3D geomarketing segmentation: A higher spatial dimension planning perspective

Geomarketing is a discipline which uses geographic information in the process of planning and implementation of marketing activities. It can be used in any aspect of the marketing such as price, promotion or geo targeting. The analysis of geomarketing data use a huge data pool such as location residential areas, topography, it also analyzes demographic information such as age, genre, annual income and lifestyle. This information can help users to develop successful promotional campaigns in order to achieve marketing goals. One of the common activities in geomarketing is market segmentation. The segmentation clusters the data into several groups based on its geographic criteria. To refine the search operation during analysis, we proposed an approach to cluster the data using a clustering algorithm. However, with the huge data pool, overlap among clusters may happen and leads to inefficient analysis. Moreover, geomarketing is usually active in urban areas and requires clusters to be organized in a three-dimensional (3D) way (i.e. multi-level shop lots, residential apartments). This is a constraint with the current Geographic Information System (GIS) framework. To avoid this issue, we proposed a combination of market segmentation based on geographic criteria and clustering algorithm for 3D geomarketing data management. The proposed approach is capable in minimizing the overlap region during market segmentation. In this paper, geomarketing in urban area is used as a case study. Based on the case study, several locations of customers and stores in 3D are used in the test. The experiments demonstrated in this paper substantiated that the proposed approach is capable of minimizing overlapping segmentation and reducing repetitive data entries. The structure is also tested for retrieving the spatial records from the database. For marketing purposes, certain radius of point is used to analyzing marketing targets. Based on the presented tests in this paper, we strongly believe that the structure is capable in handling and managing huge pool of geomarketing data. For future outlook, this paper also discusses the possibilities of expanding the structure.

General information
State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia
Authors: Suhaibah, A. (Ekstern), Uznir, U. (Ekstern), Rahman, A. A. (Ekstern), Antón Castro, F. (Intern), Mioc, D. (Intern)
Number of pages: 7
Publication date: 2016

Host publication information
Title of host publication: Proceedings of the International Conference on Geomatic and Geospatial Technology (GGT)
Volume: 42
Publisher: Copernicus GmbH

Series: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences
Volume: XLII-4/W1
ISSN: 1682-1750
Main Research Area: Technical/natural sciences
Conference: International Conference on Geomatic and Geospatial Technology (GGT) 2016, Kuala Lumpur, Malaysia, 03/10/2016 - 03/10/2016
3D Spatial Database, Geo-Clustering, Geomarketing, Information Retrievial, Market Segmentation, 3D GIS
Electronic versions:
IsPRS_Archives_XLII_4_W1_1_2016.pdf

3D Indoor Building Environment Reconstruction using Polynomial Kernel, Least Square Adjustment, Interval Analysis and Homotopy Continuation

Nowadays, municipalities intend to have 3D city models for facility management, disaster management and architectural planning. Indoor models can be reconstructed from construction plans but sometimes, they are not available or very often, they differ from 'as-built' plans. In this case, the buildings and their rooms must be surveyed. One of the most utilized methods of indoor surveying is laser scanning. The laser scanning method allows taking accurate and detailed measurements. However, Terrestrial Laser Scanner is costly and time consuming. In this paper, several techniques for indoor 3D building data acquisition have been investigated. For reducing the time and cost of indoor building data acquisition process, the Trimble LaserAce 1000 range finder is used. The proposed approach use relatively cheap equipment: a light Laser Rangefinder which appear to be feasible, but it needs to be tested to see if the observation accuracy is sufficient for the 3D building modelling. The accuracy of the rangefinder is evaluated and a simple spatial model is reconstructed from real data. This technique is rapid (it requires a shorter time as compared to others), but the results show inconsistencies in horizontal angles for short distances in indoor environments. The range finder horizontal angle sensor was calibrated using a least square adjustment algorithm, a polynomial kernel, interval analysis and homotopy continuation.

General information
State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia, University of Technology Malaysia
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Pages: 103-113
Publication date: 2016

Host publication information
Title of host publication: Proceedings of GeoAdvances 2016
Series: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences
ISSN: 1682-1750
Main Research Area: Technical/natural sciences
Conference: GeoAdvances 2016: ISPRS Workshop on Multi-dimensional & Multi-scale Spatial Data Modeling, Istanbul, Turkey, 16/10/2016 - 16/10/2016
Indoor Surveying, Least square adjustment, Interval analysis, Laser scanning, Calibration, Homotopy continuation, Polynomial kernel
Electronic versions:
DOIs:
10.5194/isprs-archives-XLII-2-W1-103-2016
Source: PublicationPreSubmission
Source-ID: 126152642
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

3D Nearest Neighbour Search Using a Clustered Hierarchical Tree Structure
Locating and analysing the location of new stores or outlets is one of the common issues facing retailers and franchisers. This is due to assure that new opening stores are at their strategic location to attract the highest possible number of customers. Spatial information is used to manage, maintain and analyse these store locations. However, since the business of franchising and chain stores in urban areas runs within high rise multi-level buildings, a three-dimensional (3D) method is prominently required in order to locate and identify the surrounding information such as at which level of the franchise unit will be located or is the franchise unit located at the best level for visibility purposes. One of the common used analyses used for retrieving the surrounding information is Nearest Neighbour (NN) analysis. It uses a point location and identifies the surrounding neighbours. However, with the immense number of urban datasets, the retrieval and analysis of nearest neighbour information and their efficiency will become more complex and crucial. In this paper, we present a technique to retrieve nearest neighbour information in 3D space using a clustered hierarchical tree structure. Based on our findings, the proposed approach substantially showed an improvement of response time analysis compared to existing approaches of spatial access methods in databases. The query performance was tested using a dataset consisting of 500,000 point locations building and franchising unit. The results are presented in this paper. Another
advantage of this structure is that it also offers a minimal overlap and coverage among nodes which can reduce repetitive
data entry.

**General information**

State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia
Authors: Suhaibah, A. (Ekstern), Uznir, U. (Ekstern), Antón Castro, F. (Intern), Mioc, D. (Intern), Rahman, A. A. (Ekstern)
Pages: 87-93
Publication date: 2016
Conference: XXIII ISPRS Congress, Prague, Czech Republic, 12/07/2016 - 12/07/2016
Main Research Area: Technical/natural sciences

**Publication information**

Journal: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences
Volume: Volume XLI-B2
ISSN (Print): 1682-1750
Ratings:
- ISI indexed (2013): ISI indexed no
- ISI indexed (2012): ISI indexed no
- ISI indexed (2011): ISI indexed no
- BFI (2008): BFI-level 1
- Web of Science (2008): Indexed yes
Original language: English
Electronic versions:
- isprs_archives_XLI_B2_87_2016.pdf
- 10.5194/isprs-archives-XLI-B2-87-2016

**Bibliographical note**

Since Volume XXXII-3/W14, 1999, the Archives are open access publications, they are published under the Creative
Common Attribution 3.0 License, see publications.copernicus.org/for_authors/license_and_copyright.html for details.
Source: PublicationPreSubmission
Source-ID: 125728871
Publication: Research - peer-review › Conference article – Annual report year: 2016

**Automated Photogrammetric Image Matching with SIFT Algorithm and Delaunay Triangulation**

An algorithm for image matching of multi-sensor and multi-temporal satellite images is developed. The method is based on
the SIFT feature detector proposed by Lowe in (Lowe, 1999). First, SIFT feature points are detected independently in two
images (reference and sensed image). The features detected are invariant to image rotations, translations, scaling and
also to changes in illumination, brightness and 3-dimensional viewpoint. Afterwards, each feature of the reference image
is matched with one in the sensed image if, and only if, the distance between them multiplied by a threshold is shorter than
the distances between the point and all the other points in the sensed image. Then, the matched features are used to
compute the parameters of the homography that transforms the coordinate system of the sensed image to the coordinate
system of the reference image. The Delaunay triangulations of each feature set for each image are computed. The
isomorphism of the Delaunay triangulations is determined to guarantee the quality of the image matching. The algorithm is
implemented in Matlab and tested on World-View 2, SPOT6 and TerraSAR-X image patches.

**General information**

State: Published
Organisations: National Space Institute, Geodesy, Technical University of Denmark
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Pages: 23-28
Publication date: 2016
Conference: XXIII ISPRS Congress, Prague, Czech Republic, 12/07/2016 - 12/07/2016
Main Research Area: Technical/natural sciences

**Publication information**

Journal: ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences
Volume: III-2
ISSN (Print): 2194-9042
Original language: English
Automated image matching, SIFT algorithm, Delaunay triangulation, Graph isomorphism, Multi-sensor image matching,
Multi-temporal image matching
Electronic versions:
Classified and Clustered Data Constellation: An Efficient Approach of 3D Urban Data Management

The growth of urban areas has resulted in massive urban datasets and difficulties handling and managing issues related to urban areas. Huge and massive datasets can degrade data retrieval and information analysis performance. In addition, the urban environment is very difficult to manage because it involves various types of data, such as multiple types of zoning themes in the case of urban mixed-use development. Thus, a special technique for efficient handling and management of urban data is necessary. This paper proposes a structure called Classified and Clustered Data Constellation (CCDC) for urban data management. CCDC operates on the basis of two filters: classification and clustering. To boost up the performance of information retrieval, CCDC offers a minimal percentage of overlap among nodes and coverage area to avoid repetitive data entry and multipath query. The results of tests conducted on several urban mixed-use development datasets using CCDC verify that it efficiently retrieves their semantic and spatial information. Further, comparisons conducted between CCDC and existing clustering and data constellation techniques, from the aspect of preservation of minimal overlap and coverage, confirm that the proposed structure is capable of preserving the minimum overlap and coverage area among nodes. Our overall results indicate that CCDC is efficient in handling and managing urban data, especially urban mixed-use development applications.
Geospatial Big Data Handling Theory and Methods: A Review and Research Challenges

Big data has now become a strong focus of global interest that is increasingly attracting the attention of academia, industry, government and other organizations. Big data can be situated in the disciplinary area of traditional geospatial data handling theory and methods. The increasing volume and varying format of collected geospatial big data presents challenges in storing, managing, processing, analyzing, visualizing and verifying the quality of data. This has implications for the quality of decisions made with big data. Consequently, this position paper of the International Society for Photogrammetry and Remote Sensing (ISPRS) Technical Commission II (TC II) revisits the existing geospatial data handling methods and theories to determine if they are still capable of handling emerging geospatial big data. Further, the paper synthetises problems, major issues and challenges with current developments as well as recommending what needs to be developed further in the near future.

General information

State: Published
Organisations: National Space Institute, Geodesy, Ryerson University, Simon Fraser University, Leibniz Universität Hannover, University of Melbourne, University of Zurich, University of New South Wales, University of Gävle, University College London, University of Twente
Authors: Li, S. (Ekstern), Dragicevic, S. (Ekstern), Anton, F. (Intern), Sester, M. (Ekstern), Winter, S. (Ekstern), Coltekin, A. (Ekstern), Pettit, C. (Ekstern), Jiang, B. (Ekstern), Haworth, J. (Ekstern), Stein, A. (Ekstern), Cheng, T. (Ekstern)
Pages: 119-133
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information

Volume: 115
ISSN (Print): 0924-2716
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 2.815 SNIP 3.006 CiteScore 6.46
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.375 SNIP 2.82 CiteScore 5.41
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.891 SNIP 2.665 CiteScore 4.6
Improving Nearest Neighbour Search in 3D Spatial Access Method

Nearest Neighbour (NN) is one of the important queries and analyses for spatial application. In normal practice, spatial access method structure is used during the Nearest Neighbour query execution to retrieve information from the database. However, most of the spatial access method structures are still facing with unresolved issues such as overlapping among nodes and repetitive data entry. This situation will perform an excessive Input/Output (IO) operation which is inefficient for data retrieval. The situation will become more crucial while dealing with 3D data. The size of 3D data is usually large due to its detail geometry and other attached information. In this research, a clustered 3D hierarchical structure is introduced as a 3D spatial access method structure. The structure is expected to improve the retrieval of Nearest Neighbour information for 3D objects. Several tests are performed in answering Single Nearest Neighbour search and k Nearest Neighbour (kNN) search. The tests indicate that clustered hierarchical structure is efficient in handling Nearest Neighbour query compared to its competitor. From the results, clustered hierarchical structure reduced the repetitive data entry and the accessed page. The proposed structure also produced minimal Input/Output operation. The query response time is also outperformed compared to the other competitor. For future outlook of this research several possible applications are discussed and summarized.

General information
State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia
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Pages: 69-73
Publication date: 2016

Host publication information
Title of host publication: Proceedings of GeoAdvances 2016
Volume: 42-2
Publisher: International Society for Photogrammetry and Remote Sensing
This paper presents a case study for comparing different multidimensional mathematical modeling methodologies used in multidimensional spatial big data modeling and proposing a new technique. An analysis of multidimensional modeling approaches (neural networks, polynomial interpolation and homotopy continuation) was conducted for finding an approach with the highest accuracy for obtaining reliable information about a cell phone consumed power and emitted radiation from streams of measurements of different physical quantities and the uncertainty ranges of these measurements. The homotopy continuation numerical approach proved to have the highest accuracy (97%). This approach was validated against another device with a different RF subsystem design. The approach modelled the power consumption of the validation device with an accuracy of 98%.

General information
State: Published
Organisations: National Space Institute, Geodesy, Micromove.com
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Pages: 208 - 219
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Volume: 11
Issue number: 3
ISSN (Print): 1755-7437
Ratings:
Scopus rating (2016): SJR 0.131 SNIP 0.365 CiteScore 0.24
Scopus rating (2015): SJR 0.115 SNIP 0.176 CiteScore 0.13
Scopus rating (2014): SJR 0.107 SNIP 0.084 CiteScore 0.19
Scopus rating (2013): SJR 0.219 SNIP 0.692 CiteScore 0.61
Scopus rating (2012): SJR 0.221 SNIP 0.421 CiteScore 0.46
Scopus rating (2011): SJR 0.207 SNIP 0.481 CiteScore 0.55
Scopus rating (2010): SJR 0.111 SNIP 0.62
Scopus rating (2009): SJR 0.157 SNIP 0.305
Original language: English

Big spatial data, Haskell, Homotopy continuation, Interval analysis, Mathematical modeling

Electronic versions:
Pages_from_eDNE_V11_N3.pdf
DOIs:
10.2495/DNE-V11-N3-208-219

Publication: Research - peer-review › Journal article – Annual report year: 2016

Theme section: Multi-dimensional modelling, analysis and visualization
Spatial data are now collected and processed in larger amounts, and used by larger populations than ever before. While most geospatial data have traditionally been recorded as two-dimensional data, the evolution of data collection methods and user demands have led to data beyond the two dimensions describing complex multidimensional phenomena. An example of the relevance of multidimensional modelling is seen with the development of urban modelling where several dimensions have been added to the traditional 2D map representation (Sester et al., 2011). These include obviously the third spatial dimension (Biljecki et al., 2015) as well as the temporal, but also the scale dimension (Van Oosterom and Stoter, 2010) or, as mentioned by (Lu et al., 2016), multi-spectral and multi-sensor data. Such a view provides an
organisation of multidimensional data around these different axes and it is time to explore each axis as the availability of unprecedented amounts of new data demands new solutions. The availability of such large amounts of data induces an acute need for developing new approaches to assist with their dissemination, visualisation, and analysis by end users. Several issues need to be considered in order to provide a meaningful representation and assist in data visualisation and mining, modelling and analysis; such as data structures allowing representation at different scales or in different contexts of thematic information. Such issues are of importance with regard to the mission of the ISPRS Commission II and, pertaining to both spatial data structures and algorithms and to geovisualisation, more specifically to Working Groups II/2 and II/6. Hence, this special issue presents some recent developments and review papers covering various aspects of multidimensional data modelling and visualisation.

**General information**

State: Published
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Pages: 173-174
Publication date: 2016
Main Research Area: Technical/natural sciences

**Publication information**

Volume: 117
ISSN (Print): 0924-2716
Ratings:
- BFI (2018): BFI-level 1
- BFI (2017): BFI-level 1
- Web of Science (2017): Indexed Yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): SJR 2.815 SNIP 3.006 CiteScore 6.46
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 2.375 SNIP 2.82 CiteScore 5.41
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.891 SNIP 2.665 CiteScore 4.6
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 2.416 SNIP 2.964 CiteScore 4.56
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 2.27 SNIP 2.942 CiteScore 4.19
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 1.96 SNIP 3.208 CiteScore 4.16
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.508 SNIP 3.004
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 1.463 SNIP 3.749
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 1.484 SNIP 3.347
- Scopus rating (2007): SJR 1.53 SNIP 3.123
- Scopus rating (2006): SJR 1.827 SNIP 3.837
- Web of Science (2006): Indexed yes
- Scopus rating (2005): SJR 1.777 SNIP 4.025
- Scopus rating (2004): SJR 1.767 SNIP 2.171
- Scopus rating (2003): SJR 0.676 SNIP 1.478
- Scopus rating (2002): SJR 1.15 SNIP 2.009
- Scopus rating (2001): SJR 1.08 SNIP 1.63
- Scopus rating (2000): SJR 1.319 SNIP 1.044
3D Indoor Building Environment Reconstruction using calibration of Range finder Data

Nowadays, municipalities intend to have 3D city models for facility management, disaster management and architectural planning. 3D data acquisition can be done by laser scanning for indoor environment which is a costly and time consuming process. Currently, for indoor surveying, Electronic Distance Measurement (EDM) and Terrestrial Laser Scanner (TLS) are mostly used. In this paper, several techniques for indoor 3D building data acquisition have been investigated. For reducing the time and cost of indoor building data acquisition process, the Trimble LaserAce 1000 range finder is used. The accuracy of the rangefinder is evaluated and a simple spatial model is reconstructed from real data. This technique is rapid (it requires a shorter time as compared to others), but the results show inconsistencies in horizontal angles for short distances in indoor environments. The range finder was calibrated using a least square adjustment algorithm. To control the uncertainty of the calibration and of the reconstruction of the building from the measurements, interval analysis and homotopy continuation are used.
3D Partition-Based Clustering for Supply Chain Data Management

Supply Chain Management (SCM) is the management of the products and goods flow from its origin point to point of consumption. During the process of SCM, information and dataset gathered for this application is massive and complex. This is due to its several processes such as procurement, product development and commercialization, physical distribution, outsourcing and partnerships. For a practical application, SCM datasets need to be managed and maintained to serve a better service to its three main categories; distributor, customer and supplier. To manage these datasets, a structure of data constellation is used to accommodate the data into the spatial database. However, the situation in geospatial database creates few problems, for example the performance of the database deteriorate especially during the query operation. We strongly believe that a more practical hierarchical tree structure is required for efficient process of SCM. Besides that, three-dimensional approach is required for the management of SCM datasets since it involve with the multi-level location such as shop lots and residential apartments. 3D R-Tree has been increasingly used for 3D geospatial database management due to its simplicity and extendibility. However, it suffers from serious overlaps between nodes. In this paper, we proposed a partition-based clustering for the construction of a hierarchical tree structure. Several datasets are tested using the proposed method and the percentage of the overlapping nodes and volume coverage are computed and compared with the original 3D R-Tree and other practical approaches. The experiments demonstrated in this paper substantiated that the hierarchical structure of the proposed partition-based clustering is capable of preserving minimal overlap and coverage. The query performance was tested using 300,000 points of a SCM dataset and the results are presented in this paper. This paper also discusses the outlook of the structure for future reference.

General information
State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia
Authors: Suhaibah, A. (Ekstern), Uznir, U. (Ekstern), Anton, F. (Intern), Mioc, D. (Intern), Rahman, A. A. (Ekstern)
Pages: 9-17
Publication date: 2015
Conference: Joint International Geoinformation Conference 2015, Kuala Lumpur, Malaysia, 28/10/2015 - 28/10/2015
Main Research Area: Technical/natural sciences

Publication information
Journal: ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences
Volume: 2
ISSN (Print): 2194-9042
Original language: English
Supply Chain Management, 3D Spatial Data Clustering, 3D Spatial Database, 3D GIS, Data Management, Information Retrieval
Electronic versions: isprsannals-II_2_W2_9_2015.pdf
DOIs: 10.5194/isprsannals-II-2-W2-9-2015

Bibliographical note
The Annals are open access publications, they are published under the Creative Common Attribution 3.0 License
Publication: Research - peer-review › Conference article – Annual report year: 2015

An amalgamation of 3D city models in urban air quality modelling for improving visual impact analysis
Geographical Information Systems (GISs) can be seen as a common tool to map and visualize the air quality index based on geographical locations. However, in urban areas, the area resolution for air quality models is less than 2 kilometres. Since the main emissions agent in urban areas is predominantly vehicular engines, the situation will become worse when pollutants are trapped between buildings and disperse inside the street canyon and move vertically to create a recirculation vortex. Studying and visualizing the recirculation zone in 3D visualization is conceivable by using 3D city models as physical data input. The Level of Details (LoD) in 3D city models (i.e. LoD1 and LoD2) ascertains the potentials of implementing air quality modelling for urban areas. Therefore, this research is focused towards investigating the integration of 3D city models in air quality modelling for urban areas. The results presented show the simplicity of using 3D city models as a physical data input in air quality modelling and the 3D air quality will improve insight for visual impact analysis (i.e. analysing the immersion of are circulation zone). The results are advantageous for city planners, architects, engineers and policy makers to design the street geometry (building height and width, green areas, pedestrian walks, roads width, etc.).

General information
State: Published
Crisp Clustering Algorithm for 3D Geospatial Vector Data Quantization

In the next few years, 3D data is expected to be an intrinsic part of geospatial data. However, issues on 3D spatial data management are still in the research stage. One of the issues is performance deterioration during 3D data retrieval. Thus, a practical 3D index structure is required for efficient data constellation. Due to its reputation and simplicity, R-Tree has been received increasing attention for 3D geospatial database management. However, the transition of its structure from 2D to 3D had caused a serious overlapping among nodes. Overlapping nodes also occur during splitting operation of the overflow node N of M + 1 entry. Splitting operation is the most critical process of 3D R-Tree. The produced tree should satisfy the condition of minimal overlap and minimal volume coverage in addition with preserving a minimal tree height.

Based on these concerns, in this paper, we proposed a crisp clustering algorithm for the construction of a 3D R-Tree. Several datasets are tested using the proposed method and the percentage of the overlapping parallelepipeds and volume coverage are computed and compared with the original R-Tree and other practical approaches. The experiments demonstrated in this research substantiated that the proposed crisp clustering is capable to preserve minimal overlap, coverage and tree height, which is advantageous for 3D geospatial data implementations. Another advantage of this approach is that the properties of this crisp clustering algorithm are analogous to the original R-Tree splitting procedure, which makes the implementation of this approach straightforward.
contribution is a methodology for automated derivation of geometric and topological invariants of the Dirichlet tiling of N + 1-dimensional hyperspheres and its dual Delone graph from the invariants of the Dirichlet tiling of N-dimensional hyperspheres and its dual Delone graph (starting from N = 3).

**General information**
State: Published
Organisations: National Space Institute, Geodesy
Authors: Antón Castro, F. (Intern)
Pages: 123-140
Publication date: 2015
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Siauliai Mathematical Seminar
Volume: 10
Issue number: 18
ISSN (Print): 1822-511X
Original language: English
Delaunay graph of hyperspheres, Geometric invariants, Ritt-Wu characteristic set method, Voronoi diagram of hyperspheres, Topological invariants
Electronic versions:
SSpc_Konica15090808570_1_.pdf
Source: PublicationPreSubmission
Source-ID: 115471575
Publication: Research - peer-review › Conference article – Annual report year: 2015

**Methods, Devices and Computer Program Products Providing for Establishing a Model for Emulating a Physical Quantity Which Depends on at Least One Input Parameter, and Use Thereof**
The present invention proposes methods, devices and computer program products. To this extent, there is defined a set X including N distinct parameter values x_i for at least one input parameter x, N being an integer greater than or equal to 1, first measured the physical quantity Pm1 for each of the N distinct parameter values x_i of the at least one input parameter x, while keeping all other input parameters fixed, constructed a Vandermonde matrix VM using the set of N parameter values x_i of the at least one input parameter x, and computed the model W for emulating the physical quantity P based on the Vandermonde matrix and the first measured physical quantity according to the equation W=(VMT*VM)-1*VMT*Pm1. The model is iteratively refined so as to obtained a desired emulation precision.; The model can later be used to emulate the physical quantity based on input parameters or logs taken from the field and thereby support device design optimization.

**General information**
State: Published
Organisations: National Space Institute, Geodesy
Authors: Musiige , D. (Ekstern), Laulagnet , V. (Ekstern), Anton, F. (Intern)
Publication date: 29 Apr 2014

**Publication information**
Country: United States
IPC: G06F7/60
Patent number: US8712742
Date: 29/04/2014
Priority date: 05/07/2011
Priority number: US201113176288
Original language: English
Electronic versions:
US8712742B2.pdf
francois_added_1_.pdf

**Bibliographical note**
Also published as: US2013013270 (A1)
Main Research Area: Technical/natural sciences
Publication: Research › Patent – Annual report year: 2015
3D Hilbert Space Filling Curves in 3D City Modeling for Faster Spatial Queries

The advantages of three-dimensional (3D) city models can be seen in various applications including photogrammetry, urban and regional planning, computer games, etc. They expand the visualization and analysis capabilities of Geographic Information Systems on cities, and they can be developed using web standards. However, these 3D city models consume much more storage compared to two-dimensional (2D) spatial data. They involve extra geometrical and topological information together with semantic data. Without a proper spatial data clustering method and its corresponding spatial data access method, retrieving portions of and especially searching these 3D city models, will not be done optimally. Even though current developments are based on an open data model allotted by the Open Geospatial Consortium (OGC) called CityGML, its XML-based structure makes it challenging to cluster the 3D urban objects. In this research, the authors propose an opponent data constellation technique of space-filling curves (3D Hilbert curves) for 3D city model data representation. Unlike previous methods, that try to project 3D or n-dimensional data down to 2D or 3D using Principal Component Analysis (PCA) or Hilbert mappings, in this research, they extend the Hilbert space-filling curve to one higher dimension for 3D city model data implementations. The query performance was tested for single object, nearest neighbor and range search queries using a CityGML dataset of 1,000 building blocks and the results are presented in this paper. The advantages of implementing space-filling curves in 3D city modeling will improve data retrieval time by means of optimized 3D adjacency, nearest neighbor information and 3D indexing. The Hilbert mapping, which maps a sub-interval of the ([0,1]) interval to the corresponding portion of the d-dimensional Hilbert's curve, preserves the Lebesgue measure and is Lipschitz continuous. Depending on the applications, several alternatives are possible in order to cluster spatial data together in the third dimension compared to its clustering in 2D.

General information
State: Published
Organisations: National Space Institute, Geodesy, Universiti Teknologi Malaysia
Authors: Ujang, U. (Ekstern), Antón Castro, F. (Intern), Azri, S. (Ekstern), Rahman, A. A. (Ekstern), Mioc, D. (Intern)
Number of pages: 18
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of 3-D Information Modeling
Volume: 3
Issue number: 2
ISSN (Print): 2156-1710
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
BFI (2015): BFI-level 1
BFI (2014): BFI-level 1
BFI (2013): BFI-level 1
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
ISI indexed (2012): ISI indexed no
Original language: English
DOIs:
10.4018/ij3dim.2014040101
Source: PublicationPreSubmission
Source-ID: 107150665
Publication: Research - peer-review › Journal article – Annual report year: 2015

An overview of the applications for early warning and mapping of the flood events in New Brunswick
This paper gives an overview of the on-line flood warning implementation in the province of New Brunswick, Canada. The on-line flood warning applications are available via the “River Watch” website provided by the New Brunswick Department of Environment. Advanced GIS technology combined with hydrological modelling, provide a mapping and visualization tool that can be used by emergency managers and the general public to predict possible flood zones. The applications developed for “River Watch” support the processing of large amounts of digital terrain and hydrological data, which are then, quantified and displayed on digital maps allowing decision makers and the general population to comprehend and visualize the possible area and impact of the flooding. The WebGIS applications that are available from the “River Watch” web site provide snow reports and maps, flood warnings and interactive maps. The searchable historical database containing reports about the impact of past floods and estimated damages provides a valuable insight into the past of the province of New Brunswick and the motivation for development of the system for flood prediction and management.

General information
Comparative Analysis of Photogrammetric Methods for 3D Models for Museums

The goal of this paper is to make a comparative analysis and selection of methodologies for making 3D models of historical items, buildings and cultural heritage and how to preserve information such as temporary exhibitions and archaeological findings. Two of the methodologies analyzed correspond to 3D models using Sketchup and Designing Reality. Finally, panoramic photography is discussed as a 2D alternative to 3D. Sketchup is a free-ware 3D drawing program and Designing Reality is a commercial program, which uses Structure from motion. For each program/method, the same comparative analysis matrix has been used. Prototypes are made partly or fully and evaluated from the point of view of preservation of information by a museum.

General information
State: Published
Organisations: National Space Institute, Geodesy, Technical University of Denmark
Authors: Hafstað Ármannsdottir, U. E. (Ekstern), Antón Castro, F. (Intern), Mioc, D. (Intern)
Pages: 149-154
Publication date: 2014
Spatial access method for urban geospatial database management: An efficient approach of 3D vector data clustering technique

In the last few years, 3D urban data and its information are rapidly increased due to the growth of urban area and urbanization phenomenon. These datasets are then maintain and manage in 3D spatial database system. However, performance deterioration is likely to happen due to the massiveness of 3D datasets. As a solution, 3D spatial index structure is used as a booster to increase the performance of data retrieval. In commercial database, commonly and widely used index structure for 3D spatial database is 3D R-Tree. This is due to its simplicity and promising method in handling spatial data. However, 3D R-Tree produces serious overlapping among nodes. The overlapping factor is important for an efficient 3D R-Tree to avoid replicated data entry in a different node. Thus, an efficient and reliable method is required to reduce the overlapping nodes in 3D R-Tree nodes. In this paper, we proposed a 3D geospatial data clustering to be used in the construction of 3D R-Tree and respectively could reduce the overlapping among nodes. The proposed method is tested on 3D urban dataset for the application of urban infill development. By using several cases of data updating operations such as building infill, building demolition and building modification, the proposed method indicates that the percentage of overlapping coverage among nodes is reduced compared with other existing approaches.

The Dual Half-Arc data structure: towards the universal B-rep data structure

In GIS, the use of efficient spatial data structures is becoming increasingly important, especially when dealing with multidimensional data. The existing solutions are not always efficient when dealing with big datasets, and therefore, research on new data structures is needed. In this chapter, we propose a very general data structure for storing any real or abstract cell complex in a minimal way in the sense of memory space utilization. The originality and quality of this novel data structure is to be the most compact data structure for storing the geometric topology of any geometric object, or more generally, the topology of any topological space. For this purpose, we generalize an existing data structure from 2D to 3D and design a new 3D data structure that realizes the synthesis between an existing 3D data structure (the Dual Half-Edge (See Footnote 1) data structure) and the generalized 3D Quad-Arc data structure, (See Footnote 2) and at the same time, improves the Dual Half-Edge towards a simpler and more effective representation of cell complexes through B-rep structures. We generalize the idea of the Quad-Arc data structure from 2D to 3D, but instead of transforming a simple
edge of the Quad-Edge data structure to an arc with multiple points along it, we group together primal edges of the Dual Half-Edge that have the same dual Half-Edge vertex tags (volume tags) into one Dual Half-Arc whose dual is the common Dual Half-Edge and primal faces corresponding to dual. This corresponds to grouping together straight line segment edges into arcs. This allows us to transform the Dual Half-Edge data structure into a 3D data structure for cell complexes with fewer Dual Half-Edges. Since the input/output operations are the most costly on any computer (even with solid state disks), this will result in a much more efficient data structure, where computation of topological relationships is much easier and efficient, like cell complex homologies (See Footnote 3) are easier to compute than their simplicial counterparts. This new data structure, thanks to its efficiency, could have a positive impact on applications that need near real time response, like mapping for natural disasters, emergency planning, evacuation, etc.
Child cancer follow-up ontology and information system

An increase in chronic diseases in Danish healthcare can be explained by the corresponding increase of population longevity. Health professionals will not be able to keep up with treating those diseases, due to the many existing and new cases of chronic diseases. This results in mistakes in treatment processes, compensations to patients due to medical negligence and duplication of work and effort. In order to address a solution for healthcare practitioners, a small subgroup of patients and diseases is chosen from all chronic diseases. Namely, children diagnosed with cancer. This research brings the methodology for child cancer treatment plan that produces an ontology to create a conceptual model and a database model. To construct the ontology, the "methontology" method is used as a structured approach for the ontology process. The method guides the ontology developer from scratch to building a complete model. The ontology is developed in two phases. In the first phase, research from other countries and process models are reviewed and the generic model is built from this research. The generic model is adapted to the ontology for the Danish hospitals including the NOPHO-ALL 2008 protocol. To develop the ontology, a data dictionary is first proposed. Then, the relationships between concepts are identified and verified: the oriented graph, where nodes are concepts and oriented edges are dependence relationships, where the definition of the concept at the origin of the edge depends on the concept at the destination of the edge, must be a directed acyclic graph. Finally, the ontology resulting from the previous steps is implemented in Protégé-OWL. The conceptual model follows directly and univocally from the ontology: an entity-relationship diagram in UML notation. © 2013 WIT Press.
Improving 3D spatial queries search: newfangled technique of space filling curves in 3D city modeling

The advantages of three dimensional (3D) city models can be seen in various applications including photogrammetry, urban and regional planning, computer games, etc. They expand the visualization and analysis capabilities of Geographic Information Systems on cities, and they can be developed using web standards. However, these 3D city models consume much more storage compared to two dimensional (2D) spatial data. They involve extra geometrical and topological information together with semantic data. Without a proper spatial data clustering method and its corresponding spatial data access method, retrieving portions of and especially searching these 3D city models, will not be done optimally. Even though current developments are based on an open data model allotted by the Open Geospatial Consortium (OGC) called CityGML, its XML-based structure makes it challenging to cluster the 3D urban objects. In this research, we propose an opponent data constellation technique of space-filling curves (space-filling curve) for 3D city model data representation.
Unlike previous methods, that try to project 3D or n-dimensional data down to 2D or 3D using Principal Component Analysis (PCA) or Hilbert mappings, in this research, we extend the Hilbert space-filling curve to one higher dimension for 3D city model data implementations. The query performance was tested using a CityGML dataset of 1,000 building blocks and the results are presented in this paper. The advantages of implementing space-filling curves in 3D city modeling will improve data retrieval time by means of optimized 3D adjacency, nearest neighbor information and 3D indexing. The Hilbert mapping, which maps a subinterval of the [0, 1] interval to the corresponding portion of the d-dimensional Hilbert’s curve, preserves the Lebesgue measure and is Lipschitz continuous. Depending on the applications, several alternatives are possible in order to cluster spatial data together in the third dimension compared to its clustering in 2D.
Review of Spatial Indexing Techniques for Large Urban Data Management

Pressure on land development in urban areas causes progressive efforts in spatial planning and management. The physical expansion of urban areas to accommodate rural migration implies a massive impact to social, economical and political situations of major cities. Most of the models used in managing urban areas are moving towards sustainable urban development in order to fulfill current necessities while preserving the resources for future generations. However, in order to manage large amounts of urban spatial data, an efficient spatial data constellation method is needed. With the ease of three dimensional (3D) spatial data usage in urban areas as a new source of data input, practical spatial data indexing is necessary to improve data retrieval and management. Current two dimensional (2D) spatial indexing approaches seem not applicable to the current and future spatial developments. Therefore, the objective of this paper is to review existing spatial data indexing approaches for managing large urban area datasets. Each approach will be reviewed and discussed according to the current spatial data scenarios. In addition, a 3D spatial data indexing method will be discussed as an alternative for organizing 3D spatial data.

RF subsystem power consumption and induced radiation emulation

The thesis introduces a novel approach towards the emulation of the RF subsystem power consumption when transmitting a LTE signal. The RF subsystem which is made up of analog components has not been covered by the status quo emulation methodologies which are compatible with digital circuits. Though the study of the RF subsystem architectures revealed numerous architectures with different impacts on power consumption, we have decided to consider the RF subsystem as a black box.

The RF subsystem power emulation has been studied for the telecommunication technology Long Term Evolution (LTE). Given the fact that major power consumptions of wireless devices are largely functions of sequences of protocol/ logical activities, it is this technology that provided the inputs to the RF subsystem as a black black box which are Tx power, carrier frequency and signal bandwidth. The physical environmental variable temperature has also proven to be very influential on power consumption. These inputs also do constitute to the input parameters of the emulation methodology.

The emulation methodology has been proven to be a mathematical mapping between the input parameters and a predefined mathematical model. For the mathematical model, multivariate modeling approaches were analyzed for an approach with the least modeling error and complexity. Herein, the homotopy continuation numerical approach proved to have the least modeling error of 3%. The RF subsystem power consumption has been emulated with accuracies of 84% ±2.25% and 94.3% ±2.25% on different devices.
Spatio-temporal map generalizations with the hierarchical Voronoi data structure

Map generalization leads to simplified maps that are needed for specific applications. However, in the map generalization process, the processing of the map objects and the operations applied to achieve this simplified map are usually lost. This is due to the transaction processing systems implemented in commercial GIS systems.

In this research, we used the Voronoi spatial data model for map generalizations. We were able to demonstrate that the map generalization does not affect only spatial objects (points, lines or polygons), but also the events corresponding to the creation and modification of map objects, together with their temporal and spatial adjacency relationships. In this paper, we present new solutions to the problems of spatio-temporal generalizations using the hierarchical Voronoi spatio-temporal data structure. The application of the hierarchical Voronoi data structure presented in this research is in spatio-temporal map generalization, which is needed for reasoning about dynamic aspects of the world, primarily about actions, events and processes.

This provides an advance in the domain of map generalization as we are able to deal not only with the cartographic objects, but also their spatio-temporal characteristics and their dynamic behaviour.

Unified Data Model of Urban Air Pollution Dispersion and 3D Spatial City Models: Groundwork Assessment towards Sustainable Urban Development for Malaysia

Understanding the behavior of urban air pollution is important en route for sustainable urban development (SUD). Malaysia is on its mission to be a developed country by year 2020 comprehends dealing with air pollution is one of the indicators headed towards it. At present monitoring and managing air pollution in urban areas encompasses sophisticated air quality modeling and data acquisition. However, rapid developments in major cities cause difficulties in acquiring the city geometries. The existing method in acquiring city geometries data via ground or space measurement inspection such as field survey, photogrammetry, laser scanning, remote sensing or using architectural plans appears not to be practical because of its cost and efforts. Moreover, air monitoring stations deployed are intended for regional to global scale model whereby it is not accurate for urban areas with typical resolution of less than 2 km. Furthermore in urban areas, the pollutant dispersion movements are trapped between buildings initiating it to move vertically causing visualization complications which imply the limitations of existing visualization scheme that is based on two-dimensional (2D) framework. Therefore this paper aims is to perform groundwork assessment and discuss on the current scenario in Malaysia in the aspect of current policies towards SUD, air quality monitoring stations, scale model and detail discussion on air pollution dispersion model used called the Operational Street Pollution Model (OSPM). This research proposed the implementation of three-dimensional (3D) spatial city model as a new physical data input for OSPM. The five Level of Details (LOD) of 3D spatial city model shows the scale applicability for the dispersion model implementation. Subsequently 3D spatial city model data commonly available on the web, by having a unified data model shows the advantages in easy data acquisition, 3D visualization of air pollution dispersion and improves visual analysis of air quality monitoring in urban areas.

Optical scanning is rapidly becoming ubiquitous. From industrial laser scanners to medical CT, MR and 3D ultrasound scanners, numerous organizations now have easy access to optical acquisition devices that provide huge volumes of image data. However, the raw geometry data acquired must first be processed before it is useful.

This Guide to Computational Geometry Processing reviews the algorithms for processing geometric data, with a practical focus on important techniques not covered by traditional courses on computer vision and computer graphics. This is balanced with an introduction to the theoretical and mathematical underpinnings of each technique, enabling the reader to not only implement a given method, but also to understand the ideas behind it, its limitations and its advantages.

Topics and features:

- Presents an overview of the underlying mathematical theory, covering vector spaces, metric space, affine spaces, differential geometry, and finite difference methods for derivatives and differential equations
- Reviews geometry representations, including polygonal meshes, splines, and subdivision surfaces
- Examines techniques for computing curvature from polygonal meshes
- Describes algorithms for mesh smoothing, mesh parametrization, and mesh optimization and simplification
- Discusses point location databases and convex hulls of point sets
- Investigates the reconstruction of triangle meshes from point clouds, including methods for registration of point clouds and surface reconstruction
- Provides additional material at a supplementary website
- Includes self-study exercises throughout the text

Graduate students will find this text a valuable, hands-on guide to developing key skills in geometry processing. The book will also serve as a useful reference for professionals wishing to improve their competency in this area.

General information

State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, Department of Mathematics, Geometry
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Number of pages: 325
Publication date: 2012

Publication information

Publisher: Springer
ISBN (Print): 978-1-4471-4074-0
ISBN (Electronic): 978-1-4471-4075-7
Original language: English
Main Research Area: Technical/natural sciences
DOIs:
10.1007/978-1-4471-4075-7
Links:
http://www.springerlink.com.globalproxy.cv.t.dk/content/978-1-4471-4074-0/
Publication: Research - peer-review › Book – Annual report year: 2012

Level Sets and Voronoi based Feature Extraction from any Imagery

Polygon features are of interest in many GEOProcessing applications like shoreline mapping, boundary delineation, change detection, etc. This paper presents a unique new GPU-based methodology to automate feature extraction combining level sets, or mean shift based segmentation together with Voronoi skeletonization, that guarantees the extracted features to be topologically correct. The features thus extracted as object centerlines can be stored as vector maps in a Geographic Information System after labeling and editing. We show application examples on different sources: paper maps, digital satellite imagery, and 2D/3D acoustic images (from hydrographic surveys). The application involving satellite imagery shown in this paper is coastline detection, but the methodology can be easily applied to feature extraction on any kind of imagery. A prototype application that is developed as part of this research work.

General information

State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, IIT Mumbay
Authors: Sharma, O. (Ekstern), Anton, F. (Intern), Mioc, D. (Intern)
Number of pages: 9
Pages: 89-97
Publication date: 2012

Host publication information
LTE modem power consumption, SAR and RF signal strength emulation
This paper presents a new methodology for emulating the LTE modem power consumption, emitted SAR and RF signal strength when transmitting an LTE signal. The inputs of the methodology are: modem logical/protocol commands, time advance, near-field specifier, and antenna characteristics. The power emulation model(s) are computed by a two layer 451 neural network based on physical power measurements. SAR is emulated by polynomial interpolation models based on FDTD simulations. The accuracies of the mathematical function approximations for the emulation models of power and SAR are 5.19% and 3.6% respectively. The RF signal strength is emulated by an analytical model.

LTE RF subsystem power consumption modeling
This paper presents a new power consumption emulation model, for all possible scenarios of the RF subsystem, when transmitting a LTE signal. The model takes the logical interface parameters, Tx power, carrier frequency and bandwidth between the baseband and RF subsystem as inputs to compute the power consumption. An analysis of modeling approaches was conducted and the modeling approach with the least sum of squared errors is used to compute the emulation model. The neural networks applying the Pseudo-Gauss Newton algorithm for optimization proved to have the least sum of squared errors. This approach was validated against a real life scenario with a relative error of 5.77%.
Map Updates in a Dynamic Voronoi Data Structure

General information
State: Published
Organisations: National Space Institute, Geodesy
Authors: Mioc, D. (Intern), Anton, F. (Intern), Gold, C. M. (Ekstern), Moulin, B. (Ekstern)
Pages: 37-64
Publication date: 2012

Host publication information
Title of host publication: Application of Geographic Information Systems
Publisher: InTech
Editor: Monwar Alam, B.
Chapter: 3
Main Research Area: Technical/natural sciences
Electronic versions:
InTech1.pdf
DOIs:
10.5772/50279
Links:

Bibliographical note
This is an open access chapter distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
Source: dtu
Source-ID: u::5978
Publication: Research - peer-review › Book chapter – Annual report year: 2012

Non-Spatial and Geospatial Semantic Query of Health Information
With the growing amount of health information and frequent outbreaks of diseases, the retrieval of health information is given more concern. Machine understanding of spatial information can improve the interpretation of health data semantics. Most of the current research focused on the non-spatial semantics of health data, using ontologies and rules. Utilizing the spatial component of health data can assist in the understanding of health phenomena. This research proposes a semantic health information query architecture that allows the incorporation of both non-spatial semantics and geospatial semantics in health information integration and retrieval.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of New Brunswick, National Research Council of Canada
Authors: Gao, S. (Ekstern), Anton, F. (Intern), Mioc, D. (Intern), Boley, H. (Ekstern)
Number of pages: 6
Pages: 167-172
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences
Volume: XXXIX-B2
ISSN (Print): 1682-1750
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Bibliographical note
Since Volume XXXII-3/W14, 1999, the Archives are open access publications, they are published under the Creative Common Attribution 3.0 License, see publications.copernicus.org/for_authors/license_and_copyright.html for details.

Source: dtu
Source-ID: u::4833
Publication: Research - peer-review › Conference article – Annual report year: 2012

Risk maps for evaluation of natural and man-made hazards

General information
State: Published
Organisations: National Space Institute, Geodesy, University of New Brunswick, New Brunswick Emergency Measures Organization, New Brunswick Department of Environment
Authors: Mioc, D. (Intern), Anton, F. (Intern), Ahmad, A. (Ekstern), Moreiri, K. K. (Ekstern), Nikerson, B. (Ekstern), McGillivray, E. (Ekstern), Mezouaghi, M. (Ekstern), Mofford, L. (Ekstern), Tang, P. (Ekstern)
Number of pages: 12
Pages: 141-151
Publication date: 2012

Host publication information
Title of host publication: Risk Analysis VIII
Publisher: WIT Press
Series: WIT Transactions on Information and Communication Technologies
Volume: 44
Main Research Area: Technical/natural sciences
Risk maps, Flood, Environmental pollution
Source: dtu
Source-ID: u::5979
Publication: Research - peer-review › Book chapter – Annual report year: 2012

Towards introducing a geocoding information system for Greenland

General information
State: Published
Organisations: National Space Institute, Geodesy, ASIAQ Greenland Survey, MBBL
Authors: Siksnans, J. (Ekstern), Pirupshvarre, H. R. (Ekstern), Lind, M. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern)
Number of pages: 7
Publication date: 2012

Publication information
Original language: English
Publisher: DTU Space
Main Research Area: Technical/natural sciences
Electronic versions:
Session 13 - Francois Anton.pdf

Bibliographical note
Oral presentation
Source: dtu
Source-ID: u::6005
Publication: Research › Sound/Visual production (digital) – Annual report year: 2012
Visualization of the Impact of the Catastrophic Flooding Events

The use of advanced tools for computation and modelling of natural hazards can be combined with a GIS that has the capability of decision support and advanced visualization to produce models, that will represent the risks of natural hazards and man-made disasters in the form of risk maps, where the risks are categorized and quantified. Very large amounts of data can be processed, quantified and displayed on digital maps, allowing decision makers to assess the situation rapidly and take appropriate actions. Furthermore, these processes can be automated, enabling near real time access to the risk maps. This can greatly help decision makers with the emergency measures and mitigation in most of the cases. In this article, we present a case study about mapping of flood risks due to a dam burst showing risk maps of flood hazards and available emergency facilities and their significance for risk prevention and mitigation.

General information
State: Published
Organisations: National Space Institute, Geodesy, University of New Brunswick, Victoria Health Centre, New Brunswick Department of Environment
Authors: Mioc, D. (Intern), Anton, F. (Intern), Morel, K. K. (Ekstern), Nickerson, B. (Ekstern), McGillivray, E. (Ekstern), Mezuoghi, M. (Ekstern), Mofford, L. (Ekstern), Tang, P. (Ekstern)
Number of pages: 9
Publication date: 2012
Main Research Area: Technical/natural sciences
Source: dtu
Source-ID: u::6002
Publication: Research - peer-review › Paper – Annual report year: 2012

AMS Mathematical review of the paper "Everett, Hazel; Lazard, Daniel (F-PARIS6-IP6); Lazard, Sylvain; Safey El Din, Mohab (F-PARIS6-IP6) The Voronoi diagram of three lines. (English summary) Discrete Comput. Geom. 42 (2009), no. 1, 94–130."

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (Intern)
Publication date: 2011
Main Research Area: Technical/natural sciences

Publication information
Journal: Mathematical Reviews
ISSN (Print): 0025-5629
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English

Bibliographical note
MR2506739 (2011b:68259) 68U05 (51M20)
Source: orbit
Source-ID: 274392
Publication: Research - peer-review › Review – Annual report year: 2010

Cut Locus Construction using Deformable Simplicial Complexes

In this paper we present a method for approximating cut loci for a given point p on Riemannian 2D manifolds, closely related to the notion of Voronoi diagrams. Our method finds the cut locus by advecting a front of points equally distant from p along the geodesics originating at p and finding the lines of self-intersections of the front in the parametric space. This becomes possible by using the deformable simplicial complexes (DSC, [1]) method for deformable interface tracking. DSC provide a simple collision detection mechanism, allows for interface topology control, and does not require the domain to have disk topology. We test our method for tori of revolution and compare our results to the benchmark ones from [2]. The method, however, is generic and can be easily adapted to construct cut loci for other manifolds of genera other than 1.

General information
State: Published
Development and challenges of using web-based GIS for health applications

Web-based GIS is increasingly used in health applications. It has the potential to provide critical information in a timely manner, support health care policy development, and educate decision makers and the general public. This paper describes the trends and recent development of health applications using a Web-based GIS. Recent progress on the database storage and geospatial Web Services has advanced the use of Web-based GIS for health applications, with various proprietary software, open source software, and Application Programming Interfaces (APIs) available. Current challenges in applying Web-based GIS for health, such as data heterogeneity, data privacy and confidentiality, powerful processing abilities, and appropriate data representation to users are also discussed. The continuous development of Web-based GIS for health applications will further enhance disease surveillance, health care planning, and public health participation.

Exact computation of the Voronoi Diagram of spheres in 3D, its topology and its geometric invariants

In this paper, we are addressing the exact computation of the Delaunay graph (or quasi-triangulation) and the Voronoi diagram of spheres using Wu’s algorithm. Our main contribution is first a methodology for automated derivation of invariants of the Delaunay empty circumcircle predicate for spheres and the Voronoi vertex of four spheres, then the application of this methodology to get all geometrical invariants that intervene in this problem and the exact computation of the Delaunay graph and the Voronoi diagram of spheres. To the best of our knowledge, there does not exist a comprehensive treatment of the exact computation with geometrical invariants of the Delaunay graph and the Voronoi diagram of spheres. Starting from the system of equations defining the zero-dimensional algebraic set of the problem, we are following Wu’s algorithm to transform the initial system into an equivalent Wu characteristic (triangular) set. In the corresponding system of algebraic equations, in each polynomial (except the first one), the variable with higher order from the preceding polynomial has been eliminated (by pseudo-remainder computations) and the last polynomial is a
polynomial of a single variable. By regrouping all the formal coefficients for each monomial in each polynomial, we get polynomials that are invariants for the given problem. We rewrite the original system by replacing the invariant polynomials by new formal coefficients. We repeat the process until all the algebraic relationships (syzygies) between the invariants have been found by applying Wu’s algorithm on the invariants.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Geodesy, National Space Institute, University of New Brunswick
Authors: Anton, F. (Intern), Mioc, D. (Intern), Santos, M. (Ekstern)
Pages: 58-66
Publication date: 2011

**Fast Streaming 3D Level set Segmentation on the GPU for Smooth Multi-phase Segmentation**

Level set method based segmentation provides an efficient tool for topological and geometrical shape handling, but it is slow due to high computational burden. In this work, we provide a framework for streaming computations on large volumetric images on the GPU. A streaming computational model allows processing large amounts of data with small memory footprint. Efficient transfer of data to and from the graphics hardware is performed via a memory manager. We show volumetric segmentation using a higher order, multi-phase level set method with speedups of the order of 5 times.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Texas
Authors: Sharma, O. (Intern), Zhang, Q. (Ekstern), Anton, F. (Intern), Bajaj, C. (Ekstern)
Pages: 72-91
Publication date: 2011

**Publication information**

Journal: Lecture Notes in Computer Science
Volume: 6750
ISSN (Print): 0302-9743
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.67 SJR 0.315 SNIP 0.552
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.328 SNIP 0.618 CiteScore 0.37
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.325 SNIP 0.678 CiteScore 0.42
BFI (2013): BFI-level 1
Flood Progression Modelling and Impact Analysis
People living in the lower valley of the St. John River, New Brunswick, Canada, frequently experience flooding when the river overflows its banks during spring ice melt and rain. To better prepare the population of New Brunswick for extreme flooding, we developed a new flood prediction model that computes floodplain polygons before the flood occurs. This allows emergency managers to access the impact of the flood before it occurs and make the early decisions for evacuation of the population and flood rescue. This research shows that the use of GIS and LiDAR technologies combined with hydrological modelling can significantly improve the decision making and visualization of flood impact needed for emergency planning and flood rescue. Furthermore, the 3D GIS application we developed for modelling flooded buildings and infrastructure provides a better platform for modelling and visualizing flood situations than previously done in 2D maps. All parts of a building could be studied in detail in the event of flooding. This provides a better tool for analyzing and preparing for emergency measures. It also presents a photo-realistic situation that can easily be understood. Public administrators who may not be familiar with GIS analytical tools like Query Languages, can still understand technical discussions on flood analysis through the use of 3D models, which are close to reality.

General information
State: Published
Organisations: National Space Institute, Geodesy
Homotopic Object Reconstruction Using Natural Neighbor Barycentric Coordinates

One of the challenging problems in computer vision is object reconstruction from cross sections. In this paper, we address the problem of 2D object reconstruction from arbitrary linear cross sections. This problem has not been much discussed in the literature, but holds great importance since it lifts the requirement of order within the cross sections in a reconstruction problem, consequently making the reconstruction problem harder. Our approach to the reconstruction is via continuous deformations of line intersections in the plane. We define Voronoi diagram based barycentric coordinates on the edges of n-sided convex polygons as the area stolen by any point inside a polygon from the Voronoi regions of each open oriented line segment bounding the polygon. These allow us to formulate homotopies on edges of the polygons from which the underlying object can be reconstructed. We provide results of the reconstruction including the necessary derivation of the gradient at polygon edges and the optimal placement of cutting lines. Accuracy of the suggested reconstruction is evaluated by means of various metrics and compared with one of the existing methods.

Homotopy based Surface Reconstruction with Application to Acoustic Signals

This work introduces a new algorithm for surface reconstruction in $\mathbb{R}^3$ from spatially arranged one-dimensional cross sections embedded in $\mathbb{R}^3$. This is generally the case with acoustic signals that pierce an object non-destructively. Continuous deformations (homotopies) that smoothly reconstruct information between any pair of successive cross sections are derived. The zero level set of the resulting homotopy field generates the desired surface. Four types of homotopies are suggested that are well suited to generate a smooth surface. We also provide derivation of necessary higher order homotopies that can generate a $C^2$ surface. An algorithm to generate surface from acoustic sonar signals is presented with results. Reconstruction accuracies of the homotopies are compared by means of simulations performed.
on basic geometric primitives.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Sharma, O. (Intern), Anton, F. (Intern)
Pages: 373-386
Publication date: 2011
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Visual Computer
Volume: 27
Issue number: 5
ISSN (Print): 0178-2789
Ratings:
- BFI (2018): BFI-level 1
- BFI (2017): BFI-level 1
- Web of Science (2017): Indexed Yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.62 SJR 0.536 SNIP 1.061
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.472 SNIP 1.037 CiteScore 1.24
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.398 SNIP 1.039 CiteScore 1.21
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.492 SNIP 1.136 CiteScore 1.43
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 0.333 SNIP 1.232 CiteScore 1.08
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): SJR 0.339 SNIP 1.065 CiteScore 1.2
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 0.306 SNIP 1.326
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 0.384 SNIP 1.525
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.432 SNIP 1.234
- Scopus rating (2007): SJR 0.387 SNIP 1.048
- Scopus rating (2006): SJR 0.316 SNIP 1.089
- Scopus rating (2005): SJR 0.299 SNIP 1.202
- Scopus rating (2004): SJR 0.221 SNIP 1.133
- Scopus rating (2003): SJR 0.521 SNIP 1.495
- Scopus rating (2002): SJR 0.617 SNIP 1.212
- Scopus rating (2001): SJR 1.003 SNIP 1.421
- Web of Science (2001): Indexed yes
- Scopus rating (2000): SJR 0.629 SNIP 0.794
- Scopus rating (1999): SJR 0.466 SNIP 0.694

Original language: English
Sonar, Surface reconstruction, Homotopy, Continuous deformations
DOIs:
10.1007/s00371-011-0544-4
Source: orbit
RF power consumption emulation optimized with interval valued homotopies

This paper presents a methodology towards the emulation of the electrical power consumption of the RF device during the cellular phone/handset transmission mode using the LTE technology. The emulation methodology takes the physical environmental variables and the logical interface between the baseband and the RF system as inputs to compute the emulated power dissipation of the RF device. The emulated power, in between the measured points corresponding to the discrete values of the logical interface parameters is computed as a polynomial interpolation using polynomial basis functions. The evaluation of polynomial and spline curve fitting models showed a respective divergence (test error) of 8% and 0.02% from the physically measured power consumption. The precisions of the instruments used for the physical measurements have been modeled as intervals. We have been able to model the power consumption of the RF device operating at 5MHz using homotopy between 2 continuous power consumptions of the RF device operating at the bandwidths 3MHz and 10MHz.

Towards introducing a Geocoding Information System for Greenland

General information

State: Published
Organisations: National Space Institute, Geodesy, Technical University of Denmark, NunaGIS, National Agency for Business and Housing
Authors: Siksnans, J. (Ekstern), Pirupshvarre, H. R. (Ekstern), Lind, M. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern)
Number of pages: 5
Publication date: 2011
Event: Paper presented at ISPRS Workshop on Geospatial Data Infrastructure: from data acquisition and updating to smarter services, Guilin, China.
Main Research Area: Technical/natural sciences
Source: dtu
Transactions on Computational Science IX: Special Issue on Voronoi Diagrams in Science and Engineering
The 9th issue of the Transactions on Computational Science journal, edited by François Anton, is devoted to the subject of Voronoi diagrams in science and engineering. The 9 papers included in the issue constitute extended versions of selected papers from the International Symposium on Voronoi Diagrams, held in Copenhagen, Denmark, June 23-36, 2009. Topics covered include: divide and conquer construction of Voronoi diagrams; new generalized Voronoi diagrams or properties of existing generalized Voronoi diagrams; and applications of Voronoi diagrams and their duals in graph theory, computer graphics, bioinformatics, and spatial process simulation.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (ed.) (Intern)
Number of pages: 203
Publication date: 2011

Publication information
Publisher: Springer
ISBN (Print): 978-3-642-16006-6
Original language: English
Series: Lecture Notes in Computer Science
Number: 6290
Main Research Area: Technical/natural sciences
Links:
http://www.springer.com/computer/theoretical+computer+science/book/978-3-642-16006-6
Source: orbit
Source-ID: 274955
Publication: Research - peer-review › Book – Annual report year: 2009

Homotopy Based Reconstruction from Acoustic Images
This thesis presents work in the direction of generating smooth surfaces from linear cross sections embedded in R2 and R3 using homotopy continuation. The methods developed in this research are generic and can be applied to higher dimensions as well. Two types of problems addressed in this research are reconstruction from an organised set of linear cross sections and reconstruction from an arbitrary set of linear cross sections. The first problem is looked upon in the context of acoustic signals wherein the cross sections show a definite geometric arrangement. A reconstruction in this case can take advantage of the inherent arrangement. The problem of reconstruction from arbitrary cross sections is a generic problem and is also shown to be solved here using the mathematical tool of continuous deformations. As part of a complete processing, segmentation using level set methods is explored for acoustic images and fast GPU (Graphics Processing Unit) based methods are suggested for a streaming computation on large volumes of data. Validation of results for acoustic images is not straightforward due to unavailability of ground truth. Accuracy figures for the suggested methods are provided using phantom object with known geometry. The results of the methods shown here can be used to gain objective knowledge about the reconstructed features. It is envisioned that due to the generic nature of the algorithms developed in this research, domains other than fisheries research can benefit from the reconstruction algorithms.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Sharma, O. (Intern), Anton, F. (Intern), Christensen, N. J. (Intern)
Publication date: Sep 2010

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Series: IMM-PHD-2010-234
Main Research Area: Technical/natural sciences
Electronic versions:
phd234_os.pdf
Source: orbit
Source-ID: 265149
AMS Mathematical Review of the book "Géométrie discrète et images numériques" (French)

This is the AMS Mathematical Review for the book: Géométrie discrète et images numériques [Discrete geometry and numerical images] Edited by David Coeurjolly, Annick Montanvert and Jean-Marc Chassery. Traité IC2. Série Signal et Image. [IC2 Treatise. Series Signal and Image] Hermes Science Publications/Lavoisier, Paris, 2007. 401+xii pp. ISBN: 978-2-7462-1643-3 65D18 (51N99 68U10 94A08) This is a collective book stemming from the French colloquium on Discrete Geometry in Imaging created in 1991, which became international in 1996 under the name of "Discrete Geometry in Computer Science". The book is structured in five parts. The first part (chapters 2 through 4) presents the general mathematical foundations of discrete geometry and topology: arithmetic (chapter 2, which is later referred to in chapters 6, 7 and 11), topology (chapter 3, which is referred to in chapter 8) and combinatorics (chapter 4, the foundation of chapter 12). The second part (chapters 5 to 8) introduces discrete geometry and discrete topology, which are the foundations of the next part. The third part (chapters 9 through 12) presents the different representations and their mappings: the medial axis (chapter 9), representations by projections obtained by accumulation (and in particular the Mojette transform, chapter 10), polygonization and polyhedrization (chapter 11) and approximation of surfaces by triangulation (chapter 12). The medial axis and the Mojette transform are key representations, whose applications are further described in the fifth part. The fourth part (chapters 13 and 14) focuses on image analysis from either original images or their representations introduced in the third part. In the fifth and last part (chapters 15 through 19), the authors present applications of the previous chapters: medial axis based coding techniques for progressive transmission (chapter 15), applications of the Mojette transform to image encoding and protection for storage and transmission (chapter 16), extraction of information from 3D images (plane sections of voxels, chapter 17) and visualization of 3D discrete images (through implicit surfaces with skeletons, chapter 18), applications of discrete geometry to medical imaging (chapter 19) and generalization of discrete geometry objects and operators to multiresolution grids (chapter 20). This book presents very interesting mathematical methodological tools from discrete geometry (and discrete topology) and their applications to digital imaging (analysis, processing and synthesis) in a very clear, didactic and interesting fashion. I enjoyed very much reading this book that brings a very refreshing and inspiring view of digital imaging, that is unfortunately not so widespread. It should benefit both specialists of imaging and geometries by its methodological contents of high quality, and its many different examples of applications of discrete geometry and topology including the very trendy domain of medical imaging. I would recommend it as a textbook in image analysis and image processing, and especially as an eye opening book presenting an alternative to statistical based digital imaging through strongly motivated methodological tools. I hope that English and Spanish translations of this book will see light and extend its audience towards this purpose of being a widely spread textbook. While the authors mention both the graph-based approach to discrete topology and the topological approach to digital topology, they cover in much more details the former than the later. The interested reader can refer to [Kong, T. Y.; Rosenfeld, A. Digital topology: a comparison of the graph-based and topological approaches. Topology and category theory in computer science (Oxford, 1989), 273–289, Oxford Sci. Publ., Oxford Univ. Press, New York, 1991.] for a comparison between the two approaches.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (Intern)
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Mathematical Reviews
ISSN (Print): 0025-5629
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: English
Discrete topology, Discrete geometry, Digital images
Electronic versions:
ReviewDiscreteGeometryAndDigitalImages.txt
Links:

Bibliographical note
Source: orbit
Source-ID: 270718
Deformable Simplicial Complexes

In this dissertation we present a novel method for deformable interface tracking in 2D and 3D (deformable simplicial complexes (DSC)). Deformable interfaces are used in several applications, such as fluid simulation, image analysis, reconstruction or structural optimization. In the DSC method, the interface (curve in 2D; surface in 3D) is represented explicitly as a piecewise linear curve or surface. However, the domain is also subject to discretization: triangulation in 2D; tetrahedralization in 3D. This way, the interface can be alternatively represented as a set of edges/triangles separating triangles/tetrahedra marked as outside from those marked as inside. Such an approach allows for robust topological adaptivity. Among other advantages of the deformable simplicial complexes there are: space adaptivity, ability to handle and preserve sharp features, possibility for topology control. We demonstrate those strengths in several applications. In particular, a novel, DSC-based fluid dynamics solver has been developed during the PhD project. A special feature of this solver is that due to the fact that DSC maintains an explicit interface representation, surface tension is more easily dealt with. One particular advantage of DSC is the fact that as an alternative to topology adaptivity, topology control is also possible. This is exploited in the construction of cut loci on tori where a front expands from a single point on a torus and stops when it self-intersects.
Homotopic Object Reconstruction Using Natural Neighbor Barycentric Coordinates

One of the challenging problems in computer vision is object reconstruction from cross sections. In this paper, we address the problem of 2D object reconstruction from arbitrary linear cross sections. This problem has not been much discussed in the literature, but holds great importance since it lifts the requirement of order within the cross sections in a reconstruction problem, consequently making the reconstruction problem harder. Our approach to the reconstruction is via continuous deformations of line intersections in the plane. We define Voronoi diagram based barycentric coordinates on the edges of n-sided convex polygons as the area stolen by any point inside a polygon from the Voronoi regions of each open oriented line segment bounding the polygon. These allow us to formulate homotopies on edges of the polygons from which the underlying object can be reconstructed. We provide results of the reconstruction including the necessary derivation of the gradient at polygon edges.

Kinetic Line Voronoi Operations and Their Reversibility

In Geographic Information Systems the reversibility of map update operations has not been explored yet. In this paper we are using the Voronoi based Quad-edge data structure to define reversible map update operations. The reversibility of the map operations has been formalised at the lowest level, as the basic algorithms for addition, deletion and moving of spatial objects. Having developed reversible map operations on the lowest level, we were able to maintain reversibility of the map updates at higher levels as well. The reversibility in GIS can be used for efficient implementation of rollback operations.
mechanisms and dynamic map visualisations. In order to use the reversibility within the kinetic Voronoi diagram of points and open oriented line segments, we need to assure that reversing the map commands will produce exactly the changes in the map equivalent to the previous map states. To prove that reversing the map update operations produces the exact reverse changes, we show an isomorphism between the set of complex operations on the kinetic Voronoi diagram of points and open oriented line segments and the sets of numbers of new / deleted Voronoi regions induced by these operations, and its explanation using the finite field of residual classes of integers modulo 5: \( \mathbb{Z}/5\mathbb{Z} \). We show also an isomorphism between the set of complex operations on the kinetic Voronoi diagram of points and open oriented line segments and the set of differences of new and deleted Quad-Edge edges induced by these operations, and its explanation using the commutative ring \( \mathbb{Z}/15\mathbb{Z} \). We show finally the application of these theoretical results to the logging of a kinetic line Voronoi data structure. © 2010 Springer-Verlag.
Multi-domain, higher order level set scheme for 3D image segmentation on the GPU

Level set method based segmentation provides an efficient tool for topological and geometrical shape handling. Conventional level set surfaces are only $C^0$ continuous since the level set evolution involves linear interpolation to compute derivatives. Bajaj et al. present a higher order method to evaluate level set surfaces that are $C^2$ continuous, but are slow due to high computational burden. In this paper, we provide a higher order GPU based solver for fast and efficient segmentation of large volumetric images. We also extend the higher order method to multi-domain segmentation. Our streaming solver is efficient in memory usage.

Online mapping and querying health data

General information
State: Published
Organisations: Geodesy, National Space Institute, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Mioc, D. (Intern), Gao, S. (Ekstern), Yi, X. (Ekstern), Anton, F. (Intern), Boley, H. (Ekstern), Oldfield, E. (Ekstern)
Publication date: 2010
Event: Abstract from Nordic Workshop on GIS and Health, Copenhagen, .
Main Research Area: Technical/natural sciences
Links:
http://geoforum.dk/Admin/Public/DWSDownload.aspx?File...programme.pdf
Source: orbit
Source-ID: 270740
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2010
Optimization-based Fluid Simulation on Unstructured Meshes

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of British Columbia, University of Copenhagen
Authors: Misztal, M. K. (Intern), Bridson, R. (Ekstern), Erleben, K. (Ekstern), Bærentzen, J. A. (Intern), Anton, F. (Intern)
Publication date: 2010

Host publication information
Title of host publication: Proceedings of the 7th Workshop on Virtual Reality Interaction and Physical Simulation : VRIPHYS
Main Research Area: Technical/natural sciences
Conference: 7th Workshop on Virtual Reality Interaction and Physical Simulation : VRIPHYS, Copenhagen, 01/01/2010
Source: orbit
Source-ID: 266365
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Camera Resectioning from a Box

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Lund University
Authors: Aanæs, H. (Intern), Josephson, K. (Ekstern), Anton, F. (Intern), Bærentzen, J. A. (Intern), Kahl, F. (Ekstern)
Publication date: 2009

Host publication information
Title of host publication: 16th Scandinavian Conference on Image Analysis
Main Research Area: Technical/natural sciences
Conference: 16th Scandinavian Conference on Image Analysis (SCIA), Oslo, Norway, 15/06/2009 - 15/06/2009
Source: orbit
Source-ID: 248643
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

CUDA Accelerated Multi-domain Volumetric Image Segmentation and Using a Higher Order Level Set Method
In this paper we present a methodology for smooth surface segmentation (partition) of volumetric images using higher order level set scheme. The segmentation allows for a multi-domain partitioning by minimizing modified Mumford-Shah functional. Since, volumetric images tend to be de-manding in terms of computation and memory space, we employ a CUDA based fast GPU segmentation and provide accuracy measures compared with an equivalent CPU implementation. Our resulting surfaces are C2-smooth resulting from tri-cubic spline interpolation algorithm. We also provide error bounds on the reconstruction/segmentation.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Texas
Authors: Sharma, O. (Intern), Anton, F. (Intern), Zhang, Q. (Ekstern), Bajaj, C. (Ekstern)
Publication date: 2009

Host publication information
Title of host publication: ISPRS International Workshop on Multidimensional & Mobile Data Model
Main Research Area: Technical/natural sciences
Conference: ISPRS International Workshop on Multidimensional & Mobile Data Model, Malaysia, 01/01/2009
GPU computation, smooth surface reconstruction, CUDA, multi-domain volumetric segmentation, Level set methods
Source: orbit
Source-ID: 249556
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

CUDA based Level Set Method for 3D Reconstruction of Fishes from Large Acoustic Data
Acoustic images present views of underwater dynamics, even in high depths. With multi-beam echo sounders (SONARs), it is possible to capture series of 2D high resolution acoustic images. 3D reconstruction of the water column and subsequent estimation of fish abundance and fish species identification is highly desirable for planning sustainable fisheries. Main hurdles in analysing acoustic images are the presence of speckle noise and the vast amount of acoustic data. This paper presents a level set formulation for simultaneous fish reconstruction and noise suppression from raw

CUDA computation, smooth surface reconstruction, CUDA, multi-domain volumetric segmentation, Level set methods
Source: orbit
Source-ID: 249556
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009
acoustic images. Despite the presence of speckle noise blobs, actual fish intensity values can be distinguished by extremely high values, varying exponentially from the background. Edge detection generally gives excessive false edges that are not reliable. Our approach to reconstruction is based on level set evolution using Mumford-Shah segmentation functional that does not depend on edges in an image. We use the implicit function in conjunction with the image to robustly estimate a threshold for suppressing noise in the image by solving a second differential equation. We provide details of our estimation of suppressing threshold and show its convergence as the evolution proceeds. We also present a GPU based streaming computation of the method using NVIDIA’s CUDA framework to handle large volume data-sets. Our implementation is optimised for memory usage to handle large volumes.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Sharma, O. (Intern), Anton, F. (Intern)
Publication date: 2009

Host publication information
Title of host publication: International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision
Volume: 17
ISBN (Print): 978-80-86943-93-0
Main Research Area: Technical/natural sciences
Conference: 17th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision, Plzen, Czech Republic, 02/02/2009 - 02/02/2009
Acoustic images, Noise suppression, Level Set method, CUDA, GPU, 3D reconstruction
Electronic versions:
wscg2009.pdf
Source: orbit
Source-ID: 239549
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Geospatial-Enabled RuleML in a Study on Querying Respiratory Disease Information
A spatial component for health data can support spatial analysis and visualization in the investigation of health phenomena. Therefore, the utilization of spatial information in a Semantic Web environment will enhance the ability to query and to represent health data. In this paper, a semantic health data query and representation framework is proposed through the formalization of spatial information. We include the geometric representation in RuleML deduction, and apply ontologies and rules for querying and representing health information. Corresponding geospatial built-ins were implemented as an extension to OO jDREW. Case studies were carried out using geospatial-enabled RuleML queries for respiratory disease information. The paper thus demonstrates the use of RuleML for geospatial-semantic querying and representing of health information.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of New Brunswick, National Research Council of Canada, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Boley, H. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern), Yi, X. (Ekstern)
Pages: 272-281
Publication date: 2009

Host publication information
Title of host publication: Third International RuleML Symposium on Rule Interchange and Applications (RuleML-2009)
Publisher: Springer
ISBN (Print): 978-3-642-04984-2
Series: Lecture Notes in Computer Science
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 249640
Publication: Research - peer-review › Book chapter – Annual report year: 2009

On kinetic line Voronoi operations and finite fields
In this paper, we show an isomorphism between the set of complex operations on the kinetic Voronoi diagram of points and open oriented line segments and the sets of numbers of new / deleted Voronoi regions induced by these operations, and its explanation using the finite field of residual classes of integers modulo 5: $\mathbb{F}_5 = \mathbb{Z}/5\mathbb{Z}$. We show also an isomorphism between the set of complex operations on the kinetic Voronoi diagram of points and open oriented line segments and the set of differences of new and deleted quad-edge edges induced by these operations, and its explanation using the finite
field $F_{15} = \mathbb{Z}/15\mathbb{Z}$. We show finally the application of these theoretical results to the logging of a kinetic line Voronoi data structure.

General information
State: Published
Organisations: Geodesy, National Space Institute, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Glamorgan, Universite Laval
Authors: Mioc, D. (Intern), Anton, F. (Intern), Gold, C. (Ekstern), Moulin, B. (Ekstern)
Pages: 65-70
Publication date: 2009

Host publication information
Title of host publication: Sixth International Symposium on Voronoi Diagrams, 2009. ISVD ‘09
Publisher: IEEE
Main Research Area: Technical/natural sciences
DOIs: 10.1109/ISVD.2009.39

Bibliographical note
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Source: orbit
Source-ID: 255645
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

On the isomorphism between the medial axis and a dual of the Delaunay graph
In this paper, we show a graph isomorphism between a dual graph of the Delaunay graph of the sampled points and the medial axis of the sampled features. This dual graph captures the fact that two Delaunay triangles share two vertices or an edge. Then, we apply it to the computation of the medial axis of the features selected in an image. The computation of the medial axis of images is of interest in applications such as mapping, climatology, change detection, medicine, etc. This research work provides a way to automate the computation of the medial axis transform of the features of color 2D images. In color images, various features can be distinguished based on their color. The features are thus extracted as object borders, which are sampled in order to compute the medial axis transform. We present also a prototype application for the completely automated or semi-automated processing of (satellite) imagery and scanned maps. Applications include coastline extraction, extraction of fields, clear cuts, clouds, as well as heating or pollution monitoring and dense forest mapping among others.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, National Space Institute
Authors: Sharma, O. (Intern), Anton, F. (Intern), Mioc, D. (Intern)
Pages: 89-95
Publication date: 2009

Host publication information
Title of host publication: Sixth International Symposium on Voronoi Diagrams, 2009. ISVD ‘09 : ISVD 2009
Volume: 6
Publisher: IEEE
Main Research Area: Technical/natural sciences
Electronic versions: Sharma.pdf
DOIs: 10.1109/ISVD.2009.18

Bibliographical note
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Sixth International Symposium on Voronoi Diagrams in Science and Engineering (ISVD 2009), Copenhagen, Denmark, June 23-26, 2009

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (ed.) (Intern)
Number of pages: 278
Publication date: 2009

Publication information
Publisher: IEEE Computer Society Press
ISBN (Print): 978-0-7695-3781-8
Original language: English
Main Research Area: Technical/natural sciences
Voronoi diagrams, Delaunay graphs, Dirichlet tessellations, applications of Voronoi diagrams
Links:
Source: orbit
Source-ID: 268347
Publication: Research - peer-review › Book – Annual report year: 2009

Tetrahedral Mesh Improvement Using Multi-face Retriangulation

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Misztal, M. K. (Intern), Bærentzen, J. A. (Intern), Anton, F. (Intern), Erleben, K. (Ekstern)
Pages: 539-556
Publication date: 2009

Host publication information
Title of host publication: 18th International Meshing Roundtable
Publisher: Springer Verlag
ISBN (Print): 978-3-642-04318-5
Main Research Area: Technical/natural sciences
Conference: 18th International Meshing Roundtable, Salt Lake City, 01/01/2009
Electronic versions:
mfrt_paper.pdf
Source: orbit
Source-ID: 247412
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

The Voronoi diagram of circles and its application to the visualization of the growth of particles
Circles are frequently used for modelling the growth of particle aggregates through the Voronoi diagram of circles, that is a special instance of the Johnson-Mehl tessellation. The Voronoi diagram of a set of sites is a decomposition of space into proximal regions. The proximal region of a site is the locus of points closer to that site than to any other one. Voronoi diagrams allow one to answer proximity queries after locating a query point in the Voronoi zone it belongs to. The dual graph of the Voronoi diagram is called the Delaunay graph. In this paper, we first show a necessary and sufficient condition of connectivity of the Voronoi diagram of circles. Then, we show how the Delaunay graph of circles (the dual graph of the Voronoi diagram of circles) can be computed exactly, and in a much simpler way, by computing the eigenvalues of a two by two matrix. Finally, we present how the Voronoi diagram of circles can be used to model the growth of particle aggregates. We use the Poisson point process in the Voronoi diagram of circles to generate the Johnson-Mehl tessellation. The Johnson-Mehl model is a Poisson Voronoi growth model, in which nuclei are generated asynchronously using a Poisson point process, and grow at the same radial speed. Growth models produce spatial patterns as a result of simple growth processes and their visualization is important in many technical processes.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, University of Glamorgan
The Voronoi diagram of half-balls and its application to the prediction of the 3D structure of proteins

The calculation of the overlap volume of half-spheres or ellipsoids is of direct interest in structural bioinformatics, which is concerned with the computational study of biological macromolecules on a genomic scale. We present an algorithm for computing the Delaunay graph and the overlap volume of a set of half-balls using exact predicates that detect the disjointness or non-disjointness of two half-balls and the validity of the generalized Voronoi vertex of four half-balls using geometric invariants and action (multiplication map) matrices. We prove the correctness of the algorithm and the optimality of the degree of the predicates by using geometric invariants and Grobner bases. The main application of these certified computations is to predict the 3D structure of proteins.

Towards Web-based representation and processing of health information

Background: There is great concern within health surveillance, on how to grapple with environmental degradation, rapid urbanization, population mobility and growth. The Internet has emerged as an efficient way to share health information, enabling users to access and understand data at their fingertips. Increasingly complex problems in the health field require increasingly sophisticated computer software, distributed computing power, and standardized data sharing. To address this need, Web-based mapping is now emerging as an important tool to enable health practitioners, policy makers, and the public to understand spatial health risks, population health trends and vulnerabilities. Today several web-based health applications generate dynamic maps; however, for people to fully interpret the maps they need data source description and the method used in the data analysis or statistical modeling. For the representation of health information through...
Web-mapping applications, there still lacks a standard format to accommodate all fixed (such as location) and variable (such as age, gender, health outcome, etc) indicators in the representation of health information. Furthermore, net-centric computing has not been adequately applied to support flexible health data processing and mapping online. Results: The authors of this study designed a HEalth Representation XML (HERXML) schema that consists of the semantic (e.g., health activity description, the data sources description, the statistical methodology used for analysis), geometric, and cartographical representations of health data. A case study has been carried on the development of web application and services within the Canadian Geospatial Data Infrastructure (CGDI) framework for community health programs of the New Brunswick Lung Association. This study facilitated the online processing, mapping and sharing of health information, with the use of HERXML and Open Geospatial Consortium (OGC) services. It brought a new solution in better health data representation and initial exploration of the Web-based processing of health information. Conclusion: The designed HERXML has been proven to be an appropriate solution in supporting the Web representation of health information. It can be used by health practitioners, policy makers, and the public in disease etiology, health planning, health resource management, health promotion and health education. The utilization of Web-based processing services in this study provides a flexible way for users to select and use certain processing functions for health data processing and mapping via the Web. This research provides easy access to geospatial and health data in understanding the trends of diseases, and promotes the growth and enrichment of the CGDI in the public health sector.

General information
State: Published
Organisations: Geodesy, National Space Institute, Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Yi, X. (Ekstern), Anton, F. (Intern), Oldfield, E. (Ekstern), Coleman, D. J. (Ekstern)
Pages: 3
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Health Geographics
Volume: 8
ISSN (Print): 1476-072X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.313 SNIP 1.274 CiteScore 3.14
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.16 SNIP 1.171 CiteScore 2.69
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.175 SNIP 1.459 CiteScore 2.87
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.013 SNIP 1.276 CiteScore 2.55
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.906 SNIP 1.369 CiteScore 2.72
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.991 SNIP 1.336 CiteScore 3.26
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.029 SNIP 1.244
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.842 SNIP 1.289
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.885 SNIP 1.024
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.938 SNIP 1.159
A methodology for automated cartographic data input, drawing and editing using kinetic Delaunay/Voronoi diagrams

This chapter presents a methodology for automated cartographic data input, drawing and editing. This methodology is based on kinematic algorithms for point and line Delaunay triangulation and the Voronoi diagram. It allows one to automate some parts of the manual digitization process and the topological editing of maps that preserve map updates. The manual digitization process is replaced by computer assisted skeletonization using scanned paper maps. We are using the Delaunay triangulation and the Voronoi diagram in order to extract the skeletons that are guaranteed to be topologically correct. The features thus extracted as object centrelines can be stored as vector maps in a Geographic Information System after labelling and editing. This research work can also be used for updates from sources that are either paper copy maps or digital raster images. A prototype application that was developed as part of the research has been presented. We also describe two reversible line-drawing methods for cartographic applications based on the kinetic (moving-point) Voronoi diagram. Our objectives were to optimize the user’s ability to draw and edit the map, rather than to produce the most efficient batch-oriented algorithm for large data sets, and all our algorithms are based on local operations (except for basic point location). Because the deletion of individual points or line segments is a necessary part of the manual editing process, incremental insertion and deletion is used. The original concept used here is that, as a curve (line) is the locus of a moving point, then segments are drawn by maintaining the topology of a single moving point (abbreviated as MP hereafter, or the “pen”) as it moves through the topological network (visualized as either the Voronoi diagram or Delaunay triangulation). This approach also has the interesting property that a “log file” of all operations may be preserved, allowing reversion to previous map states, or “dates”, as required.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Glamorgan
Authors: Gold, C. M. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern), Sharma, O. (Intern), Dakowicz, M. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: Generalized Voronoi Diagram: A Geometry-Based Approach to Computational Intelligence
Publisher: Springer Verlag
ISBN (Print): 978-3-540-85125-7
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 239551
Publication: Research - peer-review › Book chapter – Annual report year: 2008

AMS Mathematical Review of the journal paper: From Symmetry Breaking to Poisson Point Process in 2D Voronoi Tessellations: the Generic Nature of Hexagons
This is an American Mathematical Society (AMS) MathSciNet Review of the paper by Lucarini, Valerio (I-BOLO-P)

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (Intern)
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Mathematical Reviews
ISSN (Print): 0025-5629
Ratings:
A RuleML Study on Integrating Geographical and Health Information

To facilitate health surveillance, flexible ways to represent, integrate, and deduce health information become increasingly important. In this paper, an ontology is used to support the semantic definition of spatial, temporal and thematic factors of health information. The ontology is realized as an interchangeable RuleML knowledge base, consisting of facts and rules. Rules are also used for integrating geographical and health information. The implemented eHealthGeo system uses the OO jDREW reasoning engine to deduce implicit information such as spatial relationships. The system combines this with spatial operations and supports health information roll-up and visualization. The eHealthGeo study demonstrates a RuleML approach to supporting semantic health information integration and management.

Dynamic GIS

General information

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of Glamorgan
Authors: Gold, C. M. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern)
Number of pages: 527
Publication date: 2008

Host publication information

Title of host publication: Advances in Photogrammetry, Remote Sensing and Spatial Information Sciences : ISPRS 2008 Congress book
Dynamic Street Network Analysis for Evacuation Planning in Flood Events

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick
Authors: Mioc, D. (Intern), Anton, F. (Intern), Liang, G. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: GIS technology for evacuation planning
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 221318
Publication: Research - peer-review › Book chapter – Annual report year: 2008

Early warning and mapping for flood disasters

General information
State: Published
Authors: Moreri, K. K. (Ekstern), Mioc, D. (Intern), Nickerson, B. (Ekstern), Mc Gillivray, E. (Ekstern), Morton, A. (Ekstern), Anton, F. (Intern), Fraser, D. (Ekstern), Tang, P. (Ekstern), Liang, G. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: Joint ISCRAM-CHINA and Gi4DM Conference
Main Research Area: Technical/natural sciences
Conference: Joint ISCRAM-CHINA and Gi4DM Conference, Harbin, China, 04/08/2008 - 04/08/2008
Source: orbit
Source-ID: 222500
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Geospatial services for decision support on public health

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Yi, X. (Ekstern), Anton, F. (Intern), Oldfield, E. (Ekstern)
Publication date: 2008

Host publication information
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 220942
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008
Online GIS services for mapping and sharing disease information

Background Disease data sharing is important for the collaborative preparation, response, and recovery stages of disease control. Disease phenomena are strongly associated with spatial and temporal factors. Web-based Geographical Information Systems provide a real-time and dynamic way to represent disease information on maps. However, data heterogeneities, integration, interoperability, and cartographical representation are still major challenges in the health geographic fields. These challenges cause barriers in extensively sharing health data and restrain the effectiveness in understanding and responding to disease outbreaks. To overcome these challenges in disease data mapping and sharing, the senior authors have designed an interoperable service oriented architecture based on Open Geospatial Consortium specifications to share the spatio-temporal disease information. Results A case study of infectious disease mapping across New Brunswick (Canada) and Maine (USA) was carried out to evaluate the proposed architecture, which uses standard Web Map Service, Styled Layer Descriptor and Web Map Context specifications. The case study shows the effectiveness of an infectious disease surveillance system and enables cross-border visualization, analysis, and sharing of infectious disease information through interactive maps and/or animation in collaboration with multiple partners via a distributed network. It enables data sharing and users’ collaboration in an open and interactive manner. Conclusions In this project, we develop a service oriented architecture for online disease mapping that is distributed, loosely coupled, and interoperable. An implementation of this architecture has been applied to the New Brunswick and Maine infectious disease studies. We have shown that the development of standard health services and spatial data infrastructure can enhance the efficiency and effectiveness of public health surveillance.

General information
State: Published
Organisations: National Space Institute, Geodesy, Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of New Brunswick, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Anton, F. (Intern), Yi, X. (Ekstern), Coleman, D. J. (Ekstern)
Number of pages: 12
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: International Journal of Health Geographics
Volume: 7
Issue number: 1
ISSN (Print): 1476-072X
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 1.313 SNIP 1.274 CiteScore 3.14
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.16 SNIP 1.171 CiteScore 2.69
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.175 SNIP 1.459 CiteScore 2.87
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.013 SNIP 1.276 CiteScore 2.55
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.906 SNIP 1.369 CiteScore 2.72
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.991 SNIP 1.336 CiteScore 3.26
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.029 SNIP 1.244
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.842 SNIP 1.289
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
On-line street network analysis for flood evacuation planning

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics, University of New Brunswick
Authors: Mioc, D. (Intern), Anton, F. (Intern), Liang, G. (Ekstern)
Number of pages: 21
Pages: 221-242
Publication date: 2008

Host publication information
Title of host publication: Remote Sensing and GIS Technologies for Monitoring and Prediction of Disasters
Publisher: Springer
Editor: Zlatanova, S.
ISBN (Print): 3540792589
Chapter: 13
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 209104
Publication: Research - peer-review › Book chapter – Annual report year: 2008

Ontology-based querying and visualization of geo-referenced health information

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, National Research Council of Canada, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Boley, H. (Ekstern), Anton, F. (Intern), Yi, X. (Ekstern)
Publication date: 2008

Host publication information
Title of host publication: Joint ISCRAM-CHINA and Gi4DM Conference
Main Research Area: Technical/natural sciences
Conference: Joint ISCRAM-CHINA and Gi4DM Conference, Harbin, China, 04/08/2008 - 04/08/2008
Source: orbit
Source-ID: 220943
Publication: Research - peer-review › Article in proceedings – Annual report year: 2008

Polygon Feature Extraction from Satellite Imagery Based on Colour Image Segmentation and Medial Axis

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, National Space Institute, Geodesy
The Canadian Geospatial Data Infrastructure and health mapping

Due to the recent outbreak of SARS and the danger of pandemic Bird Flu, the ability to strengthen health surveillance and disease control is a growing need among governments. The development of the Canadian Geospatial Data Infrastructure (CGDI) has shown great potential in many industries such as emergency management, public health, disaster relief, environmental impact assessment, transportation, and land information systems. In this paper, our aims are to use the CGDI and to identify its usability in supporting online health mapping. To identify the usability of the CGDI for health mapping, we employed nine usability metrics. We also designed an architecture based on the CGDI to support the basic functions for health mapping, and implemented an infectious disease simulation for New Brunswick and Maine. Within the CGDI framework, this research enabled cross-border health data visualization, integration, sharing, and exploring the spatio-temporal trends of an infectious disease outbreak through thematic maps. Based on the experience of the developers and the feedback from users, an evaluation of the usability matrix with the CGDI components (technical standards, national framework data, enabling technologies, and common data policies) was explored using this cross-border health mapping application. The use of the CGDI in health applications has a great potential in supporting effective and secure health data sharing and integration. Enrichment of the CGDI would further facilitate the data sharing and improve decision making efficiency and effectiveness.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Yi, X. (Ekstern), Anton, F. (Intern), Oldfield, E. (Ekstern), MacKinnon, B. (Ekstern), Coleman, D. J. (Ekstern)
Pages: 434
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: CyberGEO
ISSN (Print): 1278-3366
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): SJR 0.127 SNIP 0.012 CiteScore 0.04
BFI (2015): BFI-level 1
Voronoi diagrams of semi-algebraic sets: Delaunay graphs of semi-algebraic sets

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Anton, F. (Intern)
Publication date: 2008

Publication information
Publisher: VDM Verlag
ISBN (Print): 978-3-639-03847-7
Original language: English
Main Research Area: Technical/natural sciences
Sparse (toric) resultants, Gröbner bases, Voronoi diagrams, Interval analysis, Generalized Voronoi vertices, Semi-algebraic sets, Delaunay graphs
Source: orbit
Source-ID: 220464
Publication: Research - peer-review › Book – Annual report year: 2008

Web-GIS application for flood prediction and monitoring

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, New Brunswick Emergency Measures Organization, New Brunswick Department of
A study of the usability of CGDI in health mapping
Due to the recent outbreak of SARS and Bird Flu, the ability to strengthen health surveillance and control is highly appreciated. Since the health problem is strongly referenced with spatial locations, integrating geospatial technology in health study could support better decision making. Right now, the development of CGDI has shown great potential in many fields like emergency management, public health, disaster relief, transportation, land information system. Our study is to use CGDI to support online mapping of infectious disease across New Brunswick and Maine and to identify the usability of CGDI for health mapping. New Brunswick and Maine are territorial neighbors which means there are significant volumes of goods and people traveling across our international border, thus infectious agents are likely to carry from one jurisdiction to the other. In this paper, with the purpose to make infectious disease information available to officials and public for better support of disease surveillance, we developed a data model for mapping, seamlessly integrating the spatial and health data across the New Brunswick and Maine border. Many factors such as map representation level, mapping variables, data diversity and privacy are considered in the infectious disease mapping. Using Web Map Service, it enables cross-border data integration, visualization, analysis, sharing and explores the spatio-temporal trends of infectious disease outbreak with multiple partners via a distributed access network through the CGDI framework. With the evolvement of CGDI and health study, it would further facilitate the health data sharing and improve decision making efficiency and effectiveness.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, University of New Brunswick, New Brunswick Lung Association
Authors: Gao, S. (Ekstern), Mioc, D. (Intern), Xialoun, Y. (Ekstern), Anton, F. (Intern), Oldfield, E. (Ekstern)
Publication date: 2007
Event: Abstract from AGILE Workshop on Spatial data usability, Aalborg, Denmark, .
Main Research Area: Technical/natural sciences
infectious disease, mapping, health surveillance, CGDI, WMS
Electronic versions:
agile.zip
Source: orbit
Source-ID: 209102
Publication: Research - peer-review › Conference abstract for conference – Annual report year: 2007

Decision Support for Flood Event Prediction and Monitoring
In this paper the development of Web GIS based decision support system for flood events is presented. To improve flood prediction we developed the decision support system for flood prediction and monitoring that integrates hydrological modelling and CARIS GIS. We present the methodology for data integration, floodplain delineation, and online map interfaces. Our Web-based GIS model can dynamically display observed and predicted flood extents for decision makers and the general public. The users can access Web-based GIS that models current flood events and displays satellite imagery and digital elevation model integrated with flood plain area. The system can show how the flooding prediction based on the output from hydrological modeling for the next 48 hours along the lower Saint John River Valley.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Authors: Mioc, D. (Intern), Anton, F. (Intern), Liang, G. (Ekstern), Nickerson, B. G. (Ekstern)
Publication date: 2007
Existence of a Unique Zero of Nonlinear Systems

Existence statements for zeros of nonlinear equations are established via the interval Newton method generalizing previous theorems requiring regularity of the inclusion for the Jacobian.
Feature Extraction and Simplification from colour images based on Colour Image Segmentation and Skeletonization using the Quad-Edge data structure

Region features in colour images are of interest in applications such as mapping, GIS, climatology, change detection, medicine, etc. This research work is an attempt to automate the process of extracting feature boundaries from colour images. This process is an attempt to eventually replace manual digitization process by computer assisted boundary detection and conversion to a vector layer in a GIS or a spatial database. In colour images, various features can be distinguished based on their colour. The features thus extracted as object border can be stored as vector maps in a GIS or a spatial database after labelling and editing. Here, we present a complete methodology of the boundary extraction and skeletonization process from colour imagery using a colour image segmentation algorithm, a crust extraction algorithm and a skeleton extraction algorithm. We present also a prototype application for the semi-automated or completely automated processing of satellite imagery with an application to coastline extraction. Other applications include extraction of fields, clear cuts, clouds, as well as heating or pollution monitoring and dense forest mapping among others.

GIS Support for Flood Rescue

Under flood events, the ground traffic is blocked in and around the flooded area due to damages to roads and bridges. The traditional transportation network may not always help people to make a right decision for evacuation. In order to provide dynamic road information needed for flood rescue, we developed an adaptive web-based transportation network application using Oracle technology. Moreover, the geographic relationships between the road network and flood areas are taken into account. The overlay between the road network and flood polygons is computed on the fly. This application allows users to retrieve the shortest and safest route in Fredericton road network during flood event. It enables users to make a timely decision for flood rescue. We are using Oracle Spatial to deal with emergency situations that can be applied to other constrained network applications as well.
Reversibility of the Quad-Edge operations in the Voronoi data structure

In Geographic Information Systems the reversibility of map update operations have not been explored yet. In this paper we are using the Voronoi based Quad-edge data structure to define reversible map update operations. The reversibility of the map operations have been formalised at the lowest level, as the basic algorithms for addition, deletion and moving of spatial objects. Having developed reversible map operations on the lowest level, we were able to maintain reversibility of the map updates at higher level as well. The reversibility in GIS can be used for efficient implementation of rollback mechanisms and dynamic map visualisations.

The Voronoi diagram of circles made easy

Proximity queries among circles could be effectively answered if the Delaunay graph for sets of circles could be computed in an efficient and exact way. In this paper, we first show a necessary and sufficient condition of connectivity of the Voronoi diagram of circles. Then, we show how the Delaunay graph of circles (the dual graph of the Voronoi diagram of circles) can be computed exactly, and in a much simpler way, by computing the eigenvalues of a two by two matrix.
Linear Feature Extraction from Satellite Imagery using Fractal Dimension

Map updates in a dynamic Voronoi data structure

This paper we are using local and sequential map updates in the Voronoi data structure, which allows us to automatically record each event and performed map updates within the system. These map updates are executed through map construction commands that are composed of atomic actions (geometric algorithms for addition, deletion, and motion of spatial objects) on the dynamic Voronoi data structure. The formalization of map commands led to the development of a spatial language comprising a set of atomic operations or constructs on spatial primitives (points and lines), powerful enough to define the complex operations. This resulted in a new formal model for map updates, similar to "cellular encoding", where each update is uniquely characterized by the numbers of newly created and inactivated Voronoi regions. This research shows that the result of the formalization of the operations on the dynamic Voronoi data structure is a spatial language or a map grammar that is deterministic and reversible.

General information
State: Published
Organisations: National Space Institute, Geodesy
Authors: Mioc, D. (Intern), Antón Castro, F. (Intern), Gold, C. M. (Ekstern), Moulin, B. (Ekstern)
Number of pages: 6
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the 3rd International Symposium on Voronoi Diagrams in Science and Engineering (ISVD’06)
Polygon Feature Extraction from Satellite Imagery based on Colour Image Segmentation and Skeletonization

General information
State: Published
Organisations: Unknown
Authors: Sharma, O. (Ekstern), Mioc, D. (Ekstern), Anton, F. (Intern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of INCREMENTAL UPDATING AND VERSIONING OF SPATIAL DATA BASES 2006 WorkShop & Commission Meeting
Main Research Area: Technical/natural sciences

Bibliographical note
8 pages.
Source: orbit
Source-ID: 312102
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Three Dimensional Modelling of Ocean Temperature Data

General information
State: Published
Organisations: Unknown
Authors: Mioc, D. (Ekstern), Anton, F. (Intern), Sharma, O. (Ekstern), Al-Obeidat, F. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of European Congress on Regional Geoscientific Cartography and Information Systems
Main Research Area: Technical/natural sciences
Conference: European Congress on Regional Geoscientific Cartography and Information Systems, Barcelona, June 12-16, 01/01/2006

Bibliographical note
4 pages.
Source: orbit
Source-ID: 287050
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

Three Dimensional Visualizations of Ocean Temperature Data Sampled with Moving Vessel Proler

General information
State: Published
Organisations: Unknown
Authors: Mioc, D. (Ekstern), Anton, F. (Intern), Sharma, O. (Ekstern), Al-Obeidat, F. (Ekstern)
Publication date: 2006

Host publication information
Title of host publication: Proceedings of CHC 2006
Main Research Area: Technical/natural sciences
Traveling salesperson approximation algorithm for real road networks

Traveling salespersons problem (TSP) is one of the unsolved problems of the day that carry significant value to the transportation networks. The exact solution of a Traveling salespersons problem is not feasible. There are some good approximation algorithms that can provide an approximate solution. Here, we propose a method to extend the conventional Traveling salespersons problem to transportation networks where the travel plan can be optimized within the Geospatial Information System. We also propose an optimized web based implementation scheme that gives a faster response to the route queries. In modern geographic informations systems, such a web accessible route query system can be very useful.

Keyword: Shortest path, Optimal tour, Christofides algorithm, Traveling Salespersons Problem, Transportation network, GIS

Voronoi Diagram Based Automated Skeleton Extraction from Colour Scanned Maps

This paper presents a methodology to automate some parts of the manual digitization process. This includes replacing the manual digitization process by computer assisted skeletonization using scanned paper maps. In colour scanned paper maps various features on the map can be distinguished based on their colour. This research work utilizes the Delaunay triangulation and the Voronoi diagram in order to extract the skeletons that are guaranteed to be topologically correct. The features thus extracted as object centrelines can be stored as vector maps in a Geographic Information System after labelling and editing. Map updates are important in any Geographic Information System. Therefore, this research work can also be used for updates from sources that are either paper copy maps or digital raster images. A prototype application that is developed as part of the research has been presented.

Voronoi diagrams of semi-algebraic sets

Most of the curves and surfaces encountered in geometric modelling are defined as the set of solutions of a system of algebraic equations and inequalities (semialgebraic sets). Many problems from different fields involve proximity queries like finding the (nearest) neighbours or quantifying the neighbourliness of two objects. The Voronoi diagram of a set of sites is a decomposition of space into proximal regions. The proximal region of a site is the locus of points closer to that site than to any other one. Voronoi diagrams allow one to answer proximity queries after locating a query point in the
Voronoi zone it belongs to. The dual graph of the Voronoi diagram is called the Delaunay graph. Only approximations by conics can guarantee a proper order of continuity at contact points, which is necessary for guaranteeing the exactness of the Delaunay graph. The theoretical purpose of this thesis is to elucidate the basic algebraic and geometric properties of the offset to an algebraic curve and to reduce the semialgebraic computation of the Delaunay graph to eigenvalues computations. The practical objective of this thesis is the certified computation of the Delaunay graph for low degree semi-algebraic sets embedded in the Euclidean plane. The methodology combines interval analysis and computational algebraic geometry. The central idea of this thesis is that a (one time) symbolic preprocessing may accelerate the certified numerical evaluation of the Delaunay graph conflict locator. The symbolic preprocessing is the computation of the implicit equation of the generalised offset to conics. The reduction of the Delaunay graph conflict locator for conics from a semi-algebraic problem to a linear algebra problem has been possible through the use of the generalised Voronoi vertex (a concept introduced in this thesis). The certified numerical computation of the Delaunay graph has been possible ii by using an interval analysis based library for solving zero-dimensional systems of equations and inequalities (ALIAS). The certified computation of the Delaunay graph relies on theorems on the uniqueness of a root in given intervals (Kantorovitch, Moore-Krawczyk). For conics, the computations get much faster by considering only the implicit equations of the generalised offsets.

General information
State: Published
Organisations: University of British Columbia
Authors: Anton, F. (Intern)
Number of pages: 216
Publication date: 2006

Publication information
Publisher: VDM Verlag
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 287048
Publication: Research › Ph.D. thesis – Annual report year: 2006

A certified Delaunay graph conflict locator for semi-algebraic sets
Most of the curves and surfaces encountered in geometric modelling are defined as the set of common zeroes of a set of polynomials (algebraic varieties) or subsets of algebraic varieties defined by one or more algebraic inequalities (semi-algebraic sets). Many problems from different fields involve proximity queries like finding the nearest neighbour, finding all the neighbours, or quantifying the neighbourliness of two objects. The Voronoi diagram of a set of sites is a decomposition of the space into proximal regions: each site’s Voronoi region is the set of points closer to that site than to any other site. The Delaunay graph of a set of sites is the dual graph of the Voronoi diagram of that set of sites, which stores the spatial adjacency relationships among sites induced by the Voronoi diagram. The Voronoi diagram has been used for solving the earlier mentioned proximity queries. The ordinary Voronoi diagram of point sites has been extended or generalised in several directions (underlying space, metrics, sites), and the resulting generalised Voronoi diagrams have found many practical applications. The Voronoi diagrams have not yet been generalised to algebraic curves or semi-algebraic sets. In this paper, we present a conflict locator for the certified incremental maintenance of the Delaunay graph of semi-algebraic sets.

Keyword: Delaunay graph, conics, semi-algebraic sets, conflict locator

General information
State: Published
Organisations: University of New Brunswick
Authors: Antón Castro, F. (Intern)
Pages: 669-682
Publication date: 2005

Host publication information
Title of host publication: Lecture Notes in Computer Science 3480
Publisher: Springer Berlin / Heidelberg
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 287040
Publication: Research - peer-review › Book chapter – Annual report year: 2005

Modified Christodes algorithm for Transportation Networks

General information
Real-time updates in Transportation network database

Route Optimization in Transportation Networks

Skeletonisation using the Voronoi diagram and the Delaunay graph,
**The offset to an algebraic curve and an application to conics**

Curve offsets are important objects in computer-aided design. We study the algebraic properties of the offset to an algebraic curve, thus obtaining a general formula for its degree. This is applied to computing the degree of the offset to conics. We also compute an implicit equation of the generalised offset to a conic by using sparse resultants and the knowledge of the degree of the implicit equation.

**General information**
- State: Published
- Organisations: National Kapodistrian University of Athens, French National Institute for Computer Science and Applied Mathematics, University of Calgary
- Authors: Anton, F. (Intern), Emiris, I. (Ekstern), Mourrain, B. (Ekstern), Teillaud, M. (Ekstern)
- Pages: 683-696
- Publication date: 2005

**Host publication information**
- Title of host publication: Lecture Notes in Computer Science
- Volume: 3480
- Publisher: Springer Berlin / Heidelberg
- Main Research Area: Technical/natural sciences
- Source-ID: 287041
- Publication: Research - peer-review › Book chapter – Annual report year: 2005

**A certified conflict locator for the incremental maintenance of the Delaunay graph of semi-algebraic sets**

**General information**
- State: Published
- Organisations: University of Calgary
- Authors: Antón Castro, F. (Intern)
- Pages: 29-32
- Publication date: 2004

**Host publication information**
- Title of host publication: Proceedings of the 20th European Workshop on Computational Geometry
- Workshop: 20th European Workshop on Computational Geometry, Seville, Spain, 24/03/2004 - 24/03/2004
- Source-ID: 312106
- Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

**An algorithm for centerline extraction using natural neighbour interpolation**

Data caption and conversion are two of the most costly operations of any GIS, in terms of computer time and manual work needed for spatial data acquisition. They can represent up to 80 percent of the total implementation costs. Manual digitising is a very error prone and costly operation, especially due to the lack of explicit topology in commercial GIS systems. Indeed, each map update might require the batch processing of the whole map. Currently, commercial GIS do not offer completely automatic raster/vector conversion even for simple scanned black and white maps. Various commercial raster/vector conversion products exist for the skeletonisation or thinning of the pixels forming the line, but these approaches have shown difficulties with the extraction of good topology. The spatial feature extraction in raster/vector conversion systems is based on line tracing algorithms. In order to operate they need user defined tolerances settings, what causes difficulties in the extraction of complex spatial features, for example: road junctions, curved or irregular lines and complex intersections of linear features. The approach we use here is based on image processing filtering techniques to extract the basic spatial features from raster data. These spatial features can be used for the reconstruction of the image within the topological data structure - the Voronoi diagram. The novel part of this research is the definition of deterministic topological rules and algorithms for extracting the spatial features from the Voronoi data structure. These spatial features can then be represented in different spatial data structures that can be implemented in a GIS. In this research we use the topological approach to develop new algorithms and data structures for integrated raster/vector models leading to the improvement of data caption and conversion in GIS and to develop a software toolkit for automated raster/vector conversion. The approach is based on computing the skeleton from Voronoi diagrams using natural neighbour interpolation. In this paper we present the algorithm for skeleton extraction from scanned maps. We show that the skeleton extracted from the map features can approximate the centreline of the map object. We apply this algorithm directly on the Voronoi cells, for the extraction of complex spatial features. This research can lead to the improvement of current practices in spatial data acquisition reducing significantly the cost and amount of work needed.
Line Voronoi diagram based interpolation and application to digital terrain modelling

Local coordinates based on the Voronoi diagram are used in natural neighbour interpolation to quantify the "neighbourliness" of data sites. In an earlier paper, we have extended the natural neighbour or stolen area interpolation technique from ordinary Voronoi diagrams to Voronoi diagrams for sets of points and line segments, by providing direct vectorial formulas for the first order and second order derivatives for the stolen area. This generalization allows one to model linear discontinuities, that are not modelable through current interpolation techniques. In this paper, we recall the continuity and differentiation properties of these local coordinates and natural neighbour interpolation, and we present their application to digital terrain modelling. In our case, the data sites can be either points or oriented line segments. We use this natural neighbour interpolation in order to interpolate elevations from the neighbouring data sites, and construct a digital terrain model. We present an example of the use of the natural neighbour interpolation technique based on the Voronoi diagram for a set of points and oriented line segments for digital terrain modelling. The applications of this extended interpolation technique are shown for the modelling of linear vertical faults, dams or bridges. This research brings novelty in the modelling of topographic artifacts represented by line segments (e.g. thalwegs, crests, faults), because in the natural neighbour interpolation technique that we are using, line segments are data objects that can have an elevation (in fact an elevation for each oriented line segment).

Keyword: technology, reconstruction, digital, triangulation, GIS modelling
A certified predicate for maintaining the topology of the Voronoi diagram for conics

Voronoi diagrams have not yet been generalised to all the conics. In this paper, we present a predicate for the certified maintenance of the topology of the Voronoi diagram for a set of conics in an incremental way.

Progressive generalization methods in GIS

Spatio-temporal map updates in the Voronoi data structure
An exact algebraic predicate for maintaining the topology of the Voronoi diagram for circles

General information
State: Published
Organisations: University of British Columbia, University of Calgary
Authors: Antón Castro, F. (Intern), Kirkpatrick, D. (Ekstern), Mioc, D. (Intern)
Pages: 72-76
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 14th Canadian Conference on Computational Geometry
Main Research Area: Technical/natural sciences
Conference: 14th Canadian Conference on Computational Geometry, Alberta, Canada, 12/08/2002 - 12/08/2002
Source: orbit
Source-ID: 312115
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

An exact predicate for the optimal construction of the Additively Weighted Voronoi diagram
Keyword: additively weighted voronoi diagram, power voronoi diagram, algebraic predicates

General information
State: Published
Organisations: French National Institute for Computer Science and Applied Mathematics, National Space Institute, University of British Columbia, University of Calgary
Authors: Antón Castro, F. (Intern), Boissonnat, J. (Ekstern), Mioc, D. (Intern), Yvinec, M. (Ekstern)
Pages: 4-7
Publication date: 2002

Host publication information
Title of host publication: Proceedings of the 18th European Workshop on Computational Geometry
Main Research Area: Technical/natural sciences
Workshop: 18th European Workshop on Computational Geometry, Warszawa, Poland, 10/04/2002 - 10/04/2002
Source: orbit
Source-ID: 312114
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Line Voronoi diagram based interpolation and application to digital terrain modelling

Local coordinates based on the Voronoi diagram are used in natural neighbour interpolation to quantify the "neighbourliness" of data sites. In this paper, we propose a generalisation of the local coordinates and natural neighbour interpolation based on the ordinary Voronoi diagram, to the Voronoi diagram for a set of points and oriented line segments in the Euclidean plane. This generalisation allows one to model linear discontinuities that are not modelable through current interpolation techniques. We present the application of the natural neighbour interpolation based on these local coordinates to digital terrain modelling. In our case, the data sites can be either points or oriented line segments. We use this natural neighbour interpolation in order to interpolate elevations from the neighbouring data sites, and construct a digital terrain model. We show an example of use of this extended interpolation technique for the modelling of linear vertical faults, dams or bridges.

General information
State: Published
Organisations: Hong Kong Polytechnic University, University of British Columbia
Authors: Antón Castro, F. (Intern), Mioc, D. (Ekstern), Gold, C. (Ekstern)
Pages: 29-32
Publication date: 2001
Reconstructing 2D images with natural neighbour interpolation

In this paper, we explore image reconstruction by natural neighbour interpolation from irregularly spaced samples. We sample the image irregularly with techniques based on the Laplacian or the derivative in the direction of the gradient. Local coordinates based on the Voronoi diagram are used in natural neighbour interpolation to quantify the "neighbourliness" of data sites. Then we use natural neighbour interpolation in order to reconstruct the image. The main result is that the image quality is always very good in the case of the sampling techniques based on the Laplacian.

Keyword: natural neighbour interpolation, irregularly spaced samples, local coordinates, image reconstruction
2D Image Reconstruction using Natural Neighbour Interpolation

In this paper we explore image reconstruction from irregularly spaced samples using natural neighbour interpolation. We sample the image irregularly using techniques based on the Laplacian or the derivative in the direction of the gradient. Local coordinates based on the Voronoi diagram are used in natural neighbour interpolation to quantify the neighbourliness of data sites. Then we use natural neighbour interpolation in order to reconstruct the image. The main result is that the image quality is always very good in the case of the sampling techniques based on the Laplacian.

Keyword: natural neighbour interpolation, irregularly spaced samples, local coordinates, image reconstruction.
Visualization of the Nucleation and Growth of Particles
This article presents a method for the visualization of the nucleation and growth of particles based on an algorithm for the dynamic construction of additively weighted Voronoi diagrams. We use the Poisson point process in the dynamic additively Voronoi diagram to generate the Johnson-Mehl tesselation. The Johnson-Mehl model is a Poisson Voronoi growth model, in which nuclei are generated asynchronously using a Poisson point process, and grow at the same radial speed. Growth models produce spatial patterns as a result of simple growth processes and their visualization is important in many technological processes.

Keyword: Visualization of nucleation and growth of particles, Voronoi diagrams, growth models, Johnson-Mehl tessellations

General information
State: Published
Organisations: Hong Kong Polytechnic University, University of British Columbia, Universite Laval
Authors: Mioc, D. (Intern), Anton Castro, F. (Intern), Gold, C. (Ekstern)
Pages: 28-35
Publication date: 2000

On the conversion of ordinary Voronoi diagrams into Laguerre diagrams
We present some geometric relationships between the ordinary Voronoi diagram, and the Voronoi diagram in the Laguerre geometry. We derive from these proper ties an algorithm for the conversion of ordinary Voronoi diagrams into Voronoi diagrams in the Laguerre geometry.

General information
"Time Travel" Visualization in a Dynamic Voronoi Data Structure

It is now widely recognized that incremental changes of cartographic data evolving in space and time cannot be maintained easily within current GISs, and therefore visualization of such changes is limited to series of "snapshots" of cartographic data. Recent research on dynamic spatial data structures based on Voronoi diagrams provides new opportunities for dynamic visualization in GIS. In this paper we present a new approach for representing and visualizing cartographic data changing in time and space. Our approach of visualization integrates reverse execution of the performed actions and the history of map construction. We use this map history for visualizing any state of the underlying Voronoi data structure via "time travel." The approach emphasizes several research efforts: on the formalization of the operations upon spatial objects in a dynamic Voronoi spatial data structure, the reversibility of its map construction commands, and their applicability to map visualization and map animation.

Keyword: DYNAMIC VORONOI DATA STRUCTURES, GEOGRAPHIC VISUALIZATION; VISUALIZATION VIA "TIME TRAVEL", INCREMENTAL UPDATES
An algorithm for the dynamic maintenance and construction of Additively Weighted Voronoi diagrams

General information
State: Published
Organisations: Universite Laval, University of British Columbia, University of Calgary
Authors: Mioc, D. (Intern), Antón Castro, F. (Intern), Gold, C. (Ekstern)
Pages: 117-119
Publication date: 1998

Host publication information
Title of host publication: Proceedings of the The Fourteenth European Workshop on Computational Geometry
Main Research Area: Technical/natural sciences
Conference: 14th European Workshop on Computational Geometry, Barcelona, Spain, 26/03/1998 - 26/03/1998
Source: orbit
Source-ID: 312125
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

An incremental algorithm for the computation of planar Johnson-Mehl tessellations

General information
State: Published
Organisations: Universite Laval, University of British Columbia, University of Calgary
Authors: Mioc, D. (Intern), Antón Castro, F. (Intern), Gold, C. M. (Ekstern)
Pages: 42-44
Publication date: 1998

Host publication information
Title of host publication: Proceedings 2nd Voronoi Conference on Analytic Number Theory and Space Tillings
Main Research Area: Technical/natural sciences
Conference: Voronoi Conference on Analytic Number Theory and Space Tillings, Kiev, Ukraine, September, 01/01/1998
Source: orbit
Source-ID: 312333
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Dynamic additively weighted Voronoi diagrams made easy

General information
State: Published
Organisations: Universite Laval
Authors: Antón Castro, F. (Intern), Mioc, D. (Intern), Gold, C. (Ekstern)
Pages: 92-93
Extending GIS - Integrating multiple spaces into a single concept

General information
State: Published
Organisations: Université Laval
Pages: 123-137
Publication date: 1998

Local coordinates and interpolation in a Voronoi diagram for a set of points and line segments

General information
State: Published
Organisations: University of British Columbia
Authors: Antón Castro, F. (Intern), Gold, C. M. (Ekstern), Mioc, D. (Intern)
Pages: 9-12
Publication date: 1998

Spatio-temporal change representation and map updates in a dynamic Voronoi data structure

General information
State: Published
Organisations: Unknown
Authors: Mioc, D. (Ekstern), Anton, F. (Intern), Gold, C. (Ekstern), Moulin, B. (Ekstern)
Pages: 441-452
Publication date: 1998

Visualizing changes in a dynamic Voronoi data structure via time travel
In recent years there has been rapidly growing interest by the GIS community in new visualization methods for cartographic data. The visualization of map changes is important for several reasons: spatio-temporal analysis, process
modelling, and animated maps. It is now widely recognized that current GIS software has no ability to maintain incremental change of spatiotemporal data, and therefore visualization of such data is limited to series of 'snapshots' of cartographic data (see [Peque94a]). The growing amount of research on spatio-temporal databases shows that today’s world of spatial data handling requires a dynamic and interactive environment for map visualization. In this paper we will present a conceptual approach for representing cartographic data changing in time and space. The approach emphasizes several research efforts: on the Voronoi spatial data structure, the reversibility of its map construction commands, and their applicability to map visualization and map animation.

General information
State: Published
Organisations: Universite Laval
Authors: Mioc, D. (Ekstern), Anton, F. (Intern), Gold, C. M. (Ekstern)
Pages: 263-269
Publication date: 1998

Host publication information
Title of host publication: Proceedings of The Sixth International Conference on Computer Graphics and Visualization in Central Europe
Main Research Area: Technical/natural sciences
Conference: International Conference on Computer Graphics and Visualization in Central Europe, Plzen City, Czech Republic, February, 01/01/1998
Publication: Research - peer-review » Article in proceedings – Annual report year: 1998

An iterative algorithm for the determination of Voronoi vertices in polygonal and non-polygonal domains
We propose a new iterative algorithm for the computation of the vertices of a Voronoi diagram for a set of geometric objects of the euclidean plane. Each one of these vertices is the centre of the circle “touching” a triple of objects (passing through points or tangent to any other geometric object). The algorithm starts with an initial triple of points pertaining to each one of the three objects. It computes its circumcentre and the closest point (called foot) of each object from the circumcentre. These three feet form the starting triple for the next iteration. We geometrically demonstrate a necessary and sufficient condition for the general case. This iterative algorithm is used as a new method for constructing a dynamic Voronoi diagram for a set of points and straight line segments.

General information
State: Published
Organisations: Universite Laval
Authors: Anton, F. (Intern), Gold, C. (Ekstern)
Pages: 257-262
Publication date: 1997

Host publication information
Title of host publication: Proceedings of the 9th Canadian Conference on Computational Geometry
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 312336
Publication: Research - peer-review » Article in proceedings – Annual report year: 1997

La numérisation rapide de cartes forestières et la numérisation automatique de cartes scannées

General information
State: Published
Organisations: Unknown
Authors: Anton, F. (Intern), Mioc, D. (Ekstern), Gold, C. (Ekstern)
Publication date: 1996
Event: Poster session presented at Geomatics R&D forum, Quebec, Canada,  .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 312799
Publication: Research - peer-review » Poster – Annual report year: 1996

Navigating in the map
Maps have traditionally been considered to be passive representations of geographic space, even after the introduction of digital techniques. The ability of the user to interact rapidly with the map on the screen has largely been limited to changes in classification and symbolism, as most, spatial data structures do not permit local real-time modification. However, with locallymodifiable “topology” the user’s cursor may be embedded in the map space, permitting the detection of
neighbouring map objects and responding to potential collisions. This approach has been implemented using the Voronoi (Thiessen) spatial model. It has many advantages in interactive applications such as manual digitizing, fluid flow modelling and robotics. Map objects such as points or line segments may be added, deleted, interacted with or queried at any stage, and the method appears to have many potential applications.

**General information**
- State: Published
- Organisations: Universite Laval, Unknown
- Authors: Gold, C. M. (Ekstern), Anton, F. (Intern)
- Pages: 287-295
- Publication date: 1995

**Host publication information**
- Title of host publication: Proceedings 17th International Cartographic Conference : 10th General Assembly of ICA
- Main Research Area: Technical/natural sciences
- Conference: International Cartographic Conference : 10th General Assembly of ICA, Barcelona, Spain, 01/01/1995
- Source: orbit
- Source-ID: 312340
- Publication: Research - peer-review › Article in proceedings – Annual report year: 1995

**An intelligent and direct manipulation digitizing system**

The Voronoi tessellation is of interest in the development of GIS methods for various reasons, especially as a form of topology. These reasons include Voronoi diagram dynamic maintenance and the idea of a “proximal query”, whereby an object may be specified merely by placing the cursor within its Voronoi region. This is a great advantage in the digitizing operation, because traditional systems need great care in generalising topological relations. The Voronoi model merely requires the specification of each end point by pointing to its Voronoi “bubble”. Because the topology is maintained during the digitizing activity, a truly interactive system is possible. Unlike the usual “rebuild and then correct the errors” procedure, “Collisions” are detected before they occur, and action taken, rather than awaiting a batch rebuild. This paper discusses the implications of this approach for the construction of a fast, efficient, interactive, user-friendly and “intelligent” (in the sense of help for geometric construction design and topological accuracy) digitizing system. Emphasis will be placed on the development of effective interaction with the user, and the minimization of digitizing time.

**General information**
- State: Published
- Organisations: Universite Laval
- Authors: Anton, F. (Intern), Gold, C. M. (Ekstern)
- Pages: 834-845
- Publication date: 1994

**Host publication information**
- Title of host publication: Proceedings, URISA 1994 Annual Conference
- Main Research Area: Technical/natural sciences
- Conference: URISA 1994 Annual Conference, Milwaukee, WI, USA, 01/01/1994
- Source: orbit
- Source-ID: 312341
- Publication: Research - peer-review › Article in proceedings – Annual report year: 1994

**Projects:**

**Emulated power and radiance minimization for safer cellular phones with longer lasting batteries**

Department of Informatics and Mathematical Modeling
- Period: 01/01/2010 → 25/10/2013
- Number of participants: 6
- PhD Student: Musiige, Deogratius (Intern)
- Supervisor: Mioc, Darka (Intern)
- Main Supervisor: Antón Castro, Francesc/François (Intern)
- Examiner: Merayo, José M.G. (Intern)
- De La Cruz Blas, Carlos A. (Ekstern)
Prasad, Ramjee (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: ErhvervsPhD-ordningen VTU
Project: PhD

Surface Reconstruction of Coherent Deformable 3D Scans with Topological Recovery

Department of Informatics and Mathematical Modeling
Period: 01/05/2009 → 31/10/2010
Number of participants: 4
Phd Student:
Giotis, Nikolaos (Intern)
Supervisor:
Bærentzen, Jakob Andreas (Intern)
Paulsen, Rasmus Reinhold (Intern)
Main Supervisor:
Antón Castro, Francesc/François (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Homotopy based 3D reconstruction of water columns from 2D cross section acoustic data

Department of Informatics and Mathematical Modeling
Period: 15/07/2007 → 29/09/2010
Number of participants: 5
Phd Student:
Sharma, Ojaswa (Intern)
Supervisor:
Christensen, Niels Jørgen (Intern)
Main Supervisor:
Antón Castro, Francesc/François (Intern)
Examiner:
Hansen, Vagn Lundsgaard (Intern)
Sellarès, Joan Antoni (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Activities:

Métodos de análisis intervalar y funcional de modelado matemático multi-dimensional para cartografía y bathymetría
Francesc/François Antón Castro (Invited speaker)
National Space Institute
Geodesy

Description
Invited conference (English title: Multi-dimensional mathematical modeling functional and interval analysis methods for cartography and bathymetry.

Related event
Semana Geomática Internacional
10/08/2015 → 14/08/2015
Bogotá, Colombia
Activity: Talks and presentations › Conference presentations

Spanish National Congress of Geographic Information Technologies (External organisation)
Period: 2014 → …
Francesc/François Antón Castro (Participant)
National Space Institute
Geodesy

Description
TIG 2014 - Congreso Nacional de Tecnologías de la Información Geográfica.

Body type: International Program Committee

Related external organisation
Spanish National Congress of Geographic Information Technologies
Activity: Membership › Membership in review committee

Member of the Editorial Committee of JGIS (External organisation)
Period: 2013 → …
Francesc/François Antón Castro (Participant)
National Space Institute
Geodesy
Degree of recognition: International

Related external organisation
Member of the Editorial Committee of JGIS
Activity: Membership › Membership in review committee

Topological / geometrical methods and data structures for real-world data analysis
Period: 22 Aug 2013
Francesc/François Antón Castro (Lecturer)
National Space Institute
Geodesy

Description
Invited lecture at the Department of Mathematics, Nanyang Technological University, Singapore.

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

Why I care about continuous functions?
Period: 22 Aug 2013
Francesc/François Antón Castro (Lecturer)
National Space Institute
Geodesy

Description
Seminar at the Department of Mathematics, Nanyang Technological University, Singapore.

Related external organisation
**Unknown external organisation**  
**Activity:** Talks and presentations › Conference presentations

**Universiti Teknologi Malaysia**  
**Period:** 30 May 2013 → 29 Aug 2013  
Francesc/François Antón Castro (Visiting researcher)  
Department of Informatics and Mathematical Modeling  
National Space Institute  
Geodesy  

**Description**  
Visiting Full Professor  
3D GIS Research Group at the Faculty of Geoinformation and Real Estate, UTM.

**Activity:** Visiting an external institution › Visiting another research institution

**Natural Sciences and Engineering Research Council of Canada (External organisation)**  
**Period:** Jan 2013  
Francesc/François Antón Castro (Member)  
National Space Institute  
Geodesy  

**Description**  
National Research Funding Agency for Natural Sciences and Engineering of Canada  
Review of a funding application in interval analysis  
Body type: Research Funding Agency  
Degree of recognition: International

**Related external organisation**  
**Natural Sciences and Engineering Research Council of Canada**  
**Activity:** Membership › Membership in review committee

**IARIA Computation Tools (External organisation)**  
**Period:** 1 Jan 2013 → …  
Francesc/François Antón Castro (Participant)  
National Space Institute  
Geodesy  

**Description**  
International Conference on Computational Logics, Algebras, Programming, Tools, and Benchmarking.

Body type: Technical Program Committee  
Degree of recognition: International

**Related external organisation**  
**IARIA Computation Tools**  
**Activity:** Membership › Membership in review committee

**IARIA GeoProcessing (External organisation)**  
**Period:** 1 Jan 2013 → …  
Francesc/François Antón Castro (Participant)  
National Space Institute
**Description**

International Conference on Advanced Geographic Information Systems, Applications, and Services

**Body type:** Technical Program Committee  
**Degree of recognition:** International

**Related external organisation**

**IARIA GeoProcessing**  
Activity: Membership › Membership in review committee

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**Working Group II/2 of Commission II of the ISPRS (External organisation)**

**Period:** 2012 → 2016  
**Francesc/François Antón Castro (Chairman)**  
National Space Institute

**Description**


ISPRS Working group II/2 aims to promote the development of new methodologies, algorithms and applications related to the representation of n-dimensional spatial data at multiple scales. Another focus of the group is on the development of topological and geometric data models, data structures and algorithms for automatic n-dimensional data generalization at different levels of detail and for various purposes. To this purpose, the WG organises workshops to exchange the latest developments on representation of n-dimensional spatial data at multiple scales. The WG will be in cooperation with WG II/1 on spatio-temporal data models and structures and on spatio-temporal topology and relationships. The WG will promote research dissemination through books, journal papers, and peer-reviewed conference papers through ISPRS and general math and computer science publications.

**Body type:** Non-Governmental Organization  
**Degree of recognition:** International

**Links:**  
http://www2.isprs.org/commissions/comm2/wg2.html (Web site)

**Related external organisation**

**Working Group II/2 of Commission II of the ISPRS**  
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

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**Hybrid scientific computing using Interval Analysis, Homotopy and Algebraic Geometry for Photogrammetry, GPS and GIS**

**Period:** 7 Nov 2011  
**Francesc/François Antón Castro (Keynote speaker)**  
National Space Institute

**Related event**

**International Workshop on Geoinformation Advances**  
07/11/2012 → 08/11/2012  
Johor Bahru, Malaysia  
Activity: Talks and presentations › Conference presentations

**Hybrid scientific computing using Interval Analysis, Homotopy and Algebraic Geometry for Photogrammetry, GPS and GIS**

**Period:** Jul 2011  
**Francesc/François Antón Castro (Invited speaker)**
National Space Institute
Geodesy

Description
Invited lectures at Tsinghua University and Shandong University

Related event
8th International Symposium on Voronoi Diagrams in Science and Engineering
28/06/2011 → 30/06/2011
Qingdao, China
Activity: Talks and presentations › Conference presentations

Geometry and Algebra
Period: 2010
Francesc/François Antón Castro (Lecturer)
National Space Institute
Geodesy

Description
Science day at the French School of Copenhagen

Related external organisation
Unknown external organisation
Activity: Talks and presentations › Conference presentations

International Symposium on Voronoi Diagrams in science and engineering (External organisation)
Period: 23 Jun 2009 → …
Francesc/François Antón Castro (Participant)
National Space Institute
Geodesy
Department of Informatics and Mathematical Modeling
Image Analysis and Computer Graphics

Description
Body type: Steering Committee
Degree of recognition: International

Related external organisation
International Symposium on Voronoi Diagrams in science and engineering
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar