Wildfire prediction using Spatio-Temporal Knowledge Graphs

D2R2'2023 28.05.2023

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Agenda

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- Introduction
- Use Case overview
  - Data format
  - Data overview
- Knowledge Graph creation
- Data Modeling
- Conclusion

Introduction

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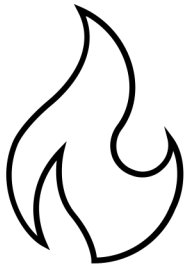
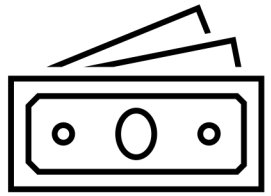


US (2021)

58.985 wildfires

California

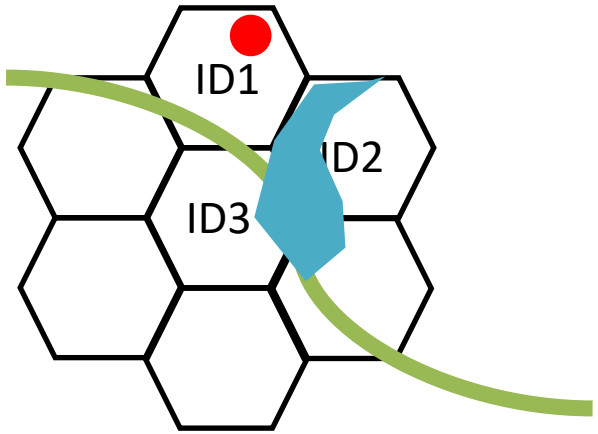
2M house at risk



California (2018)

148B $ economic damage

Current data preparation techniques



Grid Cell ID	hasRiver	hasCampfire	Wildfire
ID1	True	True	False
ID2	False	False	True
ID3	True	False	True

- Use Grid cells as single elements within datasets
- No inclusion of surrounding elements
- Limited data base

Can surrounding elements have a positive influence on wildfire prediction?

Use Case Overview

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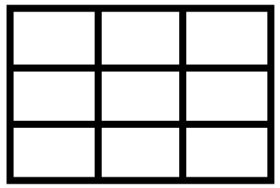
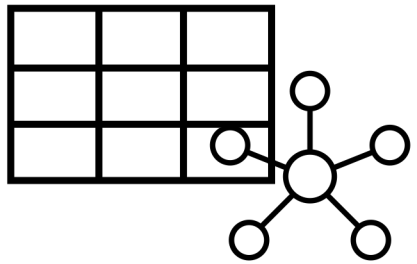
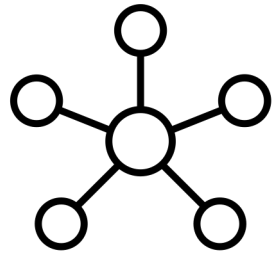


Base Case



Hybrid Case



Graph Case

Input data

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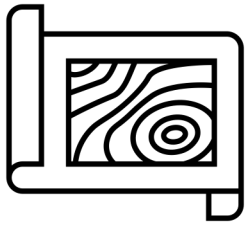
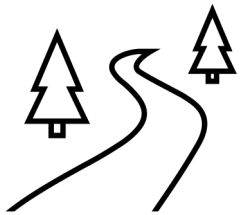


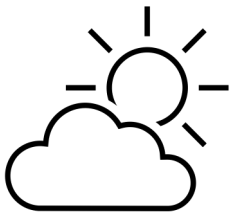
Elevation data



Openstreetmap data

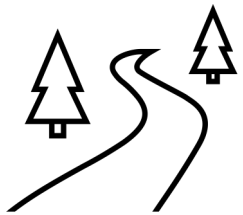
Landcover data

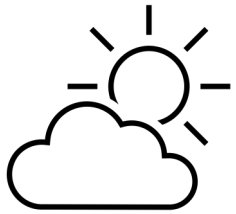
Wildfire area data

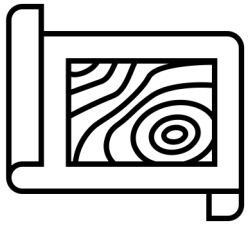


Weather data

Incorporating spatial relationships







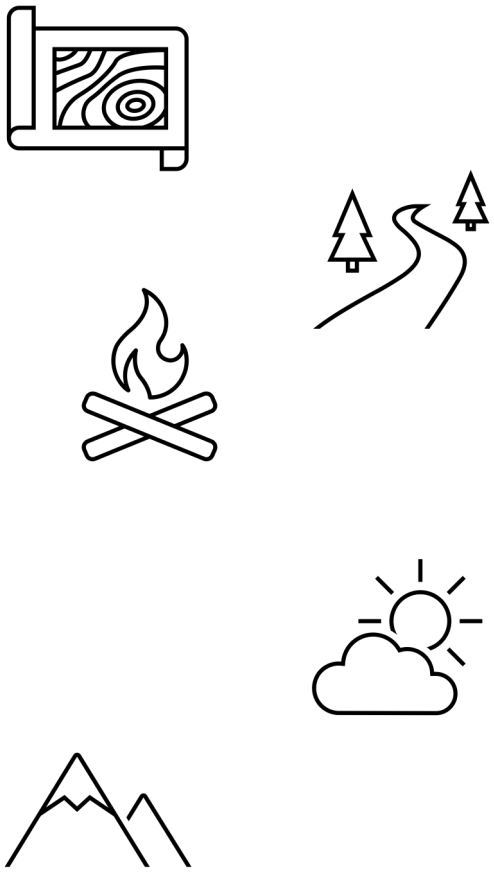
Interconnection of different data types

Transform data to spatial knowledge graph

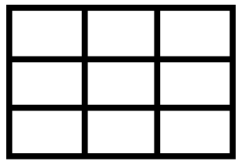
Starting point

- Divide area into regular spaces (called grid)
- Each area is a grid cell
- Possible geometric objects:
  - Triangle
  - Square
  - Hexagons

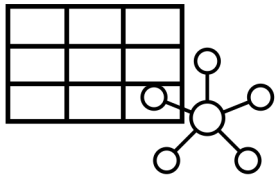
Data Preparation



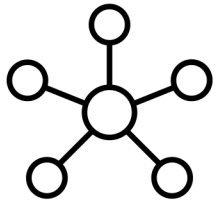
Still data preparation steps needed



Base Cases



Hybrid Cases



Graph Cases

Data Preparation - Weather

- Pointwise measurements of weather variables
- Need to interpolate data over created spatial grid
- Used interpolation technique:

  Kriging:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i * Z(s_i)$$

  Weight λ_i is determined by a semivariogram

  Semivariogram determines spatial autocorrelation and fits function to data

- Each constructed grid cell has now interpolated values for weather variables

- λ_i: Weight at i
- $Z(s_i)$: Value at point s_i
- $\hat{Z}(s_0)$: Prediction at point s_0

Data Preparation – Elevation & Landcover data

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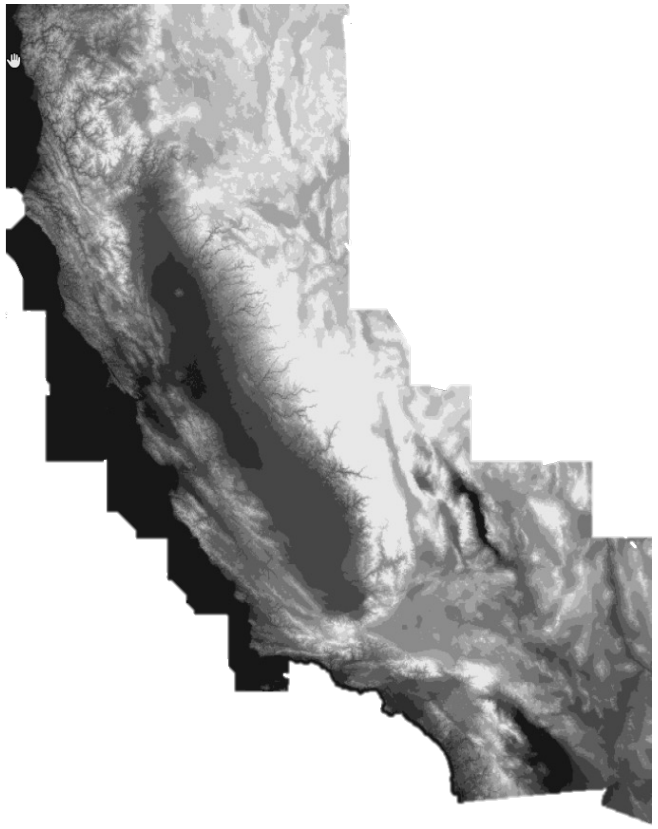
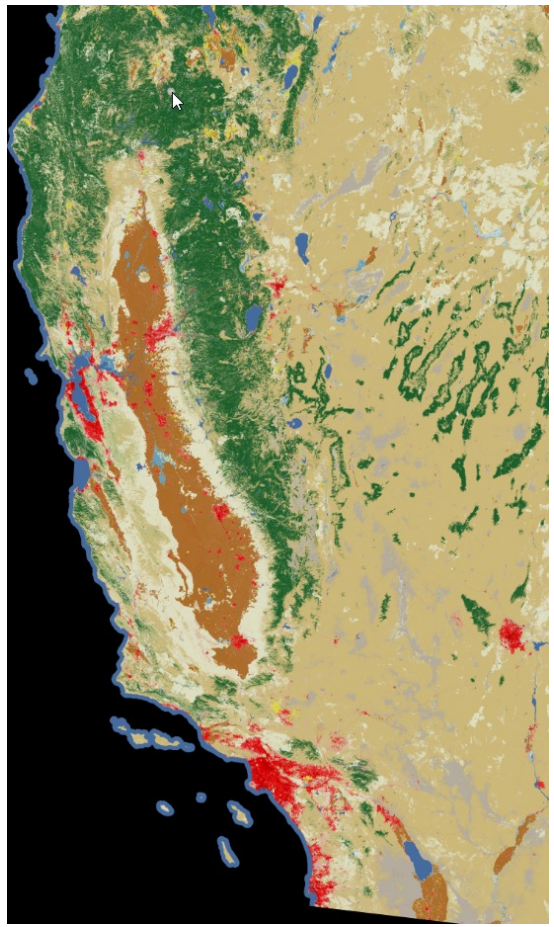
Elevation



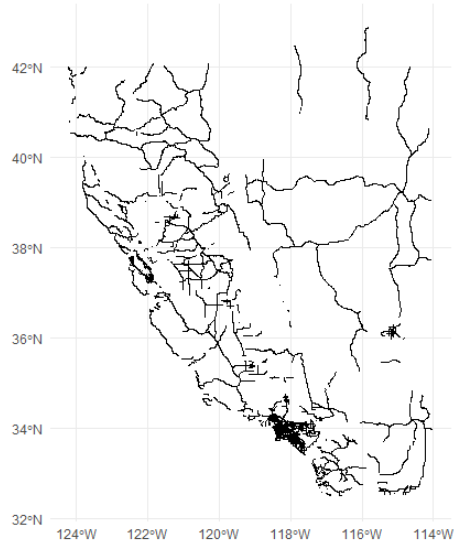
Land cover

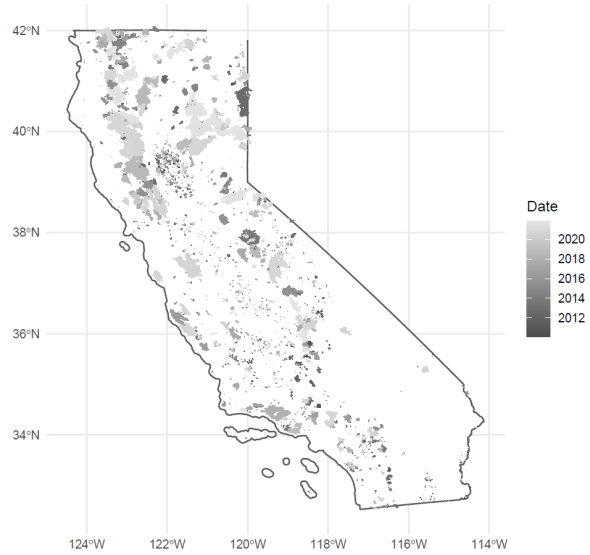


Data Preparation – Elevation & Landcover data

- Both datasets fine granular
  - Elevation 60m*60m tiles
  - Landcover 90m*90m tiles
- Elevation numeric dataset
- Landcover categorical dataset
- Elevation dataset gets aggregated with weighted mean to single grid cell
- Landcover dataset gets aggregated with weighted majority vote to single grid cell

Data Preparation – Openstreetmap & Wildfire data





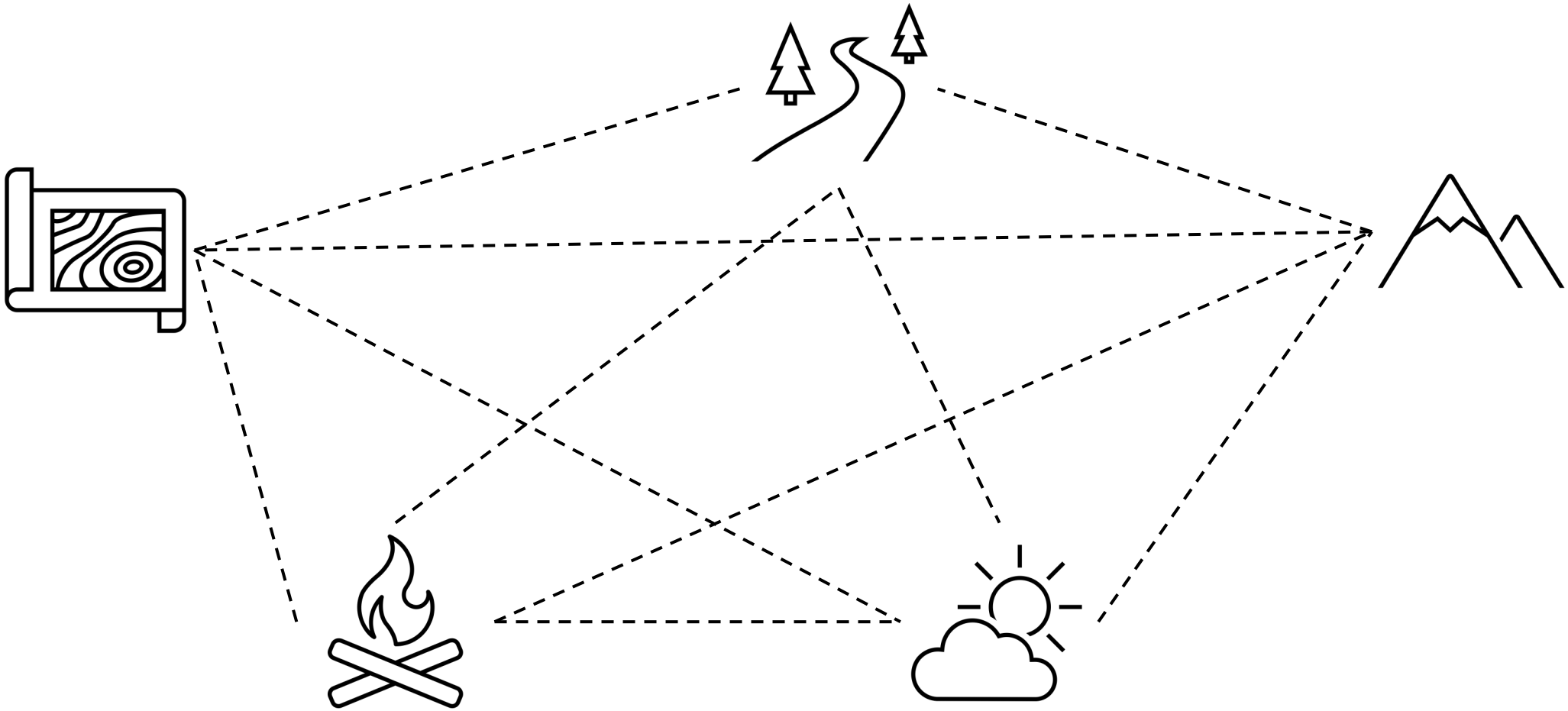
Openstreetmap

- Extract columns related to potential wildfires
- Extract necessary geometry types
- Join Openstreetmap to Grid Cell based on overlap

Wildfire

- Transform year and days to date
- Join wildfire to Grid Cell based on relation overlap

Build up spatial knowledge graph



Build up spatial knowledge graph – DE-9IM

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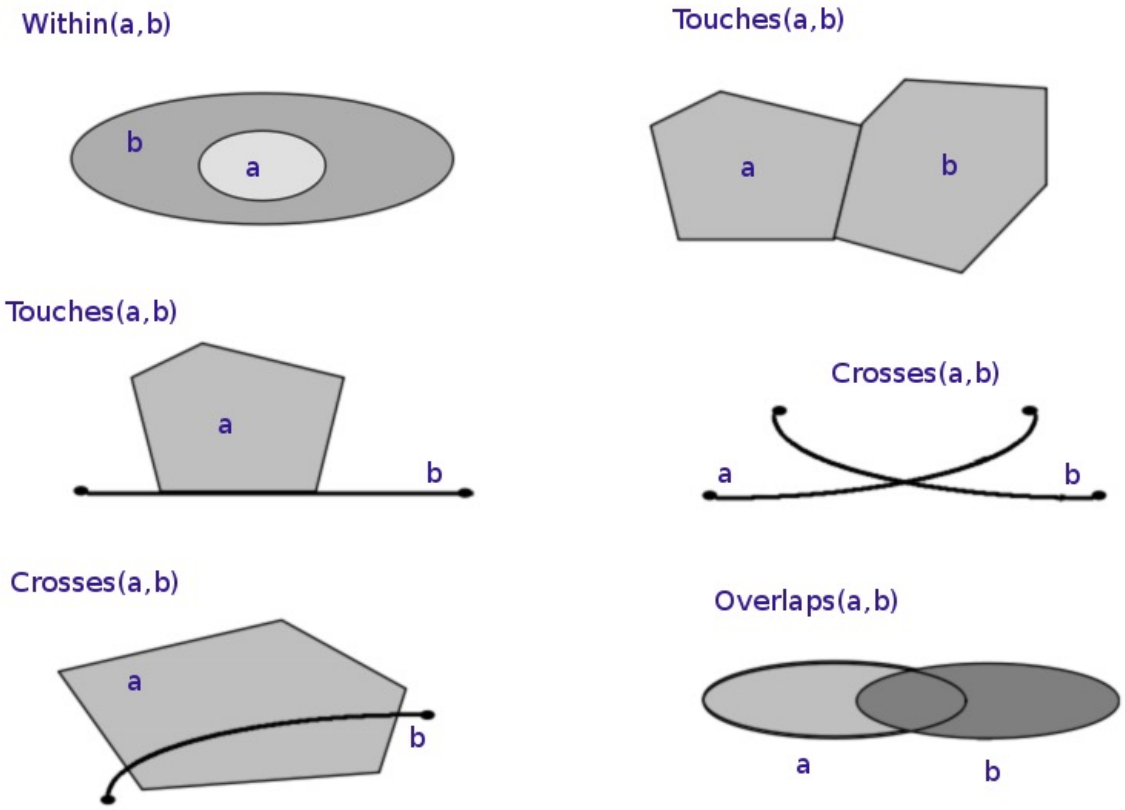
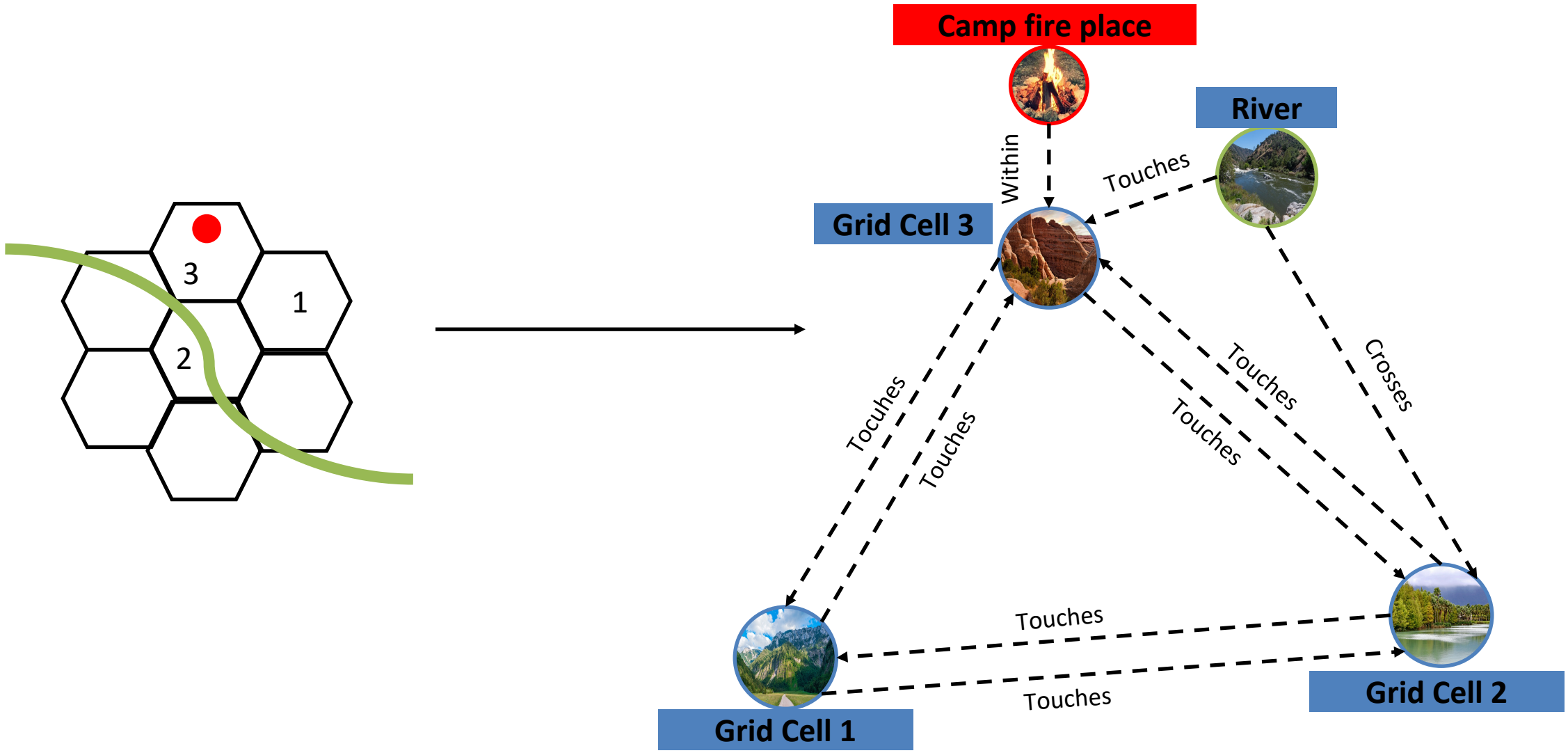
- DE-9IM is topological model to build relationships between geometric objects



Transform data to spatial knowledge graph



Wildfire detection – Create Vector representation (RDF2Vec)

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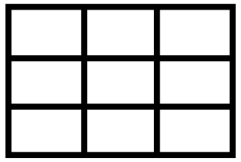
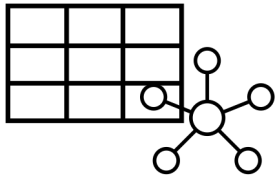
- RDF2Vec method transforms graphs to vector representations
- RDF2Vec is separated in two phases
  - Graph traversal phase with Breadth-First Search algorithm
  - Training of Word2Vec model
- Each extracted walk consists of Nodes and the Edge description transformed to sentence
- Resulting vector representation can be combined to dataset

Construct Base Case Dataset



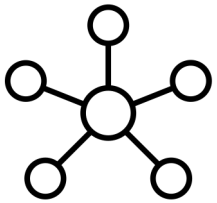
Base Cases

- Consists of tabular data where Grid Cell ID and Month build one row
- No relationship between neighboring grid cells



Hybrid Cases

- Consists of tabular data where Grid Cell ID and Month build one row
- Embeddings from OpenStreetMap knowledge graph are joined to dataset
- Neighbor semantics are modeled for single grid cell ID



Graph Cases

- Consists of embedding data where Grid Cell ID and Month build one row
- Embeddings from knowledge graph with all are joined

Result overview

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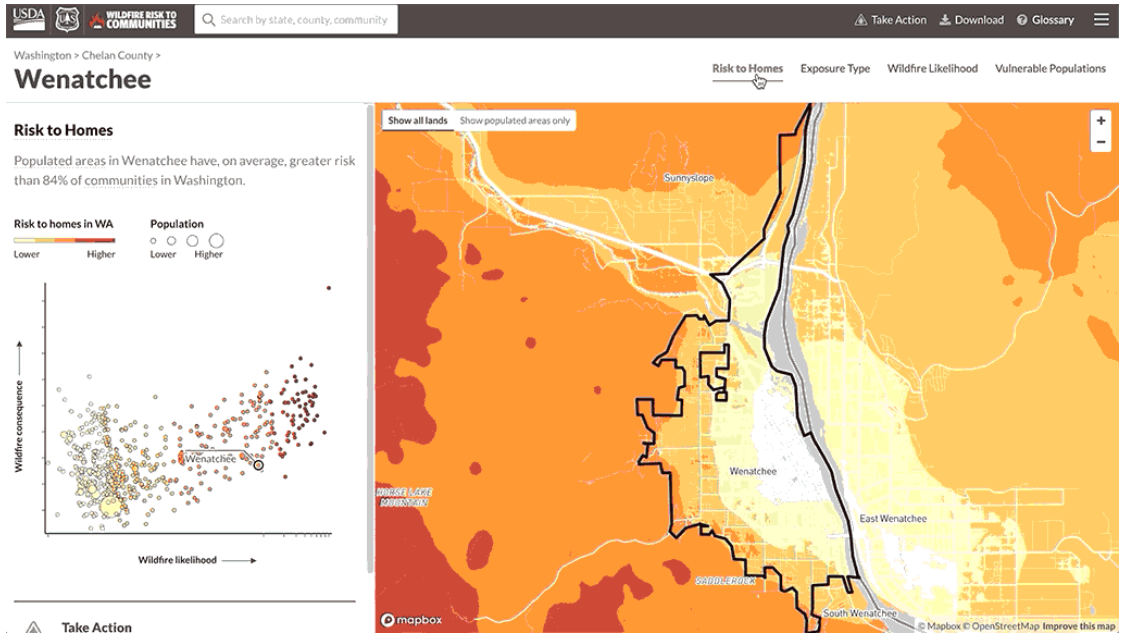
Dataset	F1	AUC
BaseCase	0.3478	0.6816
HybridCase	0.3803	0.8748
NetworkCase	0.0107	0.5341

Conclusion and outlook

- Graph based inclusion in dataset improves results for Hybrid Case dataset
- Scenarios can be modelled more accurate due to surrounding factors and semantic relations
- Outlook:
  - Create more benchmark datasets related to geography
  - Compare constructed KG with other spatial Knowledge Graph on benchmark dataset
  - Embed Knowledge Graphs with different embedding methodologies



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Thank you