An Ontology-based Standard for Transportation Planning

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Background: iCity-ORF

iCity-ORF: Supported by the Ontario Ministry of Research and Innovation through the ORF-RE program.
Goal: Planning transportation infrastructure over a long horizon

• What will demand for public transportation and roads be over the next 30 years?

• How do changes in transportation infrastructure affect travelers?

• What are the environmental impacts of growth?

• ...
Example: ILUTE

Integrated Land Use, Transportation and Environment model (simplified)
Transportation Planning

Collecting and combining this data is not straightforward
Transportation Planning Problem

• Problem:
  • Collected data is expensive, but often not reused
  • Multitude of transportation planning tools are in use by researchers and cities
  • No easy way to compare results as each has their own unique data models

• We need a standard for this data
Transportation Planning Standard: Requirements

• Requirements for a solution to the transportation planning problem
  • Must work with different tools, data formats
  • Must be easily extensible: tools and approaches are always changing
  • Must have a unique interpretation; incorrect and correct interpretations should be clearly identifiable (Limitation of traditional standards)

• Proposed Solution
  • An ontology-based transportation planning standard
Ontology Requirements

• Gathered from subject matter experts
  • Interviews
  • Datasets
• Competency Questions:
  • Retrieve data to help researchers with analysis of
    • population, land use and travel demand data
    • historical data on subway incidents and bus bridging
    • road congestion data
Requirements

• Broadly, 3 key areas to be represented:
  • Land use
  • Infrastructure
  • Behaviour (agents)
iCity Transportation Planning Suite of Ontologies (TPSO) Overview

http://ontology.eil.utoronto.ca/icity/UmbanSystem/

- **Agents**
  - Contact (Imports TOVE iContact)
  - Trip
  - Person
  - Household
  - Organization (Imports TOVE Organization)

- **Land Use**
  - Parking
  - Building (Imports LBCS)
  - Land Use

- **Infrastructure**
  - Vehicle
  - Travel Cost
  - Trip Cost
  - Transportation Network
  - Transit

- **Foundations**
  - Observations (Imports SSN)
  - Units of Measure (via OM)
  - Resource
  - Recurring Events
  - Location (Imports GeoSPARQL)
  - Time (Imports W3C Time)
  - Change
  - Mereology (via Bittner & Donnelly)
  - Activity (via TOVE Activity)
Design Decisions

• OWL2
  • Project requirements

• Reuse where possible

• No top-level ontology
  • Bottom-up approach
  • Reuse of foundational, generic ontologies as needed

• 4D approach* to capturing change
  • *a pragmatic decision rather than an official ontological view
  • Use the notion of temporal parts when change is required
Change over time in OWL
Change over time example: reuse of atemporal vocabularies
Evaluation

Evaluated in the context of iCity-ORF project
✓ Consistency checking
✓ Mapping datasets into RDF using the ontology-based representation
✓ Competency questions, proof-of-concept implementations:
  • What subway incidents occurred during the month of August 2019?
  • What buses were not located on their route after a subway incident?
  • What is the reading of the loop detector on road segment X?
  • Explore the attributes of travel behavior data:
    • What is the distribution of types of people travelling from zone A to zone B?
    • What is the distribution of mode types that people use to arrive at zone C?
    • ...

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<th>Public Safety Indicators</th>
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Foundations:
- Location
- Time
- Change
- Mereology
- Activity
Moving Forward

• Working toward standardization
  • City Data Model (ISO WG11 Smart Cities NWIP)
  • Coordination with transportation standards efforts (ISO and beyond)

• An iterative development process
  • New applications will serve to inform and improve the ontology
    • Esri Canada: working to standardize road network terms, create a knowledge graph that adopts the ontology to merge Esri data with transportation planning data
    • Expanding from the transportation planning domain to consider other city services
Questions?

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iCity TPSO links to individual ontologies

- **Activity**: [http://ontology.eil.utoronto.ca/icity/Activity/](http://ontology.eil.utoronto.ca/icity/Activity/)
- **Building**: [http://ontology.eil.utoronto.ca/icity/Building/](http://ontology.eil.utoronto.ca/icity/Building/)
- **Change**: [http://ontology.eil.utoronto.ca/icity/Change/](http://ontology.eil.utoronto.ca/icity/Change/)
- **Household**: [http://ontology.eil.utoronto.ca/icity/Household/](http://ontology.eil.utoronto.ca/icity/Household/)
- **Land use**: [http://ontology.eil.utoronto.ca/icity/LandUse/](http://ontology.eil.utoronto.ca/icity/LandUse/)
- **Mereology**: [http://ontology.eil.utoronto.ca/icity/Mereology/](http://ontology.eil.utoronto.ca/icity/Mereology/)
- **Monetary Value**: [http://ontology.eil.utoronto.ca/icity/MonetaryValue/](http://ontology.eil.utoronto.ca/icity/MonetaryValue/)
- **Parking**: [http://ontology.eil.utoronto.ca/icity/Parking/](http://ontology.eil.utoronto.ca/icity/Parking/)
- **Person**: [http://ontology.eil.utoronto.ca/icity/Person/](http://ontology.eil.utoronto.ca/icity/Person/)
- **Public Transit**: [http://ontology.eil.utoronto.ca/icity/PublicTransit/](http://ontology.eil.utoronto.ca/icity/PublicTransit/)
- **Location**: [http://ontology.eil.utoronto.ca/icity/SpatialLoc/](http://ontology.eil.utoronto.ca/icity/SpatialLoc/)
- **Time**: [http://ontology.eil.utoronto.ca/icity/Time/](http://ontology.eil.utoronto.ca/icity/Time/)
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