INSTITUTE FOR DIGITAL FORESTRY

UFZ: A Novel Method to Locate and Classify Hazardous Urban Fire Zones

PURDUE UNIVERSITY
Institute for Digital Forestry

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ABSTRACT

Motivation:

- It is estimated that 600,000+ outdoor fires occur annually across the U.S.
- Most of these fires are in an urban setting.
- Tools for predicting and simulating fire spread within these urban environments are limited.

Contributions:

- A new tool *prototype* to locate and classify hazardous urban fire zones.
- A simulation framework to provide estimated fire-related quantities such as the total emissions of CO, CO_2 and soot.

Uses:

- Identify fire-prone urban and vegetation layouts.
- Quantify the impact of fires in those regions from the simulation's visualization and output quantities.
- Simulate previous fires to quantify their emissions and visualize the impact on the environment.

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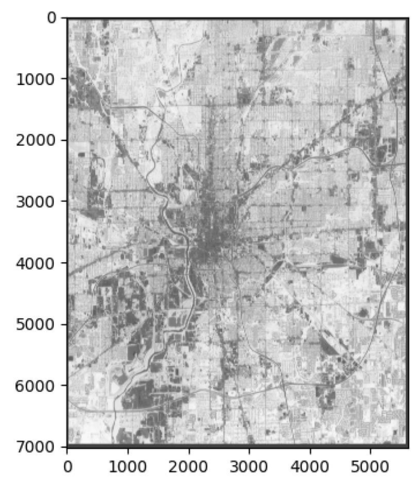
1. Finding Hazardous Regions

NDVI Map
(Indianapolis, 3mpp)



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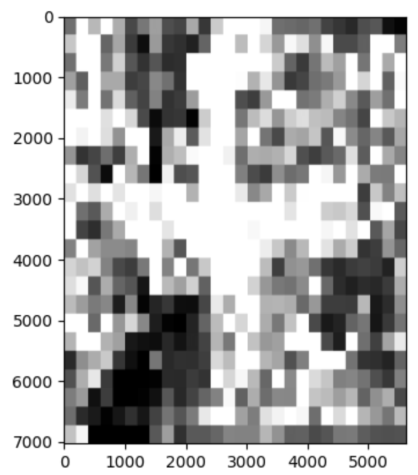

Population LandScan
(Indianapolis, 1kmpp)

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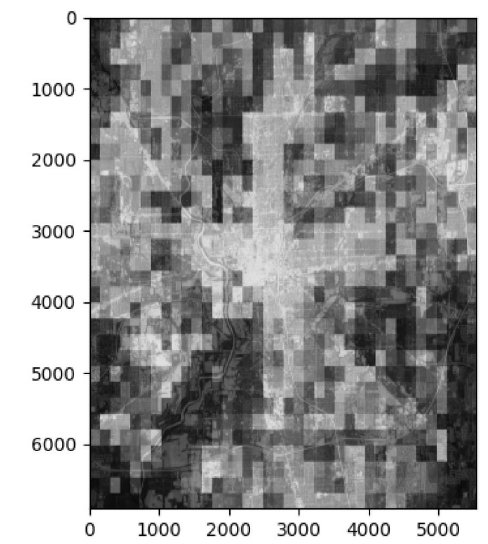
1) Combine weighted values from NDVI and LandScan datasets to create a fire-probability map.



Higher brightness = higher probability of trees/people. This is interpreted as a probable place for a fire to start.

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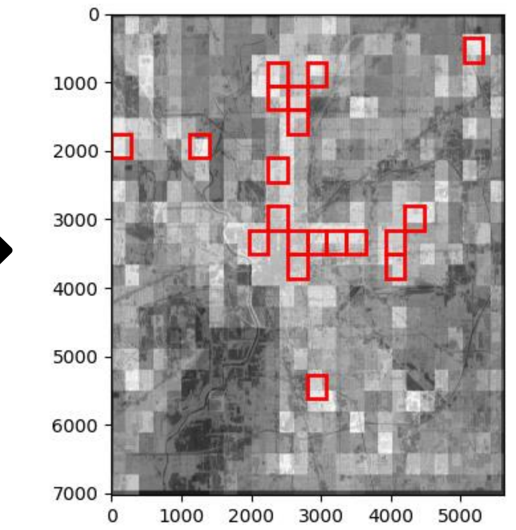
2) Split the map into regions and sample the top N regions by brightness.



This example shows the top 20 1x1 km regions selected within Indianapolis, outlined in red.

2. Modeling a Hazardous Region

1) Import building data into Blender to create a model of the buildings (e.g., OSM or iDiF urban layout project).

(Every building is imported and then voxelized to create an interactable 3D object for smoke, fire, and other particles.)

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2) Import localized tree data from the u-TREE Inventory.

(The trees are added from u-TREE, with ~1.5m accuracy.)

3) Prepare the scene for NIST Fire Dynamics Simulator (FDS). We do this by defining a voxel grid. Each voxel represents a volume in space, simulating smoke and fire spread as well as particulate materials. Total simulation time, flammable materials, and more are also defined during this preparation step.

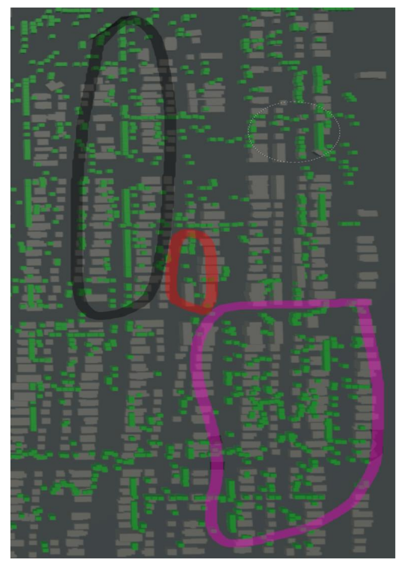
4) Export the blender file to the FDS format.

3. Urban Fire Zone Configurations

- Observations:
  - locations of interest are those which have a high probability of spread to neighboring objects.
  - we have identified an initial set of layout configurations which seem optimal for producing a maximum spread under different conditions.
  - wind and weather conditions must be taken into account when considering these locations.

1) "Scattered Zone" (Purple): A dense grouping of trees with no distinguishable pattern to its density.

2) "Chain Zone" (Black): A dense grouping of trees where the density is following a certain direction/trail.



3) "Corridor Zone" (Red): A group of trees between at least two dense clusters (such as a chain or scattered cluster configuration type), which on its own is dense enough to bridge a fire between them.

4. Simulations and Preliminary Evaluation

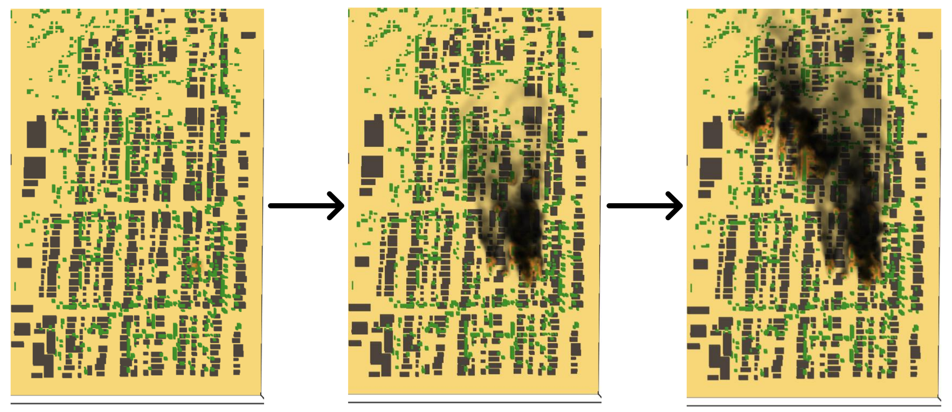
Simulations. Given an extracted urban layout cell (and zone):

- Determine random fire start locations within the cell/zone.
- Vary wind speed and direction.
- Perform FDS simulation and a visualization along with requested measurements (e.g., CO, CO_2, Soot, Temperature) which are provided as output.

Configuration Hypothesis

Analysis. After generating 20 hazardous zones in Indianapolis, we analyzed each one for our tree configuration types. This particular zone had a pattern of trees matching a potential Scattered -> Corridor -> Chain configuration for fire spread. When we simulated this area we assumed a dry condition and gave it a moderate 20mph wind blowing north-northwest. This led to a visual validation that the chain and scattered areas were dense enough to spread fire throughout their zones, and that the corridor had an important role in transferring the fire across those dense clusters.

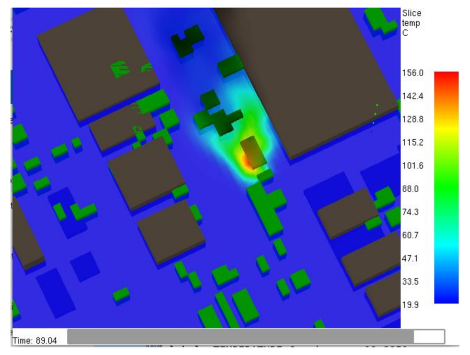
The end result, as seen through the visualization output, indicates that our hypothesis for basic configuration types could be valid.



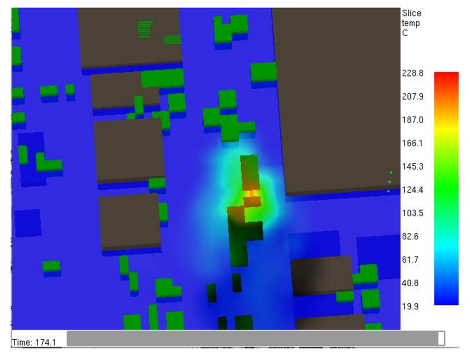
Initial → Middle → End

Wind also affects how hazardous a region is.

- In this Chain Zone, a southward wind causes higher temperatures than a northward wind.



Northward Wind



Southward Wind

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PERSEUS

UFZs: A Novel Method to Identify Urban Fire Zones

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PURDUE UNIVERSITY

Department of Computer Science

ABSTRACT

Motivation:

- It is estimated that 600,000+ outdoor fires occur annually across the U.S.
- Most of these fires occur in the intersection between wildland and urban areas – the Wildland Urban Interface (WUI).
- Tools for predicting and simulating fire spread within these urban environments are limited.

Contributions:

- A new tool *prototype* to locate and classify hazardous urban fire zones.

Uses:

- Identify fire-prone urban and vegetation layouts.
- Analyse the correlation of features of the landscape with how fire prone the region is.

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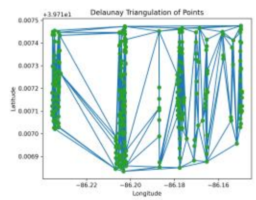
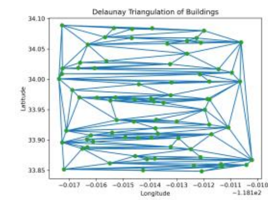
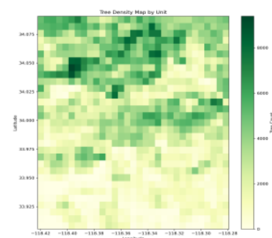
1. Prominent Landscape Features in Los Angeles: A Case Study



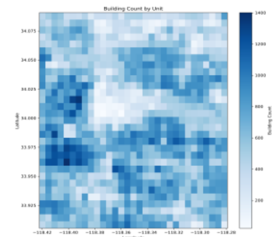
There are different **tree patterns** observable in downtown Los Angeles, from the triangulation plots shown. There are regions of structured *plantain-like street trees* (left) and regions of *scattered trees* (right). We can use the clustering patterns of the trees to predict if a region is inside a fire prone zone or not.



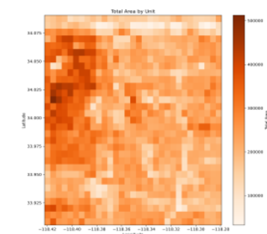
A full map of LA's landscape: Using the U-Tree and MS Buildings datasets



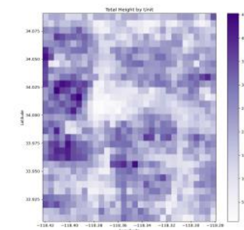
A) Number of trees



B) Number of buildings



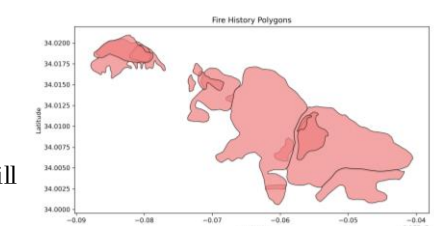
C) Amount "area" of buildings



D) Height of buildings

2. Preliminary Evaluation and Hypothesis

- The fire history data (from Cal Fire) for part of the region is displayed on the right as polygons
- We use the above data (A-D) to create a feature vector for each "unit" as a sample and then train a support vector machine to predict whether a unit is within a fire history zone
- We hypothesize that some features (like tree counts and area of buildings) will influence the prediction more than others (like height of buildings)
- Challenges and future work: Scaling to other cities and using more complex features of the landscape (example, inter-tree clustering from the triangulation)



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