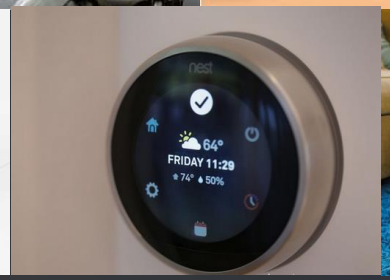
The Fourth International Workshop
on GIS Technology and Application

Applications and Techniques of AI GIS

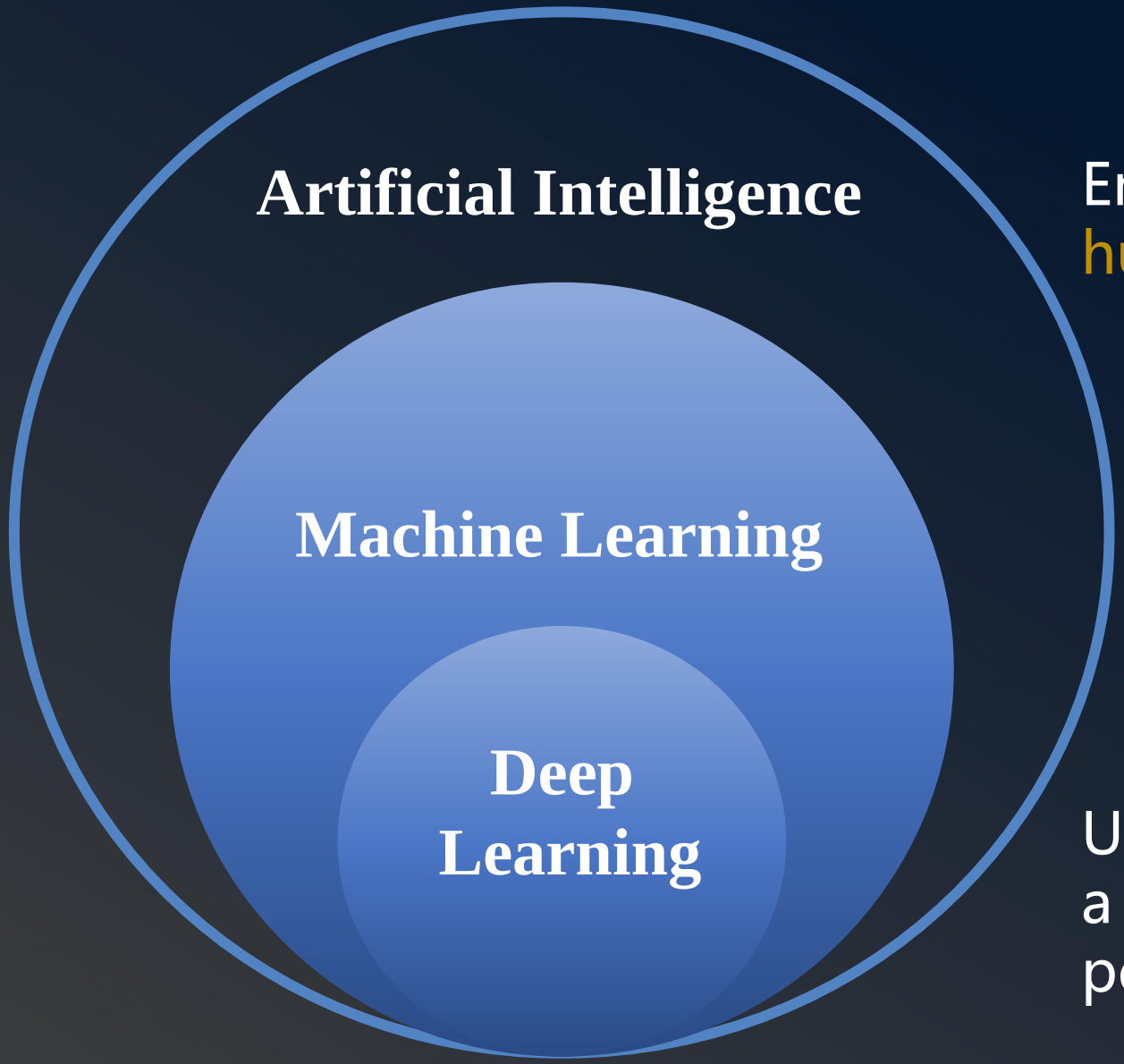
Xiaoran Li

SuperMap R&D Center

AI is Widely Used in Our Life



- Introduction of AI
- Spatial ML & DL
- AI GIS Workflow
- Applications of AI GIS

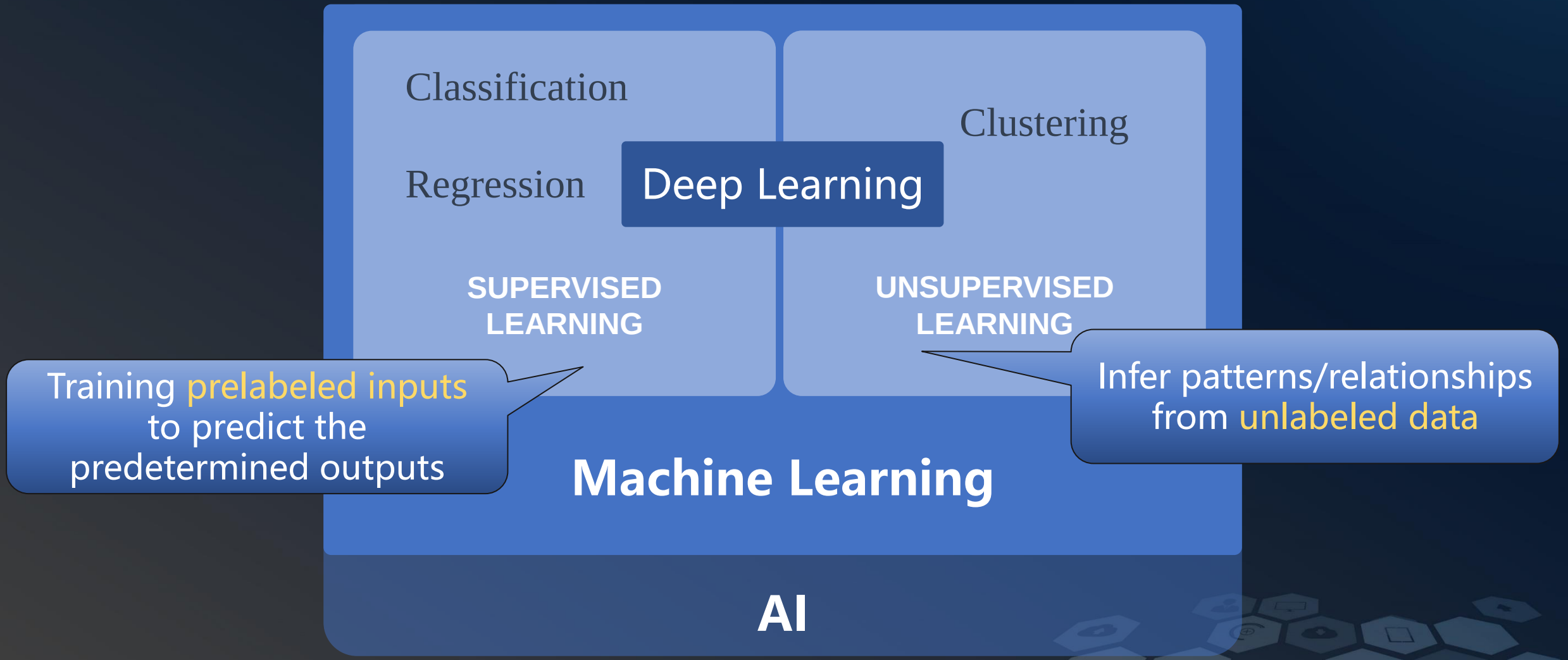


Enable computers to mimic human intelligence

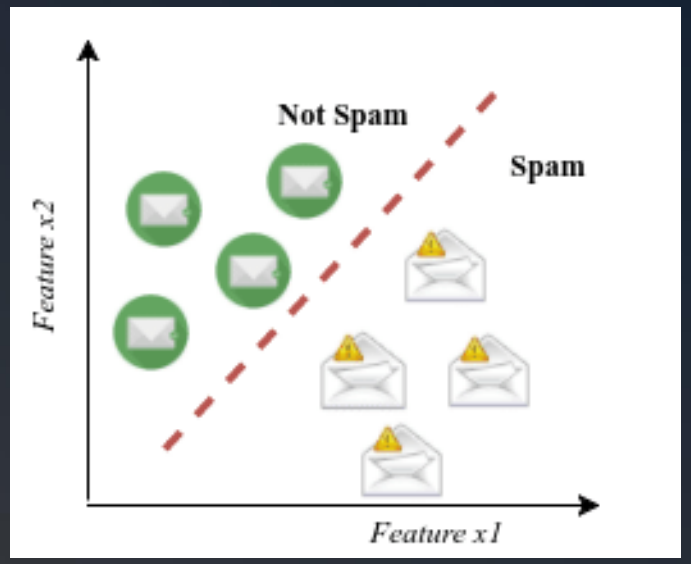
Enable machines to improve at tasks with experience.

Use neural networks that permit a machine to train itself to perform a task

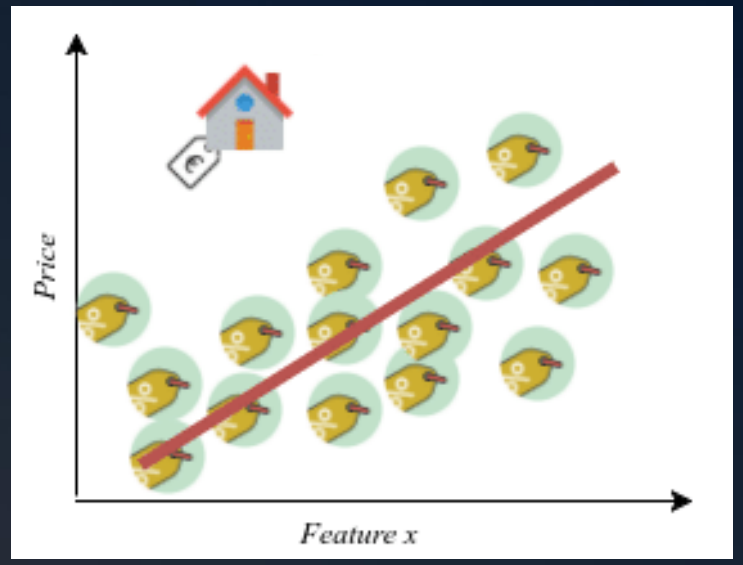
Unsupervised VS Supervised Learning



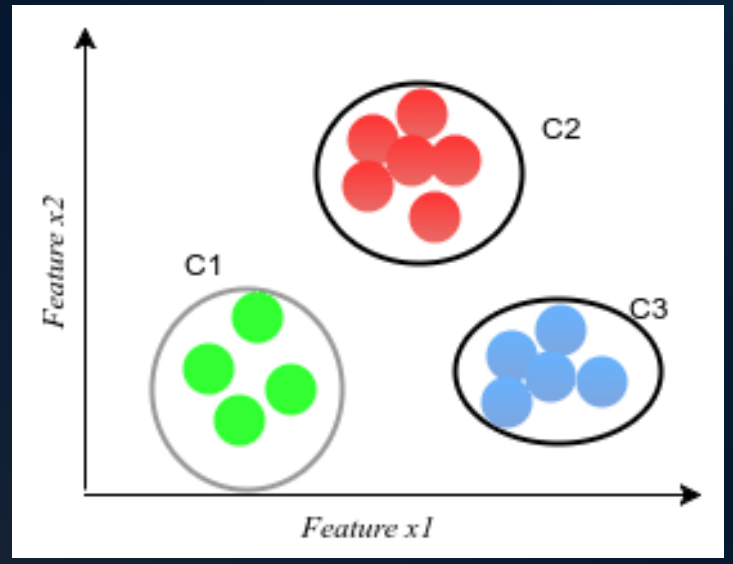
Three Main Machine Learning Tasks



Classification

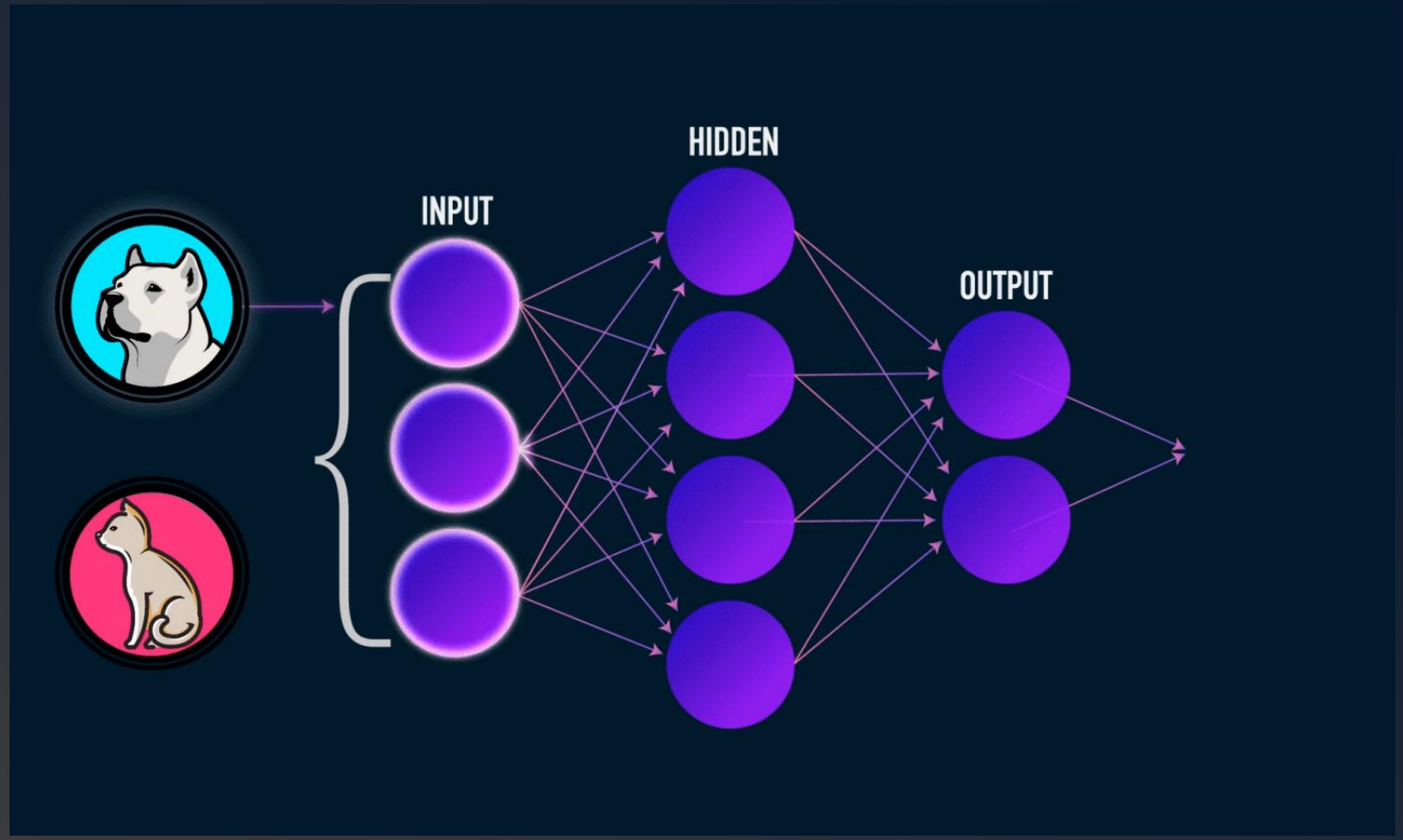


Regression



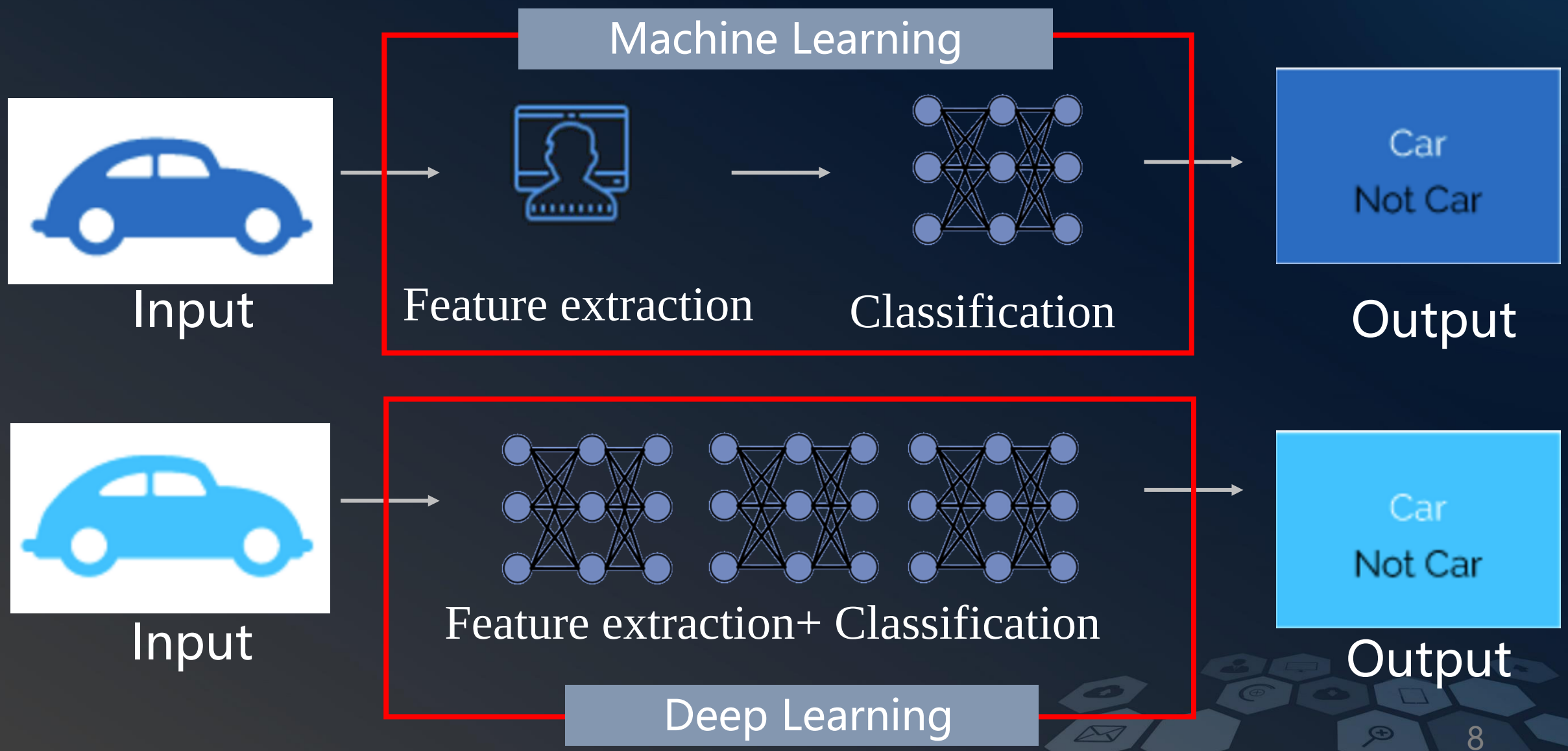
Clustering

Deep Learning & Neural Network



- Abstract of biological processes that take place in the brain
- Mimic the 'firing' of interconnected neutrons in the response to stimuli (new incoming info)

Comparison of ML & DL



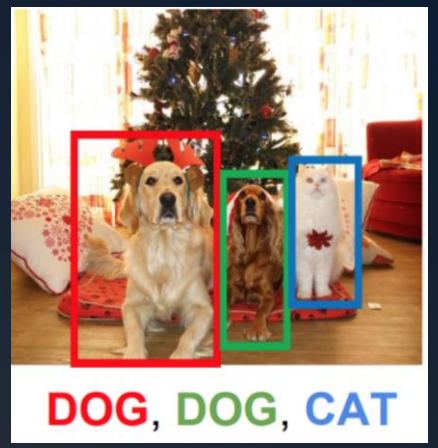
What did AI Do for Us?

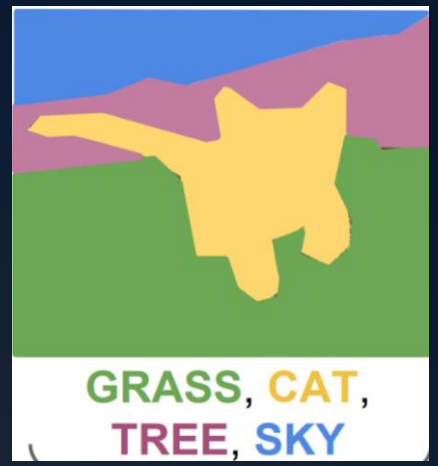
- Reduce repetitive human work
- Reduce non-intelligent work
- Multiple data can accessing in one time
- Improve work efficiency
- .....

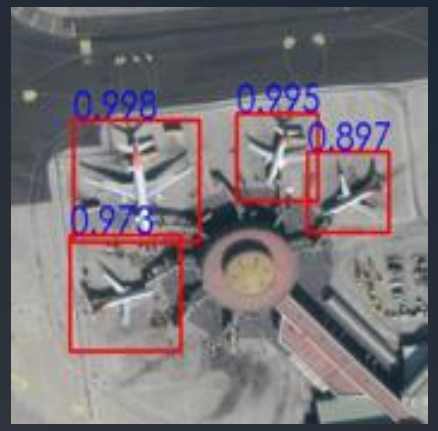
AI GIS

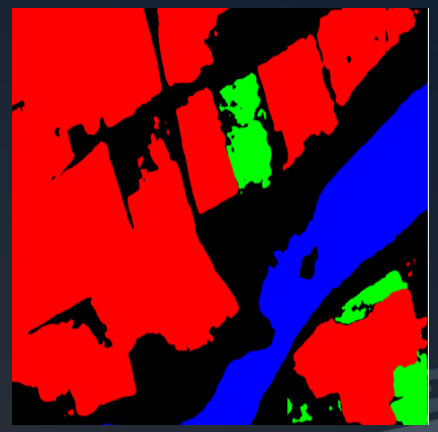
Application of Deep Learning to GIS

Image Classification *Object Detection* *Semantic Segmentation* *Instance Segmentation*

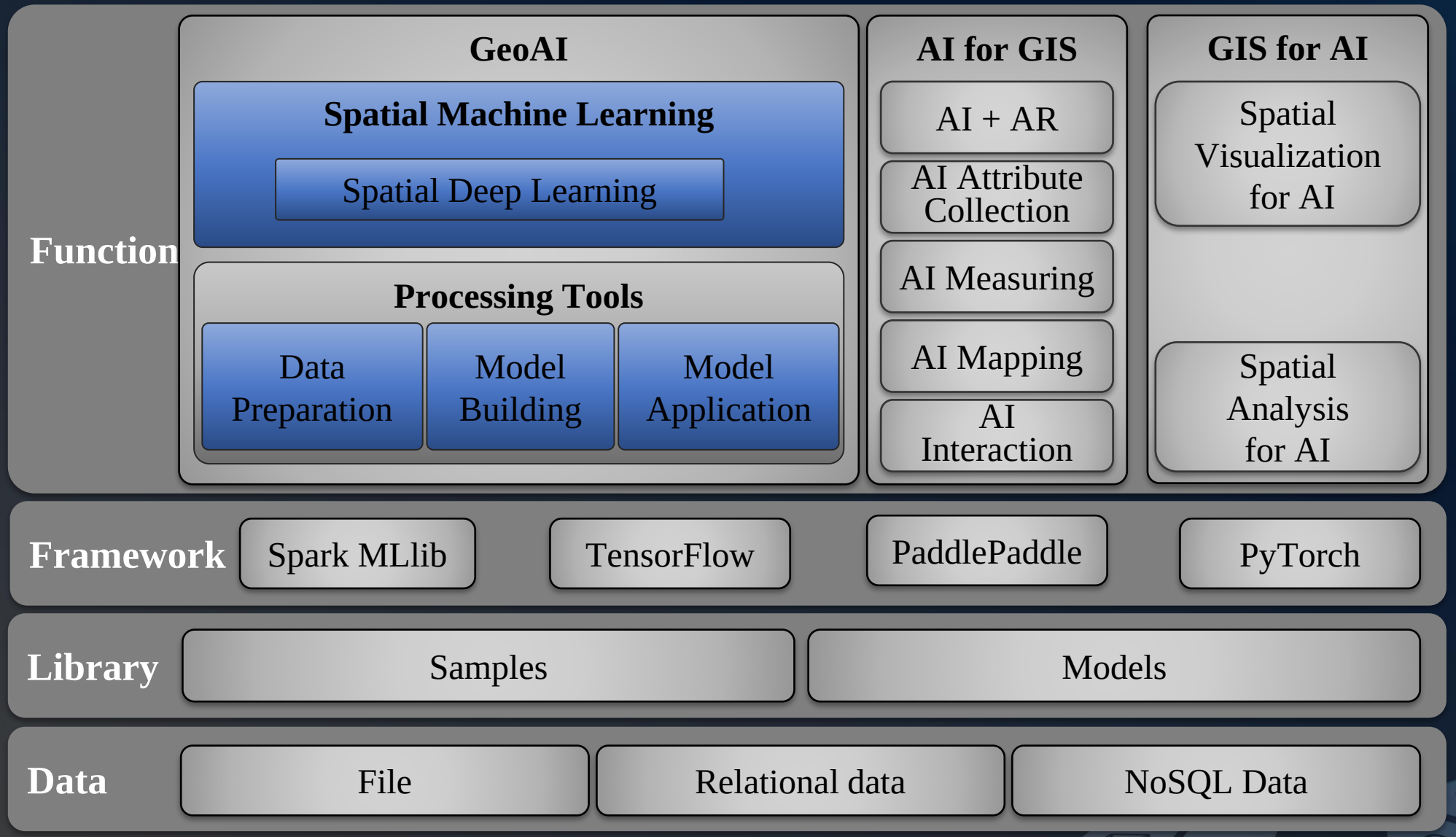








AI GIS Technology System



- Introduction of AI
- Spatial ML & DL
- AI GIS Workflow
- Applications of AI GIS

Spatial Machine Learning Operators

Cluster Analysis

- Spatial Hotspot
- Spatial Density Cluster

Classification Analysis

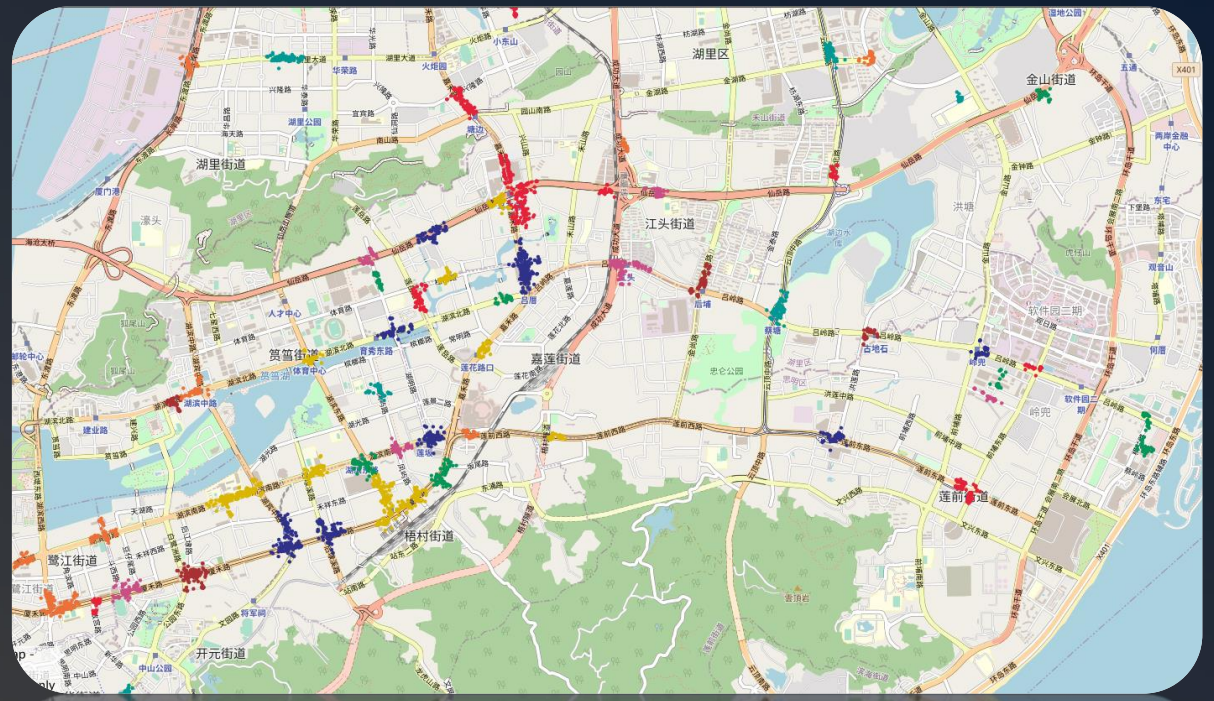
- Map Matching
- Logistic Regression
- Gradient Boosting Tree Classification
- Decision Tree Classification
- Naive Bayes Classification
- Support Vector Machine Classification
- Address Element Identification
- Random Forest Classification

Regression Analysis

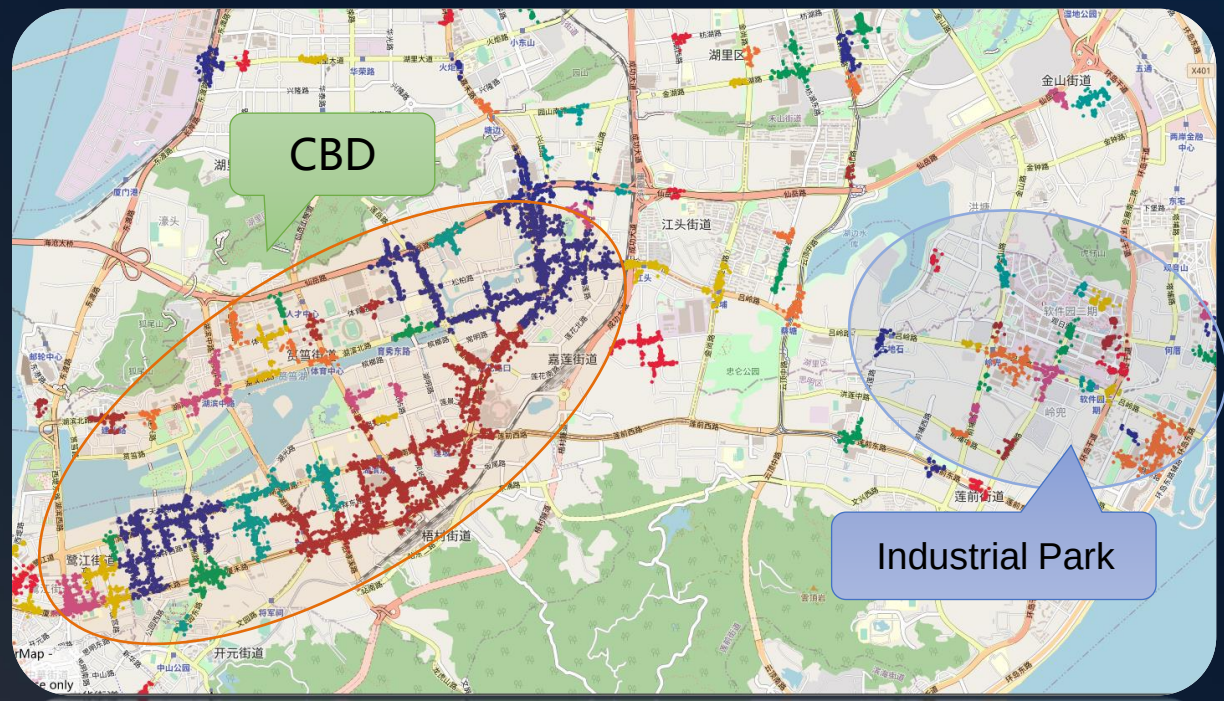
- Gradient Boosting Tree Regression
- Geographical Simulation
- Linear Regression
- Decision Tree Regression
- Geographical Weighted Regression
- Generalized Linear Regression
- Forest-based Regression

Spatial Machine Learning—Clustering

- Whether the shared bike parking position clustered?



6:00-8:00



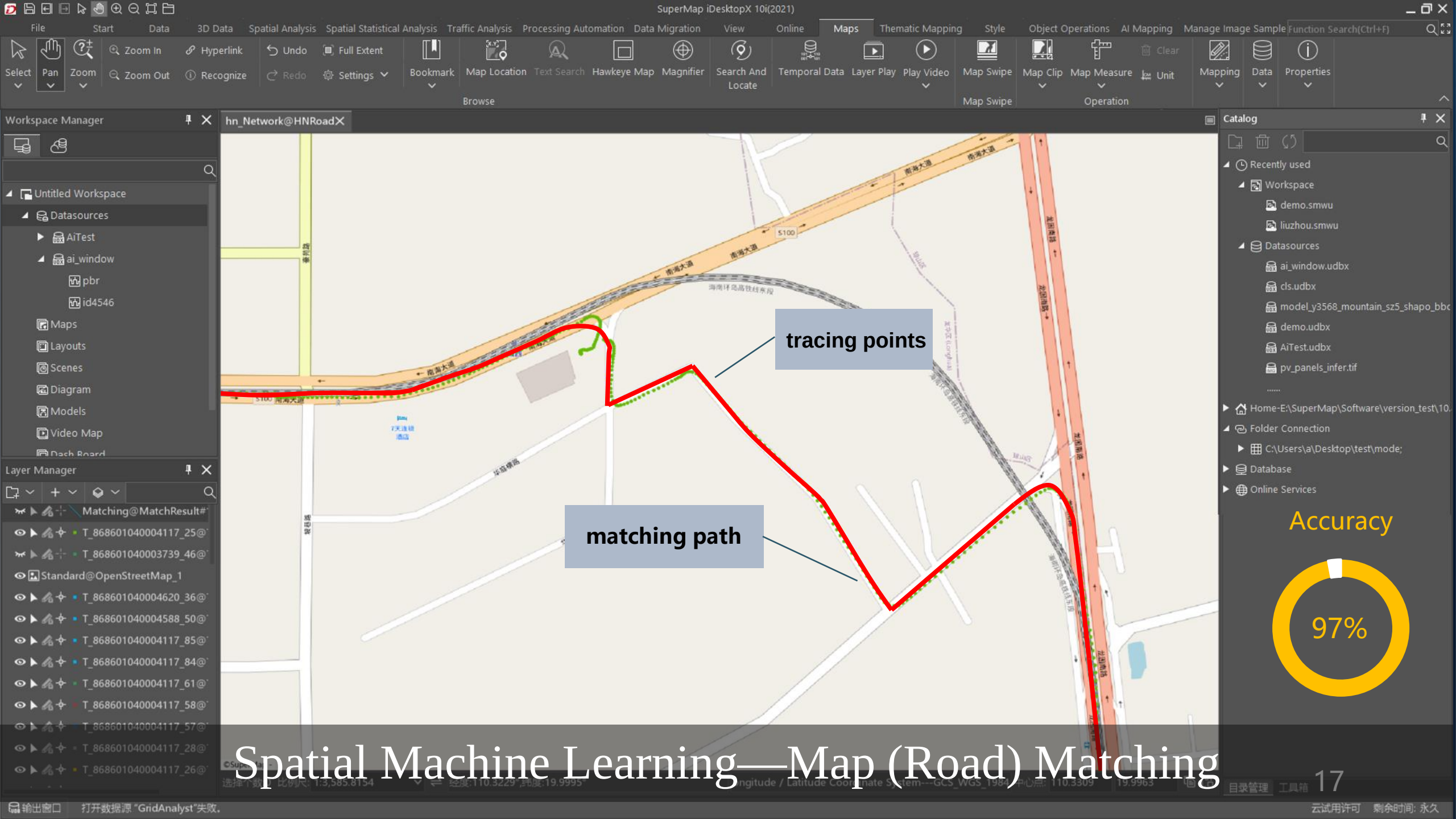
8:00-10:00

Spatial Machine Learning—Classification

Impact Factors:

- Diurnal range of mean temperature
- Lowest temperature in the coldest month
- Average temperature of the hottest season
- …

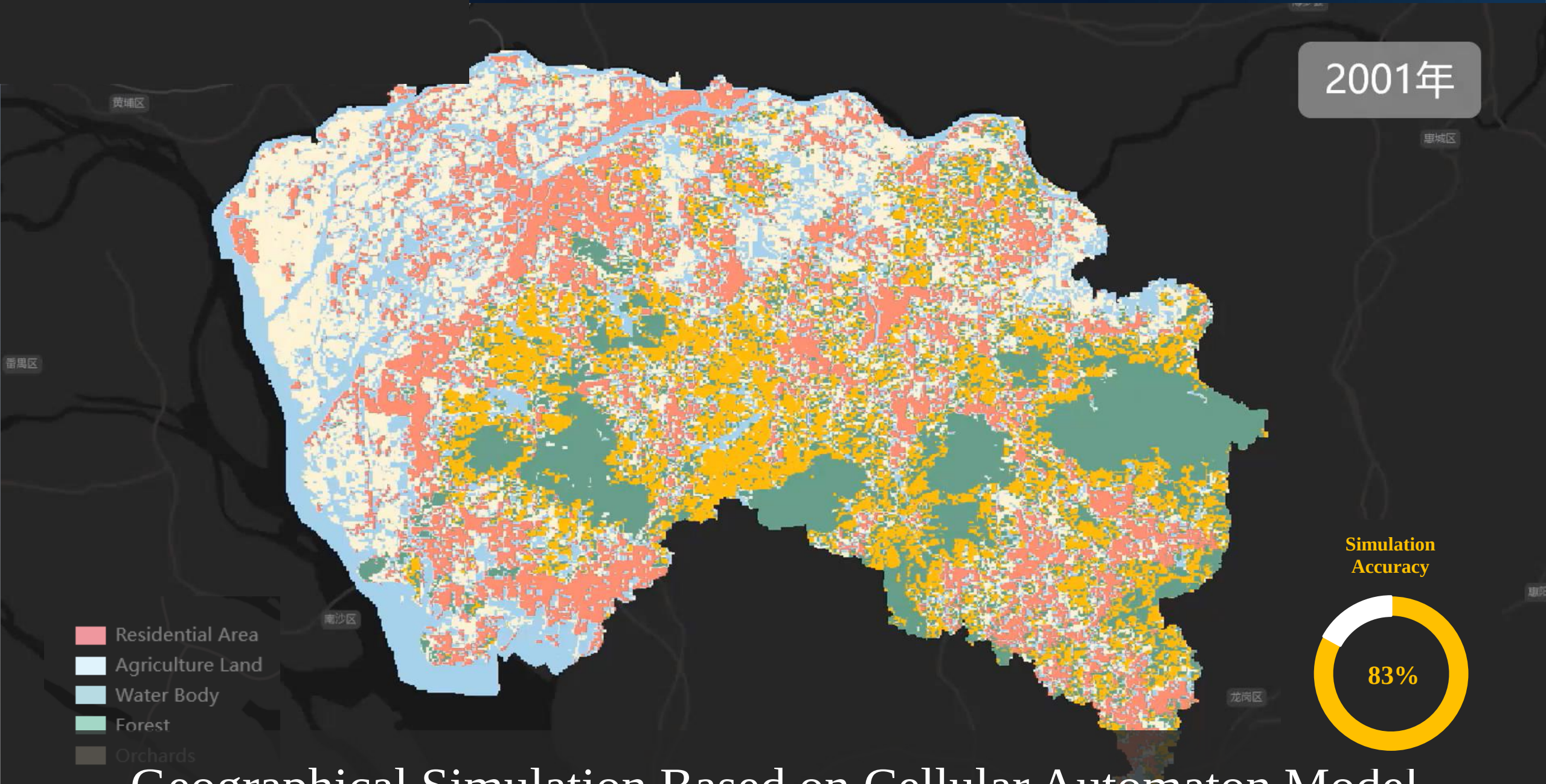
Predicting the suitable areas for Anopheles based on climatic conditions


SuperMap iDesktopX 10i(2021)
Workspace Manager
Untitled Workspace
Datasources
AiTest
ai_window
pbr
id4546
Maps
Layouts
Scenes
Diagram
Models
Video Map
Layer Manager
hn_Network@HNRoad
tracing points
matching path
Catalog
Recently used
Workspace
demo.smwu
liuzhou.smwu
Datasources
ai_window.udbx
cls.udbx
demo.udbx
AiTest.udbx
pv_panels_infer.tif
Folder Connection
Database
Online Services
Accuracy
97%
Spatial Machine Learning—Map (Road) Matching
17

Spatial Machine Learning—Regression

Impact Factors:
- Traffic Condition
- Education
- Medical Services
- …

Calculate housing prices based on the infrastructure distribution



Geographical Simulation Based on Cellular Automaton Model

基于元胞自动机的地理模拟

Spatial Deep Learning Operators

3D Analysis

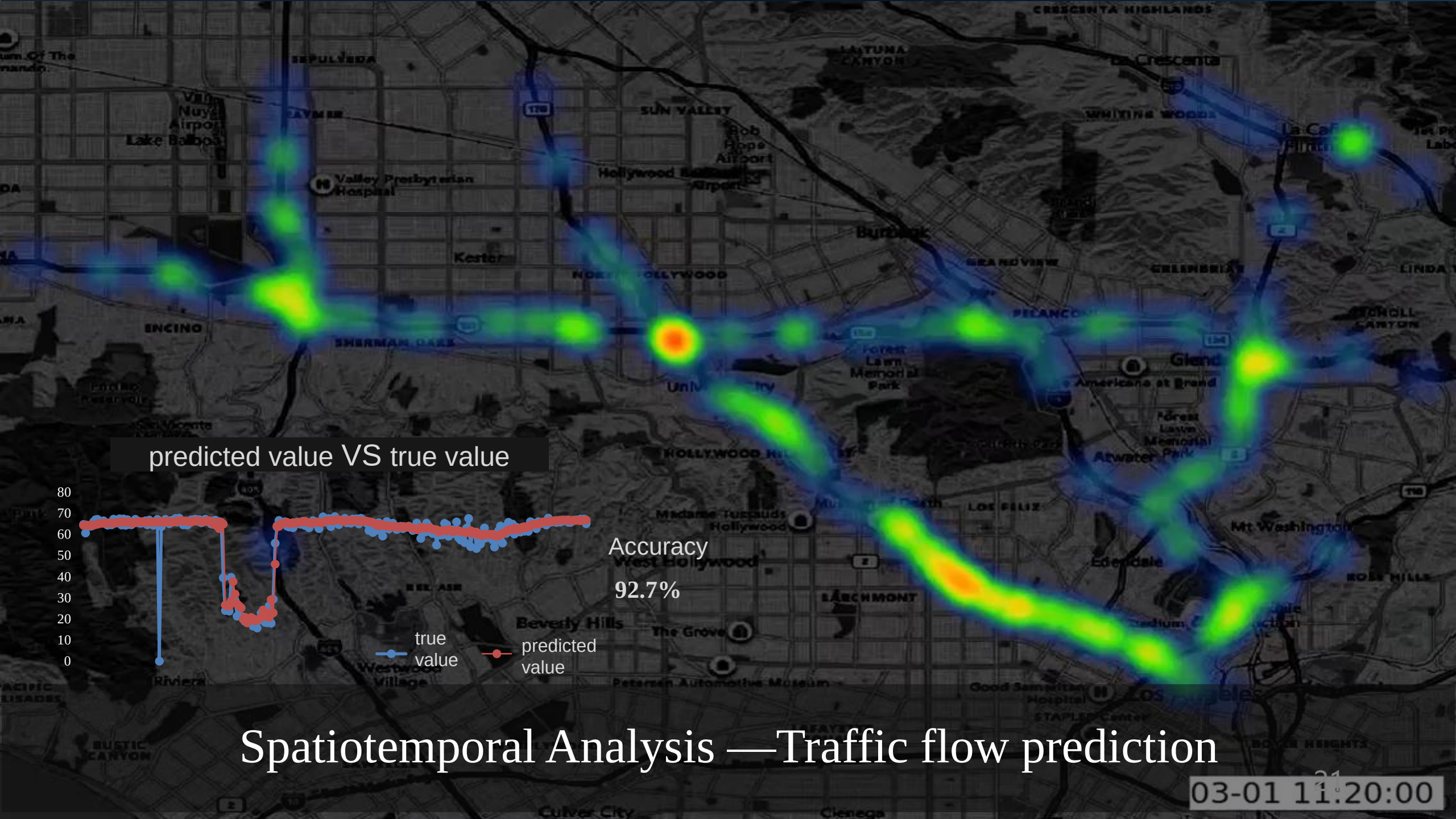
- Oblique Photogrammetry, Model DSM, Building Bottom Extraction

Image Analysis

- Object Extraction
- Object Detection
- Scene Classification
- Binary Classification
- Land Use Classification

Spatiotemporal Analysis

- Map Spatiotemporal Analysis



Spatiotemporal Analysis —Traffic flow prediction

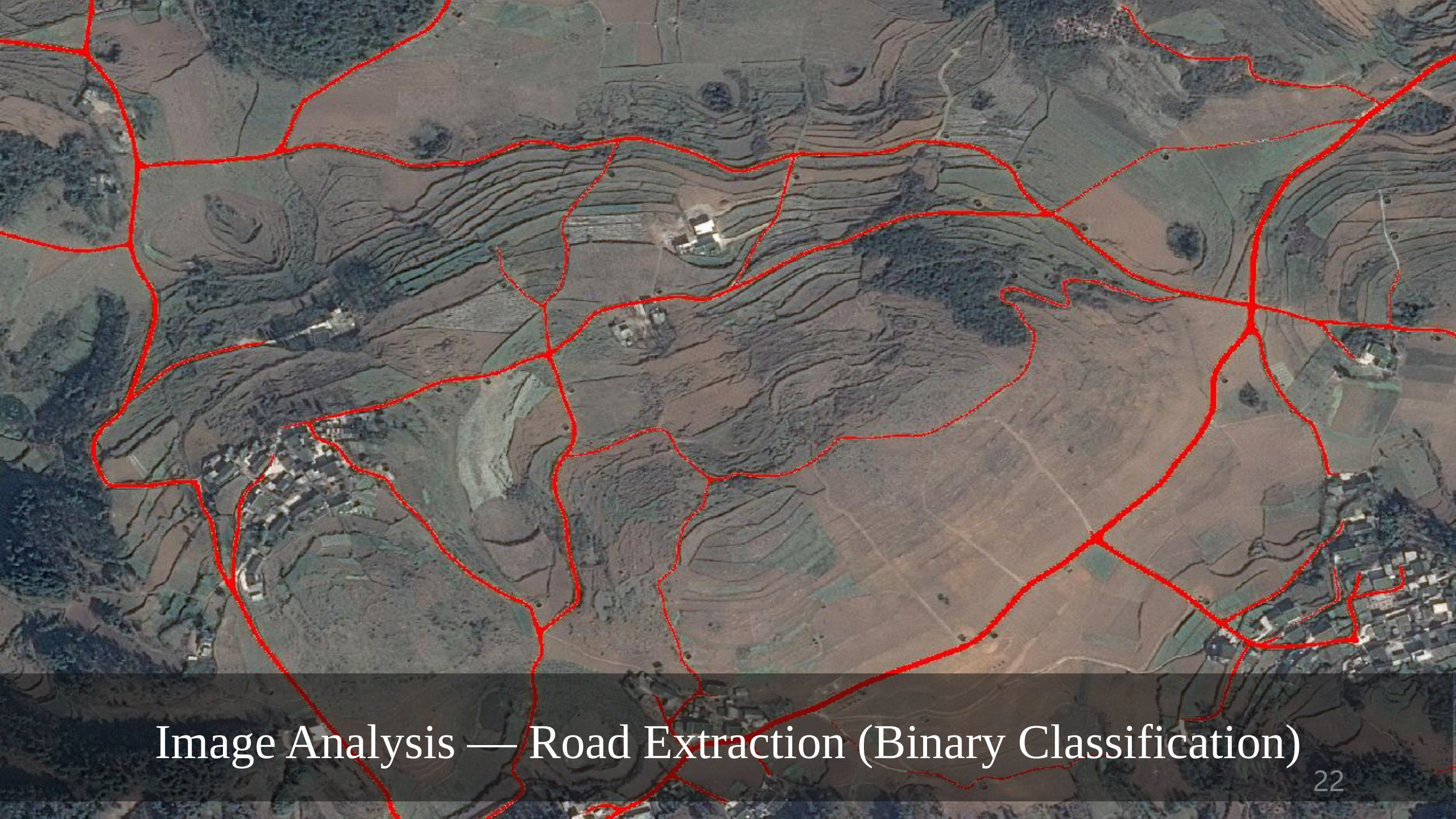


Image Analysis — Road Extraction (Binary Classification)

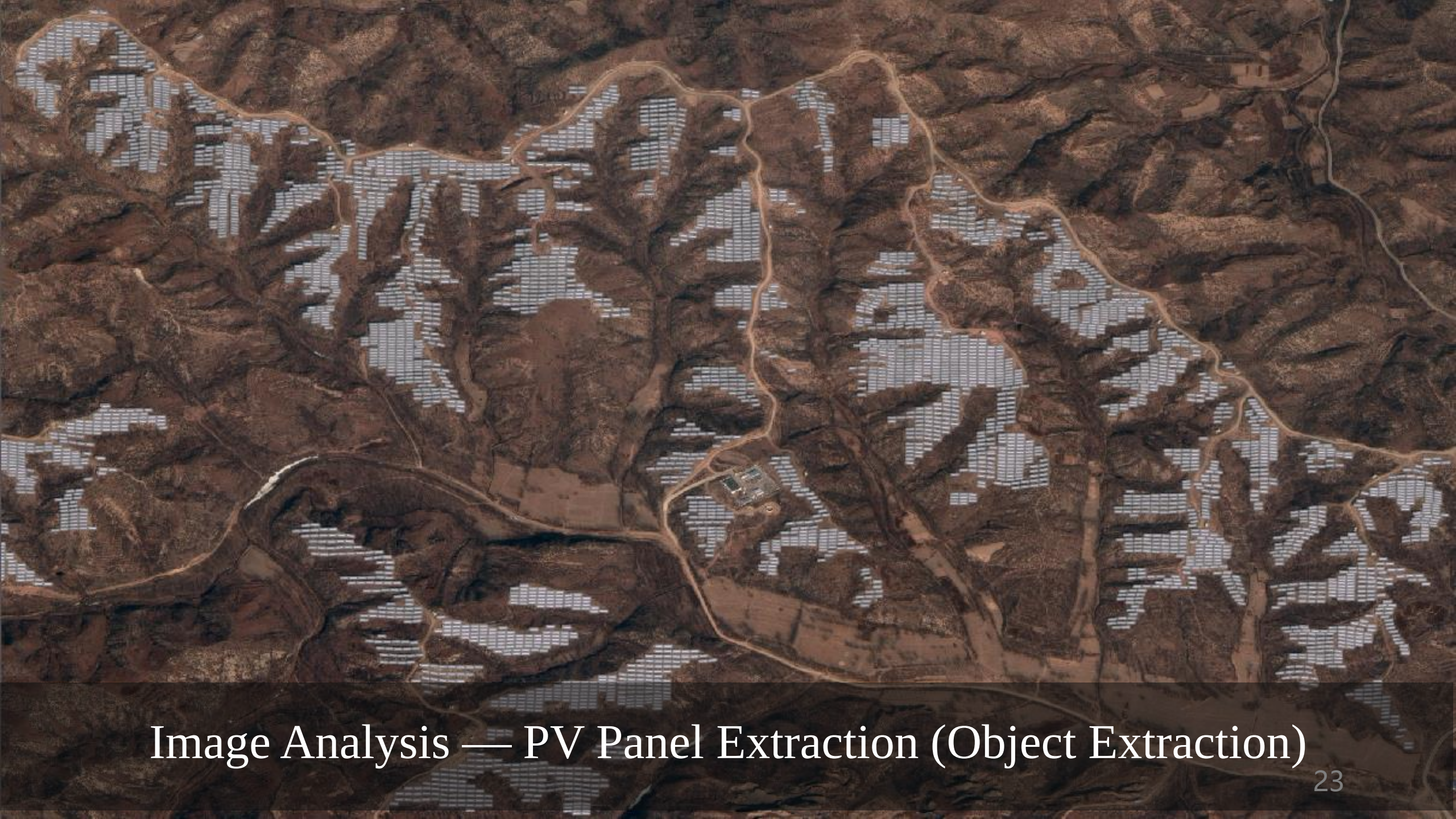


Image Analysis — PV Panel Extraction (Object Extraction)

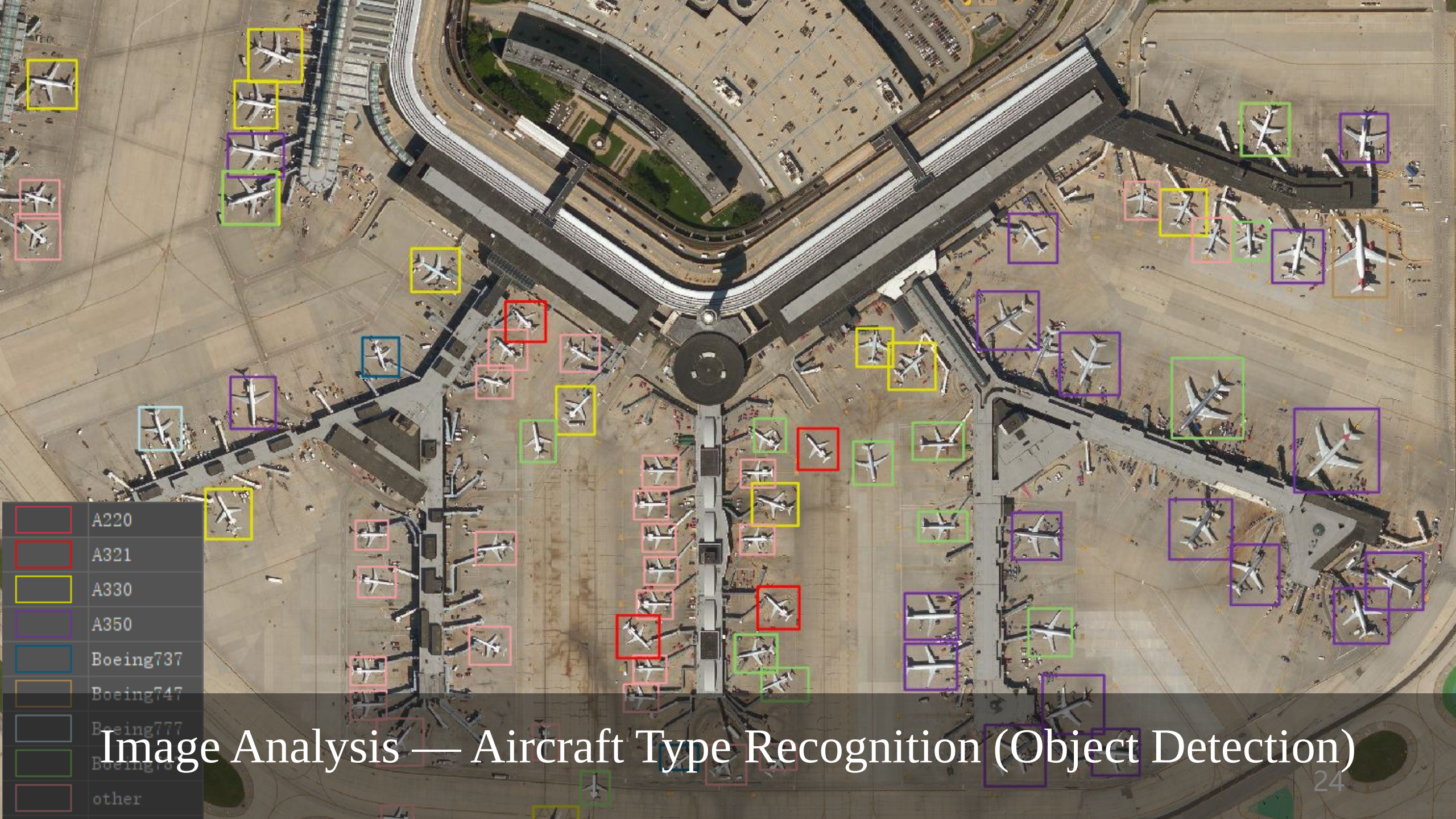


Image Analysis — Aircraft Type Recognition (Object Detection)

Deep Learning Models

	TensorFlow	Paddle	PyTorch			
Object Detection (Image)			Faster R-CNN	Cascade R-CNN	RetinaNet	
Binary/Land Use Classification			D-LinkNet	DeepLab V3+	U-Net	FPN
Object Extraction			Mask R-CNN			
Scene Classification	EfficientNet					
Object Detection (Picture)			Faster R-CNN	Cascade R-CNN	RetinaNet	
Object Detection (Video)	YOLO V4	YOLO V3				
Picture Classification	EfficientNet					
Spatiotemporal Analysis			DCRNN			

Introduction of AI

Spatial ML & DL

AI GIS Workflow

Applications of AI GIS

Deep Learning Workflow

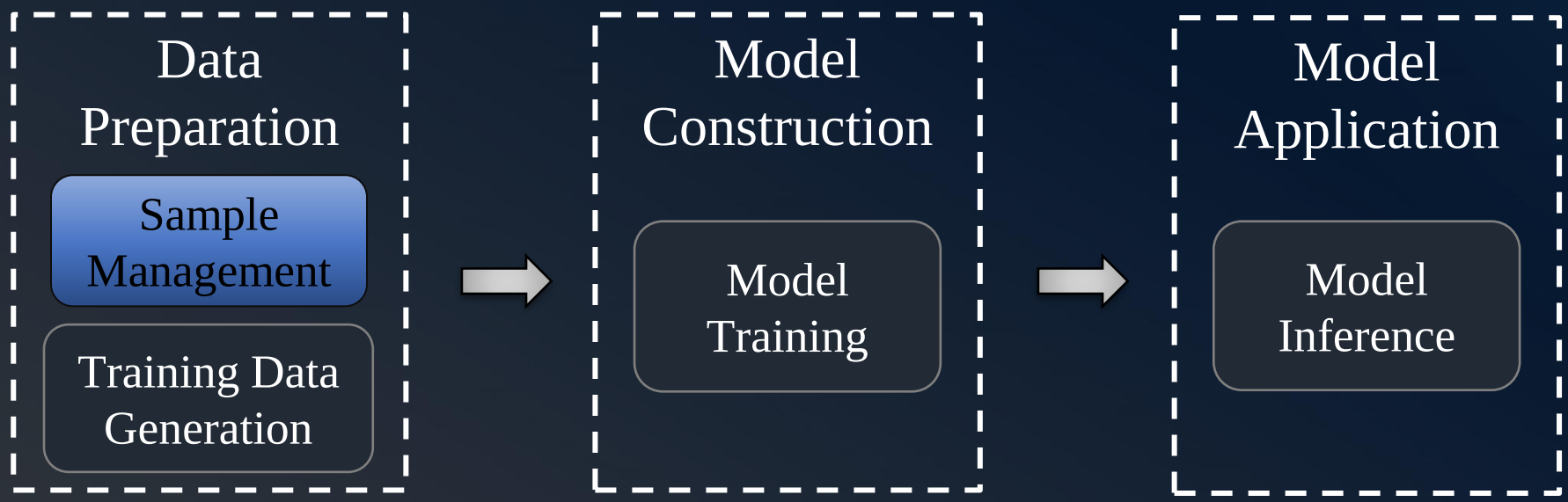
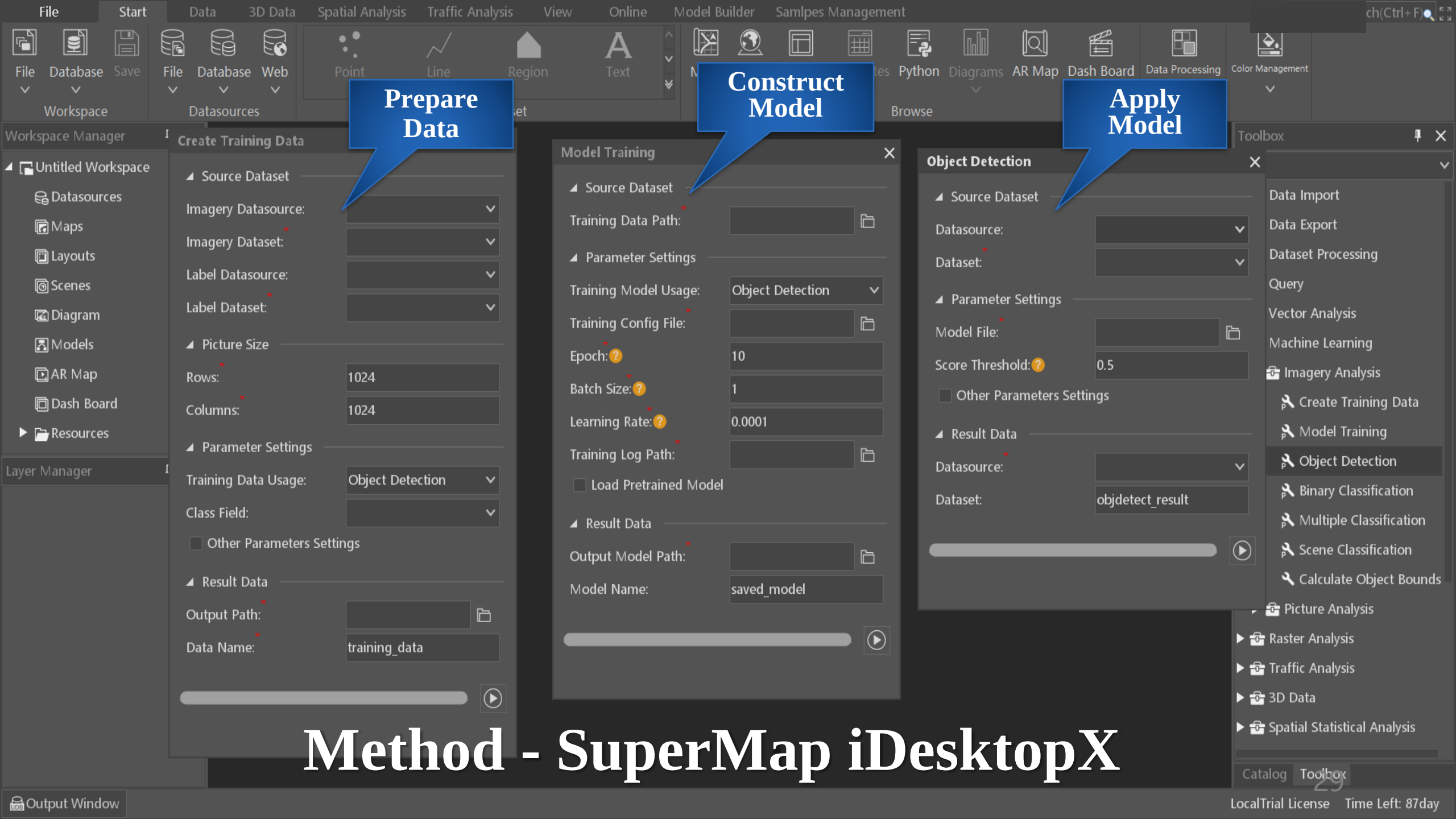


Image Sample Management

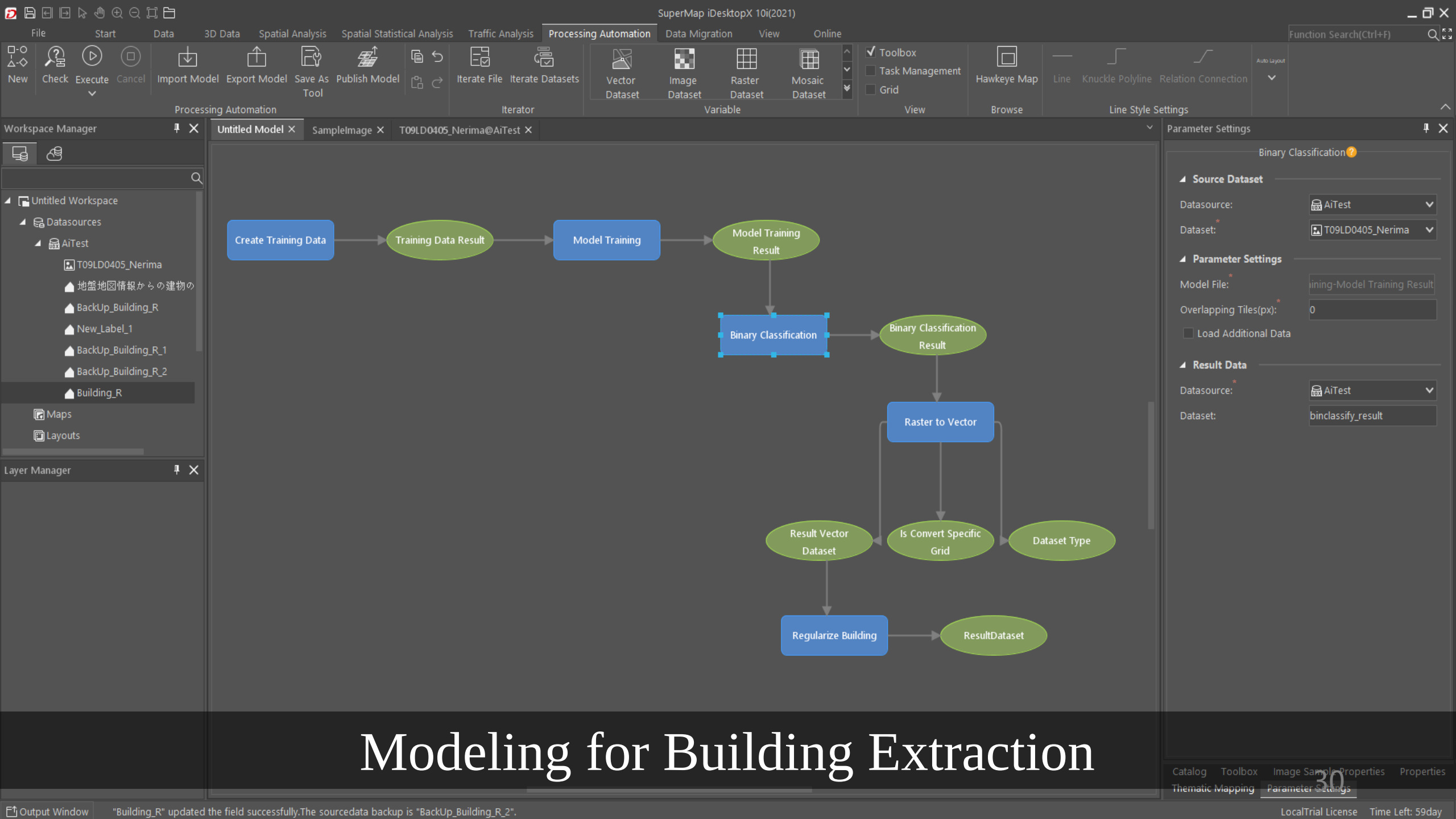
Label

Attribute Table

ID	SmID	SmUserID	SmArea	SmPerimeter	SmGeometry	Label_Type
1	4	0	90.7154	38.1376	BinaryData	villa
2	5	0	53.5357	31.1253	BinaryData	villa
3	6	0	165.5737	52.9898	BinaryData	villa
4	7	0	96.5954	46.8498	BinaryData	villa
5	8	0	75.8655	38.1571	BinaryData	apartment
6	10	0	90.4354	38.4046	BinaryData	apartment
7	11	0	111.6438	42.4805	BinaryData	apartment
8	20	0	34.0158	24.3171	BinaryData	school
9	21	0	46.1827	29.8536	BinaryData	school
10	22	0	42.5054	27.5655	BinaryData	school

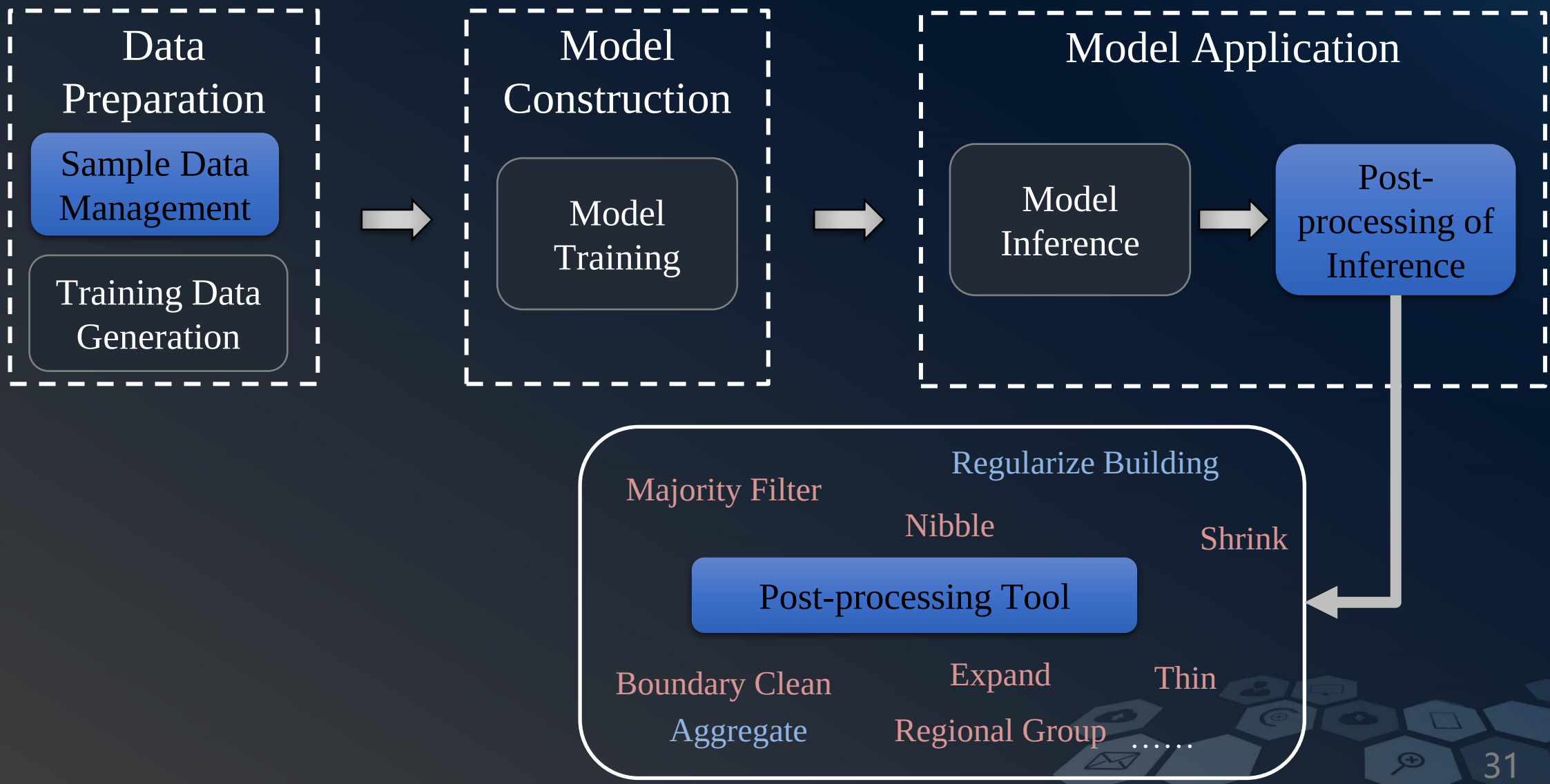


Method - SuperMap iDesktopX



Modeling for Building Extraction

Deep Learning Workflow



Post-processing——Aggregate Region

- Combine polygons elements according to distance
- Aggregate the AI extraction results to obtain the building aggregation area

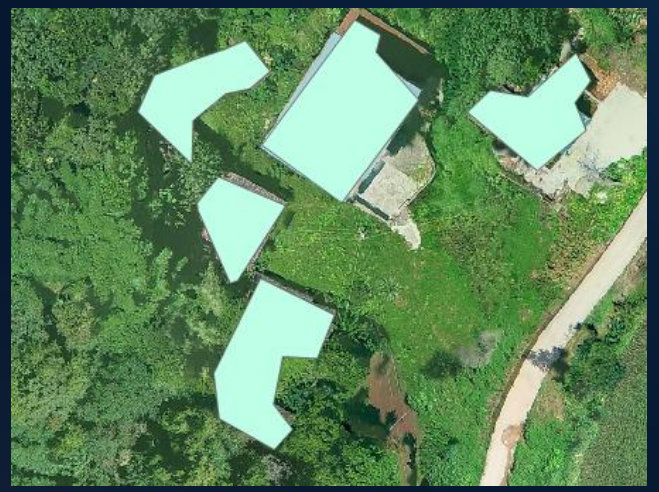
Binary Classification Result（Vector）

Region Aggregation Result

Post-processing——Regularize Building

Original Image

Binary Classification

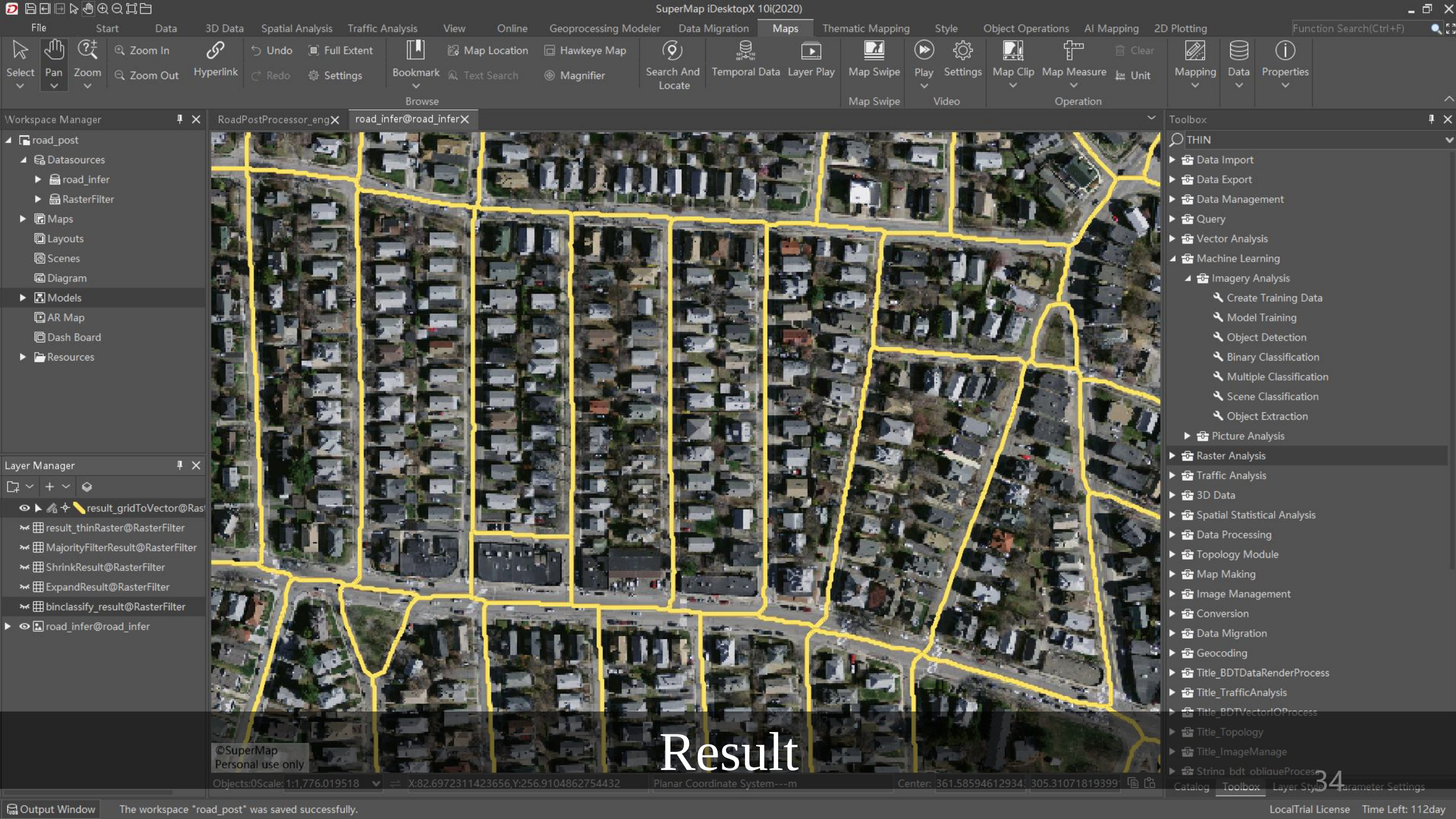


Arbitrary Angle Regularization

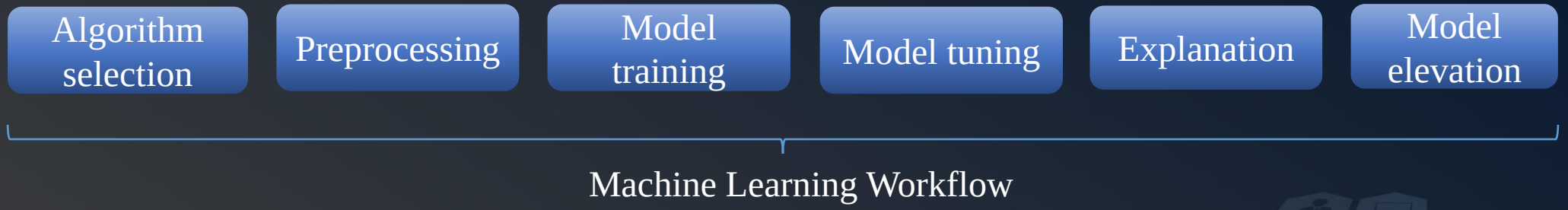
Right & Diagonal Angle Regularization

Right Angle Regularization

Circle Angle Regularization


SuperMap iDesktopX 10i(2020)
File Start Data 3D Data Spatial Analysis Traffic Analysis View Online Geoprocessing Modeler Data Migration Maps Thematic Mapping Style Object Operations AI Mapping 2D Plotting
Function Search(Ctrl+F)
Select Pan Zoom Zoom In Zoom Out Hyperlink Undo Redo Full Extent Settings Bookmark Map Location Text Search Hawkeye Map Magnifier Search And Locate Temporal Data Layer Play Map Swipe Play Settings Map Clip Map Measure Clear Unit Mapping Data Properties
Browse Map Swipe Video Operation
Workspace Manager
road_post
Datasources
road_infer
RasterFilter
Maps
Layouts
Scenes
Diagram
Models
AR Map
Dash Board
Resources
Layer Manager
result_gridToVector@Ras
result_thinRaster@RasterFilter
MajorityFilterResult@RasterFilter
ShrinkResult@RasterFilter
ExpandResult@RasterFilter
binclassify_result@RasterFilter
road_infer@road_infer
RoadPostProcessor_eng
road_infer@road_infer
©SuperMap
Personal use only
Result
Objects:0Scale: 1:1,776.019518
X:82.6972311423656,Y:256.9104862754432
Planar Coordinate System---m
Center: 361.58594612934 305.31071819399
Toolbox
THIN
Data Import
Data Export
Data Management
Query
Vector Analysis
Machine Learning
Imagery Analysis
Create Training Data
Model Training
Object Detection
Binary Classification
Multiple Classification
Scene Classification
Object Extraction
Picture Analysis
Raster Analysis
Traffic Analysis
3D Data
Spatial Statistical Analysis
Data Processing
Topology Module
Map Making
Image Management
Conversion
Data Migration
Geocoding
Title_BDTDataRenderProcess
Title_TrafficAnalysis
Title_BDTVectorIOProcess
Title_Topology
Title_ImageManage
Catalog Toolbox Layer Style Parameter Settings
Output Window
The workspace "road_post" was saved successfully.
LocalTrial License Time Left: 112day

Automated Machine Learning (AutoML) Modeling



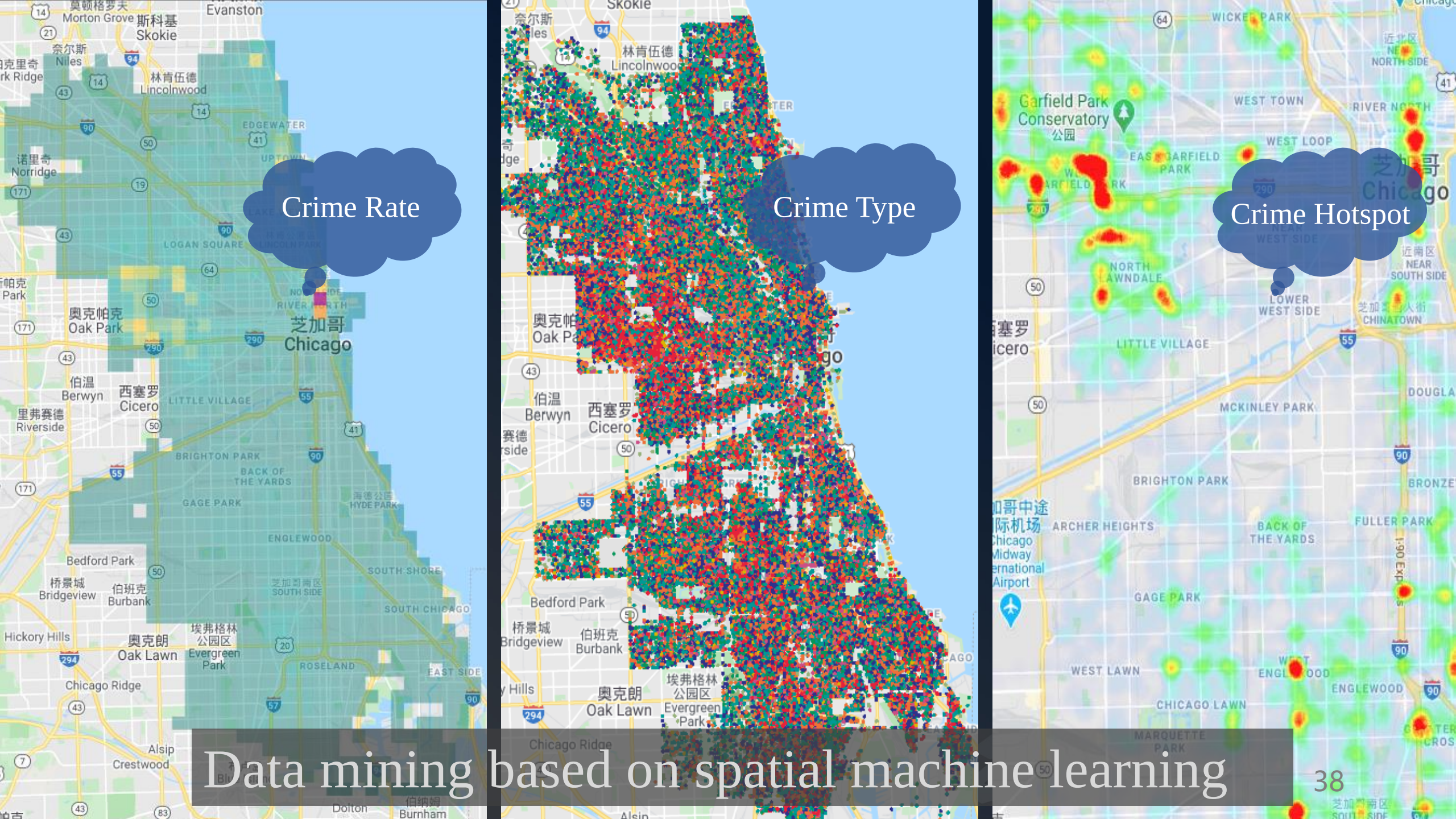
Introduction of AI

Spatial ML & DL

AI GIS Workflow

Applications of AI GIS

Criminal Spatiotemporal Data Mining


Crime Rate
Crime Type
Crime Hotspot
Data mining based on spatial machine learning

Criminal Spatiotemporal Data Mining

Spatial Big Data

Resident

Income

Education

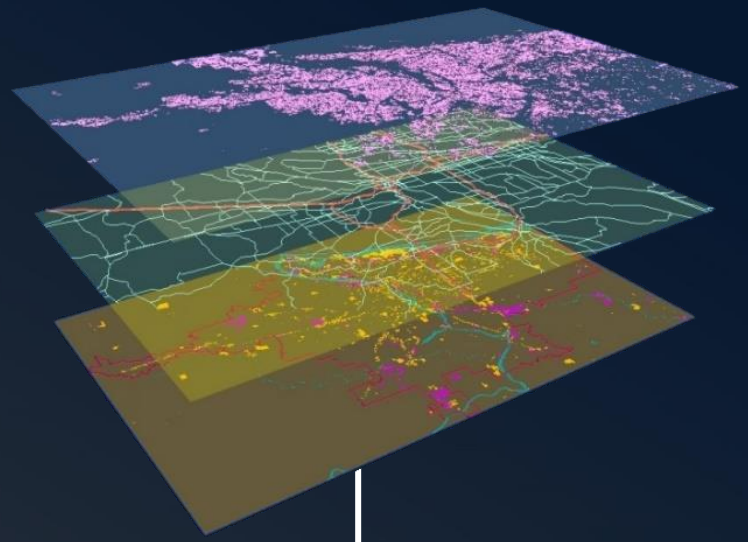
Security

Traffic

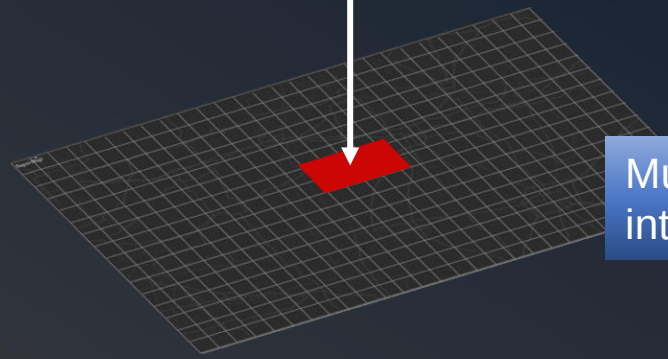
administrat ive area

...

Historical crime data



Summarize Mesh

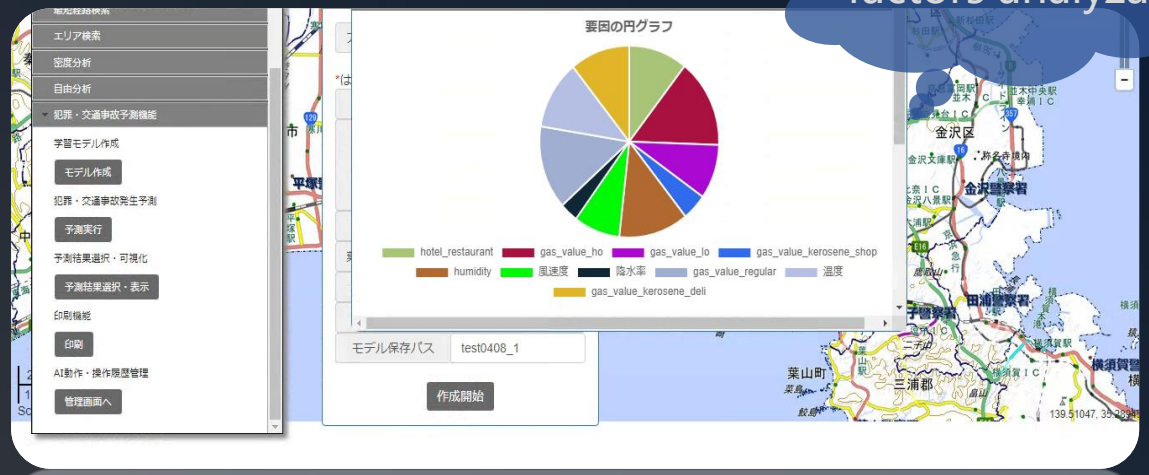


Spatial Machine Learning

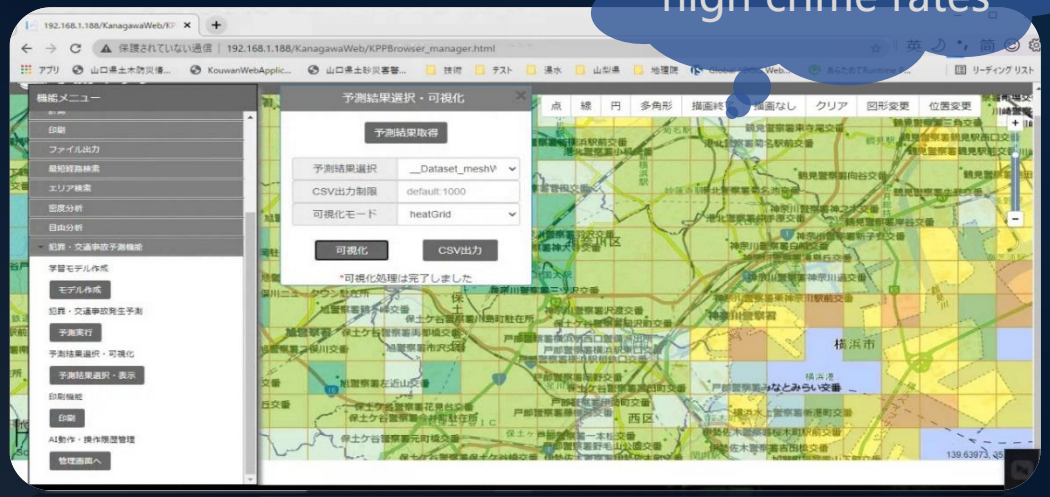
- Clustering
- Classification
- Regression

Multiple sources of data are aggregated into the same geospatial unit

Crime impact factors analyzation



Predict areas with high crime rates



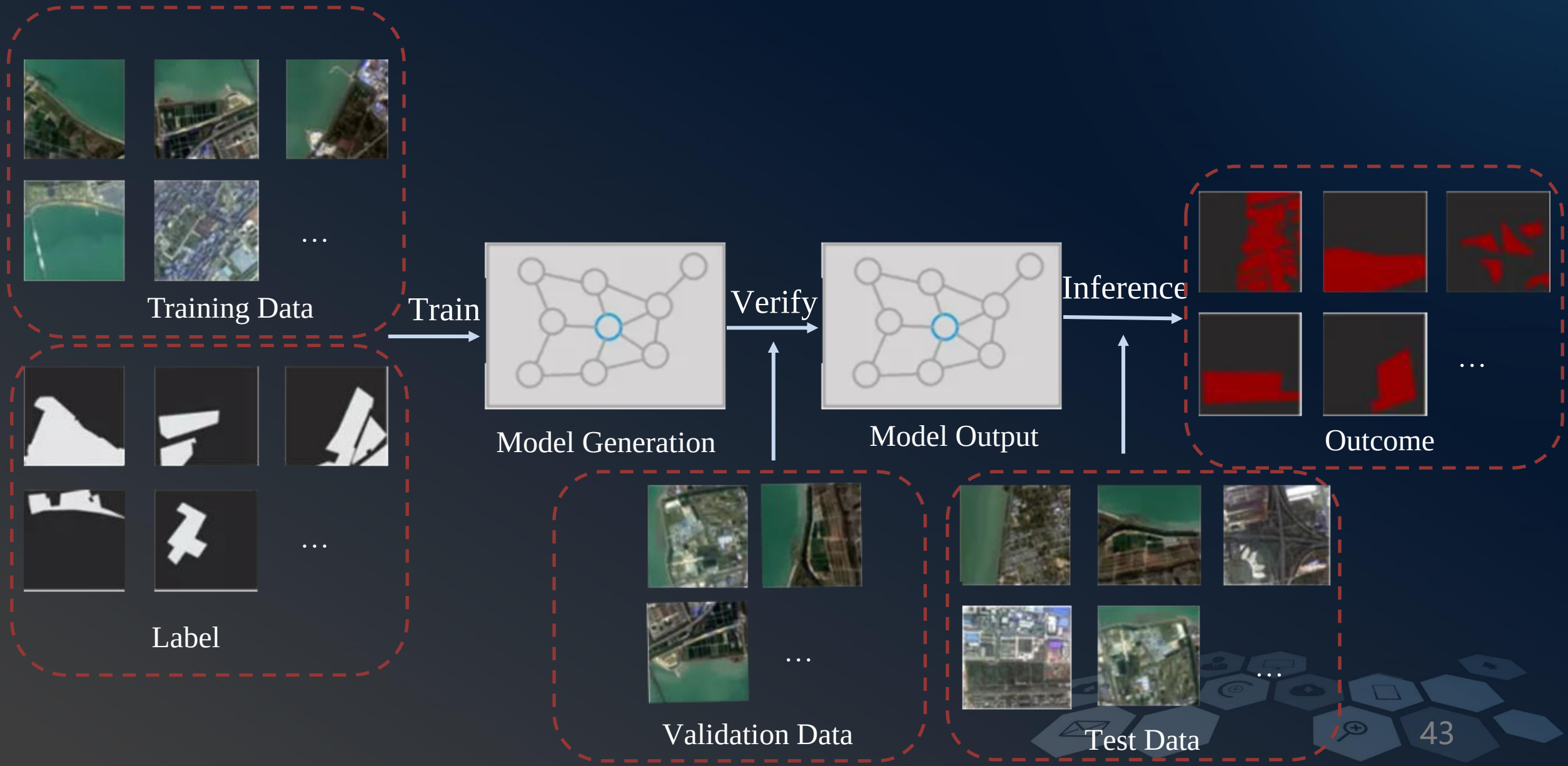
Support police deployment
Carry out effective prevention

Building Intelligent Inspection

Data Description

- Drone data
  - 0.05-meter resolution
  - About 9km^2
  - Tile Size: 800 * 800
- Building Vector Labels
  - About 1,000 labels
- Pretrained Model
  - About 50,000 labels

AI GIS Workflow



AI Extraction Results

Ground Truth

Binary classification results

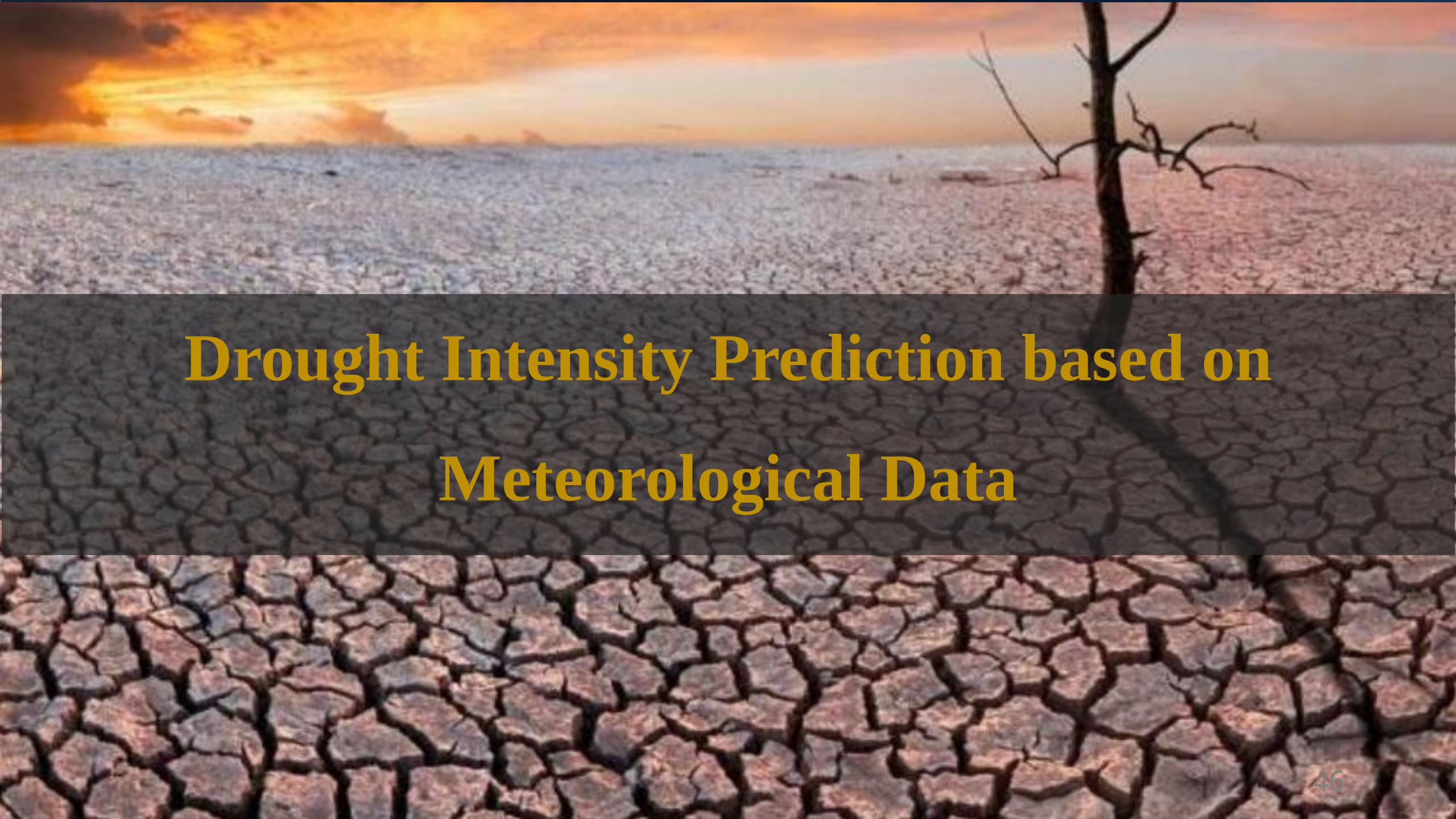
Algorithm：FPN
Training Time：3.5h（GPU）
Accuracy：IOU=0.72

Summary Statistics

Distribution of buildings in each region

Vector：Summarize Features

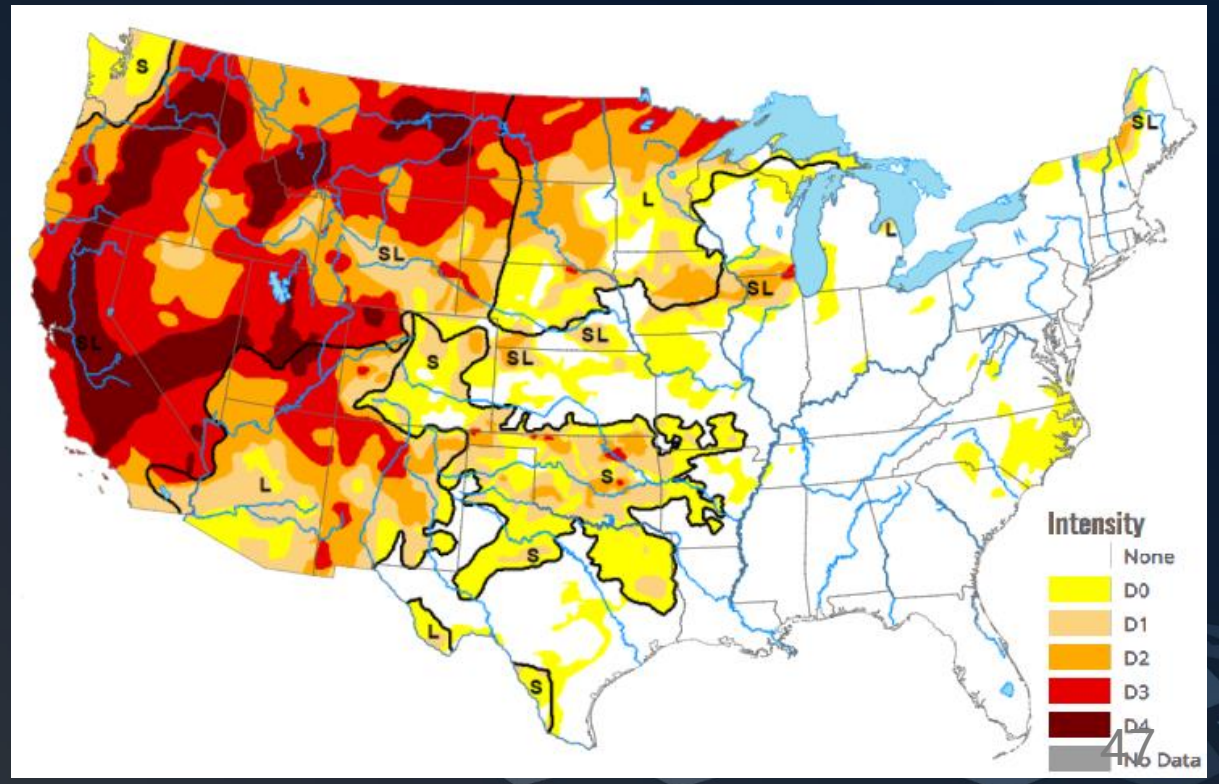
Raster：Zonal Statistic



Drought Intensity Prediction based on Meteorological Data

Data Description

- Climate data around US with drought intensity levels
- From 2000 to 2009
- Wind speed, temperature, air pressure, humidity, rainfall and other climate factors
- 5 levels of drought
  - 0: Abnormally Dry
  - 1: Moderate Drought
  - 2: Severe Drought
  - 3: Extreme Drought
  - 4: Exceptional Drought



Training Data Preprocessing

In [2]:
```
import pandas as pd
import numpy as np
from sklearn.metrics import accuracy_score
```

In [4]:
```
data = pd.read_csv(r'.\archive\train_timeseries\train_timeseries.csv')
```

In [5]:
```
train_data = data.dropna(subset = ["score"])
train_data = train_data.round({'score': 0})
train_data.astype({'score': 'int32'})
train_select = train_data.loc[(train_data.date=='2000-06-27') | (train_data.date=='2000-07-04')]
train_select = train_select[train_select.columns[2:]]
train_select
```

Out[5]:

	PRECTOT	PS	QV2M	T2M	T2MDEW	T2MWET	T2M_MAX	T2M_MIN	T2M_RANGE	TS	WS10M	WS10M_MAX	WS10M_MIN	WS10M_RANGE	WS50M	WS50M_
178	2.19	100.24	14.16	27.65	19.32	19.32	35.88	20.14	15.74	28.27	1.43	2.11	1.11	1.00	2.98	5.20
185	0.03	100.31	12.93	29.71	17.93	17.93	37.55	22.42	15.14	30.07	1.57	2.40	1.10	1.30	2.96	4.96
6388	2.46	101.29	15.59	27.32	21.14	21.15	32.81	22.40	10.41	28.07	1.98	3.24	1.10	2.14	3.13	4.33
6395	0.06	101.38	14.10	29.12	19.46	19.46	35.47	24.10	11.37	29.32	1.86	2.97	0.48	2.49	2.90	4.61
12598	2.06	100.51	14.43	27.19	19.78	19.78	33.90	20.97	12.93	27.75	1.83	3.22	1.09	2.14	3.36	4.85
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19282235	0.81	76.46	5.33	10.42	0.74	0.76	16.41	3.53	12.88	10.03	2.55	4.67	0.55	4.12	4.41	7.78
19288438	0.40	76.74	5.83	15.11	2.12	2.13	23.26	5.87	17.38	15.42	3.44	6.40	0.66	5.74	4.93	8.34
19288445	0.04	76.32	4.22	14.87	-2.63	-2.53	23.05	6.34	16.72	15.24	2.96	5.85	0.49	5.36	4.32	7.55
19294648	3.40	83.67	6.50	13.82	4.97	4.97	20.03	7.70	12.33	15.96	3.48	5.51	1.24	4.27	4.50	7.17
19294655	0.16	82.85	5.25	21.03	1.52	1.57	28.98	12.62	16.35	22.83	2.94	5.76	0.94	4.82	4.18	7.04

6216 rows × 19 columns

In [6]:
```
input_data = 'train_select.csv'
train_select.to_csv(input_data, index=False)
```

Mode Training

In [16]:
```
from iobjectspy.ml.analyst import AutoMLTrainer

config ='tabular_automl_train.sdt'
output_model_path = 'out_dir'
output_model_name = 'drought_automl_model_Perform'
train_data = os.path.join(output_data_path, output_name + '.sda')
while os.path.exists(output_model_name):
    output_model_name = output_model_name + '_1'
AutoMLTrainer(output_model_path=output_model_path, output_model_name=output_model_name, mode='Perform',
              config=config).tabular_train(train_data)
```

```
AutoML directory: out_dir\drought_automl_model_Perform
The task is multiclass_classification with evaluation metric logloss
AutoML will use algorithms: ['Decision Tree', 'Baseline', 'Linear', 'Random Forest', 'Extra Trees', 'LightGBM', 'Xgboost', 'CatBoost', 'Ne
ural Network', 'Nearest Neighbors']
AutoML will ensemble availabe models
AutoML steps: ['simple_algorithms', 'default_algorithms', 'not_so_random', 'insert_random_feature', 'features_selection', 'hill_climbing_
1', 'hill_climbing_2', 'ensemble']
* Step simple_algorithms will try to check up to 5 models
1_Baseline logloss 1.290037 trained in 1.12 seconds (1-sample predict time 0.0359 seconds)
2_DecisionTree logloss 1.090409 trained in 35.15 seconds (1-sample predict time 0.0519 seconds)
3_DecisionTree logloss 1.050297 trained in 28.86 seconds (1-sample predict time 0.0519 seconds)
4_DecisionTree logloss 1.049632 trained in 31.05 seconds (1-sample predict time 0.0748 seconds)
5_Linear logloss 1.033082 trained in 9.18 seconds (1-sample predict time 0.0798 seconds)
* Step default_algorithms will try to check up to 7 models
6_Default_LightGBM logloss 0.474582 trained in 39.73 seconds (1-sample predict time 0.0788 seconds)

ntree_limit is deprecated, use `iteration_range` or model slicing instead.
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
```

Mode Inference

In [17]:
```
from iobjectspy.ml.analyst import AutoMLInference

out_data = os.path.join('out_dir', 'test_out.csv')
model_path = os.path.join(output_model_path, output_model_name, output_model_name + '.sdm')
predictions = AutoMLInference(model_path).tabular_infer(test_data, out_data)
```

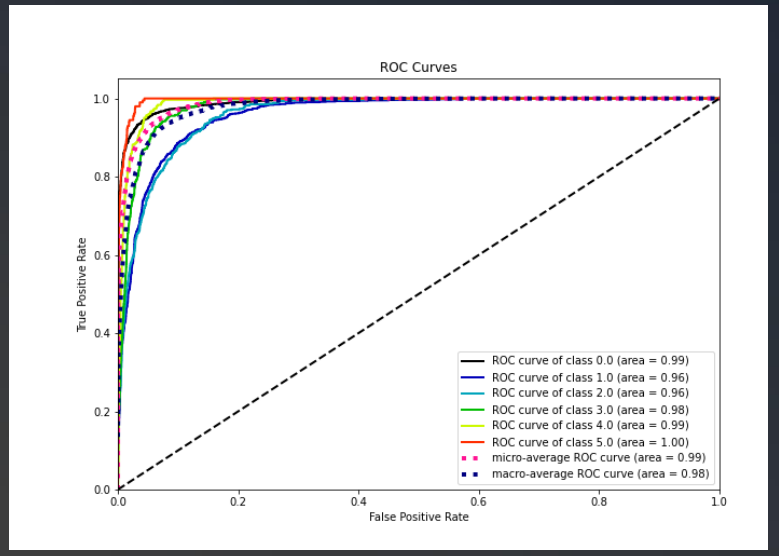
```
ntree_limit is deprecated, use `iteration_range` or model slicing instead.
```

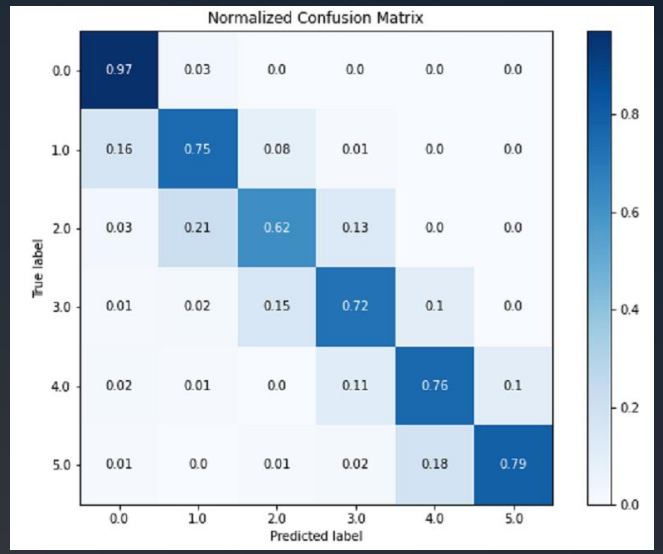
In [18]:
```
predictions
```

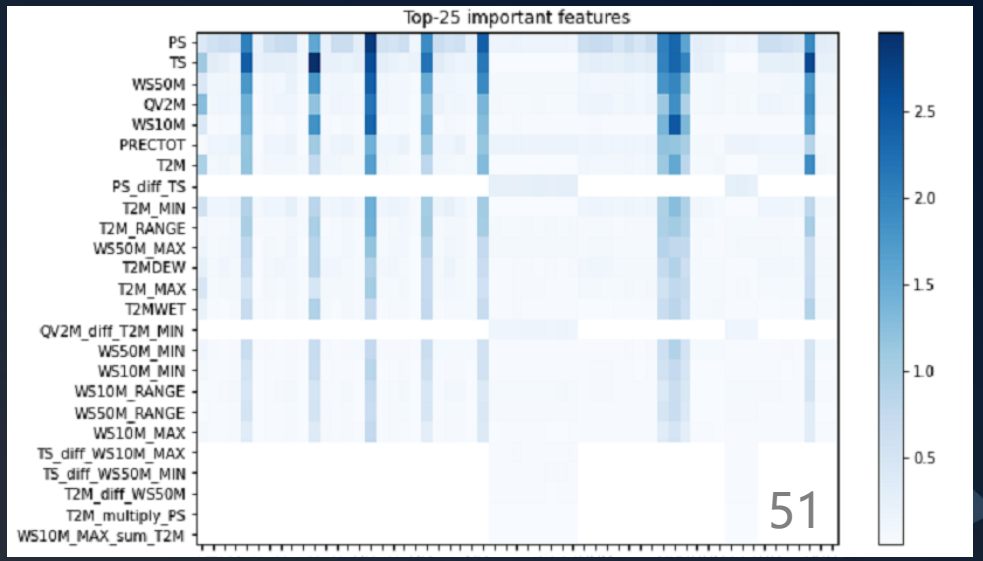
Out[18]:
```
(      predicted
 0           0.0
 1           0.0
 2           0.0
 3           0.0
 4           0.0
 ...         ...
 6211        1.0
 6212        1.0
 6213        1.0
 6214        0.0
 6215        1.0

 [6216 rows x 1 columns],
 'out_dir\\test_out.csv')
```

Automated Machine Learning (AutoML) Modeling

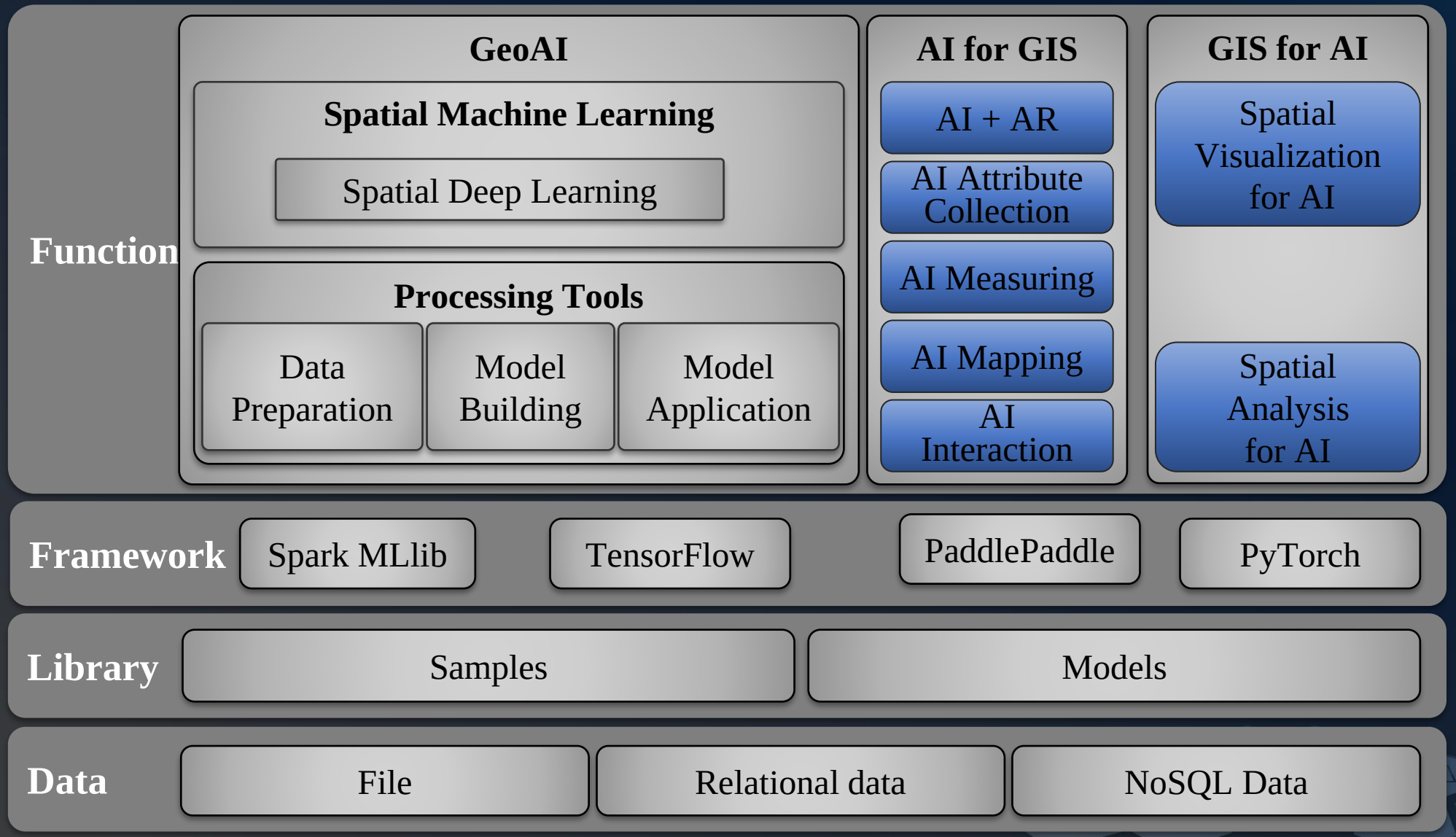
- Model training process visualization
  - Learning Curve
  - Confusion Matrix
  - Feature Importance
  - Precision Curve
  - … …



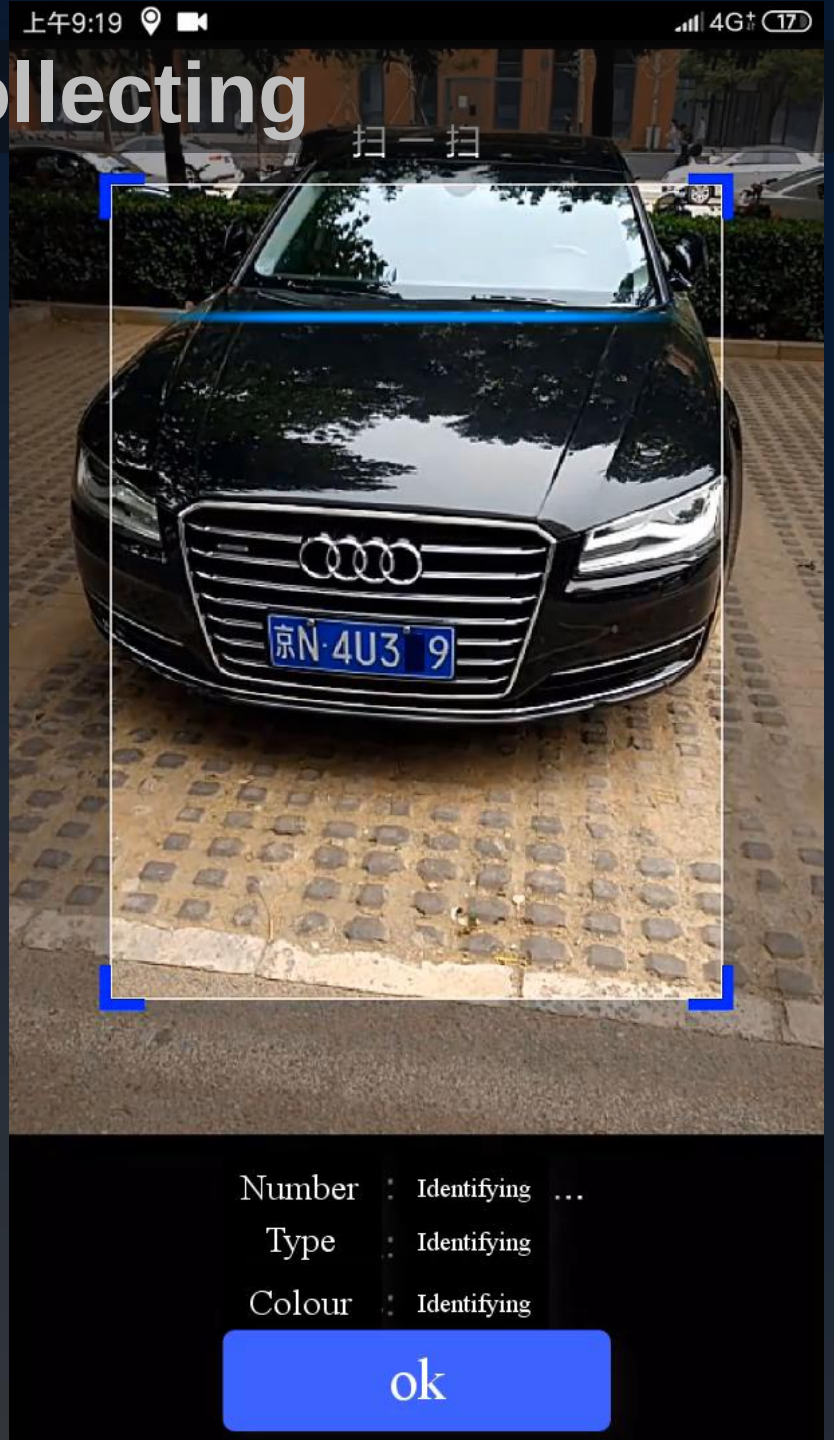




AI GIS Technology System



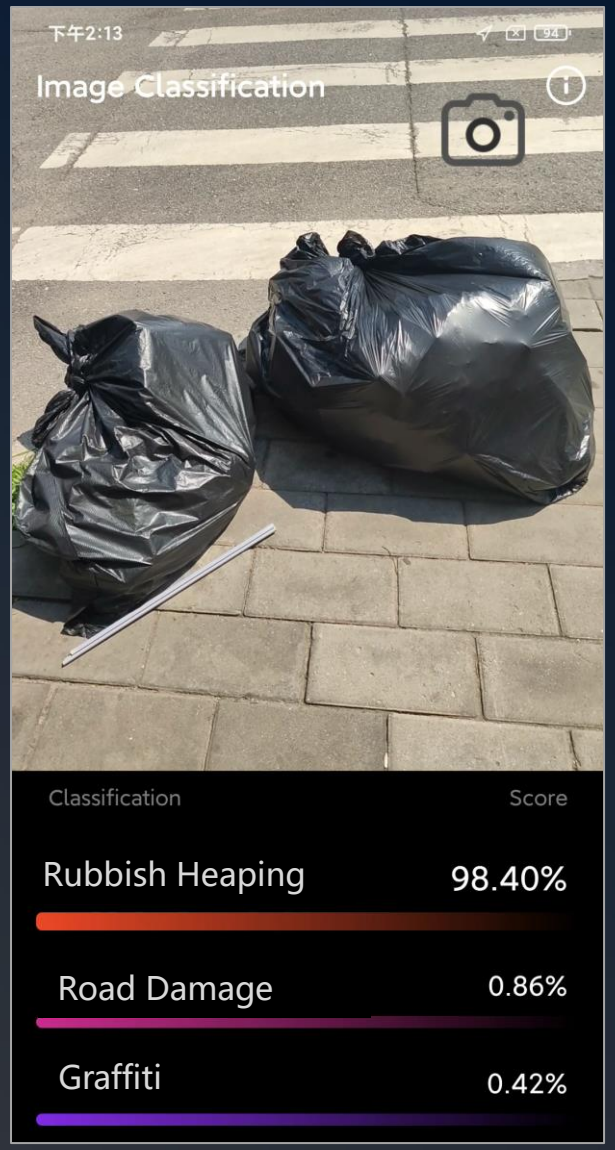
AI Attribute Collecting



Illegal Parking

AI + AR


下午4:48
SelectImage Classification
Classification
Score
AD
85.09%
Graffiti
14.83%
Illegal Buildings
0.03%


下午2:13
Image Classification
Classification
Score
Rubbish Heaping
98.40%
Road Damage
0.86%
Graffiti
0.42%


京物大厦
大山子北窑地河北一号院
环铁北桥
58同城西楼
便利蜂
乐学教育集团
ABB(中国)研究院
东方园林大厦
酒仙桥北路甲10号院
2021-07-23
14时13分
望京墩
德信大厦
科第十一研究所
北京邮电大学合众思壮移动互联与位置服务研究中心
酒仙桥
万红路
将台派出所
驼房营村史馆
Copyright 2021 SuperMap

Spatial Visualization for AI (Traffic Monitoring Visualization)

实时交通态势监控

Traffic Situation Monitoring and Control System

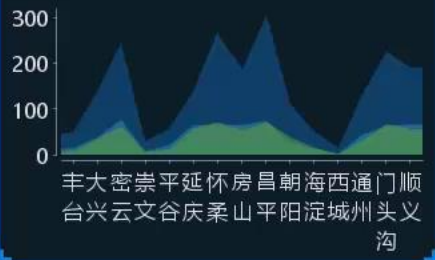
Vehicle Congestion (0-10)

4.094

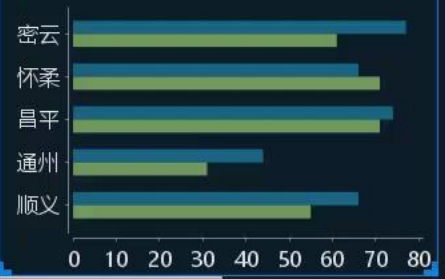
Motor Vehicle

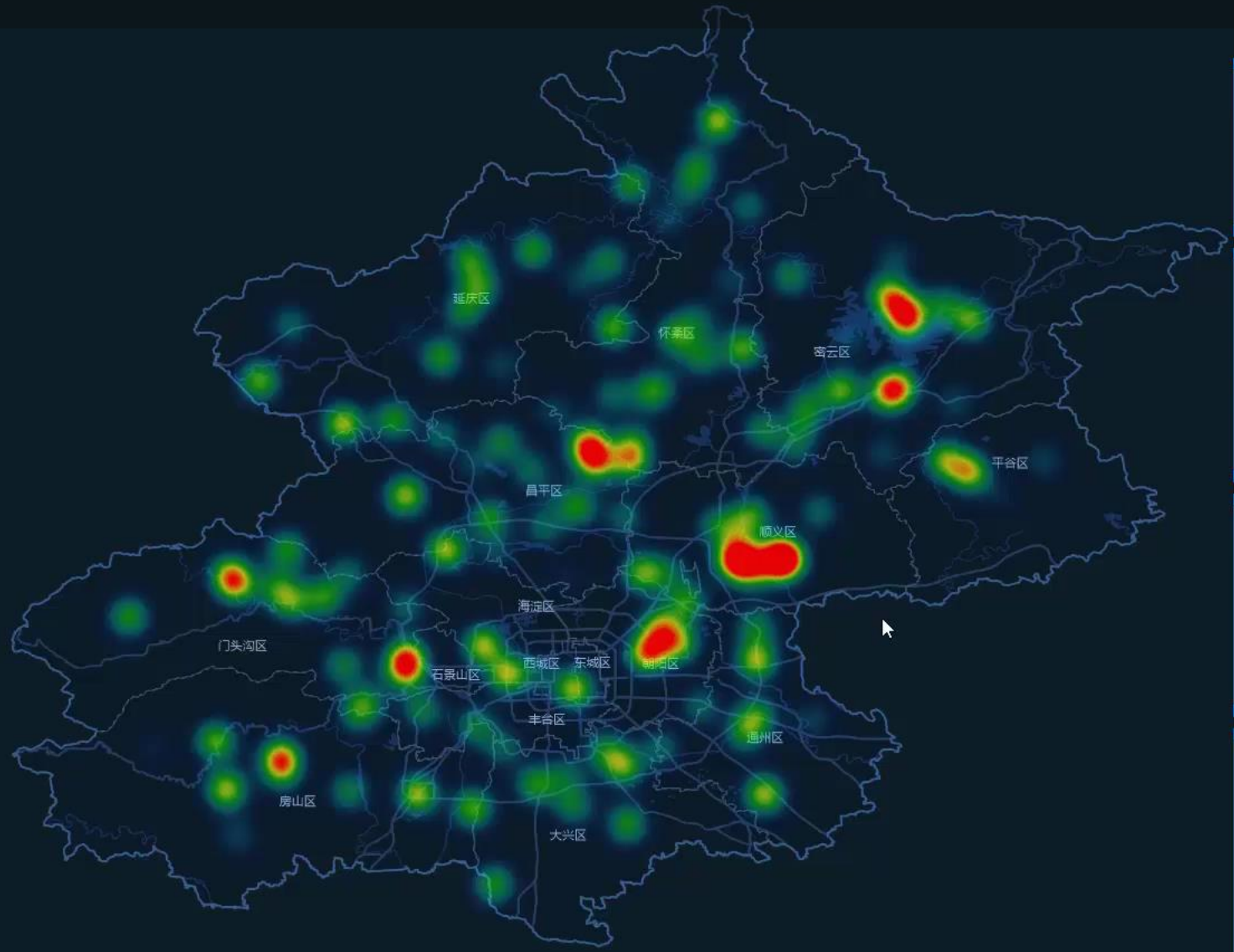
Non-motor Vehicle

Motor Vehicle, Non-motor Vehicle, Pedestrian Congestion



Top 5 Congested District



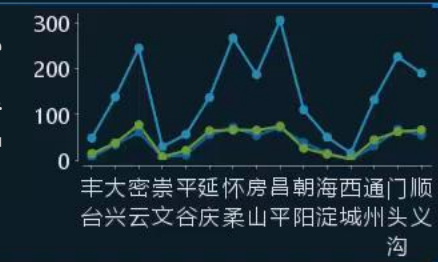


Real Time Information

区域:通州	车:9	非机动车:8
区域:丰台	车:9	非机动车:4
区域:海淀	车:6	非机动车:8
区域:昌平	车:6	非机动车:9

District Congestion

Congestion Type



Video

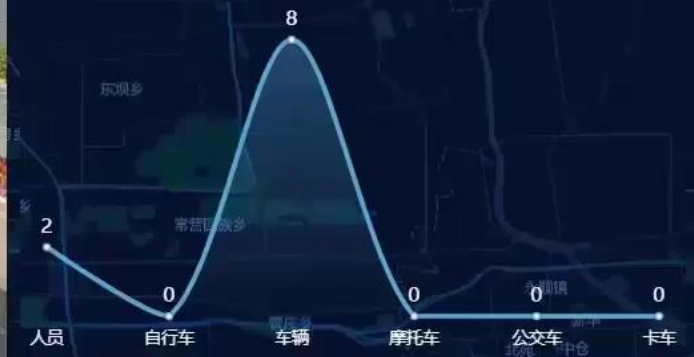
Real-Time AI Vehicle Recognizing Platform

Statistics

Pedestrian	2	Motorcycle	0
Bicycle	0	公 Bus	0
Vehicle	8	Truck	0

Illegal Vehicle

Motor Vehicle	0	Non-motor Vehicle	0



Cameras

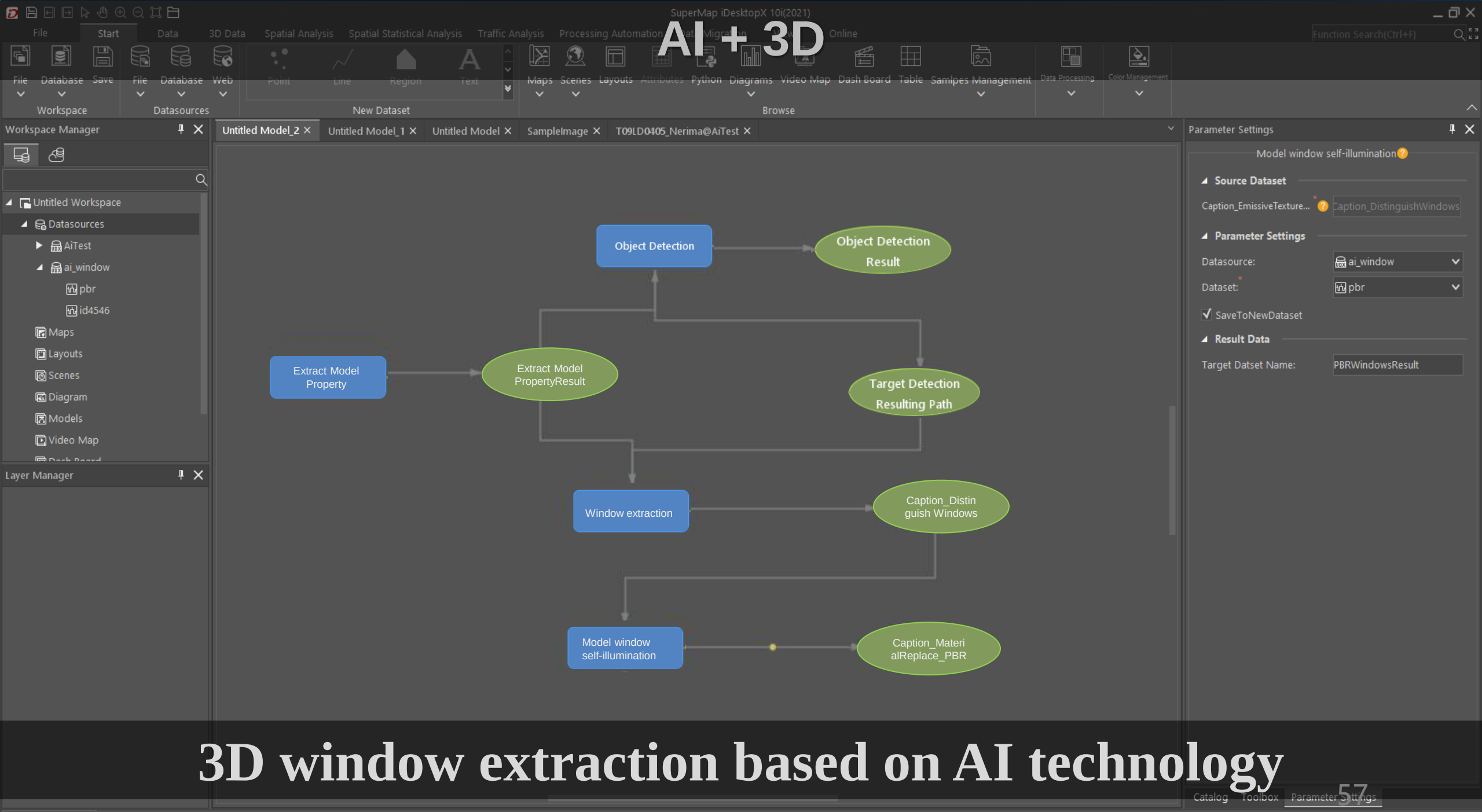
camera1

camera2

camera3

camera4

camera5



3D window extraction based on AI technology

3D window extraction based on AI technology

SuperMap

Reach us here!

Thank You!