The FireLoc System - Geolocating Forest Fires with Crowdsourced Data

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Abstract

The FireLoc system aims to allow the reporting of forest fires observed by citizens using a dedicated app developed for mobile devices. The collected data includes the observer's geolocation, a photograph of the observed event, and the orientation of the observer towards the fire. These data are integrated into the FireLoc system, which also includes other types of georeferenced data about the terrain, including, e.g., land cover and slope information. The system processes the collected data and identifies the geolocation of the observed events in near real-time. This may enable a fast geolocation of fire events and also assist in monitoring the progress of the fire. This short paper briefly describes the FireLoc System that comprises three components: 1) a data collection component developed for mobile platforms; 2) a data integration and processing component, in charge of processing the collected data and assessing the most probable location of the fire event considering the reliability of the contributed data; and 3) a component for providing information to relevant institutions and the general public, which is developed for both mobile and desktop platforms and allows to monitor the progress of the reported events.

1. Introduction

Due to climatic changes and human intervention in the environment, the frequency and severity of forest fires are increasing in several regions, a phenomena that is likely to increase even further in the next few years (e.g., Cleetus & Mulik, 2014). As these events may become uncontrollable over the right atmospheric, land cover and topographic conditions (e.g., Liu et al., 2015; Viegas, 2012; Rossa, 2015), as occurred in Portugal in 2017, it is very important to be able to geolocate ignitions as soon as possible. Several types of systems are used for this purpose, including human observers at observation towers or complex systems using digital cameras and Unmanned Aerial Vehicles (UAV). However, these systems have limitations and do not cover all locations. In some cases, they are not able to collect data near the event or, such as the UAV systems, are only able to monitor a relatively limited region and therefore may only be used when a given event has already been detected. On the other hand, many regions include villages and roads crossing forested areas, which means there may be citizens in the proximity that may help to geolocate fires at an early stage by sending data in real time, should a system be available to facilitate those contributions. This is the aim of the FireLoc system (https://fireloc.org), currently under development in the context of a project funded by the Portuguese Foundation for Science and Technology (Fundação para a Ciência e Tecnologia - FCT). This paper briefly describes the components of the FireLoc system, with emphasis on the ones that enable the interaction with users.

Other approaches based on crowdsourced data have been proposed, using, e.g., data extracted from social media (e.g., Al-Salehi et al., 2021; Tavra et al., 2021; Arapostathis & Karantzia, 2019) or dedicated apps, such as the CITISENS project in Greece (Bogdos & Manolakos, 2019). However, the geolocation with data collection from social media has many limitations, including the data and metadata obtained using the available social media

APIs (Fontes et al., 2017). Regarding projects using dedicated apps, to the best of the authors knowledge, none is available for general use. Also, none uses the FireLoc methodology to geolocate the observed events, which is based on the intersection of estimated lines of sight. For example, the CITISENS project uses a methodology that geolocates the events using additional data collected from the smartphone, such as gyroscope and accelerometer data, to identify the observer's line of sight and geolocates the observed fire events by intersecting the estimated line of sight with a Digital Elevation Model. The authors stated that the geolocation estimated following such methodology provided accurate results (Bogdos & Manolakos, 2019), even though it assumes that the observer has a direct line of sight to the fire (i.e., it would not work in case the observer is just seeing a column of smoke). Therefore, it would be interesting, in a subsequent stage, to compare the geolocation accuracy obtained with both approaches and determine if the fusion of both methodologies is able to increase the accuracy of the geolocation of observed events.

2. The FireLoc System

The FireLoc system is composed by three main components that include several modules (Fonte et al., 2021), namely: 1) a data collection component, which includes a mobile app enabling citizens to upload data, and modules to collect other types of geospatial data, such as satellite imagery, meteorological data, or data from the OpenStreetMap project (https://www.openstreetmap.org/); 2) the data processing and validation component, containing a central core module complemented by modules to: a) geolocate the observed events using data uploaded by citizens, b) assess the reliability of citizen contributions and classify the uploaded photographs as showing fire or smoke, and c) estimate the risk associated to the computed location of the observed events and its neighbourhood; 3) the interfaces component, which includes a graphical user interface to be used by end-users, and a back-office interface for system administrators. Further details on the components that enable the interaction with the citizens are given in section 3, for the FireLoc app, and section 4, for the FireLoc portal.

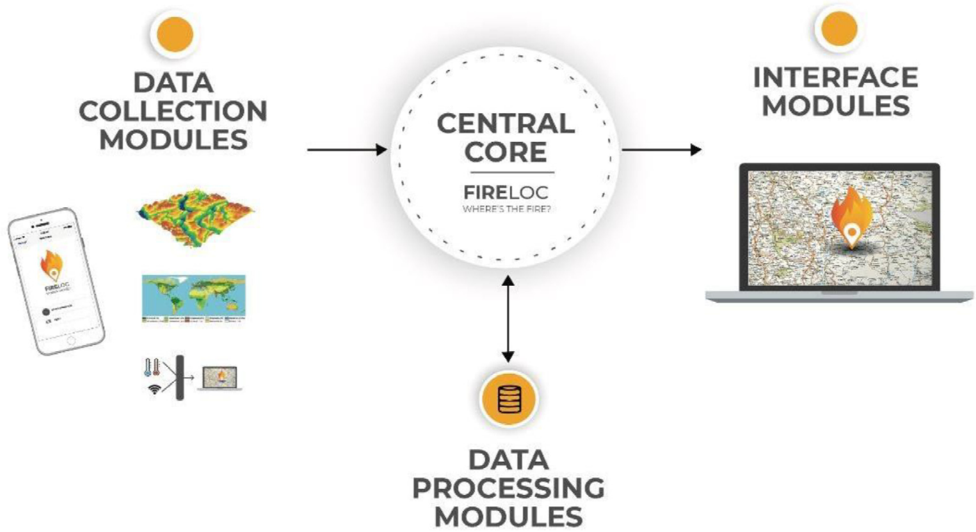

Figure 1- The FireLoc system.

3. The FireLoc app

The FireLoc app was developed to collect the data contributed by citizens. So far it is only available in Portuguese. Figure 2 shows the interfaces of some of the steps related to the data collection process, namely the geolocation, the orientation towards the fire, and the photograph collection steps.

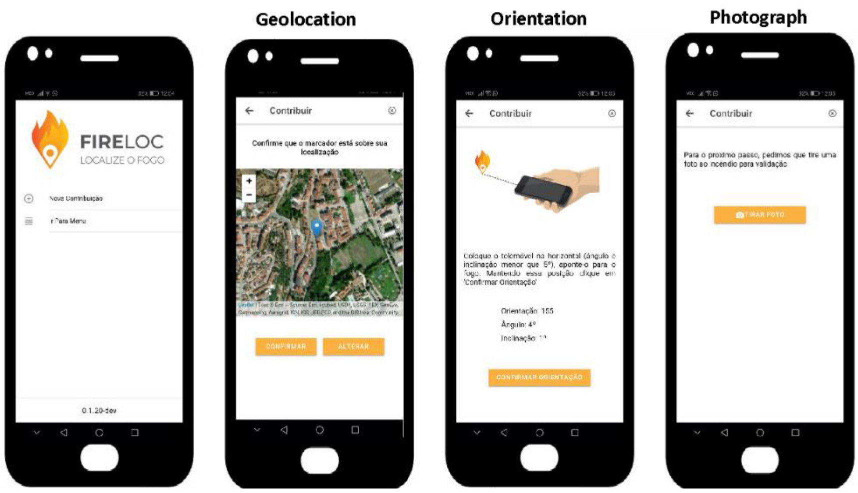

Figure 2- The FireLoc app

Part of the data required by the system are collected automatically by the app using the mobile device sensors when the volunteer starts a contribution, such as the observer geolocation (even though the volunteer may correct it over a map), the date and the time of observation. To collect other necessary data, the volunteer needs to follow a set of steps, indicated by the app, which include:

1. Orientation towards the observed fire and recording of the magnetic azimuth;
2. Orientation towards the fire and taking a photograph of the observed event.

The collection of the above-mentioned data is mandatory, and the contribution can only be uploaded if these steps are followed. However, the volunteer may also upload additional data, which will be useful to assess the quality and validity of the contribution. As in any projects involving citizen participation, a crucial aspect is related to their willingness to contribute. Therefore, there has to be a balance between the data that system administrators would like to collect and the data the volunteers are willing to provide. Due to this constraint, even though potentially useful, the contribution of additional data was considered to be optional at the current version, to avoid overloading the volunteer with too many mandatory steps. These additional data include:

1. Orientation towards the volunteer's shadow and measurement of the magnetic azimuth;
2. Additional geolocation after the volunteer moves backward or forward in the direction of the fire;
3. The indication of the approximate distance to the fire;
4. A short text message with any information the volunteer may consider useful.

The measurement of the magnetic azimuth in the direction of the volunteer's shadow is useful to compare the bearing measured by the mobile device with the known bearing of the shadow at the observation location, date and time. This will provide information about the order of magnitude that can be expected in the orientation measured by the mobile device, which can help avoiding large errors usually associated with the bearings measured by mobile devices (Fonte et al. 2022). The repeated geolocation after the volunteer's movement in the direction of the fire provides additional data to estimate the orientation towards the event. The estimate distance to the fire, even though difficult to provide by a volunteer, may be a useful insight to determine if the fire is in the close proximity of the observer's position (i.e., a few hundreds of metres) or farther away (i.e., several kilometres away). Finally, text messages may provide additional information about, for example, the stage, severity or level of dangerousness of the event.

4. The FireLoc portal

The FireLoc portal (see Figure 3) includes a webpage where information about the project is available, and a Geoportal where several types of data may be visualized (Figure 4). The data available for visualization depends upon the type of user. Four types of users were considered:

1. Common users, not registered in the system;
2. Registered users with the “volunteer profile”;
3. Registered users with privileged permissions (e.g., civil protection agents or firefighters)
4. System administrators.

Among the data available for visualization are:

- The events geolocation and evolution identified with the data provided by the citizens, within a specific interval of time or a selected region. When the user has the required permissions, these may be visualized in real time, or only in the aftermath of the event;
- Citizen contributions (different data are available depending on the type of user);
- Statistical analyses and graphs about the reported events and contributions;
- Several types of ancillary geospatial data, including land-use/land-cover maps, digital elevation models, slope maps, cartography of built-up areas, or maps of the burnt areas obtained, e.g., from satellite imagery classification.

Data available in the portal may be used in real-time to geolocate events reported by citizens. The analysis of these data may help to geolocate the event and provide a better insight about the fire, e.g., through the observation of collected photographs, which may offer useful details about the event to decision makers (e.g., the dimension or spread at the time of the contribution, or the characteristics of the landscape). Other geospatial datasets available in the system may provide additional useful information, such as the proximity to inhabited areas or the regions vulnerability to fire propagation.

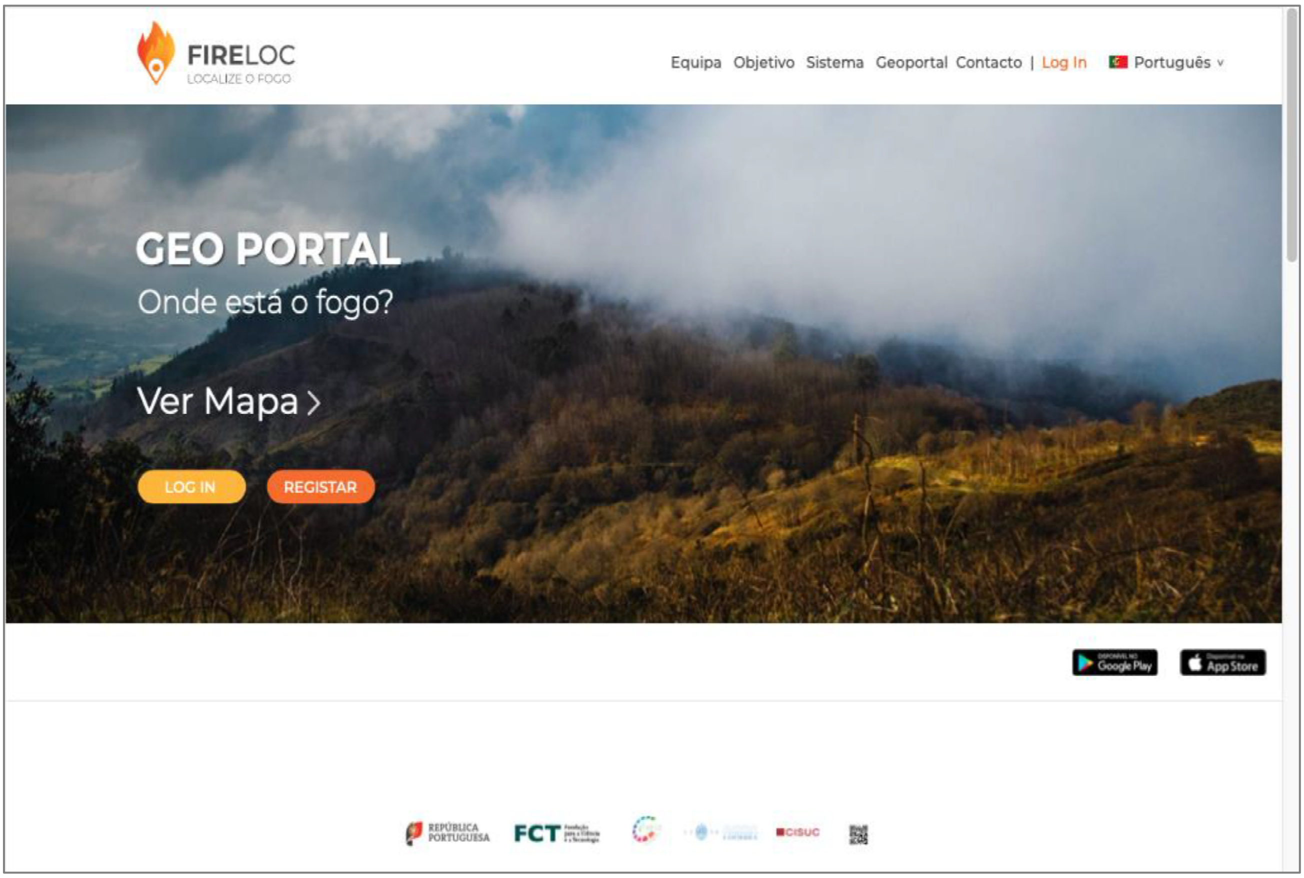

Figure 3- The FireLoc portal initial page.

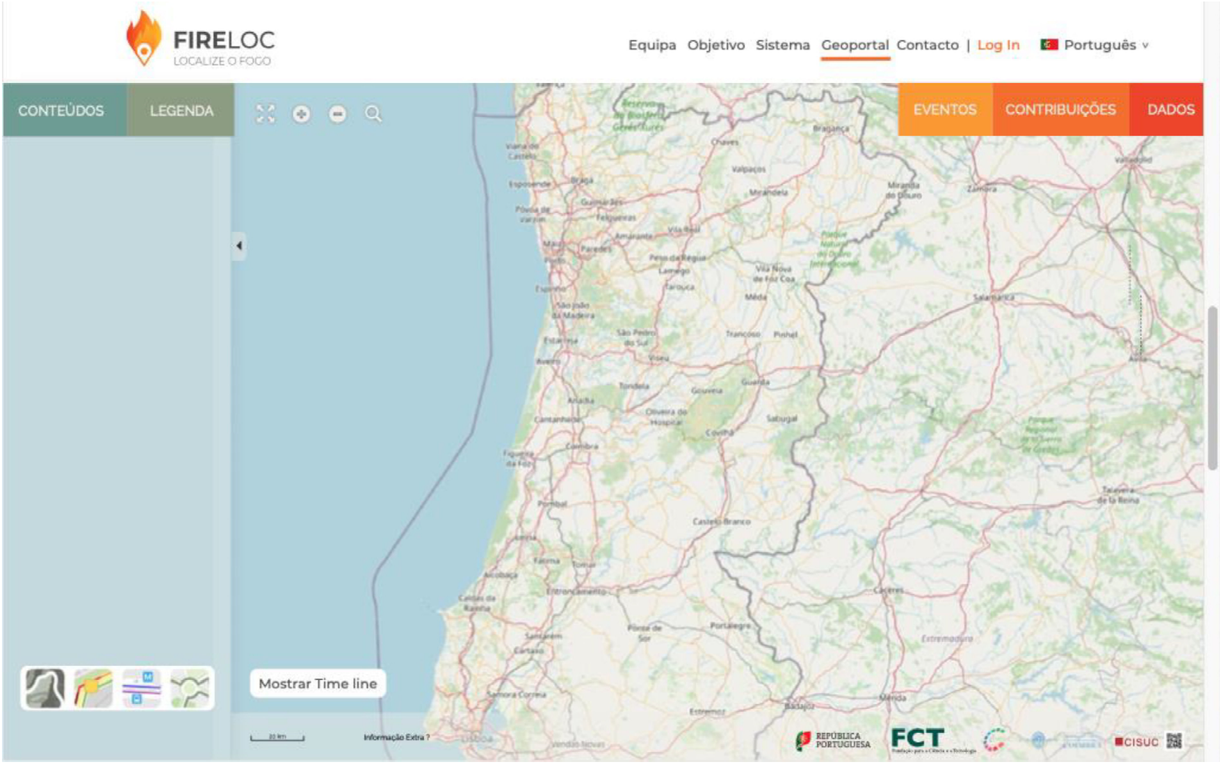

Figure 4- The FireLoc geoportal.

5. Conclusions

The FireLoc system will enable the collection of geospatial data provided by citizens that may assist in fire detection and monitoring. The uploaded photographs will enable the early visualization of the event by authorities, which proved to be crucial in previous experiments (Albuquerque et al. 2016). The geolocation of both the observer and the event may provide key information, especially in cases where reported events are not spotted by official personnel in observation towers or more complex systems, but only through a phone call to the emergency number 112 (where the geolocation of the event is made only based on the observer's oral description). Moreover, the processing of the collected data will provide additional information about the fires, that may be very useful both in real time analysis but also when analysing past events.

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