A Computational Method for Indoor Landmark Extraction

26.Nov.2014

Presenter: Hao Lyu

LFK Lehrstuhl für Kartographie

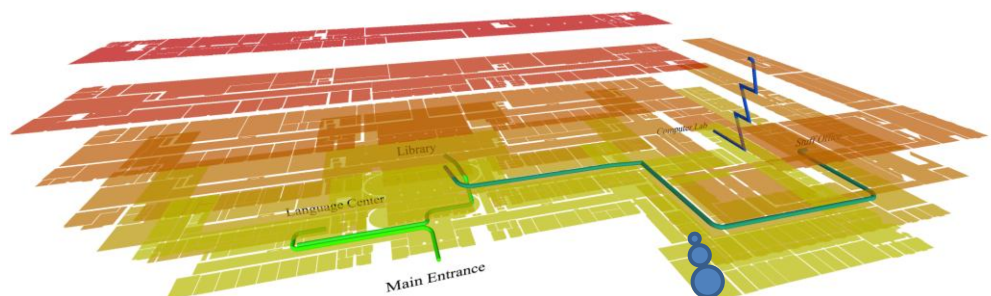
Introduction

- Landmarks are used to
  - organize spatial knowledge
  - help (re-)orientation and routes checking during wayfinding
- World wide outdoor landmarks
- Seldom conventional landmarks indoor

*Picture from Richard Oed

Introduction

- Problem tackled:
  - What property(ies) make an(a set of) indoor object(s) an indoor landmark?
  - How to extract indoor landmarks from geo-datasets?



- Benifits:
  - Dynamically landmark selection (probably context specified)
  - Enrich route communication (increase usability)

Landmark?

Theoratical Basis (I)

-- an affordance based place definition

- **Physical features:** Appearance, location, configuration of material object(s) can be included in physical features. People perceive affordances from these features;
- **Actions:** affordances that people are possible to perform with objects;
- **Narrative:** historical events or experience;
- **Symbols/names:** symbols or names that denote a specific places;
- **Socioeconomic and cultural factors:** important semantic factors related to people's cultural background;
- **Typology/Categorizations:** places that provide similar affordance for specific people and tasks can be categorized as the same type.

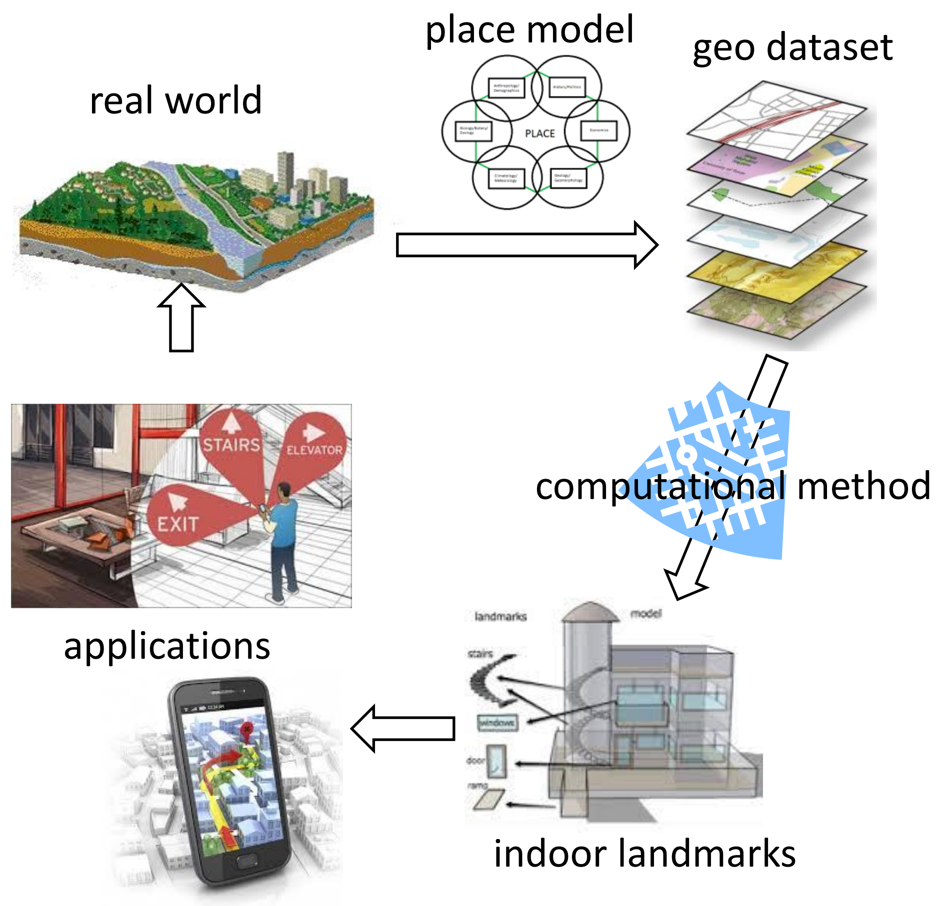


Figure 5.Workflow of landmark extraction and application

Theoratical Basis (II)

-- a cognitive model of indoor environment

- Three levels of indoor objects (Montello 1993):
  - Figural level objects,
  - Vista level objects,
  - Environmental level objects.

Figure 6. Examples of indoor object taxonomy, figural objects: (a) a set of movable rubbish bins that are smaller than human body, (b) some unmovable automatic service machines which are slightly larger than the body; vista object: (c) a corridor; (d) environmental object: the floor of a building shown in a vista object – a floor map.

Theoratical Basis (II)

-- a cognitive model of indoor environment

Level 1 – inter room level

- Adjacency Graph
- Rooms – Vertices
- Connections(doors or virtual boundaries) - Edges

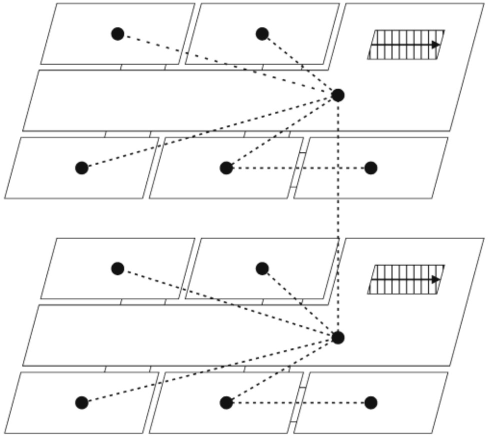


Figure 7.An illustration of adjacency graph

Level 2 – in room level

- Vista/Environmental Objects

  - Polygon features

- Figural objects

  – Point features

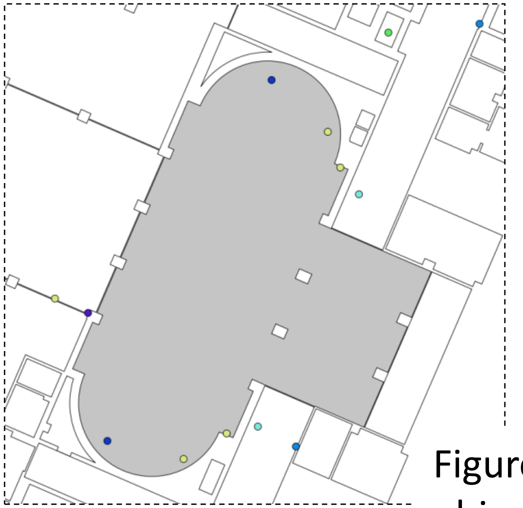


Figure 8.An illustration of objects in Level 2

Theoratical Basis (II)
-- isovist analysis and space syntax

Figure 9.An isovist polygon example

- Six measures of isovist:

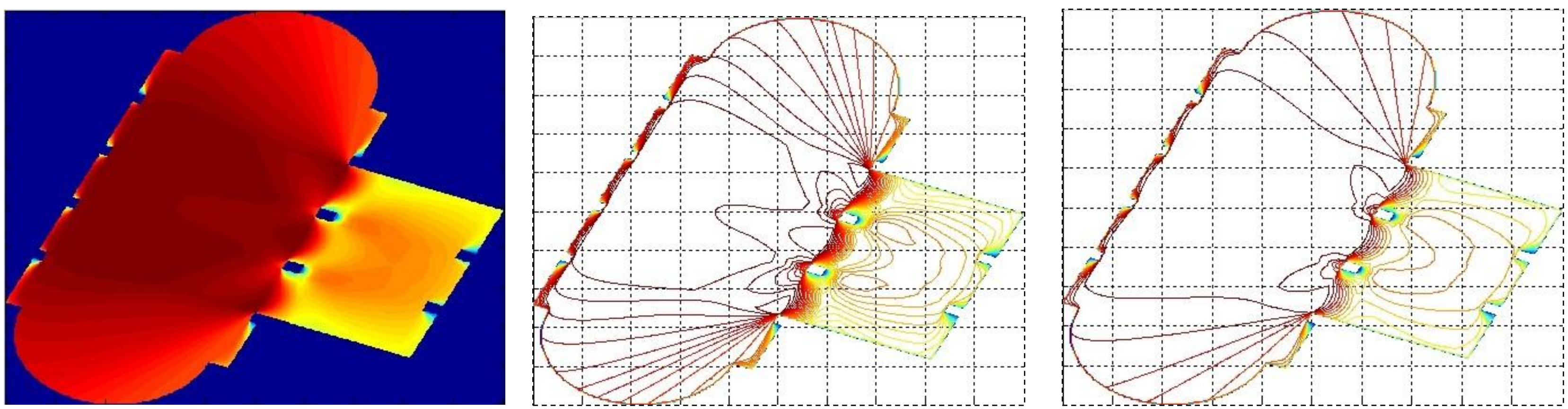
(Benedikt 1979)

- area of the isovist
  – the area of isovist polygon;
- real-surface perimeter;
- occlusivity of the isovist;
- variance of the radials;
- skewness of the radials;
- circularity of the isovist
  – the isoperimetric quotient of the isovist polygon.

Theoratical Basis (II)

-- isovist analysis and space syntax

- Isovist fields
  - created by counting the measures as space-varying quantities of all points in the environment.



(a) (b) (c)

Figure 10. isovist field based on area measure visualized by using (a) a heat map, (b) a 50 contour line map, and (c) a 50 contour line map.

Computational Salience Indicators

-- visual salience

- Visual accessibility (for figural objects)
  - *Visible Area*

$$A = area(isovist(in - obj)) \quad (1)$$

  - *Circularity*

$$Q = 4\pi A / L^2 \quad (2)$$

- Shape perceivability (vista and environmental objects)
  - *Average Height*

$$AH(F) = \iint_D F(x,y) \cdot dxdy \Big/ \iint_D 1 \cdot dxdy \quad (3)$$

  - *Variance*

$$Var(F) = \iint_D (F(x,y) - AH(F))^2 \cdot dxdy \Big/ \iint_D 1 \cdot dxdy \quad (4)$$

Computational Salience Indicators

-- structural salience

(for vista / environmental objects)

- Accessibility/Connectivity
  - the degree to which a room is available
  - one-step accessiblity
  - degree of the room vertex of the adjacency graph

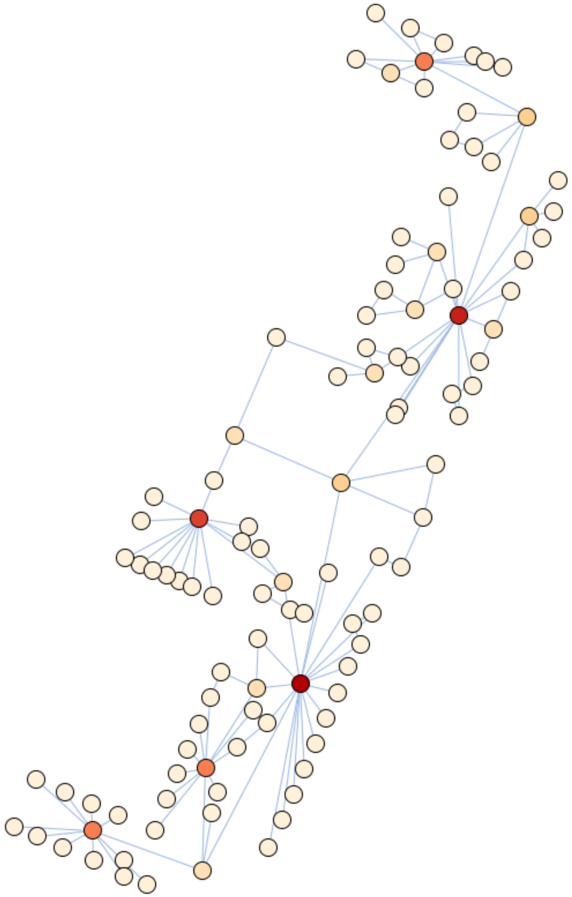


Figure 11. Room accessibility visualized by graduated color map

Computational Salience Indicators

-- structural salience

(for vista / environmental objects)

- Location importance
  - closer to centre more important
  - 'Closeness Centrality'

$$C_H(x) = \sum_{y \neq x} \frac{1}{d(y,x)} \qquad (5)$$

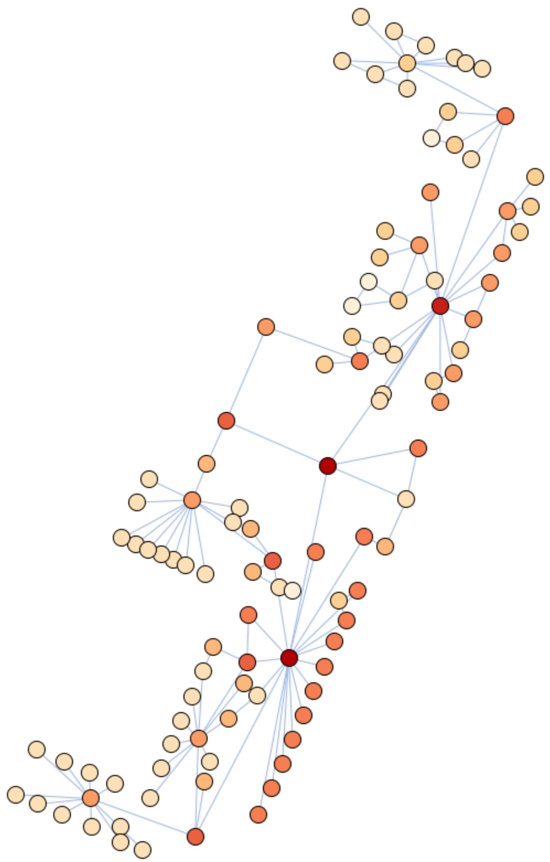


Figure 12. Closeness centrality visualized by graduated color map

Computational Salience Indicators
-- semantic salience

- Functional Importance
  - the function of a place can be related to the actions that the place offers,
  - more distinctive the function is means more functional attractiveness the place has,
  - Functional difference measurement.
- Other Semantic Properties
  - incl. cultural and historical importance.
  - currently TRUE or FALSE is assigned to indicate whether a place has such kind of importance.

Computational Salience Indicators

-- overall salience

- Finding Indoor Landmarks:
  - outlier detection
  - distance measurement for each attribute
  - combination of three salience:

$$S_{overall} = w_{vis} \times S_{vis} + w_{sem} \times S_{sem} + w_{str} \times S_{str} \qquad (6)$$

Landmarks in Campus Building

-- a Case Study

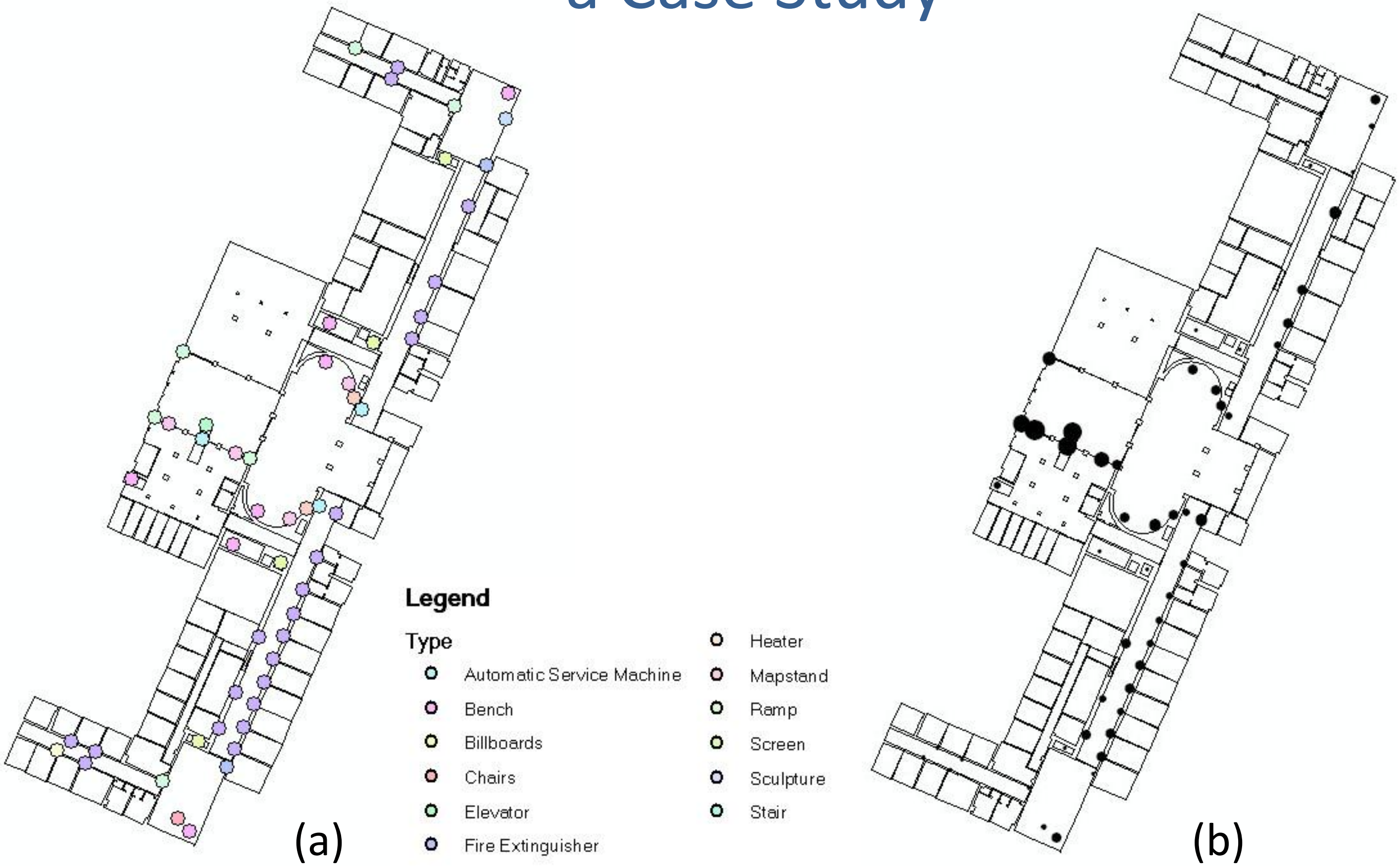


Figure 13. (a) shows the rooms and PoIs, PoIs are categorized according to their daily life affordances, (b) illustrates the salience scores of each PoIs according to their visible accessibility.

Landmarks in Campus Building

-- a Case Study

(a) (b) (c) (d)

Figure 14. Landmark extraction scores: a, b and c show scores for visual, semantic and structural salience; d presents overall scores for a combination of the above three salience scores

Conclusion & Future Work

- Three theory basis: Space cognition, affordance, space syntax;
- A computational model for extracting indoor landmarks from a geo-database;
- A case study in campus building(ground floor).

Conclusion & Future Work

- Multi-sourced dataset;
- Study of indoor environment cognition;
- Context-awareness.

Thank you !

Comments/questions are welcomed!