Mathematical Modeling of Wildfire Evacuation in Maui, Hawaii

December 6, 2023

Summary

In this paper, we present a mathematical model for wildfire evacuation in Maui, Hawaii, based on cellular automata principles. Our model consists of two sub-models: a wildfire propagation model and an evacuation model. The wildfire propagation model simulates the spread of fire on a grid of cells, where each cell represents a unit of land with certain attributes, such as vegetation type, moisture level, and elevation. The fire spread is influenced by factors such as wind speed, wind direction, temperature, and humidity. The evacuation model simulates the movement of people on a road network, where each node represents an intersection or an evacuation point, and each edge represents a road segment. The evacuation model considers the population distribution, the evacuation routes, the evacuation points, and the traffic flow in different regions. The model also incorporates the effects of factors like drought, hurricanes, and vegetation changes on the wildfire risk and the evacuation process.

Keywords: keyword1; keyword2

Contents

1 Introduction

1.1 The condition of Maui

Maui, Hawaii, located in the central Pacific, is renowned for its stunning natural landscapes and diverse vegetation, making it a popular tourist destination. However, the island faces increased wildfire risks due to factors such as drought, hurricanes, vegetation changes, and a scarcity of firefighters. According to the Hawaii Wildfire Management Organization, wildfires have burned over 25% of Hawaii's total land area since 2000, and Maui has experienced some of the largest and most destructive fires in the state's history. To ensure the safety of residents and tourists, there is a need to develop a wildfire evacuation model for planning evacuation strategies during wildfire events.

1.2 The models of Cellular Automata

Cellular automata (CA) are discrete mathematical models that consist of a grid of cells, each of which can have a finite number of states, and a set of rules that determine the state transition of each cell based on its neighborhood. CA have been widely used to model complex phenomena such as fluid dynamics, traffic flow, urban growth, and biological systems . In particular, CA have been applied to model wildfire propagation and evacuation, as they can capture the spatial and temporal dynamics of fire spread and human behavior. However, most of the existing CA models for wildfire evacuation are either too simplistic or too specific, and do not consider the effects of various factors that affect wildfire risk and evacuation efficiency in Maui.

1.3 Our work

In this paper, we aim to address this gap by presenting a comprehensive and realistic CA model for wildfire evacuation in Maui, Hawaii. Our model consists of four sub-models: a wildfire propagation sub-model, an evacuation sub-model, a firefighter deployment sub-model, and a risk assessment sub-model. We use the model to answer the following questions: Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

- How fast and how far will the wildfire spread under different conditions?
- What is the best evacuation strategy to minimize the risk of casualties among affected populations?
- How should the firefighter resources be allocated to effectively contain the spread of wildfires?
- How much time is required for residents and tourists in different areas to safely evacuate?

- How can the impact of factors such as drought, hurricanes, and vegetation changes on wildfire risk be assessed?
- How can an early warning system be established to notify residents and tourists in advance?

2 Analysis of the Problem

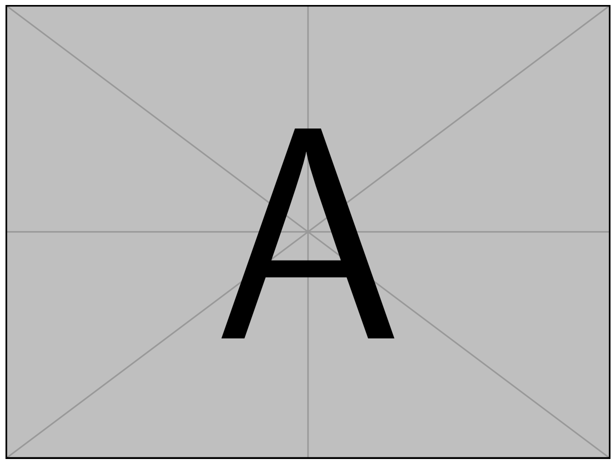

Figure 1: The name of figure

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$$a^2 \tag{1}$$

$$\begin{pmatrix} *20ca_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} = \frac{Opposite}{Hypotenuse} \cos^{-1}\theta \arcsin\theta$$

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$$p_j = \begin{cases} 0, & \text{if } j \text{ is odd} \\ r!\,(-1)^{j/2}, & \text{if } j \text{ is even} \end{cases}$$

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$$\arcsin\theta = \oiiint\limits_{\varphi} \lim_{x\to\infty} \frac{n!}{r!\,(n-r)!} \tag{1}$$

3 Calculating and Simplifying the Model

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4 The Model Results

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5 Validating the Model

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6 Conclusions

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7 A Summary

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8 Evaluate of the Mode

9 Strengths and weaknesses

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9.1 Strengths

- **Applies widely**
  This system can be used for many types of airplanes, and it also solves the interference during the procedure of the boarding airplane,as described above we can get to the optimization boarding time.We also know that all the service is automate.

- **Improve the quality of the airport service**
  Balancing the cost of the cost and the benefit, it will bring in more convenient for airport and passengers.It also saves many human resources for the airline.

-

References

[1] D. E. KNUTH The TEXbook the American Mathematical Society and Addison-Wesley Publishing Company , 1984-1986.

[2] Lamport, Leslie, LaTeX: “ A Document Preparation System ”, Addison-Wesley Publishing Company, 1986.

[3] https://www.latexstudio.net/

Appendices

Appendix A First appendix

In addition, your report must include a letter to the Chief Financial Officer (CFO) of the Goodgrant Foundation, Mr. Alpha Chiang, that describes the optimal investment strategy, your modeling approach and major results, and a brief discussion of your proposed concept of a return-on-investment (ROI). This letter should be no more than two pages in length.

Dear, Mr. Alpha Chiang

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Sincerely yours,

Your friends

Here are simulation programmes we used in our model as follow.

Input matlab source:

```
function [t,seat,aisle]=OI6Sim(n,target,seated)
pab=rand(1,n);
for i=1:n
    if pab(i)<0.4
        aisleTime(i)=0;
```

```
    else
        aisleTime(i)=trirnd(3.2,7.1,38.7);
    end
end
```

Appendix B Second appendix

some more text **Input C++ source:**

```
//============================================================================
// Name        : Sudoku.cpp
// Author      : wzlf11
// Version     : a.0
// Copyright   : Your copyright notice
// Description : Sudoku in C++.
//============================================================================

#include <iostream>
#include <cstdlib>
#include <ctime>

using namespace std;

int table[9][9];

int main() {

    for(int i = 0; i < 9; i++){
        table[0][i] = i + 1;
    }

    srand((unsigned int)time(NULL));

    shuffle((int *)&table[0], 9);

    while(!put_line(1))
    {
        shuffle((int *)&table[0], 9);
    }

    for(int x = 0; x < 9; x++){
        for(int y = 0; y < 9; y++){
            cout << table[x][y] << " ";
        }

        cout << endl;
    }

    return 0;
}
```