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Leveraging Location-Enabled Str and Machine Learning to Automa Scale Data Collection in Support Valuation

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Automated Valuation Model

A statistical algorithm that estimates market value and/or value adjustments based on property and market characteristics. When used for property tax purposes, this model is typically regression-based, and coefficients serve as value adjustments.

- IAAO

Reassessment

The revaluations of all real property by the regularly constituted assessing/valuation authority, as distinguished from assessment on the basis of valuation, most or all of which were established in some prior year.

- IAAO

Common Challenges for Assessors

- Maintaining trust and confidence of the public
- A lot of business systems….out of sync
- Keeping data current
- Minimizing appeals, better defense
- Transparent operations
- Reducing counter traffic & telephone calls
- Discover untaxed property
- Improved analysis
- Discover trends and patterns
- Sharing data
- Training/Staff churn
- Field appraiser management
- New devices
- Reducing operational costs

Proof of Concept

- **Q1:** Can street level photos and artificial intelligence be used to automate the capture and classification of property attributes in support of property valuation?
- **Q2:** Does the information derived from street level photos and artificial intelligence have a significant influence on the fair market value of the property?

Key Property Attributes Examined:

Objective Features:

- Building Material (brick, wood, vinyl, stucco)
- Graffiti
- Overgrowth
- Boarded Up
- Porch/Patio
- Number of Stories
- Type (single family or attached)

Subjective Features:

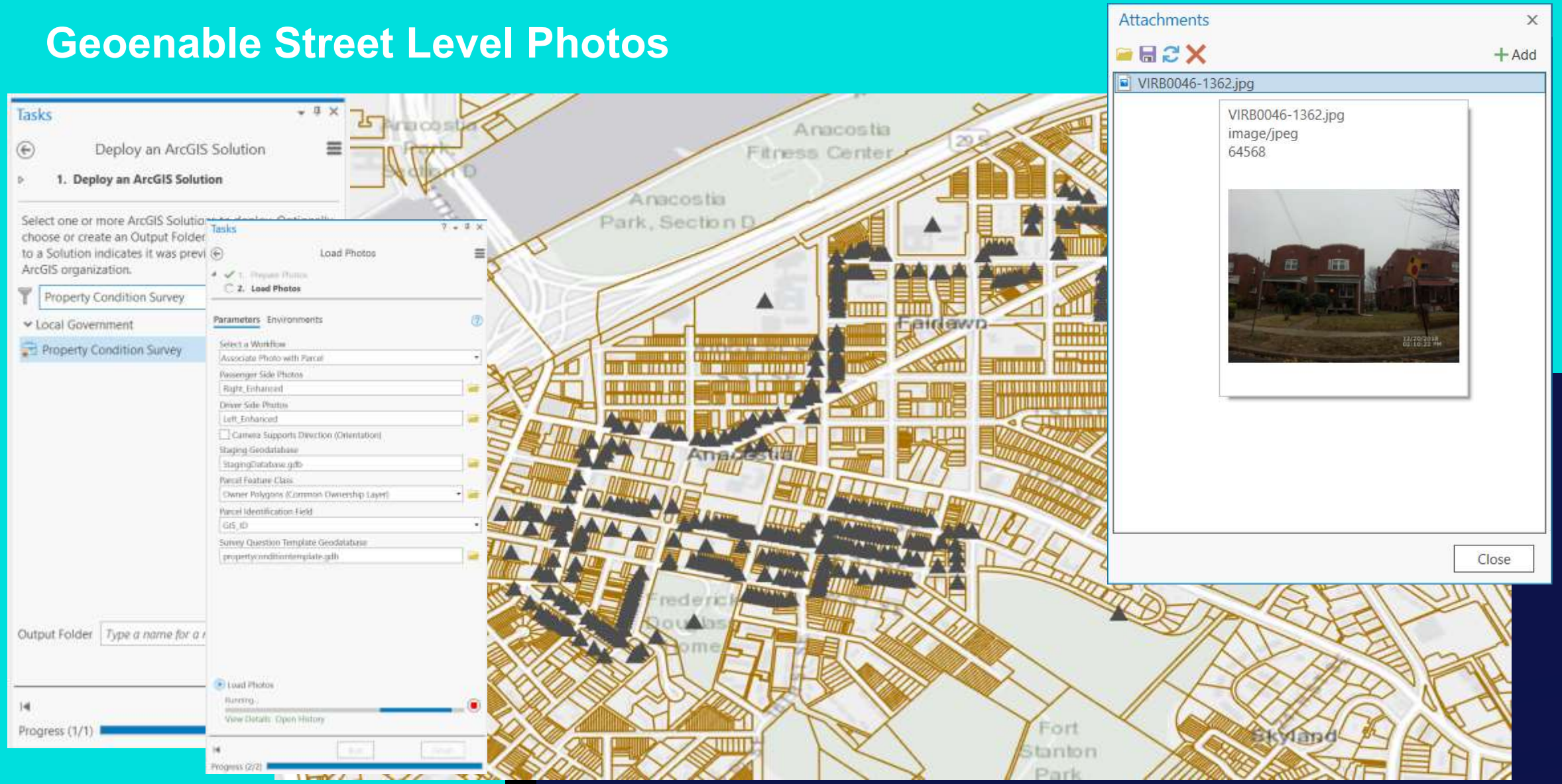
- Condition

Street Level Photo Capture and Image Interpretation

- Photos taken with 2 Garmin VIRB cameras mounted on driver and passenger side windows (1-second intervals)
- ArcGIS Pro & Property Condition Survey solution used to relate photos to parcels (downloaded from DC open data site) and label photos
- Leveraged Microsoft Azure CustomVision to train machine learning model
- Probability scores generated for each feature

Est. $400 per camera

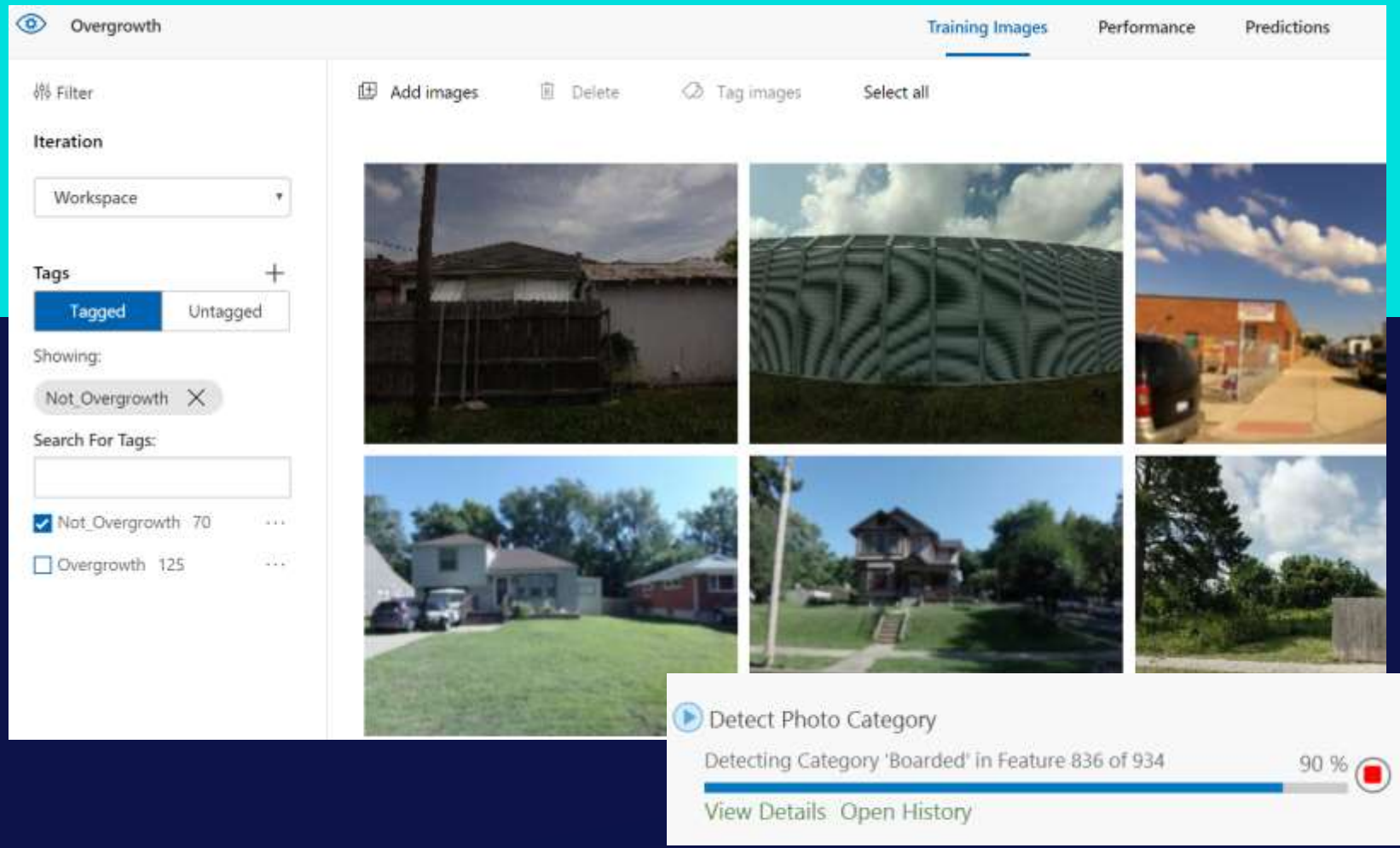
Geoenable Street Level Photos



Leveraging Solutions

Predict Property Characteristics

- Leverages Azure Custom Vision Classifier
- Train model to recognize objective property characteristics
  - Overgrowth
  - Graffiti
  - Boarded Windows
  - Building Material
- Predict presence of property characteristics with trained model
- Check accuracy with Photo Survey web application



Augment Existing Property Data with Predicted Values

- Probability scores of blight features written to parcel center points
- Join to cadastral data containing other property characteristics
- Perform visual analysis

Overgrowth

Boarded Windows

Graffiti

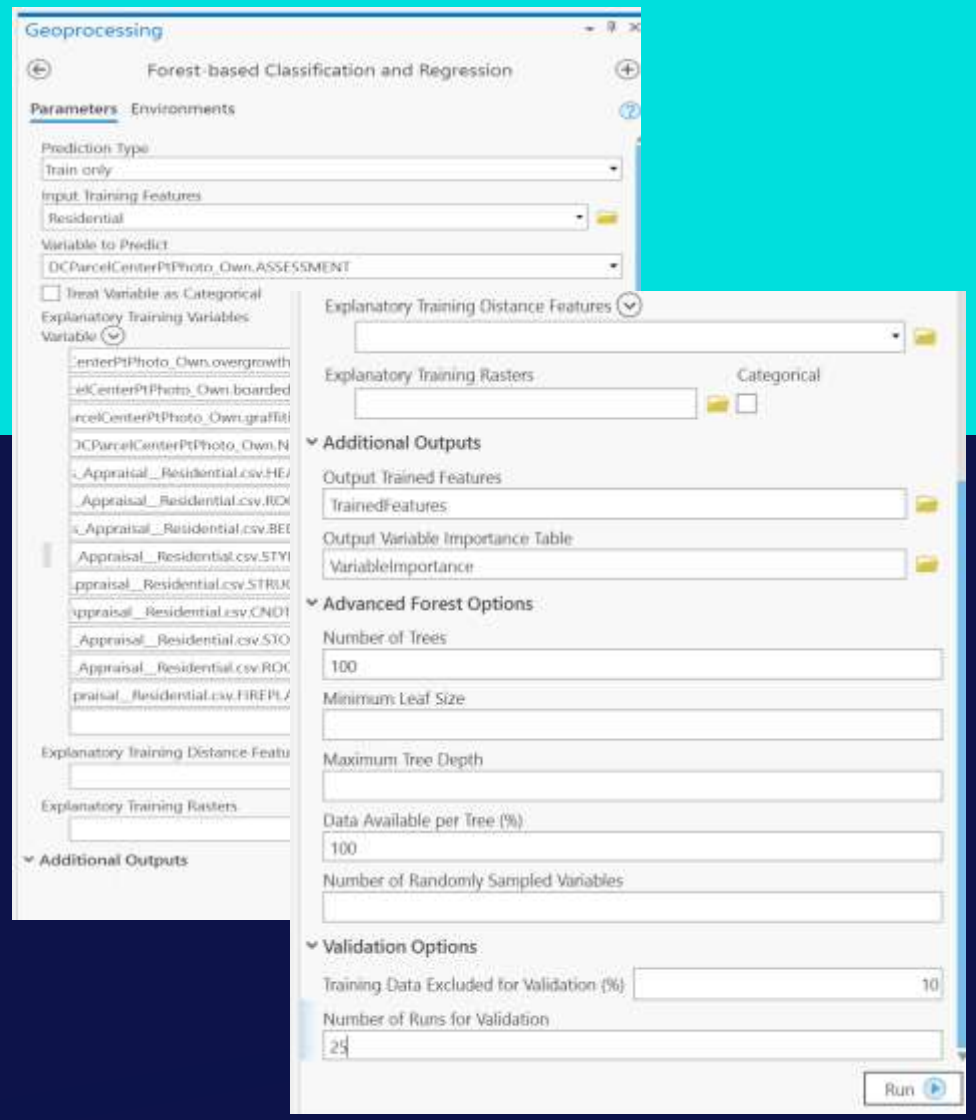
Data Collection Inputs and Outputs

- Inputs:
  - Est. $800 for 2 Garmin cameras
  - 2 hrs of drive time (4076 driver side photos/3193 passenger side photos)
  - 1 – 2 hrs setup for Property Condition Survey and joining of data
  - Training of models – time dependent upon size and quality of data
    - More samples = better results

- Outputs:
  - 934 properties were ultimately photographed, analyzed and joined to parcels using GPS data (duplicate and unrelated photos removed)
  - 4 models trained to detect probability for Overgrowth, Boarded Up, Graffiti and Building Material
  - Results written to an attribute table and published to the web as a feature service

Integration and Impact of Property Condition Results on Value Prediction

- New dataset entered into Forest-based Classification and Regression tool for both training and prediction of assessment and market values
  - 2 modes – Training and Prediction
  - Accepts continuous and categorical variables
  - Must have some existing value data to run



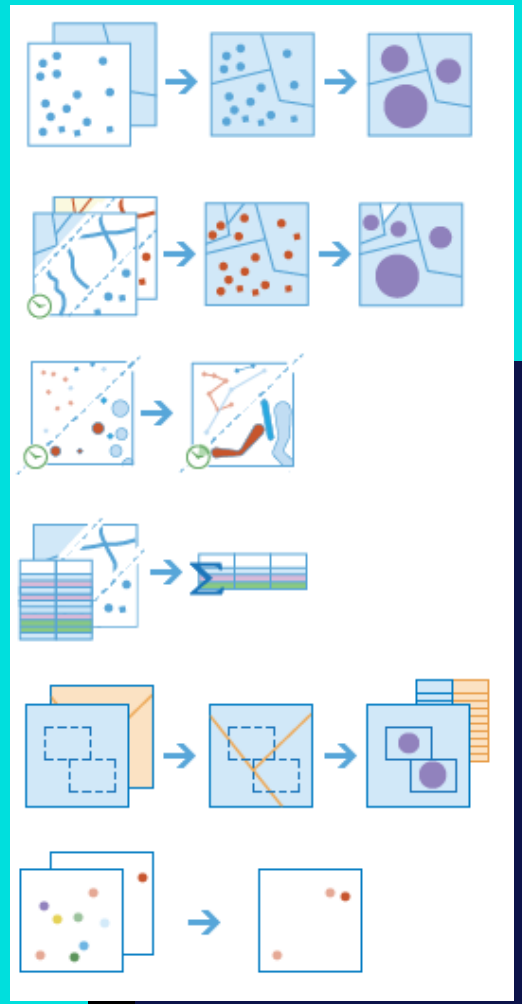
Machine Learning Tools in ArcGIS

Classification

- Maximum Likelihood Classification
- Random Trees
- Support Vector Machine

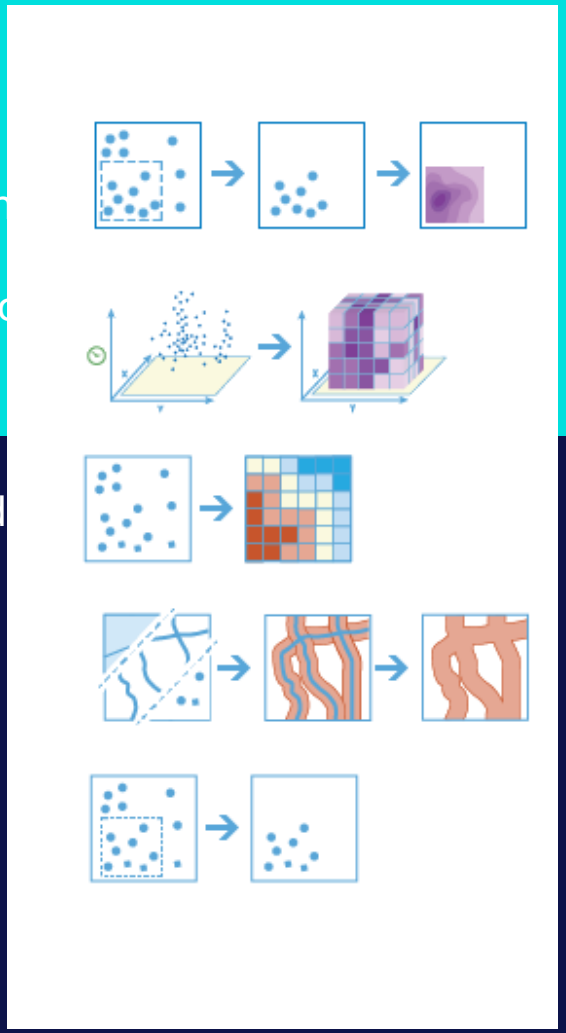
Clustering

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



Prediction

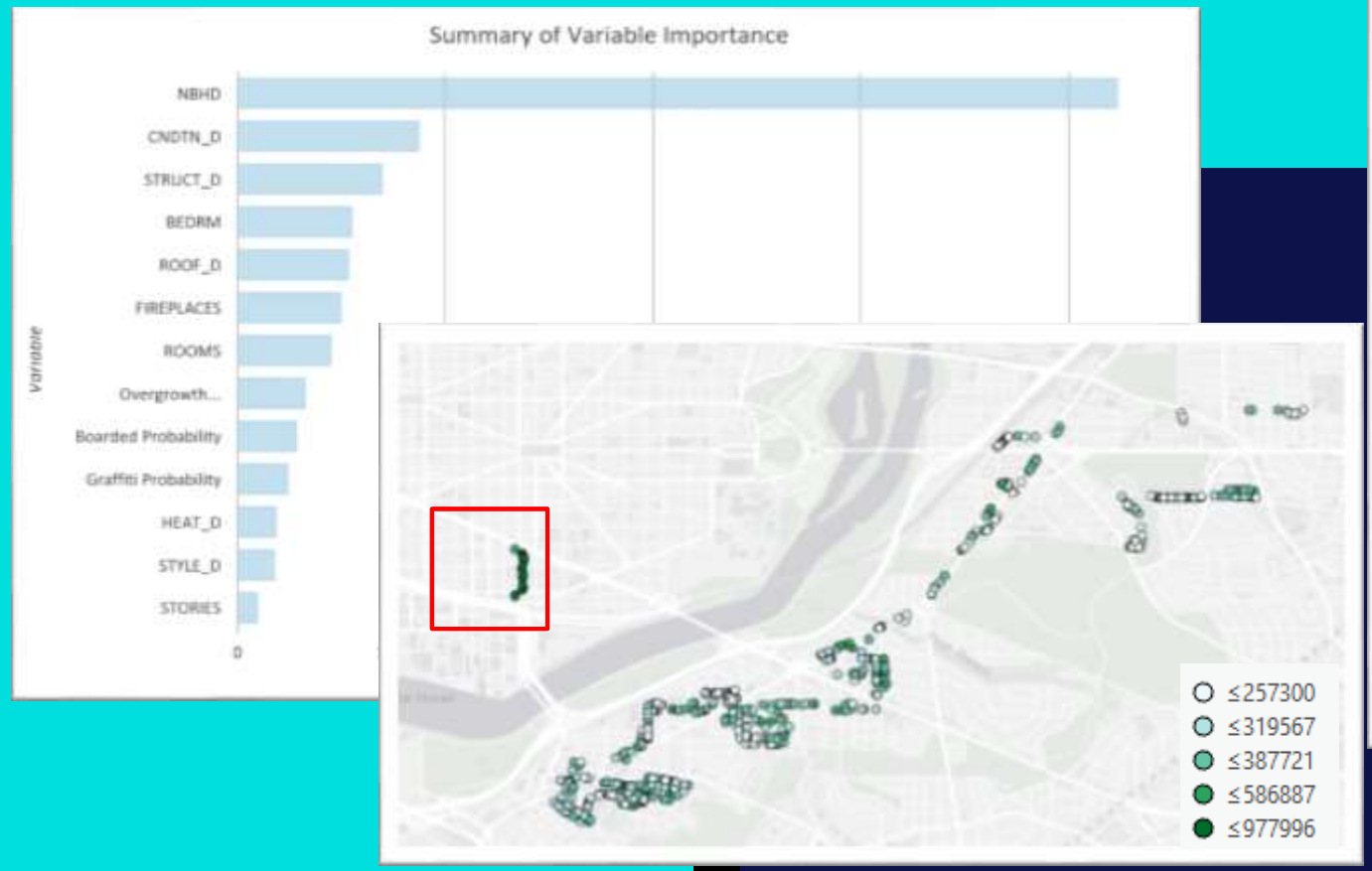
- Empirical Bayesian Krigin
- Areal Interpolation
- EBK Regression Predicti
- Ordinary Least Squares Regression and Exploratory Regression
- Geographically Weighted Regression
- Forest Based Prediction



Forest based classification Training runs #1 and #2

Testing for the influence of new variables on property values

Test Run #1

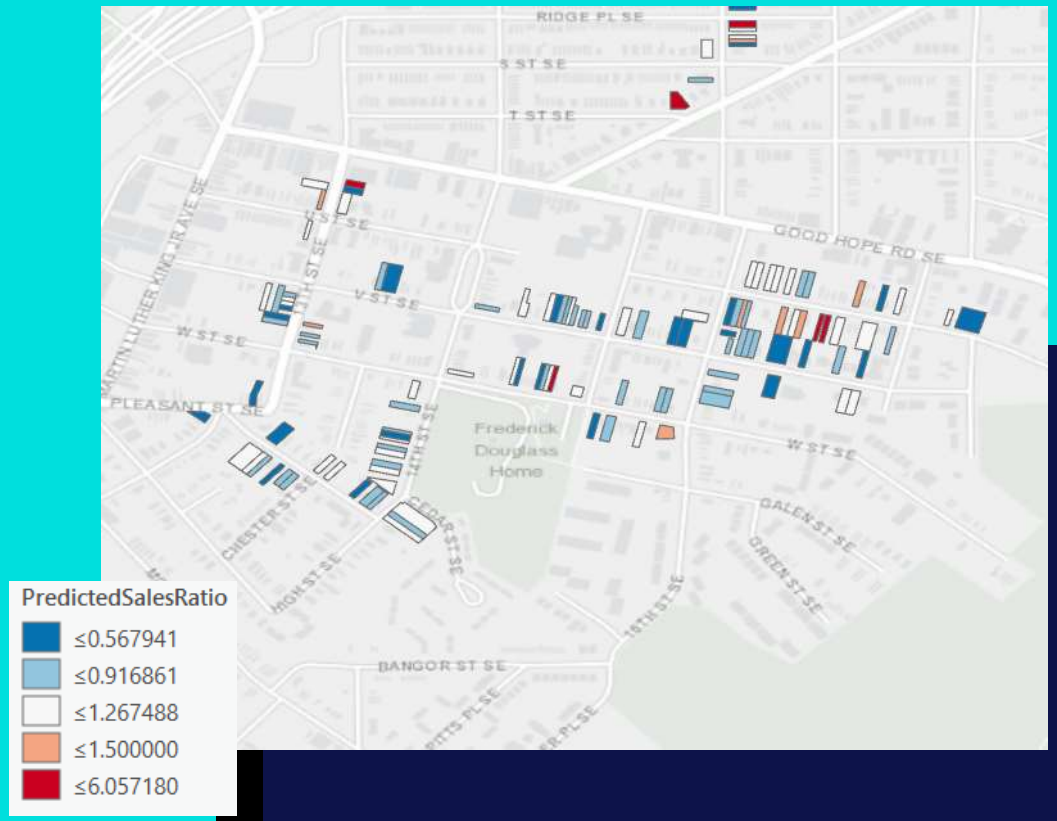


Test Run #2

VARIABLES	IMPORTANCE	PERCENTAGE	OBJECTID
RECORD_ARE	578661232111.029419	16.893	4
BATHRM	569661229522.049072	16.63	7
CNDTN_D	512764730302.765381	14.969	12
BEDRM	381358377397.786987	11.133	10
AYB	214782937900.756958	6.27	11
NBHD	176474690725.514648	5.152	5
EXTWALL_D	153472946783.54126	4.48	13
Overgrowth Probabil...	148587868386.144836	4.338	1
Boarded Probability	141122627001.945831	4.12	2
Graffiti Probability	114554873736.741745	3.344	3
Blight	112813712235.000565	3.293	6
KITCHENS	99060310462.340302	2.892	15
HEAT_D	81422299537.782135	2.377	9
HF_BATHRM	58883742690.651062	1.719	8
INTWALL_D	49978283797.866035	1.459	14
FIREPLACES	31854437561.479721	0.93	16

Predicting Sales Ratio Using Forest Based Classification

Predicting Property Values with new Valuation Model



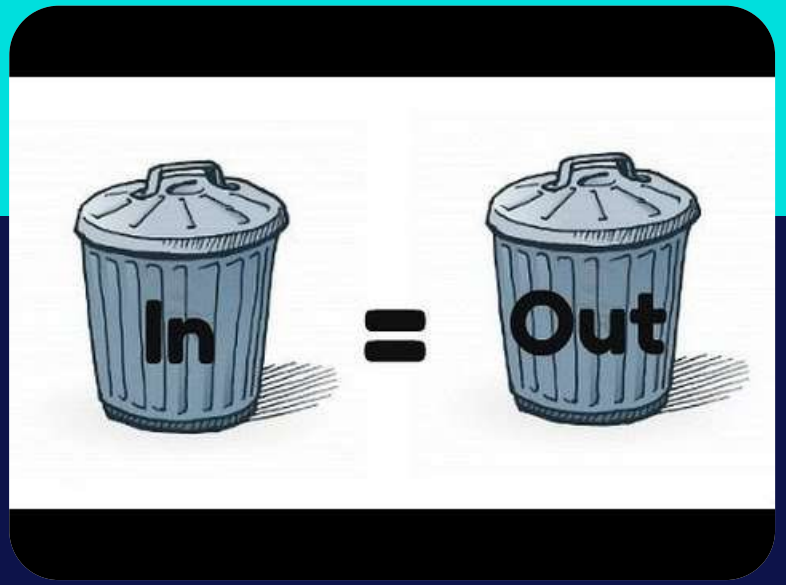
Conclusions

In the context of this PoC, it was demonstrated that:

- GIS has a supporting role to play in the collection, analysis and defense of property values
- Street level photos and artificial intelligence be leveraged as a cost-effective way to automate the capture and classification of certain property attributes in support of property valuation
- The information derived from the street level photos and artificial intelligence did have an influence on the fair market value of the properties analyzed
- This methodology could be leveraged to support the systematic collection or updating of certain exterior and objective property characteristics in support of property valuation and reassessment

Lessons Learned and Take Aways

- It’s a new technology and it is not always accurate
- Training models are needed for each type of feature and need to be adapted to the local context
- The results are only as good as the quantity and quality of data provided (garbage in garbage out)
- Good for assessing exterior features and answering objective (or binary) questions about a property
- May be another tool in the assessor’s toolbox



GIS for Valuation, Tax and Land Records Management

Accurately Determine Property Values

- Advanced data exploration, analysis and exploration
- Easily detect outliers and anomalies in data
- 3D Viewshed analysis
- Imagery comparison & change detection

Respond to and Defend Property Values

- Simplify valuation appeals
- Communicate comparable sales
- Communicate with maps
- Visualize complex analysis

Provide Taxpayers with Useful Information

- Tax parcel viewer
- Find comparable sales
- Floodplain maps
- Open Data sites
- Tell your valuation story

Maintain Current and Accurate Parcel Fabric

- Efficiently manage parcels
- Improve parcel data accuracy
- Aggregate parcel and property data
- Manage parcel history/lineage

Field Data Capture and Updating

- Collect data in the field using high accuracy mobile devices
- Manage and Understand status of field work
- Collect and extract data from street-level photos

For more information on Assessment, Tax and Land Records:

https://www.esri.com/en-us/industries/state-local-government/solutions/land-records