

Preface

Spatial Cognition is one of the hot fields of current research in cognitive science. Scientific disciplines like computer science, cognitive psychology, geography, linguistics, or philosophy cooperate in investigating how agents (i.e. humans, animals, mobile robots, or other intelligent devices) apprehend and process knowledge about their spatial environments, how they act in space, and how they interact and communicate in and about their spatial world.

This book is an interdisciplinary contribution to the investigation of human mental processing of knowledge about geographic space. In cognitive science, mental representations of spatial knowledge are metaphorically referred to as cognitive maps. However, investigations in cognitive psychology reveal that the cognitive map metaphor is inadequate, and that more suitable conceptions of human geographic knowledge processing are needed. In the present work, the issue is addressed from an artificial intelligence (AI) perspective. An experimental computational modeling approach for mental processing is presented. Results from cognitive psychology about human memory and visual mental imagery are combined with AI techniques of spatial and diagrammatic knowledge processing. The diagrammatic reasoning architecture MIRAGE is developed as a comprehensive conception of human geographic knowledge processing.

The work is based on the theses that (1) geographic knowledge representations in the human mind are constructed on demand, that (2) this construction is based on underdetermined knowledge from long-term memory, that (3) this knowledge is stored in a fragmentary, hierarchically structured form, and that (4) the resulting representation in working memory is a visual mental image.

MIRAGE is structured according to the psychological distinction of human memory in long-term memory and working memory. It uses topological, orientation, and shape information stored in spatial knowledge fragments in long-term memory. The construction of visual mental images in working memory is described as starting from the retrieval of pieces of knowledge in long-term memory. A working memory representation is then constructed on the basis of the retrieved spatial knowledge fragments. Missing spatial information is complemented by default knowledge. The representation built up in working memory is used to construct a visual mental image in a visual buffer. This image is inspected to obtain a

spatial relation. Complex image construction strategies are developed that provide solutions to the problem of representing underdetermined spatial information in a quasi-pictorial representation.

Through the integration of psychological results with AI techniques of visuo-spatial information processing in a common modeling conception, MIRAGE provides an essential contribution to the investigation of human spatial knowledge processing. This modeling conception is intended to form a basis for ongoing discussions, for empirical investigations, and for future AI projects.

Acknowledgments

I would like to thank my advisor Christian Freksa for his critical, imaginative, and friendly support. This work has been shaped in innumerable discussions with him. His comprehensive assistance helped me identify my research goals and find a way through the often pathless field of interdisciplinary research.

Special thanks also to Mary Hegarty for her constructive criticism and many valuable psychological clues. Likewise, I want to thank Stephanie Kelter who guided my basic psychological studies and accompanied my work in its early phases. I thank Dan Montello for commenting on intermediate stages of my work and for pointing to other forms of geographic knowledge than I focus on in my work.

This work has been done within the research project Spatial Structures in Aspect Maps (Fr 806/8, Spatial Cognition priority program, DFG). I thank the DFG for funding the project and for establishing the Spatial Cognition priority program, which provided a fruitful framework for spatial cognition research.

I thank the members of the Knowledge and Language Processing Group (WSV) and of the Cognitive Science Program (GrKK) in Hamburg for the pleasant work climate, for manifold discussions and constructive criticism. Special thanks are to Ladina Tschander, Markus Guhe, Lars Kulik, Alex Klippel, Sven Bertel, Steffen Egner, Simone Pribbenow, Thora Tenbrink, and Heike Tappe, who provided valuable input to my work, helped me identify specific issues to investigate, and provided essential emotional support.

I am also indebted to Christopher Habel, Markus Knauff, Paul Lee, Christoph Schlieder, Sabine Timpf, and Werner Kuhn for ideas, comments, and discussions.

Finally, I particularly thank Gabi Weise for her patience, for her loving support, and for being herself.