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Geographic Information Retrieval: Progress and Challenges in Spatial Search of Text

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ABSTRACT

Significant amounts of information available today contain references to places on earth. Traditionally such information has been held as structured data and was the concern of Geographic Information Systems (GIS). However, increasing amounts of data in the form of unstructured text are available for indexing and retrieval that also contain spatial references. This monograph describes the field of Geographic Information Retrieval (GIR) that seeks to develop spatially-aware search systems and support user's geographical information needs. Important concepts with respect to storing, querying and analysing geographical information in computers are introduced, before user needs and interaction in the context of GIR are explored. The task of associating documents with coordinates, prior to their indexing and

ranking forms the core of any GIR system, and different approaches and their implications are discussed. Evaluating the resulting systems and their components, and different paradigms for doing so continue to be an important area of research in GIR and are illustrated through a number of examples. The article concludes by setting out a range of future challenges for research in this field.

1

Introduction

1.1 Setting the scene

The importance of location in search seems obvious. A large proportion of search queries include explicitly geographic search terms, for example in the form of place names (Gan *et al.*, 2008; Aloteibi and Sanderson, 2014). Local search, that is the provision of access through search engine interfaces to structured information, such as opening hours, business locations or local product availability, is estimated to be accessed by 80% of search engine users, and these users actively wish advertising to be locally relevant to their needs¹. Location-based services, where a user's current or predicted location is used as real time contextual information in the delivery of services, are propagating at a furious pace, with a focus on providing information relevant to mobile users' needs (Reichenbacher *et al.*, 2016).

Although search engines have invested heavily in local search in recent years, results retrieved by some search engines are mostly limited to information found in commercial directory listings. The situation is certainly improving with the increasing availability via local search

¹<https://searchenginewatch.com/sew/study/2343577/google-local-searches-lead-50-of-mobile-users-to-visit-stores-study>

of other non-commercial structured or semi-structured georeferenced sources and their associated web sites. There is however a large body of unstructured web content that refers to geographical information but which at present will only be retrieved if there is a direct match between the query terms and terms in the document. Effective access to unstructured documents, in which geographical relevance can be inferred, requires methods that can recognise the presence of geographic references in documents and resolve these unambiguously to locations on the earth's surface. This includes automated interpretation both of place names and of qualifying spatial relationships in queries and in documents. The development of such methods in combination with techniques for indexing, ranking and retrieval of the associated content is the focus of this article.

Understanding geographical information in natural language or free text presents many challenges. Consider the query “beaches near Calgary”. It consists of three important parts, a theme (*beaches*), a spatial relationship (*near*) and a location (*Calgary*). As is typical of most queries in information retrieval, it is under-specified and ambiguous. The geographical nature of the query delivers a number of additional challenges, many of which are difficult to address through standard information retrieval techniques. For example, it is unclear which Calgary is referred to (the landlocked but populous capital of Alberta in Canada, or the beautiful Calgary Bay, found on the Scottish island of Mull). Furthermore, what does “near” mean in such a context? Is it simply a set of beaches ranked by distance from some point location (the centre of downtown Calgary for instance), or all of the beaches found in some constrained space (e.g. all of the beaches on Mull), or beaches within some context-specific travel time or distance from Calgary?² Finally, beaches themselves can range in length from a few tens of meters to many kilometers, raising the question of appropriate ways of representing, ranking and comparing documents describing different beaches in the user interface.

²Note that however “near” is defined for beaches, it will have a different definition when the reference and user location change. “beaches near Calgary” implies a different definition of *near* than “coffee near the Hilton” or “airports near Laramie”.

Dealing with these, and numerous other challenges, lies at the core of what has been termed geographic[al] information retrieval³. The field was initially defined by Larson (1996) as “an applied research area that combines aspects of DBMS research, User Interface Research, GIS research, and Information Retrieval research, ... concerned with indexing, searching, retrieving and browsing of geo-referenced information sources, and the design of systems to accomplish these tasks effectively and efficiently” (p. 81). Jones and Purves (2008) refined this definition by emphasising, analogous to definitions of information retrieval, the importance of unstructured text: “GIR is therefore concerned with improving the quality of geographically specific information retrieval with a focus on access to unstructured documents such as those found on the Web” (p. 219). In the context of the example query given above, this definition has the important implication that GIR must be able to detect and resolve references to locations, typically but not exclusively in the form of place names, or more formally *toponyms*, from unstructured text documents.

Figure 1.1 illustrates schematically a basic model of a GIR system (from a more system-oriented perspective), which allows us to introduce the core concepts which will make up this article. The first component in such a system is a user interface, which mediates between the user and the system and supports user interaction, for example, helping users formulate queries, evaluate results and reformulate their search. With regard to query formulation it is important to consider cognitive representations of space and how these might influence natural language used to specify an information need that includes a spatial component. After a query has been formulated, it must be processed by the system to resolve under-specified information, or present the query and/or initial results to the user for reformulation. Typically, the query is then passed to one or more indexes and documents are retrieved, along with some information as to their (system defined) relevance. Based on these values, documents are ranked, and the results presented to the user in the interface. The representation of results may be optimised to

³Further details about Information Retrieval systems can be found in IR textbooks, such as (Baeza-Yates and Ribeiro-Neto, 2011; Manning *et al.*, 2008; Hearst, 2009; White, 2016)

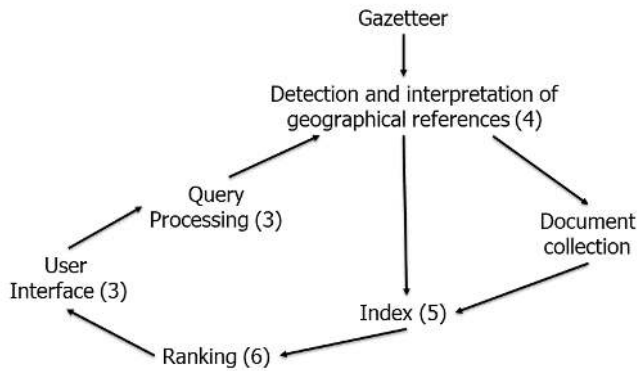


Figure 1.1: Schematic conceptual diagram of a GIR system and its related components - numbers indicate chapters where these topics are handled

allow browsing of large volumes of data or, in a more typical search paradigm, provide a ranked list of potentially relevant results. The user may then choose to refine the query, or click through to further information based on the results initially presented. Having designed a system capable of responding to queries with geographic content, an important research task is to demonstrate that a given system offers advantages over previously published work, through a thorough and reproducible evaluation.

Underlying such a system are a number of other key elements, always including a document collection itself, and typically a gazetteer (which records place names and associated information such as coordinates) or other structured geographical information. Document collections may simply be some part of the web, or more specific documents, for example relating to news stories, travel reports or mountaineering literature. The nature of these collections, for example in terms of their spatial distribution and biases or in terms of the target readership of a set of articles, have important implications for the design and evaluation of any

resulting GIR system, and should be carefully considered. Gazetteers, which typically take the form of lists of place name related information, including geographic coordinates, form one of the key bridges between the disciplines of Information Retrieval (Baeza-Yates and Ribeiro-Neto, 2011) and Geographic Information Science (GIScience) (Goodchild, 2010). These disciplines, underpinned by research in computer science and geography, form two important areas from which much work in the field of GIR has emerged.

1.2 Exemplar GIR systems

As set out in the previous section, the focus of this article is on unstructured text, and methods which allow geographic references in such text to be identified and indexed, together with associated thematic information. By indexing such information it is then possible to both perform targeted searches using some form of query interface, and to explore content with respect to location and theme. In practice, as we will show in the following sections, much research on GIR has focussed on individual aspects of the process (e.g., on georeferencing, ranking, indexing or evaluation). However, in the last decade or so numerous authors have developed more or less complete process chains aimed at performing Geographic Information Retrieval. These process chains vary widely: firstly, with respect to their purpose; secondly, in terms of the text corpora analysed; thirdly, with regard to the external resources used in, for example, structuring space and retrieving toponyms; and fourthly, through the different methods applied to carry out georeferencing, indexing, as well as querying and ranking. Here we introduce a number of exemplar systems and summarise key points with respect to the first three issues. The reader should note that the selection of systems chosen here is not exhaustive; rather these have been identified to illustrate different aspects of GIR in the remainder of this article. In selecting systems our focus was on published literature related to the systems, which have mostly been implemented in a research context and, as is typical in research, many of these systems are no longer maintained. Further examples and a comparison of systems can be found in Palacio

et al. (2010). In subsequent sections we will refer to the approaches taken by these systems where appropriate.

One of the earliest examples of a GIR system was GIPSY (Larson, 1996) which aimed to allow search within a so-called Digital Library. GIPSY focussed on analysing documents rich in geographic content, and used a gazetteer derived from the US Geological Survey's Geographic Names Information System (GNIS) for California. The Web-a-Where project was one of a number of early initiatives which linked locations from gazetteers to web pages (Amitay *et al.*, 2004). Web-a-Where used a number of corpora including a small (200 page) collection of .gov pages, mostly stemming from the US, and a second small collection from the Open Directory Project (ODP) with worldwide coverage. Gazetteer data were again derived from GNIS for the US, and from a number of other sources for non-US locations.

The SPIRIT search engine again focussed on web documents (Purves *et al.*, 2007), but used an initial corpus of some 94 million web pages to georeference 900,000 documents referring to locations in the UK, France, Germany and Switzerland. Gazetteer data were sourced from two datasets - firstly SABE (Seamless Administrative Boundaries of Europe) and, secondly, only relevant to the UK, the Ordnance Survey 1:50000 Scale Gazetteer. The STEWARD search engine (Lieberman *et al.*, 2007) was also initially developed to search general web documents, but also introduced the notion of searching on more specialised corpora, and in particular news articles.

News stories have proved very rich sources of corpora for GIR. Perhaps the most prominent example of an individual system is NewsStand (Teitler *et al.*, 2008), which focussed on collecting and effectively visually summarising news stories in real time, and required the use of gazetteers adapted to the geographic coverage of the sources used. NewsStand thus differed from the systems described previously in that the system was designed to deal with streamed, rather than static, content. Content sourced from newspapers and news wires formed the basis for many of the evaluation tasks in the cross-lingual geographic evaluation efforts known as GeoCLEF (Gey *et al.*, 2005; Mandl *et al.*, 2008a). Sources included, among others, the Los Angeles Times and the Glasgow Herald in English, Der Spiegel in German and Público in Portuguese. The vary-

ing coverage of these collections, and their underlying languages, meant that systems had to adapt in terms of the supporting data used, with challenges emerging due to the local nature of coverage and resulting gaps in gazetteer based knowledge (Stokes *et al.*, 2008).

Methods from GIR have obvious applications in allowing corpora to be analysed and explored. One commonly cited class of corpora relates to cultural heritage. Thus, for example, the Virtual Itineraries in the Pyrenees (PIV) project focussed on extracting spatial and temporal information from a regional media library containing articles pertaining to the Pyrenees (Gaio *et al.*, 2008). As with NewsStand, this in turn implies that a locally adapted gazetteer is made available, so that more fine-grained toponyms can be identified. A similar approach, focussing on natural features, was taken by Derungs and Purves (2014) to characterise spatial regions according to text used to describe them. This work analysed articles from the Swiss Alpine Club dating back to 1865, and used an administrative gazetteer provided by the Swiss national mapping agency to identify fine grained toponyms.

Both of the examples described above deal with corpora with primarily national or regional coverage. Other researchers have used GIR methods to summarise large textual corpora at coarser scales and for much larger geographic regions (ranging from the US to the entire world). The requirement for detailed information in gazetteers is correspondingly lower, and systems of this nature have also sought to use machine learning methods to georeference content without recourse to gazetteers. Key here is the availability of training data with coordinates, of which perhaps the most prominent example is GeoWiki - the set of Wikipedia pages associated with latitudes and longitudes. Two examples of such systems are FrankenPlace, which allows visualisation of thematic terms extracted from travel blogs and Wikipedia (Adams *et al.*, 2015) and an exploration of two much more specialised corpora, both of which nonetheless have global coverage, using the TextGrounder system (Brown *et al.*, 2012). A final example is recent work from Wang and Stewart (Wang and Stewart, 2015) who seek to link semantic information about hazards to both location and time.

1.3 Structure of the article

In this article we aim to bring together research on all elements of Geographic Information Retrieval, with a focus on methods which are applied directly to unstructured text⁴, where geographically relevant information is present, but must be detected and annotated through the use of appropriate methods. Our aim in writing the article is to provide an overview of the research field, and in so doing identify key remaining research challenges in GIR.

In the following chapters, we start by exploring some basic geographic concepts, and reviewing ways in which space is represented and analysed in Geographic Information Science. Chapter 3 then considers the issue of user needs in GIR and how these can be met by different forms of user interface, many of which are designed to assist the user in visualising the geographic context of the retrieved information. The next chapter, on georeferencing, addresses the fundamental problem, highlighted in this introductory chapter, of identifying references to geographic location in unstructured text, typically in the form of place names, and resolving these references to specific locations on the Earth's surface. The following chapter on indexing reviews various approaches of spatio-textual, or spatial keyword, indexing, that integrate techniques of text indexing and spatial indexing to provide efficient access to large document collections in ways that support user queries that refer both to thematic concepts and to geographical location. The challenge of how to rank the resulting retrieved documents to take account of both the thematic and geographic context is the subject of Chapter 6 on relevance and ranking. Key to improving the quality of retrieval systems in ways that help to make the results useful and accessible to the user is the effective development and implementation of schemes for evaluation, which form the subject of Chapter 7. Each of Chapters 3 to 7 refers to some of the exemplar systems that were introduced in the current chapter. This is either in a separate section of the chapter or, in the case of Chapter 3, they are referred to directly within parts of the chapter. We conclude by presenting a number of research challenges that we

⁴Our focus in this article is on written text, rather than social media.

1.3. *Structure of the article*

11

believe need to be overcome in order be successful in advancing the field of geographic information retrieval.

References

- Adams, B., G. McKenzie, and M. Gahegan. 2015. “Frankenplace: Interactive Thematic Mapping for Ad Hoc Exploratory Search”. In: *Proceedings of the 24th International Conference on World Wide Web. WWW '15*. Florence, Italy: International World Wide Web Conferences Steering Committee. 12–22. DOI: [10.1145/2736277.2741137](https://doi.org/10.1145/2736277.2741137). URL: <https://doi.org/10.1145/2736277.2741137>.
- Ahern, S., M. Naaman, R. Nair, and J. H. Yang. 2007. “World explorer: visualizing aggregate data from unstructured text in geo-referenced collections”. In: *Proceedings of the 7th ACM/IEEE-CS joint conference on Digital libraries*. ACM. 1–10.
- Ahlers, D. 2013. “Assessment of the accuracy of geonames gazetteer data”. In: *Proceedings of the 7th Workshop on Geographic Information Retrieval*. ACM. 74–81.
- Ahmed, S. M. Z., C. McKnight, and C. Oppenheim. 2006. “A user-centred design and evaluation of IR interfaces”. *Journal of Librarianship and Information Science*. 38(3): 157–172. DOI: [10.1177/0961000606063882](https://doi.org/10.1177/0961000606063882). eprint: <https://doi.org/10.1177/0961000606063882>. URL: <https://doi.org/10.1177/0961000606063882>.

- Allan, J., B. Croft, A. Moffat, and M. Sanderson. 2012. "Frontiers, Challenges, and Opportunities for Information Retrieval: Report from SWIRL 2012 the Second Strategic Workshop on Information Retrieval in Lorne". In: *ACM SIGIR Forum*. Vol. 46. No. 1. New York, NY, USA: ACM. 2–32. DOI: [10.1145/2215676.2215678](https://doi.org/10.1145/2215676.2215678). URL: <http://doi.acm.org/10.1145/2215676.2215678>.
- Alonso, O. and S. Mizzaro. 2009. "Can we get rid of TREC assessors? Using Mechanical Turk for relevance assessment". In: *SIGIR 2009 Workshop on The Future of IR Evaluation*. 15–16.
- Aloteibi, S. and M. Sanderson. 2014. "Analyzing geographic query reformulation: An exploratory study". *Journal of the Association for Information Science and Technology*. 65(1): 13–24. DOI: [10.1002/asi.22961](https://doi.org/10.1002/asi.22961). URL: <http://dx.doi.org/10.1002/asi.22961>.
- Amitay, E., N. Har'El, R. Sivan, and A. Soffer. 2004. "Web-a-where: Geotagging Web Content". In: *Proceedings of the 27th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '04*. Sheffield, United Kingdom: ACM. 273–280. DOI: [10.1145/1008992.1009040](https://doi.org/10.1145/1008992.1009040). URL: <http://doi.acm.org/10.1145/1008992.1009040>.
- Andogah, G. 2011. *Geographically Constrained Information Retrieval: Geographically Intelligent Information Retrieval*. Germany: LAP Lambert Academic Publishing.
- Andogah, G., G. Bouma, and J. Nerbonne. 2012. "Every Document Has a Geographical Scope". *Data Knowl. Eng.* 81-82(Nov.): 1–20. DOI: [10.1016/j.datak.2012.07.002](https://doi.org/10.1016/j.datak.2012.07.002). URL: <http://dx.doi.org/10.1016/j.datak.2012.07.002>.
- Andrade, L. and M. J. Silva. 2006. "Relevance Ranking for Geographic IR." In: *In Proceedings of GIR'06*.
- Armitage, L. H. and P. G. B. Enser. 1997. "Analysis of user need in image archives". *Journal of Information Science*. 23(4): 287–299. DOI: [10.1177/016555159702300403](https://doi.org/10.1177/016555159702300403). eprint: <https://doi.org/10.1177/016555159702300403>. URL: <https://doi.org/10.1177/016555159702300403>.

- Axelrod, A. E. 2003. "On Building a High Performance Gazetteer Database". In: *Proceedings of the HLT-NAACL 2003 Workshop on Analysis of Geographic References - Volume 1. HLT-NAACL-GEOREF '03*. Stroudsburg, PA, USA: Association for Computational Linguistics. 63–68. DOI: [10.3115 / 1119394.1119404](https://doi.org/10.3115/1119394.1119404). URL: <http://dx.doi.org/10.3115/1119394.1119404>.
- Baeza-Yates, R. A. and B. A. Ribeiro-Neto. 2011. *Modern Information Retrieval - the concepts and technology behind search, Second edition*. Pearson Education Ltd., Harlow, England. URL: <http://www.mir2ed.org/>.
- Bailey, P., P. Thomas, N. Craswell, A. P. D. Vries, I. Soboroff, and E. Yilmaz. 2008. "Relevance assessment: are judges exchangeable and does it matter". In: *Proceedings of the 31st annual international ACM SIGIR conference on Research and development in information retrieval*. ACM. 667–674.
- Bird, S., E. Klein, and E. Loper. 2009. *Natural Language Processing with Python*. 1st. O'Reilly Media, Inc.
- Borges, K. A. V., A. H. F. Laender, C. B. Medeiros, and A. S. D. Silva. 2003. "The web as a data source for spatial databases". In: *In Anais do V Brazilian Symposium on Geoinformatics, Campos do Jordão*.
- Borlund, P. 2009. "User-Centred Evaluation of Information Retrieval Systems". In: *Information Retrieval: Searching in the 21st Century*. Ed. by A. Göker and D. J. John Wiley & Sons. 21–37.
- Borlund, P. and P. Ingwersen. 1997. "The development of a method for the evaluation of interactive information retrieval systems". *Journal of documentation*. 53(3): 225–250.
- Brisaboa, N. R., M. R. Luaces, Á. S. Places, and D. Seco. 2010. "Exploiting geographic references of documents in a geographical information retrieval system using an ontology-based index". *GeoInformatica*. 14(3): 307–331.
- Brooke, J. 1996. "SUS: a quick and dirty usability scale". In: *Usability evaluation in industry*. Ed. by P. Jordan, B. Thomas, B. Weerdmeester, and I. McClelland.

- Brown, T., J. Baldrige, M. Esteva, and W. Xu. 2012. "The substantial words are in the ground and sea: computationally linking text and geography". *Texas Studies in Literature and Language*. 54(3): 324–339.
- Bucher, B., P. Clough, H. Joho, R. Purves, and A. K. Syed. 2005. "Geographic IR systems: requirements and evaluation". *Proceedings of the 22nd International Cartographic Conference*. 201(2005): 11–16.
- Bugayevskiy, L. and J. Snyder. 1995. *Map Projections: A Working Manual*. CRC Press.
- Buscaldi, D. 2011. "Approaches to Disambiguating Toponyms". *SIGSPATIAL Special*. 3(2): 16–19. DOI: [10.1145/2047296.2047300](https://doi.org/10.1145/2047296.2047300). URL: <http://doi.acm.org/10.1145/2047296.2047300>.
- Cai, G. 2002. "GeoVSM: An Integrated Retrieval Model for Geographic Information". In: *Geographic Information Science Second International Conference, GIScience 2002*. Springer. 70–85.
- Cai, G. 2011. "Relevance Ranking in Geographical Information Retrieval". *SIGSPATIAL Special*. 3(2): 33–36. DOI: [10.1145/2047296.2047304](https://doi.org/10.1145/2047296.2047304). URL: <http://doi.acm.org/10.1145/2047296.2047304>.
- Carbonell, J. and J. Goldstein. 1998. "The Use of MMR, Diversity-based Reranking for Reordering Documents and Producing Summaries". In: *Proceedings of the 21st Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '98*. Melbourne, Australia: ACM. 335–336. DOI: [10.1145/290941.291025](https://doi.org/10.1145/290941.291025). URL: <http://doi.acm.org/10.1145/290941.291025>.
- Cardoso, N. 2011. "Evaluating Geographic Information Retrieval". *SIGSPATIAL Special*. 3(2): 46–53.
- Carvalho, V. R., M. Lease, and E. Yilmaz. 2011. "Crowdsourcing for search evaluation". *SIGIR Forum*. 44: 17–22.
- Case, D. O. and L. M. Given. 2016. *Looking for Information: A Survey of Research on Information Seeking, Needs, and Behavior. Studies in Information*. Emerald Group Publishing Limited.

- Chapelle, O., D. Metzler, Y. Zhang, and P. Grinspan. 2009. "Expected Reciprocal Rank for Graded Relevance". In: *Proceedings of the 18th ACM Conference on Information and Knowledge Management. CIKM '09*. Hong Kong, China: ACM. 621–630. DOI: [10.1145/1645953.1646033](https://doi.org/10.1145/1645953.1646033). URL: <http://doi.acm.org/10.1145/1645953.1646033>.
- Chen, L., G. Cong, C. S. Jensen, and D. Wu. 2013. "Spatial keyword query processing: an experimental evaluation". In: *Proceedings of the 39th international conference on Very Large Data Bases. PVLDB'13*. Trento, Italy: VLDB Endowment. 217–228. URL: <http://dl.acm.org/citation.cfm?id=2448948.2448955>.
- Chen, Y., T. Suel, and A. Markowetz. 2006. "Efficient query processing in geographic web search engines". In: *SIGMOD Conference*. 277–288.
- Chin, J. P., V. A. Diehl, and K. L. Norman. 1988. "Development of an Instrument Measuring User Satisfaction of the Human-computer Interface". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '88*. Washington, D.C., USA: ACM. 213–218. DOI: [10.1145/57167.57203](https://doi.org/10.1145/57167.57203). URL: <http://doi.acm.org/10.1145/57167.57203>.
- Choi, J., C. Hauff, O. V. L. Olivier, and B. Thomee. 2015. "The placing task at mediaeval 2015". In: *MediaEval 2015, Wurzen, Germany, 14-15 September 2015; Ceur Workshop Proceedings 1436, 2015*. CEUR.
- Christoforaki, M., J. He, C. Dimopoulos, A. Markowetz, and T. Suel. 2011. "Text vs. Space: Efficient Geo-search Query Processing". In: *Proceedings of the 20th ACM International Conference on Information and Knowledge Management. CIKM '11*. Glasgow, Scotland, UK: ACM. 423–432. DOI: [10.1145/2063576.2063641](https://doi.org/10.1145/2063576.2063641). URL: <http://doi.acm.org/10.1145/2063576.2063641>.
- Cleverdon, C. W. 1991. "The significance of the Cranfield tests on index languages". In: *Proceedings of the 14th annual international ACM SIGIR conference on Research and development in information retrieval. SIGIR '91*. 3–12.
- Cleverdon, C. W., J. Mills, and M. Keen. 1966. "Factors determining the performance of indexing systems". *Aslib Cranfield Research Project Cranfield England*.

- Clough, P. 2005. "Extracting Metadata for Spatially-aware Information Retrieval on the Internet". In: *Proceedings of the 2005 Workshop on Geographic Information Retrieval. GIR '05*. Bremen, Germany: ACM. 25–30. DOI: [10.1145/1096985.1096992](https://doi.org/10.1145/1096985.1096992). URL: <http://doi.acm.org/10.1145/1096985.1096992>.
- Clough, P. D., H. Joho, and R. Purves. 2006. "Judging the Spatial Relevance of Documents for GIR". In: *Advances in Information Retrieval: 28th European Conference on IR Research, ECIR 2006, London, UK, April 10-12, 2006. Proceedings*. Ed. by M. Lalmas, A. MacFarlane, S. Rüger, A. Tombros, T. Tsirikla, and A. Yavlinsky. Berlin, Heidelberg: Springer Berlin Heidelberg. 548–552. DOI: [10.1007/11735106_62](https://doi.org/10.1007/11735106_62). URL: https://doi.org/10.1007/11735106_62.
- Clough, P. and M. Sanderson. 2013. "Evaluating the performance of information retrieval systems using test collections." *Information Research*. 18(2).
- Cohn, A. G. and N. M. Gotts. 1996. "The 'Egg-Yolk' Representation Of Regions with Indeterminate Boundaries". In: *Proceedings, GIS-DATA Specialist Meeting on Geographical Objects with Undetermined Boundaries*. Francis Taylor. 171–187.
- Cole, C. 2011. "A Theory of Information Need for Information Retrieval That Connects Information to Knowledge". *J. Am. Soc. Inf. Sci. Technol.* 62(7): 1216–1231. DOI: [10.1002/asi.21541](https://doi.org/10.1002/asi.21541). URL: <http://dx.doi.org/10.1002/asi.21541>.
- Cong, G. and C. S. Jensen. 2016. "Querying Geo-Textual Data: Spatial Keyword Queries and Beyond". In: *Proceedings of the 2016 International Conference on Management of Data. SIGMOD '16*. San Francisco, California, USA: ACM. 2207–2212. DOI: [10.1145/2882903.2912572](https://doi.org/10.1145/2882903.2912572). URL: <http://doi.acm.org/10.1145/2882903.2912572>.
- Cong, G., C. S. Jensen, and D. Wu. 2009. "Efficient Retrieval of the Top-k Most Relevant Spatial Web Objects". *Proc. VLDB Endow.* 2(1): 337–348. DOI: [10.14778/1687627.1687666](https://doi.org/10.14778/1687627.1687666). URL: <http://dx.doi.org/10.14778/1687627.1687666>.
- Coventry, K. R. and S. C. Garrod. 2004. *Saying, Seeing and Acting: The Psychological Semantics of Spatial Prepositions. Essays in Cognitive Psychology*. Taylor & Francis.

- Crandall, D., L. Backstrom, D. Huttenlocher, and J. Kleinberg. 2009. "Mapping the world's photos". In: *Proceedings of the 18th International Conference on World Wide Web*. ACM. 761–770.
- Curran, J. R. and S. Clark. 2003. "Language Independent NER Using a Maximum Entropy Tagger". In: *Proceedings of the Seventh Conference on Natural Language Learning at HLT-NAACL 2003 - Volume 4. CONLL '03*. Edmonton, Canada: Association for Computational Linguistics. 164–167. DOI: [10.3115/1119176.1119200](https://doi.org/10.3115/1119176.1119200). URL: <http://dx.doi.org/10.3115/1119176.1119200>.
- De Felipe, I., V. Hristidis, and N. Rishe. 2008. "Keyword Search on Spatial Databases". In: *Proceedings of the 2008 IEEE 24th International Conference on Data Engineering. ICDE '08*. Washington, DC, USA: IEEE Computer Society. 656–665. DOI: [10.1109/ICDE.2008.4497474](https://doi.org/10.1109/ICDE.2008.4497474). URL: <http://dx.doi.org/10.1109/ICDE.2008.4497474>.
- De Sabbata, S., O. Alonso, and S. Mizzaro. 2012. "Classical vs. crowdsourcing surveys for eliciting geographic relevance criteria". In: *IIR 2012 Italian Information Retrieval Workshop*. Ed. by G. Amati, C. Carpineto, and G. Semeraro. *CEUR Workshop Proceedings*. No. 835. Dipartimento di Informatica (DIB), Università di Bari "Aldo Moro". 65–72. URL: <https://doi.org/10.5167/uzh-66808>.
- De Sabbata, S. and T. Reichenbacher. 2010. "A Probabilistic Model of Geographic Relevance". In: *Proceedings of the 6th Workshop on Geographic Information Retrieval. GIR '10*. Zurich, Switzerland: ACM. 23:1–23:2. DOI: [10.1145/1722080.1722109](https://doi.org/10.1145/1722080.1722109). URL: <http://doi.acm.org/10.1145/1722080.1722109>.
- De Sabbata, S. and T. Reichenbacher. 2012. "Criteria of geographic relevance: an experimental study". *International Journal of Geographical Information Science*. 26(8): 1495–1520.
- DeLozier, G., J. Baldrige, and L. London. 2015. "Gazetteer-independent Toponym Resolution Using Geographic Word Profiles". In: *Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence. AAAI'15*. Austin, Texas: AAAI Press. 2382–2388. URL: <http://dl.acm.org/citation.cfm?id=2886521.2886652>.

- Derungs, C. and R. S. Purves. 2014. “From text to landscape: locating, identifying and mapping the use of landscape features in a Swiss Alpine corpus”. *International Journal of Geographical Information Science*. 28(6): 1272–1293. DOI: [10.1080/13658816.2013.772184](https://doi.org/10.1080/13658816.2013.772184). eprint: <http://dx.doi.org/10.1080/13658816.2013.772184>. URL: <http://dx.doi.org/10.1080/13658816.2013.772184>.
- Derungs, C. and R. S. Purves. 2016. “Mining nearness relations from an n-grams Web corpus in geographical space”. *Spatial Cognition & Computation*. 16(4): 301–322.
- Ding, J., L. Gravano, and N. Shivakumar. 2000. “Computing Geographical Scopes of Web Resources”. In: *Proceedings of the 26th International Conference on Very Large Data Bases. VLDB '00*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc. 545–556. URL: <http://dl.acm.org/citation.cfm?id=645926.672013>.
- Drosou, M. and E. Pitoura. 2010. “Search Result Diversification”. *SIGMOD Rec.* 39(1): 41–47. DOI: [10.1145/1860702.1860709](https://doi.org/10.1145/1860702.1860709). URL: <http://doi.acm.org/10.1145/1860702.1860709>.
- Dunlop, M. 2000. “Reflections on Mira: Interactive evaluation in information retrieval”. *Journal of the American Society for Information Science*. 51(14): 1269–1274. DOI: [10.1002/1097-4571\(2000\)9999:9999<::AID-ASI1042>3.0.CO;2-7](https://doi.org/10.1002/1097-4571(2000)9999:9999::AID-ASI1042>3.0.CO;2-7).
- Dykes, J., A. M. MacEachren, and M.-J. Kraak. 2005. *Exploring geovisualization*. Elsevier.
- Feng, J., M. Johnston, and S. Bangalore. 2011. “Speech and multimodal interaction in mobile search”. *Signal Processing Magazine, IEEE*. 28(4): 40–49.
- Ferrès, D. and H. Rodriguez. 2015. “Evaluating geographical knowledge re-ranking, linguistic processing and query expansion techniques for geographical information retrieval”. In: *International Symposium on String Processing and Information Retrieval*. Springer. 311–323.
- Fisher, P. 2000. “Sorites paradox and vague geographies”. *Fuzzy Sets and Systems*. 113(1): 7–18. DOI: [https://doi.org/10.1016/S0165-0114\(99\)00009-3](https://doi.org/10.1016/S0165-0114(99)00009-3). URL: <http://www.sciencedirect.com/science/article/pii/S0165011499000093>.

- Frontiera, P., R. Larson, and J. Radke. 2008. "A Comparison of Geometric Approaches to Assessing Spatial Similarity for GIR". *Int. J. Geogr. Inf. Sci.* 22(3): 337–360. DOI: [10.1080/13658810701626293](https://doi.org/10.1080/13658810701626293). URL: <http://dx.doi.org/10.1080/13658810701626293>.
- Gaio, M., C. Sallaberry, P. Etcheverry, C. Marquesuzaa, and J. Lesbegueries. 2008. "A global process to access documents'contents from a geographical point of view". *Journal of Visual Languages & Computing.* 19(1): 3–23.
- Gale, W., K. Church, and D. Yarowsky. 1992. "One Sense Per Discourse". In: *Proceedings of the Workshop on Speech and Natural Language. HLT '91*. Harriman, New York: Association for Computational Linguistics. 233–237. DOI: [10.3115/1075527.1075579](https://doi.org/10.3115/1075527.1075579). URL: <http://dx.doi.org/10.3115/1075527.1075579>.
- Gan, Q., J. Attenberg, A. Markowetz, and T. Suel. 2008. "Analysis of Geographic Queries in a Search Engine Log". In: *Proceedings of the First International Workshop on Location and the Web. LOCWEB '08*. Beijing, China: ACM. 49–56. DOI: [10.1145/1367798.1367806](https://doi.org/10.1145/1367798.1367806). URL: <http://doi.acm.org/10.1145/1367798.1367806>.
- Gao, S., K. Janowicz, D. R. Montello, Y. Hu, J.-A. Yang, G. McKenzie, Y. Ju, L. Gong, B. Adams, and B. Yan. 2017. "A data-synthesis-driven method for detecting and extracting vague cognitive regions". *International Journal of Geographical Information Science.* 31(6): 1245–1271.
- Gey, F. C., R. R. Larson, M. Sanderson, H. Joho, P. Clough, and V. Petras. 2005. "GeoCLEF: The CLEF 2005 Cross-Language Geographic Information Retrieval Track Overview". In: *CLEF*. 908–919.
- Gey, F., R. Larson, M. Sanderson, K. Bischoff, T. Mandl, C. Womser-Hacker, D. Santos, P. Rocha, and A. Montoyo. 2007. "Challenges to evaluation of multilingual geographic information retrieval in GeoCLEF". In: *The First International Workshop on Evaluating Information Access (EVIA)*. URL: <http://eprints.whiterose.ac.uk/4535/>.
- Goodchild, M. F. 2010. "Twenty years of progress: GIScience in 2010". *Journal of Spatial Information Science.* 2010(1): 3–20.

- Graham, M. and S. De Sabbata. 2015. "Mapping information wealth and poverty: the geography of gazetteers". *Environment and Planning A*. 47(6): 1254–1264.
- Gritta, M., M. T. Pilehvar, N. Limsopatham, and N. Collier. 2017. "What's missing in geographical parsing?" *Language Resources and Evaluation*. Mar. DOI: [10.1007/s10579-017-9385-8](https://doi.org/10.1007/s10579-017-9385-8). URL: <https://doi.org/10.1007/s10579-017-9385-8>.
- Grover, C., R. Tobin, K. Byrne, M. Woollard, J. Reid, S. Dunn, and J. Ball. 2010. "Use of the Edinburgh geoparser for georeferencing digitized historical collections". *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*. 368(1925): 3875–3889. DOI: [10.1098/rsta.2010.0149](https://doi.org/10.1098/rsta.2010.0149). eprint: <http://rsta.royalsocietypublishing.org/content/368/1925/3875.full.pdf>. URL: <http://rsta.royalsocietypublishing.org/content/368/1925/3875>.
- Hall, M. M., P. D. Smart, and C. B. Jones. 2011. "Interpreting Spatial Language in Image Captions". *Cognitive Processing*. 12(1): 67–94. DOI: [10.1007/s10339-010-0385-5](https://doi.org/10.1007/s10339-010-0385-5).
- Hariharan, R., B. Hore, C. Li, and S. Mehrotra. 2007a. "Processing Spatial-Keyword (SK) Queries in Geographic Information Retrieval (GIR) Systems". In: *19th International Conference on Scientific and Statistical Database Management (SSDBM 2007)*. 16–16. DOI: [10.1109/SSDBM.2007.22](https://doi.org/10.1109/SSDBM.2007.22).
- Hariharan, R., B. Hore, C. Li, and S. Mehrotra. 2007b. "Processing Spatial-Keyword (SK) Queries in Geographic Information Retrieval (GIR) Systems". In: *Proceedings of the 19th International Conference on Scientific and Statistical Database Management. SSDBM '07*. Washington, DC, USA: IEEE Computer Society. 16–16. DOI: [10.1109/SSDBM.2007.22](https://doi.org/10.1109/SSDBM.2007.22). URL: <http://dx.doi.org/10.1109/SSDBM.2007.22>.
- Harman, D. 2011. *Information Retrieval Evaluation*. 1st. Morgan & Claypool Publishers.
- Harter, S. P. and C. A. Hert. 1997. "Evaluation of information retrieval systems: Approaches, issues, and methods." *Annual Review of Information Science and Technology (ARIST)*. 32: 3–94.

- Hearst, M. A. 2009. *Search User Interfaces*. 1st. New York, NY, USA: Cambridge University Press.
- Henrich, A. and V. Luedecke. 2007. "Characteristics of Geographic Information Needs". In: *Proceedings of the 4th ACM Workshop on Geographical Information Retrieval. GIR '07*. Lisbon, Portugal: ACM. 1–6. DOI: [10.1145/1316948.1316950](https://doi.org/10.1145/1316948.1316950). URL: <http://doi.acm.org/10.1145/1316948.1316950>.
- Herskovits, A. 1986. *Language and Spatial Cognition: An Interdisciplinary Study of Prepositions in English*. Cambridge University Press.
- Hill, L. L. 2000. "Core elements of digital gazetteers: placenames, categories, and footprints". In: *Research and advanced technology for digital libraries*. Springer. 280–290.
- Hill, L. L. 2006. *Georeferencing: The Geographic Associations of Information (Digital Libraries and Electronic Publishing)*. The MIT Press.
- Hill, L. L., L. Carver, M. Larsgaard, R. Dolin, T. R. Smith, J. Frew, and M.-A. Rae. 2000. "Alexandria digital library: user evaluation studies and system design". *Journal of the American Society for Information Science*. 51(3): 246–259.
- Himmelstein, M. 2005. "Local Search: The Internet Is the Yellow Pages". *Computer*. 38(2): 26–34. DOI: [http://doi.ieeecomputersociety.org/10.1109/MC.2005.65](https://doi.org/10.1109/MC.2005.65).
- Hjaltason, G. and H. Samet. 1999. "Distance browsing in spatial databases". *ACM Transactions on Database Systems*. 24(2): 265–318.
- Hobona, G., P. James, and D. Fairbairn. 2005. "An Evaluation of a Multidimensional Visual Interface for Geographic Information Retrieval". In: *Proceedings of the 2005 Workshop on Geographic Information Retrieval. GIR '05*. Bremen, Germany: ACM. 5–8. DOI: [10.1145/1096985.1096988](https://doi.org/10.1145/1096985.1096988). URL: <http://doi.acm.org/10.1145/1096985.1096988>.

- Hoeber, O. and X. D. Yang. 2007. "User-Oriented Evaluation Methods for Interactive Web Search Interfaces". In: *Proceedings of the 2007 IEEE/WIC/ACM International Conferences on Web Intelligence and Intelligent Agent Technology - Workshops. WI-IATW '07*. IEEE Computer Society. 239–243.
- Hofmann, K., L. Li, and F. Radlinski. 2016. "Online Evaluation for Information Retrieval". *Foundations and Trends(R) in Information Retrieval*. 10(June): 1–117.
- Ide, N. and J. Véronis. 1998. "Introduction to the Special Issue on Word Sense Disambiguation: The State of the Art". *Comput. Linguist.* 24(1): 2–40. URL: <http://dl.acm.org/citation.cfm?id=972719.972721>.
- Janowicz, K., M. Raubal, and W. Kuhn. 2011. "The semantics of similarity in geographic information retrieval". *Journal of Spatial Information Science*. 2011(2): 29–57.
- Järvelin, K. 2011. "Evaluation". In: *Interactive information seeking, behaviour and retrieval*. Ed. by I. Ruthven and D. Kelly. London, UK: Facet Publishing.
- Järvelin, K. and J. Kekäläinen. 2000. "IR Evaluation Methods for Retrieving Highly Relevant Documents". In: *Proceedings of the 23rd Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '00*. Athens, Greece: ACM. 41–48. DOI: [10.1145/345508.345545](https://doi.org/10.1145/345508.345545). URL: <http://doi.acm.org/10.1145/345508.345545>.
- Jones, C. B., A. I. Abdelmoty, D. Finch, G. Fu, and S. Vaid. 2004. "The SPIRIT Spatial Search Engine: Architecture, Ontologies and Spatial Indexing". In: *Geographic Information Science*. Ed. by M. J. Egenhofer, C. Freksa, and H. J. Miller. Vol. 3234. *Lecture Notes in Computer Science*. Springer Berlin Heidelberg. 125–139. DOI: [10.1007/978-3-540-30231-5_9](https://doi.org/10.1007/978-3-540-30231-5_9). URL: http://dx.doi.org/10.1007/978-3-540-30231-5_9.
- Jones, C. B. and R. S. Purves. 2008. "Geographical Information Retrieval". *Int. J. Geogr. Inf. Sci.* 22(3): 219–228. DOI: [10.1080/13658810701626343](https://doi.org/10.1080/13658810701626343). URL: <http://dx.doi.org/10.1080/13658810701626343>.

- Jones, C. B., R. S. Purves, P. D. Clough, and H. Joho. 2008. "Modelling Vague Places with Knowledge from the Web". *Int. J. Geogr. Inf. Sci.* 22(10): 1045–1065. DOI: [10.1080/13658810701850547](https://doi.org/10.1080/13658810701850547). URL: <http://dx.doi.org/10.1080/13658810701850547>.
- Karimzadeh, M., W. Huang, S. Banerjee, J. O. Wallgrün, F. Hardisty, S. Pezanowski, P. Mitra, and A. M. MacEachren. 2013. "GeoTxt: A Web API to Leverage Place References in Text". In: *Proceedings of the 7th Workshop on Geographic Information Retrieval. GIR '13*. Orlando, Florida: ACM. 72–73. DOI: [10.1145/2533888.2533942](https://doi.org/10.1145/2533888.2533942). URL: <http://doi.acm.org/10.1145/2533888.2533942>.
- Karney, C. F. F. 2013. "Algorithm for Geodesics". *Journey of Geodetics*. 87(1): 43–55.
- Kelly, D. 2009. "Methods for evaluating interactive information retrieval systems with users". *Foundations and Trends in Information Retrieval*. 3(1-2): 1–224.
- Kesler, C., K. Janowicz, and M. Bishr. 2009. "An agenda for the next generation gazetteer: Geographic information contribution and retrieval". In: *Proceedings of the 17th ACM SIGSPATIAL international conference on advances in Geographic Information Systems*. ACM. 91–100.
- Khodaei, A., C. Shahabi, and C. Li. 2010. "Hybrid Indexing and Seamless Ranking of Spatial and Textual Features of Web Documents". In: *DEXA*. 450–466.
- Khodaei, A., C. Shahabi, and C. Li. 2012. "SKIF-P: a point-based indexing and ranking of web documents for spatial-keyword search". *GeoInformatica*. 16(3): 563–596.
- Kinney, K. A., S. B. Huffman, and J. Zhai. 2008. "How evaluator domain expertise affects search result relevance judgments". In: *Proceedings of the 17th ACM conference on Information and knowledge management. CIKM '08*. ACM. 591–598.
- Kinsella, S., V. Murdock, and N. O'Hare. 2011. "'I'M Eating a Sandwich in Glasgow": Modeling Locations with Tweets". In: *Proceedings of the 3rd International Workshop on Search and Mining User-generated Contents. SMUC '11*. Glasgow, Scotland, UK: ACM. 61–68. DOI: [10.1145/2065023.2065039](https://doi.org/10.1145/2065023.2065039). URL: <http://doi.acm.org/10.1145/2065023.2065039>.

- Kreveld, M., I. Reinbacher, A. Arampatzis, and R. Zwol. 2005. "Developments in Spatial Data Handling: 11th International Symposium on Spatial Data Handling". In: Berlin, Heidelberg: Springer Berlin Heidelberg. Chap. Distributed Ranking Methods for Geographic Information Retrieval. 231–243. DOI: [10.1007/3-540-26772-7_18](https://doi.org/10.1007/3-540-26772-7_18). URL: http://dx.doi.org/10.1007/3-540-26772-7_18.
- Laere, O. V., S. Schockaert, V. Tanasescu, B. Dhoedt, and C. B. Jones. 2014. "Georeferencing Wikipedia Documents Using Data from Social Media Sources". *ACM Trans. Inf. Syst.* 32(3): 12:1–12:32. DOI: [10.1145/2629685](https://doi.org/10.1145/2629685). URL: <http://doi.acm.org/10.1145/2629685>.
- Landau, B. and R. Jackendoff. 1993. "'What' and 'where' in spatial language and spatial cognition". *Behavioral and Brain Sciences*. 16(2): 217–238.
- Larson, R. R. 1996. "Geographic Information Retrieval and Spatial Browsing". *GIS and Libraries: Patrons, Maps and Spatial Information*. Apr.: 81–124. Ed. by L. Smith and M. Gluck.
- Larson, R. R. 2011. "Ranking Approaches for GIR". *SIGSPATIAL Special*. 3(2): 37–41. DOI: [10.1145/2047296.2047305](https://doi.org/10.1145/2047296.2047305). URL: <http://doi.acm.org/10.1145/2047296.2047305>.
- Larson, R. R. and P. Frontiera. 2004. "Spatial Ranking Methods for Geographic Information Retrieval (GIR) in Digital Libraries". In: *Research and Advanced Technology for Digital Libraries, 8th European Conference, ECDL 2004, Bath, UK, September 12-17, 2004, Proceedings*. 45–56.
- Leidner, J. L. 2006. "An evaluation dataset for the toponym resolution task". *Computers, Environment and Urban Systems*. 30(4): 400–417.
- Leidner, J. L. 2008. *Toponym Resolution in Text : Annotation, Evaluation and Applications of Spatial Grounding of Place Names*. Boca Raton, FL, USA: Universal Press.
- Leidner, J. L. and M. D. Lieberman. 2011. "Detecting Geographical References in the Form of Place Names and Associated Spatial Natural Language". *SIGSPATIAL Special*. 3(2): 5–11. DOI: [10.1145/2047296.2047298](https://doi.org/10.1145/2047296.2047298). URL: <http://doi.acm.org/10.1145/2047296.2047298>.

- Leveling, J. 2015. “Tagging of Temporal Expressions and Geological Features in Scientific Articles”. In: *Proceedings of the 9th Workshop on Geographic Information Retrieval. GIR '15*. Paris, France: ACM. 6:1–6:10. DOI: [10.1145/2837689.2837701](https://doi.org/10.1145/2837689.2837701). URL: <http://doi.acm.org/10.1145/2837689.2837701>.
- Levinson, S. C. 2003a. “Frames of reference”. In: *Space in Language and Cognition: Explorations in Cognitive Diversity. Language Culture and Cognition*. Cambridge University Press. 24–61. DOI: [10.1017/CBO9780511613609.003](https://doi.org/10.1017/CBO9780511613609.003).
- Levinson, S. C. 2003b. *Space in language and cognition: Explorations in cognitive diversity*. Cambridge: CUP.
- Lewis, J. R. 1995. “IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use”. *International Journal of Human-Computer Interaction*. 7(1): 57–78.
- Li, H. 2011. “A Short Introduction to Learning to Rank”. *IEICE Transactions on Information and Systems*. E94.D(10): 1854–1862. DOI: [10.1587/transinf.E94.D.1854](https://doi.org/10.1587/transinf.E94.D.1854).
- Li, H., R. K. Srihari, C. Niu, and W. Li. 2003. “InfoXtract Location Normalization: A Hybrid Approach to Geographic References in Information Extraction”. In: *Proceedings of the HLT-NAACL 2003 Workshop on Analysis of Geographic References - Volume 1. HLT-NAACL-GEOREF '03*. Stroudsburg, PA, USA: Association for Computational Linguistics. 39–44. DOI: [10.3115/1119394.1119400](https://doi.org/10.3115/1119394.1119400). URL: <http://dx.doi.org/10.3115/1119394.1119400>.
- Li, Z., K. C. K. Lee, B. Zheng, W.-C. Lee, D. L. Lee, and X. Wang. 2011. “IR-Tree: An Efficient Index for Geographic Document Search.” *IEEE Transactions on Knowledge and Data Engineering*. 23(4): 585–599. URL: <http://dblp.uni-trier.de/db/journals/tkde/tkde23.html#LiLZLLW11>.
- Lieberman, M. D., H. Samet, and J. Sankaranarayanan. 2010. “Geotagging with local lexicons to build indexes for textually-specified spatial data”. In: *2010 IEEE 26th International Conference on Data Engineering (ICDE 2010)*. 201–212. DOI: [10.1109/ICDE.2010.5447903](https://doi.org/10.1109/ICDE.2010.5447903).

- Lieberman, M. D., H. Samet, J. Sankaranarayanan, and J. Sperling. 2007. "STEWARD: Architecture of a Spatio-textual Search Engine". In: *Proceedings of the 15th Annual ACM International Symposium on Advances in Geographic Information Systems. GIS '07*. Seattle, Washington: ACM. 25:1–25:8. DOI: [10.1145/1341012.1341045](https://doi.org/10.1145/1341012.1341045). URL: <http://doi.acm.org/10.1145/1341012.1341045>.
- Lieberman, M. and H. Samet. 2012. "Adaptive Context Features for Toponym Resolution in Streaming News". In: *Proceedings of the 35th International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '12*. Portland, Oregon, USA: ACM. 731–740. ISBN: 978-1-4503-1472-5. DOI: [10.1145/2348283.2348381](https://doi.org/10.1145/2348283.2348381). URL: <http://doi.acm.org/10.1145/2348283.2348381>.
- Liu, T.-Y. 2009. "Learning to Rank for Information Retrieval". *Foundations and Trends in Information Retrieval*. 3(3): 225–331. DOI: [10.1561/1500000016](https://doi.org/10.1561/1500000016). URL: <http://dx.doi.org/10.1561/1500000016>.
- Longley, P. A., M. F. Goodchild, D. J. Maguire, and D. W. Rhind. 2015. *Geographic information science and systems*. John Wiley & Sons.
- Lowe, D. G. 2004. "Distinctive image features from scale-invariant keypoints". *International journal of computer vision*. 60(2): 91–110.
- MacEachren, A. M. 1995. *How maps work: representation, visualization, and design*. Guilford Press.
- Mackaness, W. A., A. Ruas, and L. T. Sarjakoski. 2011. *Generalisation of geographic information: cartographic modelling and applications*. Elsevier.
- Mandl, T. 2011. "Evaluating GIR: Geography-oriented or User-oriented?" *SIGSPATIAL Special*. 3(2): 42–45.
- Mandl, T., P. Carvalho, G. M. Di Nunzio, F. Gey, R. R. Larson, D. Santos, and C. Womser-Hacker. 2008a. "GeoCLEF 2008: the CLEF 2008 cross-language geographic information retrieval track overview". In: *Evaluating Systems for Multilingual and Multimodal Information Access*. Springer. 808–821.

- Mandl, T., F. Gey, G. (Di Nunzio), N. Ferro, M. Sanderson, D. Santos, and C. Womser-Hacker. 2008b. "An Evaluation Resource for Geographic Information Retrieval". In: *Proceedings of the Sixth International Conference on Language Resources and Evaluation (LREC'08)*. Ed. by N. C. (Chair), K. Choukri, B. Maegaard, J. Mariani, J. Odijk, S. Piperidis, and D. Tapias. <http://www.lrec-conf.org/proceedings/lrec2008/>. Marrakech, Morocco: European Language Resources Association (ELRA).
- Manguinhas, H., B. Martins, and J. Borbinha. 2008. "A geo-temporal web gazetteer integrating data from multiple sources". In: *Digital Information Management, 2008. ICDIM 2008. Third International Conference on*. IEEE. 146–153.
- Manning, C. D., P. Raghavan, and H. Schütze. 2008. *Introduction to Information Retrieval*. New York, NY, USA: Cambridge University Press.
- Mao, J., Y. Liu, K. Zhou, J.-Y. Nie, J. Song, M. Zhang, S. Ma, J. Sun, and H. Luo. 2016. "When Does Relevance Mean Usefulness and User Satisfaction in Web Search?" In: *Proceedings of the 39th International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '16*. Pisa, Italy: ACM. 463–472. DOI: [10.1145/2911451.2911507](https://doi.org/10.1145/2911451.2911507). URL: <http://doi.acm.org/10.1145/2911451.2911507>.
- Marchionini, G. 2006. "Exploratory Search: From Finding to Understanding". *Commun. ACM*. 49(4): 41–46. DOI: [10.1145/1121949.1121979](https://doi.org/10.1145/1121949.1121979). URL: <http://doi.acm.org/10.1145/1121949.1121979>.
- Mark, D. M., D. Comas, M. . Egenhofer, S. M. Freundschuh, M. D. Gould, and J. Nunes. 1995. "Evaluating and refining computational models of spatial relations through cross-linguistic human-subjects testing". In: *Spatial Information Theory A Theoretical Basis for GIS*. Vol. 988/1995. *Lecture Notes in Computer Science*. Springer Berlin / Heidelberg. 553–568.
- Martins, B. 2011. "A supervised machine learning approach for duplicate detection over gazetteer records". In: *GeoSpatial Semantics*. Springer. 34–51.

- Martins, B. and P. Calado. 2010. "Learning to Rank for Geographic Information Retrieval". In: *Proceedings of the 6th Workshop on Geographic Information Retrieval. GIR '10*. Zurich, Switzerland: ACM. 21:1–21:8. DOI: [10.1145/1722080.1722107](https://doi.org/10.1145/1722080.1722107). URL: <http://doi.acm.org/10.1145/1722080.1722107>.
- Martins, B., M. J. Silva, and M. S. Chaves. 2005. "Challenges and Resources for Evaluating Geographical IR". In: *Proceedings of the 2005 Workshop on Geographic Information Retrieval. GIR '05*. Bremen, Germany: ACM. 65–69.
- Al-Maskari, A., M. Sanderson, and P. Clough. 2007. "The Relationship Between IR Effectiveness Measures and User Satisfaction". In: *Proceedings of the 30th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '07*. Amsterdam, The Netherlands: ACM. 773–774. ISBN: 978-1-59593-597-7. DOI: [10.1145/1277741.1277902](https://doi.org/10.1145/1277741.1277902). URL: <http://doi.acm.org/10.1145/1277741.1277902>.
- McCurley, K. S. 2001. "Geospatial Mapping and Navigation of the Web". In: *Proceedings of the 10th International Conference on World Wide Web. WWW '01*. Hong Kong, Hong Kong: ACM. 221–229. DOI: [10.1145/371920.372056](https://doi.org/10.1145/371920.372056).
- Melo, F. and B. Martins. 2017. "Automated Geocoding of Textual Documents: A Survey of Current Approaches". *Transactions in GIS*. 21(1): 3–38.
- Mikheev, A., M. Moens, and C. Grover. 1999. "Named Entity Recognition Without Gazetteers". In: *Proceedings of the Ninth Conference on European Chapter of the Association for Computational Linguistics. EACL '99*. Bergen, Norway: Association for Computational Linguistics. 1–8. DOI: [10.3115/977035.977037](https://doi.org/10.3115/977035.977037). URL: <http://dx.doi.org/10.3115/977035.977037>.
- Montello, D. R. 2016. "Cognition and Spatial Behavior". In: *International Encyclopedia of Geography: People, the Earth, Environment and Technology*. John Wiley & Sons, Ltd. DOI: [10.1002/9781118786352.wbieg0498](https://doi.org/10.1002/9781118786352.wbieg0498). URL: <http://dx.doi.org/10.1002/9781118786352.wbieg0498>.

- Montello, D. R., M. F. Goodchild, J. Gottsegen, and P. Fohl. 2003. "Where's Downtown?: Behavioral Methods for Determining Referents of Vague Spatial Queries". *Spatial Cognition & Computation*. 3(3): 185–104.
- Morimoto, Y., M. Aono, M. E. Houle, and K. S. McCurley. 2003. "Extracting spatial knowledge from the web". In: *2003 Symposium on Applications and the Internet, 2003. Proceedings*. 326–333. DOI: [10.1109/SAINT.2003.1183066](https://doi.org/10.1109/SAINT.2003.1183066).
- Morville, P. and L. Rosenfeld. 2006. *Information Architecture for the World Wide Web*. O'Reilly Media, Inc.
- Nadeau, D. and S. Sekine. 2007. "A Survey of Named Entity Recognition and Classification". *Journal of Linguisticae Investigationes*. 30(1): 1–20. URL: <http://nlp.cs.nyu.edu/sekine/papers/li07.pdf>.
- Nielsen, J. 1993. *Usability Engineering*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.
- O'Hare, N. and V. Murdock. 2013. "Modeling locations with social media". *Information Retrieval*. 16(1): 30–62.
- O'Sullivan, D. and D. Unwin. 2014. *Geographic information analysis*. John Wiley & Sons.
- Opach, T., I. Golebiowska, and S. I. Fabrikant. 2013. "How Do People View Multi-Component Animated Maps?" *The Cartographic Journal*. online(Oct.). DOI: [dx.doi.org/10.1179/1743277413Y.0000000049](https://doi.org/dx.doi.org/10.1179/1743277413Y.0000000049).
- Overell, S. and S. Rürger. 2008. "Using co-occurrence models for place-name disambiguation". *International Journal of Geographical Information Science*. 22(3): 265–287.
- Palacio, D., G. Cabanac, C. Sallaberry, and G. Hubert. 2010. "On the Evaluation of Geographic Information Retrieval Systems: Evaluation Framework and Case Study". *Int. J. Digit. Libr.* 11(2): 91–109. DOI: [http://dx.doi.org/10.1007/s00799-011-0070-z](https://doi.org/http://dx.doi.org/10.1007/s00799-011-0070-z). URL: <http://dx.doi.org/10.1007/s00799-011-0070-z>.
- Palacio, D., C. Derungs, and R. Purves. 2015. "Development and evaluation of a geographic information retrieval system using fine grained toponyms". *Journal of Spatial Information Science*. (11): 1–29.

- Pasley, R. C., P. D. Clough, and M. Sanderson. 2007. "Geo-tagging for Imprecise Regions of Different Sizes". In: *Proceedings of the 4th ACM Workshop on Geographical Information Retrieval. GIR '07*. Lisbon, Portugal: ACM. 77–82. DOI: [10.1145/1316948.1316969](https://doi.org/10.1145/1316948.1316969). URL: <http://doi.acm.org/10.1145/1316948.1316969>.
- Purves, R. S. and P. D. Clough. 2006. "Judging spatial relevance and document location for Geographic Information Retrieval". In: *In Proceedings of 4th International Conference on Geographic Information Science (GIScience 2006)*. 159–164.
- Purves, R. S., P. Clough, C. B. Jones, A. Arampatzis, B. Bucher, D. Finch, G. Fu, H. Joho, A. K. Syed, S. Vaid, and B. Yang. 2007. "The Design and Implementation of SPIRIT: A Spatially Aware Search Engine for Information Retrieval on the Internet". *Int. J. Geogr. Inf. Sci.* 21(7): 717–745. DOI: [10.1080/13658810601169840](https://doi.org/10.1080/13658810601169840). URL: <http://dx.doi.org/10.1080/13658810601169840>.
- Purves, R. S., A. Edwardes, and M. Sanderson. 2008. "Describing the where—improving image annotation and search through geography". In: *Proceedings of the workshop on Metadata Mining for Image Understanding (MMIU 2008)*. Sheffield.
- Raper, J. 2007. "Geographic relevance". *Journal of Documentation*. 63(6): 836–852.
- Rapp, R. H. 1993. "Geometric geodesy, part II, Technical report," *tech. rep.* Ohio State Univ. URL: <http://hdl.handle.net/1811/24409>.
- Rauch, E., M. Bukatin, and K. Baker. 2003. "A Confidence-based Framework for Disambiguating Geographic Terms". In: *Proceedings of the HLT-NAACL 2003 Workshop on Analysis of Geographic References - Volume 1. HLT-NAACL-GEOREF '03*. Stroudsburg, PA, USA: Association for Computational Linguistics. 50–54. DOI: [10.3115/1119394.1119402](https://doi.org/10.3115/1119394.1119402). URL: <http://dx.doi.org/10.3115/1119394.1119402>.
- Recchia, G. and M. M. Louwerse. 2013. "A Comparison of String Similarity Measures for Toponym Matching." In: *Proceedings of The First ACM SIGSPATIAL International Workshop on Computational Models of Place. COMP '13*. Orlando FL, USA: ACM. 54:54–54:61. DOI: [10.1145/2534848.2534850](https://doi.org/10.1145/2534848.2534850). URL: <http://doi.acm.org/10.1145/2534848.2534850>.

- Reichenbacher, T., S. De Sabbata, R. S. Purves, and S. I. Fabrikant. 2016. "Assessing geographic relevance for mobile search: A computational model and its validation via crowdsourcing". *Journal of the Association for Information Science and Technology*. 67(11): 2620–2634. DOI: [10.1002/asi.23625](https://doi.org/10.1002/asi.23625). URL: <http://dx.doi.org/10.1002/asi.23625>.
- Robertson, S. E. 1981. "The methodology of information retrieval experiment". In: *Information retrieval experiment*. Butterworths. 9–31.
- Robertson, S. E. and M. M. Hancock-Beaulieu. 1992. "On the Evaluation of IR Systems". *Inf. Process. Manage.* 28(4): 457–466. DOI: [10.1016/0306-4573\(92\)90004-J](https://doi.org/10.1016/0306-4573(92)90004-J). URL: [http://dx.doi.org/10.1016/0306-4573\(92\)90004-J](http://dx.doi.org/10.1016/0306-4573(92)90004-J).
- Robertson, S. and H. Zaragoza. 2009. "The Probabilistic Relevance Framework: BM25 and Beyond". *Foundations and Trends Information Retrieval*. 3(4): 333–389. DOI: [10.1561/15000000019](https://doi.org/10.1561/15000000019). URL: <http://dx.doi.org/10.1561/15000000019>.
- Rocha-Junior, J. B., O. Gkorgkas, S. Jonassen, and K. Nørnvåg. 2011. "Efficient Processing of Top-k Spatial Keyword Queries". In: *Proceedings of the 12th International Conference on Advances in Spatial and Temporal Databases. SSTD'11*. Minneapolis, MN: Springer-Verlag. 205–222. URL: <http://dl.acm.org/citation.cfm?id=2035253.2035270>.
- Rodden, K., H. Hutchinson, and X. Fu. 2010. "Measuring the User Experience on a Large Scale: User-centered Metrics for Web Applications". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '10*. Atlanta, Georgia, USA: ACM. 2395–2398. DOI: [10.1145/1753326.1753687](https://doi.org/10.1145/1753326.1753687). URL: <http://doi.acm.org/10.1145/1753326.1753687>.
- Roller, S., M. Speriosu, S. Rallapalli, B. Wing, and J. Baldridge. 2012. "Supervised text-based geolocation using language models on an adaptive grid". In: *Proceedings of the 2012 Joint Conference on Empirical Methods in Natural Language Processing and Computational Natural Language Learning*. Association for Computational Linguistics. 1500–1510.
- Russell-Rose, T. and T. Tate. 2013. *Designing the Search Experience: The Information Architecture of Discovery*. 1st. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.

- Sanderson, M. 2010. "Test Collection Based Evaluation of Information Retrieval Systems". *Foundations and Trends in Information Retrieval*. 4(4): 247–375. DOI: [10.1561 / 1500000009](https://doi.org/10.1561/1500000009). URL: <http://dx.doi.org/10.1561/1500000009>.
- Sanderson, M. and J. Kohler. 2004. "Analyzing geographic queries". In: *Proceedings of the Workshop on Geographic Information Retrieval*. Sheffield.
- Santos, D., L. M. Cabral, C. Forascu, P. Forner, F. C. Gey, K. Lamm, T. Mandl, P. Osenova, A. Peñas, Á. Rodrigo, J. M. Schulz, Y. Skalban, and E. F. T. K. Sang. 2010. "GikiCLEF: Crosscultural Issues in Multilingual Information Access." In: *Proceedings of the Seventh conference on International Language Resources and Evaluation (LREC'10)*. Ed. by N. Calzolari, K. Choukri, B. Maegaard, J. Mariani, J. Odiijk, S. Piperidis, M. Rosner, and D. Tapias. European Languages Resources Association (ELRA). 2346–2353.
- Santos, D., N. Cardoso, P. Carvalho, I. Dornescu, S. Hartrumpf, J. Leveling, and Y. Skalban. 2009. "GikiP at GeoCLEF 2008: Joining GIR and QA forces for querying Wikipedia". In: *Evaluating Systems for Multilingual and Multimodal Information Access: 9th Workshop of the Cross-Language Evaluation Forum*. Ed. by C. Peters, T. Deselaers, N. Ferro, J. Gonzalo, G. J. F. Jones, M. Kurimo, T. Mandl, A. Peñas, and V. Petras. Vol. 5706. *Lecture Notes in Computer Science (LNCS)*. Springer. 894–905.
- Santos, R. L. T., C. Macdonald, and I. Ounis. 2015. "Search Result Diversification". *Foundations and Trends in Information Retrieval*. 9(1): 1–90. DOI: [10.1561/1500000040](https://doi.org/10.1561/1500000040). URL: <http://dx.doi.org/10.1561/1500000040>.
- Saracevic, T. 1995. "Evaluation of Evaluation in Information Retrieval". In: *Proceedings of the 18th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '95*. Seattle, Washington, USA: ACM. 138–146. DOI: [10.1145/215206.215351](https://doi.org/10.1145/215206.215351).
- Saracevic, T. 1996. "Relevance reconsidered". In: *Information science: Integration in perspectives. Proceedings of the Second Conference on Conceptions of Library and Information Science*. 201–218.

- Schockaert, S. 2011. "Vague Regions in Geographic Information Retrieval". *SIGSPATIAL Special*. 3(2): 24–28. DOI: [10.1145/2047296.2047302](https://doi.org/10.1145/2047296.2047302). URL: <http://doi.acm.org/10.1145/2047296.2047302>.
- Sehgal, V., L. Getoor, and P. D. Viechnicki. 2006. "Entity resolution in geospatial data integration". In: *Proceedings of the 14th annual ACM international symposium on Advances in geographic information systems*. ACM. 83–90.
- Shatford, S. 1986. "Analyzing the subject of a picture: a theoretical approach". *Cataloging & classification quarterly*. 6(3): 39–62.
- Shaw, B., J. Shea, S. Sinha, and A. Hogue. 2013. "Learning to Rank for Spatiotemporal Search". In: *Proceedings of the Sixth ACM International Conference on Web Search and Data Mining. WSDM '13*. Rome, Italy: ACM. 717–726. DOI: [10.1145/2433396.2433485](https://doi.org/10.1145/2433396.2433485). URL: <http://doi.acm.org/10.1145/2433396.2433485>.
- Shneiderman, B. 1996. "The eyes have it: A task by data type taxonomy for information visualizations". In: *Visual Languages, 1996. Proceedings., IEEE Symposium on*. IEEE. 336–343.
- Shneiderman, B., D. Byrd, and W. B. Croft. 1998. "Sorting out Searching: A User-interface Framework for Text Searches". *Commun. ACM*. 41(4): 95–98. DOI: [10.1145/273035.273069](https://doi.org/10.1145/273035.273069). URL: <http://doi.acm.org/10.1145/273035.273069>.
- Smart, P. D., C. B. Jones, and F. A. Twaroch. 2010. "Multi-source Toponym Data Integration and Mediation for a Meta-Gazetteer Service". In: *Geographic Information Science: 6th International Conference, GIScience 2010, Zurich, Switzerland, September 14-17, 2010. Proceedings*. Ed. by S. I. Fabrikant, T. Reichenbacher, M. van Kreveld, and C. Schlieder. Berlin, Heidelberg: Springer Berlin Heidelberg. 234–248. DOI: [10.1007/978-3-642-15300-6_17](https://doi.org/10.1007/978-3-642-15300-6_17). URL: https://doi.org/10.1007/978-3-642-15300-6_17.
- Smith, D. A. and G. Crane. 2001. "Disambiguating geographic names in a historical digital library". In: *Research and Advanced Technology for Digital Libraries*. Springer. 127–136.

- Smith, D. A. and G. S. Mann. 2003. "Bootstrapping Toponym Classifiers". In: *Proceedings of the HLT-NAACL 2003 Workshop on Analysis of Geographic References - Volume 1. HLT-NAACL-GEOREF '03*. Stroudsburg, PA, USA: Association for Computational Linguistics. 45–49. DOI: [10.3115/1119394.1119401](https://doi.org/10.3115/1119394.1119401). URL: <http://dx.doi.org/10.3115/1119394.1119401>.
- Speriosu, M. and J. Baldrige. 2013. "Text-Driven Toponym Resolution using Indirect Supervision". In: *Proceedings of the 51st Annual Meeting of the Association for Computational Linguistics, ACL 2013, 4-9 August 2013, Sofia, Bulgaria, Volume 1: Long Papers*. 1466–1476. URL: <http://aclweb.org/anthology/P/P13/P13-1144.pdf>.
- Spink, A., B. J. Jansen, D. Wolfram, and T. Saracevic. 2002. "From e-sex to e-commerce: Web search changes". *Computer*. 35(3): 107–109. DOI: [10.1109/2.989940](https://doi.org/10.1109/2.989940).
- Spink, A., D. Wolfram, M. B. J. Jansen, and T. Saracevic. 2001. "Searching the web: The public and their queries". *Journal of the Association for Information Science and Technology*. 52(3): 226–234.
- Stokes, N., Y. Li, A. Moffat, and J. Rong. 2008. "An empirical study of the effects of NLP components on Geographic IR performance". *Int. J. Geogr. Inf. Sci.* 22(3): 247–264.
- Su, L. T. 2003. "A comprehensive and systematic model of user evaluation of Web search engines: I. Theory and background". *J. Am. Soc. Inf. Sci. Technol.* 54(13): 1175–1192. DOI: [10.1002/asi.10303](https://doi.org/10.1002/asi.10303). URL: <http://dx.doi.org/10.1002/asi.10303>.
- Sutcliffe, A. and M. Ennis. 1998. "Towards a cognitive theory of information retrieval". *Interacting with Computers*. 10(3): 321–351. {HCI} and Information Retrieval. DOI: [http://dx.doi.org/10.1016/S0953-5438\(98\)00013-7](http://dx.doi.org/10.1016/S0953-5438(98)00013-7). URL: <http://www.sciencedirect.com/science/article/pii/S0953543898000137>.
- Talmy, L. 1983. "How Language Structures Space". In: *Spatial Orientation*. New York: Plenum. 225–282.

- Tang, J. and M. Sanderson. 2010. "Evaluation and User Preference Study on Spatial Diversity". In: *Advances in Information Retrieval: 32nd European Conference on IR Research, ECIR 2010, Milton Keynes, UK, March 28-31, 2010. Proceedings*. Ed. by C. Gurrin, Y. He, G. Kazai, U. Kruschwitz, S. Little, T. Roelleke, S. Rüger, and K. Van Rijsbergen. Berlin, Heidelberg: Springer Berlin Heidelberg. 179–190. DOI: [10.1007/978-3-642-12275-0_18](https://doi.org/10.1007/978-3-642-12275-0_18). URL: https://doi.org/10.1007/978-3-642-12275-0_18.
- Teitler, B. E., M. D. Lieberman, D. Panozzo, J. Sankaranarayanan, H. Samet, and J. Sperling. 2008. "NewsStand: A New View on News". In: *Proceedings of the 16th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems. GIS '08*. Irvine, California: ACM. 18:1–18:10. DOI: [10.1145/1463434.1463458](https://doi.org/10.1145/1463434.1463458). URL: <http://doi.acm.org/10.1145/1463434.1463458>.
- Thomas, P. and D. Hawking. 2006. "Evaluation by Comparing Result Sets in Context". In: *Proceedings of the 15th ACM International Conference on Information and Knowledge Management. CIKM '06*. Arlington, Virginia, USA: ACM. 94–101. DOI: [10.1145/1183614.1183632](https://doi.org/10.1145/1183614.1183632). URL: <http://doi.acm.org/10.1145/1183614.1183632>.
- Tobler, W. R. 1970. "A Computer Movie Simulating Urban Growth in the Detroit Region". *Economic Geography*. 46: 234–240. URL: <http://www.jstor.org/stable/143141>.
- Uryupina, O. 2003. "Semi-supervised Learning of Geographical Gazetteers from the Internet". In: *Proceedings of the HLT-NAACL 2003 Workshop on Analysis of Geographic References - Volume 1. HLT-NAACL-GEOREF '03*. Stroudsburg, PA, USA: Association for Computational Linguistics. 18–25. DOI: [10.3115/1119394.1119397](https://doi.org/10.3115/1119394.1119397). URL: <http://dx.doi.org/10.3115/1119394.1119397>.
- Vaid, S., C. B. Jones, H. Joho, and M. Sanderson. 2005. "Spatio-textual Indexing for Geographical Search on the Web". In: *Advances in Spatial and Temporal Databases: 9th International Symposium, SSTD 2005, Angra dos Reis, Brazil, August 22-24, 2005. Proceedings*. Ed. by C. Bauzer Medeiros, M. J. Egenhofer, and E. Bertino. Berlin, Heidelberg: Springer Berlin Heidelberg. 218–235. DOI: [10.1007/11535331_13](https://doi.org/10.1007/11535331_13). URL: https://doi.org/10.1007/11535331_13.

- Vakkari, P. 2012. "Evaluating Interactive Information Retrieval Systems". *Revista PRISMA.COM*. 2012(19): 1–15. URL: <http://revistas.ua.pt/index.php/prismacom/article/view/2410>.
- Vakkari, P. and S. Huuskonen. 2012. "Search effort degrades search output but improves task outcome". *Journal of the American Society for Information Science and Technology*. 63(4): 657–670. DOI: [10.1002/asi.21683](https://doi.org/10.1002/asi.21683). URL: <http://dx.doi.org/10.1002/asi.21683>.
- Van Rijsbergen, C. J. 1979. *Information Retrieval*. 2nd. Newton, MA, USA: Butterworth-Heinemann.
- Vaughan, M. W. and M. L. Resnick. 2006. "Search User Interfaces: Best Practices and Future Visions". *J. Am. Soc. Inf. Sci. Technol.* 57(6): 777–780. DOI: [10.1002/asi.v57:6](https://doi.org/10.1002/asi.v57:6). URL: <http://dx.doi.org/10.1002/asi.v57:6>.
- Voorhees, E. M. and D. K. Harman. 2005. *TREC: Experiment and Evaluation in Information Retrieval (Digital Libraries and Electronic Publishing)*. The MIT Press.
- Wallgrün, J. O., M. Karimzadeh, A. M. MacEachren, and S. Pezanowski. 2017. "GeoCorpora: building a corpus to test and train microblog geoparsers". *International Journal of Geographical Information Science*. 0(0): 1–29. DOI: [10.1080/13658816.2017.1368523](https://doi.org/10.1080/13658816.2017.1368523). eprint: <http://dx.doi.org/10.1080/13658816.2017.1368523>. URL: <http://dx.doi.org/10.1080/13658816.2017.1368523>.
- Wang, C., X. Xie, L. Wang, Y. Lu, and W.-Y. Ma. 2005. "Web Resource Geographic Location Classification and Detection". In: *Special Interest Tracks and Posters of the 14th International Conference on World Wide Web. WWW '05*. Chiba, Japan: ACM. 1138–1139. DOI: [10.1145/1062745.1062907](https://doi.org/10.1145/1062745.1062907). URL: <http://doi.acm.org/10.1145/1062745.1062907>.
- Wang, W. and K. Stewart. 2015. "Creating spatiotemporal semantic maps from web text documents". In: *Space-Time Integration in Geography and GIScience*. Springer. 157–174.
- White, R. W. 2016. *Interactions with Search Systems*. Cambridge University Press. DOI: [10.1017/CBO9781139525305](https://doi.org/10.1017/CBO9781139525305). URL: <http://dx.doi.org/10.1017/CBO9781139525305>.

- Wilkening, J. and S. I. Fabrikant. 2013. "How Users Interact With a 3D Geo-Browser under Time Pressure". *Cartography and Geographic Information Science*. 40: 40–52.
- Wilson, M. L. 2011. *Search User Interface Design*. Morgan & Claypool Publishers.
- Wing, B. P. and J. Baldrige. 2011. "Simple supervised document geolocation with geodesic grids". In: *Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics: Human Language Technologies-Volume 1*. Association for Computational Linguistics. 955–964.
- Woodruff, A. G. and C. Plaunt. 1994. "GIPSY: Automated Geographic Indexing of Text Documents". *J. Am. Soc. Inf. Sci.* 45(9): 645–655. DOI: [10.1002/\(SICI\)1097-4571\(199410\)45:9<645::AID-ASI2>3.0.CO;2-8](https://doi.org/10.1002/(SICI)1097-4571(199410)45:9<645::AID-ASI2>3.0.CO;2-8).
- Wu, D., G. Cong, and C. S. Jensen. 2012. "A Framework for Efficient Spatial Web Object Retrieval". *The VLDB Journal*. 21(6): 797–822. DOI: [10.1007/s00778-012-0271-0](https://doi.org/10.1007/s00778-012-0271-0). URL: <http://dx.doi.org/10.1007/s00778-012-0271-0>.
- Xiao, X., Q. Luo, Z. Li, X. Xie, and W.-Y. Ma. 2010. "A Large-scale Study on Map Search Logs". *ACM Trans. Web*. 4(3): 8:1–8:33. DOI: [10.1145/1806916.1806917](https://doi.org/10.1145/1806916.1806917). URL: <http://doi.acm.org/10.1145/1806916.1806917>.
- Yan, H., S. Ding, and T. Suel. 2009. "Inverted Index Compression and Query Processing with Optimized Document Ordering". In: *Proceedings of the 18th International Conference on World Wide Web. WWW '09*. Madrid, Spain: ACM. 401–410. DOI: [10.1145/1526709.1526764](https://doi.org/10.1145/1526709.1526764). URL: <http://doi.acm.org/10.1145/1526709.1526764>.
- Zaila, Y. L. and D. Montesi. 2015. "Geographic Information Extraction, Disambiguation and Ranking Techniques". In: *Proceedings of the 9th Workshop on Geographic Information Retrieval. GIR '15*. Paris, France: ACM. 11:1–11:7. DOI: [10.1145/2837689.2837695](https://doi.org/10.1145/2837689.2837695). URL: <http://doi.acm.org/10.1145/2837689.2837695>.
- Zandbergen, P. A. 2008. "A comparison of address point, parcel and street geocoding techniques". *Computers, Environment and Urban Systems*. 32(3): 214–232.

- Zhai, C. X., W. W. Cohen, and J. Lafferty. 2003. "Beyond Independent Relevance: Methods and Evaluation Metrics for Subtopic Retrieval". In: *Proceedings of the 26th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval. SIGIR '03*. Toronto, Canada: ACM. 10–17. DOI: [10.1145/860435.860440](https://doi.org/10.1145/860435.860440). URL: <http://doi.acm.org/10.1145/860435.860440>.
- Zhang, C., Y. Zhang, W. Zhang, and X. Lin. 2013. "Inverted linear quadtree: Efficient top k spatial keyword search". In: *2013 IEEE 29th International Conference on Data Engineering (ICDE)*. 901–912. DOI: [10.1109/ICDE.2013.6544884](https://doi.org/10.1109/ICDE.2013.6544884).
- Zhou, Y., X. Xie, C. Wang, Y. Gong, and W.-Y. Ma. 2005. "Hybrid Index Structures for Location-based Web Search". In: *Proceedings of the 14th ACM International Conference on Information and Knowledge Management. CIKM '05*. Bremen, Germany: ACM. 155–162. DOI: [10.1145/1099554.1099584](https://doi.org/10.1145/1099554.1099584). URL: <http://doi.acm.org/10.1145/1099554.1099584>.