

Forest Fire Analytics

EECS 4414 - Information Networks (Fall 2020)

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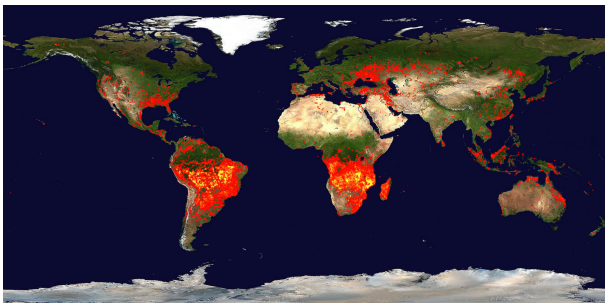
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Outline

- 1 Introduction
- 2 Problem Definition
- 3 Methodology
- 4 Experiments and Results
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- 6 Conclusions

Introduction

- Forest fire - A growing problem world widely



- Irreversible environmental and socio-economic damages
- Need for more accurate fire simulation & efficient fire control

Introduction

Research focus:

- Fire propagation modelling based on topographical and weather conditions
- Forest fire simulation
- Forest fire control strategies

Problem Definition

Problem 1

Given an area, construct the lattice network G and integrate elevation, slope, aspect and wind conditions into the network through linear threshold model.

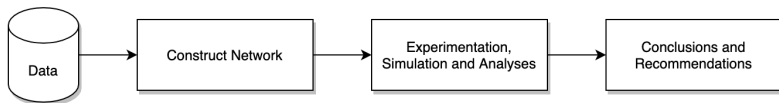
Problem 2

Given a lattice network, simulate wildfire propagation in the network.

Problem 3

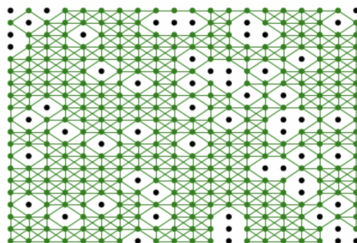
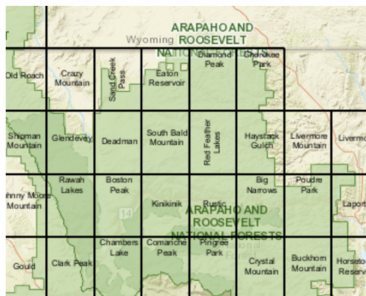
Propose fire prevention strategies to decrease the total damage caused by fire.

Framework



Dataset

- The Roosevelt National Forest in Colorado
- Lattice network: $30\text{m} \times 30\text{m}$ grid forest
- Each grid includes: elevation, slope and aspect.



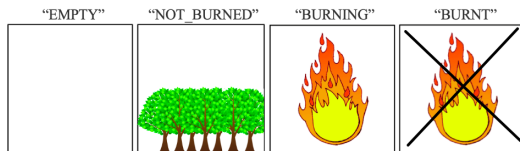
Methodology

Network Construction: a lattice network $G(N, E)$

N : set of nodes – terrain patches

E : set of edges between nodes – neighboring forests

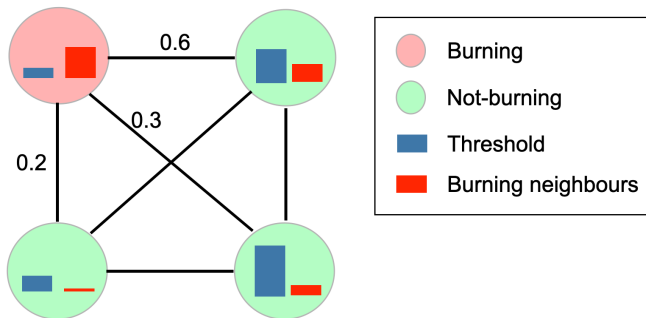
- (Forest) Node's states:



- ρ : the forest density of the network

Methodology

Network Construction - Linear Threshold Model:



Thresholds θ : determined by elevation, slope and aspect

Weights β : determined by wind and distance

Methodology

Topographic Influences on Forest Fire Behavior - Slope:

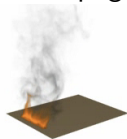


Fig1. zero slope

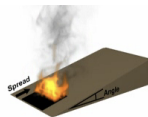


Fig2. low slope



Fig3. medium slope

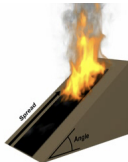
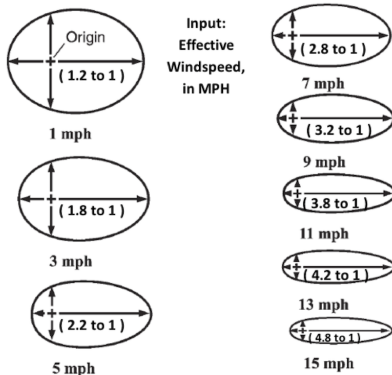


Fig4. high slope

Methodology

Weather Influences on Forest Fire Behavior - Wind:



Methodology

(Mathematical) model of features in node threshold & edge weight:

Symbol	Nomenclature	Formula
ϕ_s	slope coefficient	$5.275(\tan \phi)^2$
ξ	elevation coefficient	$\frac{1}{1 + \ln(\max\{he^{-6}, 1\})}$
α	aspect coefficient	(See Table 2)
ϕ_w	wind speed	$\gamma \cos \tau$
δ	node Euclidean distance	$\sqrt{\Delta^2 x + \Delta^2 y}$

Methodology

Fire Prevention (removal of edges strategies):

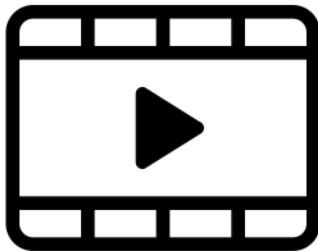
- Strategy 1: Using the Girvan-Newman (GN) algorithm:
 - removing edges with the highest betweenness scores
 - isolating communities of forests
 - limitation: location
- Strategy 2: Using the GN with extension (**FIGHTER**):
 - neighborhood-based Edge-Removal approach
 - takes into consideration the location of where edges are being pruned previously

Algorithms

- **INCINERATE:** Fire Simulation Algorithm
 - **INPUT:** The Graph $G(N, E)$
 - **OUTPUT:** The resultant forest graph after fire propagation simulation according to the LT model
- **FIGHTER:** Fire Prevention Algorithm
 - **INPUT:** Graph $G(N, E)$, K number of edges to remove, and threshold λ
 - **OUTPUT:** E' , the edges removed based on betweenness centrality and local neighborhood

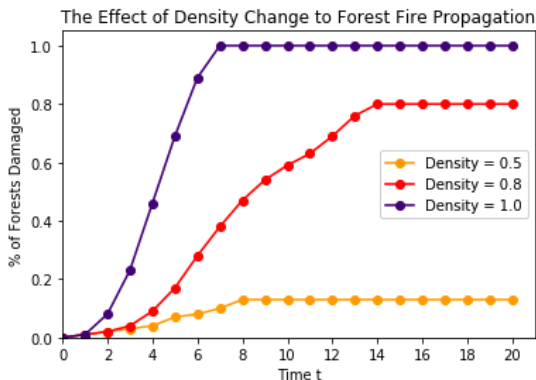
Experiments and Results

- Fire Propagation Simulator (**INCINERATE**)



Experiments and Results

Different values of the forest density ρ :



Experiments and Results

Effect of slope, elevation and wind on forest fire damages:

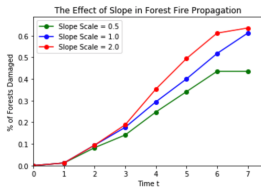


Figure: Slope

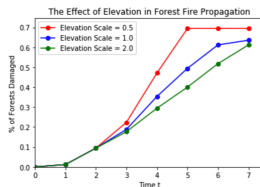


Figure: Elevation

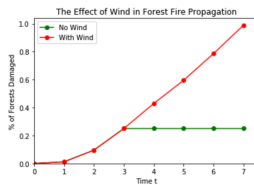
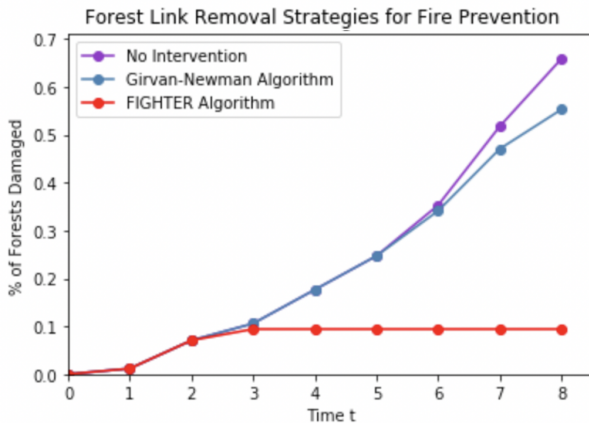


Figure: Wind

Experiments and Results

Result of different prevention strategies:



Conclusion

- We constructed the network by modelling features such as elevation, slope and aspect through linear threshold model.
- We simulated fire propagation in networks.
- We designed and implemented the prevention strategy and the strategy outperformed than Girvan-Newman.
- Possible future work could be including other factors that affect fire propagate and other prevention strategies.

Image Sources:

- <https://www.dailysabah.com>
- <https://www.nasa.gov/topics/earth/features/wildfires.html>
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Thank You!

Questions?