GESTALT

Geospatially Enhanced Search with Terrain Augmented Location Targeting

ACM SIGSPATIAL GEOSEARCH WORKSHOP

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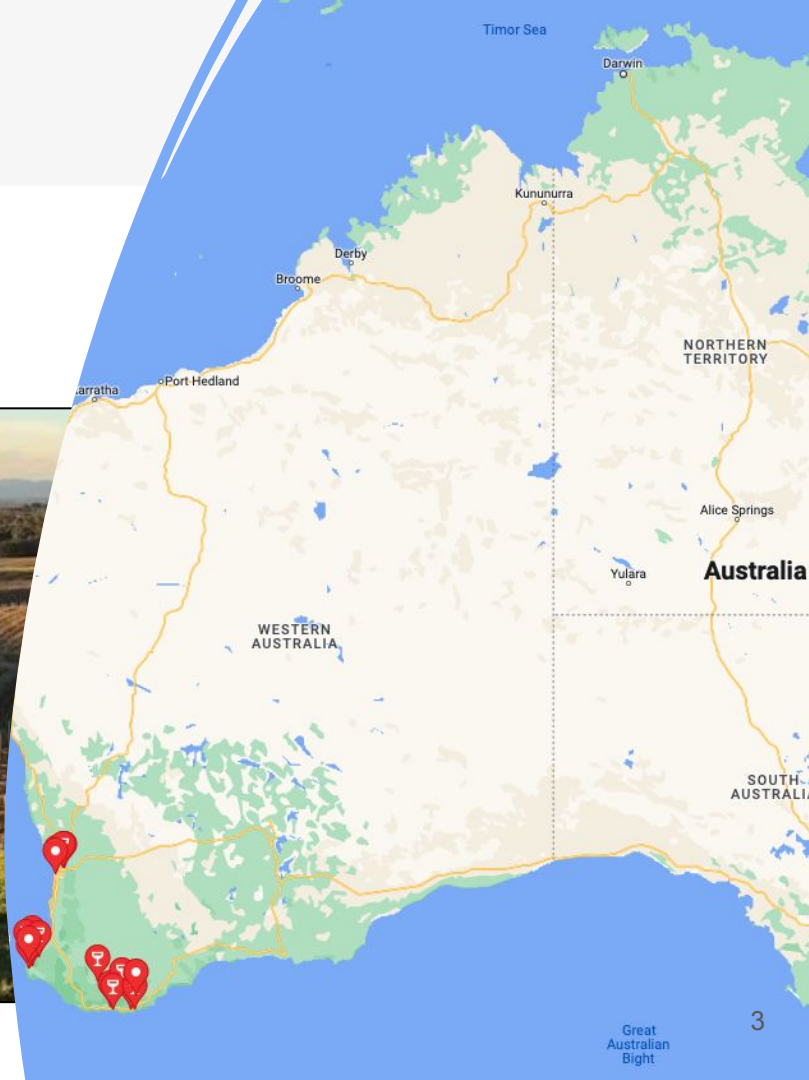
13 Nov 2023

Presentation Scope

1. Problem motivation.
2. GESTALT Architecture.
3. Data Acquisition.
4. Object-Ownership Assignment.
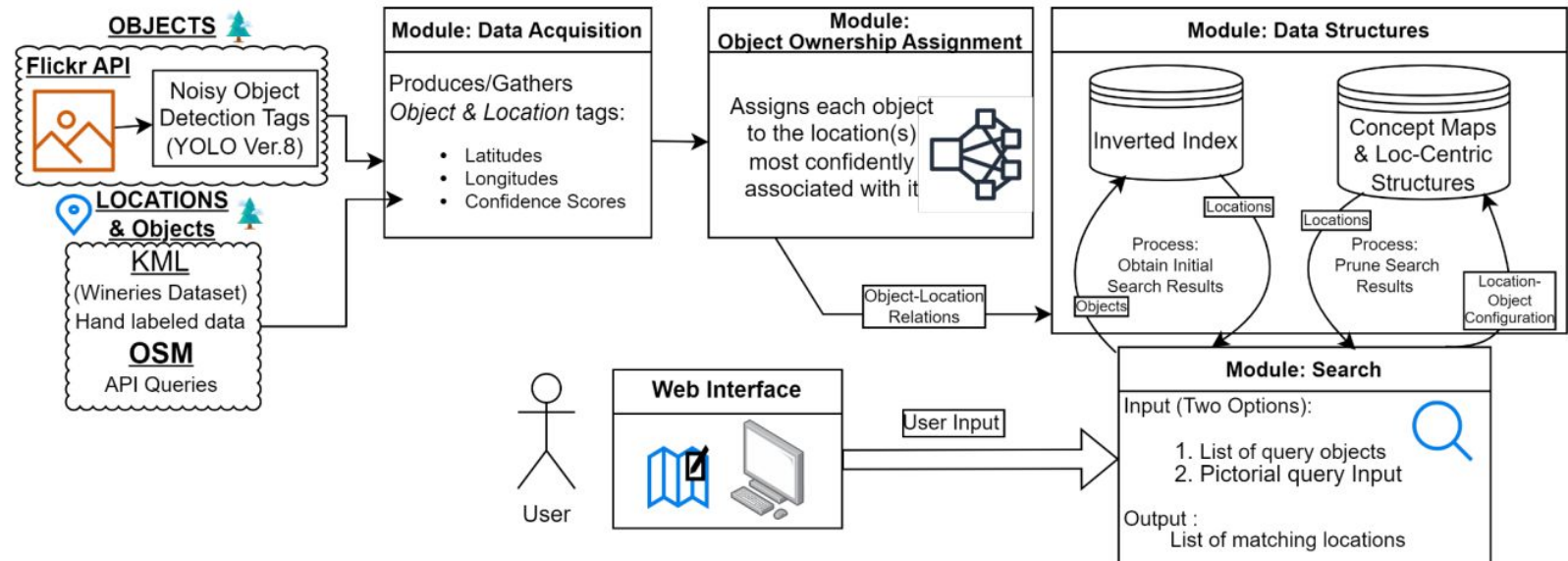5. Demo of GESTALT.
6. Experiments.
7. Future Directions.

Motivating example
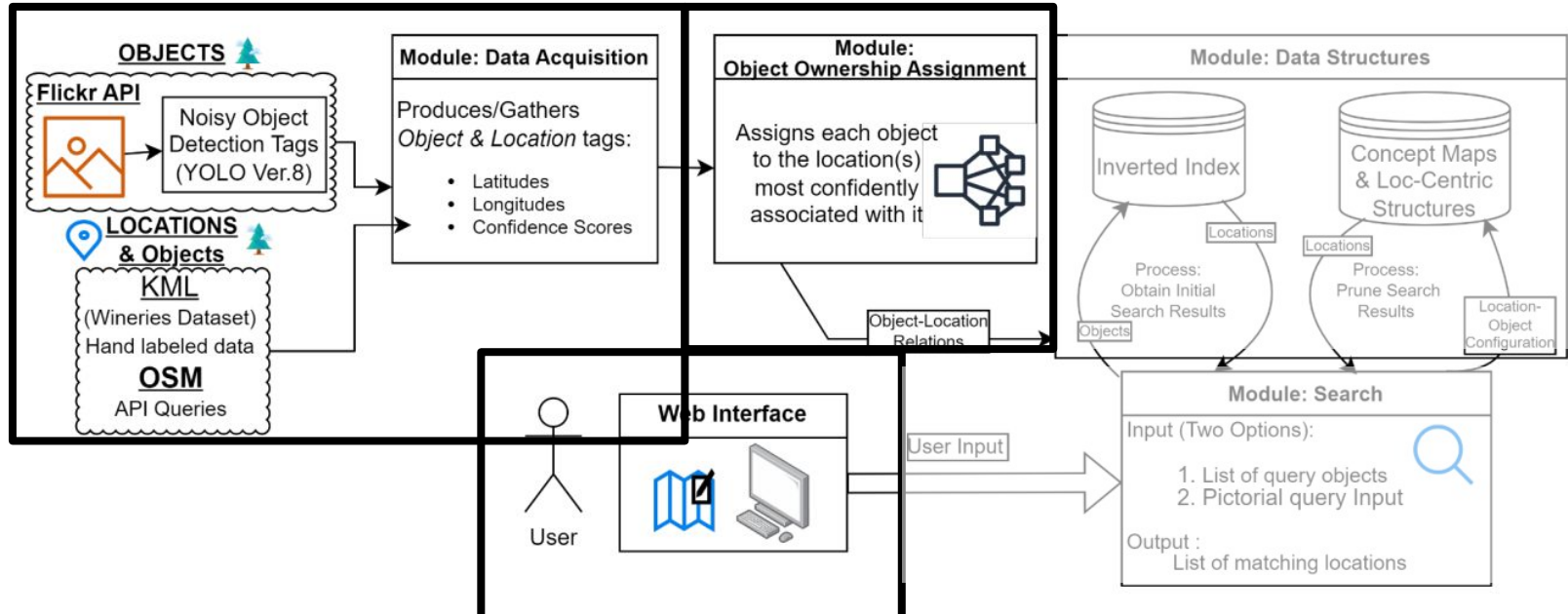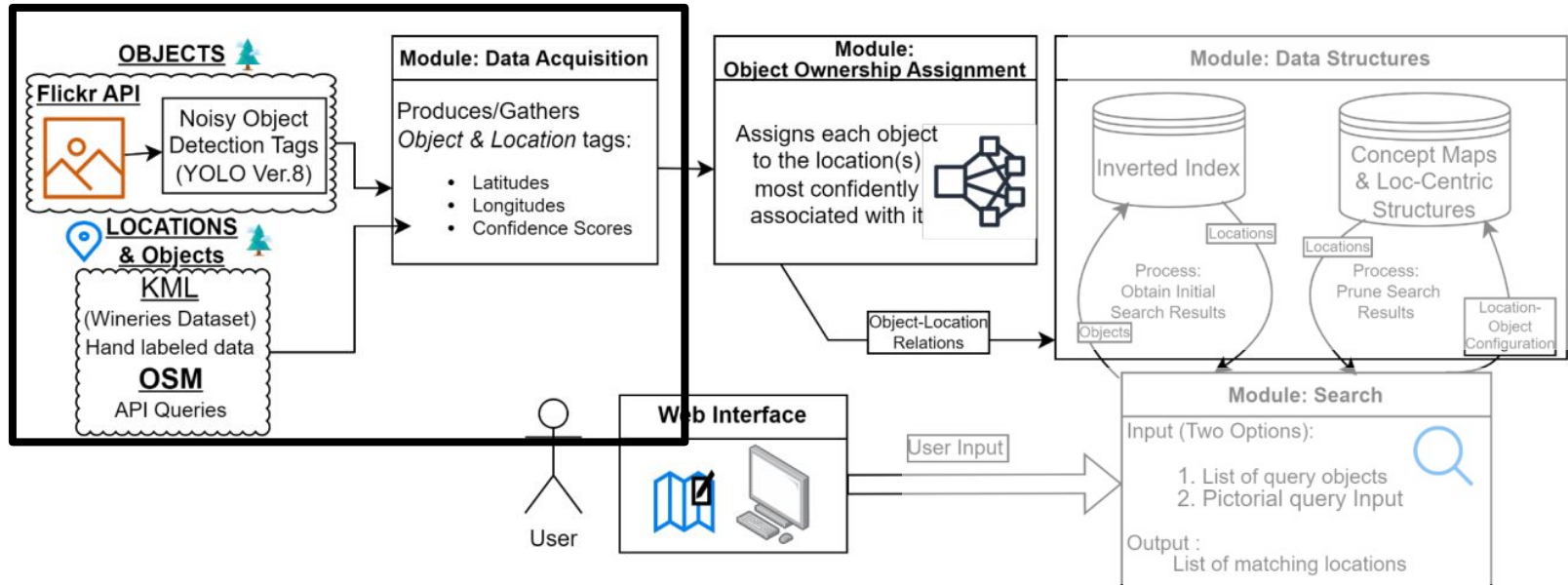
On the merits of wine tours…

GESTALT Architecture

Data collection, Ownership-Assignment, and User Interface

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GESTALT Architecture

Data collection, Ownership-Assignment, and User Interface

OBJECTS 🌲
Flickr API
Noisy Object Detection Tags (YOLO Ver.8)

LOCATIONS & Objects 🌲
KML
(Wineries Dataset)
Hand labeled data
OSM
API Queries

Module: Data Acquisition
Produces/Gathers *Object & Location* tags:
- Latitudes
- Longitudes
- Confidence Scores

Module: Object Ownership Assignment
Assigns each object to the location(s) most confidently associated with it

Object-Location Relations

Module: Data Structures
Inverted Index
Concept Maps & Loc-Centric Structures

Locations
Locations
Process: Obtain Initial Search Results
Process: Prune Search Results
Objects
Location-Object Configuration

User Input

Web Interface
User

Module: Search
Input (Two Options):
1. List of query objects
2. Pictorial query Input

Output :
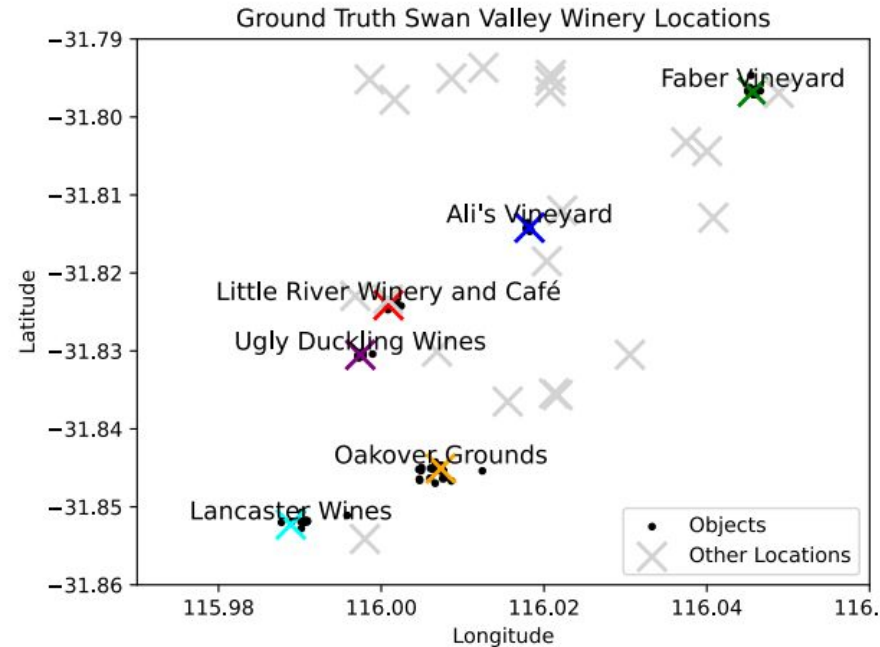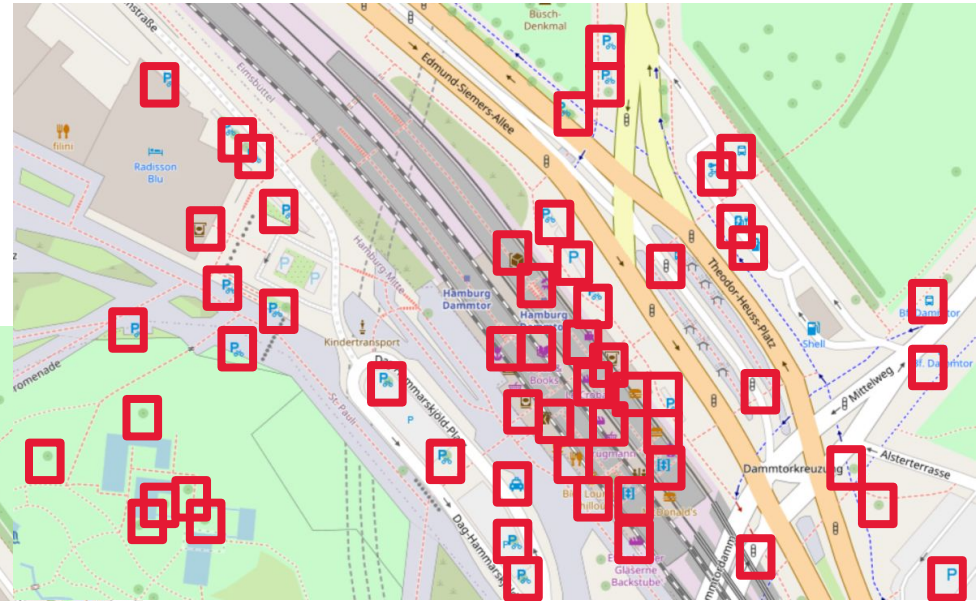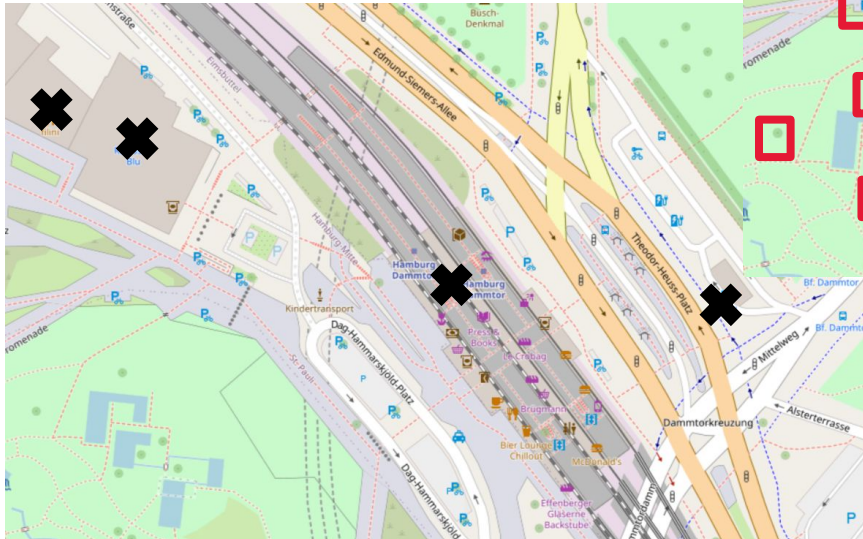List of matching locations

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GESTALT Architecture

Data collection, Ownership-Assignment, and User Interface

Data Acquisition

1. Hand-labeled ground truth data
2. OpenStreetMap labeled data
3. Automatically detected objects

Ground Truth Swan Valley Winery Locations

Data Acquisition

1. Hand-labeled ground truth data
2. OpenStreetMap labeled data
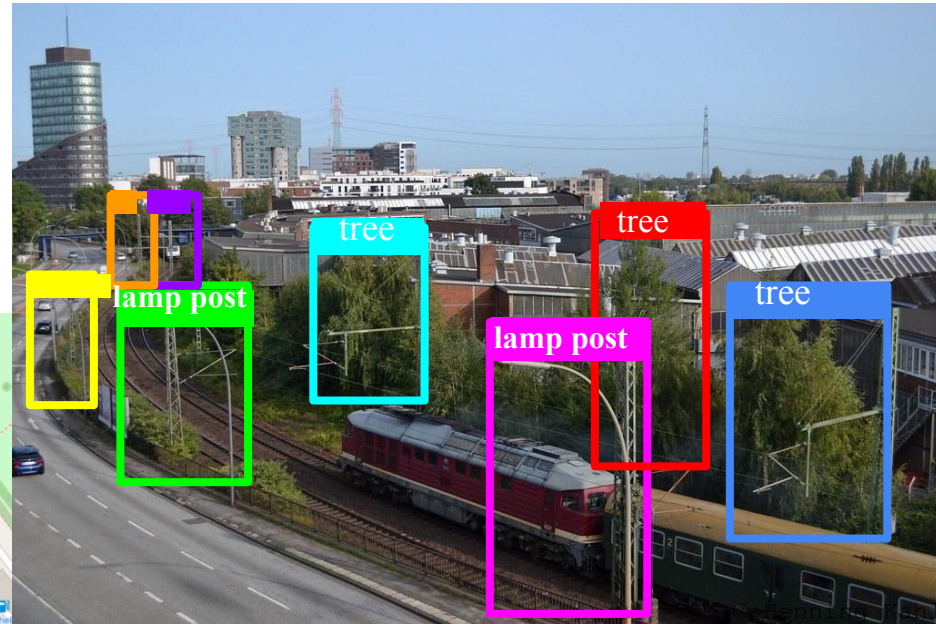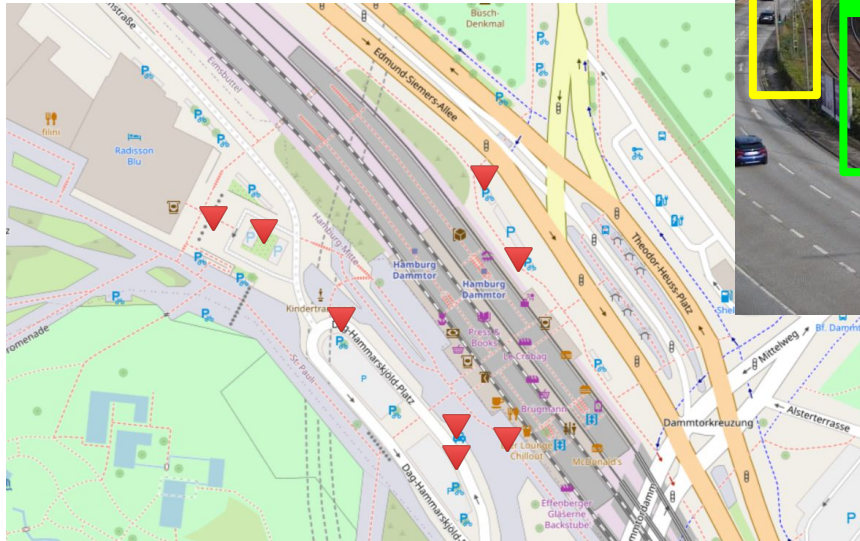3. Automatically detected objects
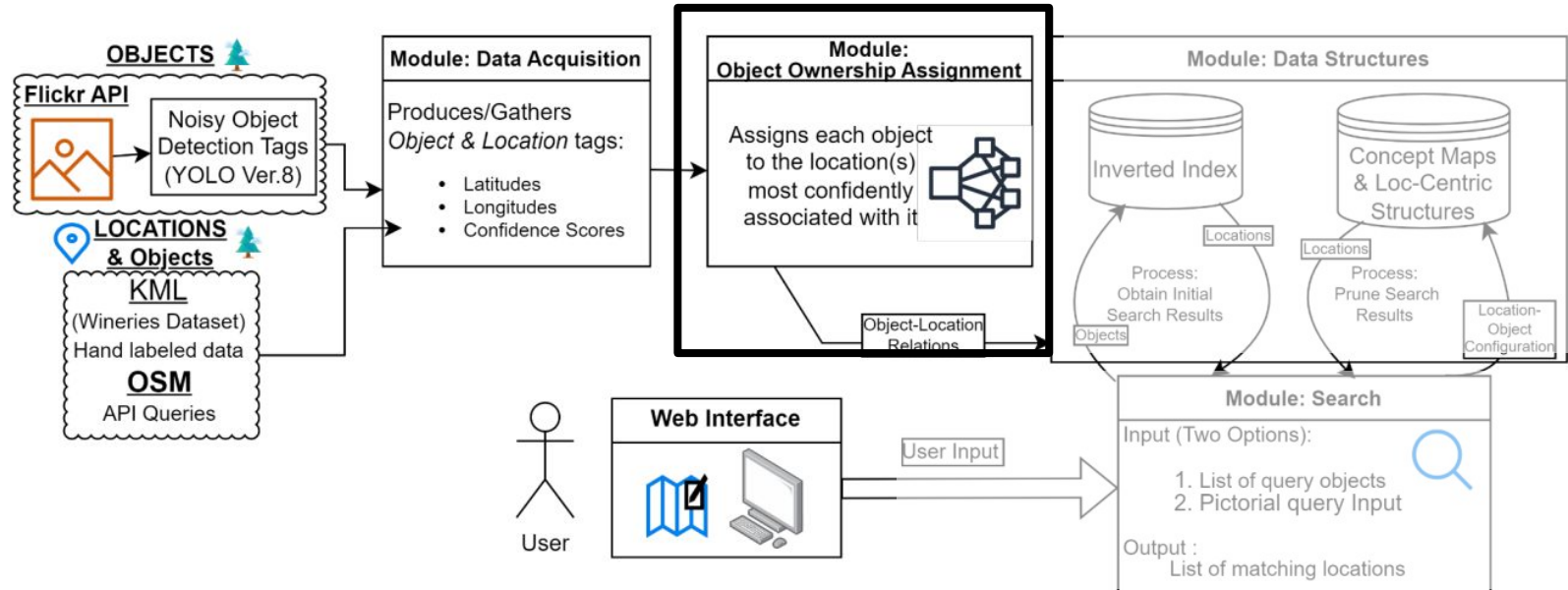

← Locations

↑ Objects

Data Acquisition

1. Hand-labeled ground truth data
2. OpenStreetMap labeled data
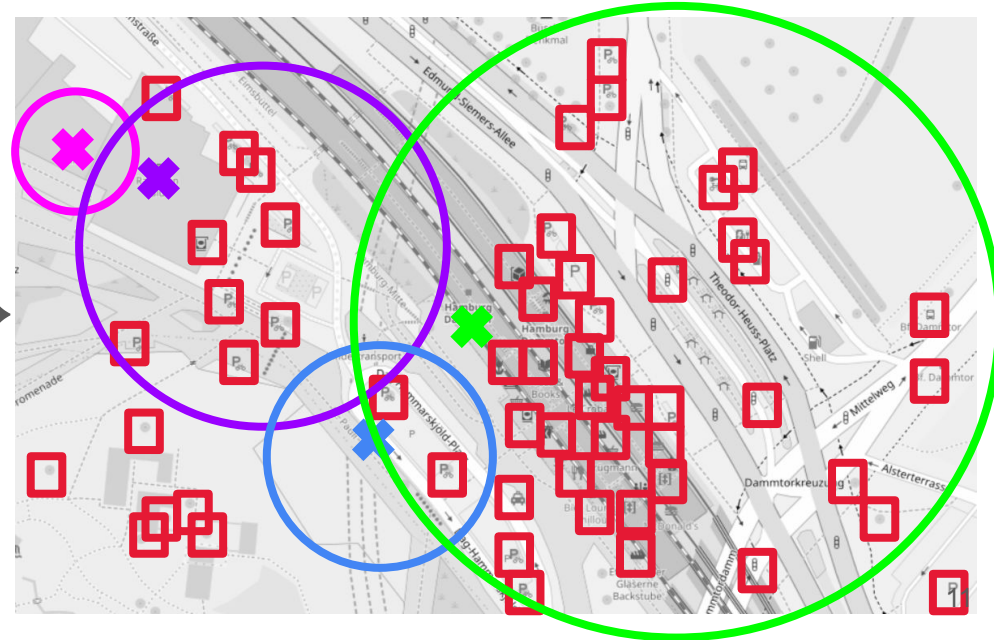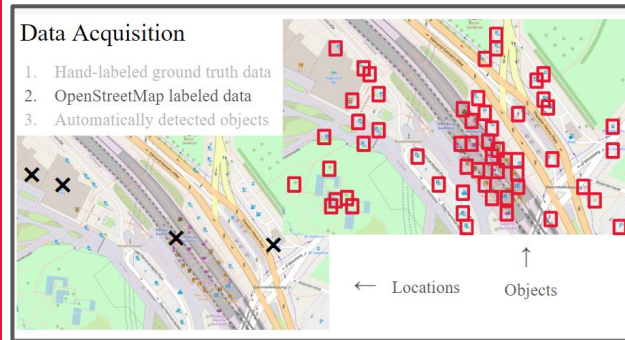3. **Automatically detected objects**

GESTALT Architecture

Data collection, **Ownership-Assignment**, and User Interface
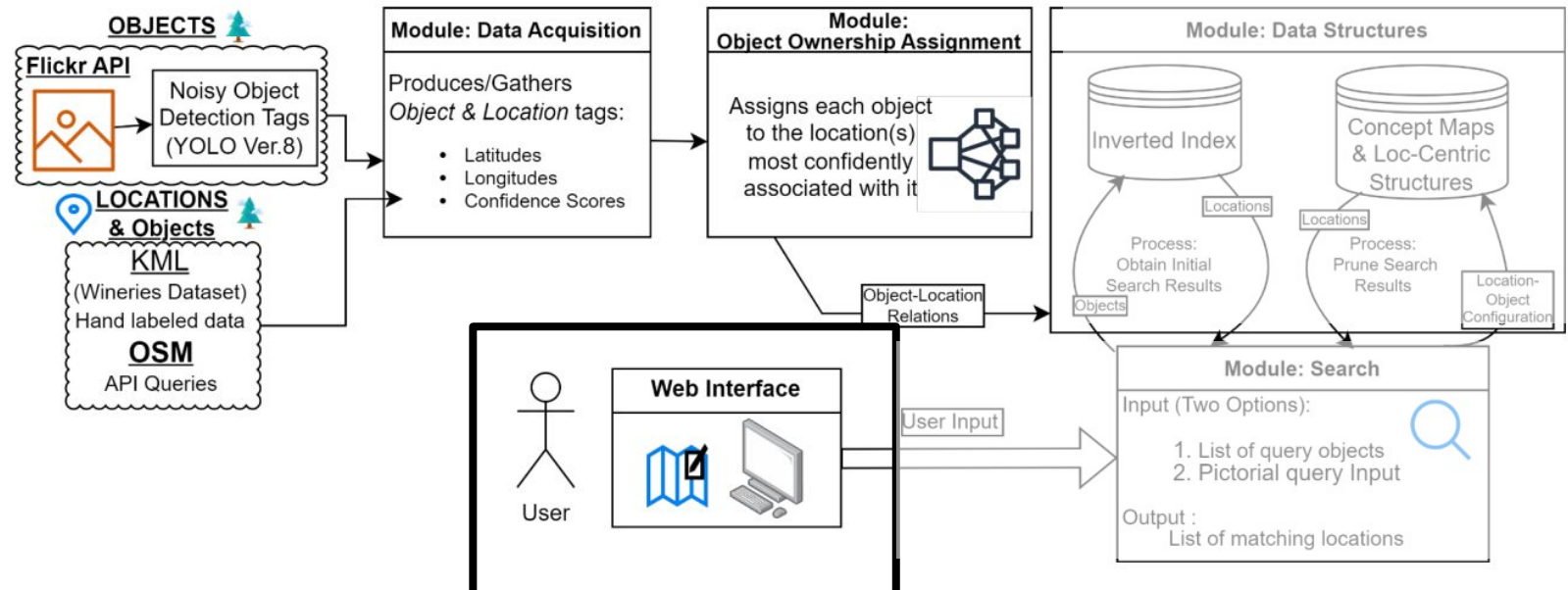
Object-Ownership Assignment

Objects are assigned to nearby locations using density-based clustering, allowing for noise in the objects and locations tagged

- Probabilistic assignment
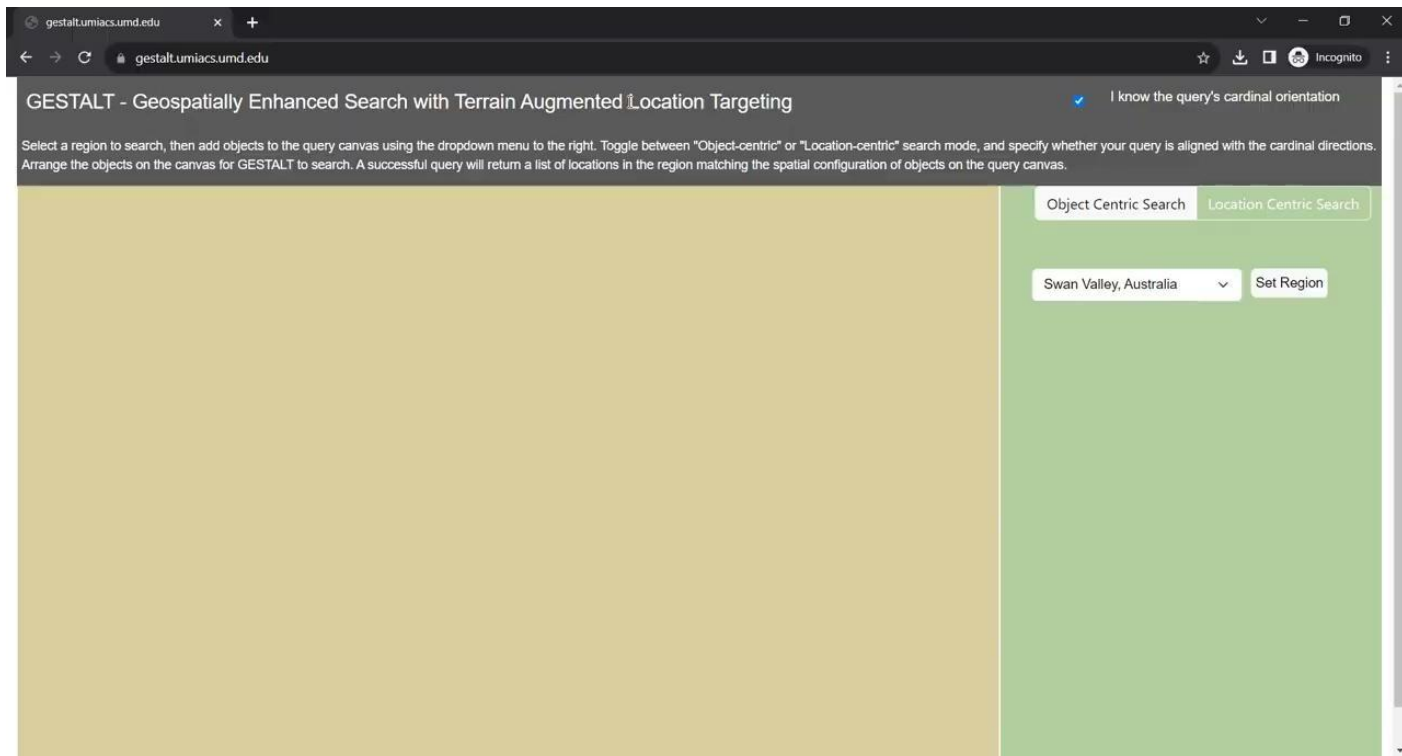- Fuzzy assignment

GESTALT Architecture

Data collection, Ownership-Assignment, and **User Interface**
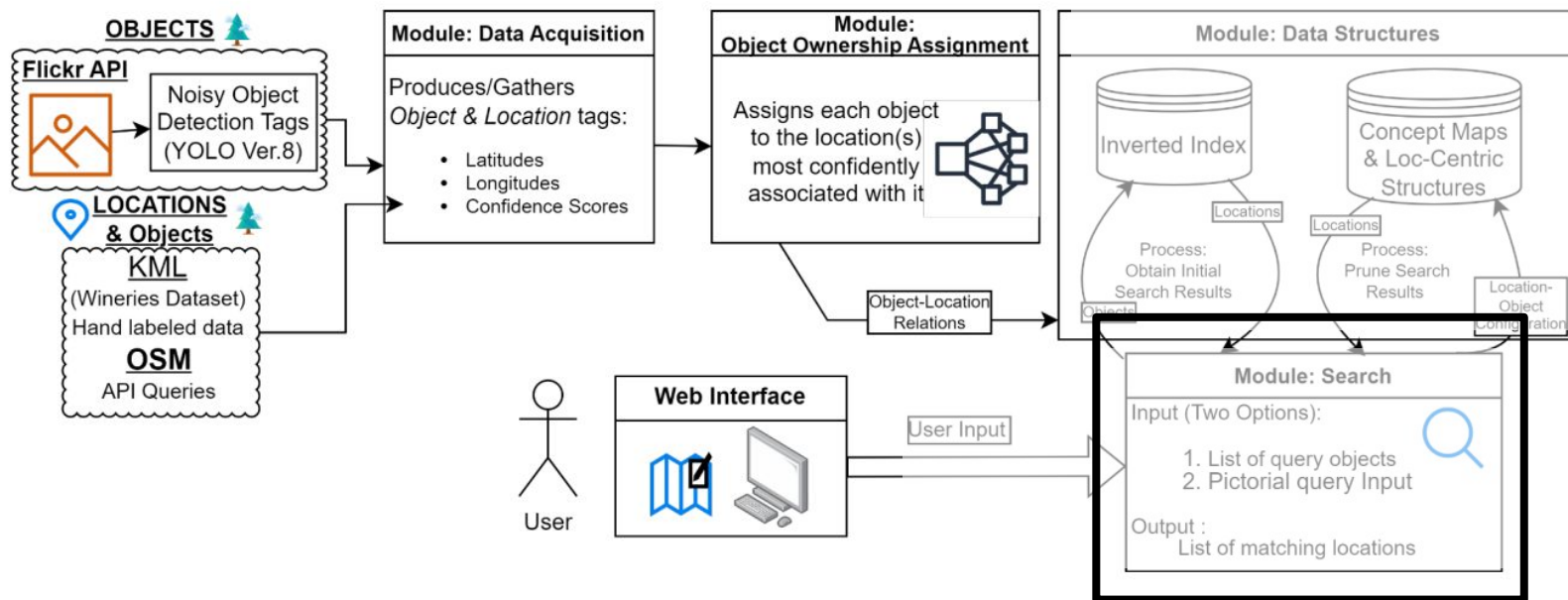

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UI Demo

https://gestalt.umiacs.umd.edu/

GESTALT Architecture

Data collection, Ownership-Assignment, and User Interface

Experiments - effectiveness

| Search Method	Metric	Results
Location-Object Search	Mean Precision	1.000
	Mean Recall	0.800
Object-Object Search	Mean Precision	0.947
	Mean Recall	0.737
Object-Object Cardinality Invariant Search	Mean Precision	0.825
	Mean Recall	0.816

Table 3: Spatial search performance results across 58 ground-truth pictorial queries run on the *Combined Swan Valley Wineries* dataset.

Dataset	Method	Fuzzy Param	Precision	Recall
Swan Valley Wineries	Exact	$c = 0$	1.0	0.89
	Fuzzy	$c = 2$	0.85	0.89
	Fuzzy	$c = 4$	0.85	0.89
	Fuzzy	$c = 6$	0.85	0.89
	Fuzzy	$c = 8$	0.85	0.89
	Fuzzy	$c = 10$	0.85	0.89
Combined	Exact	$c = 0$	-	0.88
	Fuzzy	$c = 2$	-	0.88
	Fuzzy	$c = 4$	-	0.91
	Fuzzy	$c = 6$	-	0.94
	Fuzzy	$c = 8$	-	0.97
	Fuzzy	$c = 10$	-	0.98

Table 2: Object-to-location assignment results for Swan Valley Wineries and Combined datasets. Increasing fuzziness improves recall on the noisier *Combined* dataset.

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Experiments - efficiency
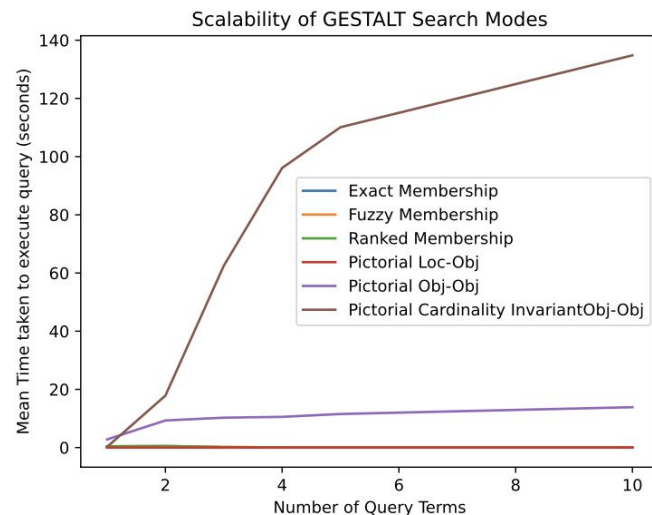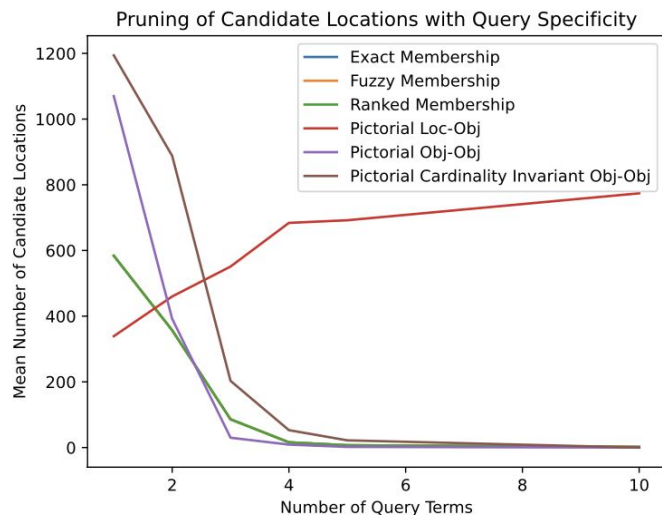
Figure 4: Spatial search complexity results measured in the number of candidate locations and query response times for each type of spatial query *GESTALT* supports. Measured on the Washington D.C. Dataset (12,179 Locations, 91,188 objects).

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What next?

Discussion of our Data Structures and Search Algorithms in GeoSearch @ 1550 today.

Future Work:

- **Data collection** → Flickr is great, but not `general' enough.
- **Data processing** → Depth estimation for photos; refine object classes.
- **Clustering** → Clustering around known `centroids' & learn parameters.
- **UI** → Links to locations, return map thumbnails, enforce ontology.
- **User Study** → Confirm assumptions about utility.

Questions

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