GeoAI for Urban Mobility: Problems and Projects

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What is GeoAI?

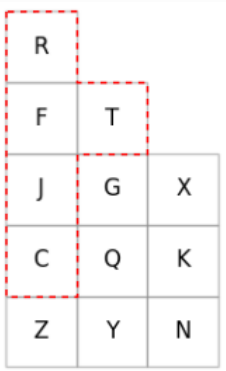
- **GeoAI** blends AI, spatial data science, geography, geosciences, and cognitive science to detect, describe, and predict geo-processes.
- **GeoAI** is not a one-way street: it utilizes AI to solve geographic problems **and** also develops new theories, models, and methods that advance the broader field of AI.
- **GeoAI** introduces **spatial thinking** into mainstream AI —making models aware of place, distance, and context.
- **GeoAI** draws on both knowledge-based (symbolic) and data-driven (representation learning) AI traditions.
- **GeoAI** is used in urban design, disaster response, transport, precision agriculture, crime, privacy, conflict studies, and many other areas.
- **AI** systems already started to **act** on the world, our task is to ensure these systems also **perceive** *our* world (*ideally similar to us...*).

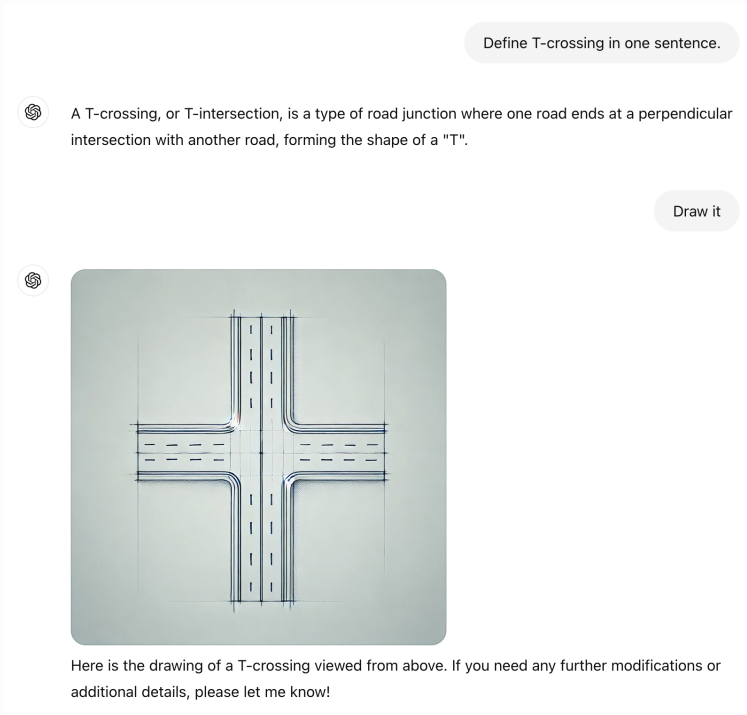
The Urban Data Landscape

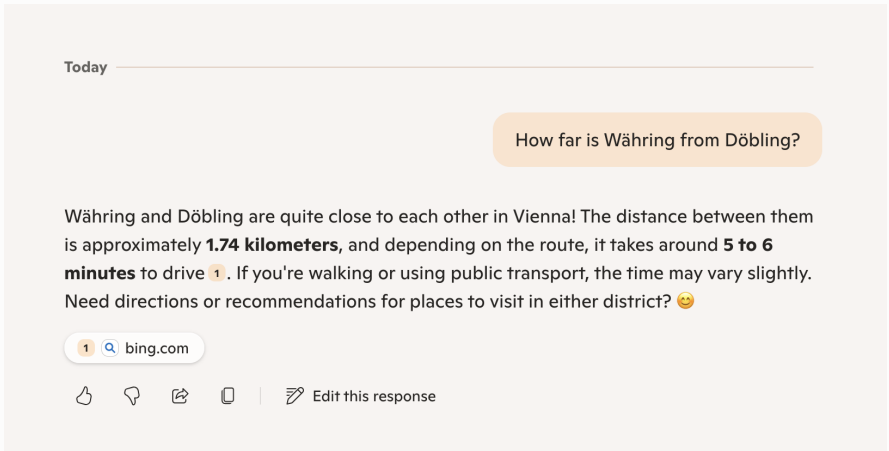
- Urban data sources range from **social sensing** (social media, mobile phones), in-situ sensors, to satellite imagery.
- In some areas, we are **drowning in data**:
  - Continuous traffic, pedestrian sensors in city centers
  - Reviews for top 10 locations
  - (High-resolution) satellite imagery
  - Street network data
- In other areas, we are **starving for data**:
  - Crime and perceived safety (known but not reported)
  - Walkability (features present, but unclear semantics)
  - Points Of Interest (beyond common attributes, point-coordinates)
  - Vague Cognitive Regions (beyond common names)
  - Events (and spatiotemporal data more generally)
  - Underserved groups/areas (e.g., air quality)
- **GeoAI** studies how to **extract knowledge** out of data and how to close data gaps.

Spatially-explicit GeoAI Methods for GenAI

- **Spatially-explicit** GeoAI addresses common gaps of more general AI models, e.g., **topology**, adjacency, connectivity.
- This is key for accurate spatial structure, realistic agent movement, policy **experiments**, training data **generation**.







Data Semantics is Tricky

Bundesland	**Unfälle mit Schulkindern** (6–15 Jahre) auf dem Schulweg	**Verletzte Schulkinder** (6–15 Jahre) auf dem Schulweg	**Getötete Sk.** (6–15 Jahre) auf dem Schulweg
Burgenland	3	8	-
Kärnten	29	31	-
Niederösterreich	78	86	-
Oberösterreich	73	79	-
Salzburg	33	30	-
Steiermark	48	59	-
Tirol	47	51	-
Vorarlberg	29	27	-
Wien	79	80	-
Österreich	**419**	**451**	**-**

Table: Unfälle mit Schulkindern, verletzte und getötete Schulkinder 2024 nach Bundesland

- How many kids got **injured** in Vienna?
- How many accidents involved **more than one** child?
- How many kids **died** in accidents in Vienna?

The Dangers of Data-Poor Methods & Models

- Human movement is shaped by **both social and physical space**, but trajectory analysis often uses only **abstract** (Euclidean) space/measures.
- Small changes that seem minor in abstract space can have **major real-world impacts** once mapped onto actual geography.

- **Synthetic** trajectories are used to protect privacy, e.g., in insurance.
- However, the measures used to guarantee their **similarity** are still data-poor.

Knowledge Graphs: Data Backbone for AI Systems

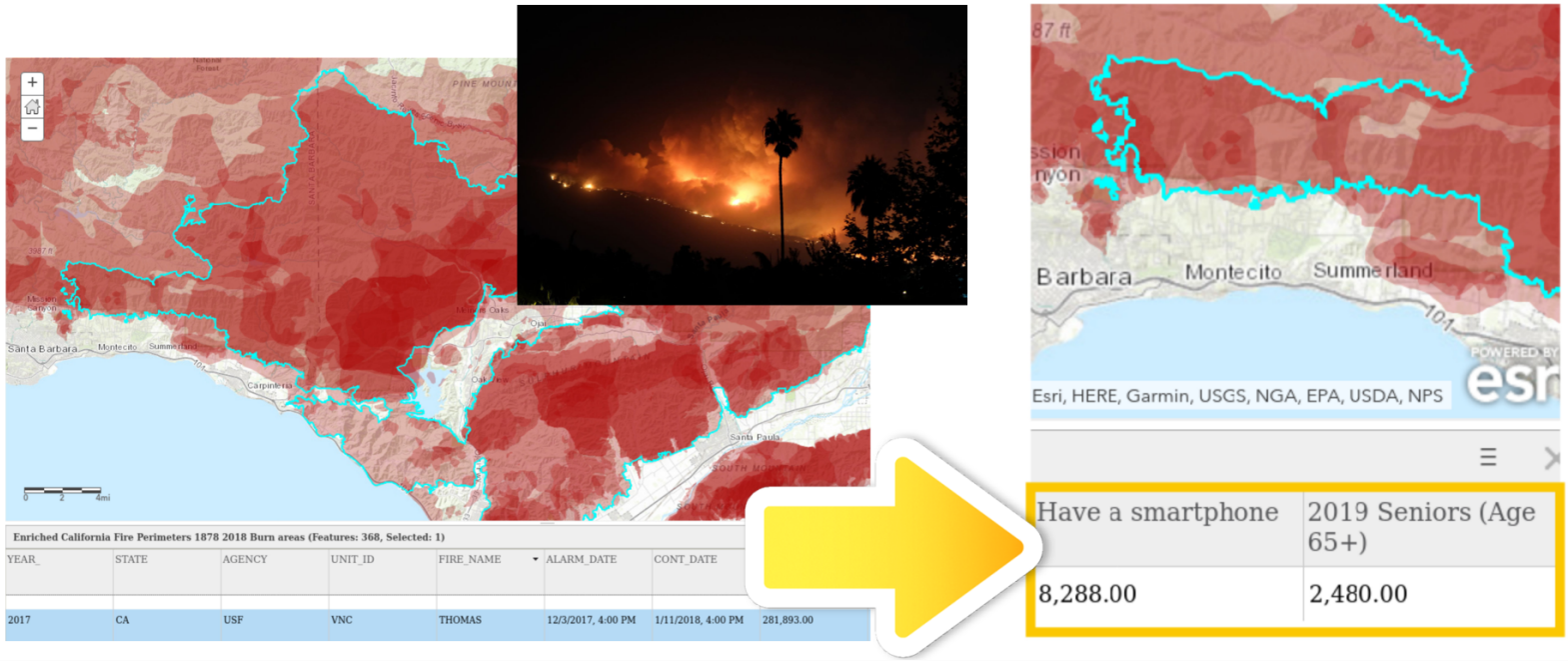
- **Knowledge graphs** (KGs) represent places, events, people, entities, and their rich relationships as a human and machine-readable and reasonable network.
- **Two main approaches**
  - **Knowledge Representation & Reasoning (KRR)**: Uses rules, (logic) axioms for declarative representation and deductive inference but cannot handle **noise** or missing data. Example:

$$\text{oneWay}(\text{Street}) \wedge \text{movesAgainstDirection}(X, \text{Street}) \Rightarrow \text{bike}(X)$$

  - **Representation Learning (RL)**: Learns latent representations (embeddings) for places and relationship from **large amounts of high-quality data**, capturing patterns not easily stated in rules.
  - E.g., X starts their day here, so it is likely their home location.
- Combining **KRR** and **RL** enables both explicit (deductive) reasoning and flexible pattern discovery.

GeoEnrichment using Knowledge Graphs

- Knowledge graphs can be used as **context provider** to enrich models on-the-fly.



- They are now also used for **RAG** by many LLM/chatbots to prevent **hallucination**.
- For instance, **KnowWhereGraph** contains 29 billion graph statements about the world.