California Wildfire Simulation

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Introduction

For this project, we focused on wildfires in California, as this is a relevant issue that affects many people. Wildfires are a significant natural disaster that commonly occur in California. We focused on fires within the general Los Angeles area, as well as the Camp fire of 2018, which was the most catastrophic fire in California History. We wanted to simulate wildfires with the intent of gaining a better understanding of fire spread and structural damages in order to provide a recommended method of preparation for these natural disasters. Utilizing Python and discrete-event simulation, we were able to make preliminary conclusions for improvements that could be made to minimize the destruction of a wildfire.

Data

The data we utilized for this project consists of real-world fire spread data of the Camp fire from the National Institute of Standards and Technology, NASA Infrared VIIRS satellite data, and Damage Inspection data (DINS) from CAL Fire. There was a lot of preparation and cleaning of the data that was necessary to be used for our purposes. For instance, the coordinates of the infrared data needed to be converted into numeric format, and there were a lot of columns with NaN values that needed to be dropped. Additionally, the fire spread data for the Camp fire was only available in a PDF report. Therefore, we needed to extract this data utilizing Microsoft Excel and convert it to a CSV file.

While there is a lot of technology that exists for the tracking of wildfires including AI, infrared satellite imagery, and ground based sensors, there are a few concerns when it comes to this project. There is not a ton of easily accessible data that is readily available. We chose this topic with the intent of focusing on optimizing emergency response times and optimizing the process of providing aid. However, there is not publicly available historical data on emergency response times

to wildfires specifically. Additionally, another big concern are external factors that contribute to the progression of a fire. Wildfires spread very inconsistently and are affected by things like terrain and weather patterns. With these factors taken into consideration, a much more extensive and complex version of this topic can be explored in order to provide other methods of preparedness and recovery when it comes to wildfires.

Methods

There are several different libraries and tools within Python that we utilized for this project including Simpy, Geopandas, Matplotlib, and Folium. We focused on utilizing the infrared data to provide visualizations of fires to show the potential uses for this type of data. By utilizing the latitude and longitude limits of the Los Angeles area, we were able to narrow down the fires occurring in Los Angeles. Regarding the simulations, we tracked the structural damage and fire spread rate of the Camp Fire in order to create these what-if scenarios.

To simulate how different construction materials can influence the fire ignition probability and structural damage, we extracted the possible materials for each of the four features related to the build material of the structures. These four features are exterior siding, roof construction, deck/porch on grade and deck/porch elevated. We extracted the unique values from each of the features as they were variable between features, and cleaned and grouped them into categories. Structures that lack values for a feature were not excluded but handled carefully in calculation of the empirical destruction rates. The destruction rate for each material type for each feature was calculated using the proportion of structures that are labeled as “Destroyed (>50%)”. These rates were then compared to the pre-defined hypothetical values to determine which set of values could be used for our simulations.

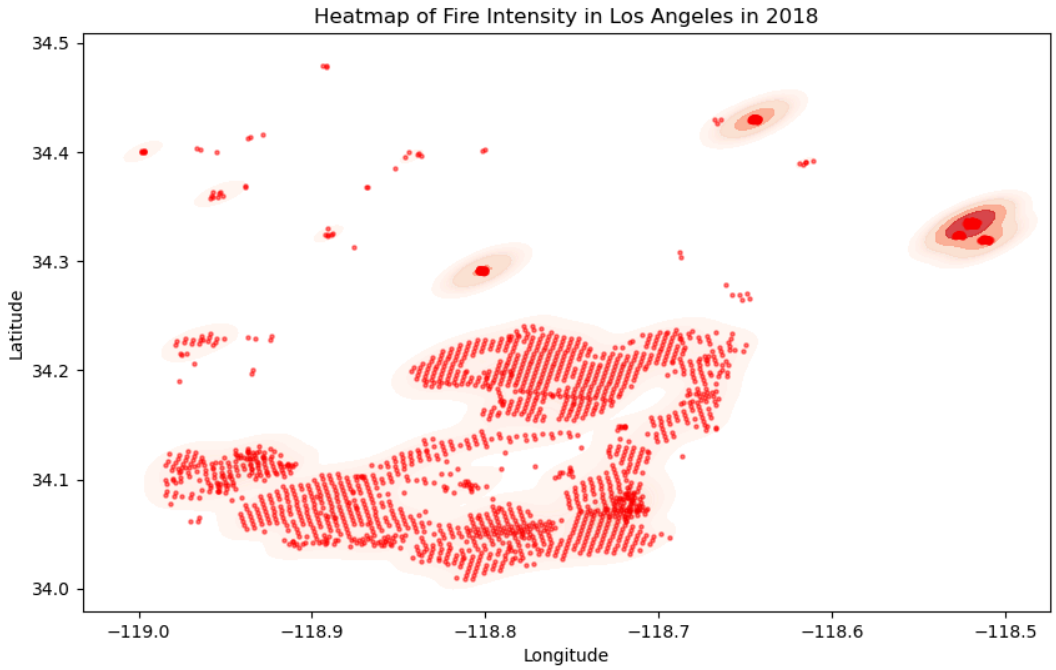
For our simulation design, we designated three stages. These stages are the fire arrival event, at which point the fire reaches a structure based on our calculation of its arrival time, the ignition event, where we simulate the structure catching fire based on it’s flammability score as well

as a random delay between 5-30 minutes, and lastly the destruction event, in which the structures that ignited are destroyed after an additional random delay between 5-90 minutes. These events were then logged with a timestamp and saved as a discrete event log.

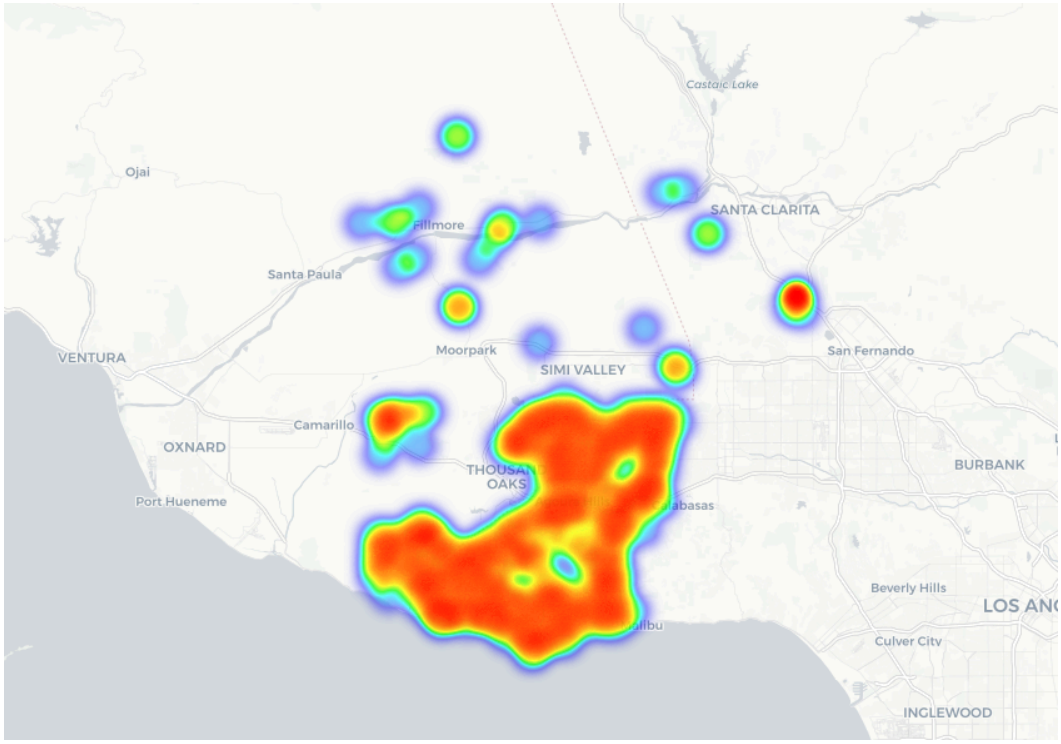
Conclusions

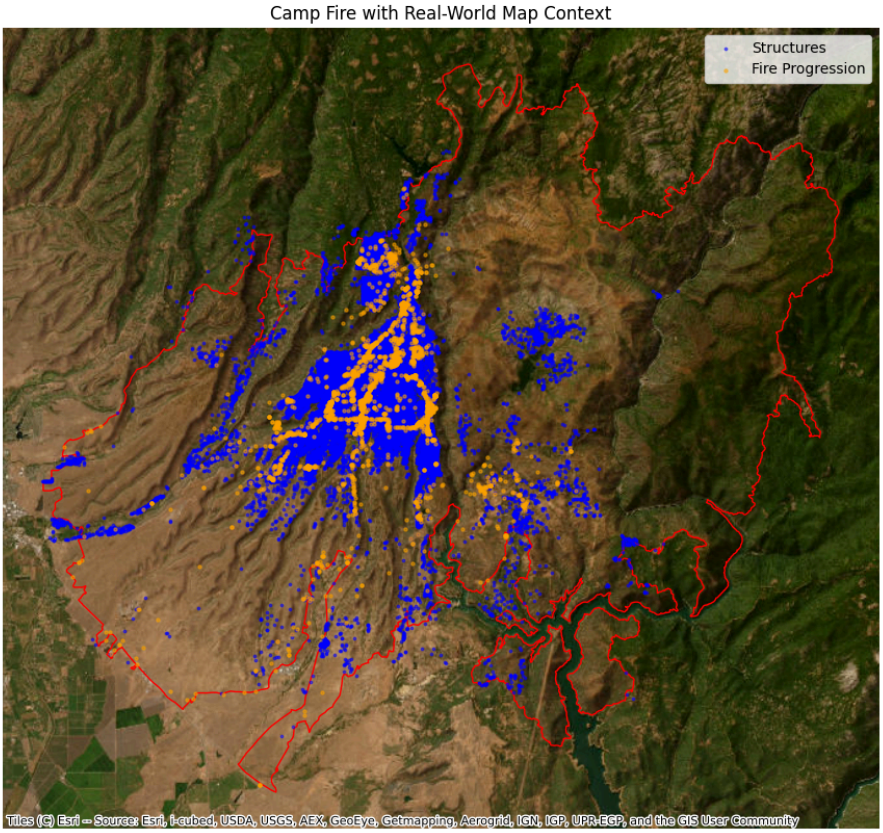
From our simulations, we found that by building structures utilizing fire-resistant materials, the level of destruction decreased drastically. By running simulations like these, we are able to provide recommendations on how to increase preparedness to minimize the destruction of wildfires in the future. We hope that future research can be done in order to provide more information on things like how weather can affect wildfires, recommendations on optimal evacuation routes, better allocation of resources and aid, and emergency response prioritization.

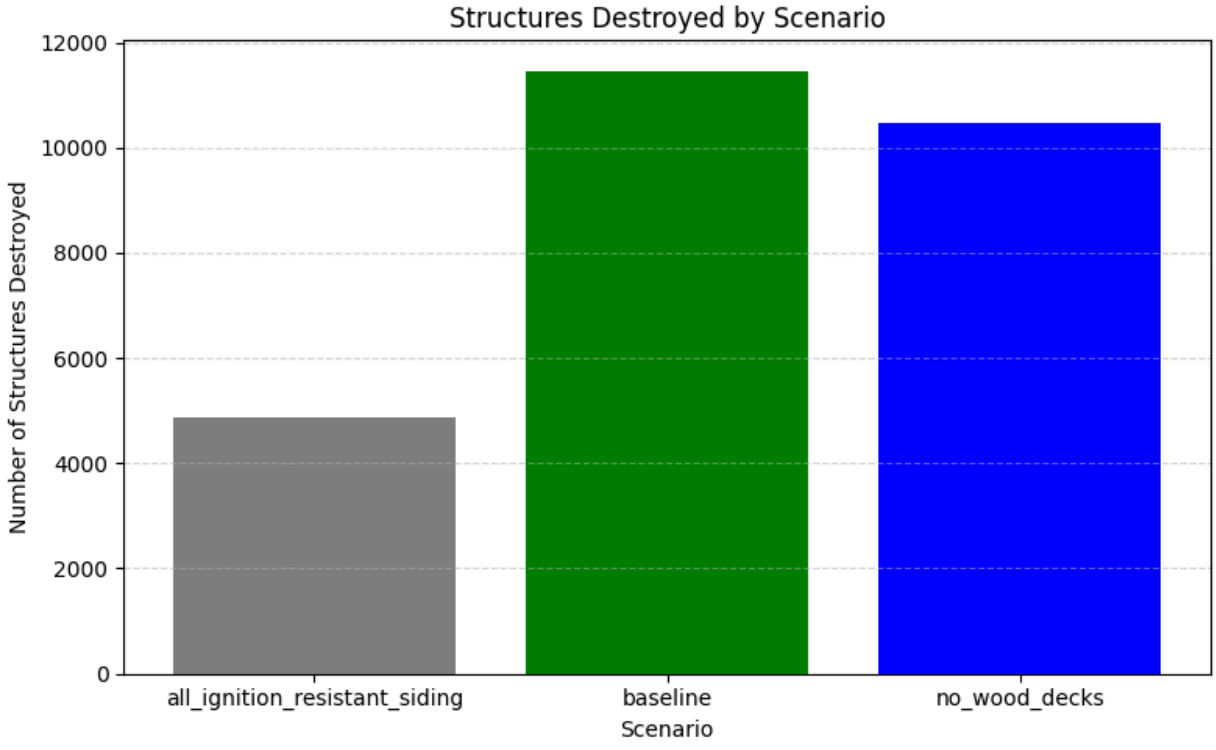
Appendix

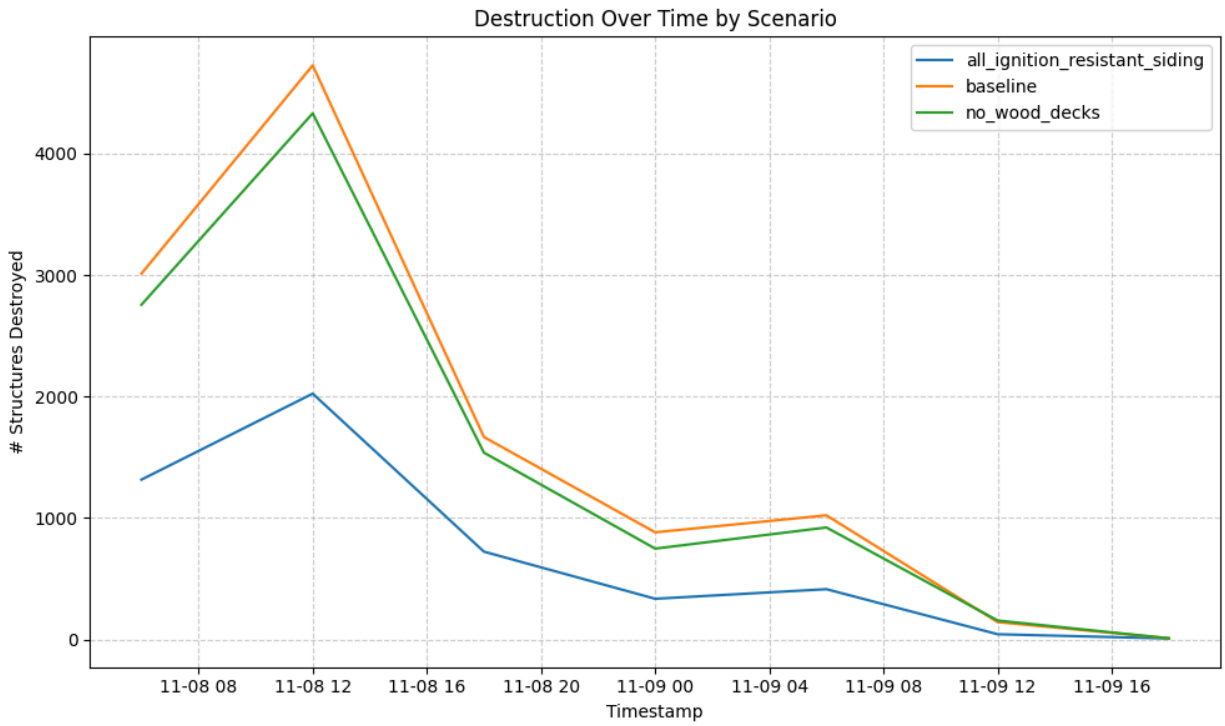


Heatmap overlaying a map of Los Angeles




Camp Fire with Real-World Map Context
Structures
Fire Progression
Tiles (©) Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community


Structures Destroyed by Scenario
Number of Structures Destroyed
0
2000
4000
6000
8000
10000
12000
all_ignition_resistant_siding
baseline
no_wood_decks
Scenario


Destruction Over Time by Scenario
all_ignition_resistant_siding
baseline
no_wood_decks
Structures Destroyed
0
1000
2000
3000
4000
11-08 08
11-08 12
11-08 16
11-08 20
11-09 00
11-09 04
11-09 08
11-09 12
11-09 16
Timestamp