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NSF-CNPq Collaborative Research on Integrating Geospatial Information

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Final Report for Period: 09/1999 - 09/2004   **Submitted on:** 02/01/2006

Principal Investigator: Egenhofer, Max J.   **Award ID:** 9970123

Organization: University of Maine

Title:

NSF-CNPq Collaborative Research on Integrating Geospatial   Information

Project Participants

Senior Personnel

    Name: Egenhofer, Max

    Worked for more than 160 Hours: Yes

    Contribution to Project:

    Name: Camara, Gilberto

    Worked for more than 160 Hours: No

    Contribution to Project:

    Research partner while visiting the Brazilians at INPE and during
    his visit to Orono. Jointly conducted research on the ontology of
    fields.

    Name: Tillio, Marcello

    Worked for more than 160 Hours: No

    Contribution to Project:

    Research partner during his visit to Orono.

Post-doc

    Name: Campos, Jorge

    Worked for more than 160 Hours: No

    Contribution to Project:

Graduate Student

    Name: Fonseca, Frederico

    Worked for more than 160 Hours: Yes

    Contribution to Project:

    Conducted research into onotology-based geographic
    information systems, as a graduate research assistant.

    Name: Rodriguez, Andrea

    Worked for more than 160 Hours: No

    Contribution to Project:

    Name: Farrugia, Jim

    Worked for more than 160 Hours: No

    Contribution to Project:

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

INPE, Brazil

UNICAMP, Brazil

Catholic University Rio de Janeiro, Braz

Other Collaborators or Contacts

A research project funded by the National Geospatial-Intelligence Agency (formerly NIMA) that fostered collaboration with the Virginia Commonwealth University
Other NSF-funded projects collaboration with UC Santa Barbara and the Univeristy at Buffalo
An NIH-funded project collaboration with the University at Buffalo
A bioinformatics project that included collaboration with Jackson Lab (Bar Harbor)
Collaboration with researchers at the University of M³nster (Germany) and the University of Bremen (Germany) during a sabbatical of the PI.

Activities and Findings

Research and Education Activities:
Development and implementation of a computational model for
semantic similarity based on ontologies.

Development and simulation of a computational model for
assessing the potential for information integration.

Development of the concept of ontology-driven GIS as a novel approach to integrate
treatment of semantics into GIS.

Development of the concept of the geospatial semantic web as a foundation for semantic
spatial search.

Findings:
Information retrieval at different levels of granularity inside the
framework of information systems based on ontologies.

We introduced a GIS architecture that can enable geographic information integration in a
seamless and flexible way based on its semantic value and regardless of its
representation. The proposed solution is an ontology-driven geographic information
system that acts as a system integrator. In this system, an ontology is a component, such
as the database, cooperating to fulfill the system's objectives. By browsing through
ontologies the users can be provided with information about the embedded knowledge of
the system. Special emphasis is given to the case of remote sensing systems and
geographic information systems. The levels of ontologies can be used to guide processes
for the extraction of more general or more detailed information. The use of multiple
ontologies allows the extraction of information in different stages of classification. The

semantic integration of aerial images and GIS is a crucial step towards better geospatial modeling.

The paper 'Using Ontologies for Integrated Geographic Information Systems' by Fonseca, Egenhofer, Agouris, and Camara, published in Transactions in GIS, has become the second most frequently cited paper in that journal.

See
publications with Fonseca for detail.

A method to compare different ontologies for similarity.

We developed a novel approach to computing semantic similarity that relaxes the requirement of a single ontology and accounts for differences in the levels of explicitness and formalization of the different ontology specifications. A similarity function determines similar entity classes by using a matching process over synonym sets, semantic neighborhoods, and distinguishing features that are classified into parts, functions, and attributes. Experimental results with different ontologies indicate that the model gives good results when ontologies have complete and detailed representations of entity classes. While the combination of word matching and semantic neighborhood matching is adequate for detecting equivalent entity classes, feature matching allows us to discriminate among similar, but not necessarily equivalent, entity classes.

The paper 'Determining Semantic Similarity Among Entity Classes from Different Ontologies' by Rodriguez and Egenhofer, published in IEEE Transactions on Knowledge and Data Engineering has already over 110 citations (according to google scholar).

 See publications with Rodriguez for further details.

Training and Development:
Ontology design, ontology construction, and similarity-based ontology alignment.
Software engineering (prototype development by graduate research assistants).
Oral and written presentations.

Outreach Activities:
Participation in the development of the UCGIS emerging
research theme on 'Ontological Foundations of Geographic
Information Science.'

11 keynote addresses related to geo-ontologies and semantic similarity at international conferences
- Interoperating Geographic Information Systems, GeoBrazil, SÒo Paulo, Brazil, June 2000
- Theory-Based Assessment of Semantic Similarity, EURESCO Conference on Ontology and Epistemology for Spatial Data Standard, La Londes-les-Maures, France, September 2000
- Research Directions for Spatial Information SystemsùFrom ôKnowing Your Locationö to ôSpatial Forecasting,ö Twelve Annual Colloquium of the Spatial Information Research Centre, Dunedin, New Zealand, December 2000
- Advances in GIScience Toward Web-Based Arctic GIS, Arctic Geographic Information Systems Workshop, Seattle, WA, January 2001
- Spatial Web, 16th Simp¾sio Brasileiro de Banco de Dados, Rio de Janeiro, Brazil, October 2001
- Toward the Semantic Geospatial Web, ACM-GIS 2002ù10th ACM International Symposium on Advances in Geographic Information Systems, McLean, VA, November 2002
- Sensors, Sensors Everywhere,. GeoSensor Networks 2003, Portland, ME, October 2003

- Spatial Semantics on the Geospatial Semantic Web. GEOPRO 2003: International
Workshop on Semantic Processing of Spatial Data, Mexico City, Mexico, November 2003
- Information Systems Fueled with Data from Geo-Sensor Networks, Information Systems
in Geomanagement, Aachen, Germany, March 2004
- A Grand Challenge for Geographic Information Science, Geoide Summer School 2004,
Ottawa, Canada, May 2004
- Geo-Ontometry: Beyond Geo-Ontologies, First International Workshop on Conceptual
Modeling for GIS, Shanghai, China, November 2004

Participation in a meeting of the NRC committee on Intersections between Geospatial
Information and Information Technology.

Journal Publications

F. Fonseca, M. Egenhofer, C. Davis, and K. Borges
, "Ontologies and Knowledge Sharing in Urban GIS", Computer, Environment and Urban Systems, p. 251, vol. 24, (2000). Published

A. Rodriguez and M. Egenhofer, "Determining Semantic Similarity Among Entity Classes from
Different Ontologies", IEEE Transactions on Knowledge and Data Engineering, p. 442, vol. 15 (2), (2003). Published

F. Fonseca, M. Egenhofer, C. Davis, and G. Camara, "Semantic Granularity in Ontology-Driven Geographic Information
Systems", Annals of Mathematics and Artificial Intelligence, p. 121, vol. 36 (1), (2002). Published

F. Fonseca and M. Egenhofer, "Sistemas de Informacao Geograficos Baseados em Ontologias", Informatica Publica, p. 47, vol. 1, (1999).
Published

A Rodriguez and M. Egenhofer, "Comparing Geospatial Entity Classes: An Asymmetric and Context-Dependent Similarity
Measure", International Journal of Geographical Information Science, p. 229, vol. 18(3), (2004). Published

F. Fonseca, M. Egenhofer, P. Agouris, and G. Camara, "Using Ontologies for Integrated Geographic Information Systems", Transactions in
GIS, p. 231, vol. 6(3), (2002). Published

Books or Other One-time Publications

G. Camara, M. Egenhofer,
F. Fonseca, A. Monteiro, "What's in an Image?", (2001). Refereed Conference Proceedings, Published
Editor(s): D. Montello
Collection: COSIT '01-Conference on
Spatial Information Theory
Bibliography: Lecture Notes in Computer
Science, Vol. 2121, pp. 474-488, Springer-Verlag

F. Fonseca, M. Egenhofer,
and C. Davis, "Ontology-Driven Information
Integration", (2000). Refereed Conference Proceedings, Published
Editor(s): C. Bettini and A. Montanari
Collection: AAAI-2000 Workshop on
Spatial and Temporal
Granularity
Bibliography: pp. 61-64

F. Fonseca, M. Egenhofer,
and C. Borges, "Ontologias e
Interoperabilitade
Semantica entre SIGs", (2000). Refereed Conference Proceedings, Published
Editor(s): C. Davis and G. Camara
Collection: GeoInfo 2000--Anais do II
Workshop Brasiliero de
GeoInformßtica, SÒo Paulo,
Brazil
Bibliography: pp. 45-52

F. Fonseca and M.
Egenhofer, "Knowledge Sharing in
Geographic Information
Systems", (1999). Refereed Conference Proceedings, Published
Editor(s): P. Scheuermann
Collection: IEEE Workshop on
Knowledge and Data
Engineering Exchange
Bibliography: pp. 85-90

F. Fonseca and M.
Egenhofer, "Ontology-Driven
Geographic Information
Systems", (1999). Refereed Conference Proceedings, Published
Editor(s): C. Bauzer Medeiros
Collection: 7th ACM Symposium on
Advances in Geographic
Information Systems
Bibliography: pp. 14-19

A. RodrÝguez and M.
Egenhofer, "Putting Similarity
Assessments into Context:
Matching Functions with the
User's Intended Operations", (1999). Refereed Conference Proceedings, Published
Editor(s): P. Bouquet, L. Serafini, P.
Brezillon, and F. Castellani
Collection: Modeling and Using
Context, CONTEXT-99
Bibliography: Lecture Notes in Artificial
Intelligence, Vol. 1688, pp. 310-323,
Springer-Verlag,

Frederico Fonseca, "Ontology-Driven
Geographic Information
Systems", (2001). Thesis, Published
Bibliography: Ph.D. in Spatial Information
Science and Engineering

A. Rodriguez, "Assessing Semantic
Similarity Among Spatial
Entity Classes", (2000). Thesis, Published
Bibliography: Ph.D. in Spatial Information
Science and Engineering

A. Rodriguez, M. Egenhofer, and A.
Blaser, "Query Pre-Processing of Topological
Constraints: Comparing a
Composition-Based with a
Neighborhood-Based Approach", (2003). Fully refereed conference proceedings, Published
Editor(s): T. Hadzilacos, Y. Manolopoulos, J.
Roddick, and Y. Theodoridis
Collection: SSTD 2003: Eighth International
Symposium on Spatial and Temporal
Databases
Bibliography: Lecture Notes in Computer Science,
Vol. 2750, pp. 362-379, Springer.

M. Egenhofer, "Towards the geospatial semantic web", (2002). Fully refereed conference proceedings, Published
Collection: ACM-GIS 2002
Bibliography: ACM Press, pp. 1-4

J. Farrugia and M. Egenhofer, "Presentations and Bearers of
Semantics on the Web", (2002). Fully refereed conference proceedings, Published
Collection: Semantic Web Track at FLAIRS 2002
Bibliography: pp. 408-412

C. Bauzer Medeiros, M. Egenhofer, and E.
Bertino (eds.), "Advances in Spatial and Temporal
Databases, 9th International Symposium,
SSTD 2005, Angra dos Reis, Brazil,
August 2005, Proceedings", (2005). Book, Published
Editor(s): C. Bauzer Medeiros, M. Egenhofer, and E.
Bertino
Collection: Lecture Notes in Computer Science, Vol.
3633
Bibliography: Springer

A. Rodriguez, I. Cruz, M. Egenhofer, and
S. Levashkin (eds.), "GeoSpatial Semantics, First International
Conference, GeoS 2005, Mexico City,
Mexico, November 2005, Proceedings", (2005). Book, Published
Editor(s): A. Rodriguez, I. Cruz, M. Egenhofer, and
S. Levashkin
Collection: Lecture Notes in Computer Science
Bibliography: Lecture Notes in Computer Science, Vol.
3799

Web/Internet Site

URL(s):
http://www.spatial.maine.edu/~max/CNPq.html
l
Description:

Other Specific Products

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Contributions

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Contributions within Discipline:

The newly developped concepts of ontology-driven GISs and the geospatial semantic web have had a profound impact on the research domain in geographic information science. The University Consortium for Geographic Information Science selected as one of its emerging research themes 'Geospatial Semantic Web' (http://www.personal.psu.edu/ faculty/f/u/fuf1/Fonseca-Sheth.pdf), founding this research challenge explicitly on the work that came out of this research award.

The Brazilian collaborators at INPE have integrated these research results into their master's and GIS programs.

Several doctoral dissertations are under way at the University of M³nster that are extensions of the work on semantic similarity comparisons, the development of which was also funded by this award.

Contributions to Other Disciplines:

In a cross-discplinary effort, the PI co-organized a workshop on Semantic Web Technologies for Searching and Retrieving Scientific Data (Sanibel Island, FL, October 2003), which addressed research issues related to the geospatial semantic web to a broad audience.

PI also initiated the GeoS conference on geospatial semantics, bringing together researchers from computer science, geography, and engineering working.

Contributions to Human Resource Development:

Two PhD students who were partially funded under this grant completed their doctoral degrees (Andrea Rodriguez, 2000; Fred Fonseca, 2001), who are now faculty (Computer Science, University of Concepcion, Chile; and Information Science, PennState, respectively).

One post-doc (Jorge Campos) funded on this project is faculty at the University of Salvador, Brazil.

One doctoral dissertation (Jim Farrugia) is still ongoing.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

The similarity measures have become the foundation for an intelligent spatial search mechanism that Lockheed Martin developped in collaboration with our research group.

A significant new development was the creation of a spin-off company from our research group (Intelligent Spatial Technologies, www.i-spatialtech.com), which focuses on mobile devices. Some parts of the semantic search methods are being incorporated into their iPointer
product.

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Categories for which nothing is reported:

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Any Product

Contributions: To Any Resources for Research and Education

Principle Investigator: Max Egenhofer
Award ID: 9970123
Organization: University of Maine
Title: NSF-CNPq Collaborative Research on Integrating Geospatial Information

Project Participants

Senior Personnel:

Name: Max Egenhofer
Worked More than 160 hours: Yes

Name: Gilberto Camara
Worked More than 160 hours: No

Name: Marcello Tillio
Worked More than 160 hours: No

Name: Peggy Agouris
Worked More than 160 hours: No

Graduate Student
Name: Frederico Fonseco
Worked More than 160 hours: No

Name: Andrea Rodriquez
Worked More than 160 hours: No

Name: Markus Wuersch
Worked More than 160 hours: No

Name: Dominik Wilmsen
Worked More than 160 hours: No

Name: Kostas Nedas
Worked More than 160 hours: No

Organizational Partners

INPE, Brazil
UNICAMP, Brazil
Catholic University Rio De Janiero, Brazil

Activities and Findings

Development and implementation of computation models for semantic similarity based on entity classes

Development and implementation of computation models for semantic similarity based on entity attributes

Outreach Activities

Program Committee Member, Semantic Web and Databases, Berlin, Germany September 2003.

Program Committee Member, Ontologies for Business Information Systems- OntoBIS, Special Session at 6th International Conference on Business Information Systems BIS 2003, Colorado Springs, CO June 2003.

Program Committee Member, Semantic Web and Artificial Intelligence, Special track on Semantic Web at FLAIRS 2003. St Augustine FL. May 2003

Program Committee Member, IV Brazilian Symposium on Geoinformatics-GeoInfo 2002, Caxambu, Brazil, December 2002.

Frederico Fonseca and Amit Sheth authored a research agenda for the Geospatial Semantic Web. Research Priority Series for the University Consortium for Geographic Information Science. http://www/personal.psu.edu/faculty/f/u/fufl/Fonseca-Sheth.pdf

Journal Publications

Rodrìguez, A. and M. Egenhofer. 2004 Comparing Geospatial Entity Classes: An Asymmetric and Context-Dependent Similarity Measure *International Journal of Geographical Information Science*, 18 (3): 229-256.

Rodrìguez, A. and M. Egenhofer. 2003.Determining Semantic Similarity Among Entity Classes from Different Ontologies *IEEE Transactions on Knowledge and Data Engineering*, 15 (2): 442-456.

Fonseca, F. M. Egenhofer, P. Agouris, and G. C,mara. 2002.
Using Ontologies for Integrated Geographic Information Systems
 Transactions in GIS, 6(3): 231-257.

Fonseca, F. M. Egenhofer, C. Davis, and G. C,mara 2002. Semantic Granularity in Ontology-Driven Geographic Information Systems. *Annals of Mathematics and Artificial Intelligence*, 36 (1-2): 121-151.

Book Chapters

Fonseca, F. martin, J. and Rodriguez, A. 2002 From geo to eco-ontolgies. In Geogrpahic Information Science 2002. Lecture Notes in Computer Science. Vol. 2478 (Berlin: Springer) pp. 93-107.

Refereed Conference Proceeding Papers and Presentations

Egenhofer, M. 2002. Toward the Semantic Geospatial Web, ACM-GIS 2002, McLean, VA. A. Voisard, and S.C. Chen (eds) pp. 1-4.

Nedas, K. and M. Egenhofer, 2003. Spatial Similarity Queries with Logical Operators *Advances in Spatial and Temporal Databases, Eighth International Symposium, SSTD 2003*, Santorini, Greece T. Hadzilacos, Y. Manolopoulos, J. Roddick, and Y. Theodoridis (eds.), *Lecture Notes in Computer Science*, Vol. 2750, Springer, pp. 430-448, July 2003.

C,mara, G. M. Egenhofer, F. Fonseca, A. Monteiro
What's in an Image? *COSIT '01-Conference on Spatial Information Theory*, Morro Bay, CA. D. Montello (ed.), *Lecture Notes in Computer Science*, Vol. 2121, Springer-Verlag, pp. 474-488, September 2001.