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Multi-Modal Spatial Querying

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Final Report for Period: 10/1996 - 09/2002**Submitted on:** 07/06/2003**Principal Investigator:** Egenhofer, Max J.**Award ID:** 9613646**Organization:** University of Maine**Title:**

Multi-Modal Spatial Querying

Project Participants**Senior Personnel****Name:** Egenhofer, Max**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Turner, Elise**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Turner, Roy**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Overmyer, Scott**Worked for more than 160 Hours:** No**Contribution to Project:****Name:** Bertolotto, Michela**Worked for more than 160 Hours:** Yes**Contribution to Project:****Post-doc****Graduate Student****Name:** Blaser, Andreas**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Schlaisich, Isolde**Worked for more than 160 Hours:** Yes**Contribution to Project:****Name:** Caduff, David**Worked for more than 160 Hours:** Yes**Contribution to Project:**

Participated in the prototype implementation.

Undergraduate Student**Technician, Programmer**

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Lockheed-Martin Management and Data Systems funded a tech transfer project, porting the Query-by-Sketch user interface to a Palm Pilot. The effort ultimately failed, because the Palm platform with its limited OS and RAM, was a serious impediment to the conversion. A slim version as a thin client, used only for collecting the sketch but not for the query processing part, was implemented on a PocketPC.

Activities and Findings

Research and Education Activities:

We performed a survey testing people for the sketching preferences.

We completed the development of the sketching part of the multi-modal query system. The sketch parser detects line strokes and groups of line strokes, identifies them as lines or regions, and distinguishes them from text scribbled to annotate a sketch.

We also completed the implementation of the sketch analyzer, which translates a sketch into a symbolic representation so that it can be combined with verbally expressed queries.

During Year 3, we enhanced the sketching system to allow formulations of queries that are difficult or impossible with a sketch. They include negation, disjunction (or), and selection of the relevant spatial relations.

We investigated the diagrammatic representation of a sketch. We designed a method that derives such a diagram from a sketched spatial query. The diagram is complementary to the sketch.

During year 4 we tested the overlap between sketched and spoken parts of a multi-modal spatial query.

Findings:

From the survey we found that users draw for each query

- * a constant number of objects (12-17)
- * primarily artificial (i.e., constructed) objects (e.g., buildings, roads), no topographic structures.
- * a map-like, 2-dimensional representation
- * abstract objects, e.g., boxes and simple lines

In developing the sketch parser, we found the need for mechanisms that allow users to

- * view whether the current line stroke is or is not part of the sketched object

- * edit parts of sketches
- * convert explicitly lines to regions and vice versa

We found that an abstract diagrammatic representation of the sketch allows for complementary query formulation and manipulation, which is otherwise impossible in a sketch alone.

The tests of sketched and spoken query parts revealed that objects mentioned in the verbal description are more likely to have a graphical counterpart, while almost half of the drawn objects lack a verbal annotation. We also found that subjects took advantage of the possibility of simultaneous input of sketches and voice, and produced a remarkable quantity of redundant information

Training and Development:

The primary graduate research assistant, who has been working on this project, learnt about scientific publications (he participated in a research methods course I taught) and I mentored him in the successful completion of his first refereed journal article. He also gave numerous presentations, including a poster at the Conference on Spatial Information Theory in Pittsburgh in September 1997.

In year 3 a second graduate student has started to work on the project. She has attended two conferences where she gave short papers and poster presentations about Sketch-and-Talk. She is also the lead author of a paper on sketching that has been accepted at a refereed conference.

In year 4 another graduate research assistant was brought on board to develop a model for sketching in a distributed environment. He completed his M.S. thesis in Fall 2002.

Outreach Activities:

I presented the project at a number of science fairs, both in the State of Maine and in Washington. These presentations were primarily for politicians, including the Maine delegation in DC.

We have produced a CD with a mockup of the prototype, and distributed this widely. The Vice Provost at the University of Maine has been using this CD as promotional material to generate excitement in the State of Maine about scientific research.

Also several presentations to high school students were made.

In year 3, we produced a new version of the CD which includes the complete prototype, including a set of approx. 1000 data sets over which the query processor works.

We have had discussions with a small-business software developer about the extension and use of the prototype for searching patterns in a weather-forecasting system.

With the acquisition of a SmartBoard (from a State-of-Maine R&D initiative) we gained the opportunity to use Spatial-Query-by-Sketch on a large-scale screen with pen input.

We had countless demonstrations of this exciting technology, including one in May 2001 to former Senator John Glenn and former Secretary of Defense William Cohen.

Journal Publications

Andreas Blaser, Monica Sester, and Max Egenhofer, "Visualization in an Early Stage of the Problem Solving Process in GIS", Computers and Geosciences, p. 57, vol. 26, (2000). Published

M. Egenhofer and R. Shariff, "Metric Details for Natural-Language Spatial Relations", ACM Transactions in Information Systems, p. 295, vol. 16, (1998). Published

Max J. Egenhofer, "Query Processing in Spatial-Query-by-Sketch", Journal of Visual Languages and Computing, p. 403, vol. 8, (4). Published

A. R. Shariff, M. Egenhofer, and D. Mark
, "Natural-Language Spatial Relations Between Linear and Areal
Objects: The Topology and Metric of English-Language Terms", International Journal of Geographical Information Science, p. 215, vol. 12, (1998). Published

M. Bertolotto and M. Egenhofer, "Progressive Transmission of Vector Map Data over the World Wide Web", GeoInformatica, p. 345, vol. 5, (2001). Published

A. Blaser, "A Study of people's sketching habits in GIS", Spatial Cognition and Computation, p. 293, vol. 2, (2000). Published

Books or Other One-time Publications

Max J. Egenhofer and Reginald Golledge (eds.), "Spatial and Temporal Reasoning in Geographic Information Systems", (1998). Book, Published
Bibliography: Oxford University Press

I. Schlaisich and M. Egenhofer, "Multimodal Spatial Querying: What People Sketch and Talk About", (2001). Refereed Conference Proceedings, Published
Editor(s): C. Stephanidis
Collection: 1st International Conference on Universal Access in Human-Computer Interaction
Access in
Human-Computer Interaction
Bibliography: pp. 732-736

A. Blaser, "Sketching Spatial Queries", (2000). Thesis, Published
Bibliography: Ph.D. in Spatial Information Science and Engineering

D. Caduff, "Sketch-Based Queries in Mobile GIS Environments", (2002). Thesis, Published
Bibliography: M.S. thesis in Spatial Information Science and Engineering,
University of Maine

A. Blaser and M. Egenhofer, "A Visual Tool for Querying Geographic Databases", (2000). refereed conference proceedings, Published
Editor(s): V.~Di~Ges\{u}, S.~Levialdi, and L.~Tarantini

Collection: AVI2000--Advanced Visual Interfaces

Bibliography: pp. 211-216

A. Rodriguez, M. Egenhofer, and A. Blaser, "Query Pre-Processing of Topological Constraints: Comparing a Composition-Based with a Neighborhood-Based Approach", (2003). refereed conference proceedings, Published Editor(s): Y.~Manolopoulos and J.~Roddick Collection: SSTD~'03---Eighth International Symposium on Spatial and Temporal Databases Bibliography: -

Web/Internet Site

URL(s):

<http://www.spatial.maine.edu/~max/S&T.html>

Description:

Other Specific Products

Product Type: Software (or netware)

Product Description:

Sketching prototype

Sharing Information:

Available through the web site. Also distributed on a CD, together with pertinent publications.

Product Type: Software (or netware)

Product Description:

Integrated Geometric and Semantic Similarity Assessment

An extension of Spatial-Query-by-Sketch that allows a user to annotate the sketched objects with their classes. The similarity assessor works with an ontology and calculates semantic and geometric similarity values.

Sharing Information:

Available on a CD, which is being

Contributions

Contributions within Discipline:

My work on user interfaces for GIS is being cited frequently in the GIS literature, and was mentioned explicitly at an NSF/NRC workshop on Geo-Libraries. Although the discipline is cautious about too innovative user interfaces, spatial querying by sketching (and speech) is seen by many colleagues as an exciting new way of interacting with GISs.

Contributions to Other Disciplines:

Since GIS is broadly interdisciplinary, any contributions mentioned on the previous page extend through geography, computer science, and engineering, to name a few.

Contributions to Human Resource Development:

The research and graduate assistants involved in this research have started to make

their own contributions to the science and engineering field related to geographic information science. Dr. Bertolotto, who was supported as a post-doctoral research on this project, is now faculty at the University College Dublin, where she is actively involved in research that stems from her post-doc time funded on this project. She is program chair of the upcoming workshop on web-based GIS and has published several articles in the refereed literature since her departure from Maine.

Dr. Blaser moved upon completion of his dissertation to ESRI in Redlands, CA, where he is part of the development team for ArcGIS. He continues to publish results that originated from his dissertation.

Mr. Caduff, who completed a master's degree, is working with Intelligent Spatial Technologies, a start-up company in the Target Development Center at Orono. This company is developing software for innovative mobile-computing concepts, and he is their chief architect and software designer.

Ms. Schlaisich is continuing graduate studies at the University of Maine in the area of image processing and completed her thesis proposal this Summer. She will continue to work toward a Ph.D. in Spatial Information Science and Engineering.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

The underlying model for spatial relations, which we developed under previous NSF funding, has become the foundation of several international standards. ISO TC/211 (geographic information/geomatics) had a committee draft on spatial relations which acknowledges explicitly the foundation that my work provided. Likewise, the committee draft of SQL/Multimedia has such an explicit reference. The ISO draft standard become an international standard last year, with the references to my work.

In 2002 and 2003, the PI received two research awards --- the 2002 University of Maine Presidential Research and Creative Achievements Award and the 2003 Researcher of the Year award from the University Consortium for Geographic Information Science. In May 2002, the PI also was cited by a Joint Order from the State of Maine's Senate and House of Representatives for his research accomplishments.

Categories for which nothing is reported:

Organizational Partners

Contributions: To Any Resources for Research and Education