

GeoAI Demystified

mraad@esri.com

thunderheadxplor.blogspot.com

@mraad

Artificial Intelligence Is Changing Our World...

1997



Agencies

2011



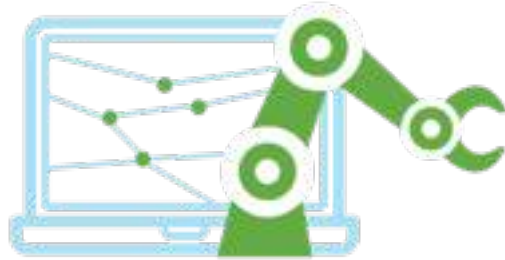
Carol Kaelson/Jeopardy Productions Inc.,
via Associated Press

2016



Google

Ubiquitous Intelligent Applications...



Preventive Maintenance



Crime Prevention



1N73LL1G3NC3

15 7H3

4B1L17Y

70 4D4P7 70

CH4NG3.

-573PH3N H4WK1NG

RIP

Intelligence Is...

“...ability to perceive or **infer** information, and to **retain** it as knowledge to be applied towards **adaptive** behaviors within an environment or context.”

<https://en.wikipedia.org>

Artificial Intelligence Is...

“...intelligence demonstrated by machines...”

“...mimics ‘cognitive’ functions that humans associate with other human minds, such as ‘learning’ and ‘problem solving’...”

<https://en.wikipedia.org>

Why AI Is Trending Now ?



Big Data

Tremendous advancement to Computing power & Storage for massive amounts of data are fueling AI to “learn” about so many paradigms very FAST and with little costs



Internet of Things

IoT is connecting literally “everything” to the realm of intelligence, enabling the extraction of data from different objects and hence the ability to apply AI techniques to it making it smarter



Cloud Computing

Cloud computing is enabling 1. cheap & convenient storage for massive amounts of data 2. Easily setting up Big Data & AI infrastructure - which used to be very complex before

<https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/an-executives-guide-to->

Feature Engineering

“...is the process of using domain knowledge of the data to create **features** (and **labels**) that make machine learning algorithms work.”

<https://en.wikipedia.org>

What is a Feature and Label ?

Features **Output (label)**

Call Drops	# Complains	Subscribed Package	Call Rate Decline	Churned?
4	5	ABC	20%	Yes
6	2	ABC	5%	No
9	4	XYZ	12%	Yes



Predicting Churn

What is a Feature and Label ?



Road Accidents Prediction

Segment Type	Proximity to Intersection	Time of Day	Weather	Accident
Highway	0.1 M	Morning	Raining	Injury
Tunnel	0.3 M	Evening	Sunny	Property
Inner	0.2 M	Noon	Foggy	Injury

What is a Feature and Label ?



Water Leakages Prediction

Pipe Age	Depth	Temperature	Pressure	Break
20	3 m	95 F	20 P	Yes
15	4 m	5 F	35 P	Yes
6	3.5 m	2 F	17 P	Yes

What is a Feature and Label ?



Retail Sales Prediction

# Females 35 - 50	F&B Sales	% Urban Chic	# Competitors	Sales
35,000	\$400M	55%	15	\$20M
14,000	\$150M	15%	27	\$5M
27,000	\$210M	26%	9	\$12M

Coming up with features is difficult, time-consuming, requires expert knowledge. "Applied machine learning" is basically feature engineering.

— Andrew Ng, *Machine Learning and AI via Brain simulations*

For Big-Data Scientists, 'Janitor Work' Is Key Hurdle to Insights

By STEVE LOHR AUG. 17, 2014

<https://www.nytimes.com/2014/08/18/technology/for-big-data-scientists-hurdle-to-insights-is-janitor-work.html>

NEWS

Hottest job? Data scientists say they're still mostly digital 'janitors'

Upcoming priorities include a focus on machine learning, this report suggests



By Katherine Noyes

Senior U.S. Correspondent, IDG News Service | MAR 23, 2016 5:35 PM PT

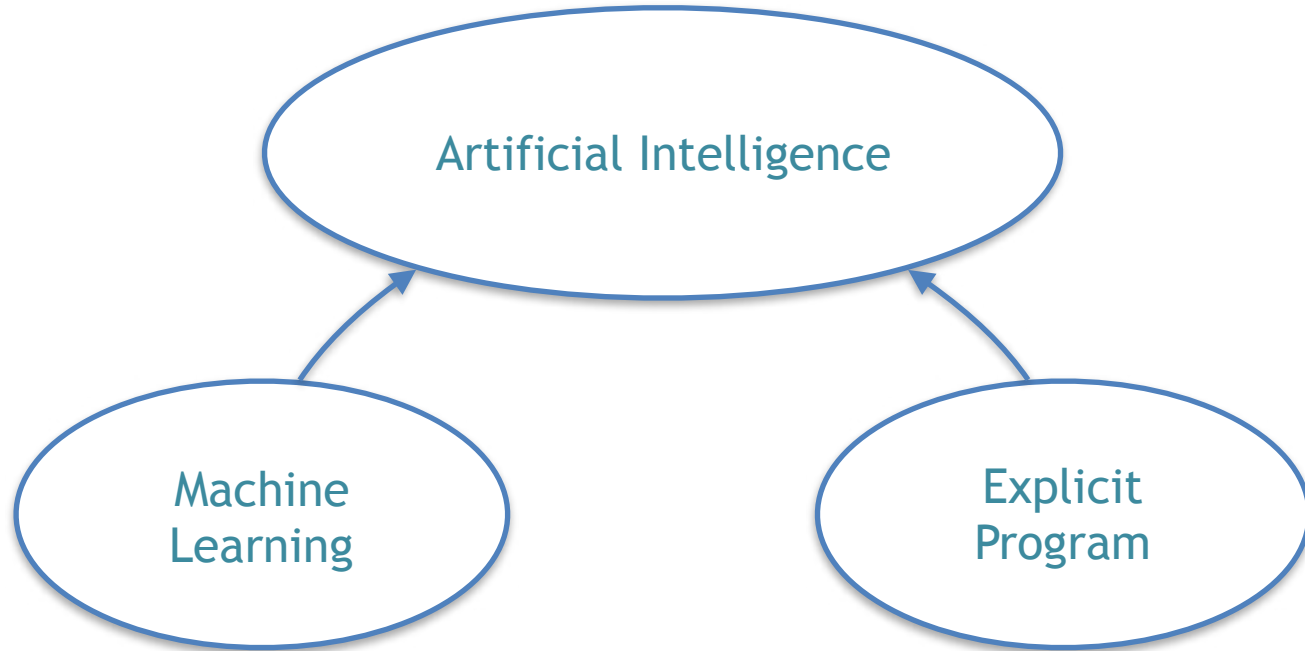
<https://www.computerworld.com/article/3047642/big-data/hottest-job-data-scientists-say-theyre-still-mostly-digital-janitors.html>

Machine Learning

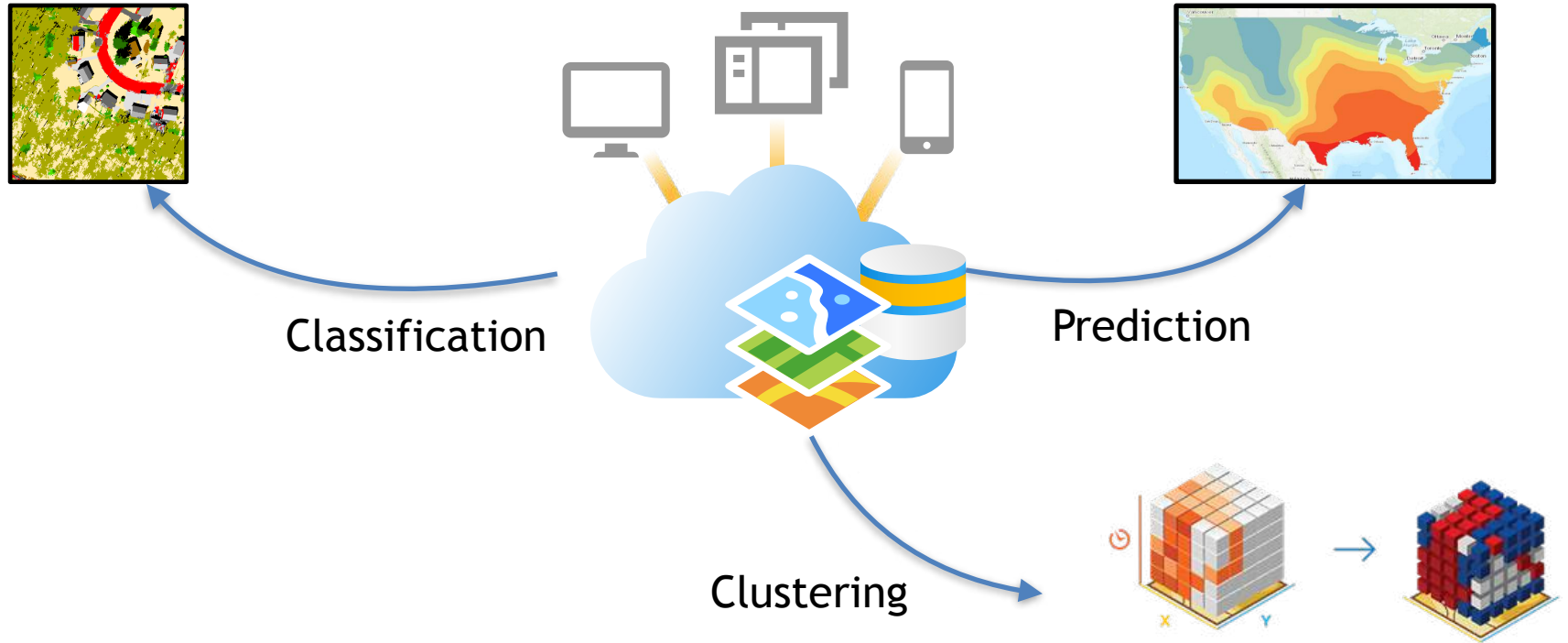
“...techniques to give the machine the ability to “learn” with data, ***without being explicitly programmed***”

https://en.wikipedia.org/wiki/Machine_learning

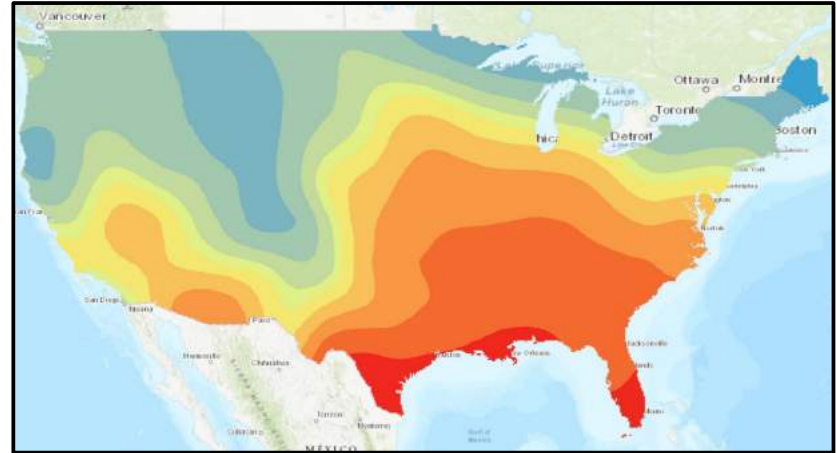
Machine Learning



ArcGIS Has Machine Learning Tools



Prediction



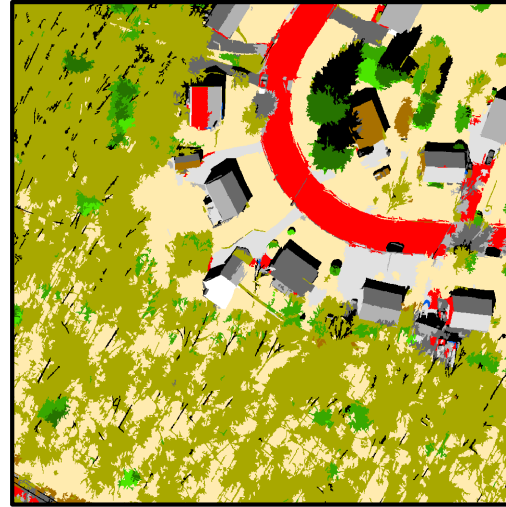
Empirical Bayesian Kriging, Areal Interpolation, EBK Regression Prediction, Ordinary Least Squares Regression and Exploratory Regression, Geographically Weighted Regression

Clustering



Spatially Constrained Multivariate Clustering, Multivariate Clustering, Density-based Clustering, Image Segmentation, Hot Spot Analysis, Cluster and Outlier Analysis, Space Time Pattern Mining

Classification



Maximum Likelihood Classification, Random Trees, Support Vector Machine

ArcGIS Integrates with AI Frameworks



Machine Learning Types

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

Supervised Learning

- Set of algorithms that use **Features** and **Labels**
- Algorithm learn relationship between **Features** and **Labels**

Supervised Learning Algorithms

- Linear Regression
- Logistic Regression
- Decision Trees
- Support Vector Machines
- Random Forest
- Neural Network

Unsupervised Learning

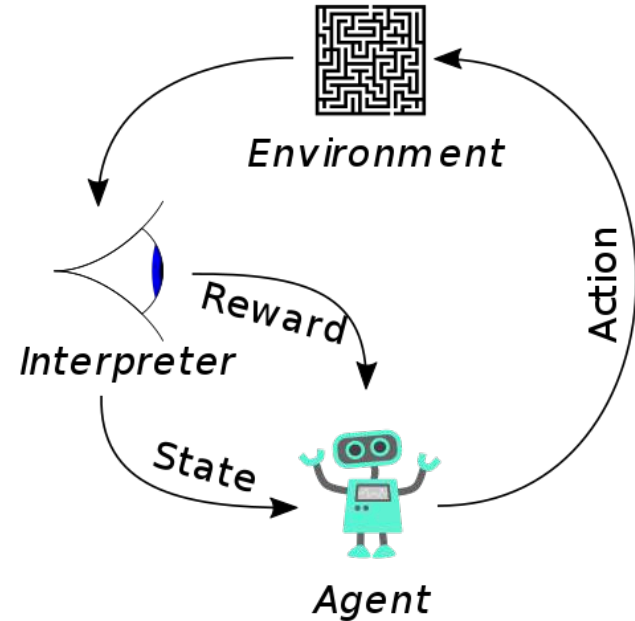
- Set of algorithms that use **Features** to discover Labels
- Algorithm learn relationship between **Features without Labeling**

Unsupervised Learning Algorithms

- K-Mean Clustering
- H/DBSCAN
- Self Organizing Maps

Reinforcement Learning

“Set of algorithms that enable software agents to take *actions* in an *environment* so as to maximize some notion of cumulative *reward*”



https://en.wikipedia.org/wiki/Reinforcement_learning



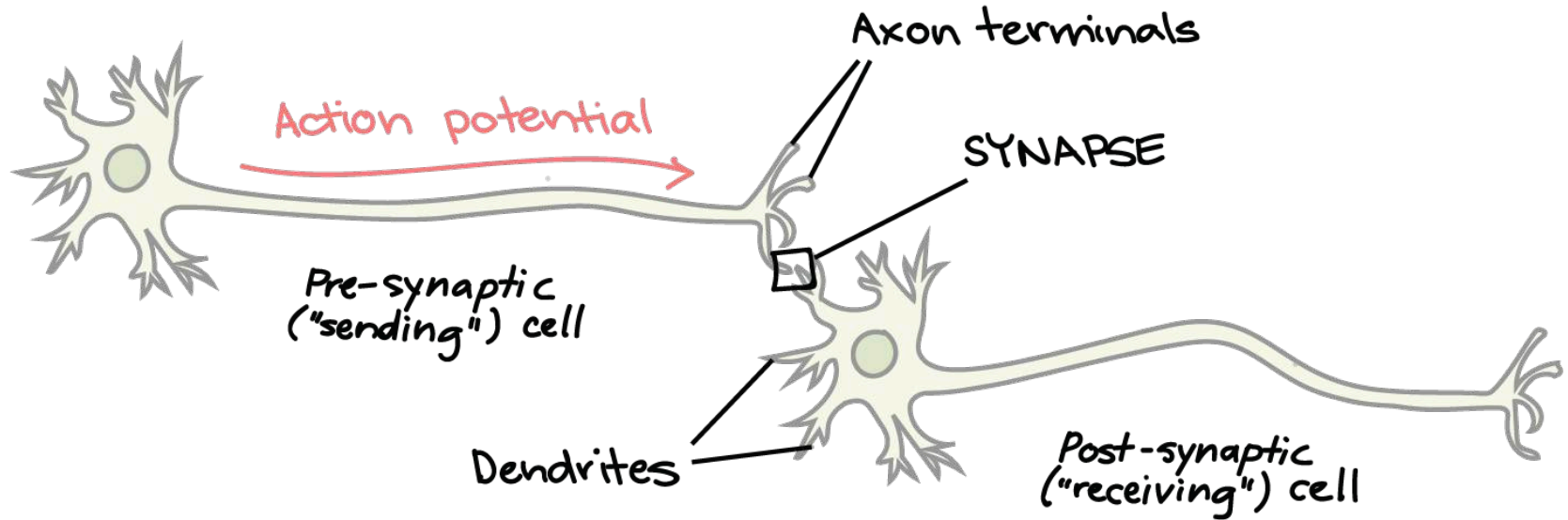
<https://www.youtube.com/watch?v=V1eYniJ0Rnk>

DeepLearning and Neural Networks

Deep learning neural network models are loosely related to information processing and communication patterns based on the neural encoding in the brain.

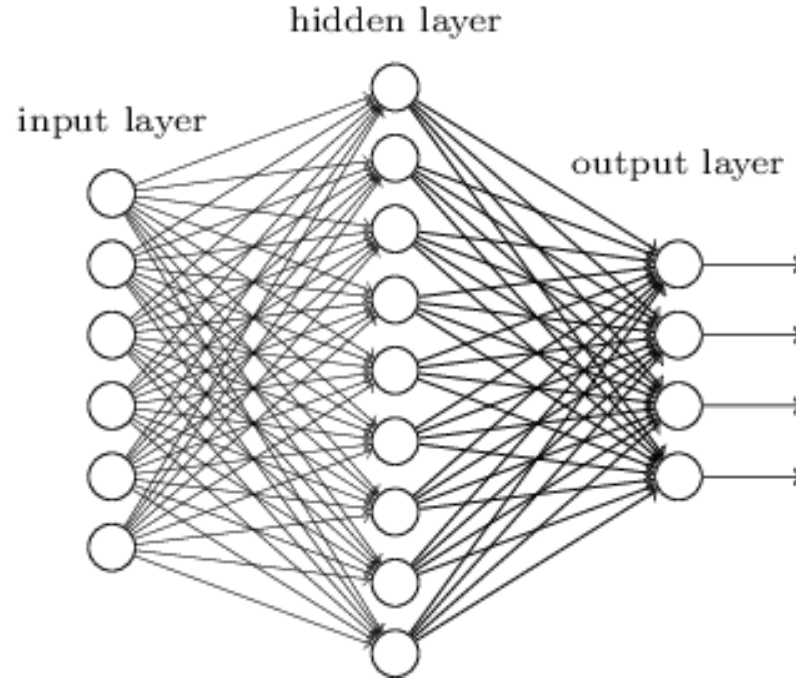
https://en.wikipedia.org/wiki/Deep_learning

Neural Networks In The Brain



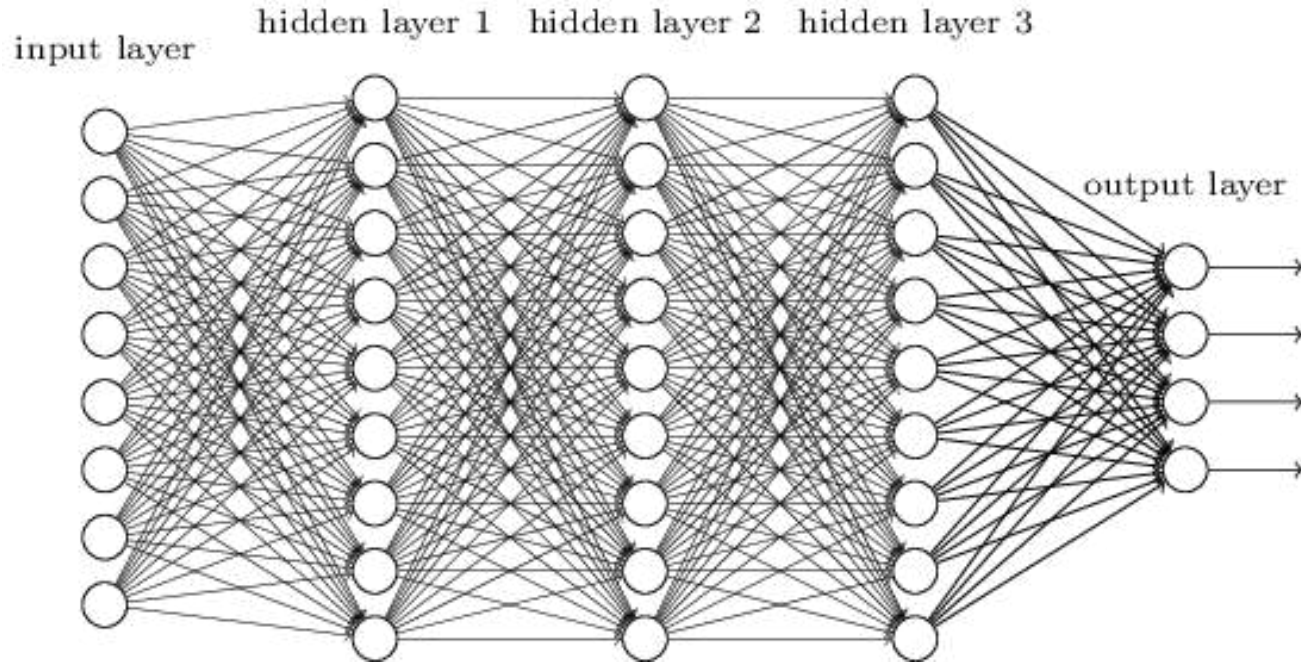
<https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-synapse>

Artificial Neural Network



<http://neuralnetworksanddeeplearning.com/chap5.html>

Artificial Deep Neural Network

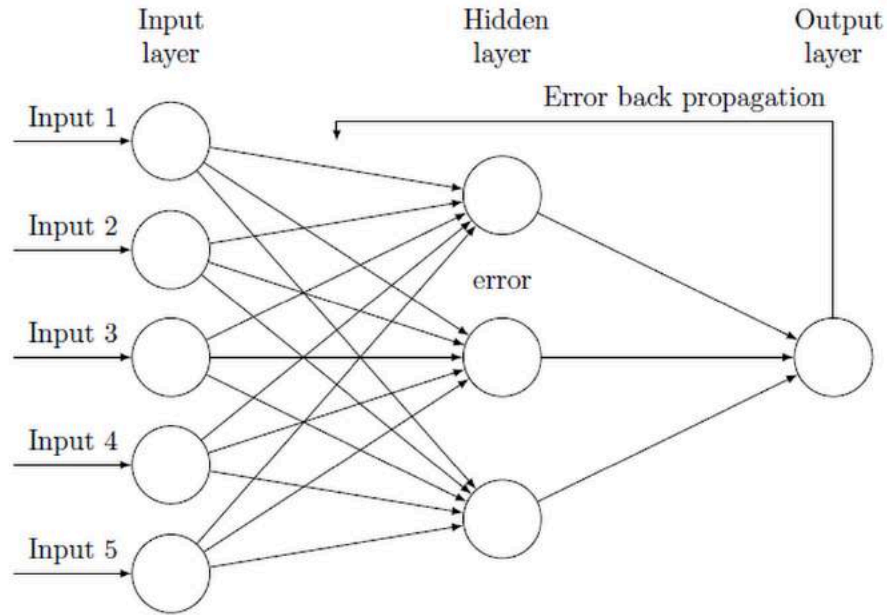


<http://neuralnetworksanddeeplearning.com/chap5.html>

DeepLearning

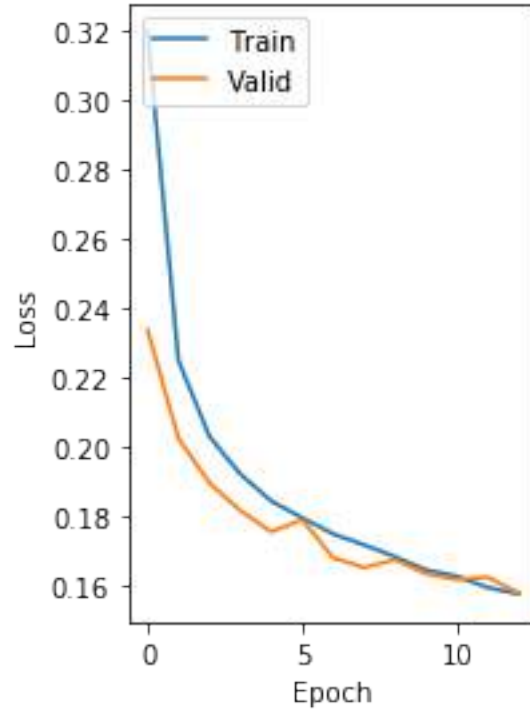
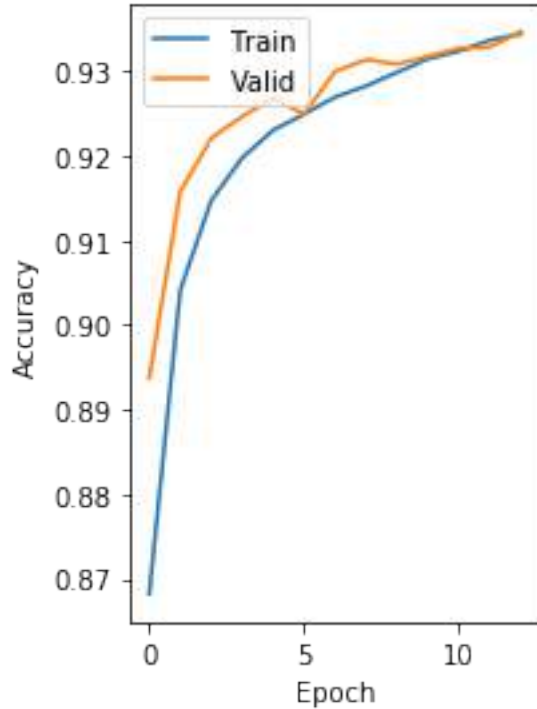
- Set of algorithm that use Features and or Labels
- To discover relation between Features and Label (supervised)
- To discover relation between Features with no labels (unsupervised)
- Use
 - Gradient Descent
 - Back Propagation

DeepLearning Gradient Computation - Back Propagation

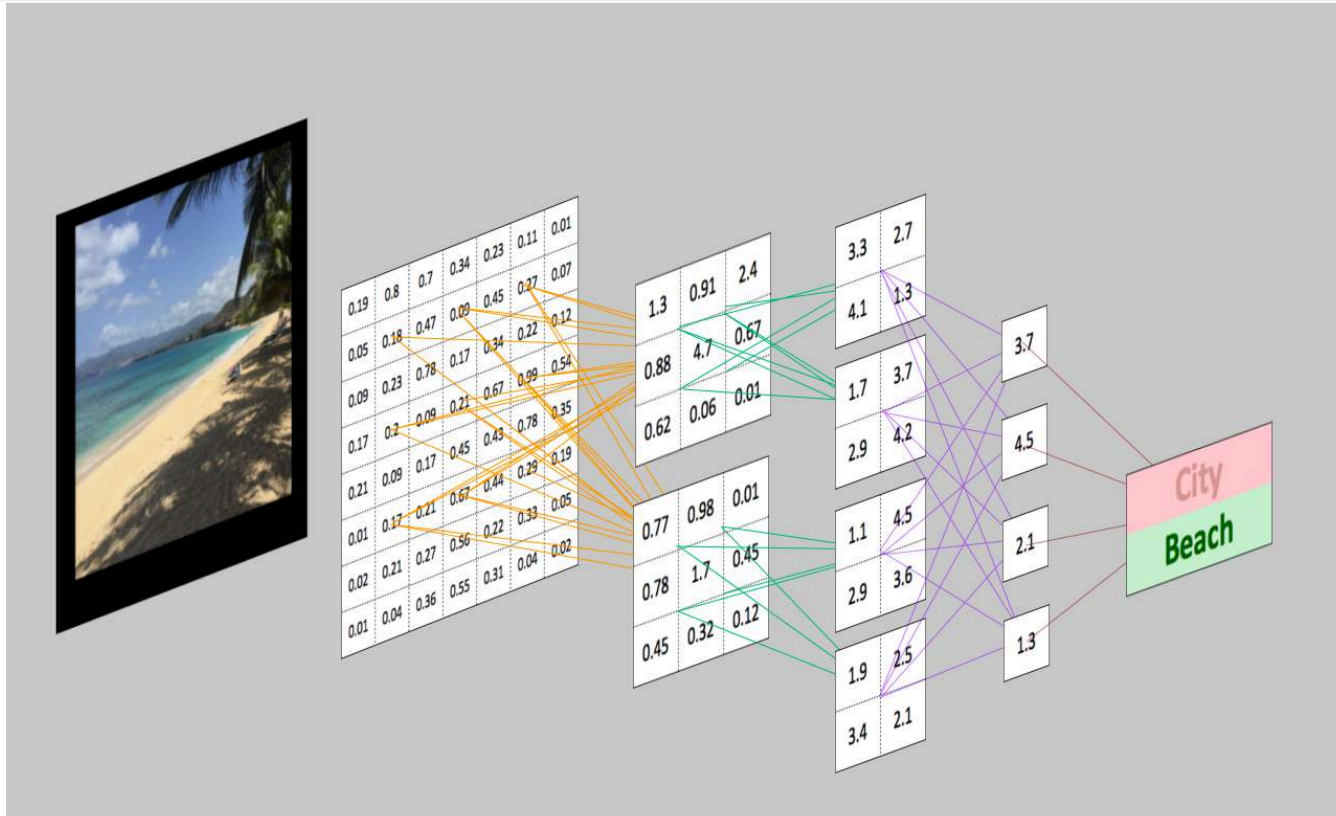


<https://plus.google.com/+DavidAmerland/posts/CJoCoAjDBoC>

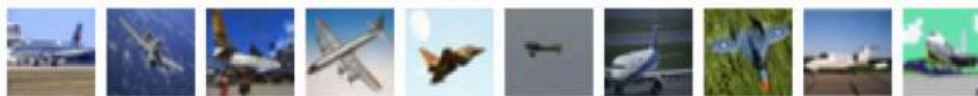
Epochs, Loss, Accuracy



Convolution Neural Network - CNN



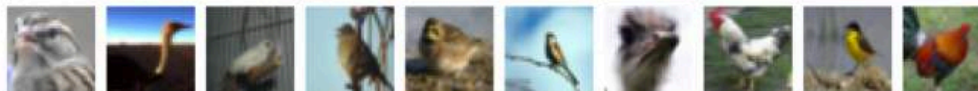
airplane



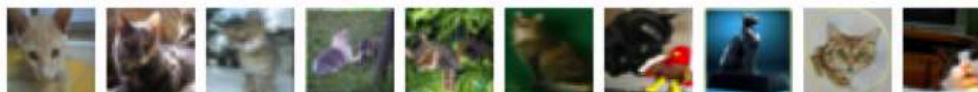
automobile



bird



cat



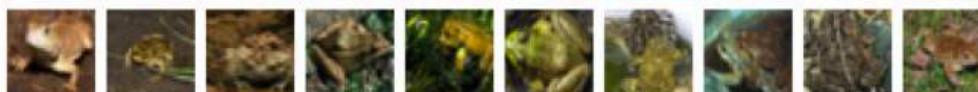
deer



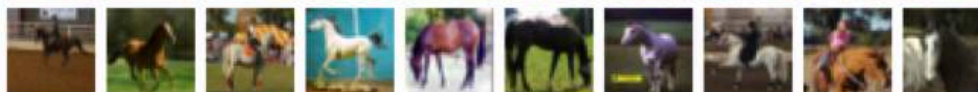
dog



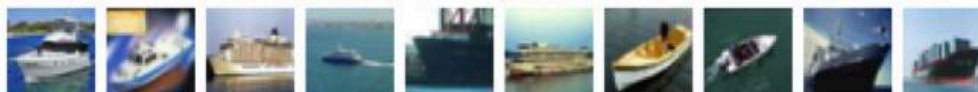
frog



horse



ship

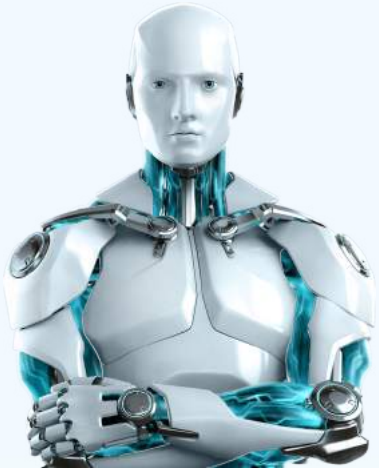


truck



Geo.AI: Hype to Action

Use-cases



City Movements Analytics

Reveal underlying patterns in Human Movement Behavior for
Transport, Retail, Local Government, etc.

Big Data Aggregation

Phone Big Data ST Events Aggregation, highlighting trends, patterns and anomalies in data

Telco Data

GPS

LBS



Fishnet,
Hexagon Grids,
Districts,
Road Congestion,
Point Features.
Heat Maps



Big Data Aggregation

Phone Big Data ST Events Aggregation, highlighting trends, patterns and anomalies in data

Telco Data

GPS

LBS

Fishnet,
Hexagon Grids,
Districts,
Road Congestion,
Point Features.
Heat Maps

City in Motion

VIEW ROBBERY SUSPECTS

SHOW MAX LOCATIONS

SUBSCRIBERS

33844

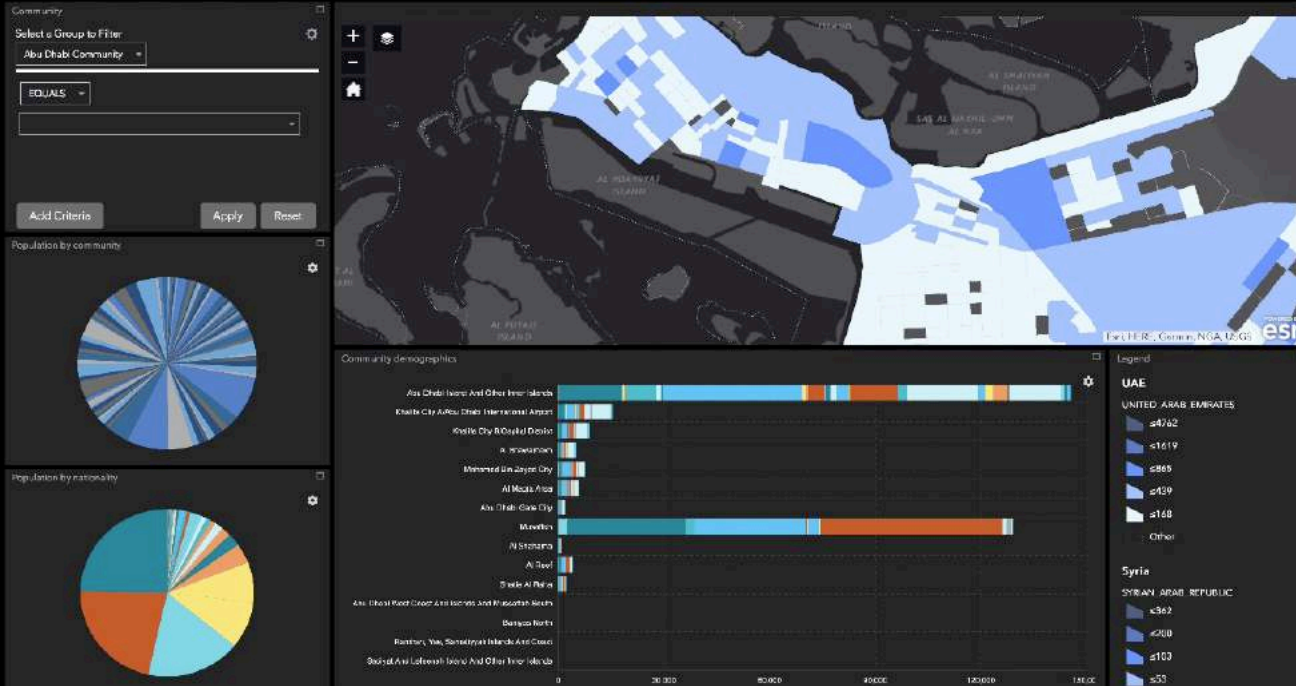
SUSPECTS

89

Powered by Esri

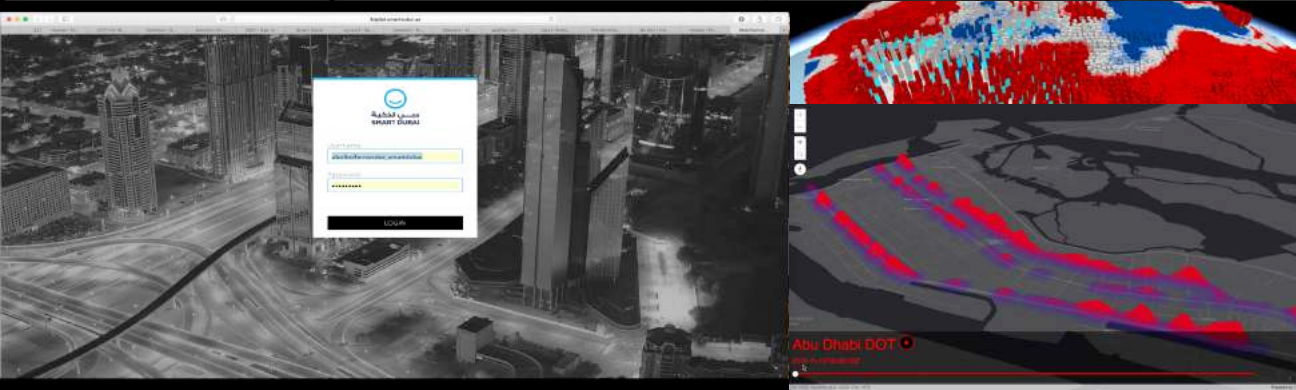
NOV 25 2017

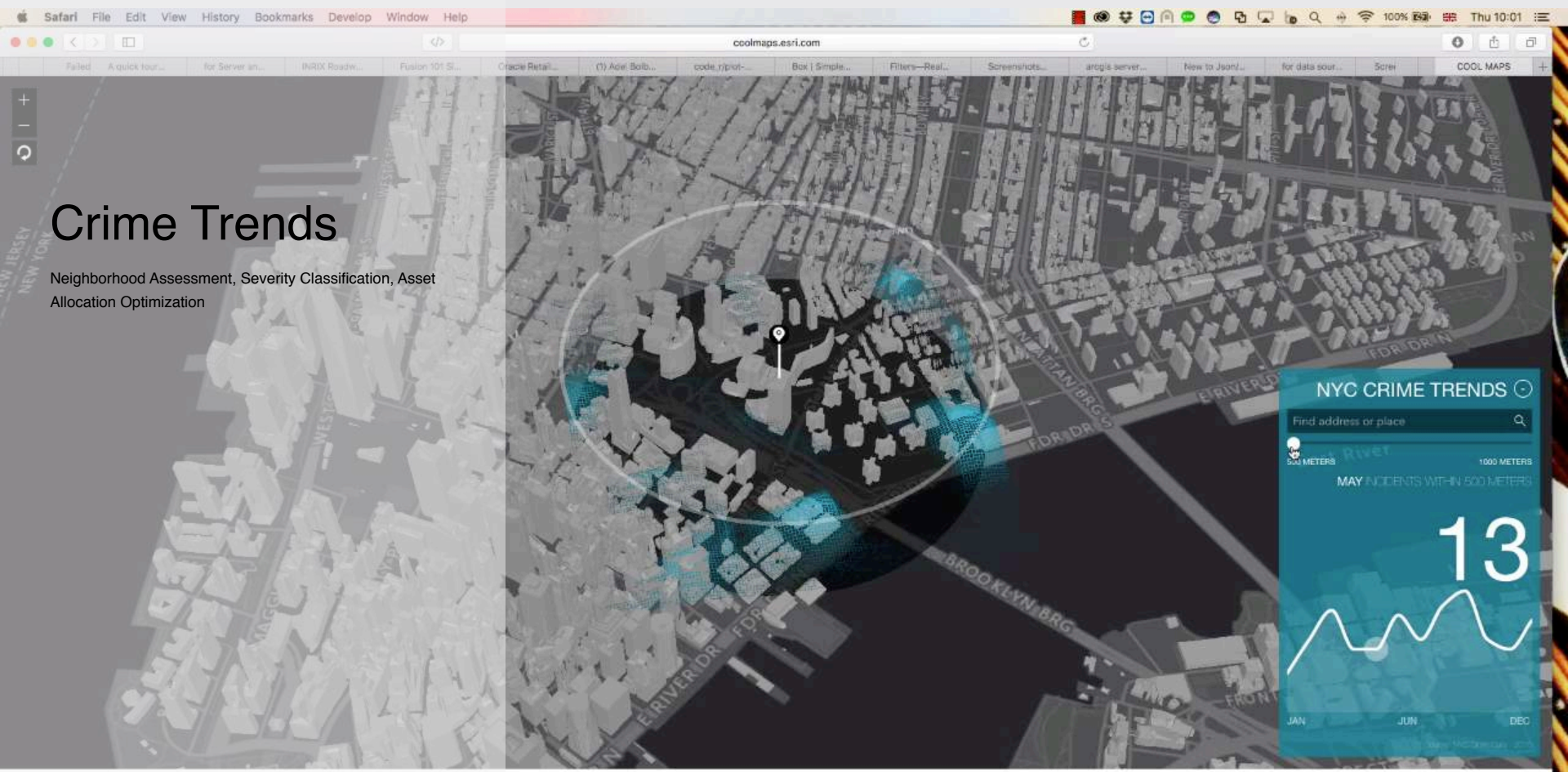
12:00 PM



Transportation Dynamics

Identifying & Visualizing travel trends, Building Origin-Destination Matrices, Highlighting problem-areas, ESRI Live Traffic Information (Tourism, Transport, City Planning, etc.)





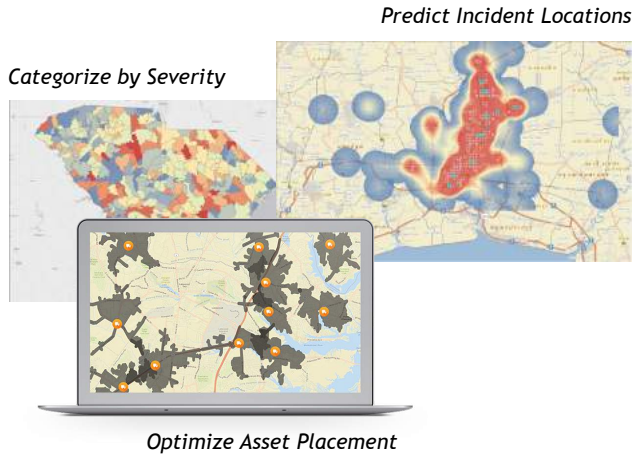


Incident Prediction

Predict Incident Locations, Classify by Severity, Optimize Asset Allocation

Predictive Incident Analytics

- Predicting the Location, Type and Time of Incidents before they occur by utilizing Advanced Statistical Modelling and Machine Learning on Historical Incident Data
- This helps in Cutting Incident Rates, Optimizing Patrols Allocation, exploring Incident Rout-Causes, and better Response Planning



1. Data Extraction

Pulling Data from difference sources and passing it to the Predictive Models



Incidents

Type of Incident, and the Details of it



Location

of Incident & surrounding Spatial Aspects



Time

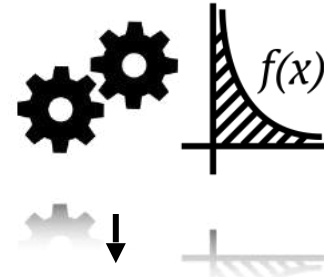
Date, Time of the Day, Temperature, Humidity, Day of the Month
Rains..



Weather

2. Predictive Analytics

Engine captures the data and runs it against Advanced Statistical Models



3. Interactive Maps

Predicted Locations of Incidents are shown on ArcGIS or Insights for Dynamic Analysis



Spatiotemporal Variables that might correlate to Accidents



Road Alignment
Straight / Curved



Road Type
*Double / Single
Carriageway*



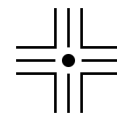
Num of Lanes
1,2,3..



Road Width
20-30 M



Segment Type
*Highway, Bridge,
Tunnel..*



Road Junction
*Crossroads,
Roundabout..*



Day of the Week
Sun, Mon, Fri..



Time of the Day
12:45, 23:00



Rush Hour
Yes/No



Weekend
Yes/No



Raining
Yes/No



Fog
Yes/No



Temperature
Sun, Mon, Fri..



Nearby Event
Sports, Festivals..



Nearby block
*From related
roads*



Speed Limit
120 km/h

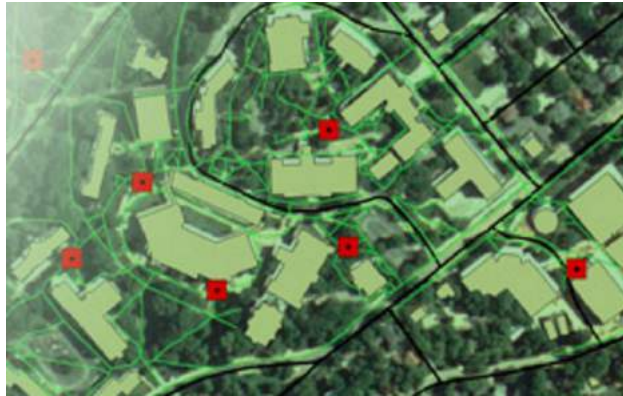


Road Works
Yes/No

.. & more

1. Training Set:

Listing the values of all independent features variables that were associated with historical accident incidents - and using this to train the predictive model



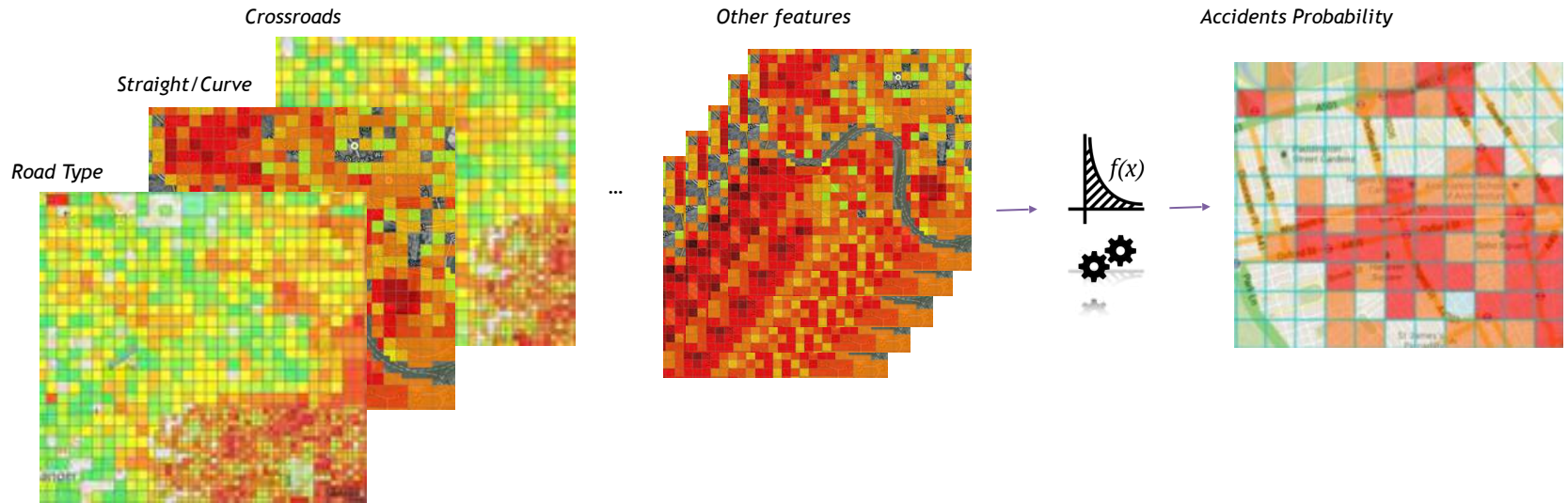
Independent Variables

Dependent Variable

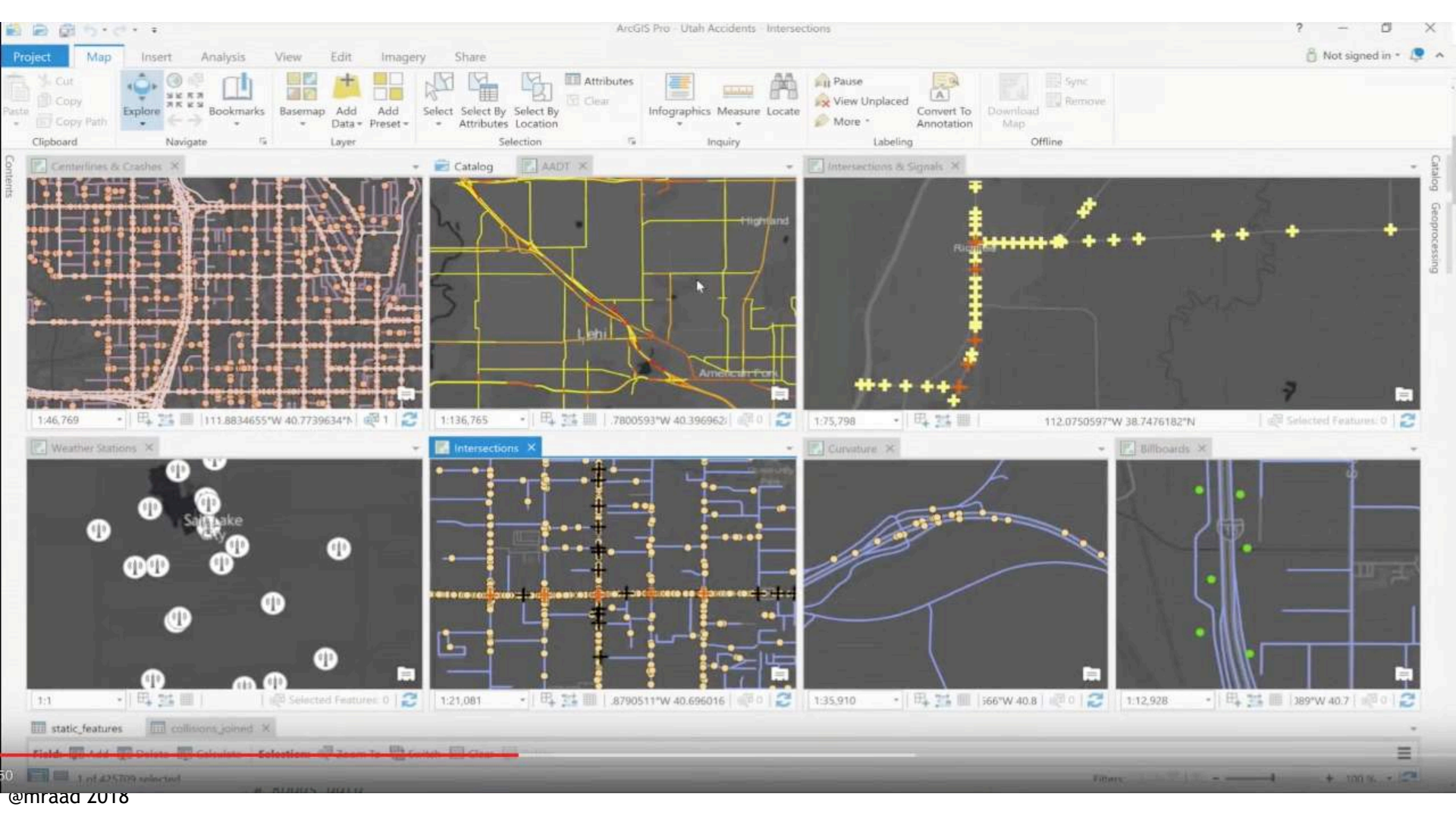
Time	Segment	Curved	Lanes	Type	Width	Rain	Wind	Temp	Crossroad	Weekend	...	Accident
17:05	A123	Yes	2	Highway	30	Yes	65 km/h	28	No	No	...	Two Cars
23:50	B742	No	3	Tunnel	45	No	23 km/h	18	No	Yes	...	Road Deviation

2. Running the Predictive Model:

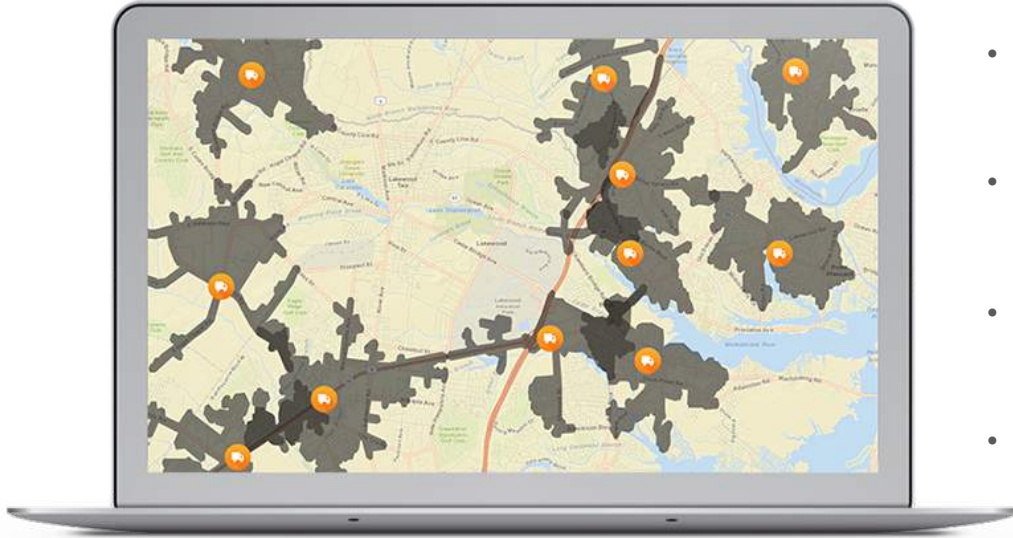
Mapping Raster layer for each feature per Time to a common Dataset then applying Logistic Regression to predict Accident Probability



Time	Segment	Curved	Lanes	Type	Width	Rain	Wind	Temp	Crossroad	Weekend	Accident Probability
17:05	A123	Yes	2	Highway	30	Yes	65 km/h	28	No	No	82%
23:50	B742	No	3	Tunnel	45	No	23 km/h	18	No	Yes	25%



Optimizing Asset Allocation: based on Accident Predictions



- Optimize the allocation of Police Patrols & Ambulance Cars based on the Predicted Accident Locations
- Take Accident type into consideration (Critical, Medium..)
- Inputs: Asset types, numbers, allocation constraints, shifts, etc.
- Root-cause Analysis



Intelligent Transportation Systems

Congestion Forecasting, Demand Prediction, Delay Root-cause Analysis, & more

Event-based Traffic State Prediction

- Modelling traffic propagation
 - across the network for road segments on the 1st, 2nd, and 3rd degree segments
 - across Space & Time
- Predicting the traffic state based on real-time segment events

Accidents



Road Works



Bottle Necks



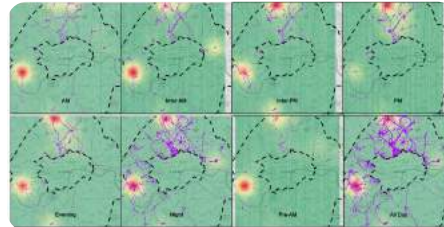
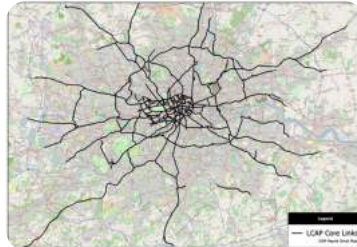
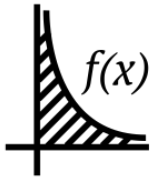
Lane Closure



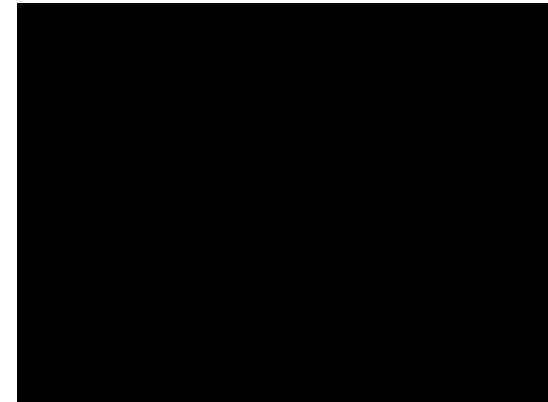
Real-time Planning & Response

Eliminate & Reduce Congestion

Predictive Model

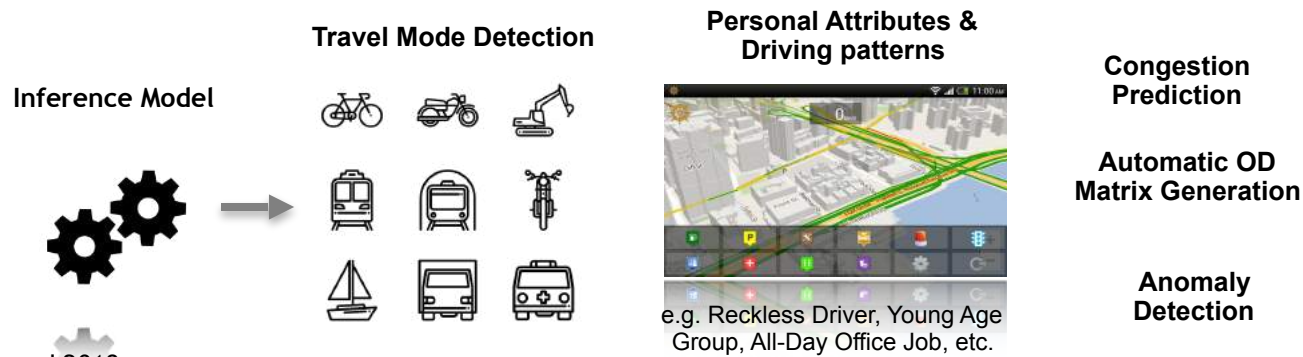
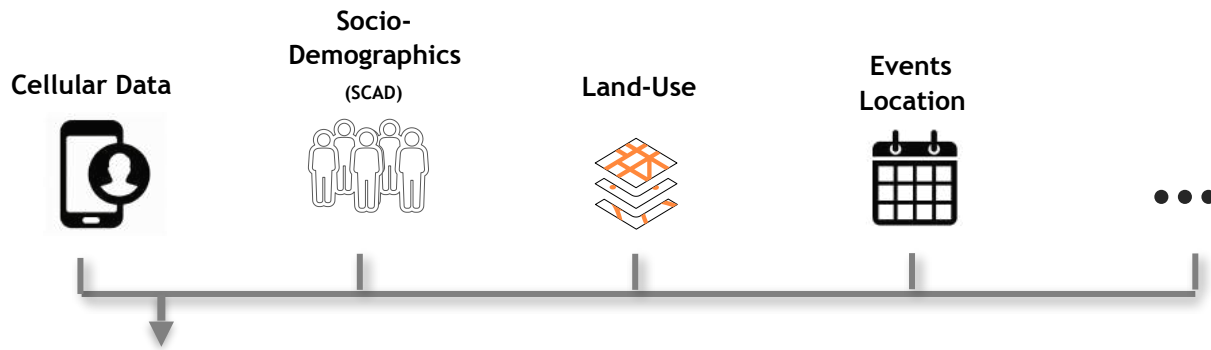


Traffic Flow Prediction during the Day



Transport Data Analytics from GPS/Smart Phone Data

- Inferring Information from GPS/Smart Phone Data



Raw Smart Phone Data

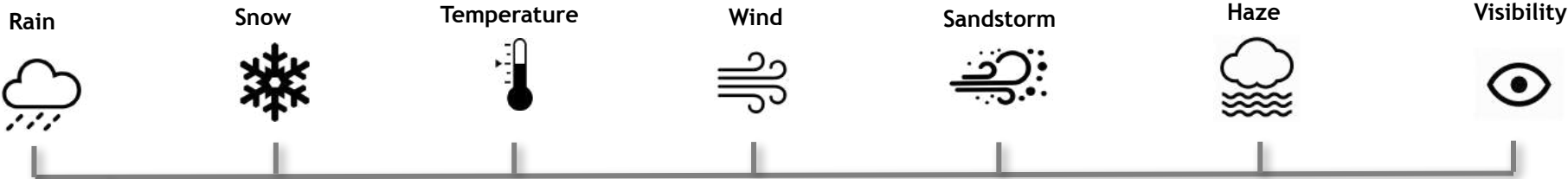


Travel Mode, Places & Personal Information

Impact of Weather Conditions on Travel Times

- Extracting journey time info from Automatic Number Plate Recognition (ANPR) cameras
- Impact of different intensities of weather conditions on macroscopic travel times
- Adjusting forecast based on weather prediction ensembles

London Congestion Analysis Project Data



Predictive Model



Enhanced Traffic Forecast



Weather-Sensitive Traffic Simulations



Impact Analysis & Risk Management

algebraic and percentage changes in operating speeds from several studies.

Variable	Range	Categories derived from HCM (2000)	Reduction in operating speeds	
			HCM (2000) This Study (2010) London, UK (%)	
Rain (mm/h)	0-0.2	Light	2-14	0.1-2.1
	0.2-6	Light	2-14	1.3-3.8
	>6	Heavy	5-17	3.6-6
Snow (mm/h)	<1	Light	8-10	5.5-7.6
	1-2	Light	8-10	5.5-7.6
	2-12	Light	8-10	7.4-11.4
Temperature (°C)	>12	Heavy	30-40	7.4-11.4
	1-10	N/A	N/A	-1.2 to 1.9
Temperature (°C)	0 to (-20)	N/A	N/A	-0.9 to 3.2
	<-20	N/A	N/A	-0.9 to 3.2
	<-20	N/A	N/A	-0.9 to 3.2

Work done with:



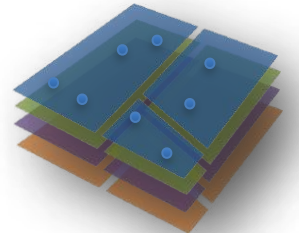
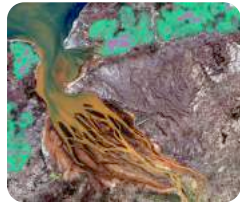
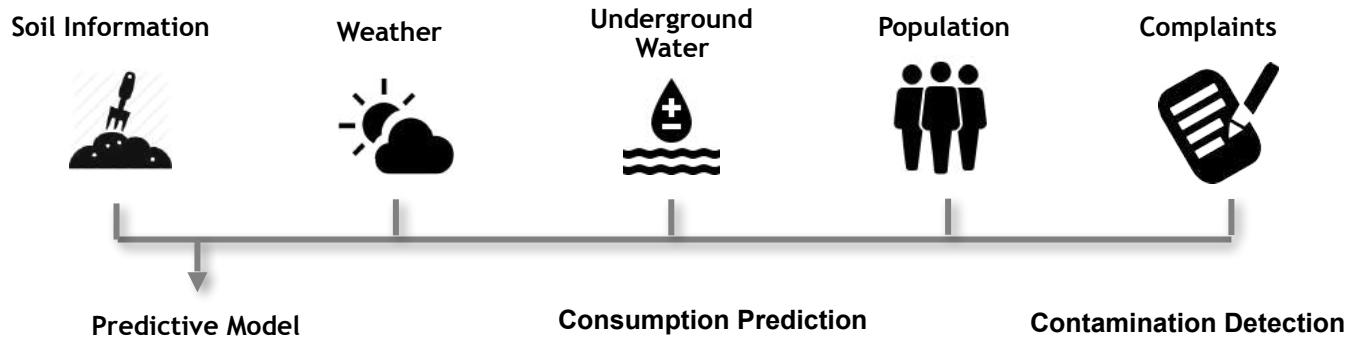


Water Resource Systems

Contamination Detection, Consumption Prediction

Water Resource Monitoring

- Modelling Weather, Underground Water & Soil conditions in the spatiotemporal domain
- Forecasting water demand based on historical consumption, weather predictions and soil data
- Predicting water contamination based on mineral level changes over Space & Time
- Identifying unusual data records (outliers, pattern change, data deviation) in weather and hydrological time series variables



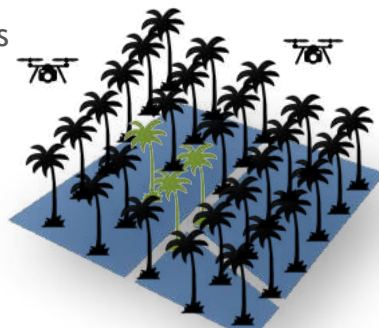


Precision Agriculture (Data-Driven Farming)

Field Monitoring, Sprayer & Pest Control, In-Field Sensing

Autonomous Drone Enabled Precision Agriculture

- Harnessing drone real-time capabilities of monitoring of crops and plants (e.g. Palm Trees)
- Inferring presence of fungal & bacterial diseases using image classification enabling an immediate response to identify containment zones & to contain contaminations
- Business Benefits:
 - Supervised Classification for autonomous systems
 - Real-Time Detection & Accelerated Response



Leaf Spots and Leaf Blights of Palm

Bird Rot of Palm



Graphium leaf Spot (False Smut) of Palm

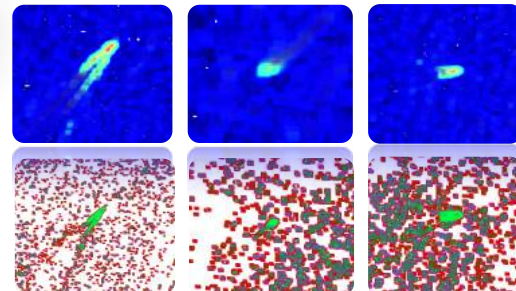


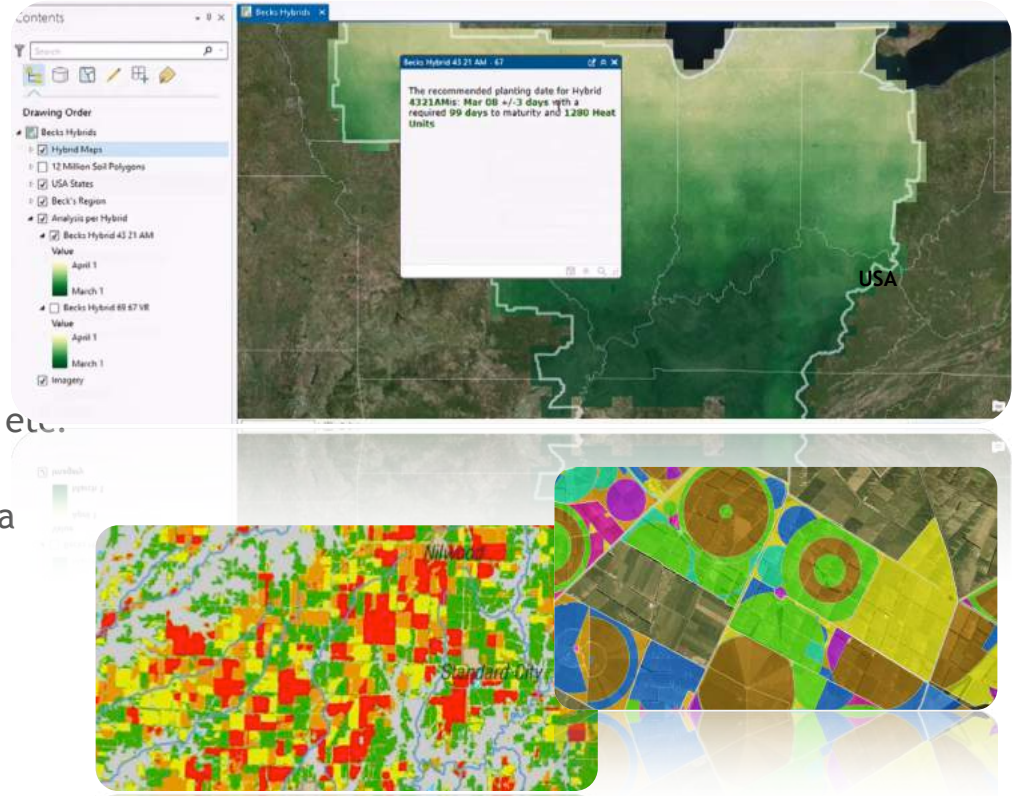
Image Classification can precisely presence of contamination

Relevant work done with:



Yield Optimization: Best Conditions for Maximum Production

- Analyze Historical Production Data together with Location, Time, Weather, Fertilizers, Irrigation Method, Soil Characteristics, and more
- Predict the optimum factors per Crop to produce maximum Yield: time of the year, area, fertilizers, etc.
- Scenario Modelling: examine the predicted yield via different scenarios of the factors mentioned



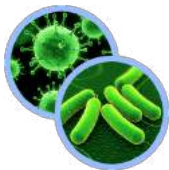


Predicting Disease Propagation

Predict where the Diseases will hit again and Simulate their Effect

Predicting Disease Propagation

Diseases



- Kind of Disease
- Severity
- Spread Level (Incidents)

Demographics



- Age
- Gender
- Nationality
- Population
- .. & more

Location



- Infected Area
- Proximity to Water
- Proximity to Industrial
- Proximity to City Center

Time



- Time of Infection
- Season
- Time of the Month

Weather



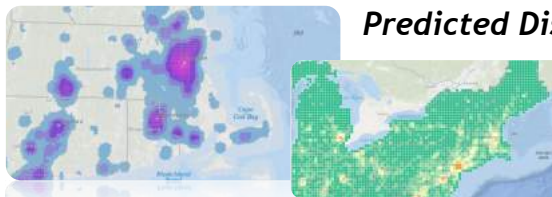
- Temperature
- Humidity
- Rain

Pollution



- Air Quality
- Water Quality

Machine Learning Model

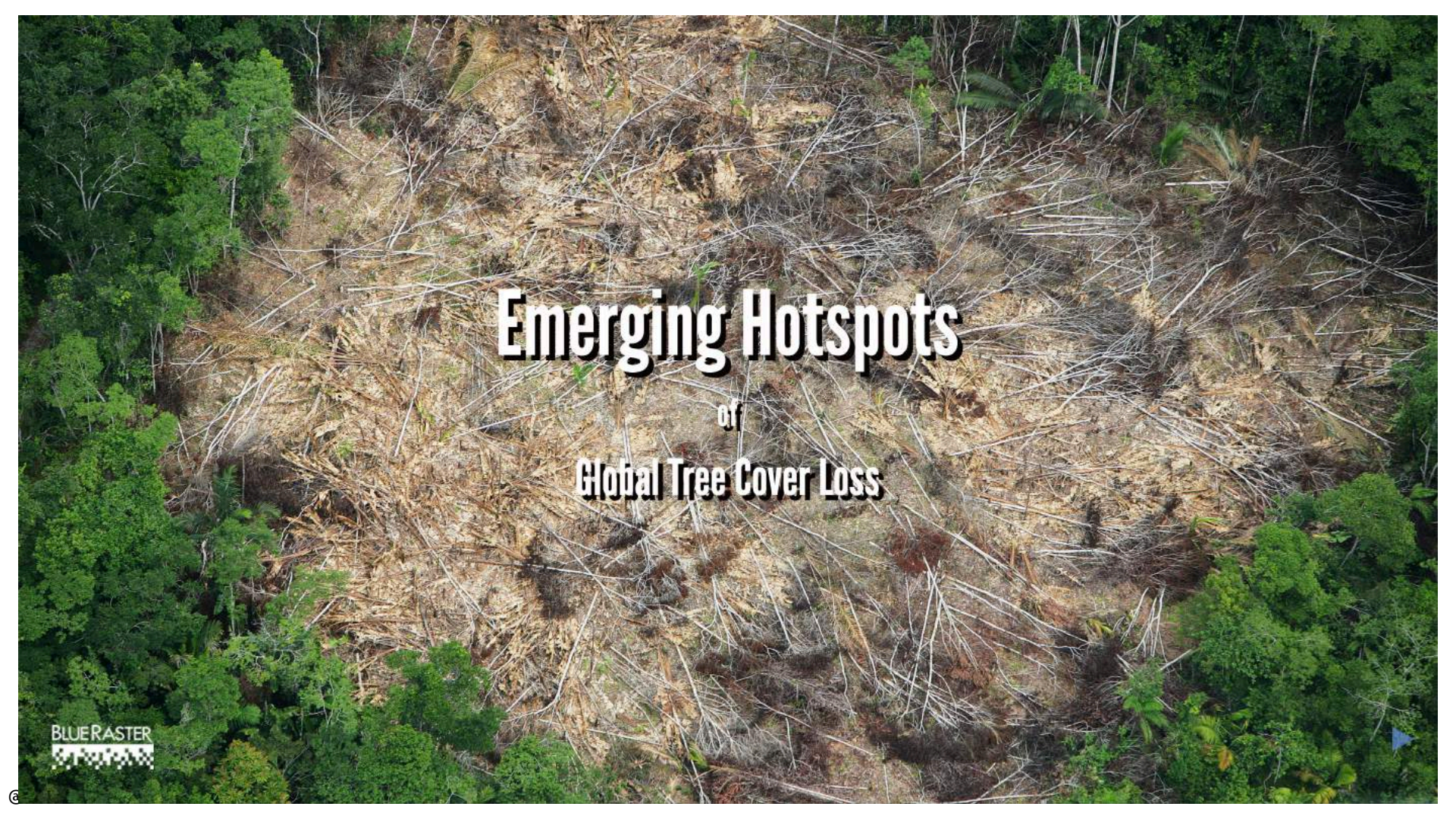


Predicted Disease Propagation



Earth Monitoring

Urban Expansion, Land Use Detection, Environmental Monitoring



Emerging Hotspots of Global Tree Cover Loss

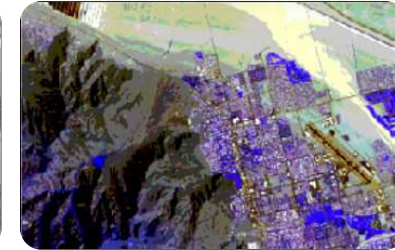
Land Change Prediction

- Forecasting land desertification based on the change rate using prediction models leveraging data from historical imagery, weather & tidal information
- Prediction of agricultural land efficiency from elevation, weather, crop yield, soil type information
- Business Benefits:
 - Urban Expansion
 - Land Use Detection
 - Environmental Monitoring

Predicting
Desertification



Land Erosion



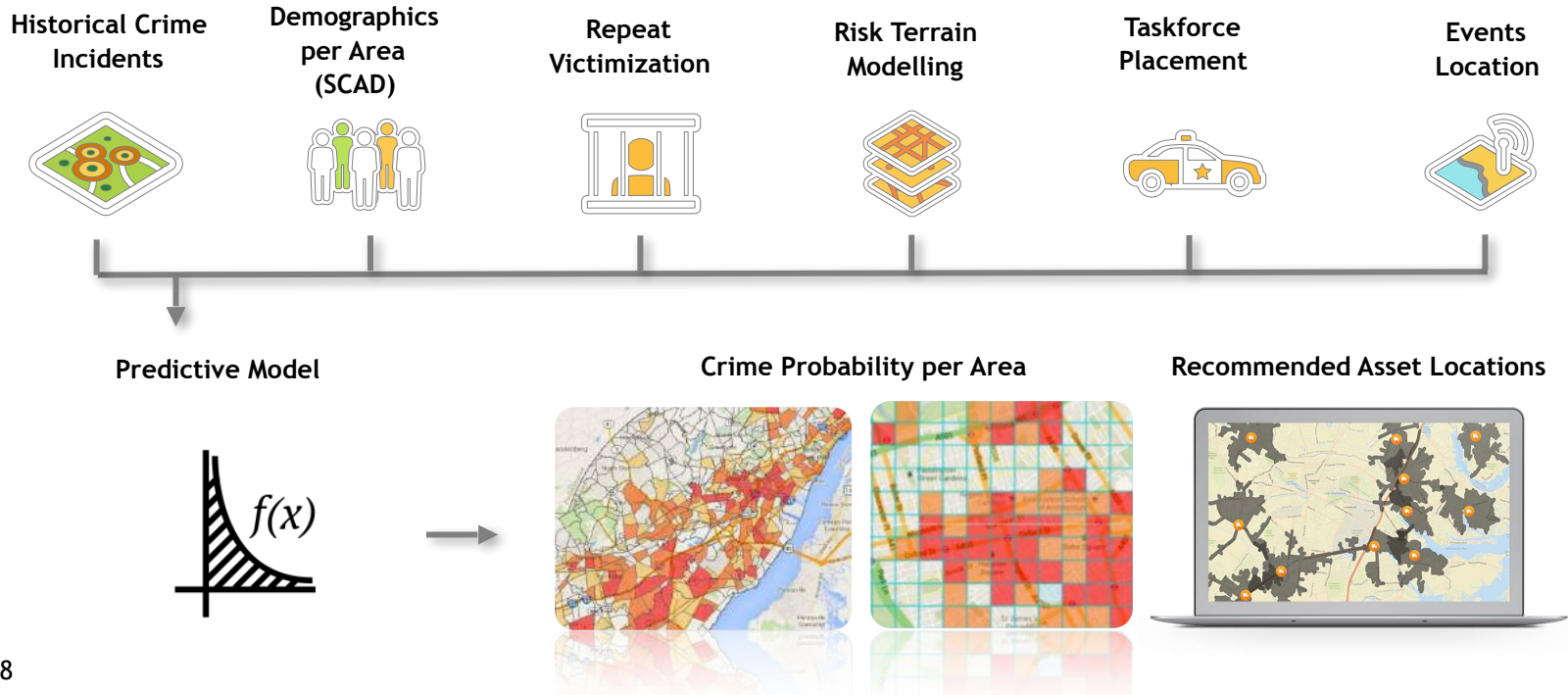


Predictive Policing

Predict Crime Possibility, Classify by Severity, Optimize Asset Allocation

Predictive Policing


Analyzing historical data from multiple sources to highlight areas of high Crime Likelihood, and the optimum placement of police assets accordingly




ucdemo/ UC2017V6 localhost:8888/notebooks/UC2017V6.ipynb#

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Identifying Broken Insulators at Georgia Power



Broken Contaminated Flashed



6:54 / 9:31 CC HD

esri



Oil & Gas

Health & Safety, Accidents, Oil Spills

Road Detection From GPS Breadcrumbs

Contents

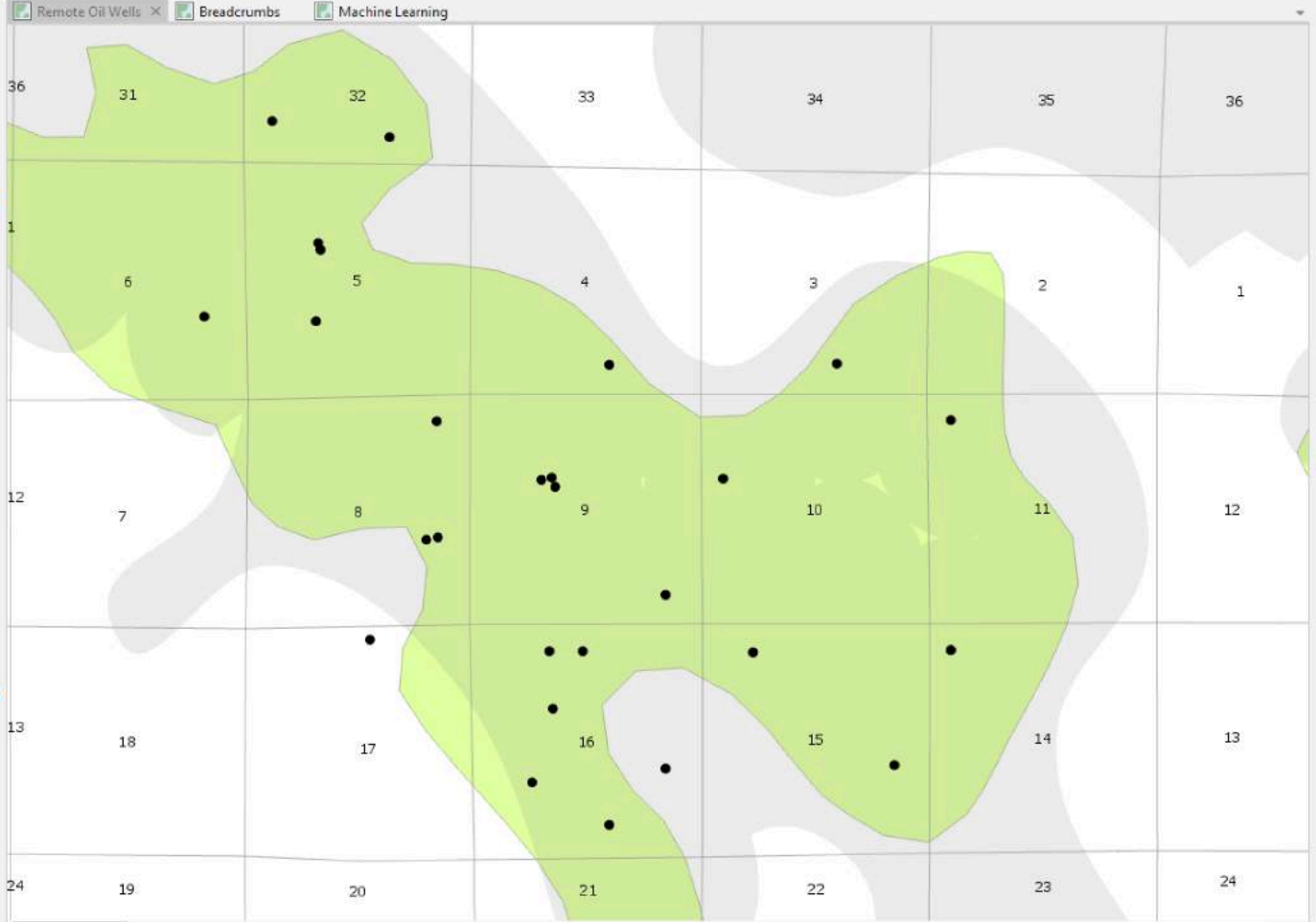
- Search
- Drawing Order
- Remote Oil Wells
 - Active Oil Wells
 - Machine Generated Streets
 - Density Based Clusters
 - GPS Breadcrumbs Not On Streets
 - GPS
 - GPS Breadcrumbs
 - Existing Streets
 - Oil and Gas

Tasks

Unsupervised ML Digitization

1. Oil Wells

Progress (1/10) Next St..

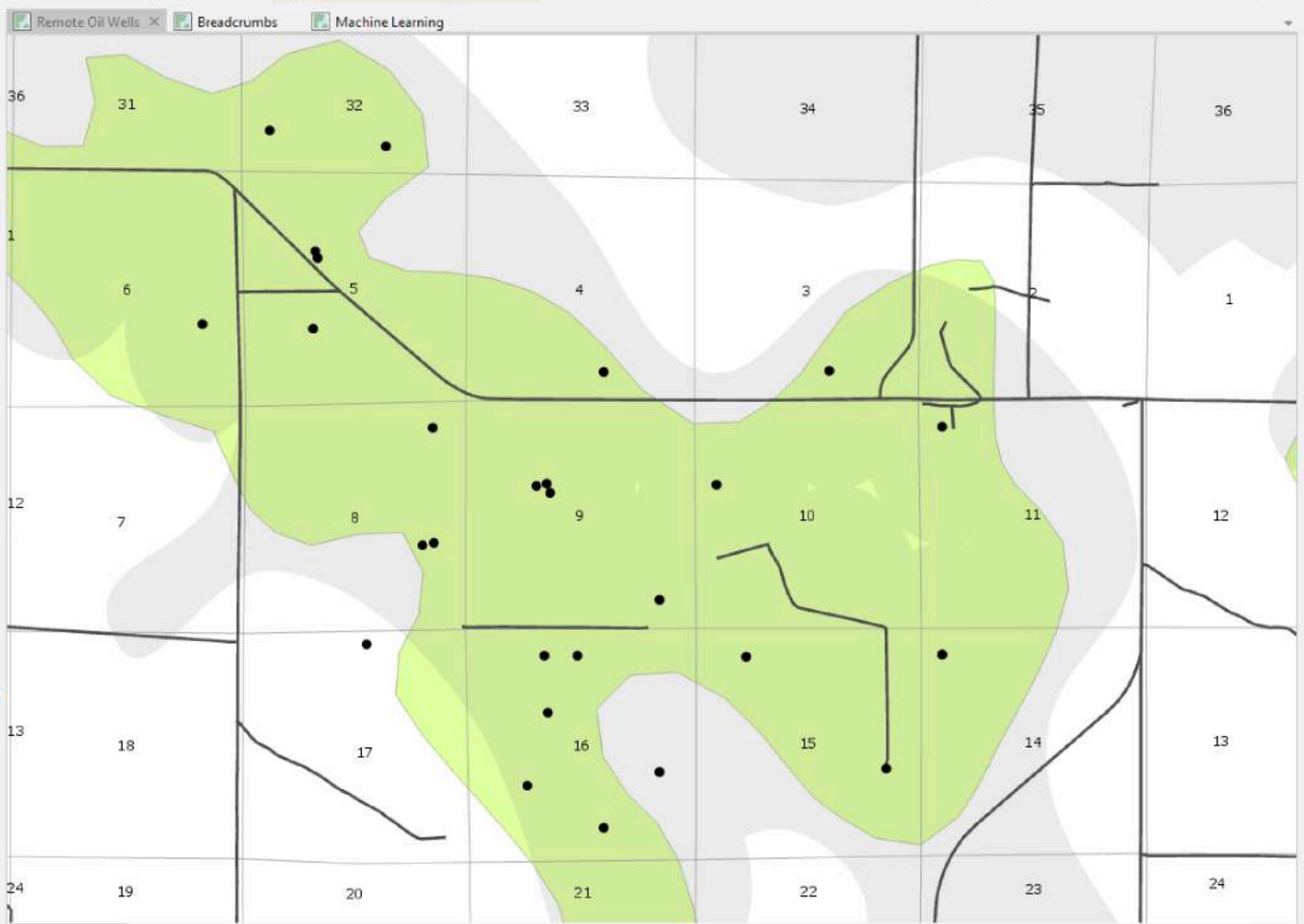


Contents

Search

Drawing Order

- Remote Oil Wells
 - Active Oil Wells
 - Machine Generated Streets
 - Density Based Clusters
 - GPS Breadcrumbs Not On Streets
 - GPS
 - GPS Breadcrumbs
 - Existing Streets
 - Oil and Gas



Tasks

Unsupervised ML Digitization

2. Missing Streets

Progress (2/10) [Progress Bar] Next St..

Contents

Search

Drawing Order

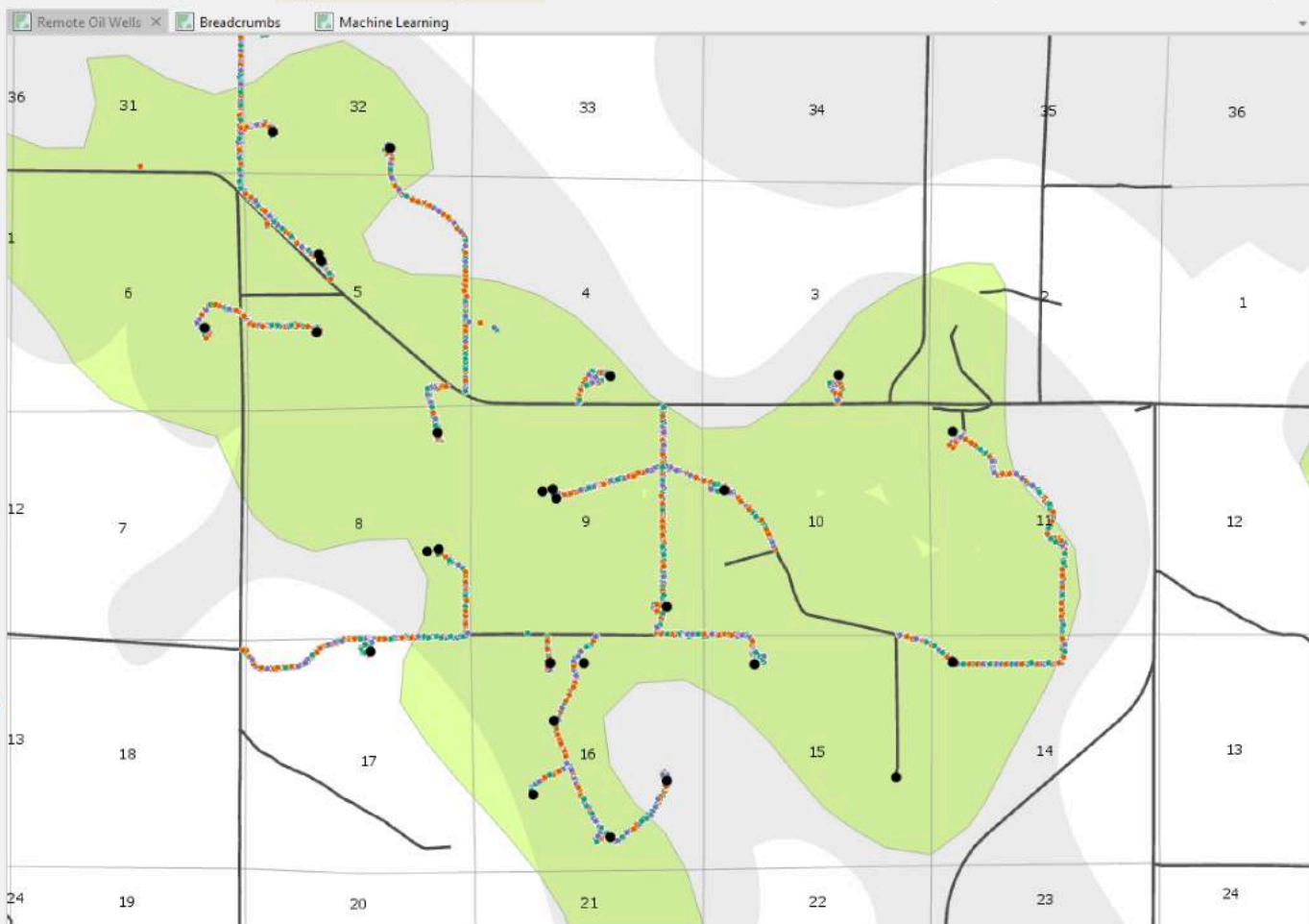
- Remote Oil Wells
 - Active Oil Wells
 - Machine Generated Streets
 - Density Based Clusters
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 - GPS
 - GPS Breadcrumbs
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Tasks

Unsupervised ML Digitization

6. Breadcrumbs Not On Streets

Progress (6/10) Next St...

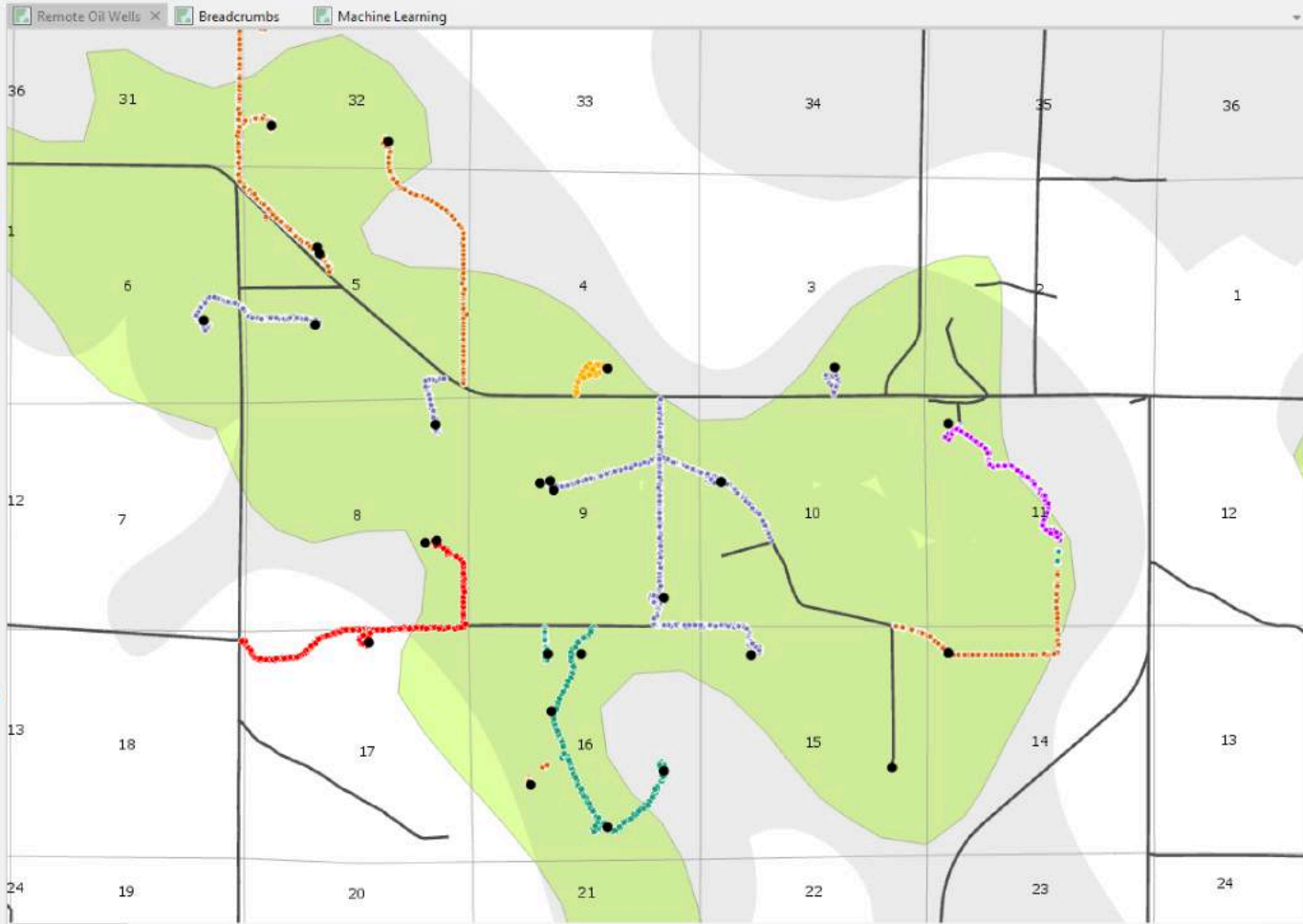


Contents

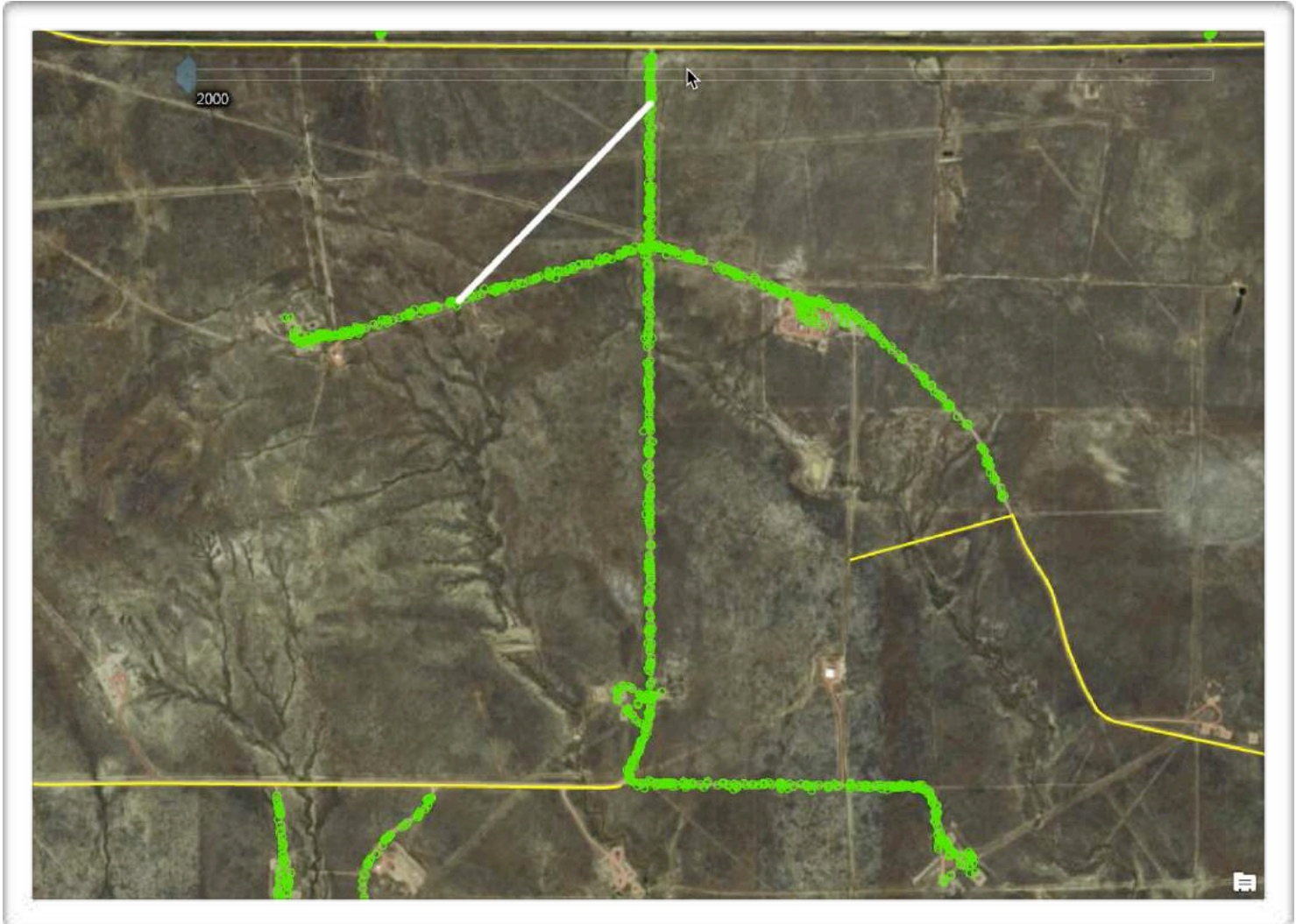
- Search
- Drawing Order
- Remote Oil Wells
 - Active Oil Wells
 - Machine Generated Streets
 - Density Based Clusters
 - GPS Breadcrumbs Not On Streets
 - GPS
 - GPS Breadcrumbs
 - Existing Streets
 - Oil and Gas

Tasks

- Unsupervised ML Digitization
 - 7. Density Based Clustering
- Progress (7/10) Next St...







Contents

Remote Oil Wells x Breadcrumbs Machine Learning

Search

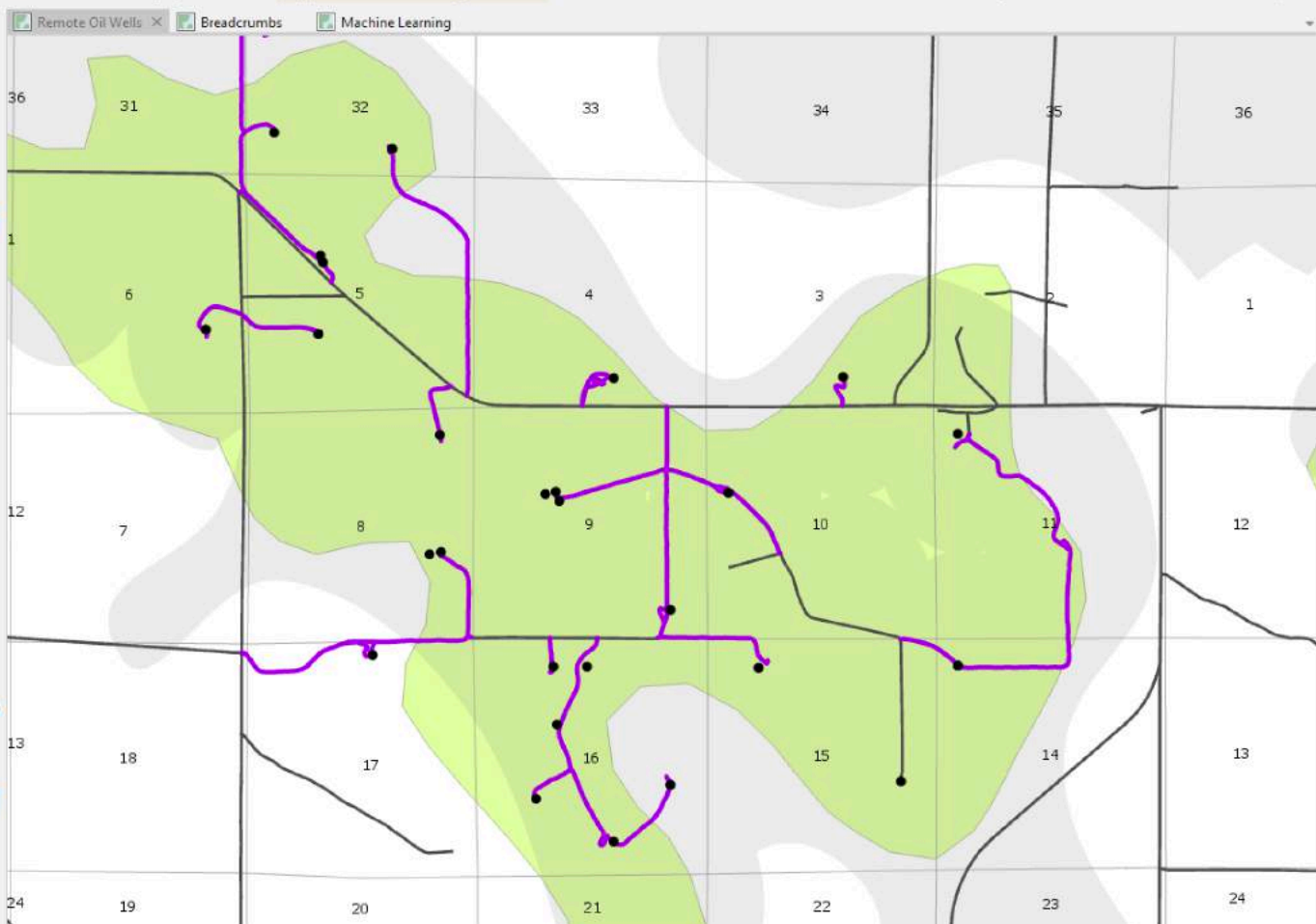
Drawing Order

- Remote Oil Wells
- Active Oil Wells
- Machine Generated Streets
- Density Based Clusters
- GPS Breadcrumbs Not On Streets
- GPS
- GPS Breadcrumbs
- Existing Streets
- Oil and Gas

Tasks

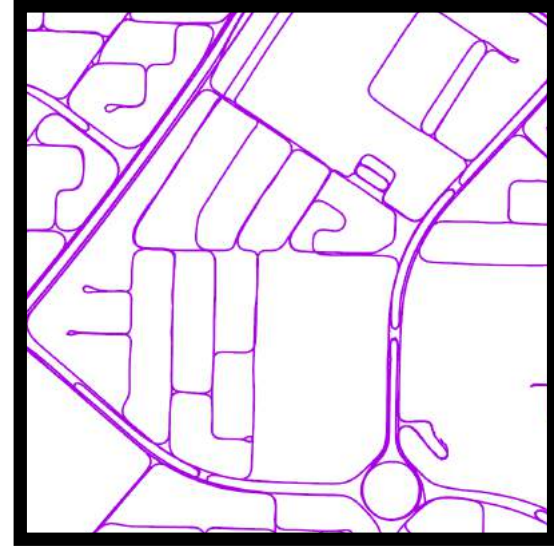
Unsupervised ML Street Digitization

- Unsupervised ML Digitization



Road Detection In Images

Ultimate Challenge



Input raster

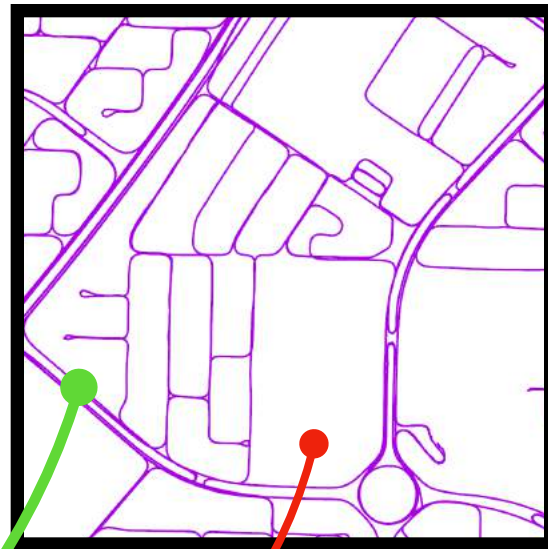


Output set of polylines

What is a “Road”?

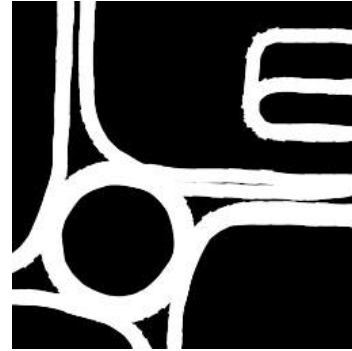
Supervised Learning

- For a given area...
 - We have rasters at specific scale (1:10,000)
 - We have *previously* “human” digitized polylines
 - For each pixel in a raster...
 - Look up location of pixel and see if “on” a polyline
 - Label that pixel **ONROAD** or **NOROAD**



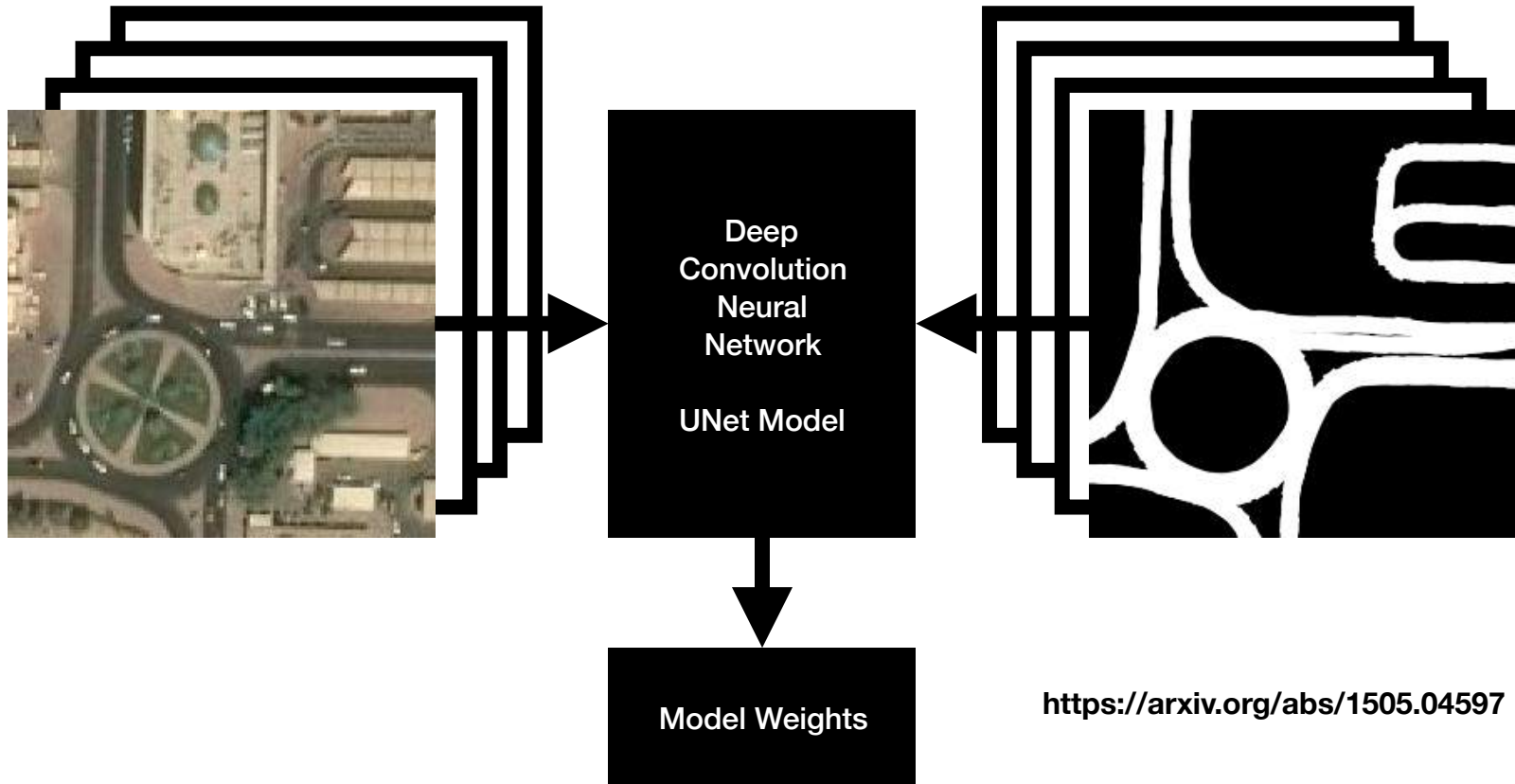
ONROAD

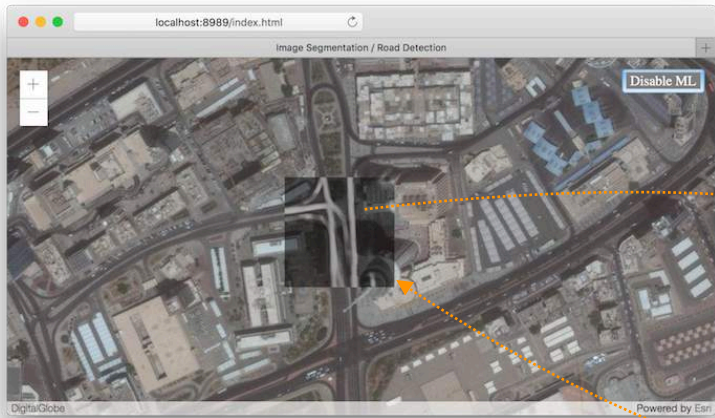
NOROAD



- Given hand digitized area
- At scale 1:10,000
- Generate pair of 256x256 pixel patches
 - Data raster with 3 channels from raster source (ie. image server)
 - Mask raster with 1 channel from polyline source (ie. map server)

Model Training

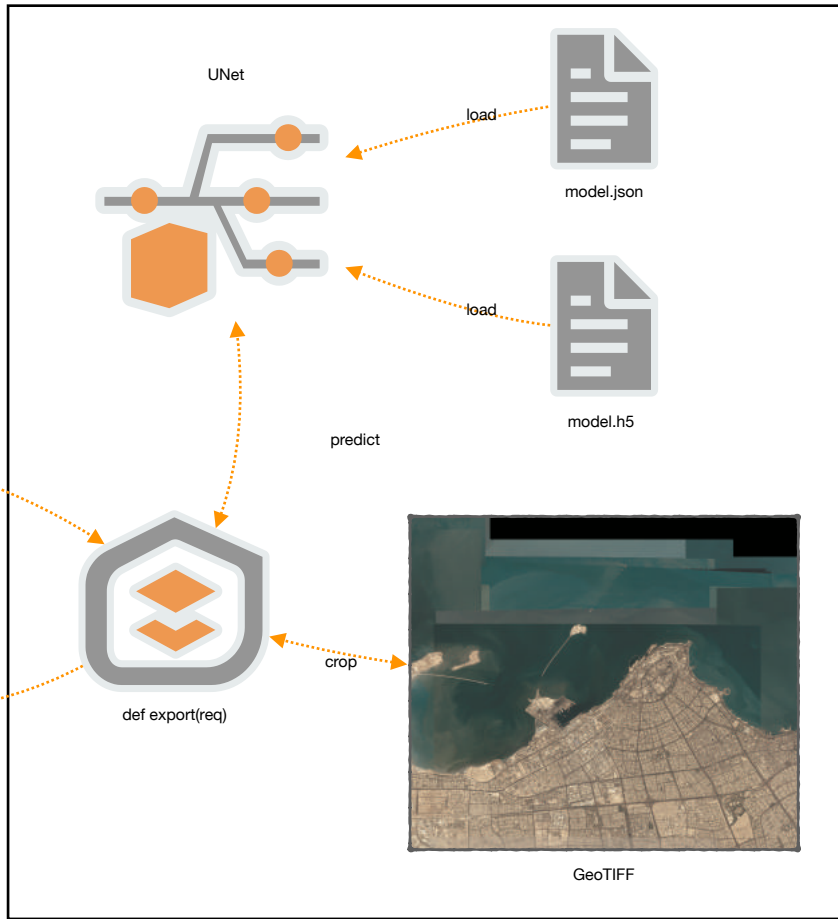




"Aspect"
Parameters

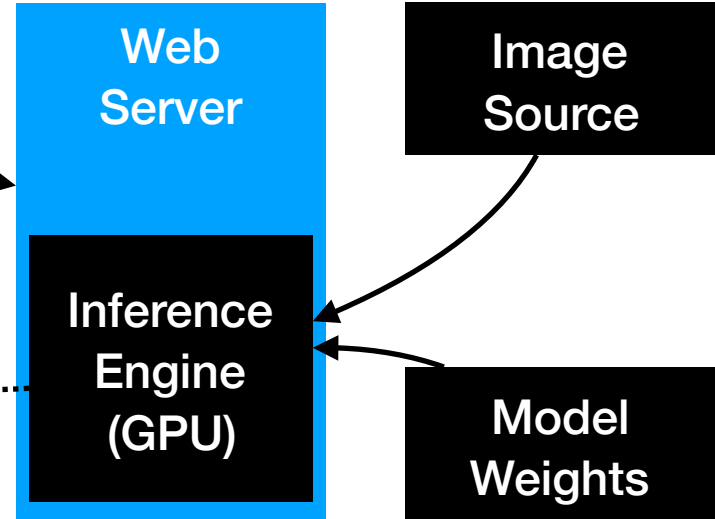
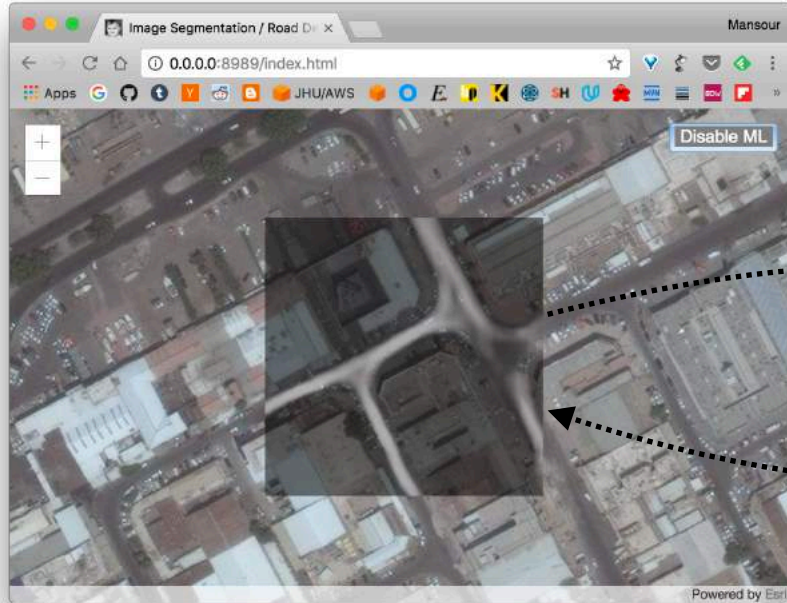
/MapServer/export?x&y

png



index.py

Model Deployment



Resilient To Noise



Recommendations

- Understand The Technology
- Guide Regulations
- Prepare for Job Loss
- Prepare for Job Gains
- Prioritize Education
- Invest More
- AI is now a race...

<https://www.technologyreview.com/s/610379/heres-how-the-us-needs-to-prepare-for-the-age-of-artificial-intelligence/>

Parting Words....

Correlation is ***NOT*** causation !