A Navigation Ontology for Outdoor-Indoor Space

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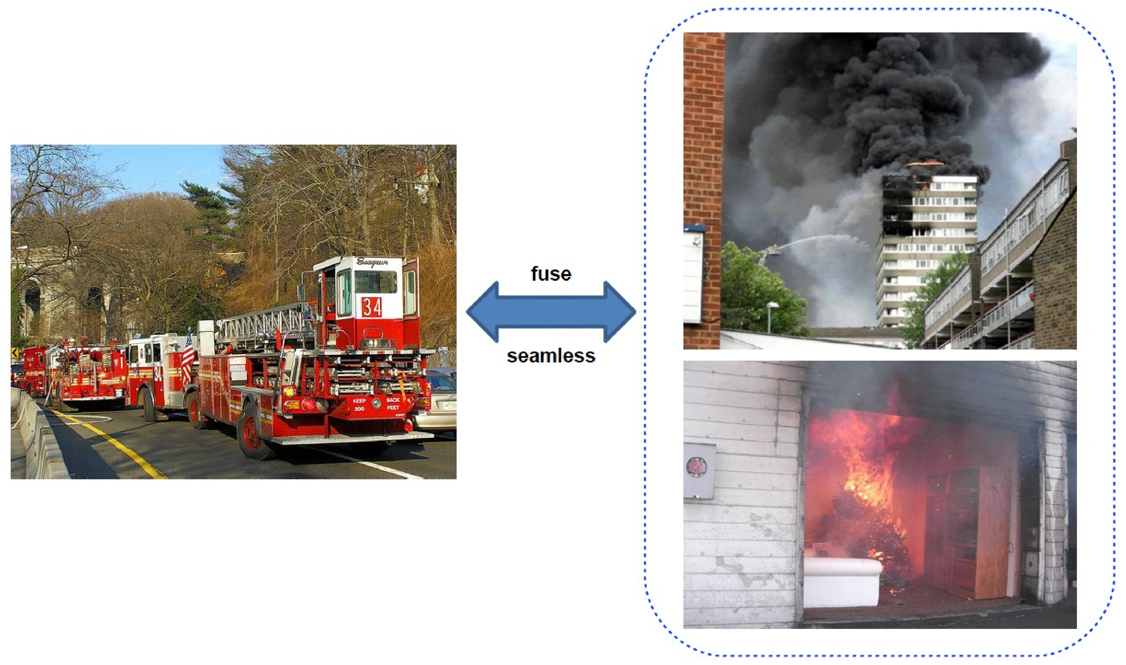
Motivation

The terms "outdoor space" (**O-space**) and "indoor space" (**I-space**) here both refer to **built environments** (e.g., cities and rooms) instead of natural ones (e.g., forests and caves).

I-space covers the enclosed **interiors** of buildings **above** the ground and spaces **underneath the ground** that provide environments for human activities.

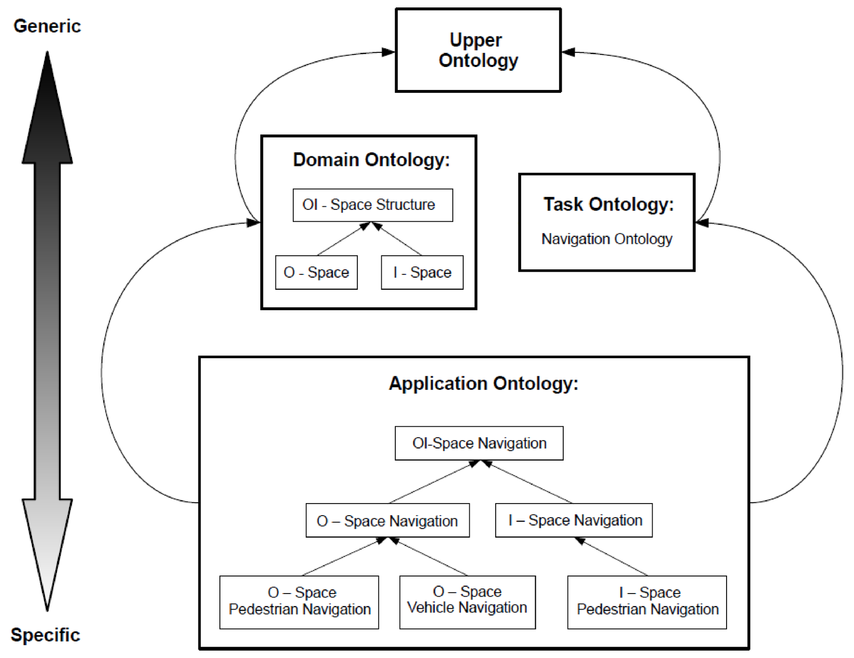
Traditional geospatial science focuses mainly on O-space. However, studies show that on average **humans spend most (87%) of their time indoors.**

Our research goal is to construct a **unified** outdoor-indoor space (**OI-space**) supporting **seamless navigation** between and within O-space and I-space. This requires us to explore I-space as well as the transition between O-space and I-space.



OI-space Navigation Ontology

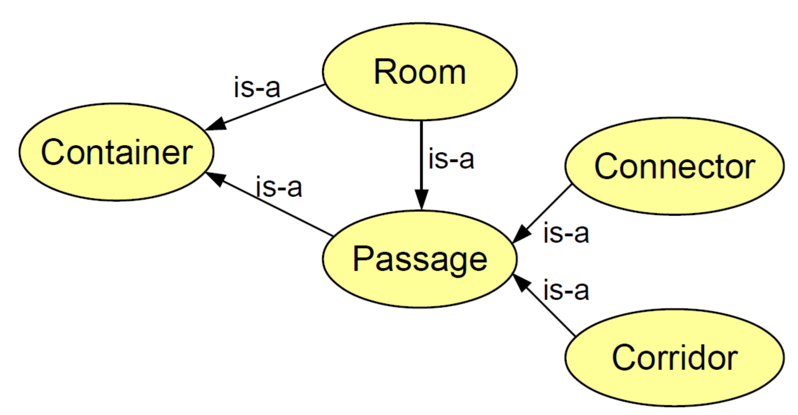
An ontology captures **key concepts and relationships** in a domain of interest. Our OI-space navigation ontology joins an upper ontology (high level concepts) with ontologies for spatial structures, navigation tasks, and specific navigation applications. This **modularization** makes it **easier to share and reuse knowledge** in different contexts.

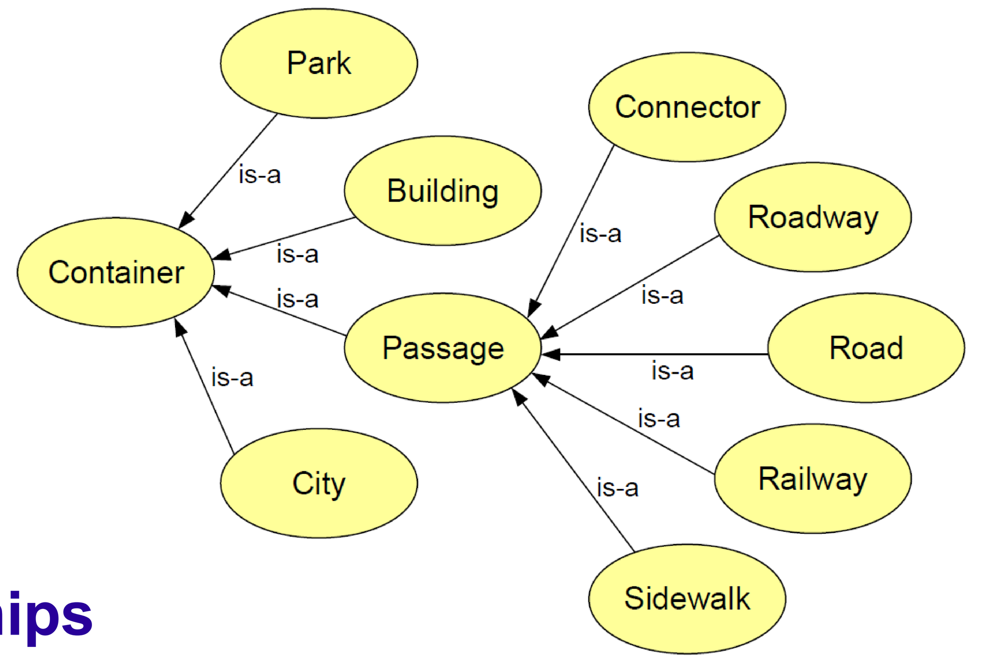


A **novel aspect** of our approach is the use of **affordances** (*qualities* of environments that allow an individual with certain *capabilities* to perform an action) to **classify structural spaces and navigation tasks** based on agent capabilities and environmental features. For example, an *unlocked* door affords most *adults* (but not *infants*) the ability to turn the door knob and go inside.

Domain ontology taxonomies

The taxonomies associated with the structure ontologies of O-space and I-space share a common **Container** superclass, which supports the **contains** relationship. The subclasses of **Container** shown in the partial taxonomies below inherit this relationship (e.g., rooms contain tables) in the full ontology.



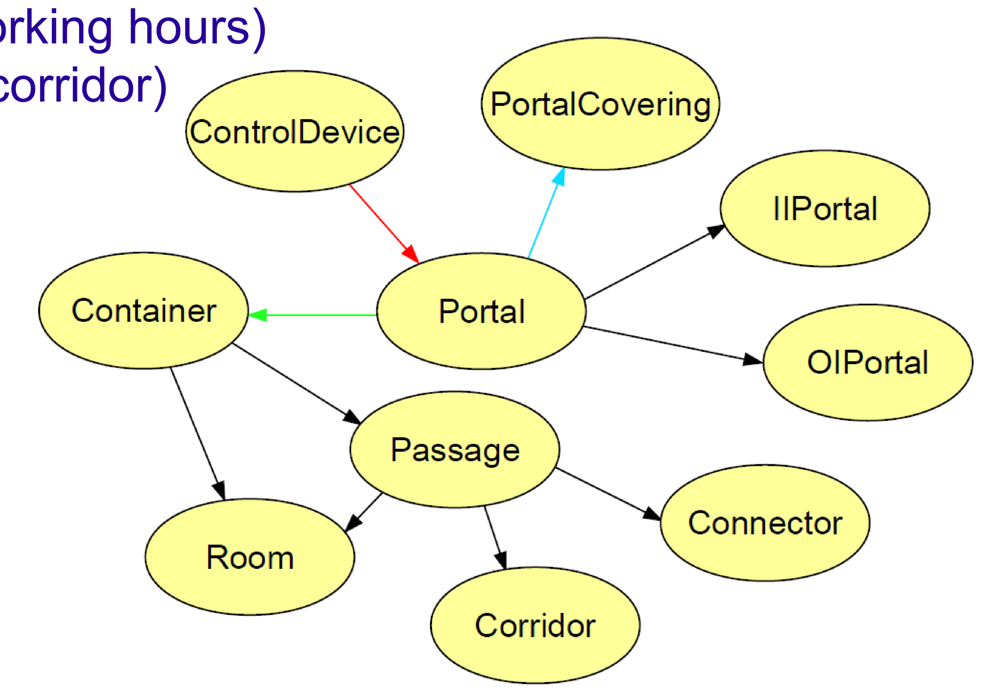


Context and semantic relationships

Context is important. E.g., when a **room** (often viewed as a *container*) **has two or more doors** it can also serve as a *passage* in particular task contexts involving:

- **specific types of people** (e.g., janitors can always pass through rooms)
- **specific times** (e.g., only open during working hours)
- **emergency** (e.g., a fire blocks a nearby corridor)

Semantically related concepts within and between different levels of the ontology relevant to real world navigation are shown in the diagram to the right. **Key I-space relationships** are shown in the legend below.

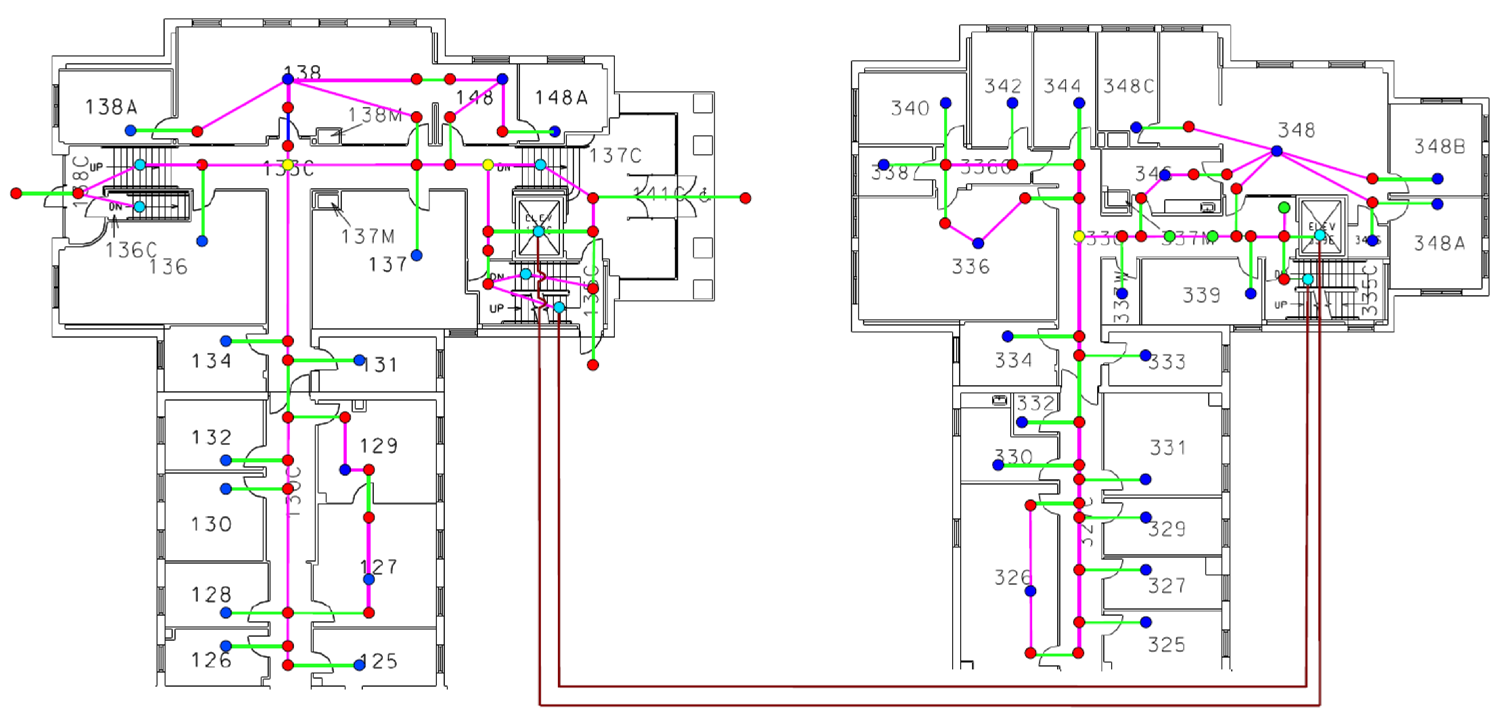


hasSubclass — controlAccess
connects — isCoveredBy

Navigation Graph

Existing models often represent an entire corridor with only one node. But this is not enough to accurately support real world navigation tasks (e.g., there is a fire in a corridor and we need to find a way around it). **Fine-grained subdivisions** of corridors are needed. Our navigation ontology provides this.

Using **our navigation ontology**, we can generate a navigation graph for most floor plans (see the diagram for a specific example).



Elevator/Stairs
Room
Portal Node
Junction Node
Landmark Node

Portal Link
Passage Link
Connector Link

Future Work

Our expected outcome is a **unified informatic framework** supporting seamless navigation in OI-space.

The framework will be evaluated in two ways:

- Can the framework **correctly model** navigation tasks in OI-space? This requires a **formal test** for internal consistency.
- Are the solutions produced by the framework **meaningful to and usable by humans**? This can be answered with **human subject experiments.**

This work will have many **applications** in areas like emergency management, smart spaces, and transportation. Our work will **provide the informatic foundation** for the development of systems that support such applications.

http://www.spatial.maine.edu/iospace

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