Algorithms to Fight Wildfires

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Spain is one of the countries with a large forest cover and also one of the most affected by wildfires. The northwest, region of Galicia in particular, has recorded the most number of fires and burnt surface in recent years.

"Emergency critical missions with manned and unmanned aerial resources in cooperative flight" (Project ENJAMBRE), of the CIEN programme (2014-2018), is one of the research and transfer projects aimed at tackling this problem of wildfires. It is co-financed by the Spanish Centre for the Development of Industrial Technology (CDTI).

Wildfires are included in the priority of protection in emergencies and disasters of the Spanish National Security Strategy, one of the priorities on which ENJAMBRE is focused; with the objective to develop technologies that allow manned aircraft to carry out intervention tasks and unmanned aircraft to undertake the observation tasks, to operate in the same airspace in a cooperative and secure way; to support the decision-making process during the observation tasks and to reduce costs.

ITMATI's main objective is the development of mathematical algorithms to help decision-making in wildfire extinction. The main algorithms in focus are the following: an algorithm for the estimation of wildfire perimeter by applying set estimation techniques to thermal images; an algorithm for collision prevention between the aircrafts that operate in a fire; an algorithm for the calculating escape routes for the brigades working on the extinction, taking into account the orography, vegetation and existing roads; an algorithm for calculating efficiency of water discharges from the aerial resources working in extinction operations; and, an algorithm for management of aerial resources, considering the current regulations for pilots and aircraft.

In the extinction of a forest fire, the use of brigades is an essential element for controlling the fire from the ground. Therefore, it is necessary to maintain good communication and organization between the brigades, so that they face it safely and prevent the fire from surrounding them. The Brigades' Escape Routes Algorithm arises with the objective of calculating an escape route for the evacuation of the brigades working on the ground, in such a way that the brigade always has an exit even in extreme situations in which the probability of being trapped is elevated. For this, it is necessary to calculate a displacement layer by the land for the brigades, based on the slope of the terrain, the existing vegetation, the available roads and the obstacles that the brigade must avoid. The maximum speed of displacement is calculated using the formula proposed by Tobler (1993) and takes into account the values proposed by Wood and Schmidtlein (2011) that reduce the speed depending on the vegetation and the type of road. Once the displacement layer is calculated, the shortest path (the escape route) is computed to go from the brigades' position to the safe zone chosen beforehand, as shown by van Etten (2017).

Another important resource in the extinction of wildfires are aircrafts. The Aerial Resources' Optimization Algorithm's objective is to plan the aerial resources available on

the level of investment resources and intervention needs, minimizing the periods without work and under consideration of the applicable legal regulations (Operational Circular 16-B). For this, an integer linear programming model is proposed based on Rodriguez-Veiga et al. (2018), which minimizes the unfulfillment of intervention needs and ensures fulfillment of legal regulations, expressed as the constraints in the problem.

Keywords: wildfire, escape routes, resources

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