A Navigation Ontology for Outdoor-Indoor Space

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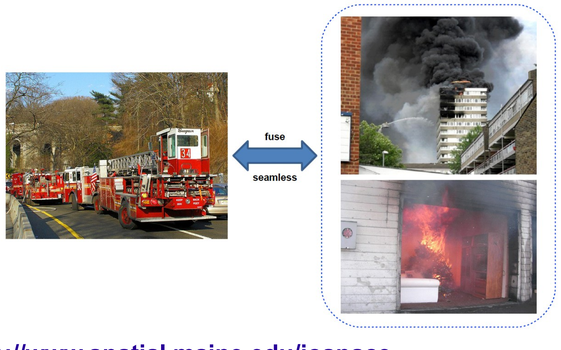
Motivation

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.**

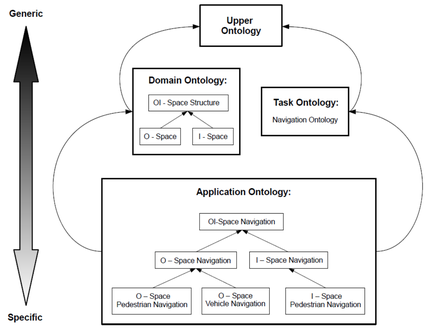
Our research goal is to construct a **unified** outdoor-indoor space (**OI-space**) supporting **seamless navigation** between and within O-space and I-space. This requires us to explore I-space as well as the transition between O-space and I-space.



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

OI-space Navigation Ontology

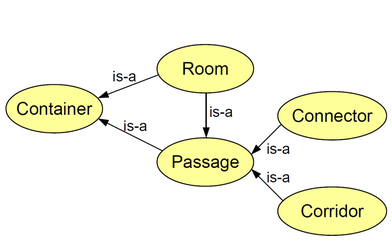
An ontology captures **key concepts and relationships** in a domain of interest. Our OI-space navigation ontology joins an upper ontology (high level concepts) with ontologies for spatial structures, navigation tasks, and specific navigation applications. This **modularization** makes it **easier to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

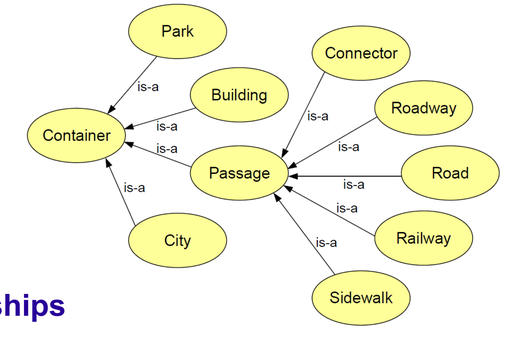


A **novel aspect** of our approach is the use of **affordances** (*qualities* of environments that allow an individual with certain *capabilities* to perform an action) to **classify structural spaces and navigation tasks** based on agent capabilities and environmental features. For example, an *unlocked* 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.



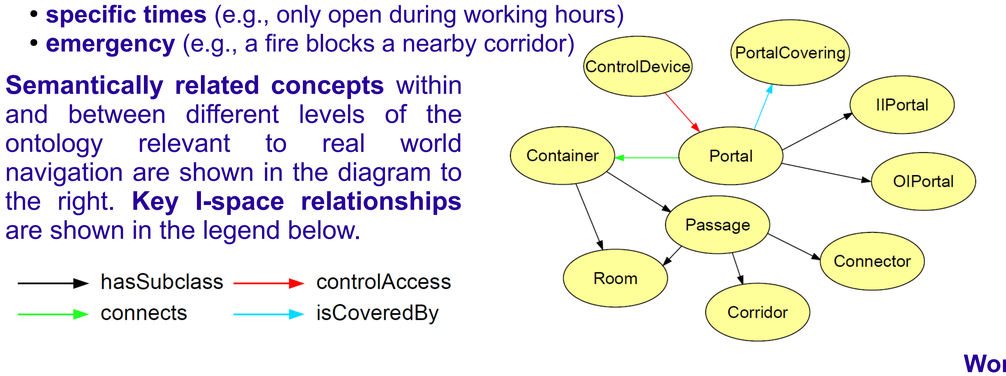


Context and semantic relationships

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)

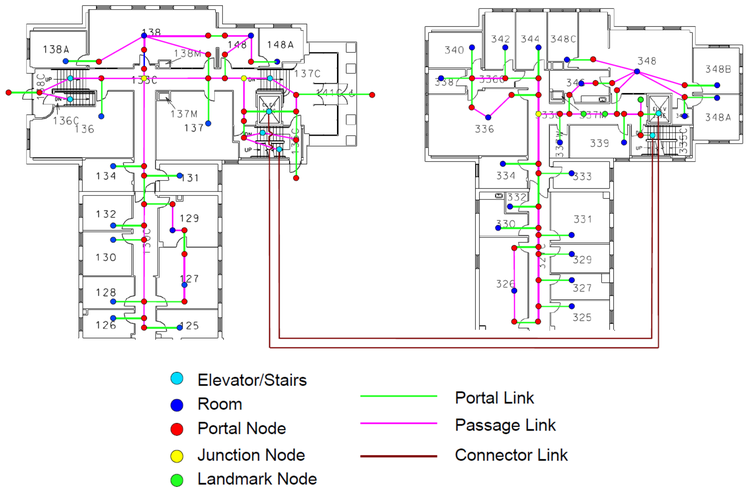
Semantically related concepts within and between different levels of the ontology relevant to real world navigation are shown in the diagram to the right. **Key I-space relationships** are shown in the legend below.



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).



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.

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