Interpreting Motion Expressions in Route Instructions Using Two Projection-Based Models

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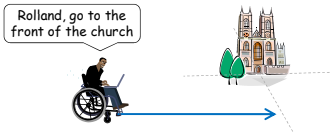
Motivation

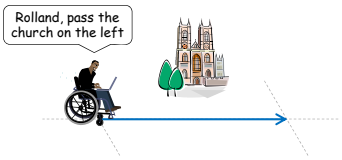
Mobile robots and intelligent vehicles that navigate in human living spaces, such as the intelligent wheel chair **Rolland**[1], should equip with an ability to communicate with human users about their action plans through natural language

Two types of expressions people may use:

- **Goal-Oriented Expressions**
  e.g., go to the front of …
  go behind …
  go to the north of …



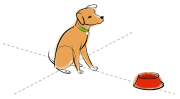
- **Path-Centric Expressions** *our target*
  e.g., pass … on the left
  go along …
  go toward …
  go into …



Research Goal

To model the semantics of **path-centric motion expressions** using **projection-based spatial models**

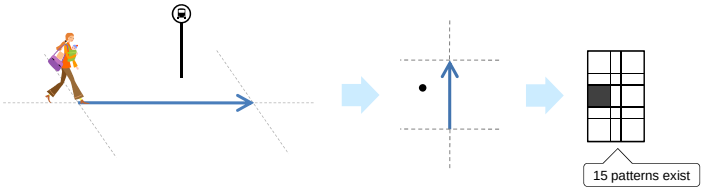
spatial models that project **a frame of spatial reference** onto a space, by which the spatial arrangements of objects are distinguished



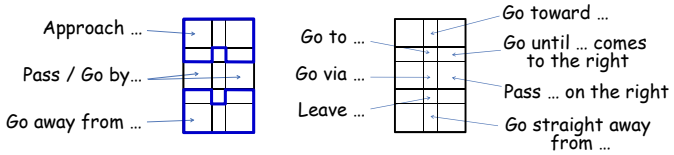
Analysis

Scenario 1: if the landmarks are represented by points

Model: Double Cross [2]

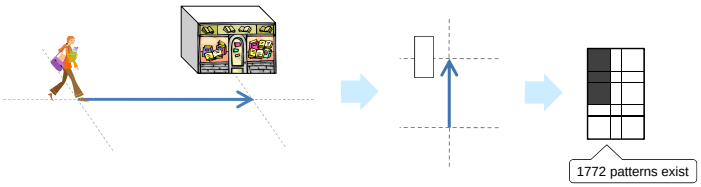


Correspondence between Motion Expressions and Spatial Patterns:
— there is a clear correspondence



Scenario 2: if the landmarks are represented by regions

Model: RfDL$_{3\text{-}12}$ *new!*

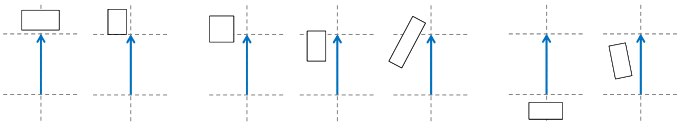


- **RfDL$_{3\text{-}12}$** is a model that belongs to **RfDL** model series [3], which consists of eight models that categorize the spatial arrangements between a path and a region-like landmark with different levels of granularities
- The frame adopted by **RfDL$_{3\text{-}12}$** is equivalent to that of **Double Cross**

Correspondence between Motion Expressions and Spatial Patterns:

(i) When the route and the landmark are disjoint
—the correspondence is sometimes ambiguous

e.g., Approach

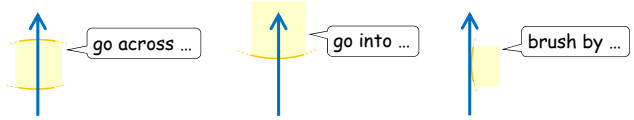


Clearly 'approach'	May or may not 'approach'	Clearly not 'approach'
Strong Condition	In these cases, we cannot tell anything from **RfDL$_{3\text{-}12}$** pattern	Weak Condition
at least one	Thus, we may have to evaluate the degree of 'approach' using additional criteria	at least one
If this condition is satisfied, the motion is always characterized as 'approach'	e.g., Fuzzy Membership Function $\mu_{approach} = \frac{1}{\lvert\mathbf{b}-\mathbf{a}\rvert}\lim_{\lvert\Delta\mathbf{x}\rvert\to 0}\left(\sum_{\mathbf{x}\in[\mathbf{a},\mathbf{b}]_{\mathbf{x}}} \frac{-d(\mathbf{x},R)}{\lvert\Delta\mathbf{x}\rvert}\lvert\Delta\mathbf{x}\rvert\right)$	If this condition is not satisfied, the motion is never characterized as 'approach'

In the same way, we determined the strong and weak conditions for other expressions, such as 'go away from' and 'go by'

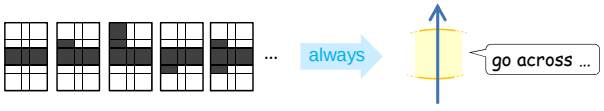
(ii) When the route intersects with the landmark
—topological relations can be used to model the expressions

In this scenario, people typically describe a motion using topological information (i.e., how the route intersects with the landmark). Thus, **topological line-region relations**[4] can be used as a basis for capturing typical expressions:



Interestingly, when the landmark is convex, every RfDL$_{3\text{-}12}$ pattern is mapped to a unique topological line-region relations[3]. Moreover, even if the landmark may not be convex, 77% of RfDL$_{3\text{-}12}$ patterns are mapped to a unique topological relation[3].

This indicates that RfDL$_{3\text{-}12}$ patterns are useful for capturing not only directional, but also topology-featured motion expressions.



Ongoing Work

Generalization of the above approach using a spatial ontology [5]

All the expressions in the left figure refer to the same motion concept. Thus, once we associate such a concept with **RfDL$_{3\text{-}12}$** patterns, we can support all these expressions simultaneously.

'*Go-Across*' concept ⇔ …

References

[1] Lankenau & Röfer (2000) The Role of Shared Control in Service Robots —the Bremen Autonomous Wheelchair as an Example. In: Service Robotics—Applications and Safety Issues in an Emerging Market

[2] Freksa (1992) Using Orientation Information for Qualitative Spatial Reasoning. In: International Conference GIS

[3] Kurata & Shi (2008) RfDL: Models for Capturing Directional and Topological Characteristics of Path-Landmark Arrangements. In: Workshop on Moving Object.

[4] Kurata, Y., Egenhofer, M. (2007) The 9*-Intersection for Topological Relations between a Directed Line Segment and a Region. In: Workshop on Behavioral Monitoring and Interpretation

[5] Shi & Kurata (2008) Modeling Ontological Concepts of Motions with Two Projection-Based Spatial Models. In: Workshop on Behavioral Monitoring and Interpretation.