An Ontology-based Method in Agent-based Modeling -- Land Use as a Case Study

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Introduction

• Ontologies have been widely applied in spatial data modeling (Kuhn 2001)
• Event-based modeling with sensor data (Devaraju 2015)
• Ontology and agent-based modeling (Raubal 2001)
Introduction

• Galton’s viewpoints about ontological relations between state and event (Galton 2012)
  • Only events may strictly cause other events
  • Events may initiate or terminate states.
  • States (of the world) only affect causation in as much as they can allow events to cause other events.
Introduction

(Galton, 2012)

(Bleisch, 2014)
Objective

• Design an ontology-based agent-based modeling method
• Define behavior and actions of agents using ontology
• Use BFO (Basic Formal Ontology) for definition
• Use land use as a case study
Upper Ontology: BFO
State and Process in BFO
Case study: Land Use and Land Cover

- **Model**: Hybrid model with agent-based modeling and Cellular Automata (CA) model
- **Agent**: Government, Developer and Resident
- **Land type**: Available land → New development land → Established development land
Agents and Goals

• Government: Sustainable Development
• Developer: Making profits from land use
• Resident: Maximize the living suitability
Government

\[ B_T = I(a - bq_t) \, dq_t \]
\[ = aq_t - bq_t^2 / 2. \]

\[
\text{Max}_{q_t} \sum_{t=1}^{n} \left( aq_t - bq_t^2 / 2 - cq_t \right) / (1 + r)^{t-1} + \lambda \left[ Q - \sum_{t=1}^{n} q_t \right]
\]

(Li 2008)
Developer and Resident Agents

• Developer
  • Maximize Profit = House Price – Land Price – Developing Cost

• Resident: Maximize suitability index
  • Surrounding environment (Parks, water)
  • Accessibility to major roads
  • Accessibility to schools
Ontology Structure

```
- Thing
  - Continuant
    - Generically_Dependent_Continuant
      - Developing_Cost
      - House_Price
      - Land_Price
      - Society_Benefit
      - Profit
      - Suitability_Index
    - Behavior
      - Maximize_Suitability_Index
      - Maximize_Profit
      - Sustainable_Development
    - State
      - Government_State
      - Land_Type
      - Resident_State
    - Independent_Continuant
      - Immaterial_Entity
      - Material_Entity
        - Object
          - Land_cell
          - Agent
            - Resident
            - Government
            - Developer
        - Specifically_Dependent_Continuant
    - Suitability_index
      - Behavior
        - Maximize_Suitability_Index
        - Maximize_Profit
        - Sustainable_Development
      - State
        - Government_State
        - Land_Type
        - Resident_State
          - High_income_with_children
          - High_income_without_children
          - Low_income_with_children
          - Low_income_without_children
          - Middle_income_with_children
          - Middle_income_without_children
      - Independent_Continuant
        - Immaterial_Entity
        - Spatial_Region
          - Zero_Dimensional_Spatial_Region
          - Continuant_Flat_Boundary
        - Site
```
Ontology Structure
Ontology Structure
Conclusion

• Ontology can be a good tool to clearly define agent behavior.
• Geography process can be clearly shown in ontology structure
Future work

• Define more relations between three main agents
• Apply this ontology-based model into advanced analysis
• Integrate this ontology model with CA model
• Use this hybrid model into city sprawling as spatial epidemic (Batty 2007)