ElectroCap Project Proposal

Forest Fires Detection

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1. Advisors and Mentor

- Scientific Advisor: Luís Correia
- Scientific Co-advisor: João Felício
- Coordinator:
- Mentor:

2. Problem definition

One of the challenges in forest fire detection is the inability to detect them quickly and safely. This incapacity can lead to a rapid spread of fire in certain remote areas, resulting in a delayed immediate response and potentially causing damage of significant proportions. There are several factors that can impede the development of a viable solution to this problem, such as the need for effective detection over large forested areas, which hinders the use of traditional methods like smoke detectors, and the lack of widespread pursuit for a potential solution.

3. Solution beneficiaries

Primarily, it would be more accessible to alert local communities as they would benefit from swift detection, enabling a prompt and effective response to contain initial fires, thereby minimizing environmental damage and protecting properties. Additionally, firefighters and rescue teams would directly benefit as they would have real-time information about the location and extent of the fire, enhancing the safety and efficiency of firefighting operations. Biodiversity preservation would also be favored, as early detection would reduce negative impacts on natural ecosystems, allowing for more targeted intervention and minimizing habitat destruction.

4. Technological solution

We propose a solution that involves a drone equipped with an integrated thermal camera, which will be operated by trained authorities, such as forest rangers or firefighters. The thermal camera, upon detecting an area of excessive heat, indicating a fire or an area at high risk of fire, will emit an alert to notify the relevant authorities (firefighters and civil protection), enabling a swift and more effective response. This solution addresses certain limitations, as it does not necessitate a significant financial effort for implementation—only the investment in drones and training for operators. Moreover, the capability of a drone to cover a large forested area means that a substantial number of devices are not required for a given forest.

5. Competitors and previous work

Competitors have high-resolution thermal cameras (in one case capable of accurately identifying and locating a fire within a radius of 5km with the accuracy of a 2m^2 fire), dual camera systems, offer various colorizations for the image, among other proposals. It's important to note that the (advertised) prices for this equipment are high.

We want to stand out from the competition by integrating sensors that measure certain parameters that influence the risk of fire; in this case, temperature and relative humidity. Above certain values, the combination of these three factors makes the risk of fire high (temperature above 30ºC, relative humidity below 30% and wind speed above 30km/h).

5. Competitors and previous work

MOBOTIX - https://www.mobotix.com/en/m73-thermal

Teledyne FLIR - https://www.flir.com/products/a500f_a700f-environmental-housing-camera/?vertical=rd%20science&segment=solutions

AXIS Communication - https://www.axis.com/products/axis-q19-series

Inteccon - https://inteccon.com/pt/monitoramento-da-qualidade-do-ar/cameras-de-deteccao-de-incendios-florestais/

ACRE - https://grupoacre.com.pt/es/catalogo-categoria/camaras-termograficas-para-drones/

6. Solution requirements

To apply our proposed solution, we will need software that collects the images from the thermal camera and processes and analyzes them. The images, along with other data such as temperature, will then be transmitted to a receiver. In this receiver, there will be a control responsible for forwarding both the alert message and the image captured by the thermal camera to the display, allowing the operator to distinguish between a fire and a false alarm. With regard to the drone, a long battery life is essential to sustain prolonged periods of surveillance. In terms of usability, an intuitive user interface is required to facilitate remote control, as well as simplifying the configuration and deployment processes. In terms of security, encryption measures will be required for data transmission to protect information, such as secure login and authentication procedures.

7. Technical challenges

Generally speaking, technical requirements are subdivided into the following sectors:

- Data transmission:

Data transmission will be ensured by means of low communication latency wireless protocols, through Wi-Fi, Bluetooth, 4G or 5G networks, Zihbee in the context of a proof of concept or protocols such as LPWAN (Low Power Wide Area Network), communication satellites, proprietary long-range RF systems, point-to-point microwave or terrestrial microwave, wirelessHART and ISA100.11a if we are talking about a more professional realization.

- Simulation materials:

In order to simulate a forest fire, materials will be used whose combustion gives rise to a low-temperature flame, namely ethyl alcohol(ethanol), candles, lighters, propane or butane gas or flame lamps.

7. Technical challenges

- Hardware:

Since the aim of the work is to detect fire, the camera in question must be able to take temperature measurements in a range from -5 ºC to 300 ºC.

The MLX90640 thermal camera module fits the requirements of the project. The camera's resolution is 32 x 24 pixels and it detects temperatures in the range of -40 ºC to 300 ºC with an accuracy of approximately 1 ºC.

In addition to the above, an Arduino board or alternatively a Raspberry Pi will be needed to collect and analyze the information obtained by each of the sensors. In the case of the thermal camera, the temperature value recorded by each pixel will be analyzed to create a criterion that associates the temperature of a given number of pixels with fire.

With regard to data reception, a display will be required to provide visualization of any thermal image captured by the respective camera and the data obtained by the sensors.

7. Technical challenges

- Sensors:

The main source of information will be the thermal image obtained by a thermal camera. In addition, atmospheric temperature and relative humidity sensors and flame sensors will be used to help verify the veracity of fire detection.

The desired temperature and atmosphere sensor reads values from -5ºC to 40ºC for atmospheric temperature and between 0 and 50% for humidity. The model that best fits the conditions imposed is the Grove Temperature and Humidity Sensor Module Pro (AM2302).

As far as flame sensors are concerned, the fact that they are sensitive to infrared radiation makes it possible to detect fire sources at short range. The compatible sensor is the YG100 Flame Sensor, which takes radiation readings in the 760nm - 1100nm range, which coincides with the frequency range of infrared radiation.

8. Partners

In touch with the fire department and companies.

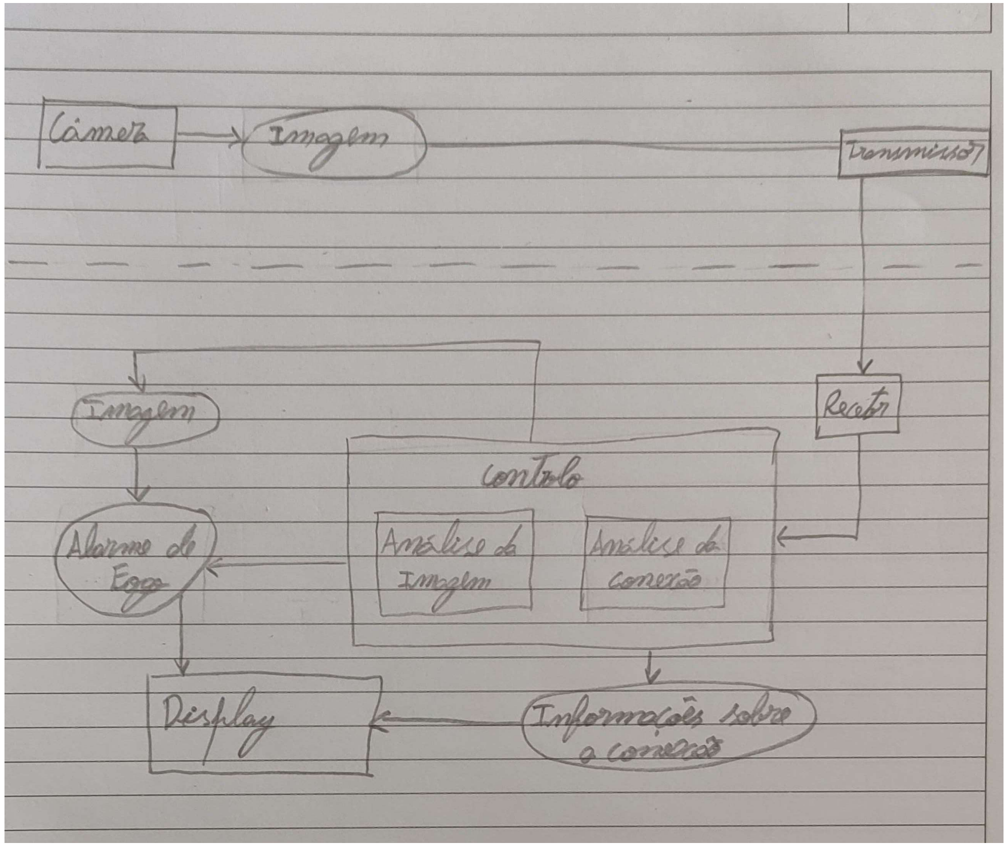
9. Testing and validation metrics

To test and validate the results, we will use a thermal camera and a flame sensor that will be fixed or incorporated into a drone and a temperature and humidity sensor. The distance metrics of the sensors and cameras can only be defined depending on the resolution and range of the sensors and cameras. Measuring the system's accuracy in correctly identifying potential fire areas, which involves comparing the drone's detections with real fire events. Evaluating the rate of false positives (incorrect fire alerts) and false negatives. Measuring the time between the drone's detection of a fire and the transmission of relevant alerts or data to the control center on the ground. A quick response time is essential in emergency situations. Carrying out tests in adverse conditions, such as strong wind, low visibility or extreme temperature variations, which ensures that the system works reliably in different scenarios. Evaluating the effectiveness of the integration of the fire detection system, ensuring fast and accurate communication with the relevant authorities. Ensuring that operators can easily interpret the data provided by the thermal camera.

9. Testing and validation metrics

Evaluate the ease of maintenance of the system, as well as the overall reliability of the system in situations of continuous use. All of this will be possible through our proposed solution to the problem, which consists of a thermal camera that captures images of the surrounding space and uses software to control them. The software will analyze the images, process them and if it detects 10% of the pixels in the thermal camera's resolution with a temperature higher than normal, it will send a notification of a possible fire to the fire station in the area. After this notification, the image that gave rise to it will appear and the firefighter will be able to assess whether it really is a fire or not. If so, the coordinates of the location will be published. Notifications will vary according to the severity or otherwise of the fire outbreak. In addition to the thermal camera, there will be flame sensors which will also send a notification if they detect any kind of flame. Finally, there will be a temperature and humidity sensor to help firefighters more easily detect whether or not the areas covered by the drone and thermal cameras are at high risk of fire. While the drone will only work during the day with the routes already defined, the fixed cameras will work 24 hours a day, which solves the problem of detecting fires at night.

9. Testing and validation metrics



10. Division of labor (I)

André Alves	Catarina Salazar	Inês Coelho
Main role	**Main role**	**Main role**
Escolha da câmara térmica, do sensor de chama e do sensor de temperatura e humidade.	Página Web do Projeto	Página Web do Projeto
Código câmara térmica	Código sensor de chama	Código sensor de chama
Definir e implementar processo de comunicação entre dispositivo e recetor	Código sensor temperatura e humidade	Código sensor temperatura e humidade

11. Division of labor (II)

Inês Martins	José Marques	Pedro Rodrigues
Main role	**Main role**	**Main role**
Página Web do Projeto	Escolha da câmara térmica, do sensor de chama e do sensor de temperatura e humidade	Código câmara térmica
Código sensor de chama	Código câmara térmica	Definir e implementar processo de comunicação entre dispositivo e recetor
Código sensor temperatura e humidade	Definir e implementar processo de comunicação entre dispositivo e recetor	

12. Schedule

22/12-4/01: Página Web do Projeto

23/12-6/01: Definir e implementar processo de comunicação entre dispositivo e recetor

6/01-12/02: Desenvolvimento do código da câmara térmica e dos sensores

12/02-12/03: Prova de conceito e melhorias