Generative Design for Precision Geo-interventions

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Geo-interventions

Action

e.g., Reduce road speeds, Increase police patrols

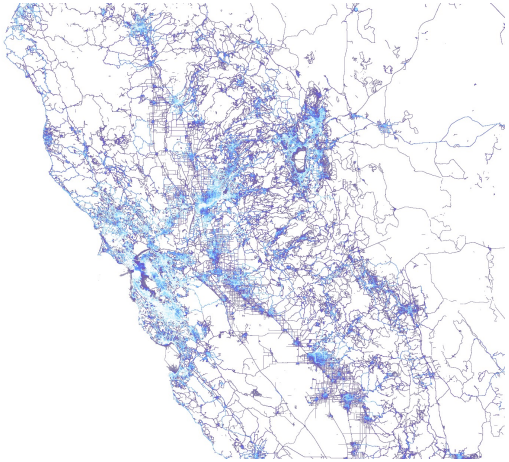
Location

e.g., School zones, Crime hotspots

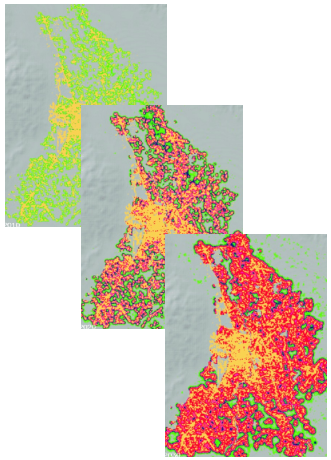
Outcome

e.g., Lower traffic collisions, Reduce crime

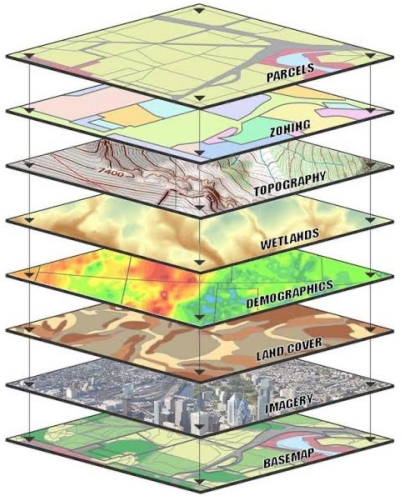
Common Approaches



Cluster Mapping



Cellular Automata



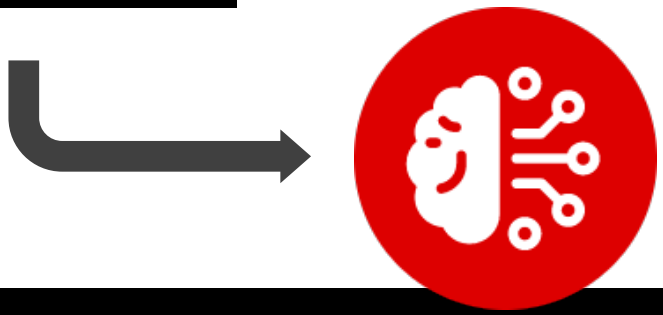
Multi-Criteria Decision Analysis

Ref. [1-3]

Recent Advancements

Computing

Big Data



Automated Machine Learning (AutoML)

Ref. [4-14]

THEN

NOW

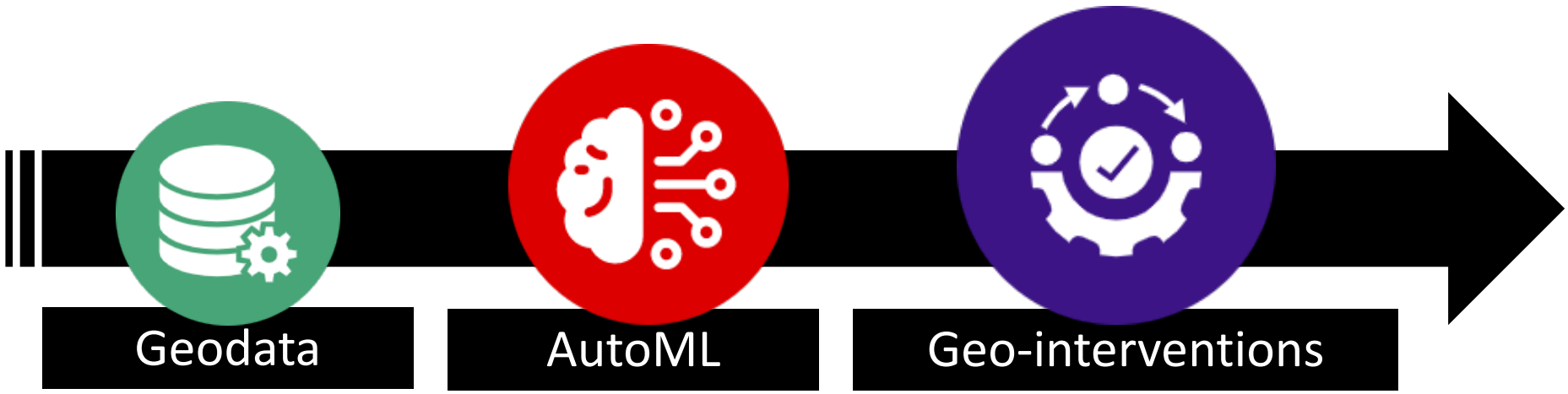
Expertise

Data Driven

1-10 Scenarios

100-1000 Scenarios

The Idea



Research Objective

Generate Geo-interventions with AutoML using Geodata

Geodata	AutoML	Geo-interventions
• Vector • Tabular	• Target Variable • Search Time	• Variable Changes • Locatable

Methods

1

Geo-binning

- Standardization
- Aggregation
- Spatial Joins

2

AutoML

- Preprocessing
- Model Outcome
- Var. Importance

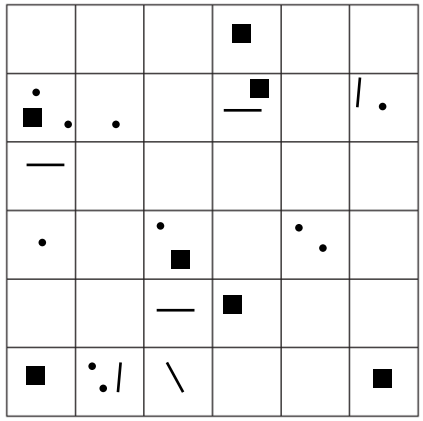
3

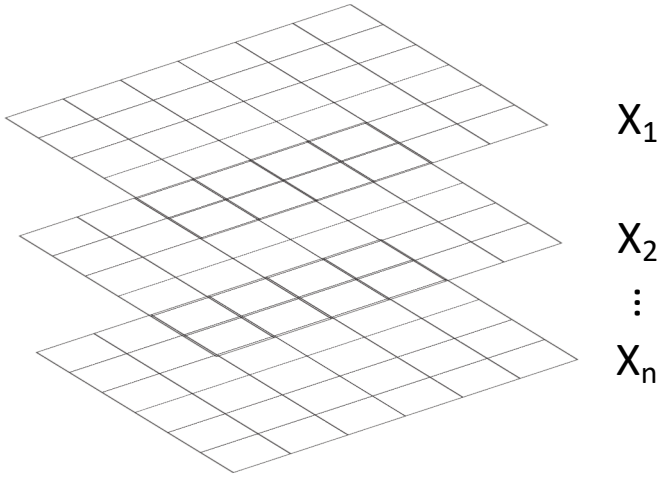
Prediction Optimization

- Generate geo-interventions
- Optimize AutoML predictions
- User-guided

1 Geo-binning

- Point
- Line
- Polygon

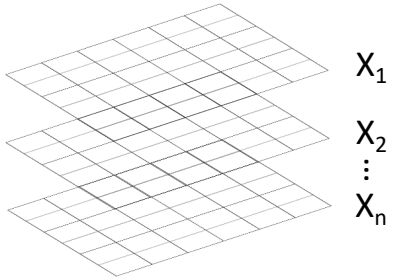




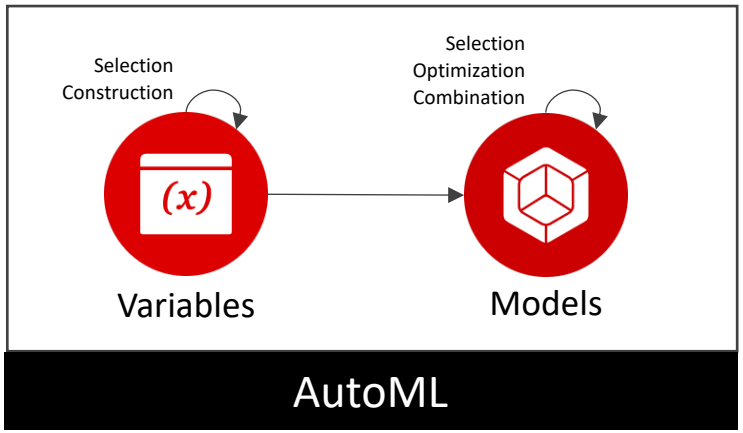
Geodata	Geo-bins	Aggregation
Geodata with geometry and variables	Spatial join geom. to each grid cell	For each grid cell, count geom. and calc. stats (sum, unique, etc) for variables

Ref. [15]

2 AutoML



Geo-binned Data



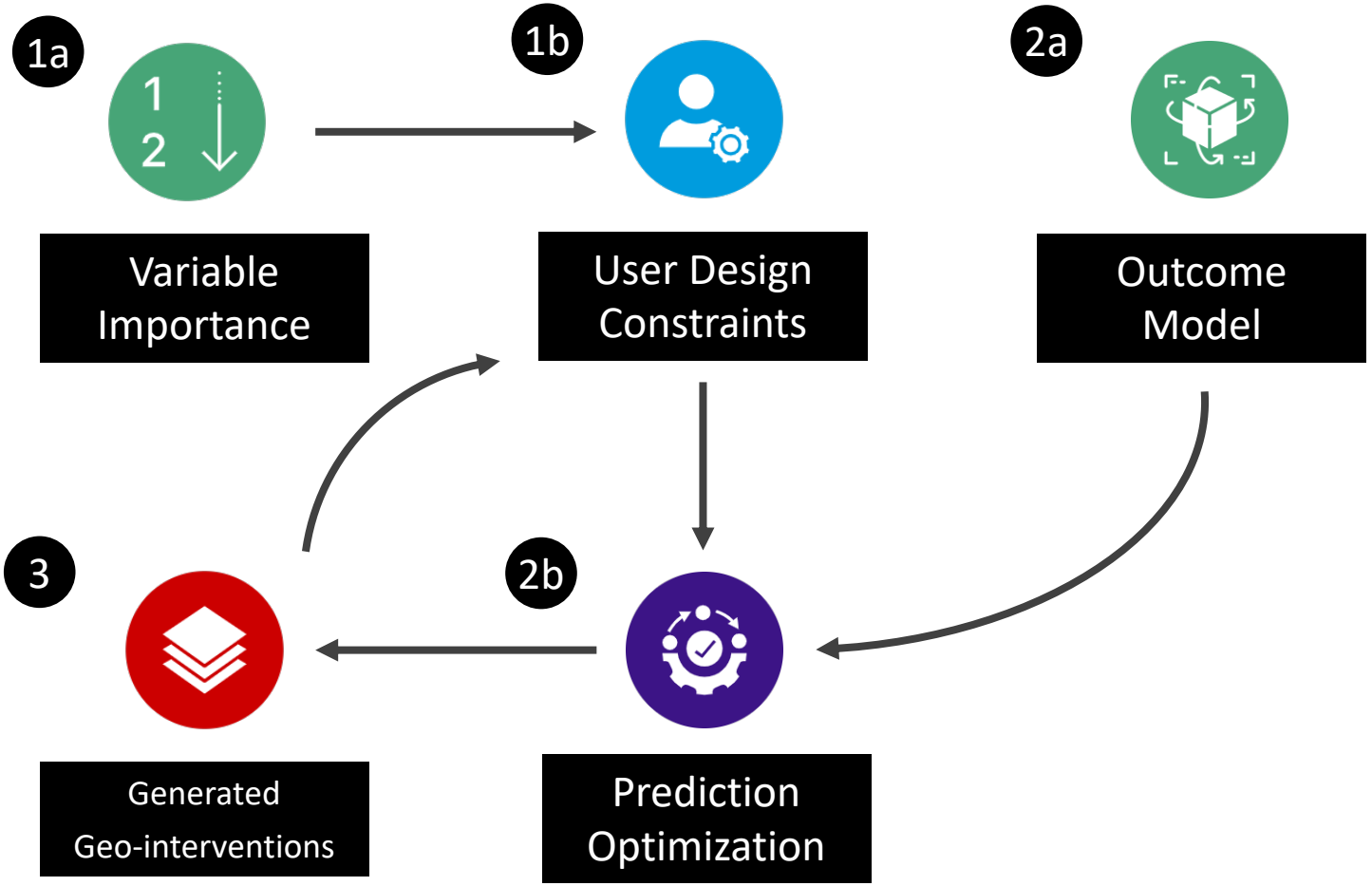
AutoML

Outcome Model

Variable Importance

Ref. [16]

3 Prediction Optimization



Ref. [17]

Experiment

21 Datasets
550 Variables
1,140,927 Rows

Python Packages
tpot / auto-sklearn / bayes_opt

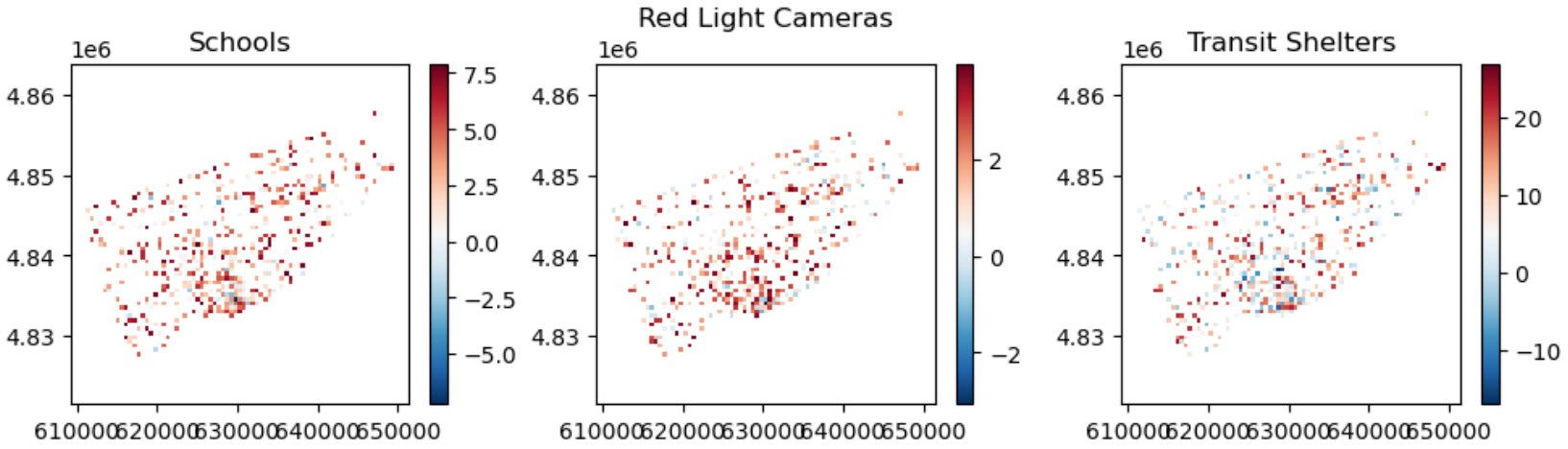
Geo-binned Grids
10x10 / 40x40 / 80x80

Reduce Traffic Collisions
Infrastructure Changes

Ref. [12,18-21]

Results

Auto-Sklearn Model (80x80 grid)
117.68 Mean Absolute Error (MAE)
~50% Reduction in Traffic Collisions



Future Work

Interactive GUI
Exploration

Distributed AutoML & Optimization
Scalability

References

[1] Strava. (2022). *Global Heatmap*. Strava. Retrieved October 18, 2022, from https://www.strava.com/heatmap#7.00/-120.90000/38.36000/hot/all

[2] McGrath, B., Sangawongse, S., Thaikatoo, D., & Barcelloni Corte, M. (2017). The architecture of the metacity: Land use change, patch dynamics and urban form in Chiang Mai, Thailand. Urban Planning, 2(1).

[3] Nimick, S. R. and E. (2019, August 11). *Multi-criteria decision analysis and GIS*. ArcGIS StoryMaps. Retrieved October 18, 2022, from https://storymaps.arcgis.com/stories/b60b7399f6944bca86d1be6616c178cf

[4] https://www.ibm.com/cloud [5] https://cloud.google.com [6] https://azure.microsoft.com

[7] https://aws.amazon.com [8] https://www.kaggle.com [9] https://www.facebook.com [10] https://twitter.com

[11] https://data.nasa.gov [12] https://www.toronto.ca/city-government/data-research-maps/open-data

[13] https://data.gov [14] https://www.openstreetmap.org

[15] Brinkhoff, T., Kriegel, H. P., & Seeger, B. (1993). Efficient processing of spatial joins using R-trees. ACM SIGMOD Record, 22(2), 237-246.

[16] Waring, J., Lindvall, C., & Umeton, R. (2020). Automated machine learning: Review of the state-of-the-art and opportunities for healthcare. Artificial intelligence in medicine, 104, 101822.

[17] Snoek, J., Larochelle, H., & Adams, R. P. (2012). Practical bayesian optimization of machine learning algorithms. Advances in neural information processing systems, 25.

[18] https://data.torontopolice.on.ca/pages/open-data [19] https://pypi.org/project/TPOT

[20] https://pypi.org/project/bayesian-optimization [21] https://pypi.org/project/auto-sklearn