

# Developing an Ontology to Link Housing Data for Information Retrieval

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**Abstract:** As urbanization accelerates, there has been a significant increase in housing information and the demand for its retrieval. Nonetheless, housing data sources are numerous and scattered across various departments and platforms, with inconsistent formats and ambiguous semantics. Meanwhile, housing-related knowledge is not systematically organized, resulting in retrieval difficulties and reduced efficiency. This paper constructs a housing domain ontology that encompasses relevant information on people, locations, organizations, residential communities, construction projects, and normative documents. It correlates housing-related data through entities, relationships, and properties, and establishes a structured, semantic knowledge system within the housing domain. Subsequently, leveraging the advantages of knowledge graphs in integrating heterogeneous data and preserving semantic associations, this paper collects housing data examples from specific regions and cities to establish a knowledge graph for information retrieval verification. The results indicate that it can effectively assist housing information seekers in fulfilling specific requirements, such as housing source searches, construction project overviews, and housing policy queries.

**Keywords:** Housing; Ontology; Knowledge Graph.

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## 1. Introduction

With the continuous development of society and the economy, people's housing demand has gradually expanded and improved [1]. Concurrently, demand for housing-related information is increasing daily. Each stage of the housing life cycle involves substantial data [2]. The data in the housing field originates from various departments and organizations, is stored across diverse databases and platforms, and takes many forms. Among various data sets, there may be issues such as data duplication and ambiguous semantics. This situation necessitates that people spend significant time and energy screening and organizing housing-related information. How to systematically integrate various housing data, make more efficient use of knowledge in the housing field, and enable housing information demanders to obtain high-quality data and information more conveniently is an urgent problem that needs to be resolved.

Knowledge graphs are highly effective for representing knowledge [3]. They can manage different data structures by representing them as nodes and edges within a knowledge base, thus maintaining semantic information [4]. Google was the first to innovate this technology to improve the retrieval capabilities of its query engine. The deployment of large-scale knowledge graphs has significantly enhanced the retrieval efficiency and traceability of Google's query system. The data model of the knowledge graph clearly specifies the types, attributes, and relationships among its entities. It ensures that knowledge from various data sources can be smoothly integrated into the knowledge graph and that data can be presented and used consistently, thereby aiding machine comprehension and processing.

Currently, certain researchers have developed housing-related ontologies to meet diverse application requirements. For example, Cho and Kang [5] showed that semantic Web technology was employed to develop an apartment ontology, standardizing various terms of apartment information and establishing a buyer knowledge system. This system was applied to the real estate market in Busan, South Korea, facilitating property searches based on buyers' priority requirements, such as school districts, convenience, and ease of maintenance, thereby helping buyers find apartments that interest them. Hu et al. [6] developed a four-step knowledge-extraction method based on knowledge graphs for the housing market, addressing the complexity and multifaceted nature of the real estate market. This method can summarize housing information for selected geographic areas and analyze the surrounding environment and regional attractiveness using census data. Alexander et al. [7] established an ontology encompassing entities and relationships in aspects such as economy, location, layout, and infrastructure to address user inquiries regarding the characteristics of houses, apartments, and builders, and to retrieve information on housing utility issues. Keena et al. [8] developed a semantic data dictionary for the "House Passport", including definitions and relationships of elements such as houses, construction times, roofs, and roof coverages, to support the establishment of a knowledge graph for the "House Passport", aiming to assess the affordability and circularity of house buildings under different temporal and spatial scales and socio-economic contexts. A knowledge graph of housing passports, comprising approximately 62 million data points, was established using data from over 1.2 million residential buildings across five Canadian cities.

Naanaa et al. [9] developed a semantic search system based

on a knowledge graph, which uses ontology to organize information retrieval for building or renovation projects. In this system, the building element ontology focuses on specific housing elements, including doors, windows, walls, and roofs. Malczewski and Jelokhani-Niaraki [10] addressed the house-selection problem. A house-selection ontology was constructed using the Web Ontology Language (OWL), covering concepts such as quantitative and qualitative criteria, decision selection (houses for sale), standard weights, and location attributes of selection. An ontology-based multi-criteria spatial decision support system (MC-SDSS) was proposed to assist users in making housing choices according to their preferences.

Due to semantic disparities in the definitions of housing buildings and types across countries, as well as differing purposes for knowledge utilization, existing ontologies in the housing field have specific requirements and application scenarios. This paper, targeting housing information characterized by large volumes of data, strong correlations, and rich semantics, employs top-down and bottom-up fusion strategies. First, it constructs a housing-domain ontology that encompasses concepts and relationships, including basic housing information, residential communities, construction projects, and normative documents, thereby forming a systematic housing knowledge system. By collecting local housing data examples, a knowledge graph for the housing field is established to address scattered data, diverse data types, and poor data regularity, and to enhance the efficiency and accuracy of housing information retrieval.

## 2. Housing Ontology

### 2.1. Ontology Structure

When constructing the domain ontology [11, 12], it is essential to begin with the domain data characteristics and integrate the detailed requirements of downstream tasks to design the corresponding construction methods. To build an ontology, it is necessary to identify the key entity categories within the domain, determine the relationships among different concepts, and define attributes and descriptions for these entity types and relationship types. The semantics of entities are primarily established through relationship constraints among them, thereby forming a semantic relationship graph. The housing ontology can assist in organizing and understanding information in the housing field, thereby improving the efficiency and accuracy of subsequent data integration and application. To ensure that the knowledge graph constructed from the ontology has sufficient detail and covers as many aspects of housing as possible, it is crucial to strike a balance between the fineness and coverage of the pattern layer. It should neither be overly simplified to avoid information loss nor overly detailed to prevent the pattern layer from being non-universal and difficult to manage and use. Either overly fine or overly coarse granularity can impact knowledge decomposition and subsequent knowledge retrieval. Overly complex and dense entity networks may reduce the readability and usability of the graph, and not all concept types are appropriate.

Data in the housing sector covers a wide range of aspects, including housing source information, departmental institutions, policies and regulations, and standards and norms. These elements are complementary and permeate all stages of the housing life - cycle, starting from planning and design to subsequent maintenance, collectively establishing the

knowledge system of the entire field. The housing ontology constructed in this paper centers on housing architecture and uses the housing life cycle as the main axis, extending and elaborating on core concepts closely associated with housing, thereby comprehensively aggregating information and knowledge in this field.

The concepts in the housing domain are classified based on domain requirements and semantic features. Initially, the general concepts in the housing ontology are precisely defined, and the basic modules are established as its core units. This approach not only prevents digression from the topic but also minimizes unnecessary, repetitive definitions and reduces redundancy in the ontology. Subsequently, considering the field's characteristics, the housing field is horizontally partitioned into three sub-fields centered on residential communities, construction projects, and normative documents, respectively, to construct the conceptual knowledge system of the housing field.

Residential buildings spread throughout urban areas are the most important part of housing systems. Construction projects are the main way to develop residential areas, involving land-use planning, architect-designed plans by developers, and physical building work by contractors. These activities, which include planning, building, marketing, and running the facilities, follow formal behavioral rules. These rules are outlined in normative documents, mainly laws, regulations, technical standards, and professional norms, with additional reference entries like encyclopedic definitions. These documents form a hierarchy that clearly connects rules to their specific parts. Within each function, ideas are systematically organized through a mix of top-down and bottom-up methods, combining broad categories and detailed levels. Ideas are grouped into primary (core) and secondary (specific) categories.

The entire ontology is built upon the fundamental module. There are significant, synergistic interactions among the residential community module, the construction project module, and the normative document module. The residential community module and the construction project module have a mapping relationship. The normative document module imposes constraints and regulations on both the residential community and the construction project modules, collectively forming an ontology model specifically designed for the housing sector. This model is used to break down domain information and provides the conceptual foundation for the question-answering application.

### 2.2. Basic Information Module

**Table 1.** Entity types of the basic module

First-level concept	Secondary concept
Region	Provinces, prefecture-level cities, districts and counties, and sub-districts and towns
Cycle	Annual, quarterly
Personnel	Policy-making managers, housing construction and development personnel, housing transaction service personnel, and housing users
Unit	Government departments, real estate development enterprises, construction enterprises, real estate service enterprises, financial institutions, and real estate industry associations
Work	Position and title
Grade	Special Grade, First Grade, Second Grade, Third grade

The basic module establishes the fundamental concepts in the housing field, highlighting key elements such as people,

organizations, time, and location. The other three sub-domain modules all delve deeper and expand from specific perspectives based on this module. In the pattern layer, the basic module acts as a bridge, connecting all the conceptual modules into a tightly-knit semantic network. The data examples in this module come from the "Shandong Statistical Yearbook" and the "Jinan Statistical Yearbook," as well as relevant data downloaded from the "Shandong Public Data Open Website." Its entity, relationship, and property types are presented in Tables 1, 2, and 3, respectively.

**Table 2.** Relationship types of the basic module

First-level concept	Secondary concept
Located	The province to which it belongs, the prefecture-level city to which it belongs, the district or county to which it belongs, and the sub-district or town to which it belongs
Corresponding period	Corresponding year, corresponding quarter
Position	Administrative positions, professional titles, and committee positions
Included	Administrative divisions include, types include, departments include, and levels include

**Table 3.** Property types of the basic module

First-level concept	Secondary concept
Name	Personal names, place names, institution names, project names, file names
Contact information	Personal contact information, official contact information
Address	Registered address, office address, and correspondence address
Time	The time of enterprise filing, the date of certificate issuance, and the validity period of qualifications
Number	Enterprise filing number, unified social credit code, and qualification certificate number

### 2.3. Residential Community Module

**Table 4.** Entity types of the residential community module

First-level concept	Secondary concept
Residential community	Low-rise residences, multi-story residences, high-rise residences, apartments, villas, garden villas
Status	Project progress and sales status
Type	Building type, property type, and property rights type

**Table 5.** Relationship types of the residential community module

First-level concept	Secondary concept
Supporting property management company	Independent property management companies and property management companies affiliated with developers
Corresponding construction projects	New construction projects, expansion projects, renovation projects, relocation projects, and restoration projects
Type	Single ownership type, multiple ownership types

The residential community module primarily delineates the

attributes of residences. Its objective features are among the most critical considerations for prospective homebuyers and tenants. The data exemplars within this module are derived from property datasets of Jinan City, sourced from the online real estate platform "Anjuke," as well as various housing-related datasets from Jinan City obtained through the "Shandong Public Data Open Website." The types of entities, relationships, and properties for the residential community module are presented in Tables 4, 5, and 6, respectively.

**Table 6.** Property types of the residential community module

First-level concept	Secondary concept
Quantity	Plan the number of households, the number of housing units, the number of parking Spaces, the number of buildings, the number of units and the number of floors
Time	Completion time, property rights term, opening time, sales time, and delivery time
Amount	Reference price, maintenance fund, property management fee
Area	Land area, green space area, building area
Address	Regional location, specific address, and sales office address
Ratio	Parking space ratio, floor area ratio, and green space ratio
Number	Administrative division code, building number, unit number, room number
House type	One-bedroom households, two-bedroom households, three-bedroom households, multi-bedroom households
Floor condition	Low-rise, multi-story, small high-rise, high-rise, super high-rise
Features of the property	Architectural style, geographical location, supporting facilities, floor plan design, living environment, price range, property management services
Surrounding facilities	Education, healthcare, transportation, business services, cultural and entertainment, financial services, community services, public security

### 2.4. Construction Project Module

**Table 7.** Entity types of the construction project module

First-level concept	Secondary concept
Construction project	Residential, commercial and service, industrial, infrastructure, public facilities
Construction land	Residential, commercial and service, industrial, infrastructure, public facilities
Comprehensive score	Grading system scoring, fractional system scoring

Development projects and housing construction show a one-to-one or one-to-many relationship. The presence of housing construction depends on the implementation of development projects, and the planning and design of these projects determine the spatial arrangement and form of housing. This module creates links between development

projects and entities such as construction land, residential communities, and institutional units, forming a conceptual network for housing development projects. The project data comes from relevant information about Jinan City published by the Shandong Provincial Public Data Open Platform. Its entity types, relationship types, and property types are shown in Tables 7, 8, and 9.

**Table 8.** Relationship types of the construction project module

First-level concept	Secondary concept
Involved units	Construction units, development units, surveying units, design units, construction units, and supervision units
Construction purpose	Residential life, public services, infrastructure, commercial economy, industrial manufacturing
Evaluation result	Personal evaluation, organizational evaluation, project evaluation

**Table 9.** Property types of the construction project module

First-level concept	Secondary concept
Quantity	Total project scale, total land supply, land quantity, building quantity, and number of units to be constructed
Area	Construction land area, area of land expropriated on behalf of others, net land area, total building area, occupied area, planned building area, and currently sold and filed area
Time	The time of license issuance, the period of use, the planned start time of construction, the planned completion time, the actual start time of construction, the actual completion time, and the transaction time
Number	Land use number, license number
Address	Administrative division address, detailed address, and plot range address
Ratio	Floor area ratio, building density, green space ratio
Amount	Investment amount, starting price, transaction price

## 2.5. Normative Document Module

This paper categorizes housing regulations into six themes, selects representative texts such as the "Urban Real Estate Administration Law of the People's Republic of China," the "Measures for the Administration of the Sale of Commercial Housing," and the "Measures for the Administration of the Safety of House Use in Shandong Province." It conducts dependency syntax analysis on their original texts and synthesizes textual features and statistical information to summarize and generalize the conceptual knowledge system of housing-related laws and regulations.

When abstracting regulatory texts into a set of concepts, analysis is conducted from two perspectives concerning the granularity of knowledge decomposition: text structure and text semantics. The knowledge elements within the text structure comprise hierarchical components such as file titles, chapters, sections, and articles, which are interconnected in a top-down manner through inclusion relationships. The extraction of knowledge elements related to text semantics

involves conducting linguistic analysis of the scenarios described in the regulations, linking rights, obligations, behaviors, and consequences into detailed nodes. Furthermore, the hierarchical relationships among regulations are established through a combined application of regulatory validity level labels and hierarchical links.

The data sources for normative documents are diverse, including authoritative and timely government official websites such as the "National Laws and Regulations Database," "Ministry of Housing and Urban-Rural Development of the People's Republic of China," and "National Standard Information Public Service Platform," supplemented by "Baidu Baike Entries" related to housing. The entity types, relationship types, and property types of this module are shown in Tables 10, 11, and 12, respectively.

**Table 10.** Entity types of the normative document module

First-level concept	Secondary concept
Baidu Baike entry	Housing policy and system category, housing type and form category, housing structure and function category, housing development and construction category, housing decoration and renovation category, housing market transaction category, housing management and service category, housing safety maintenance category, housing cultural influence category
Standard Specification	International standards, national standards, industry standards, local standards, group standards, and enterprise standards
Legal regulations	National regulations and rules, local regulations and rules
Regulatory effectiveness level	Constitution, laws, administrative regulations, local regulations, administrative rules
The structure of regulatory documents	Part, chapter, section, article
Subject and object of regulations	Individuals, institutions, organizations
Semantic elements of legal provisions	Formulation, publication, implementation, revision, citation, scope of application, purpose, principles, definitions, procedures, conditions, rights, obligations, responsibilities, acts, consequences of acts, exceptional circumstances, interpretation of appendices

**Table 11.** Relationship types of the normative document module

First-level concept	Secondary concept
Regulatory theme	Planning and design, construction acceptance, sales and marketing, delivery and occupancy, renovation and reconstruction, and others
Issuing unit	Legislative bodies, judicial organs, executive organs, and standard organizations
Rank of effectiveness	Higher than or equal to
Validity	Not yet effective, currently valid, modified, abolished

## 3. Collect Housing Data Instances to Establish a Knowledge Graph

Based on the aforementioned housing ontology model, data in the housing sector is collected intentionally and specifically, mainly from three areas: real estate information, construction projects, and housing regulations. The primary sources for the

collection include official government websites, online real estate platforms, encyclopedic knowledge retrieval sites, and various official databases. The collection focuses on Shandong Province, particularly Jinan City.

**Table 12.** Property types of the normative document module

First-level concept	Secondary concept
Name of Regulation	Title name, part name, chapter name, section name, article name
URL link	Web page URL, file URL, image URL
Time flow	Date of adoption, date of promulgation, date of implementation, date of revision, date of abolition
File number	Standard number, document number
Explanation and description	Entry description, entry interpretation, supplementary explanation

Choosing an appropriate graph database for storing knowledge is essential. Neo4j models complex relational networks from the real world using nodes and edges and can visually display results from graph queries. It is the ideal option for creating and managing knowledge graphs in the housing sector. In Neo4j, "Node Labels", "Relationship Types", and "Property Keys" correspond to entity types, relationship types, and property types in the previously constructed pattern layer. In this paper, UTF-8 encoded CSV data is batch-stored in Neo4j according to the schema layer using Cypher commands. This process is divided into three forms: "entity-relationship-entity", "entity-entity attribute-attribute value", and "relationship-relation attribute-attribute value".

In the construction of the instance layer within the knowledge graph, it is segmented into four subdomain graphs conforming to the ontology model. The foundational sub-map primarily encompasses general knowledge pertinent to the housing sector, such as administrative divisions, personnel, and units, thereby interconnecting the entire knowledge layer. The sub-map dedicated to residential communities expands to incorporate various institutions, facilities, projects, and other components that serve the residential sector. The construction projects sub-map pertains to construction activities related to

residential communities, project lands, real estate firms, and related entities. The normative document sub-graph includes legal statutes, regulations, standards, norms, encyclopedic entries, and analogous items. Notably, the legal regulations section not only archives all elements of regulatory documents comprehensively but also disaggregates and stores the semantic constituents of legal provisions. This design facilitates providing users with both overarching summaries and detailed clause analyses. Ultimately, a housing domain knowledge graph was developed and stored within the Neo4j graph database, comprising 34,507 nodes, 72,495 relationships, and a total of 197,270 node properties and relationship properties.

#### 4. Verify the Usability of the Ontology Model Through Housing Information Retrieval

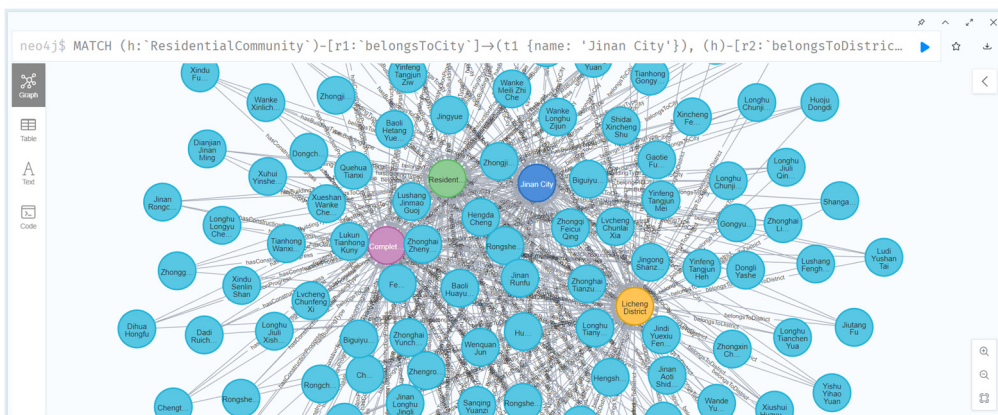
Different stakeholders in the housing sector seek useful information based on their individual needs. For example, when citizens select commercial residential properties, they consider the qualifications of the construction company, the location and surrounding amenities, information about the construction project, and whether the residence complies with pre-sale regulations, among other factors. For these issues, the housing knowledge graph established in this paper was used for retrieval, and the expected results were successfully obtained.

(1) What residential projects have been completed in Licheng District, Jinan City?

Its Cypher query statement is:

```
MATCH (h:'ResidentialCommunity')-[r1:'belongsToCity']->(t1 {name:'Jinan City'}),
(h)-[r2:'belongsToDistrict']->(t2 {name:'Licheng District'}),
(h)-[r3:'hasBuildingType']->(t3 {name:'Residential Buildings'}),
(h)-[r4:'hasConstructionProgress']->(t4 {name:'Completed Buildings'})
RETURN DISTINCT h, r1, t1, r2, t2, r3, t3, r4, t4
```

The query results are displayed in Figure 1. The blue nodes in the graph represent all residential projects that have been completed in Licheng District, Jinan City to date.



**Figure 1.** Residential projects that have been completed in Licheng District, Jinan City

(2) What construction projects are developed by "Jinan Jinko Xicheng Real Estate Development Co., LTD." in Huaiyin District, Jinan City?

Its Cypher query statement is:

```
MATCH (h:'ConstructionProject')-[r1:' belongsToCity']->
```

```
(t1 {name:'Jinan City'}),
(h)-[r2:'belongsToDistrict']->(t2 {name:'Huaiyin District'}),
(h)-[r3:'hasDevelopmentUnit']->(t3 {name:'Jinan Jinke Xicheng Real Estate Development Co., Ltd.'})
```

RETURN DISTINCT h, r1, t1, r2, t2, r3, t3  
 The green nodes in Figure 2 denote the construction

projects developed by Jinko Company in Huaiyin District, Jinan City, which have been queried.

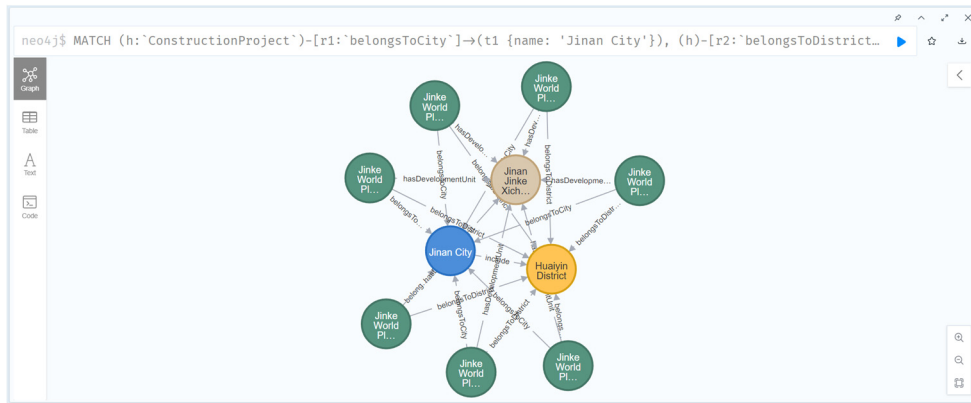


Figure 2. Construction project developed by Jinko Company in Huaiyin District, Jinan City

(3) What conditions must be satisfied for the pre-sale of commercial housing, and what are the procedures and requirements involved?

Its Cypher query statement is:

MATCH path = (n:Article {name: "Article 45 of the Urban Real Estate Administration Law of the People's Republic of China"})<-[include\*1..3]->(ancestor)

RETURN 'ancestor' AS direction, nodes(path) AS nodes, relationships(path) AS relationships

UNION ALL

MATCH path = (n:Article {name: "Article 45 of the Urban Real Estate Administration Law of the People's Republic of China"})<-[include\*1..3]->(descendant)

RETURN 'descendant' AS direction, nodes(path) AS nodes, relationships(path) AS relationships

The query results are displayed by the yellow nodes in Figure 3.

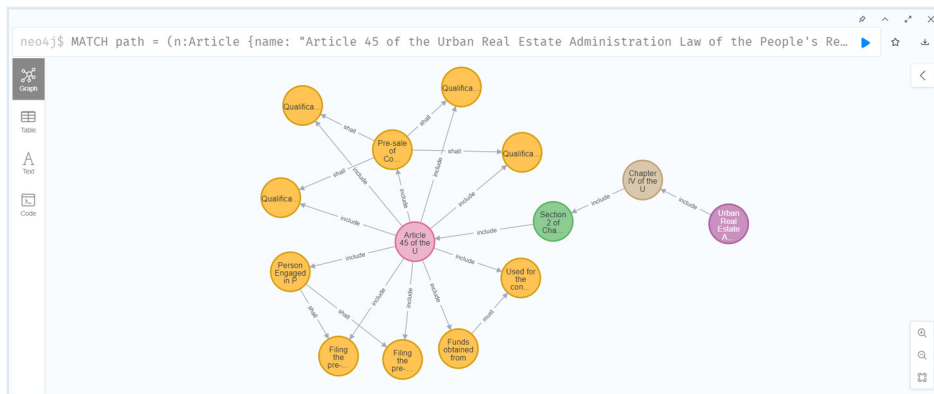


Figure 3. Regulations that should be followed for the pre-sale of houses

## 5. Conclusion

This paper presents a schema-level formalization of core concepts, their defining attributes, and the semantic relationships among them within the housing domain. Building on this formalization, a well-structured housing ontology is developed to serve as the conceptual foundation for knowledge representation. Housing-related data instances—diverse and sourced from multiple administrative, transactional, and regulatory systems—are systematically collected and carefully processed to represent a metropolitan area. Using the ontology as a semantic schema, raw data are transformed into standardized entity–relationship–attribute triples that adhere to the ontology’s constraints. The resulting knowledge graph is instantiated and stored in Neo4j, a graph-native database, to enable scalable storage, efficient traversal-based querying, and consistent knowledge management. Applications made possible by the graph include semantic housing search, project-level summarization, and policy-document linkage—each based on ontological reasoning rather than simple keyword matching. The ontology is designed with extensibility and interoperability in mind: its

modular structure supports incremental refinement, domain-specific specialization, and integration with complementary ontologies (e.g., urban planning or building standards). Future work will explore incorporating multimodal data sources (e.g., satellite imagery, floor plans, and textual policy documents) and developing domain-adapted systems.

## References

- [1] Lu Y, Yang D, Tang H, et al. Trends in Urban Housing Demand. *Macroeconomic Management*, 2021, (11): 34-38.
- [2] Fan L, Li Y, Zhou X. Research on the Construction of the Housing Full Life Cycle Service System in Hubei Province. *China Construction*, 2022, (10): 36-38.
- [3] Tiwari S, Al-Aswadi N F, Gaurav D. Recent Trends in Knowledge Graphs: Theory and Practice. *Soft Computing*, 2021, 25(13): 1-19.
- [4] Vetle R, Ahmet S, Dumitru R. Building Semantic Knowledge Graphs from (Semi-)Structured Data: A Review. *Future Internet*, 2022, 14(5): 129.
- [5] Cho H J, Kang H M. Design of a Real Estate Knowledge Information System Based on Semantic Search. *Journal of the*

- Korea Industrial Information Systems Research, 2011, 16(2): 111-124.
- [6] Hu Z, Zhao Z, Rostami M, et al. Demo: Knowledge Graph-Based Housing Market Analysis. Proceedings of the 2nd International Workshop on Knowledge Graph Construction, 2021, 2873.
- [7] Alexander Z, Timur S, Nikolay B. Knowledge Graph Mining for Realty Domain Using Dependency Parsing and QAT Models. Procedia Computer Science, 2021, 193: 32-41.
- [8] Keena N, Friedman A, Parsaee M, et al. Housing Passport Knowledge Graph: Promoting a Circular Economy in Urban Residential Buildings. Sustainable Cities and Society, 2025, 119(2), 106050.
- [9] Naanaa H, Bril El Haouzi H, Derigent W, et al. A Semantic Search System for Efficient Information Retrieval in the Construction Domain. Smart and Sustainable Built Environment, 2025, March 18. DOI: 10.1108/sasbe-10-2024-0415.
- [10] Malczewski J, Jelokhani-Niaraki M. An Ontology-Based Multicriteria Spatial Decision Support System: A Case Study of House Selection. Geo-spatial Information Science, 2012, 15(3): 177-185.
- [11] Sattar A, Surin E S M, Ahmad M N, et al. Comparative Analysis of Methodologies for Domain Ontology Development: A Systematic Review. International Journal of Advanced Computer Science and Applications, 2020, 11(5).
- [12] Li A, Xu Y, Chi Y. A Review of Ontology Construction and Applications. Information Studies: Theory & Application, 2023, 46(11): 189-195.