A Case-based Search Engine for Mapping Urban Patterns and Cases Integrating Street View Imagery

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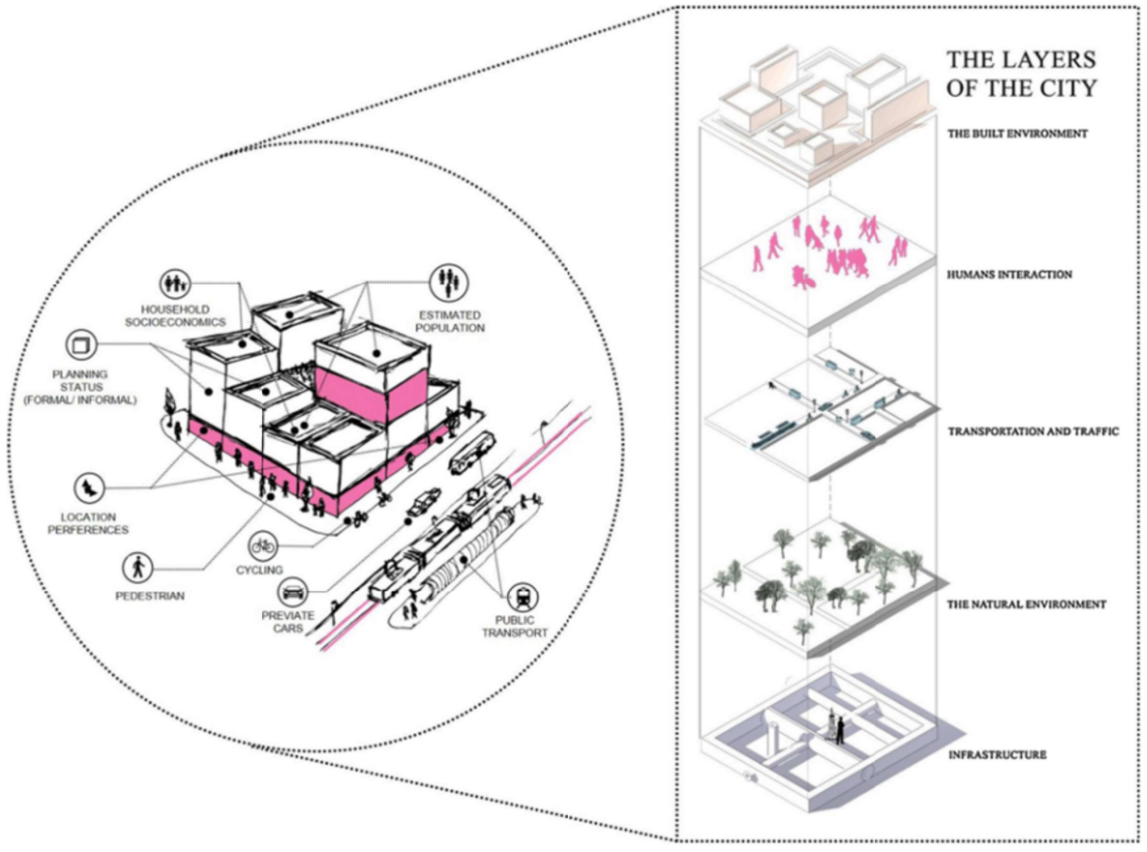
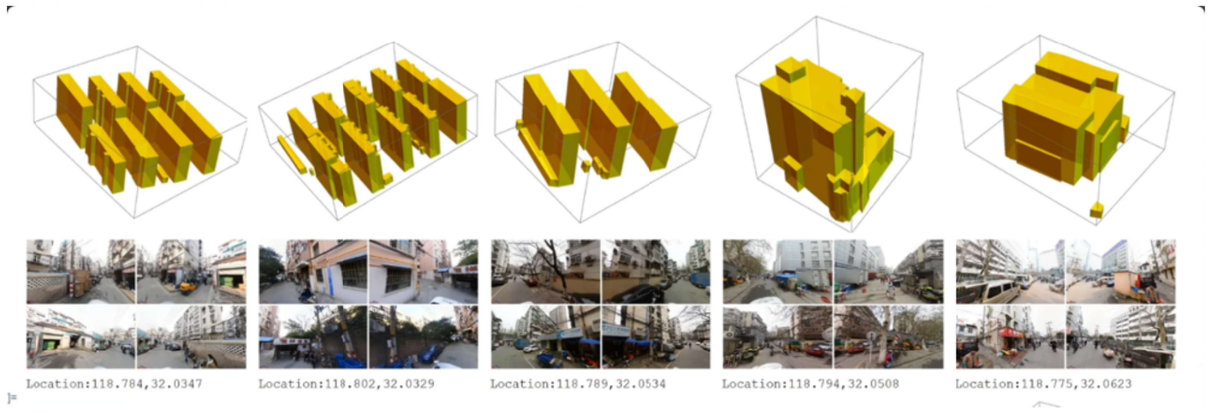
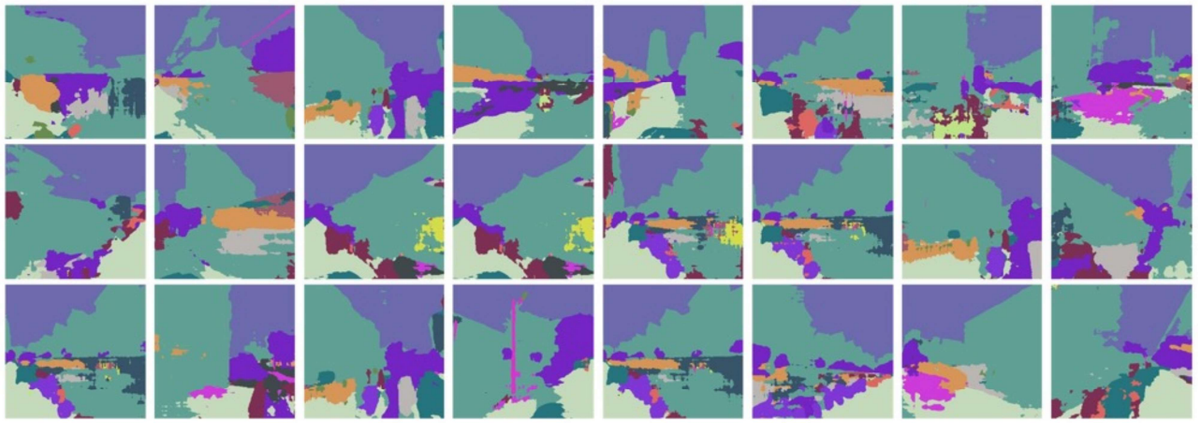
Cities are complex systems with multi-dimensional characteristics.
Urban designers rely on case-based understanding to develop approaches.

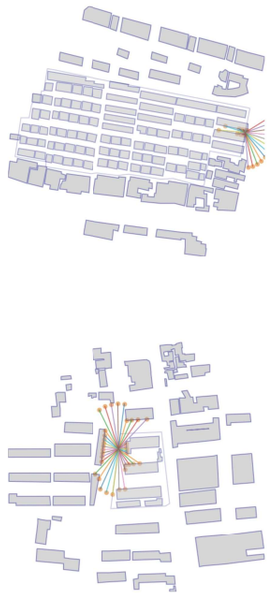


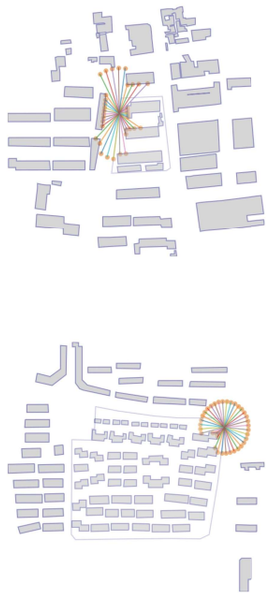


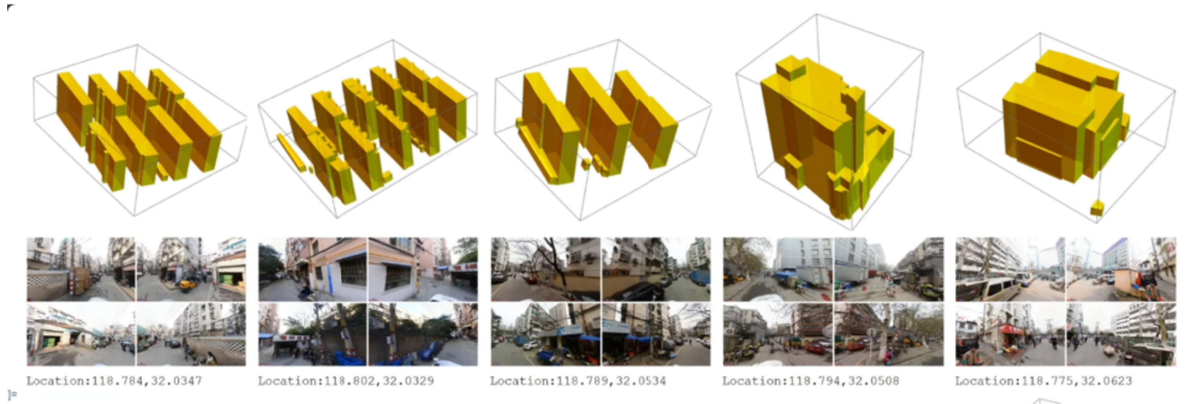
MR Ibrahim, 2020, Understanding cities with machine eyes

Cities are complex systems with multi-dimensional characteristics.
Urban scientists search for general patterns that apply across unique cases.

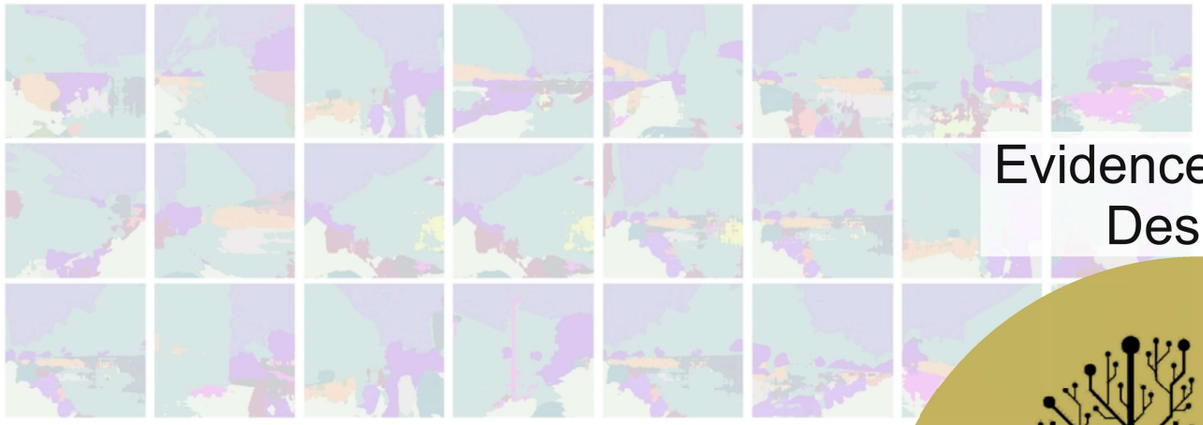




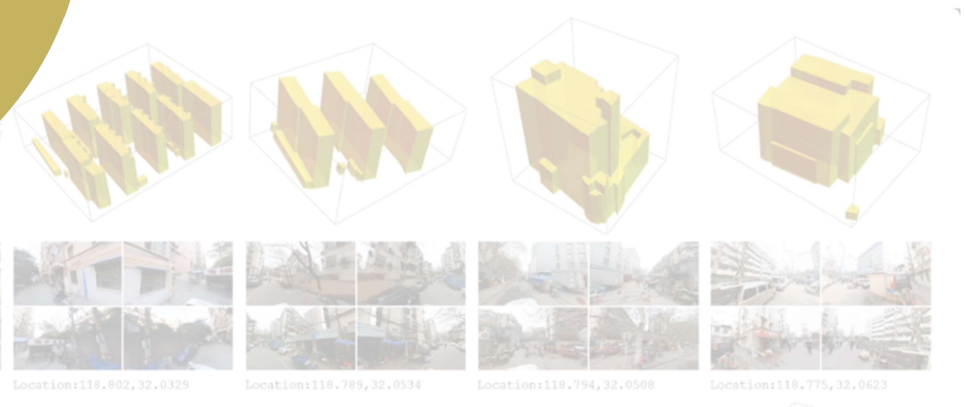




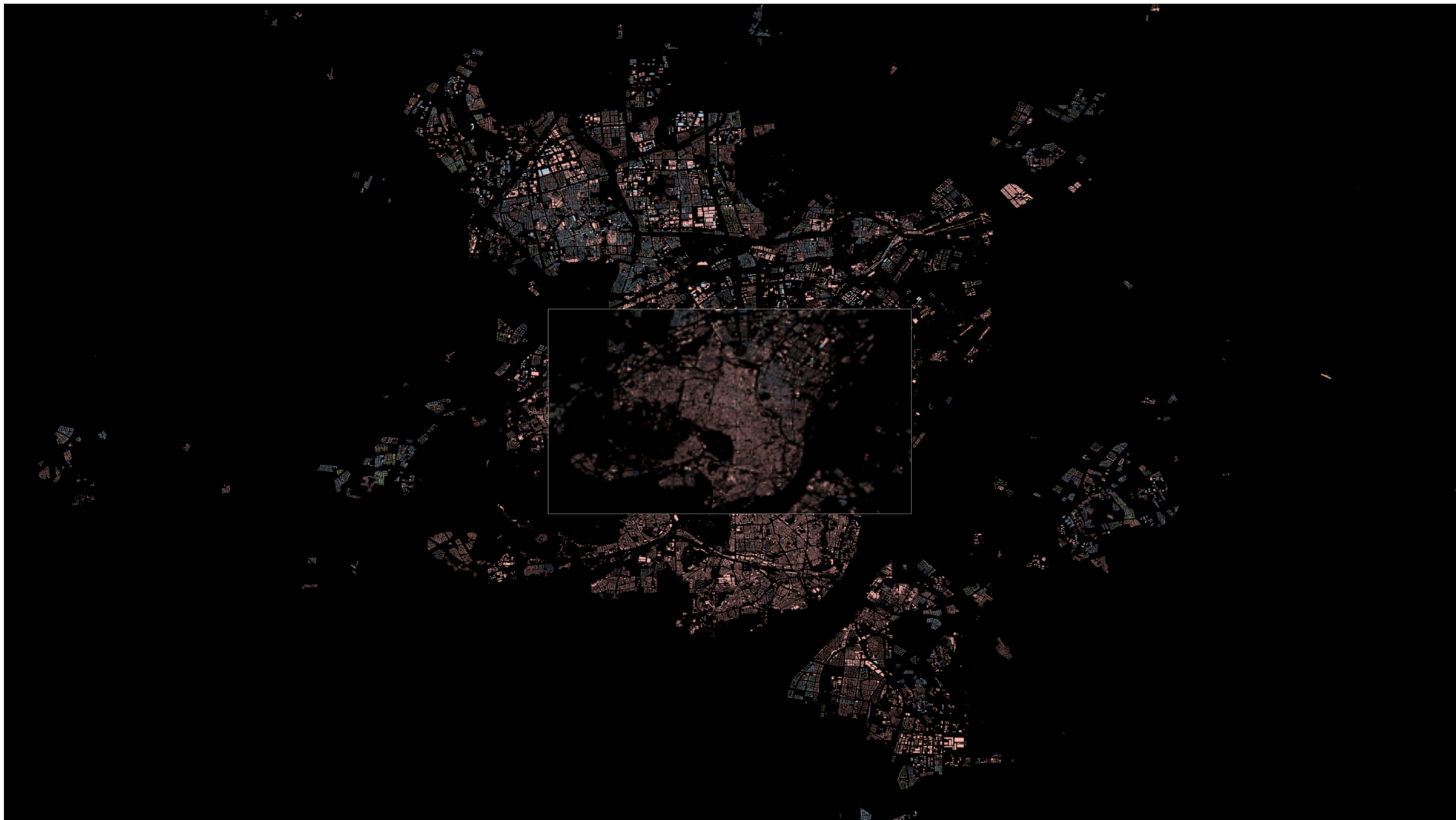
We need approaches that tightly couple our advances
in urban design and science, in case-based reasoning and pattern detection.

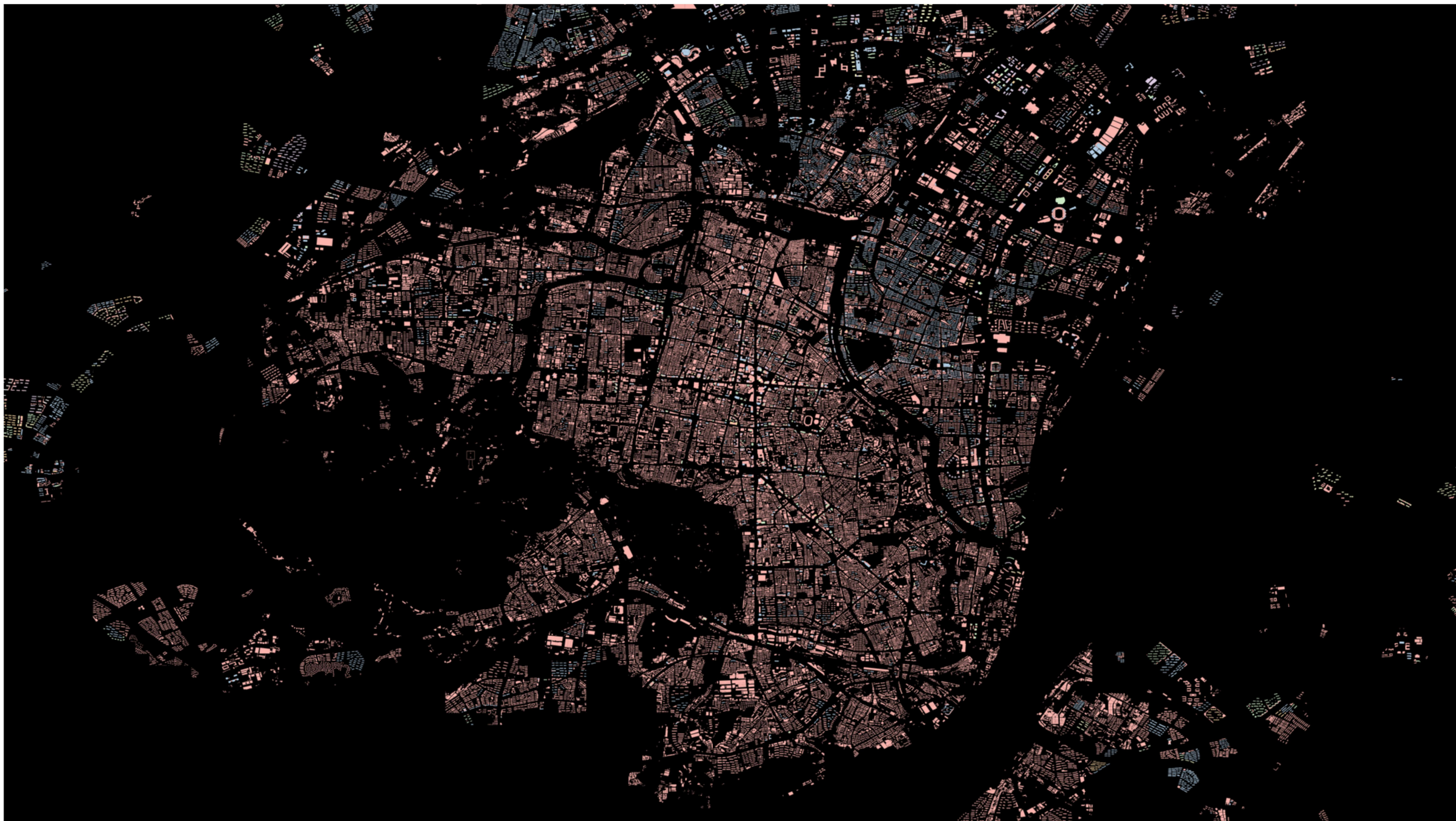


Evidence-Based
Design



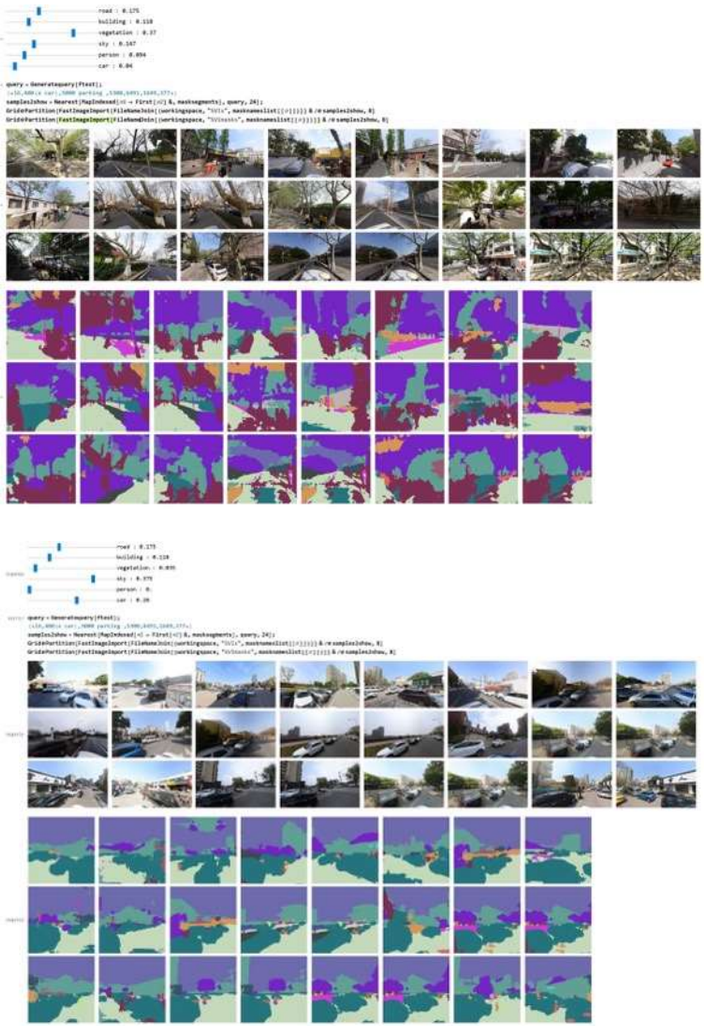
Design-Based
Evidence

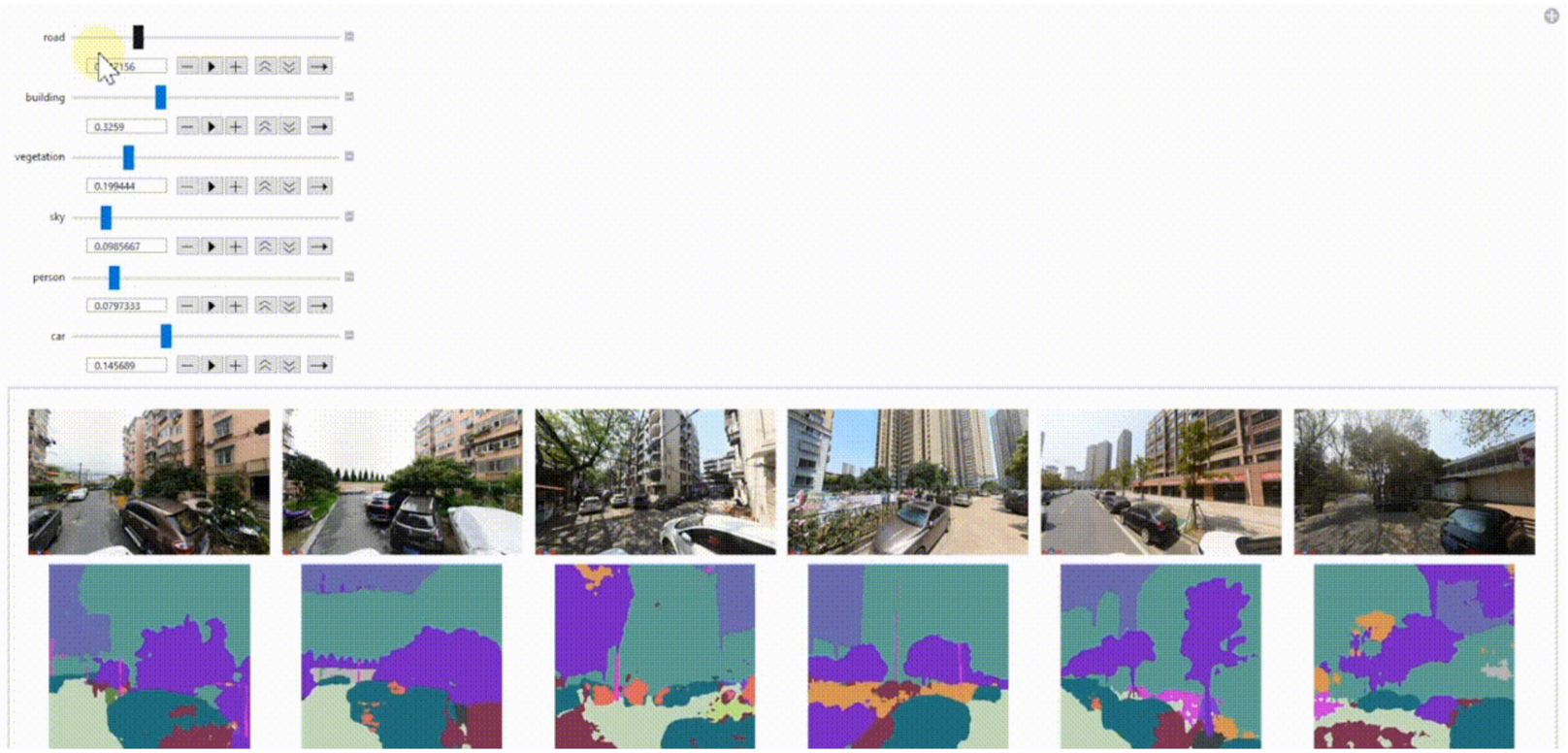




Case-based search engines can help designers find case-based patterns

e.g. searching for cases with similar *proportions of visible elements*

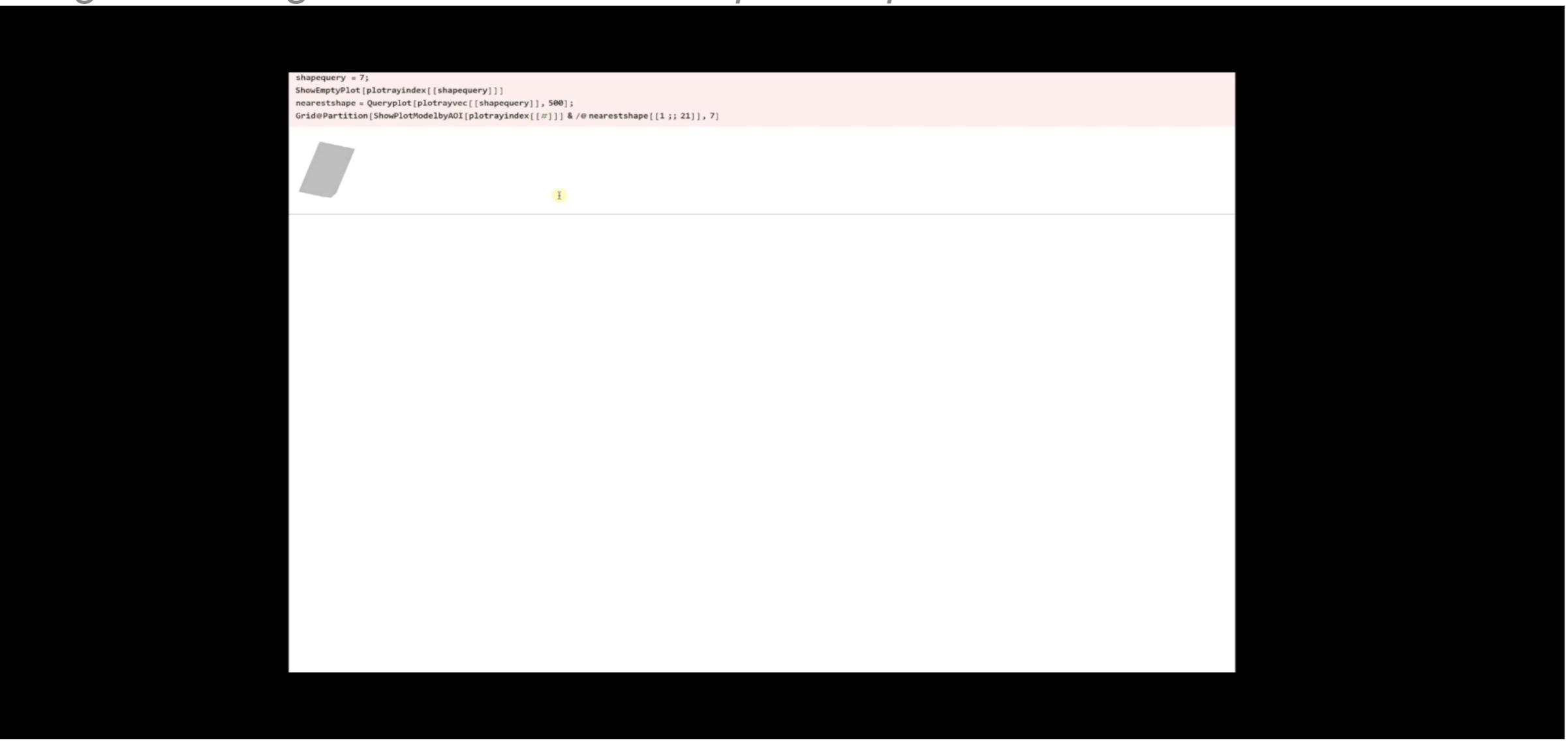




> This search engine retrieves cases with similar proportions of visible elements, such as roads, buildings, vegetation, or cars.

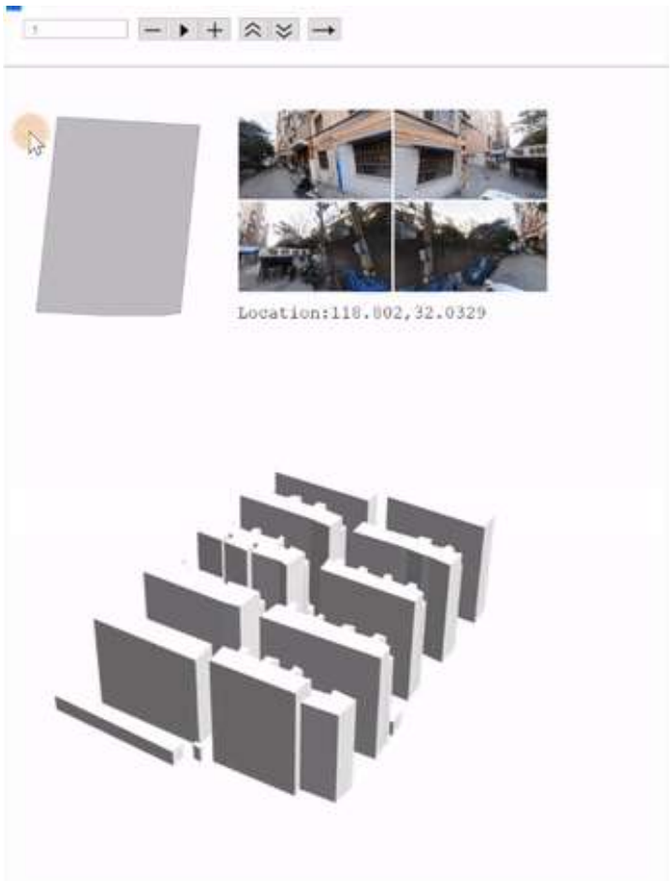
Case-based search engines can help designers find case-based patterns

e.g. searching for cases with similar *plot shapes*



Case-based search engines can help designers find case-based patterns

e.g. searching for cases of similar *plot shape* and *street view* appearance



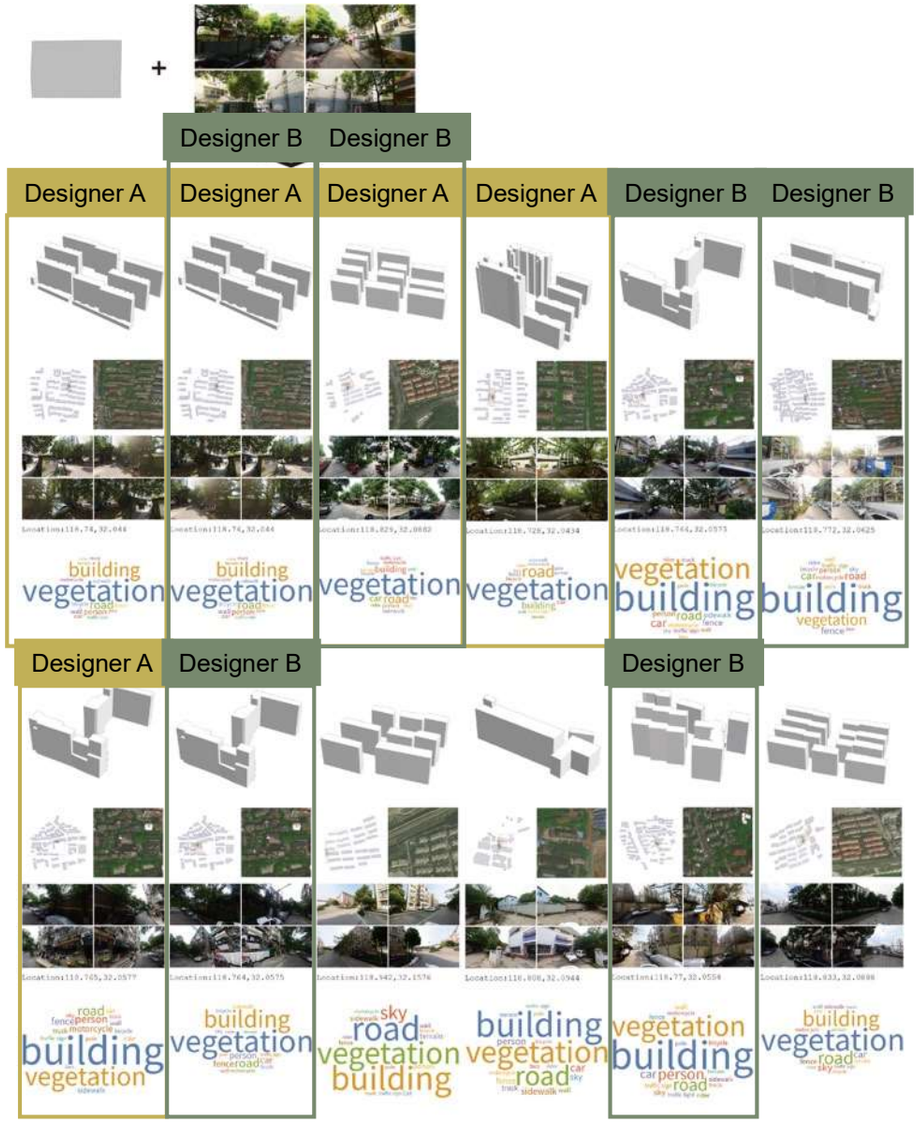
> We developed a case-based search engine that enables flexible case retrieval based on street view imagery characteristics and 3D built environment models.

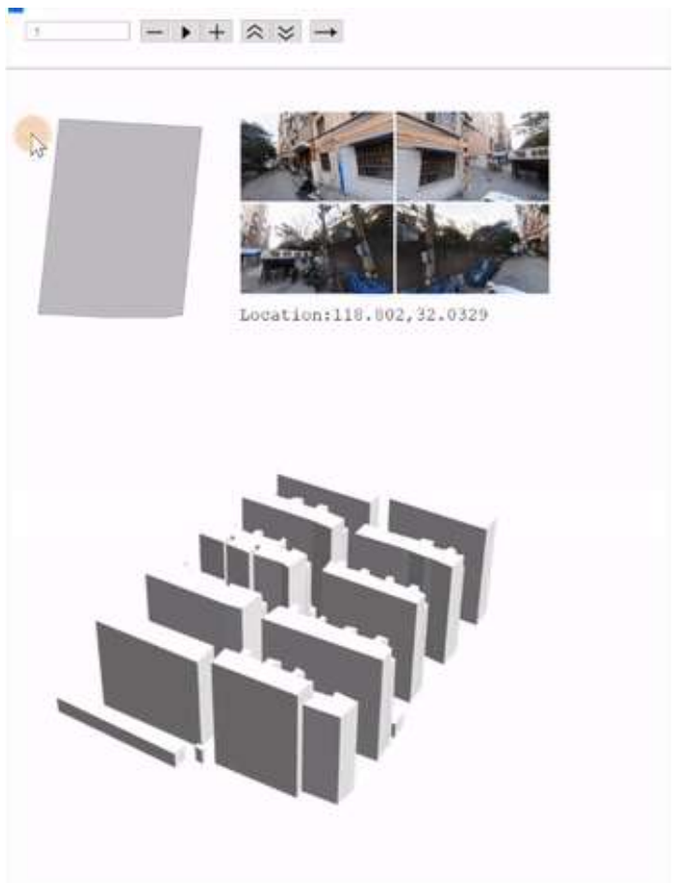
> This search engine allows users to navigate existing cases through the lens of desirable or less desirable characteristics.

> Hence, it can support case-based learning in urban design.

Case-based search engines can help designers find case-based patterns

e.g. searching for cases of similar *plot shape* and *street view* appearance





> We developed a case-based search engine that enables flexible case retrieval based on street view imagery characteristics and 3D built environment models.

> **e.g. Designer A** might use our engine to search for rectangular plots with good greenery.

> **e.g. Designer B** might do the same search, but looking for examples of streets with good enclosure.

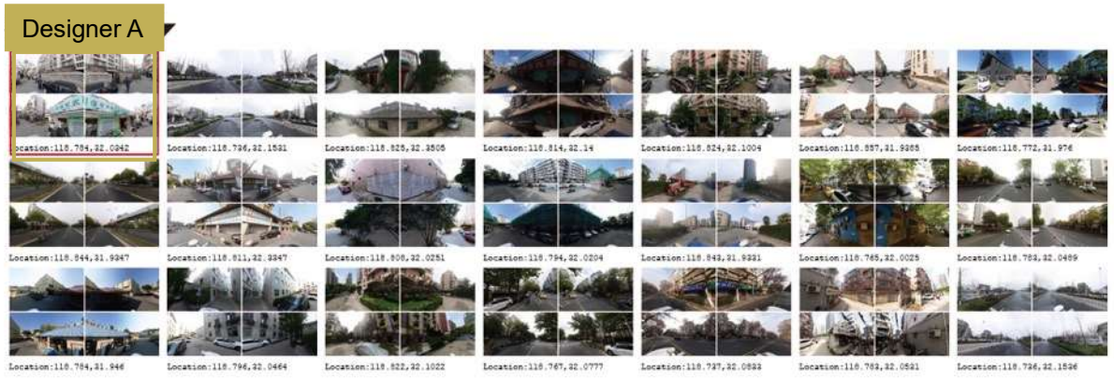
> Both **A** and **B** have certain assumptions or hypotheses about which characteristics make a particular urban design case good (or bad).

> **Search A** might support assumptions, while **Search B** might contradict them, depending on which characteristics are of interest to the designer.

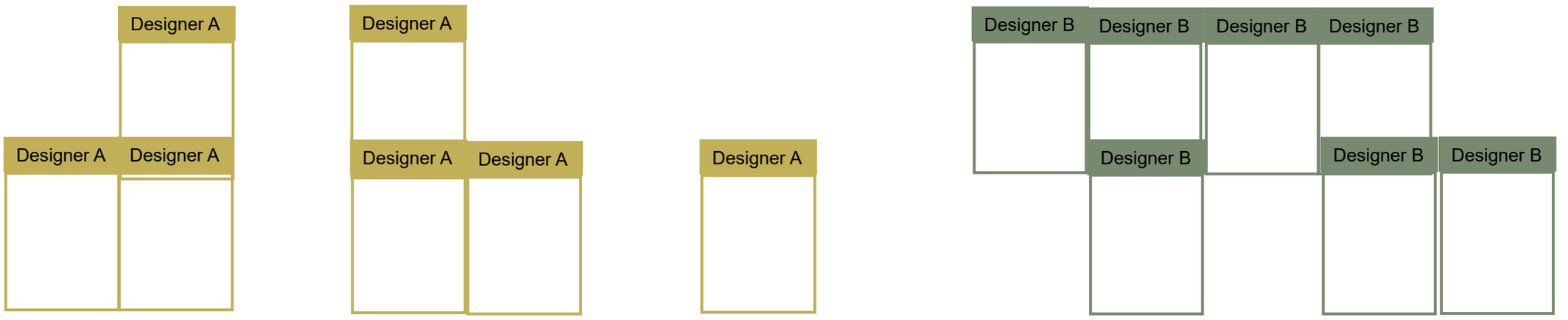
Case-based search engines can help designers find case-based patterns

e.g. searching for cases with similar *isovists* and *street view* appearances

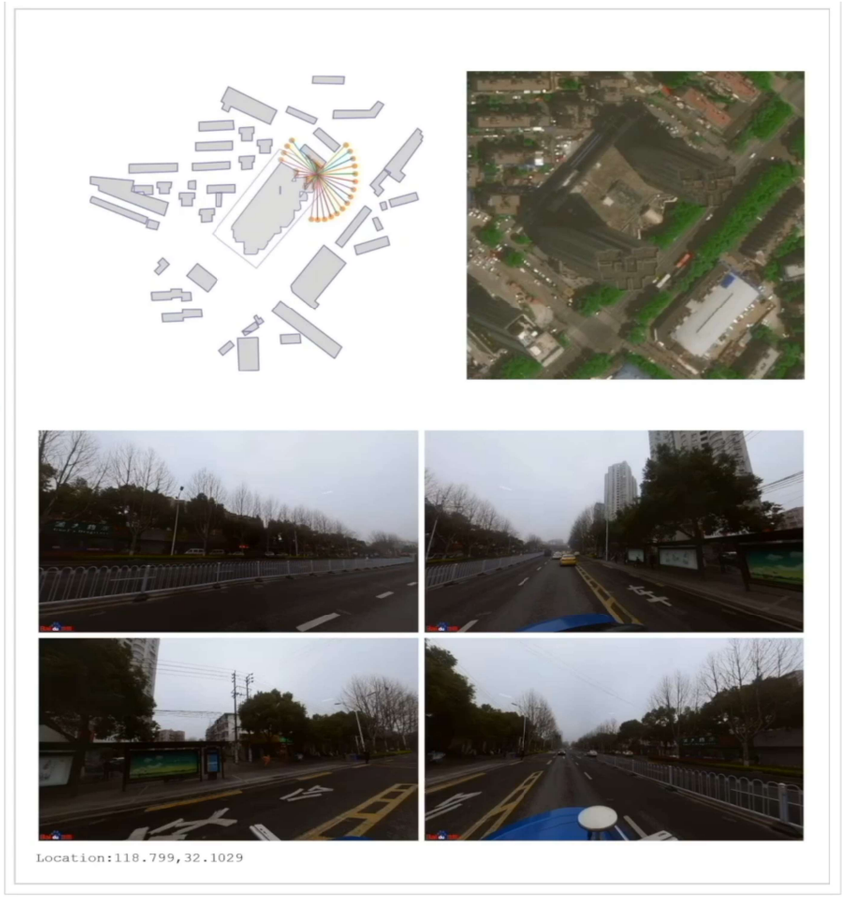
> Designer A looks for cases with narrow streets and old residential buildings.



> Designer B looks for cases with semi-open space and significant amounts of greenery.



The workflow to create our search engine platform automatically collects urban semantic, spatial and image data



> The data required for all the search engine examples shown can be gathered automatically

> Street View Image (SVI) panoramas are retrieved for each point of observation.

> Spatial elements are extracted by applying Isovist analysis in each point of observation.

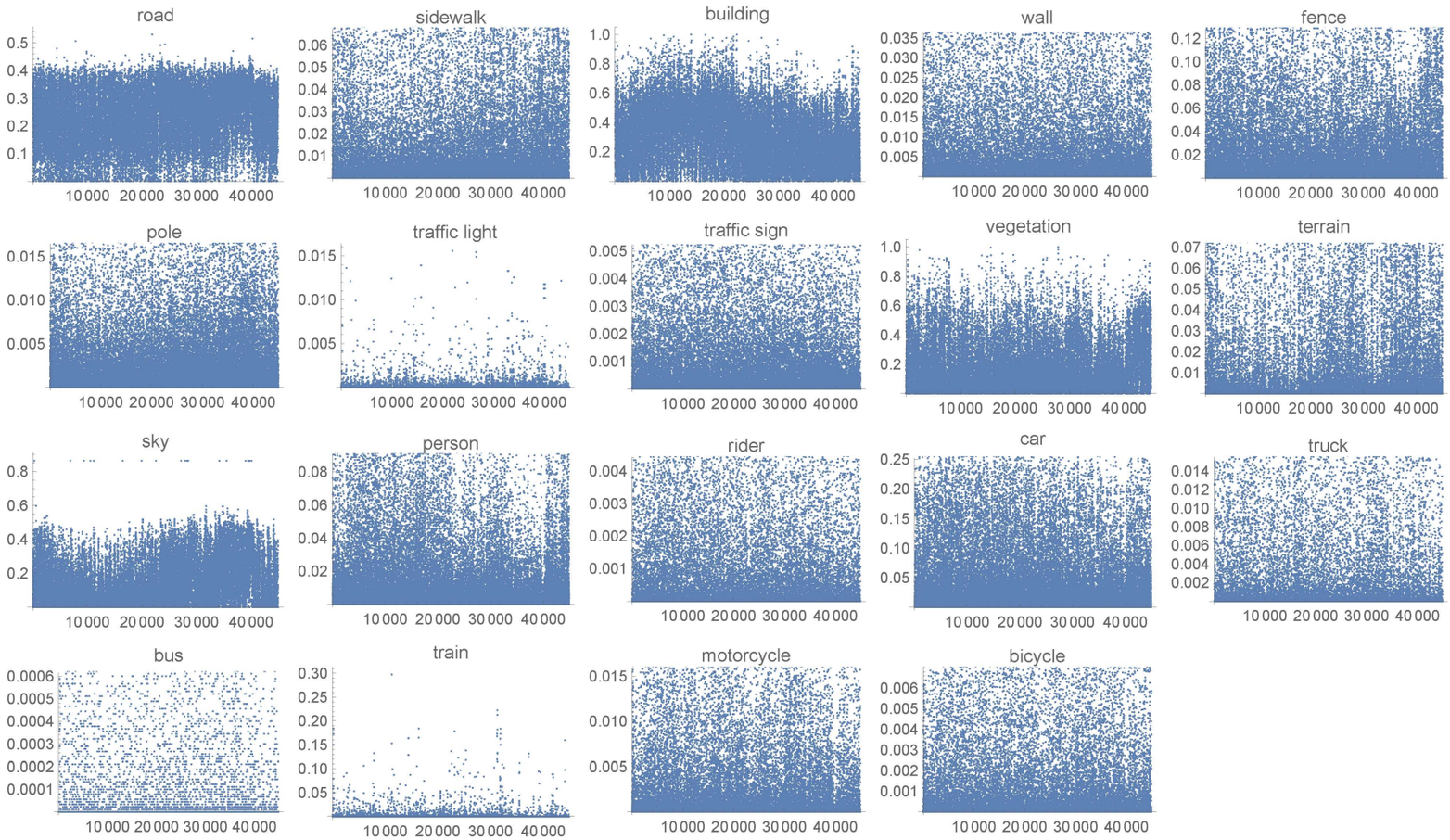
> Satellite images of the plots are requested.

> 3D buildings and plot outlines are extracted from shapefile data.

Our search engine automatically extracts and analyses geometry and image using machine learning

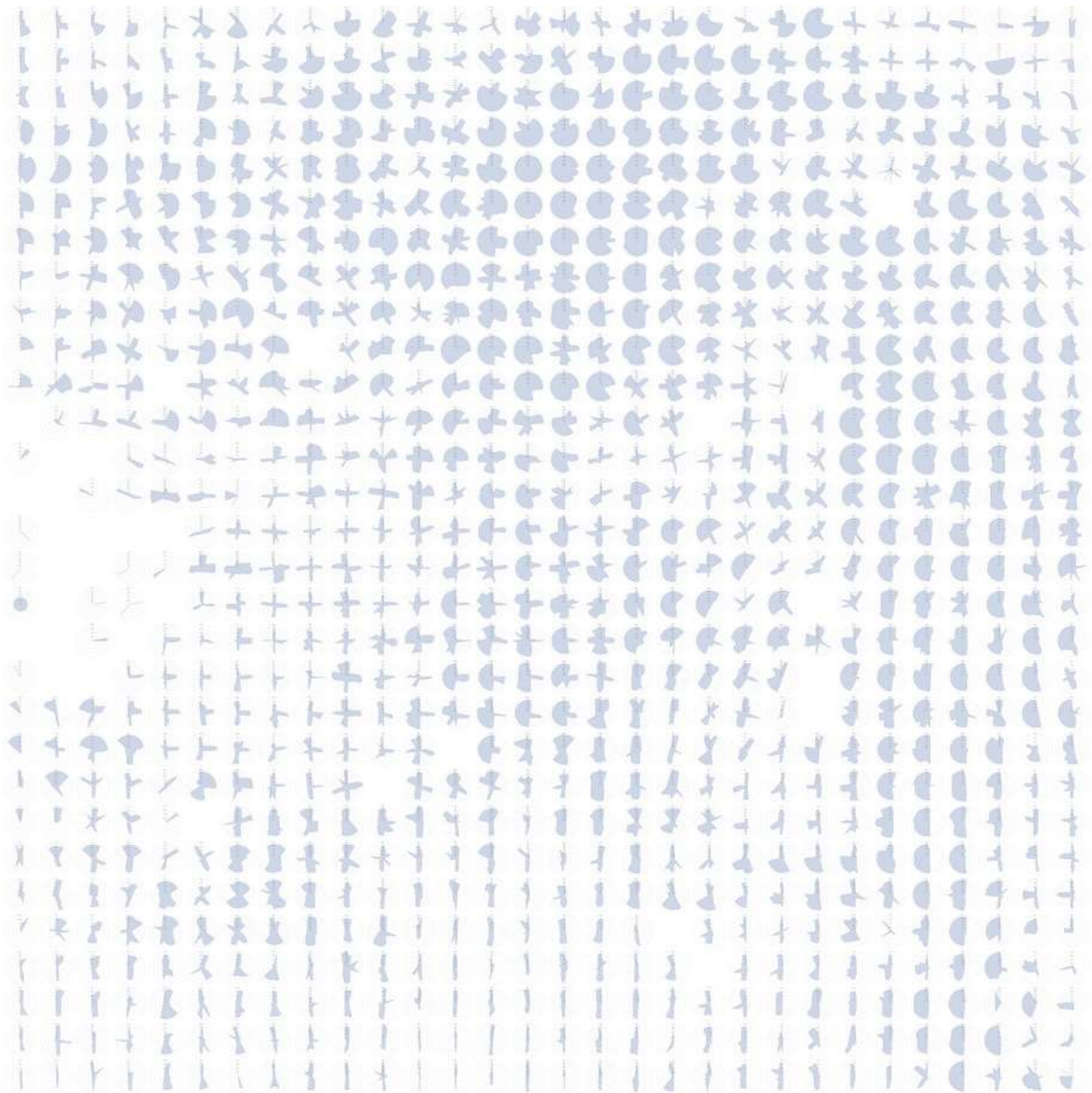
> Semantic Segmentation of the SVIs is done using a pre-trained macine learning model (Ademxapp Model A1 Trained on Cityscapes Data) in Mathematica. The images above color-code nineteen visible element types (road, sidewalk, …) as semantic features.

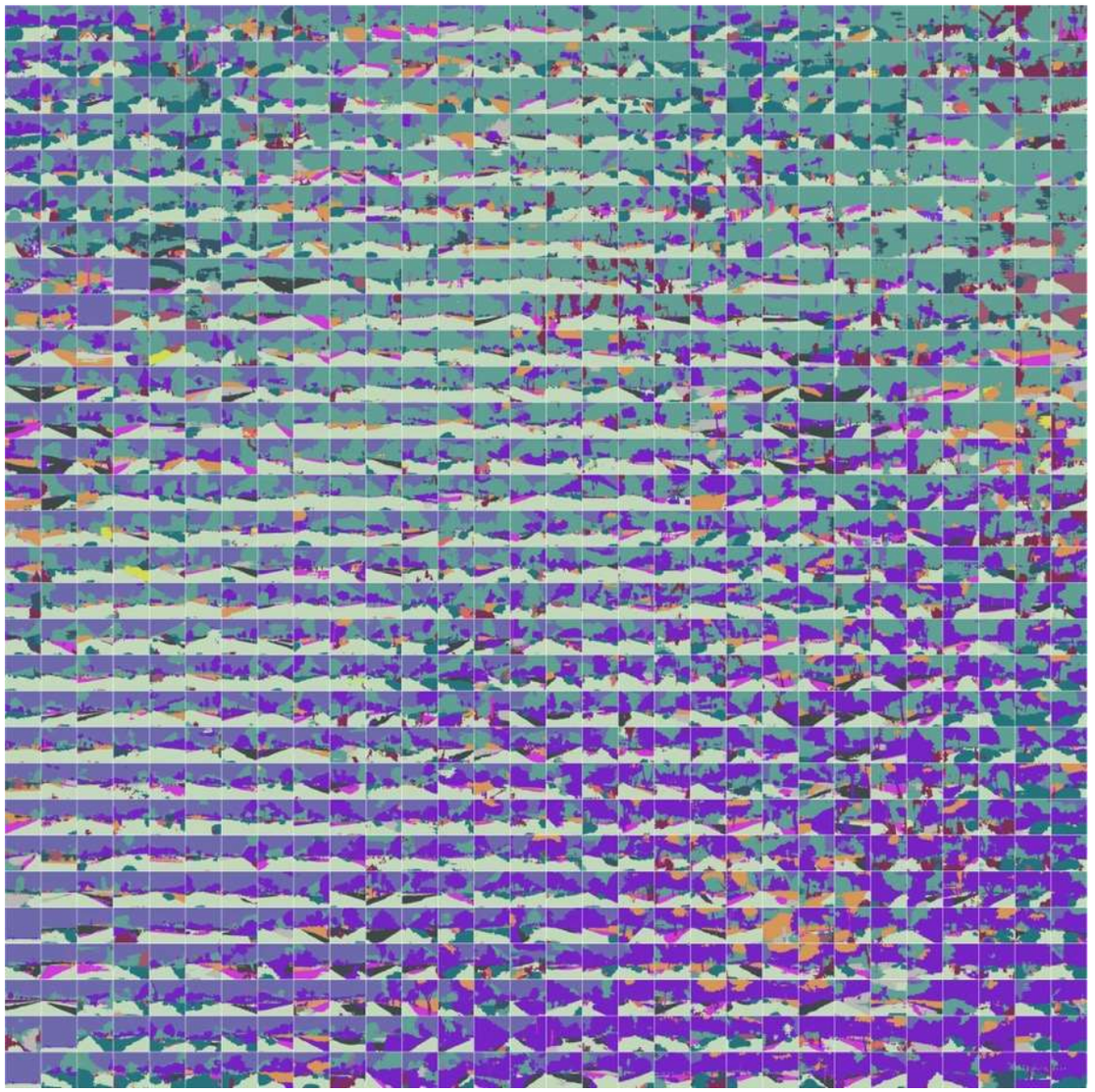
Our search engine automatically extracts and analyses geometry and image using machine learning



> 19 Semantic Features have different proportions for each of the samples (approx. 40000 images).

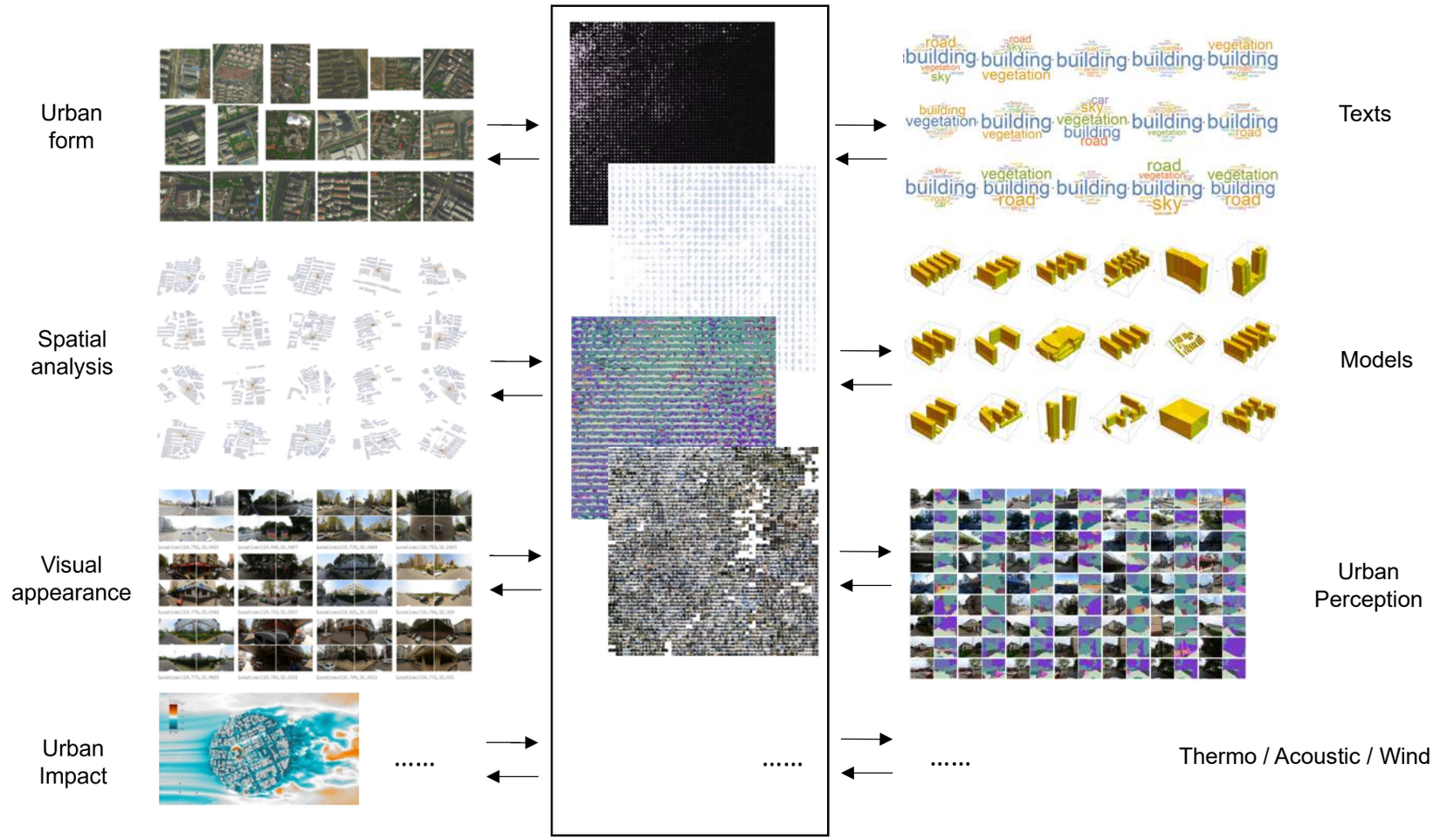
We map links between general patterns and specific cases by training several self-organizing maps (SOMs), resulting in ‘urban dictionaries’





We map links between general patterns and specific cases by training several self-organizing maps (SOMs), resulting in ‘urban dictionaries’

Our proposed methodology can be expanded by integrating additional heterogenous data



> We can expand these search engines by integrating more datatypes, themes and domains.

> The work I presented is a first step towards new methods to augment the learning and decision-making processes of architects and urban designers

> supporting the derivation of hidden rules in complex cities based on in-field, case-based experiences.

In the Semantic Urban Elements project, we are exploring how case-based search can support new approaches linking urban science and design

Evidence-Based Design

Design-Based Evidence

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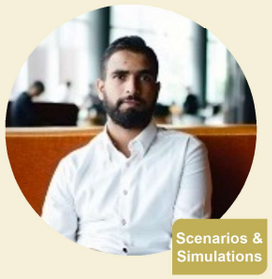

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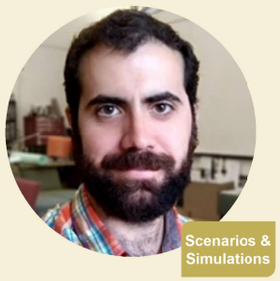

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