

# **Fighting Wildfire with Unmanned Aerial Vehicle**

## **Summary**

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**key words :** 关键词 1; 关键词 2; 关键词 3

## **Budget Request**

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To: The group of Governors

Date: February 8, 2020

这里是 br 正文。

Sincerely yours,  
MCM Team 2120710

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Restatement of the Problem . . . . .	1
1.2	Our Works . . . . .	1
<b>2</b>	<b>Assumptions and Notations</b>	<b>1</b>
2.1	Assumptions . . . . .	1
2.2	Notations . . . . .	2
2.2.1	<i>ijk</i> -coordinate system . . . . .	2
2.2.2	Notations . . . . .	2
<b>3</b>	<b>Model Construction</b>	<b>4</b>
3.1	Bushfire risk model . . . . .	4
3.1.1	why . . . . .	4
<b>4</b>	<b>Conclusion</b>	<b>4</b>
	<b>References</b>	<b>5</b>
	<b>Appendices for Code and Data</b>	<b>6</b>

# 1 Introduction

## 1.1 Restatement of the Problem

Many people...Therefore we are facing the following problems:

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## 1.2 Our Works

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# 2 Assumptions and Notations

## 2.1 Assumptions

Due to the lack of necessary data, we make the following assumptions to help us perform modeling:

1. The circumstance remain unchanged in the time interval we investigated.
2. We omit the possibility of any other kinds of aerial vehicle or flying creature hitting our UAV.
3. According to Bureau of Meteorology of Australian Government, lightning is the major causation of bushfire in some area, Victoria included. [1] Based on this fact, we evaluate the possibility for a certain place to catch fire with the possibility of a lightning to occur there.
4. We adopt the Equal Possibility Hypothesis when our UAVs are patrolling for the purpose of monitoring any outbreak of fire. Under this hypothesis, an area of high possibility to catch fire indicates the frequency of fire outbreak here is high, thus the command center should pay closer attention to this area to alarm fire outbreaks timely.
5. All UAVs are equipped with a timer.

6. All UAVs are directed by a preprogrammed system given by us, which means they are all automatic.
7. Staffs are always available in any charging stations, which guarantees the UAVs will always work in the stanterd situation.
8. A drone can carry either a set of thermal imaging cameras and telemetry sensors or a radio repeater. The former combination can and can only detect any fire outbreak, while the latter can and can only extend the valid zone of radio wave signals.

## 2.2 Notations

### 2.2.1 $ijk$ -coordinate system

Before illustrating the notations for model construction, we would like to introduce a special coordinate system called  **$ijk$ -coordinate system**[2], which was first proposed by Uber Technologies Inc.

Discrete hexagon planar grid systems naturally have 3 coordinate axes spaced  $120^\circ$  apart. We refer to such a system as an  $ijk$  coordinate system, for the three coordinate axes  $i$ ,  $j$ , and  $k$ .

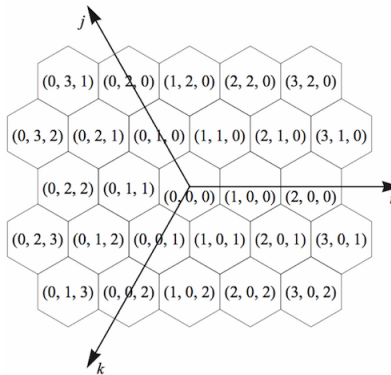


Figure 1: One possible map example that using the  $ijk$  coordinate system

### 2.2.2 Notations

Here are all the notations and their meanings in this paper.

Table 1: Notations used in model construction

Notation	Meaning
$M(i, t)$	Location of the $i$ -th drone I at time $t$
$R(j, t)$	Location of the $j$ -th drone II at time $t$
$h(x, y, z)$	Elevation of the point $(x, y, z)$
$S(x, y, z)$	Fire history of the point $(x, y, z)$ in the passed 5 years
$a_i(x, y, z)$	Fire history of the point $(x, y, z)$ in the 2020 – $i$ -th year, $i \in [1, 5] \cap \mathbb{N}$
$F(x, y, z)$	Vegetative and structural condition of the point $(x, y, z)$
$S(i, x, y, z, t)$	Strength of the signal from the $i$ -th drone at point $(x, y, z)$ at time $t$
$E(x, y, z, N)$	Supervisory density of the point $(x, y, z)$ when there are $N$ drones in the field
$Slope(x, y, z)$	Maximum slope of the point $(x, y, z)$
$\gamma$	Factor related to the weight of slope in causing bushfire
$\beta(x, y, z)$	Weight of slope in causing bushfire
$\omega(x, y, z)$	Decreasing rate of signal at point $(x, y, z)$
$\alpha$	Factor related to the weight of elevation in causing bushfire
$Chg(q, x, y, z)$	Location of the $q$ -th charging station
$V_{\max}$	Maximum flying velocity of a drone
$N_{SSA}$	Amount of drone I
$N_{\text{rep}}$	Amount of drones II
$PF$	Power consumption for a flying drone
$PH$	Power consumption for a hovering drone
$t_{\text{fl}}(t, l)$	Flight time of the $l$ -th drone until time $t$
$t_{\text{hov}}(t, l)$	Hovering time of the $l$ -th drone until time $t$
$T$	Duration of a day (i.e. $T = 1440$ min)
$t$	Current time
$Br$	Total battery power of a drone
$Ini$	Location of the EOC

### 3 Model Construction

#### 3.1 Bushfire risk model

##### 3.1.1 why

for segmentation and assessment of the topography

In this section, we introduce a H3 model to data-orienting the topographic conditions of the state Victoria in Australia. First in order to simplify the question, we cover the state with hexagons in dense tiled layout. We consider that the valid zone of radio wave signal radiated by a UAV is a spherical area of radius 20km, and the length of each side of hexagon is 1.22 km. Next, we evaluated each segment from 4 dimensions, which are: density of forest coverage, elevation, slope and fire history. We consider the influence of the listed dimensions from two aspects: how dose it influence the possibility to catch fire for the area and how does it influence the propagation of radio wave signal. The mechanism and significance of these factors are discussed below.

### 4 Conclusion

We build a.....interesting findings:

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## References

- [1] M. Kilinc and J. Beringer, "The spatial and temporal distribution of lightning strikes and their relationship with vegetation type, elevation, and fire scars in the northern territory," *Journal of Climate*, vol. 20, no. 7, pp. 1161 – 1173, 01 Apr. 2007. [Online]. Available: <https://journals.ametsoc.org/view/journals/clim/20/7/jcli4039.1.xml>
- [2] "The h3 core library documentation: Coordinate systems," <https://h3geo.org/docs/core-library/coordsystems>.



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## Appendices

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### Appendices A

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