- AI & Computer Vision for Nat Hazards
- Enhancing Data with AI

SimCenter NHERI
Center for Computational Modeling and Simulation

AI & Computer Vision for Nat Hazards

What is AI?

The science/engineering that makes machines/programs smart.

SVM

Decision tree

KNN

PCA

Artificial neural nets

Random forest

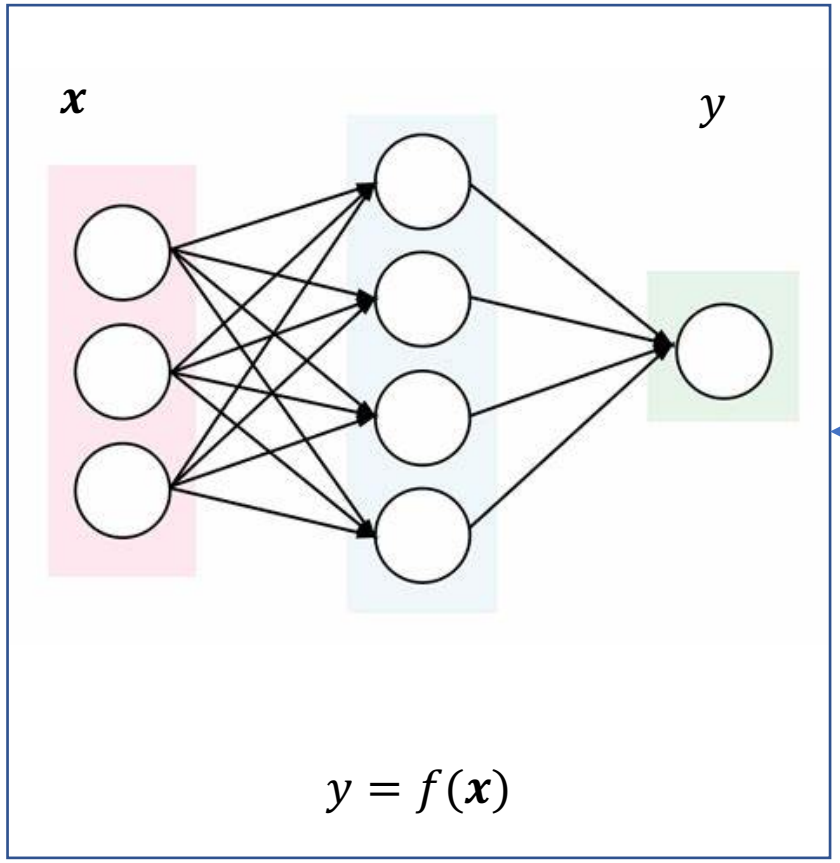
Markov chains

Adaboost

AI & Computer Vision for Nat Hazards

What is AI?

The science/engineering that makes machines/programs smart.



Artificial neural nets

Decision tree

SVM

KNN

PCA

Random forest

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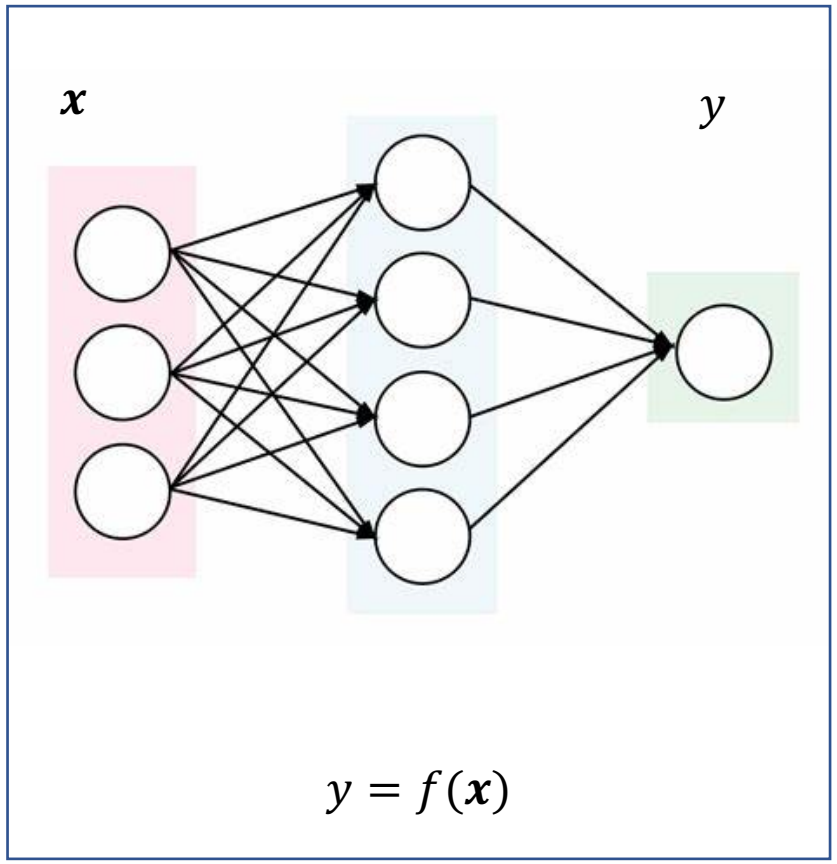
Adaboost

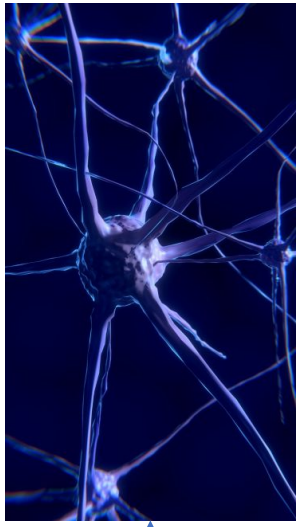
AI & Computer Vision for Nat Hazards

What is AI?

Neural nets (NN)

NN architecture





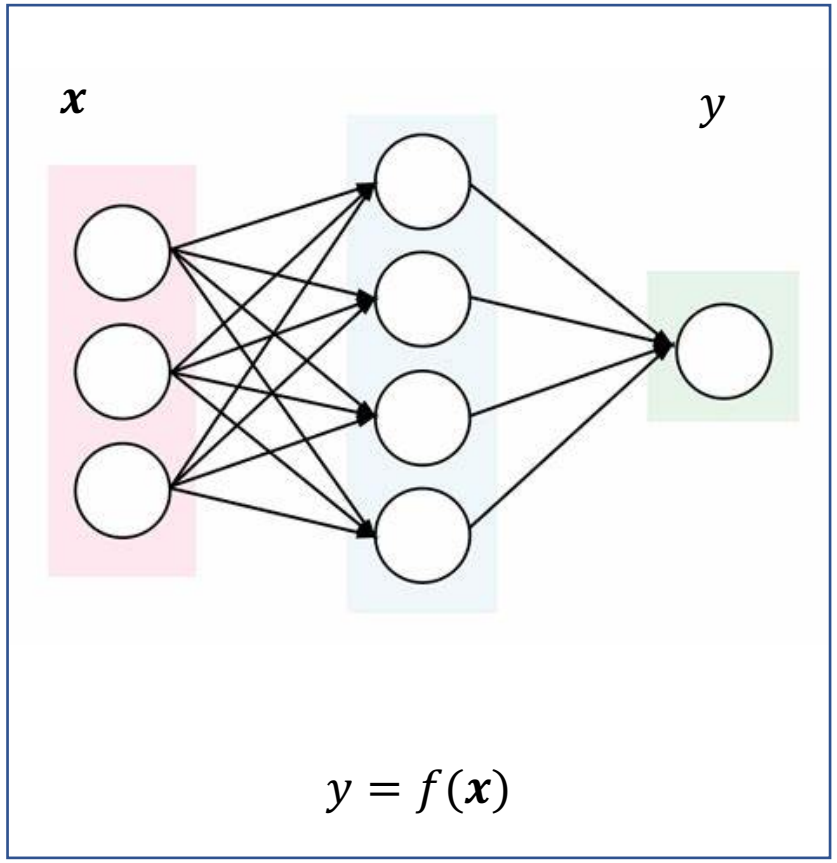
A neuron

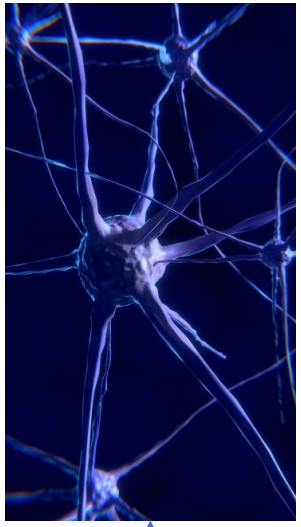
AI & Computer Vision for Nat Hazards

What is AI?

Neural nets (NN)

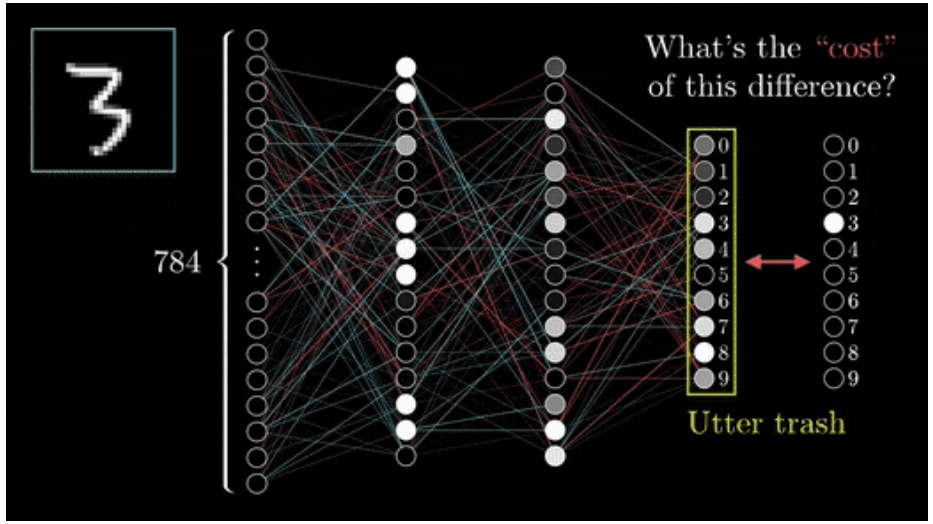
NN architecture





A neuron

How does it work?

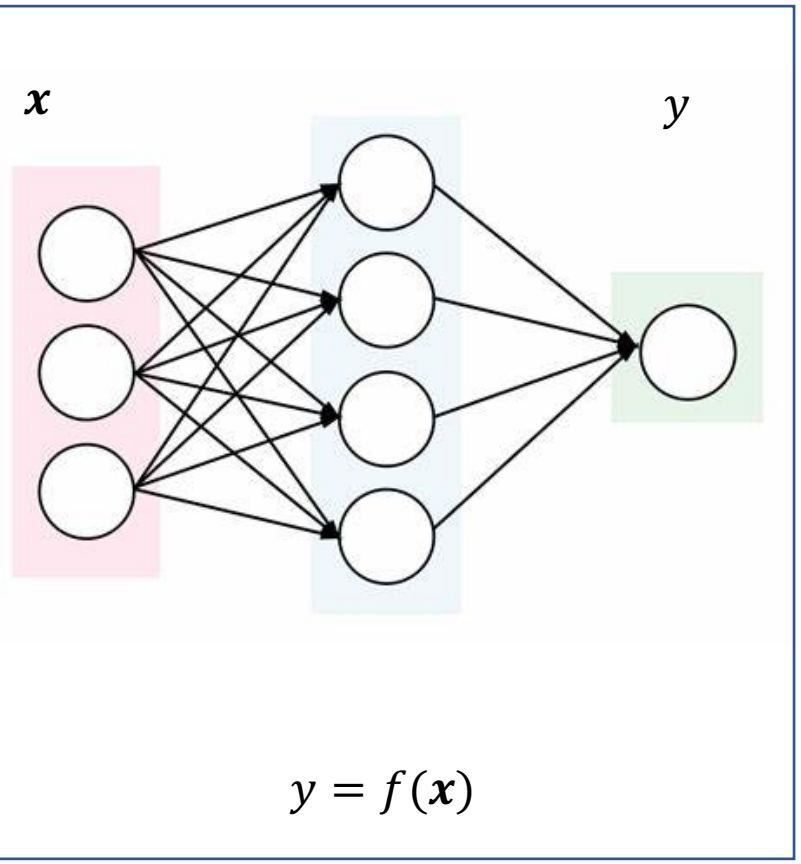


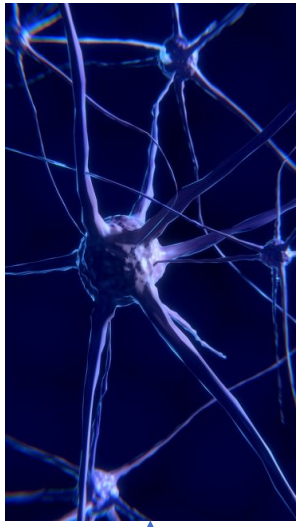
AI & Computer Vision for Nat Hazards

What is AI?

Neural nets (NN)

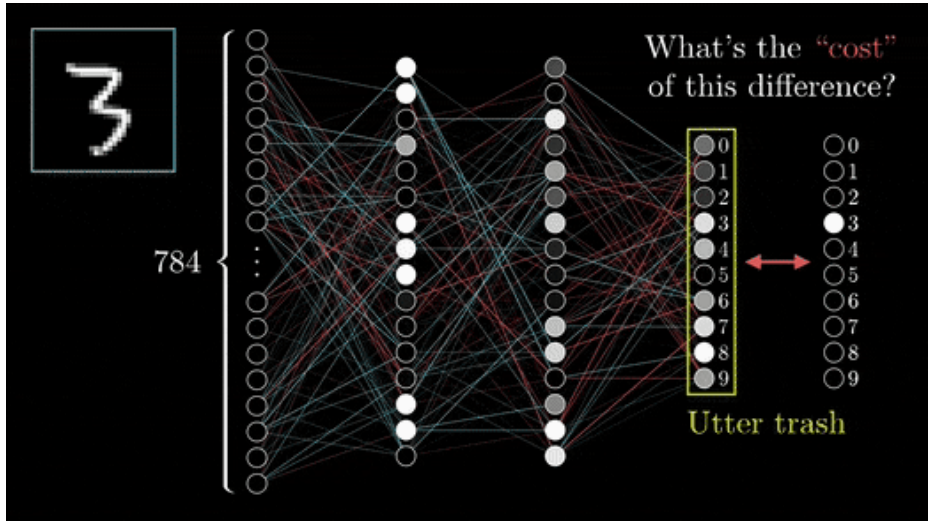
NN architecture





A neuron

How does it work?



The "weights" are learned results.

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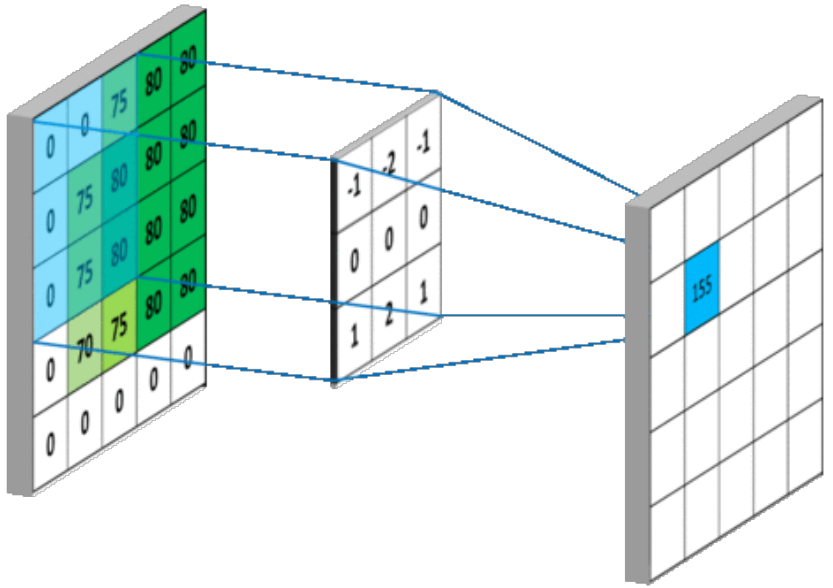
What is a convolutional neural net (CNN)?

Kernel matrix



Image

Convolved feature

A convolution operation

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Learning resources

Machine Learning, Andrew Ng
https://www.coursera.org/learn/machine-learning

CS231n: Convolutional Neural Networks for Visual Recognition
http://cs231n.stanford.edu/

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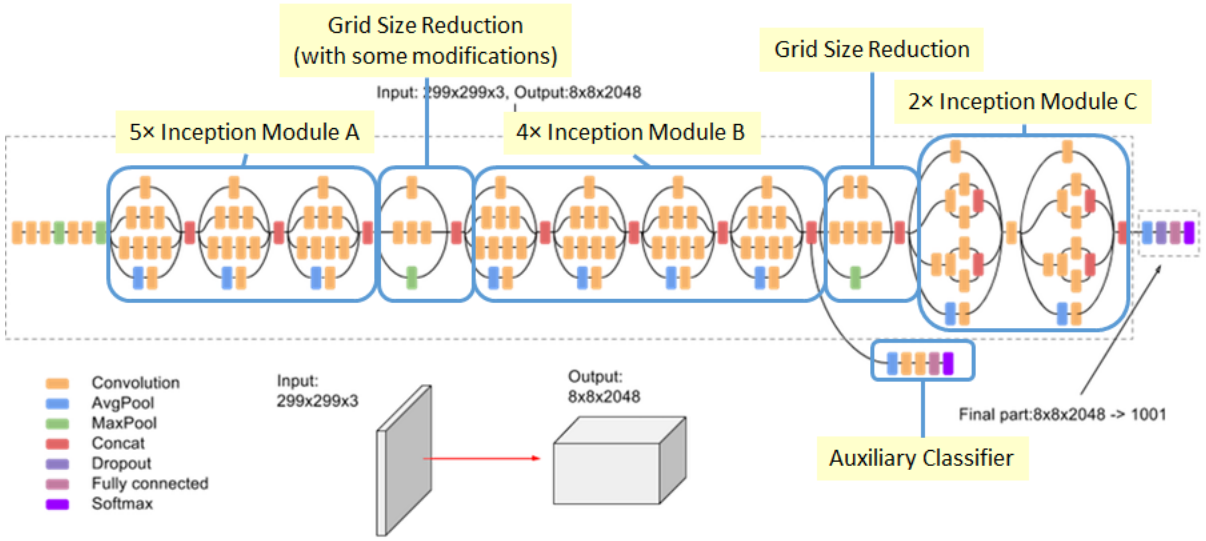
CNN architectures

- AlexNet
- VGGNet
- GoogLeNet
- Microsfot ResNet
- Google Inception
- …



Inception v3

AI & Computer Vision for Nat Hazards

Tensorflow and TF-slim

TensorFlow is a good start point for ML
It makes it easy for you to build and deploy ML models.

TF-slim https://github.com/tensorflow/models/tree/master/research/slim

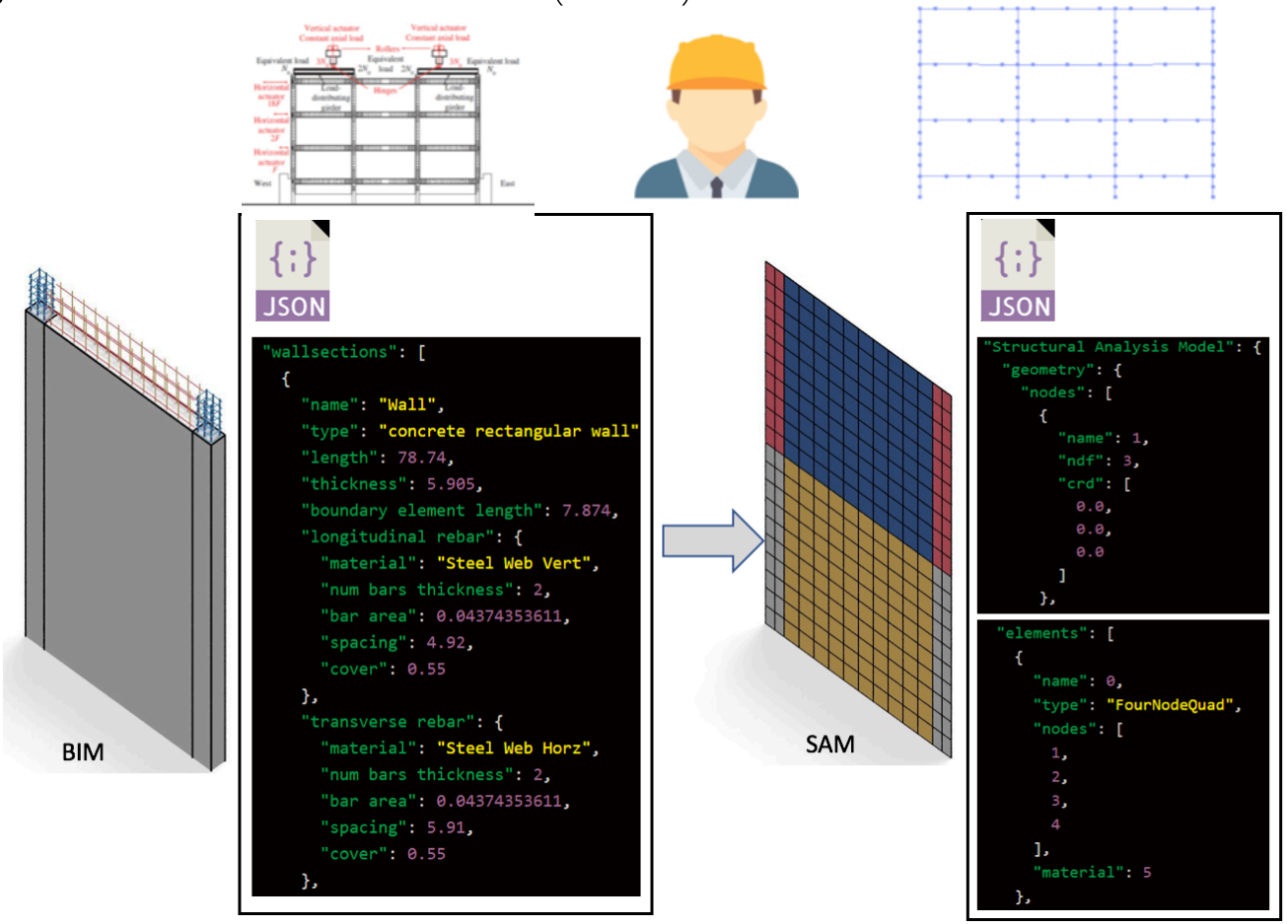
TF-slim is lightweight high-level API of TensorFlow for defining,
training and evaluating complex models.

AI & Computer Vision for Nat Hazards

SimCenter AI projects

BIM2SAM (https://github.com/charlesxwang/BIM2SAM.AI)

Converting Building Information Models (BIM) to Structural Analysis Models (SAM)



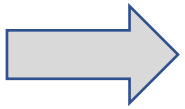
AI & Computer Vision for Nat Hazards

SimCenter AI projects

Soft story building detection

Detecting soft story building that are vulnerable to earthquakes using convolutional neural nets (CNN)

CNN



Soft story building
Not soft story building

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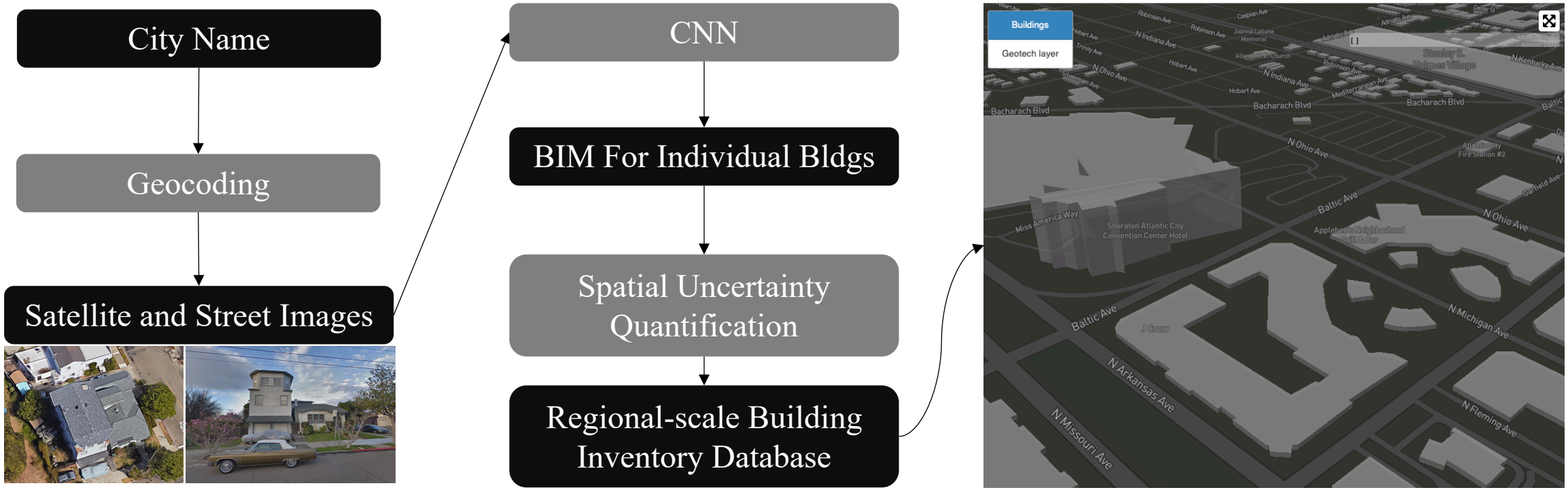
SimCenter AI projects

Regional building information model procument (https://github.com/charlesxwang/BIM.AI)



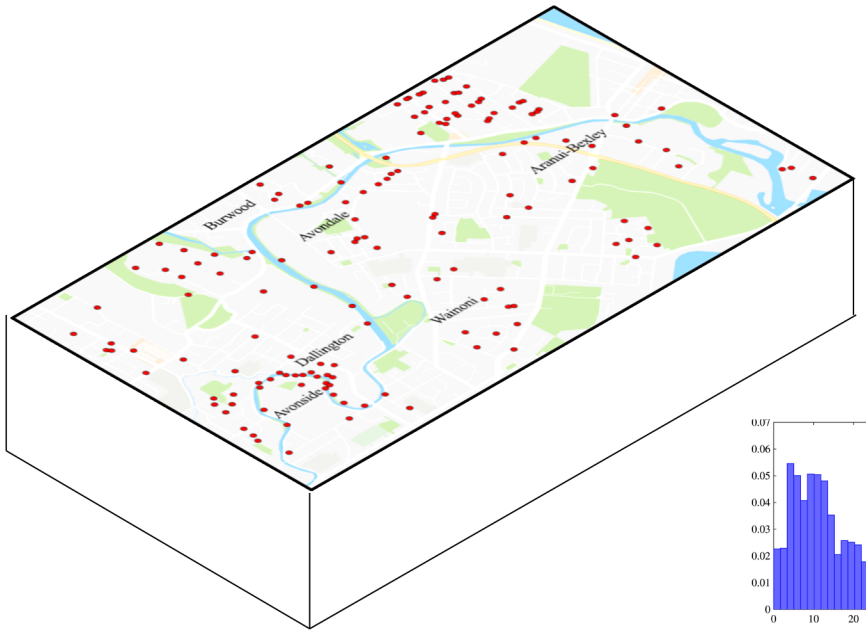
Building Inventory

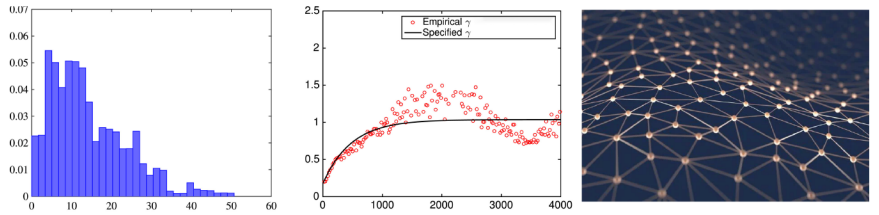
AI-Based Pipeline for Regional Building Inventory Procurement

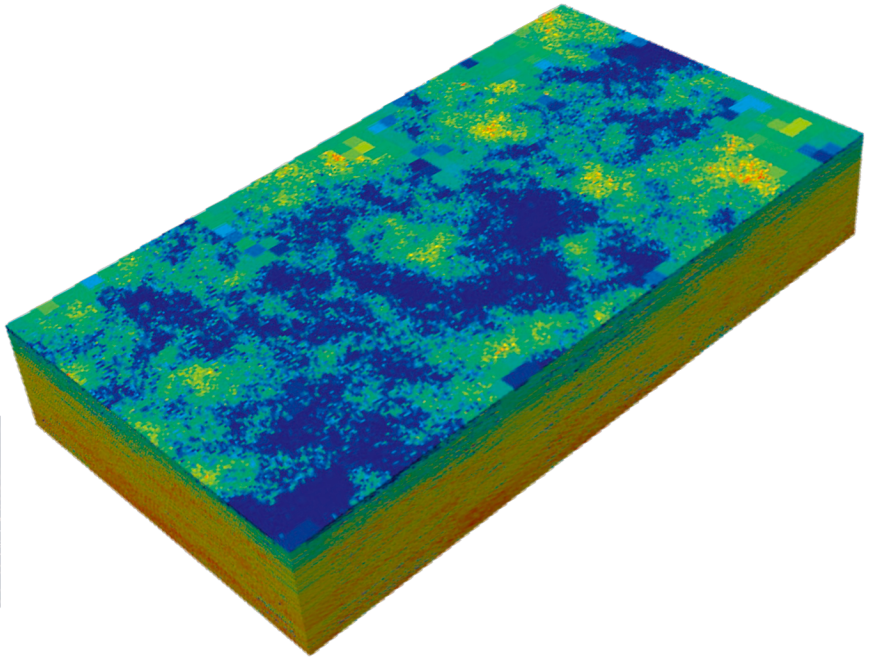
AI & Computer Vision for Nat Hazards

SimCenter AI projects

Spatial Uncertainty Quantification (https://github.com/charlesxwang/SURF)







Scattered Raw Data

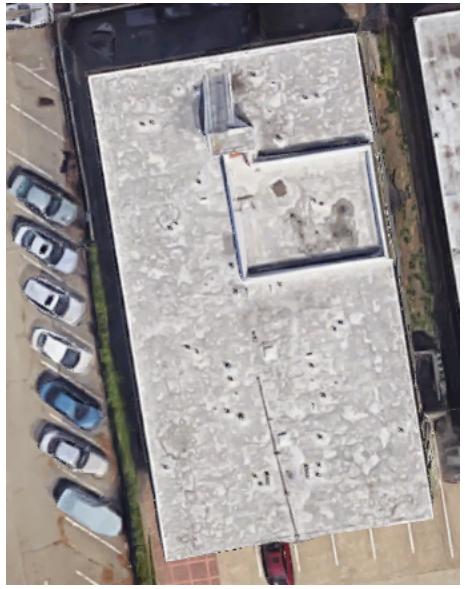
Statistical & Spatial Structure Analysis

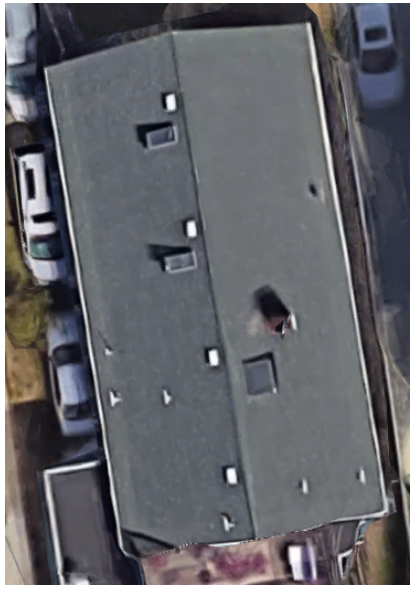
Random Field Realization

Hands on example 1. Image classification

AI & Computer Vision for Nat Hazards

Image classification: roof type





Flat

Gabled

Hipped

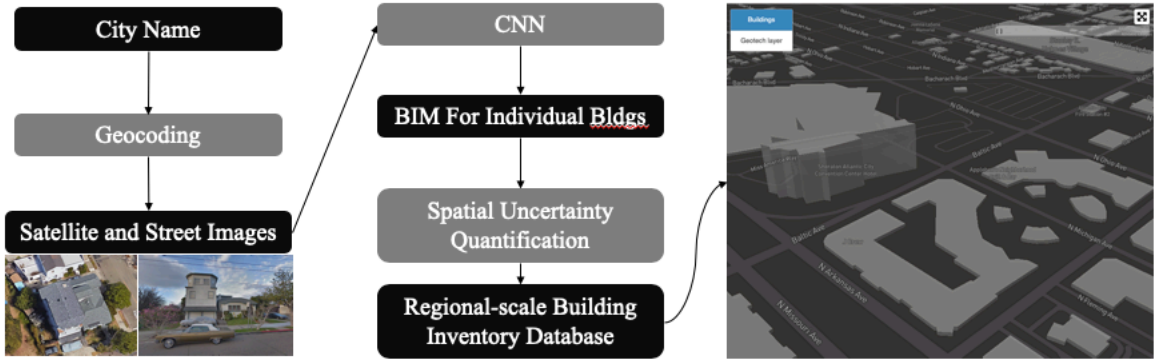
AI & Computer Vision for Nat Hazards

Image classification: roof type

Regional building information model procurement (https://github.com/charlesxwang/BIM.AI)

Get the code and prepare the environment:

cd to-the-dir-you-like
git clone https://github.com/charlesxwang/BIM.AI
cd BIM.AI/src
pip install –r requirements.txt



Building Inventory

AI & Computer Vision for Nat Hazards

Image classification: roof type

a. Download the images

mkdir training/roof/tmp/
cd training/roof/tmp/
wget -v -O roof.zip https://berkeley.box.com/shared/static/x2sslz2scsut6yo1ro2x5gvun2tumj6d.zip
unzip roof.zip

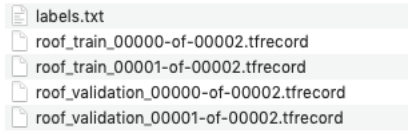
AI & Computer Vision for Nat Hazards

Image classification: roof type

b. Images => TFRecords

cd ../../../training/roof/1_create_tfrecords
python3 create_tfrecord.py --dataset_dir=**dir/containing/roofImages** --tfrecord_filename=roof

You get these:



lables.txt

```
0:flat
1:gabled
2:hipped
```

AI & Computer Vision for Nat Hazards

Image classification: roof type

c. Train a CNN (inception-v3) using Tensorflow-slim

```
cd ../2_train
sh finetune_inception_v3_on_roof_train.sh
```

The training takes a long time on laptops. If you don‘t want to run the training process, we have a CNN trained on TACC and can be downloaded https://berkeley.box.com/shared/static/awyyc22sjwknn9xg3p7wru4v5zwnlkjp.zip. Put the downloaded file inside src/training/roof/tmp/roof-traindir/ and unzip it.
You can use Ctrl+c in the terminal to stop the training process.

AI & Computer Vision for Nat Hazards

Image classification: roof type

d. Test the trained CNN

sh finetune_inception_v3_on_roof_eval.sh

In order to run the above script, you need to setup 1. the path of trained CNN 2. the path containing testing images in file finetune_inception_v3_on_roof_eval.sh:
checkpoint_file=${TRAIN_DIR}/your-ckpt-file-name #for example : model.ckpt-119999
TEST_DIR=/dir/containing/images/

AI & Computer Vision for Nat Hazards

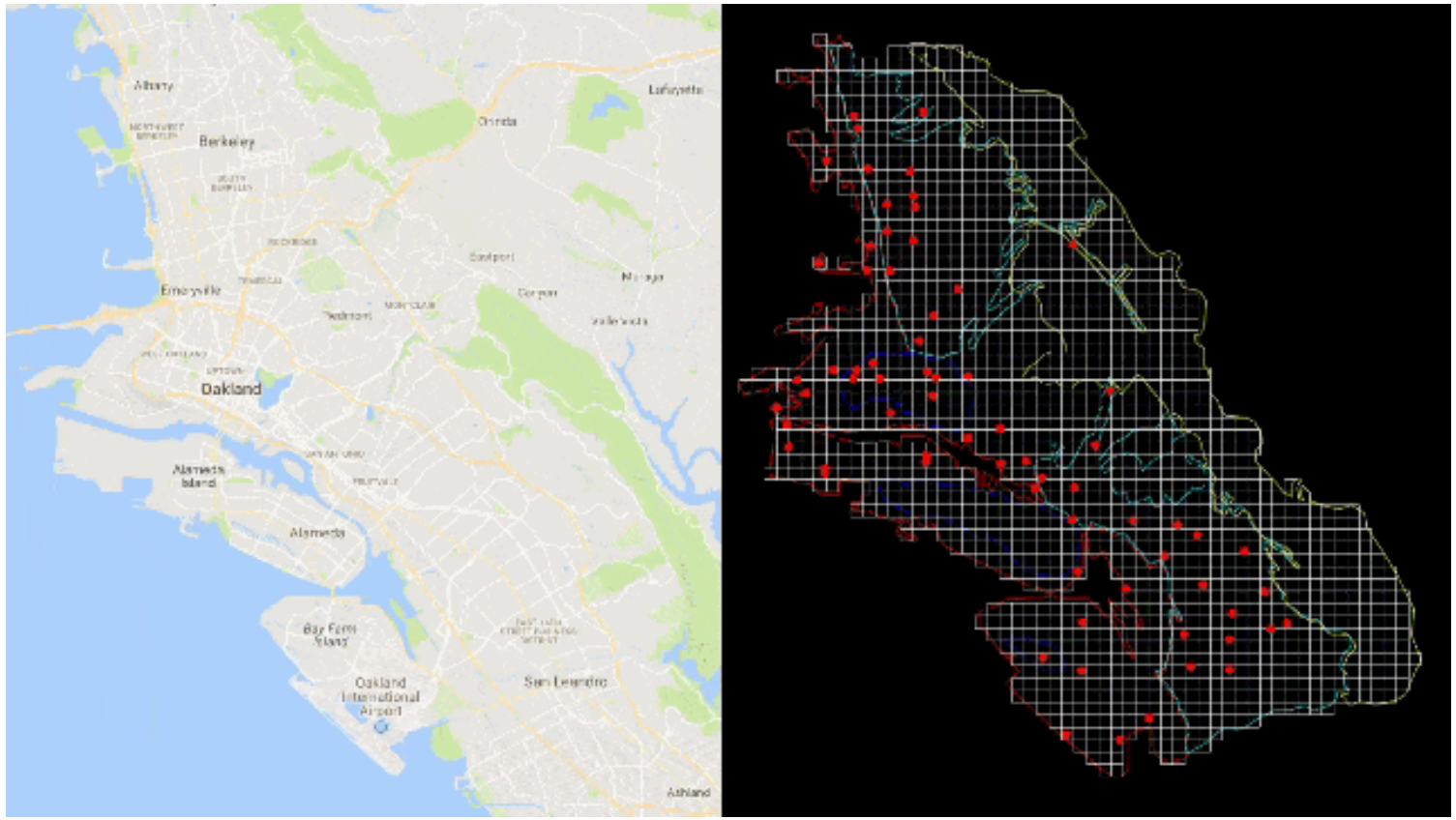
Image classification: roof type

e. Practice: try to set up a training process for soft-story building classification

Data is here: https://berkeley.box.com/shared/static/0ejgwp56aux32opa4mwfawj0vglxnact.zip

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

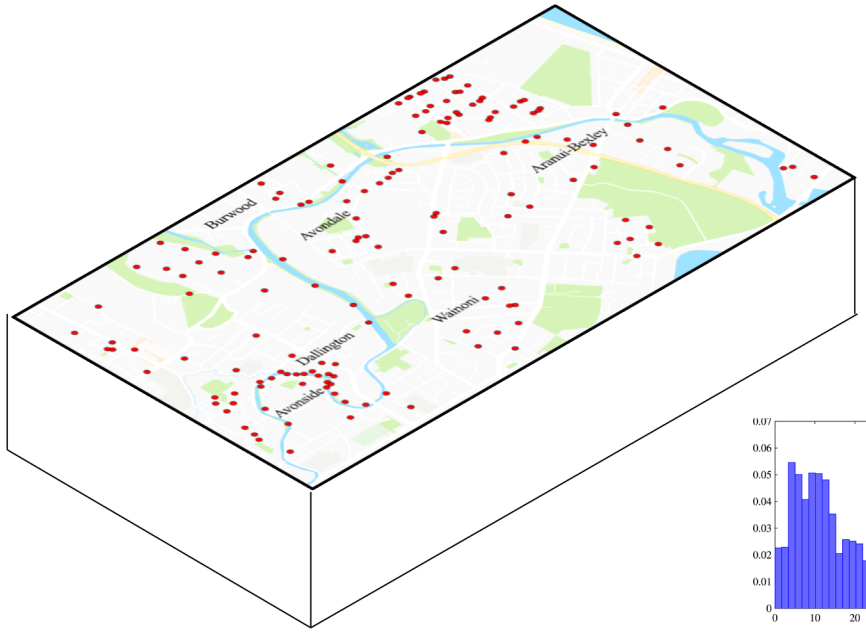


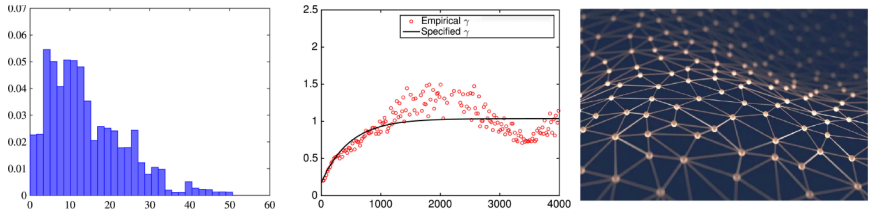
A framework for spatial uncertainty quantification

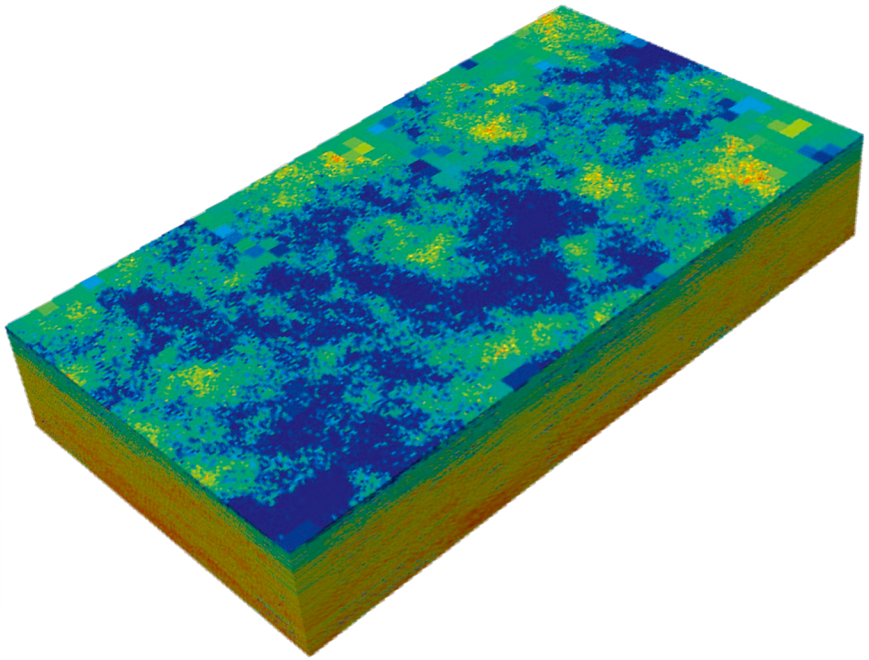
https://github.com/charlesxwang/SURF

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)







Scattered Raw Data

Statistical & Spatial Structure Analysis

Random Field Realization

https://github.com/charlesxwang/SURF

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

Random field engine

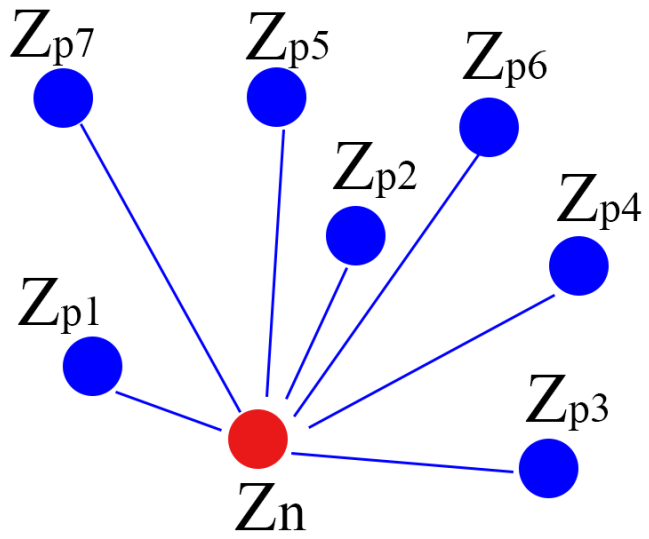
$$\boldsymbol{Z} \sim N(\boldsymbol{\mu}, \boldsymbol{\Sigma}) \xrightarrow{\text{partition}} \begin{bmatrix} \boldsymbol{Z}_n \\ \boldsymbol{Z}_p \end{bmatrix} \sim N\left(\begin{bmatrix} \boldsymbol{\mu}_n \\ \boldsymbol{\mu}_p \end{bmatrix}, \begin{bmatrix} \boldsymbol{\Sigma}_{nn} & \boldsymbol{\Sigma}_{np} \\ \boldsymbol{\Sigma}_{pn} & \boldsymbol{\Sigma}_{pp} \end{bmatrix} \right)$$

multivariate Gaussian distribution

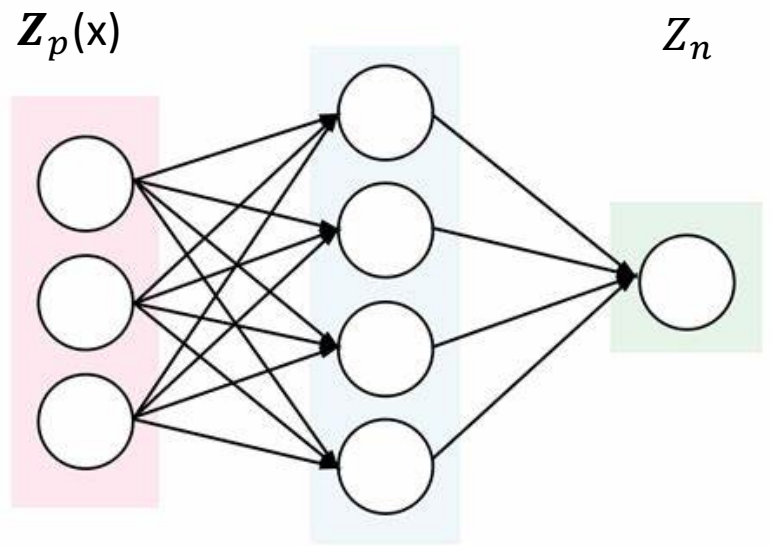
conditional distribution of RV Z_n:

$$\boldsymbol{Z}_n | \boldsymbol{Z}_p \sim N(\boldsymbol{\mu}_{\boldsymbol{Z}_n|\boldsymbol{Z}_p}, \Sigma_{\boldsymbol{Z}_n|\boldsymbol{Z}_p})$$

C. Wang and Q. Chen, A hybrid geotechnical and geologic data-based framework for multiscale regional liquefaction hazard mapping, *Géotechnique*, 68(7):614-625, doi:10.1680/jgeot.17.P.074, 2018.



Machine learning engine



$$Z_n = f(\boldsymbol{Z}_p(\mathrm{x}))$$

Hands on example 2. Data enhancement (build your own neural nets)

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

We have this BIM.geojson, https://berkeley.box.com/shared/static/mmcjsjfkfl6q4it83cv16xzku1jdogz4.geojson which contains BIM for each building.
But the information of some parts of some buildings is missing.


```
{
        "type": "Feature",
        "id": "8461",
        "properties": {
                "id": "8461",
                "lat": 39.3716807,
                "lon": -74.4513949,
                "address": "1619 COLUMBIA AVE, ATLANTIC CITY,NJ",
                "stories": 2,
                "yearBuilt": 1979,
                "occupancy": "Residential",
                "structureType": "Frame",
                "buildingDescription": "2SF",
                "city": "ATLANTIC CITY CITY"
        },
        "geometry": {
                "type": "Polygon",
                "coordinates": [
                        [
                                [-74.451353, 39.371717],
                                [-74.451493, 39.371755],
                                [-74.451526, 39.37168],
                                [-74.451386, 39.371643],
                                [-74.451353, 39.371717]
                        ]
                ]
        }
}
```

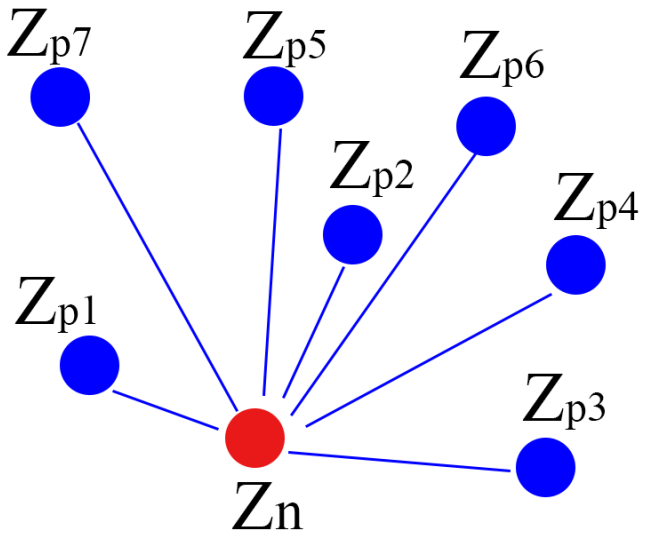

For example, yearBuilt is missing for some buildings

Enhancing Data with AI

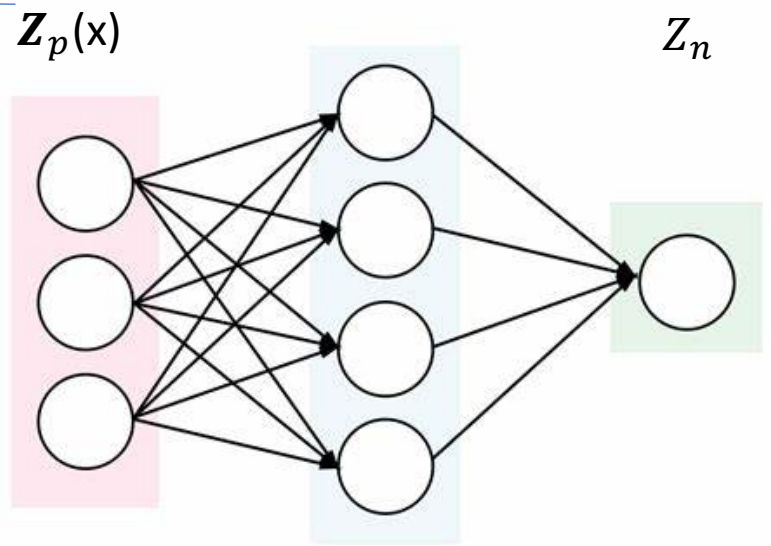
Spatial Uncertainty Research Framework (SURF)

Construct the input vector $\boldsymbol{Z_p}(x)$

Zn_lon
Zn_lat
Distance_Zn_Zp1
Value_Zp1
Distance_Zn_Zp2
Value_Zp2
Distance_Zn_Zp3
Value_Zp3
.
.
.
.



Machine learning engine



$$Z_n = f(\boldsymbol{Z_p}(x))$$

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

Continuous

Put the following into SURF-bootcamp.py:

```
from surf.NN import SpatialNeuroNet

# construct dada (columns are: lon,lat,value) as numpy.ndarray

nn = SpatialNeuroNet(rawData = data, numNei = 2)
nn.build_model()
nn.train()
nn.test()
```

Categorical

```
from surf.NN import SpatialNeuroNet

# construct dada (columns are: lon,lat,value) as numpy.ndarray

nn = SpatialNeuroNet(rawData = data, numNei = 2)
nn.build_classification_model(numofTypes)
nn.train_classification_model()
nn.test_classification_model()
```

Then issue this in your terminal under SURF/

python SURF-bootcamp.py

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

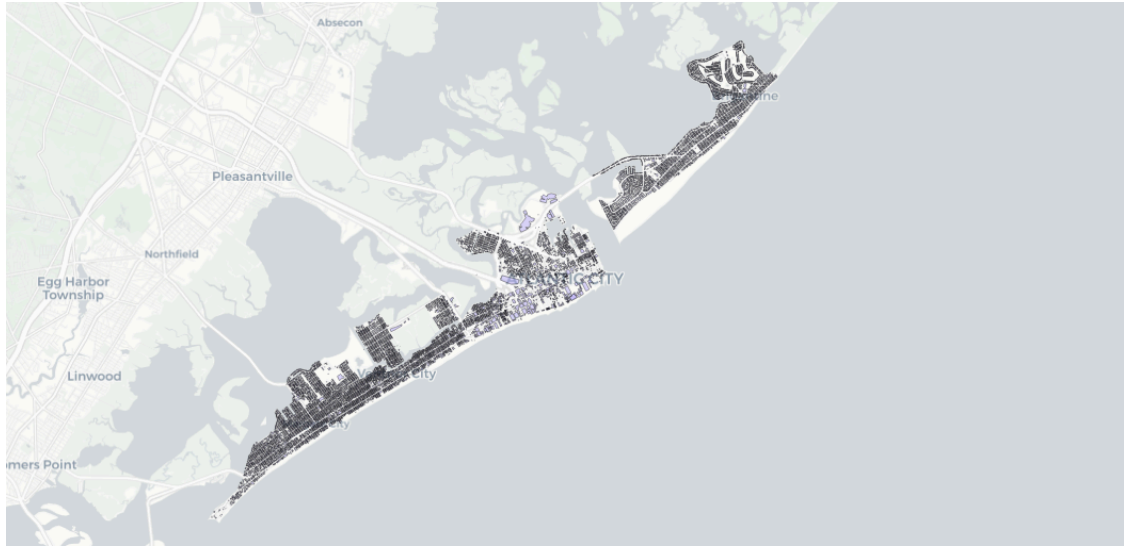
You can modify the architecture of the NN (SURF/surf/NN.py)

```
model = keras.Sequential([
layers.Dense(256, activation=tf.nn.rel u,input_shape=[len(self.train_dataset.T)]),
layers.Dense(64, activation=tf.nn.relu),
layers.Dense(64, activation=tf.nn.relu),
layers.Dense(64, activation=tf.nn.relu),
layers.Dense(1)
])
```

Enhancing Data with AI

Spatial Uncertainty Research Framework (SURF)

Results



Feature	Value
Atlantic_Cities_BIM OGRGeoJSON Polygon	
buildingDescription	F3S
(Derived)	
(Actions)	
city	ATLANTIC CITY CITY
structureType	Frame
lon	-74.4601876
roofType	hipped
occupancy	Residential
stories	3
buildingDescription	F3S
address	55 S RALEIGH AVE, ATLANTIC CITY,NJ
lat	39.3474871
yearBuilt	1920
id	964101