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GUEST EDITORIAL

Spatial Reasoning

Avi Kak

We conceive of space as a completely empty, infinite, three-dimensional, isotropic, disembodied receptacle distinct from the earth or any object that might be located on the earth, one that is capable of housing not only things but also such incorporeal mathematical entities as points and infinite straight lines. Such a strange idea—especially if it were taken to describe something that exists in this world—was unthinkable before the seventeenth century; yet not even Galileo fully accepted the idea of such a world as real. For him, a "straight line" was still bound to the earth's surface. Not until Newton was the task of "geometrization of the world" … completed. The transformation that led to the reification of geometry, though basically one of attitude and perception rather than of empirical observation, profoundly affected the course of science.

—From the preface of *Computation and Cognition: Toward a Foundation for Cognitive Science* by Zenon Pylyshyn.

If one were to categorize the behavior of the intelligent machine of the future, one might do so on the basis of the machine's capabilities to carry out temporal reasoning over interrelated entities that change with time; to carry out spatial reasoning for solving problems dealing with entities occupying space; and, on a more complex level, to reason over interrelated entities occupying space and changing in time with respect to their attributes and spatial interrelationships. These capabilities would have to be in addition to the more generic ones like deduction, induction, truth maintenance, and so on. The purpose of this special issue is to bring into focus some aspects of the evolving art and science of reasoning over space.

The dominant questions are those that deal with the flow of control in a reasoning process, accumulation of evidence for various hypotheses about the nature and identity of groupings in spatial data, incremental assimilation of newly discovered spatial facts into an existing knowledge base, and retrieval of spatial information from a data base at different scales of detail. Answers to these questions will play a central role in the design of sensor-based robot systems of the future for industrial automation and terrestrial exploration. The articles selected for this special issue address some of these questions. I'm sure the authors would agree that the current state of our answers to the questions addressed is more in the nature of an ongoing intellectual exploration and that, to borrow from Robert Frost, we have miles to go before we sleep.

Consider, for example, the nature of our present understanding about the subject of flow of control in spatial reasoning for image understanding. On one extreme, we can have fine-grained control in which the control knowledge is distributed among highly domain specific rules; and, on the other, we can design systems in which the flow of control is entirely domain independent although driven by a scene expectation map. In the former, an image understanding system may contain a rule that invokes a driveway finding procedure if it has already detected a house; while, in the latter, we may employ a blackboard architecture for comparing at different levels of abstractions the expected scene with the spatial data—the expected scene being generated by an object modeling program. Beyond rather superficial considerations, such as the ease with which a system may be modified or adapted to different domains, it is not at all clear at this time how the various possible control strategies differ with regard to deeper criteria like the robustness of a reasoning process. (By robustness I mean a certain lack of sensitivity to obscuring detail, as in, for example, our own ability to see and recognize a house through foliage.) Therefore, currently, the flow of control in any implementation is more likely to be a matter of personal faith, as opposed to being dictated by any sound set of engineering principles. Evidently, much work remains to be done.

A note of explanation is in order for the selection of Gudula Retz-Schmidt's article. If there is any merit to the possibility that our thinking is shaped by our language—a possibility stated by Whorf in *Language, Thought, and Reality*—then, clearly, those of us who are interested in reasoning about space must stay in tune with that component of our language that deals with spatial attributes, relationships, and frames of reference. The article by Retz-Schmidt is intended to raise the reader's consciousness along such dimensions.