ONTOLOGIES FOR URBAN SOCIAL-ECOLOGICAL SYSTEMS: PAST, PRESENT AND FUTURE

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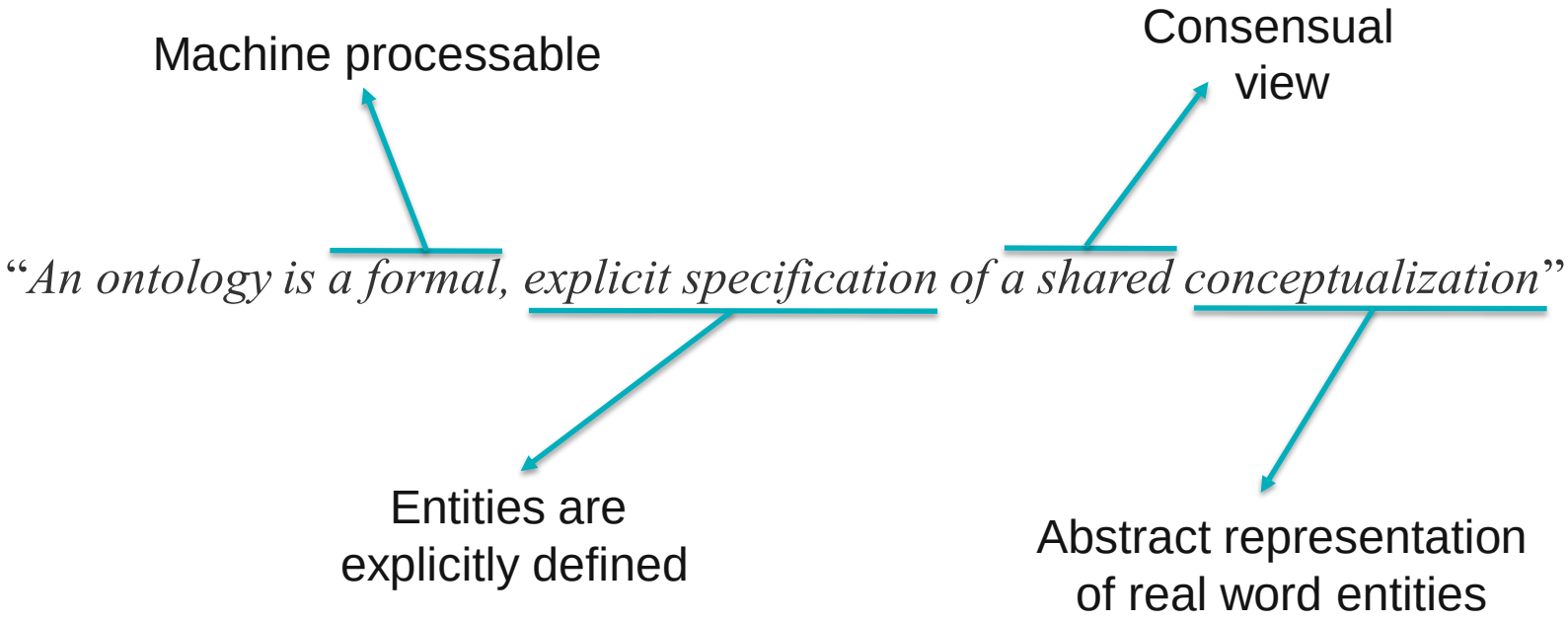
WHAT ARE ONTOLOGIES?

FROM DATA TO WISDOM

- **Data:**
  - Collection of facts in a raw or unorganized form such as numbers or characters.
- **Information:**
  - Processed data
- **Knowledge:**
  - Useful information
- **Wisdom:**
  - Integrated knowledge

ONTOLOGIES

The heart and soul of the Semantic Web



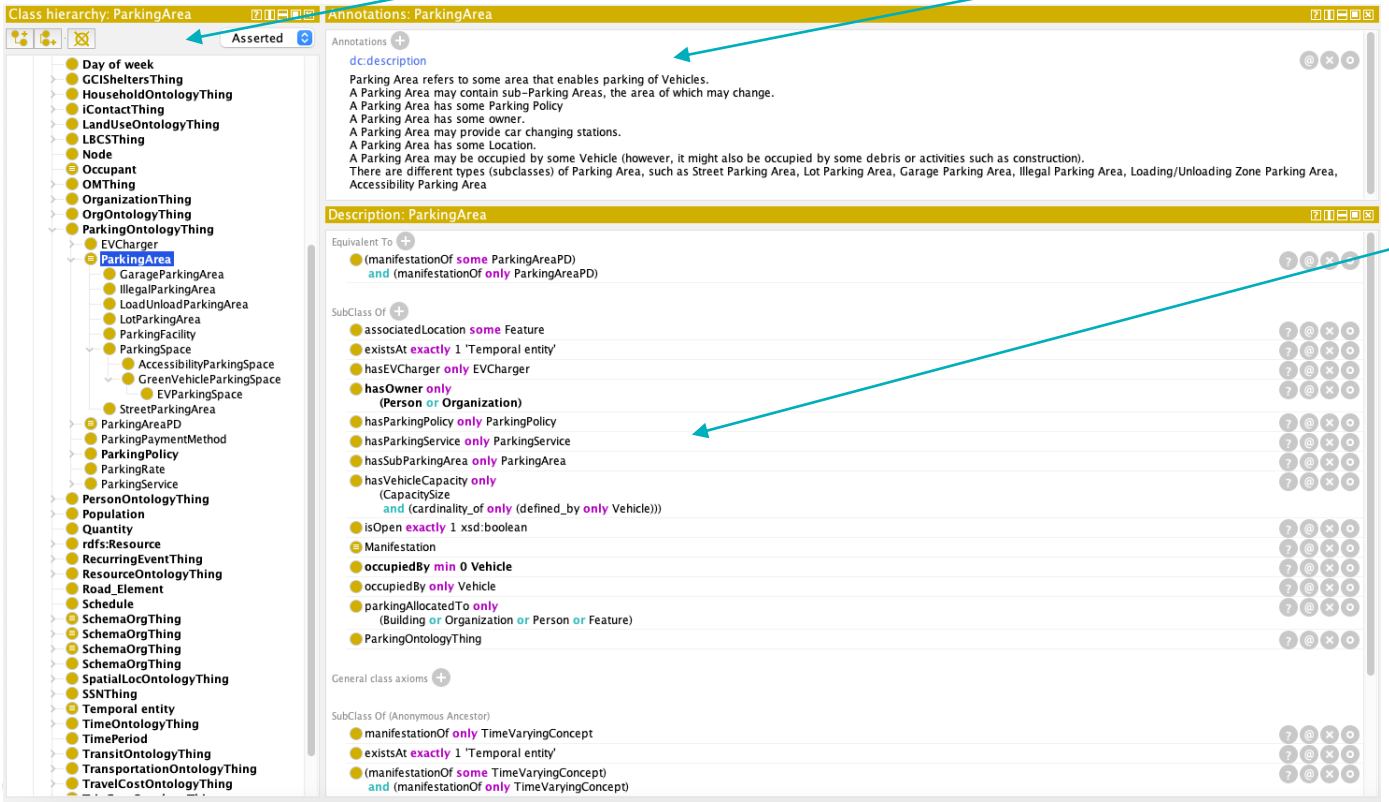
EXAMPLE

Urban system ontology

Hierarchy of concept

Entities description

Axioms (expressed in Description Logics)



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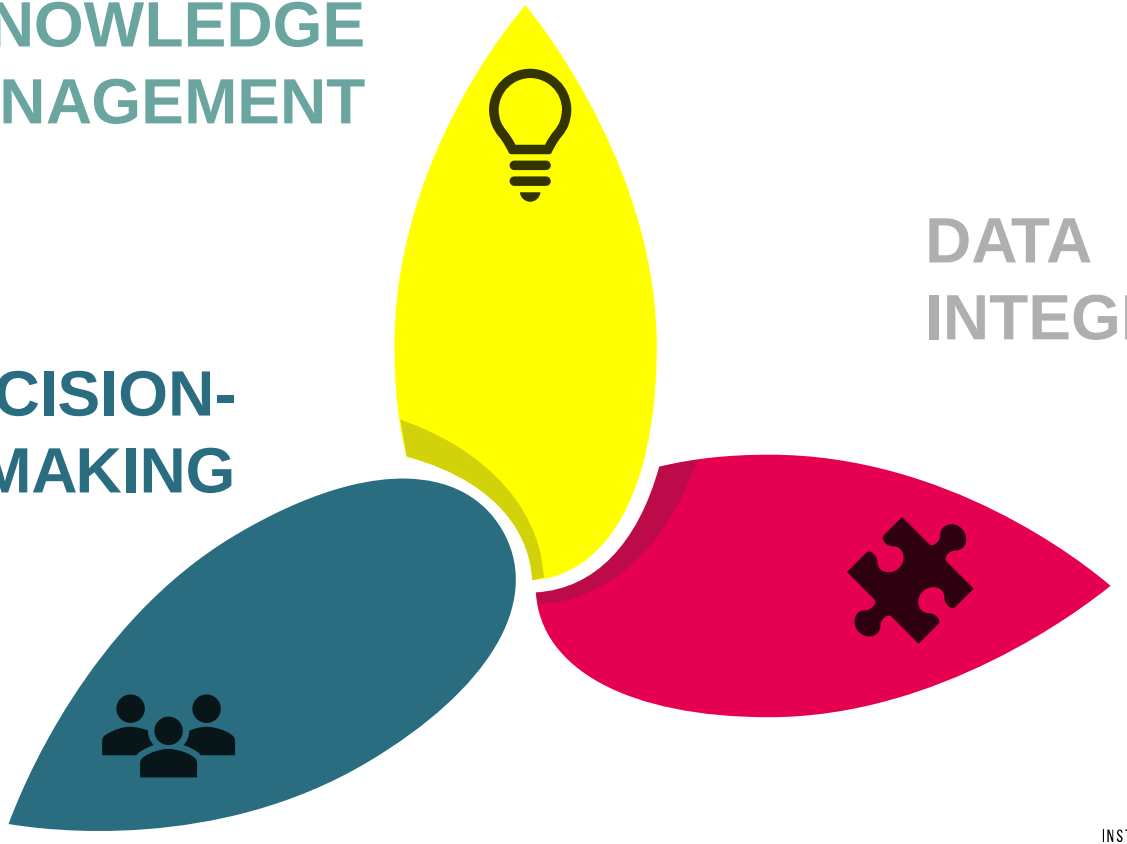
BENEFITS OF USING ONTOLOGIES

KNOWLEDGE MANAGEMENT

DATA INTEGRATION

DECISION-MAKING



HOW ARE ONTOLOGIES USED IN URBAN SOCIAL-ECOLOGICAL SYSTEMS?

Pruski, C., and Sunguroğlu Hensel, D. "The Role of Information Modelling and Computational Ontologies to Support the Design, Planning and Management of Urban Environments: Current Status and Future Challenges." Informed Urban Environments. Springer, Cham, 2022. 51-70.

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MAIN USAGE

Knowledge discovery

Knowledge representation

Data integration

Knowledge retrieval

Decision support

KNOWLEDGE REPRESENTATION

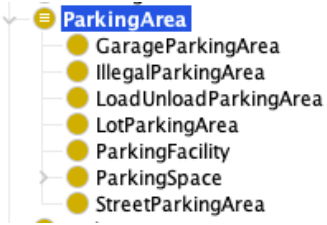
… and knowledge retrieval

- **Models for representing knowledge**
  - BIM for representing buildings and surroundings (OWL version of BIM)
  - Modelling of smart city, green/blue area (http://smartcity.linkeddata.es)
  - Semantic interoperability for robot navigation

- **Ontology-based information retrieval for:**
  - Simulation purpose: models needs to be instantiated with data to produce a result
  - Recommendation done based on data extracted from knowledge/data base using ontology
  - Sustainability indicators computation

EXAMPLE

Ontology-based information retrieval



What are documents talking about Parking area?

Initial query: parking area

new query: parking area or Garage Parking area or Illegal Parking area or … or Street Parking area

DECISION SUPPORT

Decision making / decision assistance / …

- **Simulation**
  - Ontology-based method to predict urban form
  - Simulation in agricultural systems modelling

- **(Home) Garden management**
  - Building energy performance assessment using linked data and cross-domain semantic reasoning.
  - IoT data for water management (use of linked data and ontology to find data on the Web to take decisions)

- **Recommender systems development**

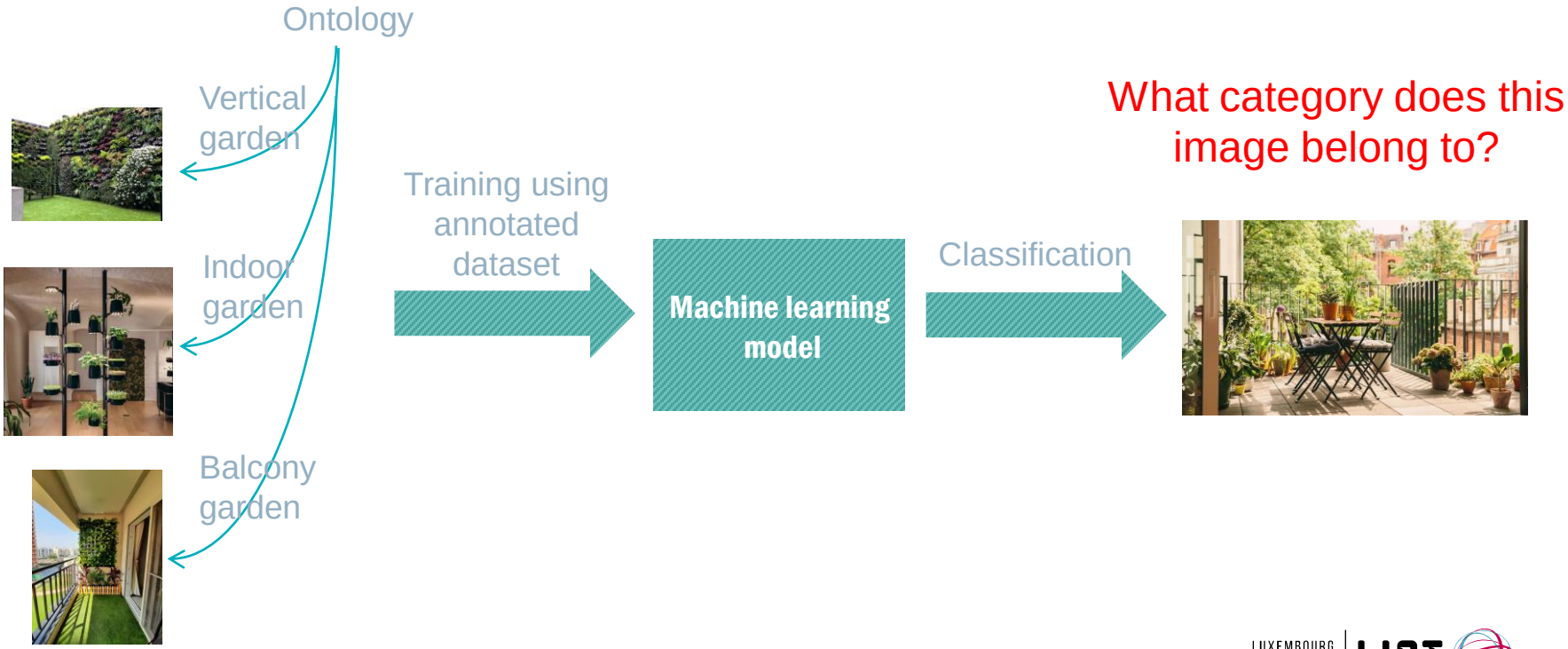
KNOWLEDGE DISCOVERY

Building classification

- **Ontologies for urban planning**
  - Classification of land use according to different characteristics including zoning, services, infrastructure and easement
  - Classification of images representing buildings into “Residential/Small Buildings”, “Apartment Buildings”, and “Industrial and Factory Building” classes by means of domain ontology and machine learning techniques.
  - Classification of shops in urban environment using an ontology of geographical concepts to automatically propagate business category information and create a large, multi label, training data
  - Using a knowledge graph to support automatic generation of dashboards (i.e. mining KG content to generate KPIs)

EXAMPLE

Ontology-based images classification



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DATA INTEGRATION

Data fusion / merging / mapping /…

- **Ontologies for integrating GIS and BIM**
  - CityGML for modelling 3D city. It can be used to integrate data from different sources such as BIM, terrain data, and sensor data.
  - Linked Data method to integrate data from different sources, by using URIs to identify entities and RDF to describe the relationships between them.

- **Integration of BIM and Building Topology Ontology**
  - Integration with other types of models, such as energy models and computational fluid dynamics models, to provide a more comprehensive representation of the building and its interaction with the surrounding environment.

OPEN CHALLENGES

Pruski, C., and Sunguroğlu Hensel, D. "The Role of Information Modelling and Computational Ontologies to Support the Design, Planning and Management of Urban Environments: Current Status and Future Challenges." Informed Urban Environments. Springer, Cham, 2022. 51-70.

ONTOLOGIES HAVE TO BE FAIR

To maximise impact

<u>Observation:</u> Current SES projects involving ontologies fail to make the ontologies available which limits impact

- **Publish the ontology at a permanent URL**
- **Reference the ontology in dedicated ontology portals (LOV, Bioportal …)**
- **Use standard metadata for describing the ontology and its content (e.g. Dublin CORE, Schema.org …)**

EXPLOITATION OF REASONING CAPABILITIES

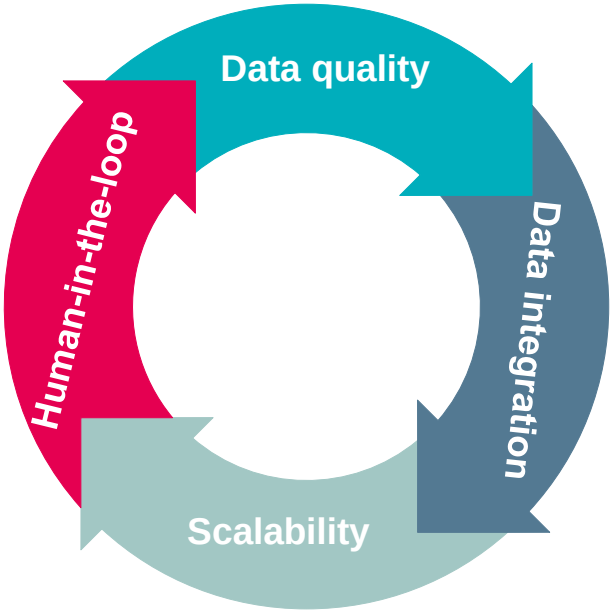
<u>Observation:</u> Ontologies are mainly used for their modelling capabilities but their reasoning capabilities remain largely underexploited.

Data quality

In urban SES, the data is often incomplete, inconsistent, and of low quality, which makes it difficult to reason with.

Data integration

In urban SES data is often collected and stored by different organizations and in different formats.



Scalability

Urban SES are complex systems with many components and relationships, and the number of concepts and relationships represented in an ontology can quickly become large.

Human-in-the-loop

Urban SES are shaped by human decision-making and interactions, and reasoning with ontologies alone may not be sufficient to capture these aspects.

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MAINTENANCE OVER TIME

<u>Observation:</u> Current SES projects involving ontologies fail to maintain the ontologies over time

- **Ontology content must be:**
  - Revised
  - Enrich with new concepts
  - Linked with other artefacts

- **Ontology changes must be documented and propagated to preserve consistency in the underlying systems**

UNDER EXPLOITATION OF DATA AND KNOWLEDGE

<u>Observation:</u> Urban SES generate large amount of data that remain unexploited

- **Heterogeneity and complexity issues:** different KR, data and information models are used in the same context
- **Lack of standardization:** Urban SES are complex systems with many components and relationships, and the lack of standardization can make it challenging to share and integrate knowledge across different systems and organizations.
- **Expertise**: Combining symbolic and sub-symbolic approaches requires a high level of expertise in both fields, and can be challenging for organizations that lack the necessary resources and skills.

thank you

contact information

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