Investigating the Dimensions of Spatial Language

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Abstract

- Spatial prepositions in the English language can be used to denote a vast array of configurations which greatly diverge from any typical meaning
- There is general agreement that *non-geometric* aspects play a significant role in spatial preposition usage. However, there is a lack of available data providing insight into how these extra semantic aspects should be modelled
- We introduce a framework intended to facilitate the collection of rich data; including geometric, functional and conventional features

Aims

- We aim to create a semantic model of spatial prepositions which:
  - Can be incorporated into a situated dialogue system to aid referring expression comprehension and generation
  - Support existing theories of spatial language

Semantic Domains

- Many features influence spatial preposition usage [1] and there are no clear boundaries demarcating when a preposition is, or is not, appropriate to use
- As well as representing geometric concepts, spatial prepositions denote functional relationships [2,3]
- Figure 1 provides an illustrative example. In (a) the pear is generally considered to be 'in' the bowl, whereas in (b) it is not

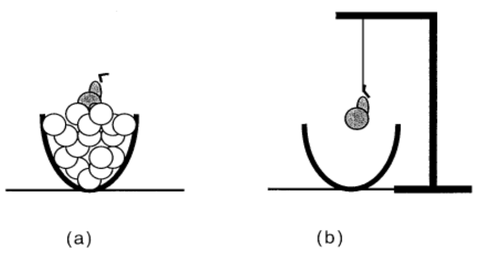

Figure 1 (from [2]). When is the pear 'in' the bowl?

Functional Features

- How can we quantify functional relationships like 'support' and 'location control'?
- Using virtual environments allows assessment of features via *simulation*
  - If the *ground* is removed, how far does the *figure* fall?
  - If a force is applied to the *ground*, does the *figure* move?

Conventional Features

- Convention generally influences the acceptability of a preposition
- Some features also distinguish polysemes, affecting the salience of geometric and functional features
- We can extract some of these from the scene e.g. orientation of the ground [4]
- Others are inherent to objects e.g. whether the object is a *container*. We are exploring extracting these from the commonsense knowledge base ConceptNet [5]

Data Collection

- We set up a framework in order to collect richer data on spatial prepositions and explore these issues

Framework & Tasks

- Using the Blender game engine we created environments in which users can navigate, select objects and provide descriptions and developed two tasks. See the GitHub repository for the software[1]
- The Selection Task asked users to select pairs of objects which fit a given preposition:

Figure 2. Selection Task

- The Description Task asks users to provide descriptions of given objects:

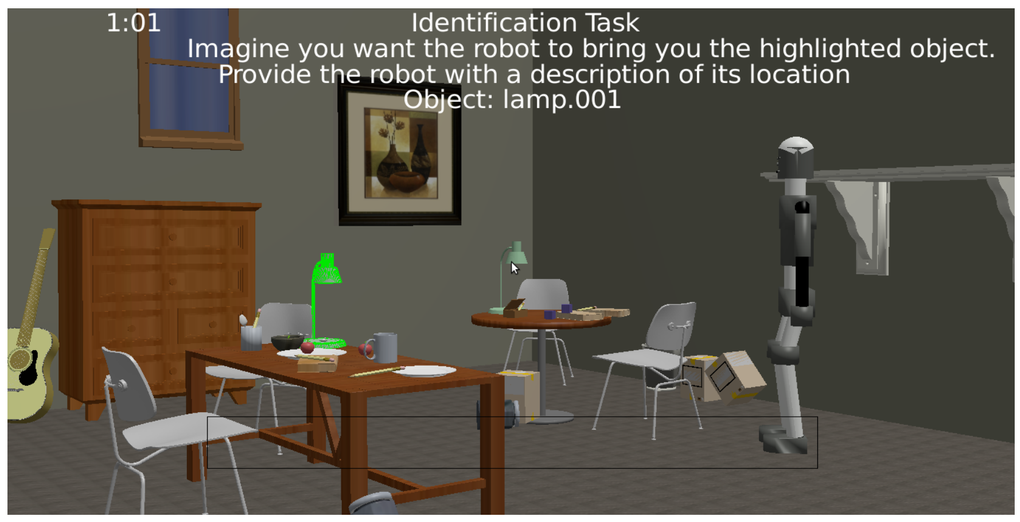

Figure 3. Description Task

Preliminary Study

- Informed future studies and provided tentative insights:
  - Importance of conventional features
  - Similarity and vagueness of spatial prepositions
  - Success of simple models for REG/C
- Focus on open/unconstrained selections and descriptions hindered detailed analysis

Ongoing Work

- Improved and refined data collection
  - We are currently running a study online[2]
- Developing game-like testing environment to explore pragamtic aspects of referring expression generation and interpretation in more detail

1. github.com/alrichardbollans/spatial-preposition-annotation-tool-blender/
2. adamrichard-bollans.co.uk/spatial_language_project.html

References

[1] Richard-Bollans, A. (2018). Towards a Cognitive Model of the Semantics of Spatial Prepositions. In ESSLLI Student Session Proceedings. Springer. **[2]** Garrod, S., Ferrier, G., & Campbell, S. (1999). In and on: investigating the functional geometry of spatial prepositions. *Cognition*, 72(2), 167-189. **[3]** Herskovits, A. (1987). Language and spatial cognition. Cambridge University Press. **[4]** Platonov, G., & Schubert, L. (2018). Computational Models for Spatial Prepositions. In Proceedings of the First International Workshop on Spatial Language Understanding (pp. 21-30). **[5]** Speer, R., & Havasi, C. (2012). Representing General Relational Knowledge in ConceptNet 5. In LREC (pp. 3679-3686).