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DRONE APPLICATION FOR PREDICTING FOREST FIRE PROPAGATION

APLICAȚIE CU DRONE PENTRU PREZICEREA PROPAGĂRII INCENDIILOR DE PĂDURE

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Rezumat*. Incendiile de pădure reprezintă o problemă din ce în ce mai gravă. Din cauza schimbărilor climatice, nu doar dimensiunea suprafețelor arse crește de la un an la altul, ci și costurile de stingere a acestora cresc drastic. Dronele, ca ramură a aviației cu cea mai dinamică dezvoltare, pot juca un rol important în stingerea incendiilor de pădure. Acestea pot furniza echipelor de intervenție o varietate de informații care nu pot fi evaluate de la sol. Articolul analizează în detaliu cele mai importante aspecte, precum detectarea timpurie a incendiilor, recunoașterea și monitorizarea intervențiilor, precum și posibilitățile de utilizare a dronelor după stingerea incendiilor.*

Cuvinte-cheie: *dronă, incendiu de pădure, recunoaștere, detectare puncte fierbinți, eficiență*

Introduction

The possibility of using drone in forest fires is mentioned in the recommendations of almost all manufacturers, but barely we find a proposal or example of its specific implementation [1]. One of the obvious reasons for this may be that the manufacturers have never examined or analyzed the details of this application with firefighting experts. The recommendation clearly focuses on aerial reconnaissance, although drones can now do much more than this. The concept of aerial reconnaissance includes active reconnaissance aimed at detecting the fire before the civil report; reconnaissance before the start of firefighting, which assists effective intervention with information; constant monitoring of the development of the fire during the firefighting process; and finding smoldering parts during the post-firefighting work following the extinguishing of the fire, obtaining information to prevent re-ignition [2]. The article presents the above options based on a structural division, focusing on the fire propagation.

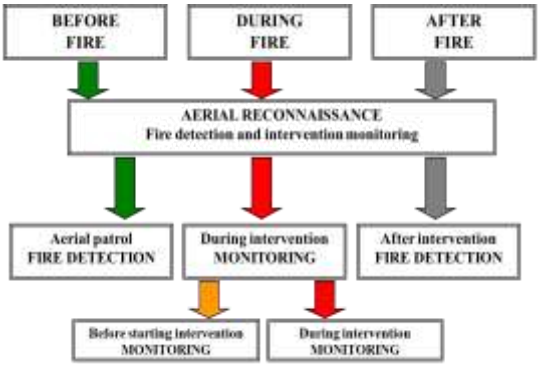


Figure 1. Structural division of drone applications in case of forest fires. Source: author

Aerial patrol for hot spot detection

The logical first option for using drones in forest fires is pre-fire activity, which can be implemented in the form of aerial patrolling [3]. The aim of aerial patrolling is to ensure faster fire detection than spontaneous reporting by individuals. This allows intervention to be started earlier, resulting in faster extinguishing and greater lost value. If aerial patrolling results in faster reporting than citizen reporting, then in absolute terms this method can be considered more efficient. By quickly detecting fires, we can not only start intervention earlier, but we can also learn a lot of other information about the characteristics of the fire. Thus, about the factors influencing their spread, and about the intensity of the fire. The implementation of aerial patrolling with drones is basically the same as the patrolling of classic aircraft with a crew on board. The difference is that instead of the crew on board the aircraft, the detection of fires is carried out by the crew in the monitoring center by monitoring the image transmitted by the camera installed on board the drone. The usefulness of the application should primarily be examined in terms of efficiency. If the increase in the value saved equals or exceeds the costs of aerial patrolling, then this method of detection is also economically efficient. The effectiveness of firefighting without aerial patrolling and with aerial patrolling should be demonstrated in the difference between the damage value and the value saved. If, as a result of the earlier report, the damage decreases to such an extent or the value saved increases to such an extent that at least equals or rather exceeds all the costs of aerial patrolling, then patrolling is also economically advantageous [4].

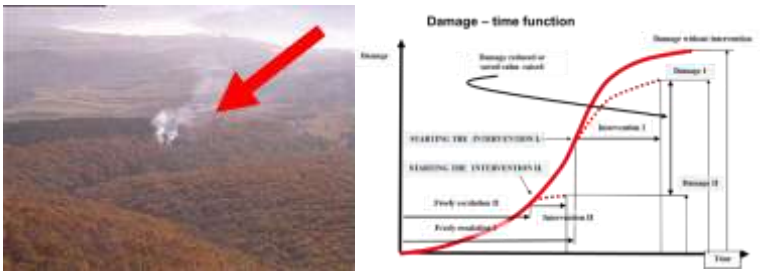


Figure 2. Hot spot detection (left) and the economic aspects of the drone application based on damage-time function (right). Source: author

For the implementation of aerial patrolling, a drone with operating parameters that allow for a few hours of airtime (1-3 hours), medium-altitude flight (1000-6000 m) and long-distance transmission of real-time data (min. 100 km) may be considered. The above definitions are approximate values, they fundamentally depend on the size and characteristics of the area to be monitored (flatland – mountainous area).

Aerial reconnaissance before starting intervention

Before starting firefighting, the most important thing is reconnaissance, which is used to obtain basic information that is essential for the intervention. Any method that can provide assistance in this regard can be considered effective from a professional perspective. Based on the above, the use of drones as a tool enabling aerial reconnaissance can be considered useful from a professional perspective. One of the most important criteria for reconnaissance is quickness [5]. Satisfying the lack of information before deployment as soon as possible helps to make firefighting more effective than the traditional

method – i.e. intervention without the support of drones. This also clearly follows from the analysis of the so-called damage -time function. The condition of rapid application can be considered fulfilled, based on author's own experience, if the drone is able to take off within 5 minutes of arriving at the fire front. Taking into account the time spent on ascent after take off and turning to fire direction, based on the experiments, we can get an evaluable picture of the fire within as quick as 2 minutes. During this time, the firefighter can cover a maximum of 420 meters on foot, which would only be enough to walk around a fire area with a radius of 67 meters. That is, the efficiency of pedestrian reconnaissance could be higher for a fire of this size at most, and in the case of a larger fire (T_{fire}>1.5 ha), the drone can provide information about the entire area faster.

The feasibility of the above requires a drone equipped with a visual and, if necessary, thermal camera, broadcasting the data to the decision-maker in real time. The immediate deployment excludes the possibility of this method of detection being provided as a service by an external body, so the firefighters must provide the application themselves. The latter generates new requirements, which include the training of some firefighters, end-user-friendly design and operation. This can be set as a condition that even one firefighter can operate the drone after it is launched. This can be easily achieved with the drone's autonomous control system (autopilot). Take-off within 5 minutes also dictates the technical requirements. Since the operation and servicing of internal combustion engines (fuel filling, maintenance, etc.) is significantly more complicated, the applicable drive can only be electric. [6]

The basic information necessary to start an effective intervention, the characteristics of the fire spread, must be provided within the shortest possible time. Based on my own experience, it is sufficient for the drone to remain in the air continuously for 15–20 minutes. If a longer flight time is needed, a landing must be made and the flight can be continued with a battery change.

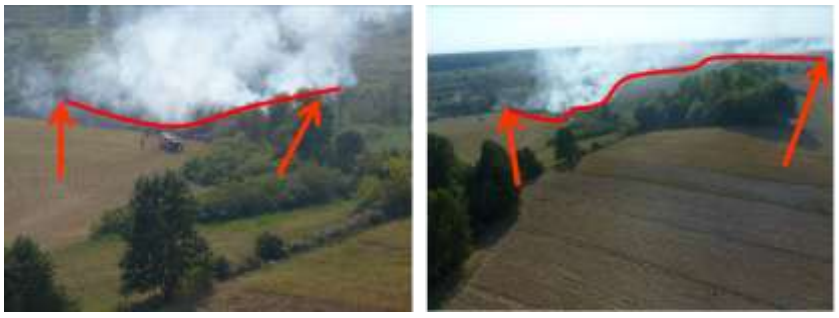


Figure 3. Estimated fire front after arriving to the fire scene without drone supported reconnaissance (left) and with drone supported reconnaissance (right). Source: author

From a firefighting tactical perspective, there are many advantages to using a drone. A number of examples can be presented to assess the objectivity of information related to the propagation of a fire. Topography and terrain conditions, as well as smoke formation and, occasionally, smoke settling in valleys, also limit reconnaissance. The firefighters who are far from each other, so their reports are based on their subjective assessment of their own situation. The information obtained about the propagation of the fire does not give the real picture, the relative proportions of the subjective reports distort it.

By using a drone, the higher altitude and the more favorable angle of view allow us to get a complete picture of the current situation and expected development of the forest fire. [7]

Aerial reconnaissance using a drone can not only be used to assess and judge the static situation, but also provides an accurate determination of the direction and speed of fire spread by conducting route flights at specific intervals. This allows for the appropriate pooling of forces and equipment and the professional, tactically optimal selection of the intervention site. This method of aerial reconnaissance leads to the discussion of its use during the intervention.

Aerial reconnaissance during intervention

Accurate reconnaissance is generally a requirement for professional intervention, but it plays a special role in forest fires. Due to the large extent of the fire, ground response personnel cannot see the entire area, so they are limited in their ability to accurately detect it. One of the fundamental characteristics of forest firefighting is that the burning area continues to grow during the extinguishing process, so the firefighter must take this into account when determining the effective extinguishing technique. In other words, the focus should not only be on the area that is already burning, but also on the parts that are expected to burn out, can be saved, etc. during the extinguishing process. The fire should be treated together with its surroundings [3]. This criterion determines that drone flights should not be carried out over the fire and should not provide close visibility of the fire front line, but should provide a perspective view of the entire area, which can be used to track the change in the fire front line, the change in vegetation, the possibility of access routes, etc.

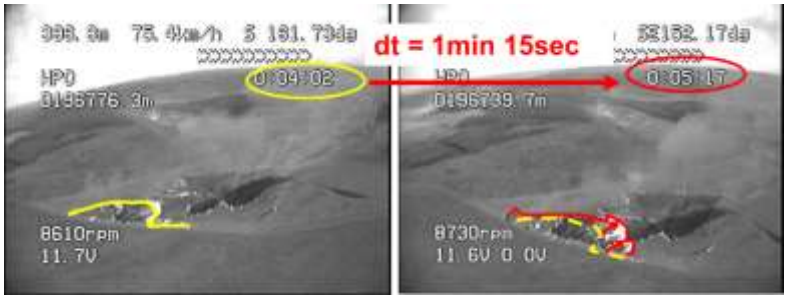


Figure 4. Estimated fire propagation based on drone supported intervention monitoring. Source: author

Based on the practical of aerial reconnaissance [4][5], and my own experience [2], a flight altitude below 500 meters already provides a sufficient view of the area, but even for extensive fires, a range below 1000 meters is sufficient. Drones will be used by first responders, so it is expected that the spread of the fire will still be limited. Therefore, we need to focus on monitoring a small area, which allow the viewing angle to be favorable even below 500 meters. The concentration of forces and equipment is expediently done in order to protect the most endangered objects and to control the most intensively burning areas. However, the intensity of the fire may change significantly over time.

This may be influenced by changes in the type of vegetation, the fire load of the given area, and natural obstacles. Intense spread at a given moment may later slow down and vice versa: the burning of a front line with a low spread may become more intense and its spread faster when it reaches an area with a higher fire load.

The consequence of the above is that effective extinguishing of forest fires requires not only the professional extinguishing of currently burning front lines, but also the selection of extinguishing locations adapted to the front lines expected in the future. Timely extinguishing of fires that are not burning or smoking in a significant area and that are beyond the field of view of ground observers can save the permanent commitment of forces and equipment in the future. New hot spots that form behind the fire line not only increase the number and length of the fire front lines, but if not detected in time, they also pose a threat to the safety of the responding personnel. The images provided by the drone show that the fire front line is sharply separated from its surroundings, so not only its exact location, but also its main characteristics, fire intensity, and main propagation directions can be determined.

Aerial patrol after suppression for remained hot spot detection

After extinguishing the fire, tasks include inspecting the area, searching for any smoldering areas, and extinguishing them completely. This prevents the fire from reigniting spontaneously or due to wind, making the extinguishing work previously carried out for nothing. Simultaneous monitoring of a large area can require significant resources [8]. The effectiveness of personal surveillance is limited, since the size of the simultaneously visible area depends significantly on the observer's position, and the search for glowing woods are only possible by detecting by its accompanying phenomenon that can be observed by humans, the glow and smoke. By using a thermal camera, parts below the visibility threshold can also be easily detected, objectively, based on the temperature of the environment, avoiding errors caused by subjective perception.

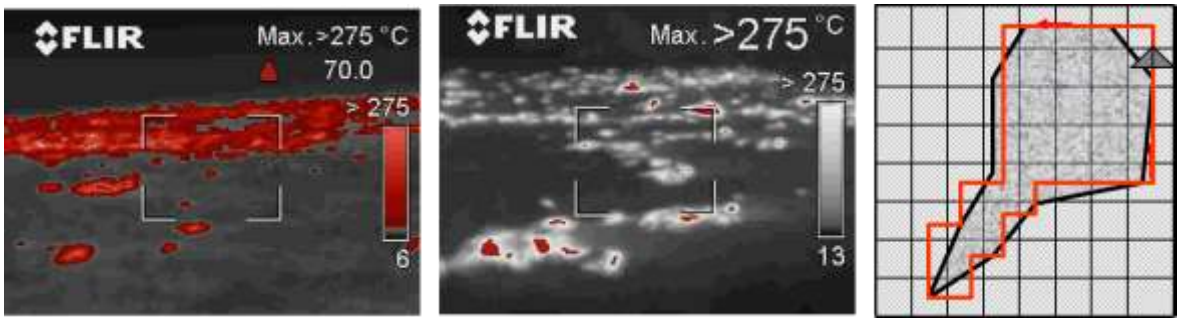


Figure 3. Hot spot detection by thermal camera after suppressing the visible fire (left, middle) and the planned flight path above the suppressed fire front (right). Source: author

If the surveillance of the extinguished area is carried out using a thermal camera and a drone, it is possible to simultaneously provide transparency of the given area and easily detect smoldering spots. From the point of view of the use of a drone, this task does not represent a significant difference from those outlined earlier, so the findings regarding the detection and monitoring of fires can be applied here as well. Its implementation is significantly facilitated by the fact that there is less responsibility compared to intervention, there is no obligation to take action and the task is simpler [6]. Therefore, it is excellently suited for the education and training of drone pilots.

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