

A Knowledge Graph as a Decision Support System for Urban Green Systems

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Abstract The increasing impacts of climate change necessitate the implementation of urban green systems (UGS) to help mitigate them. By studying historical land use systems, the design, planning, and management of UGS can adapt strategies and methods harnessed in the past. Achieving this goal requires the collection and integration of extensive knowledge from diverse environments. In this work, we have constructed an ontology and knowledge graph (KG) that connects in a holistic way data sources stemming from local trees and ecosystem services, nursery catalogs, street tree list and best practices, scientific data from publications on trees, books on designing with trees, and the trees represented in Wikidata KG. The aim of the proposed ontology and KG is to serve as a decision support system for the design of urban areas. It aims to ensure the implementation of best practices, fulfillment of various design requirements and target parameters, and the incorporation of pruning techniques to shape tree forms that align with specific design and ecological objectives.

Keywords urban biodiversity; urban green systems; knowledge graphs; ontologies


1. Motivation

The urban context is characterized by complex, diverse conditions and competing demands. Traditionally, the design with urban trees has focused on achieving standardized forms, often accompanied by ad hoc pruning practices, with little or no consideration for their impact on ecosystem services. Therefore, a decision support system (DSS) is needed to assist designers in meeting both design and ecological objectives. Achieving this requires the integration of data and knowledge originating from diverse domains. Knowledge graphs (KGs), grounded in ontologies, offer the necessary foundation for integrating, linking, and semantically describing heterogeneous data sources (Fig. 1).

The DSS should provide assistance in the task of selecting trees based on preferences, e.g. the following competency questions (CQ) - *“Give me suggestions for a tree species that...”*:

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- has a slender canopy;
- reaches a minimum of 16 meters high;
- has high cooling rate in summer;
- is heat tolerant;
- grows well/suitable under street conditions;
- sheds leaves in winter.

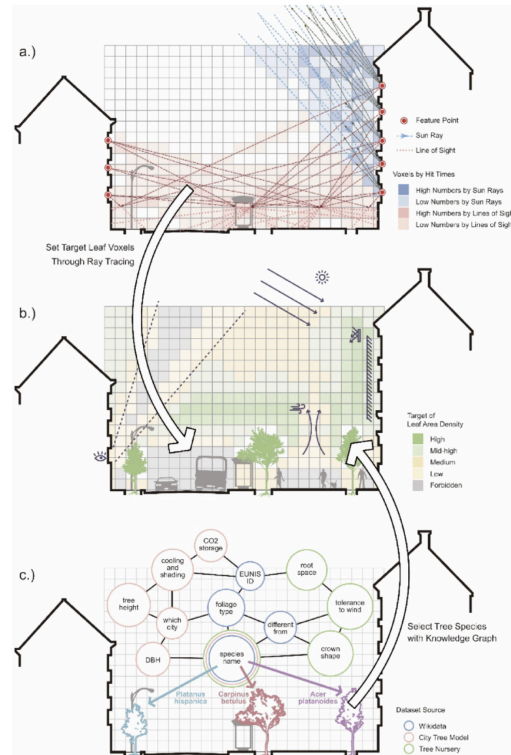


Figure 1: Voxel model exemplifying design and target parameters, following the aim of improving the microclimatic conditions of an urban streetscape [1]. UGS4.0 KG integrates various knowledge on trees, which can be used to answer CQs, as well as in relation to meeting design and target parameters.

2. Methods

In order to provide a DSS for the design of urban areas, we have constructed an UGS4.0 ontology and KG that connects in a holistic way structured and unstructured data sources stemming from local trees and ecosystem services, nursery catalogs (Ebben¹ and Bruns²), street tree list and best practices³, scientific data from publications on trees [2], books on designing with trees [3], and trees represented in Wikidata KG. The ontology was developed using a combination of top-down and bottom-up approaches to ensure both conceptual consistency and practical applicability, while providing enough expressivity to map and align disparate data sources into a unified conceptual


¹ <https://www.ebben.nl/en/>

² <https://www.brunns.de/>

³ <https://galk.de/arbeitskreise/stadtbaeume/themenuebersicht/strassenbaumliste/>

model, resulting in the creation of UGS4.0 KG.

Fig. 2 displays a snapshot of the UGS4.0 KG that integrates diverse data using the ontological terms, and can be leveraged to answer CQs. The current plant statistics of the KG are shown in Table 1.

Visual graph 

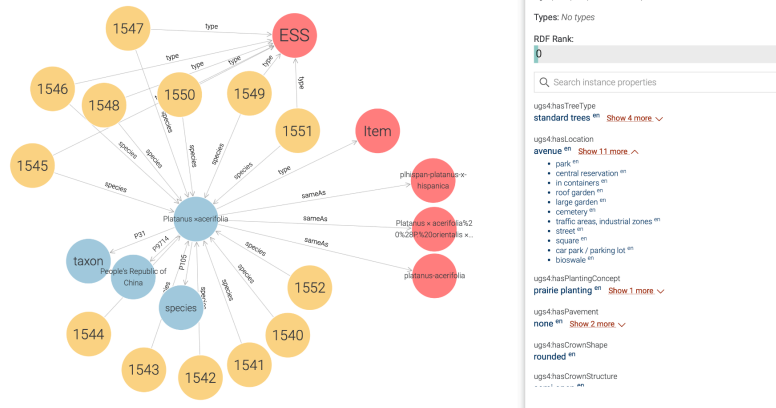


Figure 2: ‘London plane’ tree as a central node that has relationships to other nodes integrated in the knowledge graph. The visualisation feature is provided by the GraphDB triple store.

Table 1

Named graphs along with the number of triples stored.

Graph	Count
<urn:wikidata>	23708
<urn:ess>	79200
<urn:bruns>	97
<urn:ebben>	523
<urn:galk>	1469
<urn:appendix>	12439
<urn:crossovers>	21
<urn:taxonomy>	1111
<urn:ontology>	131

3. Discussion

In this paper, we have described the ongoing work on the UGS4.0 ontology and KG that aim to support the DSS in the task of designing with trees in the urban context. The DSS powered by the KG, can be of the form of a semantic search system, i.e., faceted search based on the UGS4.0 ontology, in which designers can pick a tree based on different characteristics, significance to ecological criteria, design properties, as well as pruning techniques that are applicable on those trees. The DSS can even provide and facilitate free text queries by using ‘Talk to Your Graph’ functionality on top of the UGS4.0 ontology and KG, by exploiting Large Language Models.⁴ As future work, we plan to evaluate

⁴ <https://graphdb.ontotext.com/documentation/11.0/talk-to-graph.html>

the validity of the DSS and the KG through a case study conducted in the city of Munich.

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