Qualitative Modeling of Spatial Prepositions and Motion Expressions

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The ability to understand spatial prepositions and motion in natural language will enable a variety of new applications involving systems that can respond to verbal directions, map travel guides, display incident reports, etc., providing for enhanced information extraction, question-answering, information retrieval, and more principled text to scene rendering. Until now, however, the semantics of spatial relations and motion verbs has been highly problematic. This tutorial presents a new approach to the semantics of spatial descriptions and motion expressions based on linguistically interpreted qualitative reasoning. Our approach allows for formal inference from spatial descriptions in natural language, while leveraging annotation schemes for time, space, and motion, along with machine learning from annotated corpora. We introduce a compositional semantics for motion expressions that integrates spatial primitives drawn from qualitative calculi.

No previous exposure to the semantics of spatial prepositions or motion verbs is assumed. The tutorial will sharpen cross-linguistic intuitions about the interpretation of spatial prepositions and motion constructions. The attendees will also learn about qualitative reasoning schemes for static and dynamic spatial information, as well as three annotation schemes: TimeML, SpatialML, and ISO-Space, for time, space, and motion, respectively.

While both cognitive and formal linguistics have examined the meaning of motion verbs and spatial prepositions, these earlier approaches do not yield precise computable representations that are expressive enough for natural languages. However, the previous literature makes it clear that communication of motion relies on imprecise and highly abstract geometric descriptions, rather than Euclidean ones that specify the coordinates and shapes of every object. This property makes these expressions a fit target for the field of qualitative spatial reasoning in AI, which has developed a rich set of geometric primitives for representing time, space (including distance, orientation, and topological relations), and motion. The results of such research have yielded a wide variety of spatial and temporal reasoning logics and tools. By reviewing these calculi and resources, this tutorial aims to systematically connect qualitative reasoning to natural language.

Tutorial Schedule:

I. Introduction. i. Overview of geometric idealizations underlying spatial PPs; ii. Linguistic patterns of motion verbs across languages; iii. A qualitative model for static spatial descriptions and for path verbs; iv. Overview of relevant annotation schemes.

II. Calculi for Qualitative Spatial Reasoning. i. Semantics of spatial PPs mapped to qualitative spatial reasoning; ii. Qualitative calculi for representing topological and orientation relations; iii. Qualitative calculi to represent motion.

III. Semantics of Motion Expressions. i. Introduction to Dynamic Interval Temporal Logic (DITL); ii. DITL representations for manner-of-motion verbs and path verbs; iii. Compositional semantics for motion expressions in DITL, with the spatial primitives drawn from qualitative calculi.

IV. Applications and Research Topics. i. Route navigation, mapping travel narratives, QA, scene rendering from text, and generating event descriptions; ii. Open issues and further research topics.

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