.

2.2. Pre-processing Management

CERTEC software was implemented in order to convert recorded video into a readable format for the image analysis module. As can be seen in Figure 1, *.RAVI* is the format extension used for the Optris PI camera and *.SEQ* is the specific format for the FLIR cameras. All the recorded files using the Optris PI camera are stored in IR raw files. In this case, the IR camera uses a specific format such as *.RAVI* extension. These files has the inconvenient that should open them using the software provided for the same company called PI-Connect. Then, it exists limited options to extract the data in other formats but should be manually performed and it is not useful for a long records.

For this reason, specific software has been developed and implemented to convert these original (and unreadable) data into a standard format that allows an overall thermal analysis. This application was implemented using libirimager library. This library grants you access to all cameras featured in the Optris PI series. In order to obtain a human-interpretable representation, the SDK supports several conversion functions. This developer library enables your software team to process a camera's data stream with C/C++.

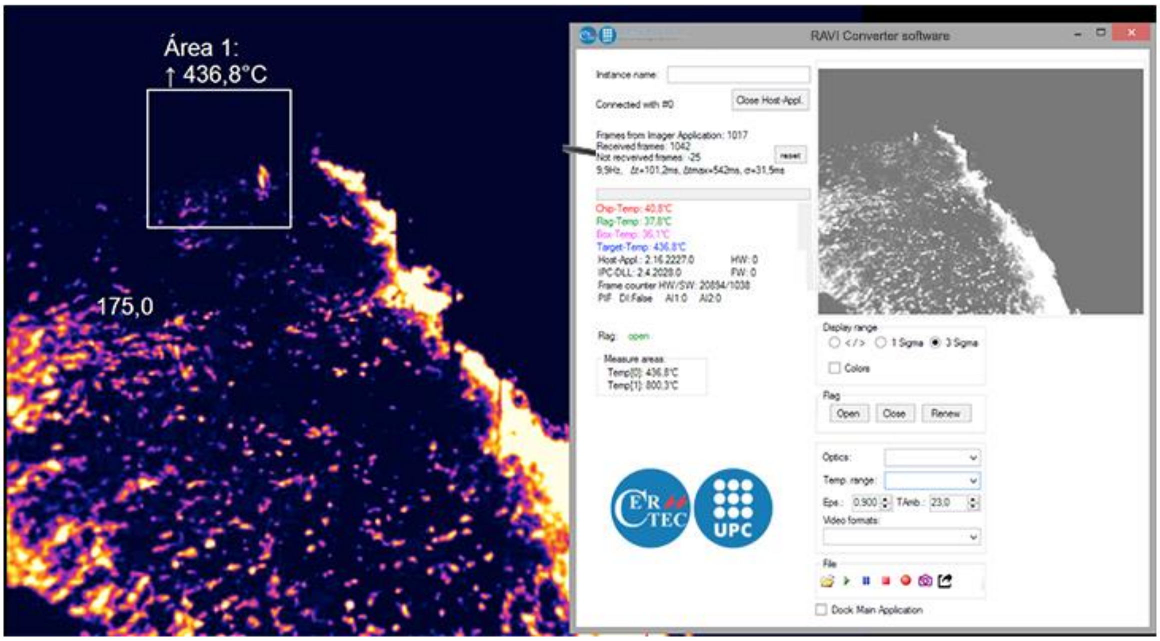

Figure 2 - Sample screenshot of the video format converter developed for Optris .RAVI files

One of the advantages of this library is the representation of the IR data with different colouring palettes so that the user can get a false colour representation of their data takes. Figure 2 depicts an example of the implemented graphical interface that allows loading a thermal record, visualizing it and using different options to extract into your workspace all the frames (thermal images), and information related with the image such as frame time, geo-reference position, etc. Notice that this software was implemented in Windows environment integrated in an EXE file, then it is not necessary a previous installation neither an additional library packages.

2.3. Post-processing analysis

The importance to acquire thermal data from a robust system for a post-processing analysis was the main objective of this work. According to this analysis, the proposed system architecture and pre-processing management were designed. We also incorporated our previous work on the coupling of remote sensing data with fire spread simulation (Valero et al. 2017a). Figure 3 displays sample screenshots of the graphical user interface and their knowledge distribution. The methodology proved able to automatically detect the location of the fire perimeter and emit a reliable forecast of its future evolution. It is based on edge detection algorithms applied to TIR aerial imagery and data assimilation techniques, fire rates of spread being computed through an on-line-adjustable Rothermel model.

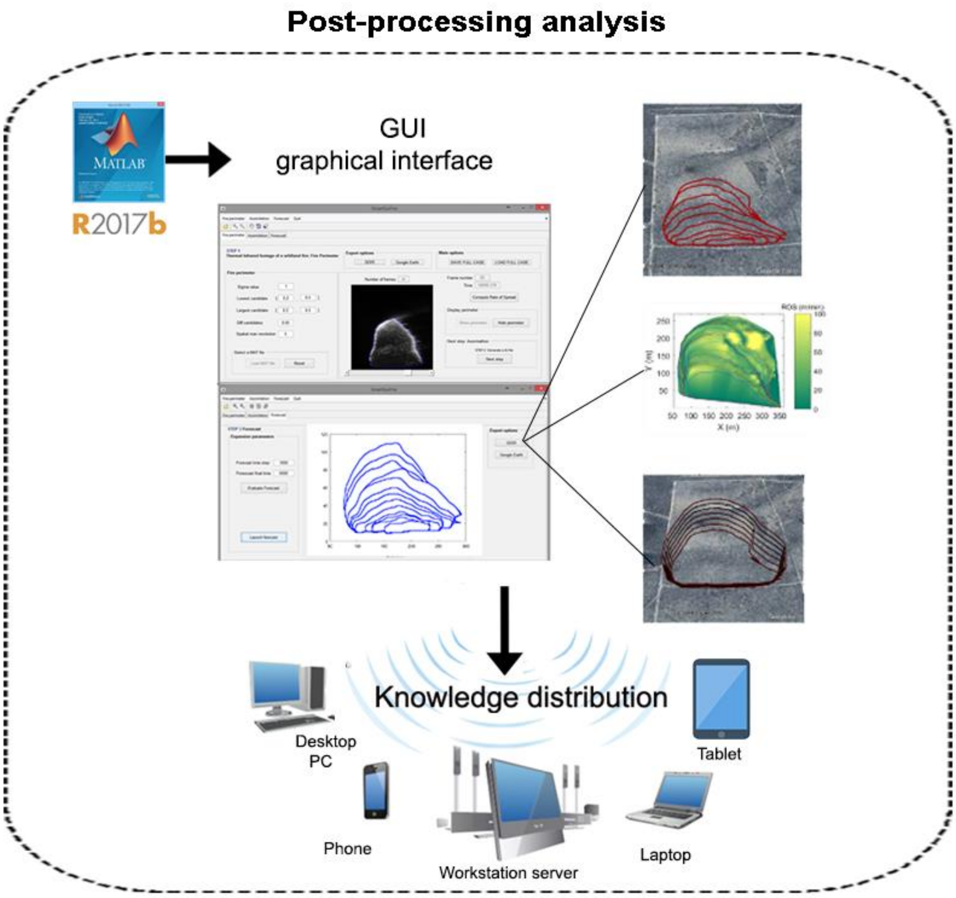

Figure 3 - Benchmark design of the proposed architecture system. Three different tasks are described in this architecture within the scope of this work

3. Conclusions

We hereby presented the management of an infrared imaging system for wildfire monitoring. One of the important advantages of this management is the contribution to develop a suitable system architecture promoting a decision support system for a wildfire emergency. Firstly, an acquisition task of the benchmark design of the proposed architecture system was detailed. It is adaptable to IR imagery of different formats and sources and it can be coupled with different pre- and post-processing modules.

This architecture is easily adaptable to other low cost IR monitoring cameras and to our knowledge is the most cost-effective solution for wildfire monitoring. According to a specific format of the infrared camera used, a pre-processing software is also presented in order to export thermal sources. In case that uses want to use another camera, it should be implemented a new pre-processing software according to their features.

Finally, the post-processing task allows an easy analysis of the IR data, facilitating the extraction of fire information.

4. Acknowledgements

This research was partially funded by the Spanish Ministry of Economy and Competitiveness (project CTM2014-57448-R and, CTQ2017-85990-R, co-financed with FEDER funds).

5. References

Rios O, Jahn W, Rein G (2014). Forecasting wind-driven wildfires using an inverse modelling approach, Nat. Hazards Earth Syst. Sci. **14**, 1491-1503.doi: 10.5194/nhess-14–1491.

Rios O, Pastor E, Valero MM, Planas E (2016). Short-term fire front spread prediction using inverse modelling and airborne infrared images. *International Journal of Wildland Fire* **25**, 1033–1047.

Valero MM, Rios O, Mata C, Pastor E, Planas E (2017a). An integrated approach for tactical monitoring and data-driven spread forecasting of wildfires. Fire Safety Journal 91, 835-844. doi: 10.1016/j.firesaf.2017.03.085.

Valero MM, Verstockt S, Rios, O, Pastor, E, Vandecasteele, F., Planas, E (2017b). Flame filtering and perimeter localization of wildfires using aerial thermal imagery, in: Proc. SPIE 10214. Thermosense: Thermal Infrared Applications XXXIX. https://doi.org/10.1117/12.2262100

Rios, O., Jahn, W., Pastor, E., Valero, M.M., Planas, E., 2018. Interpolation framework to speed up near-surface wind simulations for data-driven wildfire applications. Int. J. Wildl. Fire 27, 257–270. https://doi.org/10.1071/WF17027

Valero MM, Rios O, Pastor E, Planas E. (2018). Automated location of active fire perimeters in aerial infrared imaging using unsupervised edge detectors. Int. J. Wildl. Fire 27, 241–256. https://doi.org/10.1071/WF17093.