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# Collaborative Research: Matching Levels of Detail in Descriptions and Depictions of Geographic Space

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**Final Report for Period:** 09/2005 - 09/2006**Submitted on:** 12/29/2006**Principal Investigator:** Worboys, Michael .**Award ID:** 0327615**Organization:** University of Maine**Title:**

Collaborative Research: Matching Levels of Detail in Descriptions and Depictions of Geographic Space

**Project Participants****Senior Personnel****Name:** Worboys, Michael**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Graduate Student****Name:** Battson, Adam**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Adam Battson is the graduate student supported to work on this project. He joined us in January 2004. He left the project in September 2005 to return to England.

**Undergraduate Student****Technician, Programmer****Other Participant****Research Experience for Undergraduates****Organizational Partners****Tufts University**

These are the partners who agreed to collaborate on the project at the proposal stage.

**Other Collaborators or Contacts**

Dr Matt Duckham, Department of Geomatics, University of Melbourne, Australia

Dr Alex Klippel, Department of Geomatics, University of Melbourne, Australia

Dr Kathleen Stewart Hornsby, Department of Spatial Information Science and Engineering, University of Maine, USA

**Activities and Findings****Research and Education Activities:**

The aim of this research is to extend the capabilities of current geographic information representations by examining how dual verbal&pictorial modalities interact. We have made progress in the development of analytic approaches that are properly grounded in relevant cognitive and geographic information theory to support this research project. The central question addressed by this project is 'What is the relationship between verbal and pictorial representations of geographic information and how can both representation types be successfully integrated in

systems relating geographic information to users?' This question has been extended to, 'How can representations of dynamic data be integrated into such systems?'

The work required a formal means of representing ontologies of spatial environments based on dual mode (verbal and graphical) representations. For this purpose we used the ontology editor Protege, available from Stanford University, and its accompanying module on OWL, the WWW standard ontology working language. OWL was also employed in our representation of ontologies of dynamic geographic phenomena. We also used a framework from information theory based on information flow (Barwise and Seligman) to represent communication of dual mode geographic information.

We have worked on formal theories of qualitative distance and direction information, in collaboration with Duckham and Kulik, postdocs in the department, and now with faculty positions at the University of Melbourne, Australia.

Another direction that has proved to have great promise is to view the wayfinding environment as providing the potential (affordance) for a structured collection of wayfinding events. Research in this area has now been completed and submitted for publication (see below).

Throughout the project lifetime, we have had regular meetings with our collaborators at Tufts University, Boston, both at Boston and the University of Maine. We have been involved in the submission of a joint publication to the Journal of Spatial Cognition and Computation, reporting our completed joint research.

We have also collaborated with Dr Alex Klippel of the University of Melbourne, Australia, on a major new development of this research, exploring the multimedia aspects of dynamic geographic information. Alex has a background in psychology and spatial cognition, and has designed further psychological experiments. We have a joint paper (also with Dr. Matt Duckham) reporting this work.

A further collaborative direction has been with the UK formalist Anthony Galton, with whom we developed some of the dynamic ontology required for navigation and coordination within transportation networks.

### **Findings:**

A description logic, forming the basis of OWL Web Ontology Language, has proved suitable for formally representing information useful for dual mode (verbal-pictorial) spatial representation. This logic is also tractable to computational reasoning. We have found that OWL provides a useful vehicle for the formal representation of ontologies of dynamic phenomena in geographic space. However, some extensions are required, in particular a means of representing transitive relations such as 'part-of' will be essential.

We have shown that it is possible to construct a theory of qualitative distance and direction relationships, suitable for reasoning in environmental spaces. This qualitative theory has been related to quantitative distance and bearing metrics. Results have been published in the Journal of Spatial Cognition and Computation.

The 'event oriented approach' to geographic space has been investigated, and results published in the International Journal of Geographic Information Science. We have found that an entirely distinct ontological category of occurments is required for this approach. We have also begun to consider the relationships between traditional objects and events, formulated in our Geographic Events Model (GEM), published in collaboration with colleague Hornsby at the International Conference on Geographic Information Science. Further results in this area have been submitted for publication (joint publications with colleagues at Tufts University and University of Melbourne, Australia).

### **Training and Development:**

We had some delay recruiting a suitable graduate student for the project. Adam Battson, our first choice, started on the project in January 2004. He has a master's degree from Manchester University, UK. This has meant a delayed start to the project. Adam Battson, our graduate student, completed most of his graduate courses, gaining mostly A grades throughout.

More directly related to the project, Battson surveyed research on textual summarisation, description logics, GIS development, as well as the extensive literature on wayfinding. He has formed useful working relationships with colleagues at the University of Melbourne interested in spatial cognition (in particular with Alexander Klippel). He has been engaged in system development related to the prototype Mobile Wayfinding Assistant, in collaboration with our partners at Tufts University, Boston. Unfortunately, the last activity was curtailed as Battson left the project in October 2005 to return to England, for personal and family reasons.

**Outreach Activities:**

Michael Worboys has input ideas on verbal forms of geographic information to a start-up company in Maine: Intelligent Spatial Technologies, specialising in the development of 'smart' handheld devices for wayfinding assistance.

The project continues to inform Worboys' teaching of the graduate course 'Uncertainty in Spatial Information Systems', particularly the component on qualitative spatial reasoning. Worboys also convened in 2005 a graduate seminar course on formal approaches to event-based reasoning. This was attended by faculty and students, including a faculty member from the mathematics department at UMaine.

The postdocs Duckham and Kulik (later, faculty at the University of Melbourne, Australia) collaborated on a joint paper with Worboys on qualitative distance and bearing metrics.

Worboys collaborated with a research faculty, Hornsby, on event-based approaches to geographic information.

Worboys collaborated with Galton, University of Exeter, UK.

Worboys has also collaborated with the University of Melbourne researcher, Dr. Alex Klippel, who specializes in spatial cognition.

**Journal Publications**

Worboys, M., Duckham, M. and Kulik, L., "Commonsense notions of proximity and direction in environmental space", *Spatial Cognition and Computation*, p. 285, vol. 4, (4 ). Published

Worboys, M.F. and Hornsby, K., "From objects to events: GEM, the geospatial event model", *Third International Conference on GIScience 2004*, M. Egenhofer, C. Freksa, H. Miller (eds.), *Lecture Notes in Computer Science*, p. 327, vol. 3234, (2004). Published

Worboys, M.F., "Event-oriented approaches to geographic phenomena", *International Journal of Geographic Information Science*, p. 1, vol. 19, (2005). Published

Brunye, T.T., Taylor, H.A., and Worboys, M.F., "Matching Levels of Detail in Descriptions and Depictions of Geographic Space: Implications for Handheld GPS Devices", *Spatial Cognition and Computation*, p. , vol. , ( ). Submitted

Klippel, A., Worboys, M.F., and Duckham, M., "Conceptual Neighborhood Blindness? On the Cognitive Adequacy of Gradual Topological Changes", *Conference on Spatial Cognition, Workshop on Talking about and perceiving moving objects: exploring the bridge between natural language, perception and formal ontologies of space.*, p. xx, vol. 1, (2006). Published

Worboys, M.F. and Duckham, M., "Formalizing mobility in dynamic location-aware sensor networks", *International Workshop on Mobile Location-Aware Sensor Networks*, Nara, Japan, IEEE Publications, p. xx, vol. , (2006). Published

Klippel, A., Worboys, M.F., and Duckham, M., "Geographic event conceptualization", *International Journal of Geographic Information Science*, p. , vol. , (2006). Submitted

Worboys, M.F. and Duckham, M., "Monitoring qualitative spatial change for geosensor networks", *International Journal of Geographic Information Science*, p. 1087, vol. 20, (2006). Published

Galton, A. and Worboys, M.F., "Processes and events in dynamic geospatial networks", *Proceedings of First International Conference on Geospatial Semantics*, p. 45, vol. 3799, (2005). Published

**Books or Other One-time Publications**

Hornsby, K.H. and Worboys, M.F., "Event-oriented approaches in geographic information science", (2004). Book, Published  
Editor(s): Hornsby, K.H. and Worboys, M.F.

Bibliography: Lawrence Erlbaum, Mahwah, NJ, ISBN: 0-8058-9531-0

**Web/Internet Site****URL(s):**

<http://www.spatial.maine.edu/%7Eworboys/nsf%20matching/page.htm>

**Description:****Other Specific Products****Contributions****Contributions within Discipline:**

The principal disciplinary field of this project is geographic information science, and in this case specifically the intersection between geocomputation and spatial cognition. It has been a collaboration between geographic information scientists and psychologists. The contribution has been in the area of communication of geographic information by different means - primarily textual and graphical. We have also researched the issue of geographic information containing dynamic elements, such as occurrences of accidents or blockages to routes, as well as changes in topological relationships of spatial objects.

**Contributions to Other Disciplines:**

Our work is interdisciplinary between geographic information science (itself a multidisciplinary endeavor) and computation. Therefore, contributions have impacted several disciplines, including geography, computing science, mathematics, and psychology. We have collaborated with geomaticians, mathematicians/philosophers, computer scientists, and psychologists.

**Contributions to Human Resource Development:****Contributions to Resources for Research and Education:**

Input to University of Maine graduate course 'Uncertainty in Spatial Information Systems'

Publication of 2nd edition of the textbook: Worboys, M.F. and Duckham, M., Geographic Information Systems: A Computing Perspective (2nd Edition), CRC Press, Boca Raton, Florida, ISBN: 0415283752, 2004. The new chapter on Uncertainty was directly informed by some of the work in this project.

Publication of an edited collection of papers on the theme of event-based approaches to geographic phenomena. This was published both as a special issue of the Journal of Spatial Cognition and Computation, and later as a book volume published by Lawrence Erlbaum.

**Contributions Beyond Science and Engineering:****Categories for which nothing is reported:**

Any Product

Contributions: To Any Human Resource Development

Contributions: To Any Beyond Science and Engineering