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Both problems are NP-hard in general. We give efficient constant-factor approximation algorithms for both problems. In particular, we give a $(3+\epsilon)$-approximation algorithm for the lawn mowing problem and a 2.5-approximation algorithm for the milling problem. Furthermore, we give a simple 6/5-approximation algorithm for the TSP problem in simple grid graphs, which leads to an 11/5-approximation algorithm for milling simple rectilinear polygons.

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1689 Mark de Berg, Otfried Cheong, Olivier Devillers, Mark van Kreveld, and Monique Teillaud. Computing the maximum overlap of two convex polygons under translations. *Theory of Computing Systems*, 31:613–628, 1998. [bcdkt-cmotc-98] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* bdkst-cmotc-96. *Cites:* ast-apsgo-92, abb-amps-91, ag-mrpc-92, absstz-sacp-96, ab-pptr-88, c-pcp-83, c-oaitd-92, c-chdc-93, cghkkk-gpmem-93, ck-cppop-93, f-fapct-85, fj-gsrsm-84, g-cp-67, h-ampac-92, hkk-dvdmh-92i, hks-uevsi-93, l-rmp-91, msw-aotp-93, pt-cocpc-92, scklps-gadss-86, v-aitco-95. *Abstract:* Let P be a convex polygon in the plane with n vertices and let Q be a convex polygon with m vertices. We prove that the maximum number of combinatorially distinct placements of Q with respect to P under translations is $O(n^2 + m^2 + \min(nm^2 + n^2m))$, and we give an example showing that this bound is tight in the worst case. Second, we present an $O((n + m) \log(n + m))$ algorithm for determining a translation of Q that maximizes the area of overlap of P and Q. We also prove that the placement of Q that makes the centroids of Q and P coincide realizes an overlap of at least 9/25 of the maximum possible overlap. As an upper bound, we show an example where the overlap in this placement is 4/9 of the maximum possible overlap.

1690 Mark de Berg, Olivier Devillers, Katrin Dobrindt, and Otfried Schwarzkopf. Computing a single cell in the overlay of two simple polygons. *Inform. Process. Lett.*, 63(4):215–219, August 1997. [bdds-cscot-97] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* bdds-cscut-95. *Cites:* bds-lric-94, bdsty-arsol-92, cct-rpatd-92, cs-arscg-89, d-rysoa-92, gks-ricdv-92, gss-gmppt-89, m-cgitr-93, s-sfira-91. *Abstract:* This note combines the lazy randomized incremental construction scheme with the technique of "connectivity acceleration" to obtain an $O(n(\log^* n)^2)$ time randomized algorithm to compute a single face in the overlay of two simple polygons in the plane.

1691 Mark de Berg, Olivier Devillers, Katrin Dobrindt, and Otfried Schwarzkopf. Computing a single cell in the union of two simple polygons. Research Report 2626, INRIA, BP93, 06902 Sophia-Antipolis, France, 1995. [bdds-cscut-95] *URL:* http://www.inria.fr/RRRT/RR-2626. *Precedes:* bdds-cscot-97. *Abstract:* This note presents a non trivial combination of two techniques previously used with randomized incremental algorithms: the lazy cleaning scheme [1695] to maintain structures with 'non local' definition and the $O(n \log^* n)$ acceleration when some additional information about the data is known [3358, 4015, 11942]. Authors assume that the reader is somehow familiar with this techniques. If, we are interested in computing a single face in the intersection of two simple polygons, the two previous techniques can be used. The lazy approach allows to compute a single face in an arrangement of line segments in expected time $O(n\alpha(n) \log n)$ but this technique do not exploit the organization of the segments in simple polygons. The accelerated framework compute the whole intersection of the two simple polygon in $O(n \log^* n + A)$ where $A = O(n^2)$ is the number of intersection points, and then the relevant connected component can be extracted easily in $O(n)$ time. The two techniques can be combined to reach an algorithm whose expected time complexity is $O(n \log^{*2} n)$ which improve previous bounds above.

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2149 Jean-Daniel Boissonnat. Representing 2d and 3d shapes with the Delaunay triangulation. In *Proc. 7th IEEE Internat. Conf. Pattern Recogn.*, pages 745–748, New York, NY, 1984. IEEE. [b-r2d3d-84] *Keywords:* Delaunay triangulation, automatic modeling, 3d shapes, 2d shapes, computer vision. *Annote:* 3D DT. We eliminate tetras until all points are on boundary surface. *Abstract:* In order to represent and measure a 2-dimensional or a 3-dimensional shape defined by a finite number of points on its boundary, the author proposes to use the Delaunay triangulation. It is shown that a good polyhedral approximation of the shape can be obtained and that a number of applications become straightforward. The Delaunay triangulation appears to be a useful tool in discrete curve and surface analysis. 2 refs.

2150 Jean-Daniel Boissonnat. Shape reconstruction from planar cross-sections. Report 546, INRIA Sophia-Antipolis, Valbonne, France, 1986. [b-srpcs-86]

2151 Jean-Daniel Boissonnat. Shape reconstruction from planar cross-sections. *Comput. Vision Graph. Image Process.*, 44(1):1–29, October 1988. [b-srpcs-88] *Keywords:* shape reconstruction, planar cross sections, Delaunay triangulation, computational geometry. *Annote:* Computes the 3D DT between two contours (extra points are added to force the boundary—by repeatedly adding midpoints to edges not in DT) by merging DTs of each contour. Then tetras are eliminated so that each point is on the surface. *Abstract:* We propose a new solution to the problem of constructing a shape over a set of cross-sectional contours. We construct a volume whose boundary is a polyhedron with triangular faces intersecting the cutting planes along the given contours. This volume is obtained, slice by slice, by pruning the Delaunay triangulations formed between two adjacent cross sections. The Delaunay triangulation can be computed efficiently in this specific situation: an algorithm is presented that is optimal with respect to the input size and the output size and that only uses 2-dimensional operations. The shape reconstruction method extracts, from that triangulation, a maximum solid with no singularity. It can handle the case where the number of contours varies from one cross section to the other and thus, can handle contour-defined objects which are branched and have holes. This algorithm has been fully implemented and tested on various examples; results on medical images are presented. (Author abstract) 28 Refs.

2152 J.-D. Boissonnat and X.-N. Bui. Accessibility region for a car that only moves forwards along optimal paths. Research Report 2181, INRIA Sophia-Antipolis, 1994. [bb-arcto-94] *Abstract:* In [BSBL93], the synthesis problem has been solved for a non-holonomic car-like robot only allowed to move forwards in a plane. Here we complete the study of this mobile robot by computing the SP-accessibility regions which are the sets of points reached from the origin configuration with an optimal path of length less than or equal to a given value. For that, we consider the problem of optimising the paths starting from an oriented point and arriving at another point with free orientation. After characterising these optimal paths, we compute the partition of the plane w.r.t. the types of the optimal paths, and finally we find the shapes of the SP-accessibility regions.

2153 Jean-Daniel Boissonnat and Frédéric Cazals. Coarse-to-fine surface simplification with geometric guarantees. In A. Chalmers and T.-M. Rhyne, editors, *Eurographics'01*, Manchester, 2001. Blackwell. [bc-cfssg-01]

2154 Jean-Daniel Boissonnat and Frédéric Cazals. Natural coordinates of points on a surface. *Comput. Geom. Theory Appl.*, 19:155–173, 2001. [bc-ncps-01]

2155 J.-D. Boissonnat and F. Cazals. Natural neighbor coordinates of points on a surface. *Comput. Geom. Theory Appl.*, 19:155–173, 2001. [bc-nncps-01]

2156 Jean-Daniel Boissonnat and Frédéric Cazals. Smooth surface reconstruction via natural neighbour interpolation of distance functions. In *Proc. 16th Annu. ACM Sympos. Comput. Geom.*, pages 223–232, 2000. [bc-ssrnn-00]

2157 Jean-Daniel Boissonnat, Frédéric Cazals, Frank Da, Olivier Devillers, Sylvain Pion, François Rebufat, Monique Teillaud, and Mariette Yvinec. Programming with CGAL: The example of triangulations. In *Proc. 15th Annu. ACM Sympos. Comput. Geom.*, pages 421–423, 1999. [bcddprty-pcet-99] *URL:* http://www-sop.inria.fr/prisme/publis/bcddprty-pcet-99.ps.gz.

2158 Jean-Daniel Boissonnat, Frédéric Cazals, and Julia Flötotto. $2d$-structure drawings of similar molecules. In Joe Marks, editor, *Graph Drawing: 8th international symposium*, volume 1984 of *Lecture Notes Comput. Sci.*, pages 115–126. Springer-Verlag, 2000. [bcf-2sdsm-00]

2159 Jean-Daniel Boissonnat, Frédéric Cazals, and Stéphane Nullans. Smooth shape reconstruction. In *Abstracts 15th European Workshop Comput. Geom.*, pages 63–68. INRIA Sophia-Antipolis, 1999. [bcn-ssr-99]

2160 Jean-Daniel Boissonnat, André Cérézo, Elena Degtiariora-Kostova, Vladimir Kostov, and Juliette Leblond. Shortest plane paths with bounded derivative of the curvature. *C. R. Acad. Sci.*, 329-I:613–618, 1999. [bcdkl-sppbd-99] *Succeeds:* bcl-nspps-94.

2161 Jean-Daniel Boissonnat, André Cérézo, Olivier Devillers, Jacqueline Duquesne, and Mariette Yvinec. An algorithm for constructing the convex hull of a set of spheres in dimension d. In *Proc. 4th Canad. Conf. Comput. Geom.*, pages 269–273, 1992. [bcddy-acchs-92] *Precedes:* bcddy-acchs-96. *Cites:* c-ochap-91, cs-arscg-89, bdsty-arsol-92, ms-cpubc-71, r-chada-92, ss-tddsp-90, ZZZ.

2162 Jean-Daniel Boissonnat, André Cérézo, Olivier Devillers, Jacqueline Duquesne, and Mariette Yvinec. An algorithm for constructing the convex hull of a set of spheres in dimension d. *Comput. Geom. Theory Appl.*, 6:123–130, 1996. [bcddy-acchs-96] *URL:* http://www-sop.inria.fr/prisme/publis/bcddy-acchs-96.ps.gz. *Succeeds:* bcddy-acchs-92. *Cites:* r-chada-92, ss-tddsp-90, m-mnfcp-70, c-ochap-91, cs-arscg-89, s-sdlpc-91, bdsty-arsol-92. *Abstract:* We present an algorithm which computes the convex hull of a set of n spheres i n dimension d in time $O(n^{\lceil \frac{d}{2} \rceil} + n \log n)$. It is worst-case optimal in three dimensions and in even dimensions. The same method can also be used to compute the convex hull of a set of n homo thetic convex objects of E^d. If the complexity of each object is constant, the time needed in the worst case is $O(n^{\lceil \frac{d}{2} \rceil} + n \log n)$.

2163 Jean-Daniel Boissonnat, André Cérézo, Olivier Devillers, and Monique Teillaud. Output-sensitive construction of the 3-d Delaunay triangulation of constrained sets of points. Research Report 1415, INRIA Sophia-Antipolis, Valbonne, France, April 1991. [bcdt-osc3d-91t] *URL:* http://www.inria.fr/RRRT/RR-1415. *Keywords:* Delaunay triangulation, Voronoi diagrams, output-sensitive algorithms, shape reconstructions, shelling, tomography. *Precedes:* bcdt-osc3d-91i, bcdt-oscdt-96.

2164 Jean-Daniel Boissonnat, André Cérézo, Olivier Devillers, and Monique Teillaud. Output-sensitive construction of the 3-d Delaunay triangulation of constrained sets of points. In *Proc. 3rd Canad. Conf. Comput. Geom.*, pages 110–113, 1991. [bcdt-osc3d-91i] *Keywords:* Delaunay triangulation, Voronoi diagrams, output-sensitive algorithms, shape reconstructions, shelling, tomography. *Succeeds:* bcdt-osc3d-91t. *Precedes:* bcdt-oscdt-96. *Cites:* b-srpcs-88, bcdt-osc3d-91t, bdsty-olgag-91a, bm-sdcs-71, cs-arscg-89, e-acg-87, em-feptd-85, s-chdch-86, ZZZ.

2165 Jean-Daniel Boissonnat, André Cérézo, Olivier Devillers, and Monique Teillaud. Output-sensitive construction of the Delaunay triangulation of points lying in two planes. *Internat. J. Comput. Geom. Appl.*, 6(1):1–14, 1996. [bcdt-oscdt-96] *URL:* http://www-sop.inria.fr/prisme/publis/bcdt-oscdt-96.ps.gz. *Succeeds:* bcdt-osc3d-91t, bcdt-osc3d-91i. *Cites:* ps-cgi-85, e-acg-87, a-vdsfg-91, s-chdch-86, ms-loq-92, cs-arscg-89, bdsty-arsol-92, bcdt-osc3d-91i, bm-sdcs-71, bcdt-osc3d-94t, b-srpcs-88, a-pdpaa-87, c-ig-61, p-gcc-70, dmt-ssgtu-92i, gs-ccrs-87, eg-tsa-89, b-gdg-83. *Abstract:* In this paper, we propose an algorithm to compute the Delaunay triangulation of a set S of n points in 3-dimensional space when the points lie in 2 planes. The algorithm is output-sensitive and optimal with respect to the input and the output sizes. Its time complexity is $O(n \log n + t)$, where t is the size of the output, and the extra storage is $O(n)$.

2166 J. D. Boissonnat, A. Cérézo, and J. Duquesne. An algorithm for constructing the convex hull of a set of spheres in three dimensional space. In *Abstracts 8th European Workshop Comput. Geom.*, pages 51–53. Utrecht University, 1992. [bcd-acchs-92]

2167 Jean-Daniel Boissonnat, André Cérézo, and Juliette Leblond. A note on shortest paths in the plane subject to a constraint on the derivative of the curvature. Rapport de recherche 2160, INRIA, 1994. [bcl-nspps-94] *URL:* http://www-sop.inria.fr/RRRT/RR-2160.html. *Precedes:* bcdkl-sppbd-99.

2168 Jean-Daniel Boissonnat, André Cérézo, and Juliette Leblond. Shortest paths of bounded curvature in the plane. Report 1503, INRIA Sophia-Antipolis, Valbonne, France, July 1991. [bcl-spbcp-91] *Precedes:* bcl-spbcp-92.

2169 Jean-Daniel Boissonnat, André Cérézo, and Juliette Leblond. Shortest paths of bounded curvature in the plane. In *Proc. 9th IEEE Internat. Conf. Robot. Autom.*, 1992. [bcl-spbcp-92] *Succeeds:* bcl-spbcp-91. *Precedes:* bcl-spbcp-94.

2170 Jean-Daniel Boissonnat, André Cérézo, and Juliette Leblond. Shortest paths of bounded curvature in the plane. *Internat. J. Intell. Syst.*, 10:1–16, 1994. [bcl-spbcp-94]

2171 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, Jean-Marc Robert, and Mariette Yvinec. Convex tours of bounded curvature. In *Proc. 2nd Annu. European Sympos. Algorithms*, volume 855 of *Lecture Notes Comput. Sci.*, pages 254–265. Springer-Verlag, 1994. [bcdry-ctbc-94] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Precedes:* bcdry-ctbc-99. *Abstract:* We consider the motion planning problem for a point constrained to move along a smooth (C1) closed (cycle) convex path of bounded curvature. The workspace of the moving point is bounded by a convex polygon with m vertices, containing an obstacle in a form of a simple polygon with n vertices. We present an O(m + n) time algorithm finding the path, going around the obstacle, whose curvature is the smallest possible.

2172 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, Jean-Marc Robert, and Mariette Yvinec. Convex tours of bounded curvature. *Comput. Geom. Theory Appl.*, 13:149–159, 1999. [bcdry-ctbc-99] *URL:* http://www-sop.inria.fr/prisme/biblio/. *Succeeds:* bcdry-ctbc-94. *Cites:* agss-ltacv-89, dxcr-kmp-93, d-cmlca-57, fw-pcm-91, jc-pspmr-89, kslo-prpph-96, k-osps-83, l-rmp-91, o-mpic-87, o-ramp-92, os-plamp-94, p-masp-77, rs-mppmo-94, ss-ampr-90, w-mpav-88. *Abstract:* We consider the motion planning problem for a point constrained to move along a smooth closed convex path of bounded curvature. The workspace of the moving point is bounded by a convex polygon with m vertices, containing an obstacle in a form of a simple polygon with n vertices. We present an $O(m + n)$ time algorithm finding the path, going around the obstacle, whose curvature is the smallest possible.

2173 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, Jorge Urrutia, and Mariette Yvinec. Computing largest circles separating two sets of segments. Research Report 2705, INRIA, BP93, 06902 Sophia-Antipolis, France, 1995. [bcduy-clcst-95] *URL:* http://www.inria.fr/cgi-bin/wais_ra_sophia?question=2705. *Abstract:* A circle C separates two planar sets if it encloses one of the sets and its open interior disk does not meet the other set. A separating circle is a largest one if it cannot be locally increased while still separating the two given sets. An $\Theta(n \log n)$ optimal algorithm is proposed to find all largest circles separating two given sets of line segments when line segments are allowed to meet only at their endpoints. This settles an open problem from a previous paper [2176]. In the general case, when line segments may intersect $\Omega(n^2)$ times, our algorithm can be adapted to work in $O(n\alpha(n) \log n)$ time and $O(n\alpha(n))$ space, where $\alpha(n)$ represents the extremely slowly growing inverse of Ackermann function.

2174 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, Jorge Urrutia, and Mariette Yvinec. Computing largest circles separating two sets of segments. In *Proc. 8th Canad. Conf. Comput. Geom.*, pages 173–178, 1996. [bcduy-clcst-96] *Precedes:* bcduy-clcst-00.

2175 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, Jorge Urrutia, and Mariette Yvinec. Computing largest circles separating two sets of segments. *Internat. J. Comput. Geom. Appl.*, 10:41–54, 2000. [bcduy-clcst-00] *URL:* http://www-sop.inria.fr/prisme/publis/bcduy-clcst.ps.gz. *Succeeds:* bcduy-clcst-96. *Cites:* abosy-fmcnp-89, b-cspps-88, bcdy-csp-95, bg-aoscf-95, cegss-cfals-93, dj-cmcnp-90, bds-lric-95, dk-ladsc-85, egs-cmcap-90, ep-mps-88, f-spcrd-86, ka-dd-84, k-eccs-79, k-osps-83, ld-gvdp-81, mt-cppna-85, m-lpltw-84, ms-sapo-95, m-idssp-92, okm-ccs-86. *Abstract:* A circle C separates two planar sets if it encloses one of the sets and its open interior disk does not meet the other set. A separating circle is a largest one if it cannot be locally increased while still separating the two given sets. An $\Theta(n \log n)$ optimal algorithm is proposed to find all largest circles separating two given sets of line segments when line segments are allowe d to meet only at their endpoints. In the general case, when line segments may intersect $\Omega(n^2)$ times, our algorithm can be adapted to work in $O(n\alpha(n) \log n)$ time and $O(n\alpha(n))$ space, where $\alpha(n)$ represents the extremely slowly growing inverse of the Ackermann function.

2176 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, and Mariette Yvinec. Circular separability of polygons. In *Proc. 6th ACM-SIAM Sympos. Discrete Algorithms*, pages 273–281, 1995. [bcdy-csp-95] *Keywords:* separation, containment, largest disk, Voronoi diagrams. *Precedes:* bcdy-csp-01. *Abstract:* Two planar sets are circularly separable if there exists a circle enclosing one of the set and whose open interior disk does not intersect the other set. This paper studies two problems related to circular separability. A linear-time algorithm is proposed to decide if two polygons are circularly separable. The algorithm outputs the smallest separating circle. The second problem asks for the largest circle included in a preprocessed, convex polygon, under some point and/or line constraints. The resulting circle must contain the query points and it must lie in the halfplanes delimited by the query lines.

2177 Jean-Daniel Boissonnat, Jurek Czyzowicz, Olivier Devillers, and Mariette Yvinec. Circular separability of polygons. *Algorithmica*, 30:67i–82, 2001. [bcdy-csp-01] *URL:* http://link.springer.de/link/service/journals/00453/contents/00/10078/%paper/10078.pdf. *Succeeds:* bcdy-csp-95. *Cites:* abosy-fmcnp-89, agss-ltacv-89, bcdry-ctbc-94, bg-aoscf-95, b-cspps-88, c-bvdcp-86, dj-cmcnp-90, dk-ladsc-85, ep-mps-88, f-spcrd-86, ka-dd-84, k-osps-83, l-sss-71, l-fchsp-83, m-lpltw-84, m-idssp-92, ms-sapo-95, okm-ccs-86. *Abstract:* Two planar sets are circularly separable if there exists a circle enclosing one of the set and whose open interior disk does not intersect the other set. This paper studies two problems related to circular separability. A linear-time algorithm is proposed to decide if two polygons are circularly separable. The algorithm outputs the smallest separating circle. The second problem asks for the largest circle included in a preprocessed, convex polygon, under some point and/or line constraints. The resulting circle must contain the query points and it must lie in the halfplanes delimited by the query lines.

2178 Jean-Daniel Boissonnat, Olivier Devillers, LeonBattista Donati, and Franco P. Preparata. Motion planning for a spider robot. In *Proc. 9th IEEE Internat. Conf. Robot. Autom.*, pages 2321–2326, 1992. [bddp-mpsr-92] *Keywords:* motion planning, legged robot. *Precedes:* bddp-mplrs-95.

2179 Jean-Daniel Boissonnat, Olivier Devillers, LeonBattista Donati, and Franco P. Preparata. Motion planning of legged robots: the spider robot problem. *Internat. J. Comput. Geom. Appl.*, 5(1–2):3–20, 1995. [bddp-mplrs-95] *URL:* http://www-sop.inria.fr/prisme/publis/bddp-mplrs-95.ps.gz. *Succeeds:* bddp-mpsr-92,bddp-spsr-92. *Cites:* ps-cgi-85, l-knnvd-82, agss-ltacv-87, s-ksacs-91, hs-ompc-91, p-pplr-90, w-cvgnl-85, bdp-cu3ct-91. *Abstract:* We consider the problem of planning motions of a simple legged robot called the spider robot. The robot is modelled as a point where all its legs are attached, and the footholds where the robot can securely place its feet consist of a set of n points in the plane. We show that the space $\mathcal{F}$ of admissible and stable placements of such robots has size $\Theta(n^2)$ and can be constructed in $O(n^2 \log n)$ time and $O(n^2)$ space. Once $\mathcal{F}$ has been constructed, we can efficiently solve several problems related to motion planning.

2180 Jean-Daniel Boissonnat, Olivier Devillers, LeonBattista Donati, and Franco P. Preparata. Stable placements of spider robots. In *Proc. 8th Annu. ACM Sympos. Comput. Geom.*, pages 242–250, 1992. [bddp-spsr-92] *URL:* http://www.inria.fr/cgi-bin/wais_ra_sophia?question=1767. *Keywords:* motion planning, legged robot. *Precedes:* bddp-mplrs-95. *Cites:* agss-ltacv-89, bddp-mpsr-92, bdp-cu3ct-91, hs-ompc-91, hk-gsftq-91, hnku-agcqw-84, l-knnvd-82, ps-cgi-85, -sill-84, -sill-90, s-ksacs-91, ZZZ.

2181 Jean-Daniel Boissonnat, Olivier Devillers, and Sylvain Lazard. From spider robots to half-disk robots. In *Abstracts 10th European Workshop Comput. Geom.*, pages 62–63. Universidad de Cantabria, Santander, 1994. [bdl-srhdr-94c] *Precedes:* bdl-mplr-00.

2182 Jean-Daniel Boissonnat, Olivier Devillers, and Sylvain Lazard. From spider robots to half disks robots. In *Proc. 11th IEEE Internat. Conf. Robot. Autom.*, pages 953–958, 1994. [bdl-srhdr-94] *Succeeds:* bdl-srhdr-94c. *Precedes:* bdl-mplr-00.

2183 Jean-Daniel Boissonnat, Olivier Devillers, and Sylvain Lazard. Motion planning of legged robots. In *Proc. 1st Workshop Algorithmic Found. Robot.* A. K. Peters, Boston, MA, 1994. [bdl-mplr-94] *Precedes:* bdl-mplr-00.

2184 Jean-Daniel Boissonnat, Olivier Devillers, and Sylvain Lazard. Motion planning of legged robots. *SIAM J. Comput.*, 30:218–246, 2000. [bdl-mplr-00] *URL:* http://www-sop.inria.fr/prisme/publis/bdl-mplr.ps.gz. *Succeeds:* bdl-mplr-94,bdl-srhdr-94,bdl-srhdr-94c. *Cites:* bddp-mplrs-95, dd-frspp-90, h-fuenl-89, ks-empac-90, kst-coksm-97, l-ptrmn-96, s-ksacs-91, ss-nempa-87, t-frnns-91. *Abstract:* We study the problem of computing the free space $\mathcal{F}$ of a simple legged robot called the spider robot. The body of this robot is a single point and the legs are attached to the body. The robot is subject to two constraints: each leg has a maximal extension R (accessibility constraint) and the body of the robot must lie above the convex hull of its feet (stability constraint). Moreover, the robot

can only put its feet on some regions, called the foothold regions. The free space $\mathcal{F}$ is the set of positions of the body of the robot such that there exists a set of accessible footholds for which the robot is stable. We present an efficient algorithm that computes $\mathcal{F}$ in $O(n^2 \log n)$ time using $O(n^2\alpha(n))$ space for n discrete point footholds where $\alpha(n)$ is an extremely slowly growing function ($\alpha(n) \leq 3$ for any practical value of n). We also present an algorithm for computing $\mathcal{F}$ when the foothold regions are pairwise disjoint polygons with n edges in total. This algorithm computes $\mathcal{F}$ in $O(n^2\alpha_8(n)\log n)$ time using $O(n^2\alpha_8(n))$ space ($\alpha_8(n)$ is also an extremely slowly growing function). These results are close to optimal since $\Omega(n^2)$ is a lower bound for the size of $\mathcal{F}$.

2185 Jean-Daniel Boissonnat, Olivier Devillers, and Franco P. Preparata. Computing the union of 3-colored triangles. Technical Report 1293, INRIA, Sophia-Antipolis, France, October 1990. [bdp-cu3ct-90] *URL:* http://www.inria.fr/RRRT/RR-1293. *Precedes:* bdp-cu3ct-91.

2186 Jean-Daniel Boissonnat, Olivier Devillers, and Franco P. Preparata. Computing the union of 3-colored triangles. *Internat. J. Comput. Geom. Appl.*, 1(2):187–196, 1991. [bdp-cu3ct-91] *URL:* http://www-sop.inria.fr/prisme/publis/bdp-cu3ct-91.ps.gz. *Keywords:* convex hull, motion planning, legged robot. *Abstract:* Given is a set s of n points, each colored with one of $k \geq 3$ colours. We say that a triangle defined by three points of f is 3-colored if its vertices have distinct colours. We prove in this paper that the problem of constructing the boundary of the union $\sqcup f$ of all such 3-colored triangles can be done in optimal $O(n \log n)$ time.

2187 Jean-Daniel Boissonnat, Olivier Devillers, René Schott, Monique Teillaud, and Mariette Yvinec. Applications of random sampling to on-line algorithms in computational geometry. Technical Report 1285, INRIA Sophia-Antipolis, Valbonne, France, 1990. [bdsty-arsol-90] *URL:* http://www.inria.fr/RRRT/RR-1285. *Succeeds:* bt-hrodt-86. *Precedes:* bdsty-olgag-91i.

2188 Jean-Daniel Boissonnat, Olivier Devillers, René Schott, Monique Teillaud, and Mariette Yvinec. Applications of random sampling to on-line algorithms in computational geometry. *Discrete Comput. Geom.*, 8:51–71, 1992. [bdsty-arsol-92] *URL:* http://www-sop.inria.fr/prisme/publis/bdsty-arsol-92.ps.gz. *Keywords:* randomized algorithms, Delaunay triangulation, semi-dynamic algorithms, arrangement of line-segments. *Succeeds:* bdsty-olgag-91i. *Abstract:* This paper presents a general framework for the design and randomized analysis of geometric algorithms. These algorithms are on-line and the framework provides general bounds for their expected space and time complexities when averaging over all permutations of the input data. The method is general and can be applied to various geometric problems. The power of the technique is illustrated by new efficient on-line algorithms for constructing convex hulls and Voronoi diagrams in any dimension, Voronoi diagrams of line segments in the plane, arrangements of curves in the plane and others.

2189 Jean-Daniel Boissonnat, Olivier Devillers, René Schott, Monique Teillaud, and Mariette Yvinec. On-line geometric algorithms with good expected behaviours. Technical Report INRIA 1285, August 1990. [bdsty-olgag-90t] *Precedes:* bdsty-olgag-91i, bdsty-olgag-91a.

2190 Jean-Daniel Boissonnat, Olivier Devillers, René Schott, Monique Teillaud, and Mariette Yvinec. On-line geometric algorithms with good expected behaviours. In *Proc. 13th World Congress on Computation and Applied Math.*, pages 137–139, 1991. [bdsty-olgag-91i] *Succeeds:* bdsty-arsol-90. *Precedes:* bdsty-arsol-92.

2191 Jean-Daniel Boissonnat, Olivier Devillers, René Schott, Monique Teillaud, and Mariette Yvinec. On-line geometric algorithms with good expected behaviours. *IMACS*, ??, 1991. [bdsty-olgag-91a] *Succeeds:* bdsty-olgag-90t.

2192 Jean-Daniel Boissonnat, Olivier Devillers, and Monique Teillaud. A dynamic construction of higher-order Voronoi diagrams and its randomized analysis. Technical Report 1207, INRIA Sophia-Antipolis, Valbonne, France, 1990. [bdt-dchov-90] *URL:* http://www.inria.fr/RRRT/RR-1207. *Keywords:* randomized algorithms, higher order Voronoi diagrams, dynamic algorithms. *Succeeds:* bdt-olcho-90, bt-hrodt-86. *Precedes:* bdt-schov-93.

2193 Jean-Daniel Boissonnat, Olivier Devillers, and Monique Teillaud. A semidynamic construction of higher-order Voronoi diagrams and its randomized analysis. *Algorithmica*, 9:329–356, 1993. [bdt-schov-93] *URL:* http://www-sop.inria.fr/prisme/publis/bdt-schov-93.ps.gz. *Keywords:* randomized algorithms, higher order Voronoi diagrams, dynamic algorithms. *Succeeds:* bdt-olcho-90. *Abstract:* The k-Delaunay tree extends the Delaunay tree introduced in [2221]. It is a hierarchical data structure that allows the semi-dynamic construction of the higher order Voronoi diagrams of a finite set of n points in any dimension. In this paper, we prove that a randomized construction of the k-Delaunay tree, and thus, of all the order $\leq k$ Voronoi diagrams, can be done in $O(n \log n + k^3 n)$ expected time and $O(k^2 n)$ expected storage in the plane, which is asymptotically optimal for fixed k. The algorithm is simple and experimental results are given.

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4015 Olivier Devillers. Randomization yields simple $O(n \log^* n)$ algorithms for difficult $\Omega(n)$ problems. *Internat. J. Comput. Geom. Appl.*, 2(1):97–111, 1992. [d-rysoa-92] *URL:* http://www-sop.inria.fr/prisme/publis/d-rysoa-92.ps.gz. *Keywords:* randomized algorithms, Delaunay triangulation, skeleton, medial axis, minimum spanning tree, simple polygon. *Succeeds:* d-sroa-91. *Abstract:* We use here the results on the influence graph [2188] to adapt them for particular cases where additional information is available. In some cases, it is possible to improve the expected randomized complexity of algorithms from $O(n \log n)$ to $O(n \log^* n)$. This technique applies in the following applications : triangulation of a simple polygon, skeleton of a simple polygon, Delaunay triangulation of points knowing the EMST (euclidean minimum spanning tree).

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4018 Olivier Devillers. Simultaneous containment of several polygons: analysis of the contact configurations. Report 1179, INRIA Sophia-Antipolis, Valbonne, France, 1990. [d-scspa-90] *URL:* http://www.inria.fr/RRRT/RR-1179. *Keywords:* polygon placement, contact configurations. *Precedes:* d-scspa-93.

4019 Olivier Devillers. Simultaneous containment of several polygons: analysis of the contact configurations. *Internat. J. Comput. Geom. Appl.*, 3(4):429–442, 1993. [d-scspa-93] *URL:* http://www-sop.inria.fr/prisme/publis/d-scspa-93.ps.gz. *Keywords:* motion planning, polygon containment, robotics. *Succeeds:* d-scspa-90. *Abstract:* The main concern of this paper is the detection of double contact configurations for some polygons moving in translation in a polygonal environment. We first establish some general properties about such configurations and give conditions of existence of double contacts for two or three objects. For three

convex polygons moving in a polygonal environment or three simple polygons moving in a rectangle there always exists a double contact. Two examples without possibility of double contacts are given, one with three polygons (not convex) moving in a polygonal environment, and one with four convex polygons moving in a rectangle. We deduce an algorithm detecting a double contact position in time $O(n^2)$ (resp $O(n^3)$) for two (resp three) convex polygons of constant sizes moving in a non-convex polygon of size n.

4020 Olivier Devillers and Andreas Fabri. Scalable algorithms for bichromatic line segment intersection problems on coarse grained multicomputers. In *Proc. 3rd Workshop Algorithms Data Struct.*, volume 709 of *Lecture Notes Comput. Sci.*, pages 277–288, 1993. [df-sabls-93] *Precedes:* df-sabls-96. *Abstract:* We present output-sensitive scalable parallel algorithms for bichromatic line segment intersection problems for the Coarse Grained Multicomputer model. Under the assumption that $n \geq p^2$, where n is the number of line segments and p the number of processors, we obtain an intersection counting algorithm with a time complexity of $O(\frac{n \log n \log p}{p} + T_s(n \log p, p))$, where $T_s(m, p)$ is the time used to sort m items on a p processor machine. An additional $O(\frac{k}{p})$ time is spent on the reporting of the k intersections. As the sequential complexity is $O(n \log n)$ and $O(k)$ for counting and reporting, respectively, we obtain a speedup of $\frac{p}{\log p}$.

4021 Olivier Devillers and Andreas Fabri. Scalable algorithms for bichromatic line segment intersection problems on coarse grained multicomputers. *Internat. J. Comput. Geom. Appl.*, 6:487–506, 1996. [df-sabls-96] *URL:* http://www-sop.inria.fr/prisme/publis/df-sabls-96.ps.gz. *Succeeds:* df-sabls-93. *Cites:* adh-cgaiaccl-93, b-sna-68, bt-pdcnm-89, cegs-ablsp-89, cp-dsnlthrc-90, dfr-spgac-93, gsg-pmvsppsp-92, grand-ch, gl-rrft-89, l-ipaa-92, ps-crrbsi-92, ps-cgi-85, rv-ltslsn-87. *Abstract:* We present output-sensitive scalable parallel algorithms for bichromatic line segment intersection problems for the Coarse Grained Multicomputer model. Under the assumption that $n \geq p^2$, where n is the number of line segments and p the number of processors, we obtain an intersection counting algorithm with a time complexity of $O(\frac{n \log n \log p}{p} + T_s(n \log p, p))$, where $T_s(m, p)$ is the time used to sort m items on a p processor machine. An additional $O(\frac{k}{p})$ time is spent on the reporting of the k intersections. As the sequential complexity is $O(n \log n)$ and $O(k)$ for counting and reporting, respectively, we obtain a speedup of $\frac{p}{\log p}$.

4022 Olivier Devillers, Alexandra Fronville, Bernard Mourrain, and Monique Teillaud. Algebraic methods and arithmetic filtering for exact predicates on circle arcs. In *Proc. 16th Annu. ACM Sympos. Comput. Geom.*, pages 139–147, 2000. [dfmt-amafe-00] *Cites:* bp-rpsis-97, bs-ealcs-99, bv-earic-99, svy-crm-99, cloiva-92, lpt-rpqid-99, p-gacg-99p-iaeia-99, y-tegc-97, y-fpaa-00. *Abstract:* The purpose of this paper is to present a new method to design exact geometric predicates in algorithms dealing with curved objects such as circular arcs. We focus on the comparison of the abscissae of two intersection points of circle arcs, which is known to be a difficult predicate involved in the computation of arrangements of circle arcs. We present an algorithm for deciding the x-order of intersections from the signs of the coefficients of a polynomial, obtained by a general approach based on resultants. This method allows the use of efficient arithmetic and filtering techniques leading to fast implementation as shown by the experimental results.

4023 Olivier Devillers, Alexandra Fronville, Bernard Mourrain, and Monique Teillaud. Algebraic methods and arithmetic filtering for exact predicates on circle arcs. In *Abstracts 16th European Workshop Comput. Geom.*, pages 117–120. Ben-Gurion University of the Negev, 2000. [dfmt-amafe-00i]

4024 Olivier Devillers and Pierre-Marie Gandoin. Compression géométrique pour une transmission progressive. Rapport de recherche 3766, INRIA, 1999. [dg-cgtp-99] *URL:* http://www-sop.inria.fr/prisme/biblio/. *Cites:* bb-srmua-97, bg-tdrcs-93, sk-ltrdt-97. *Abstract:* The compression of geometric structures is a relatively new field of data compression. Since about 1995, several articles have dealt with the coding of meshes, using for most of them the following approach: the vertices of the mesh are coded in an order such that it contains partially the topology of the mesh. In the same time, some simple rules attempt to predict the position of the current vertex from the positions of its neighbours that have been previously coded. In this article, we describe a compression algorithm whose principle is completely different: the order of the vertices is used to compress their coordinates, and then the topology of the mesh is reconstructed from the vertices. This algorithm, particularly suited for terrain models, achieves compression factors that are slightly greater than those of the currently available algorithms, and moreover, it allows progressive and interactive transmission of the meshes.

4025 Olivier Devillers and Pierre-Marie Gandoin. Geometric compression for interactive transmission. In *Proc. of IEEE Visualization 2000*, pages 319–326, 2000. [dg-cgit-00]

4026 Olivier Devillers and Mordecai Golin. Dog bites postman: Point location in the moving Voronoi diagram and related problems. In *Proc. 1st Annu. European Sympos. Algorithms*, volume 726 of *Lecture Notes Comput. Sci.*, pages 133–144. Springer-Verlag, 1993. [dg-dbppl-93] *Keywords:* Voronoi, Delaunay, moving points, randomized algorithms, dynamic algorithms, localisation. *Precedes:* dg-dbppl-98.

4027 Olivier Devillers and Mordecai Golin. Dog bites postman: Point location in the moving Voronoi diagram and related problems. *Internat. J. Comput. Geom. Appl.*, 8:321–342, 1998. [dg-dbppl-98] *URL:* http://www-sop.inria.fr/prisme/publis/dg-dbppl.ps.gz. *Succeeds:* dg-dbppl-93. *Cites:* ar-vdmph-92, a-vdsfg-91, bdsty-arsol-92, bt-rcdt-93, c-bvdcp-86, cms-frric-92i, cs-arscg-89, d-rysoa-92, dg-dbppl-93, dmt-fddtl-92, dty-dlals-92, egs-oplms-86, fl-vdmpp-91, gt-dtdpl-91, gmr-vdmpp-91, gks-ricdv-92, iklm-cdf3s-93, m-rmstd-91, ms-dplah-91, p-pplr-90, r-dvd-91, r-vdds-92, rn-dvdmp-91, s-dmgsm-91, s-barga-91, s-vdr-92. *Abstract:* In this paper, we discuss two variations of the two-dimensional post-office problem that arise when the post-offices are n postmen moving with constant velocities. The first variation addresses the question: given a point q_0 and time t_0 who is the nearest postman to q_0 at time t_0? We present a randomized incremental data structure that answers the query in expected $O(\log^2 n)$ time. The second variation views a query point as a dog searching for a postman to bite and finds the postman that a dog running with speed v_d could reach first. While it is quite straightforward to design a data structure for the first problem, designing one for the second appears more difficult. We show that if the dog is quicker than all of the postmen then there is a nice correspondence between the problems. This correspondence will permit us to use the data structure developed for the first problem to solve the second one in $O(\log^2 n)$ time as well. The proposed structure is semi-dynamic, that is the set of postmen can be modified by inserting new postmen. A fully dynamic structure that also supports deletions can be obtained, but in that case the query time becomes $O(\log^3 n)$.

4028 Olivier Devillers and Mordecai Golin. Incremental algorithms for finding the convex hulls of circles and the lower envelopes of parabolas. In *Proc. 6th Canad. Conf. Comput. Geom.*, pages 153–158, 1994. [dg-iafch-94] *Precedes:* dg-iafch-95. *Cites:* a-sdcgp-85, bcddy-acchs-92, r-chada-92, ZZZ.

4029 Olivier Devillers and Mordecai Golin. Incremental algorithms for finding the convex hulls of circles and the lower envelopes of parabolas. *Inform. Process. Lett.*, 56(3):157–164, 1995. [dg-iafch-95] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* dg-iafch-94. *Cites:* a-dcgp-85, bcddy-acchs-92, r-chada-92. *Abstract:* The existing $O(n \log n)$ algorithms for finding the convex hulls of circles and the lower envelope of parabolas follow the divide-and-conquer paradigm. The difficulty with developing incremental algorithms for these problems is that the introduction of a new circle or parabola can cause $\Theta(n)$ structural changes, leading to $\Theta(n^2)$ total structural changes during the running of the algorithm. In this note we examine the geometry of these problems and show that, if the circles or parabolas are first sorted by appropriate parameters before constructing the convex hull or lower envelope incrementally, then each new addition may cause at most 3 changes in an amortized sense. These observations are then used to develop $O(n \log n)$ incremental algorithms for these problems.

4030 Olivier Devillers, Mordecai Golin, Klara Kedem, and Stefan Schirra. Queries on Voronoi diagrams of moving points. *Comput. Geom. Theory Appl.*, 6:315–327, 1996. [dgks-qvdmp-96] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* dgks-rdqvd-94i. *Cites:* ar-vdmph-92, c-sssl-86, dg-dbppl-93, dsst-mdsp-89, fl-vdmpp-91, gt-dtdpl-91, gks-ricdv-92, gmr-vdmpp-91, m-apcad-83, r-vdds-90, r-dvd-91, rn-dvdmp-91, st-pplup-86, sadsstg-95, s-vdr-92. *Abstract:* Suppose we are given n moving postmen described by their motion equations $p_i(t) = s_i + v_i t$, $i = 1, \ldots, n$, where $s_i \in R^2$ is the position of the i'th postman at time $t = 0$, and $v_i \in R^2$ is his velocity. The problem we address is how to preprocess the postmen data so as to be able to efficiently answer two types of nearest-neighbor queries. The first one asks "who is the nearest postman at time t_q to a dog located at point s_q. In the second type a query dog is located at point s_q at time t_q, its speed is $v_q > |v_i|$ (for all $i = 1, \ldots, n$), and we want to know which postman the dog can catch first. The first type of query is relatively simple to address, the second type at first seems much more complicated. We show that the problems are very closely related, with efficient solutions to the first type of query leading to efficient solutions to the second. We then present two solutions to these problems, with tradeoff between preprocessing time and query time. Both solutions use deterministic data structures.

4031 Olivier Devillers, Mordecai Golin, Klara Kedem, and Stefan Schirra. Revenge of the dog: Queries on Voronoi diagrams of moving points. Report MPI-I-94-149, Max-Planck-Institut Inform., Saarbrücken, Germany, 1994. also INRIA-2329. [dgks-rdqvd-94t] *Precedes:* dgks-rdqvd-94i.

4032 Olivier Devillers, Mordecai Golin, K. Kedem, and S. Schirra. Revenge of the dog: Queries on Voronoi diagrams of moving points. In *Proc. 6th Canad. Conf. Comput. Geom.*, pages 122–127, 1994. [dgks-rdqvd-94i] *Succeeds:* dgks-rdqvd-94t. *Precedes:* dgks-qvdmp-96. *Cites:* c-sssl-86, dg-dbppl-93, dsst-mdsp-89, fl-vdmpp-91, gks-ricdv-92, gmr-vdmpp-92, gt-dtdpl-91, m-apcad-83, st-pplup-86, ZZZ.

4033 Olivier Devillers and Philippe Guigue. The shuffling buffer. *Internat. J. Comput. Geom. Appl.*, 11:555–572, 2001. [dg-sb-01]

4034 Olivier Devillers and Matthew Katz. Optimal line bipartitions of point sets. *Internat. J. Comput. Geom. Appl.*, 9:39–51, 1999. [dk-olbps-99] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* dk-olbps-96. *Cites:* as-pglp-94, abky-cabmm-88, a-dp-86, cms-frric-93, gks-sgsop-95, hr-tcpp-93, hs-ftp-91, jk-eaetc-94, k-iagoe-95, ks-ebago-93, mw-fobpp-91, ms-ppgmm-91, ol-mcp-81, ps-cgi-85, rww-obps-92, s-nlap2-96. *Abstract:* Let S be a set of n points in the plane. We study the following problem: Partition S by a line into two subsets S_a and S_b such that $max\{f(S_a), f(S_b)\}$ is minimal, where f is any monotone function defined over 2^S. We first present a solution to the case where the points in S are the vertices of a convex polygon and apply it to some common cases — $f(S')$ is the perimeter, area, or width of the

convex hull of $S' \subseteq S$ — to obtain linear solutions (or $O(n \log n)$ solutions if the convex hull of S is not given) to the corresponding problems. This solution is based on an efficient procedure for finding a minimal entry in matrices of some special type, which we believe is of independent interest. For the general case we present a linear space solution which is in some sense output sensitive. It yields solutions to the perimeter and area cases that are never slower and often faster than the best previous solutions.

4035 Olivier Devillers and Matthew J. Katz. Optimal line bipartitions of point sets. In *Proc. 7th Annu. Internat. Sympos. Algorithms Comput.*, pages 45–54, 1996. [dk-olbps-96] *Precedes:* dk-olbps-99.

4036 Olivier Devillers, Giuseppe Liotta, Franco P. Preparata, and Roberto Tamassia. Checking the convexity of polytopes and the planarity of subdivisions. In *Proc. 5th Workshop Algorithms Data Struct.*, volume 1272 of *Lecture Notes Comput. Sci.*, pages 186–199. Springer-Verlag, 1997. [dlpt-ccpps-97] *Precedes:* dlpt-ccpps-98.

4037 Olivier Devillers, Giuseppe Liotta, Franco P. Preparata, and Roberto Tamassia. Checking the convexity of polytopes and the planarity of subdivisions. *Comput. Geom. Theory Appl.*, 11:187–208, 1998. [dlpt-ccpps-98] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Keywords:* graph drawing, planar, straight-line, checking. *Succeeds:* dlpt-ccpps-97. *Cites:* -dcgs-, bbdgt-ccgg-97, bo-arcgi-79, bk-dpcw-95, b-ecvdl-96, c-tsplt-91a, dtv-olcpt-95, dtv-olcpt-95t, dv-aptg-96, f-slrpg-48, glm-othsr-96, h-gt-72, ht-ept-74, k-eops-88, ll-abgtc-87, lpt-rpqid-97, lpt-rpqid-99, mn-cgs-96, mnssssu-cgpvg-96, mnssssu-cgpvg-97, swm-ccr-95, y-tegc-97. *Abstract:* This paper considers the problem of verifying the correctness of geometric structures. In particular, we design simple optimal checkers for convex polytopes in two and higher dimensions, and for various types of planar subdivisions, such as triangulations, Delaunay triangulations, and convex subdivisions. Their performance is analyzed also in terms of the algorithmic degree, which characterizes the arithmetic precision required.

4038 Olivier Devillers, Stefan Meiser, and Monique Teillaud. Fully dynamic Delaunay triangulation in logarithmic expected time per operation. Technical Report 1349, INRIA, 1991. [dmt-fddtl-91t] *Succeeds:* dmt-fddtl-92. *Precedes:* dmt-fddtl-91.

4039 Olivier Devillers, Stefan Meiser, and Monique Teillaud. Fully dynamic Delaunay triangulation in logarithmic expected time per operation. In *Proc. 2nd Workshop Algorithms Data Struct.*, volume 519 of *Lecture Notes Comput. Sci.*, pages 42–53. Springer-Verlag, 1991. [dmt-fddtl-91] *Keywords:* randomized algorithms, Delaunay triangulation, dynamizing datastructures. *Succeeds:* dmt-fddtl-91t. *Precedes:* dmt-fddtl-92.

4040 Olivier Devillers, Stefan Meiser, and Monique Teillaud. Fully dynamic Delaunay triangulation in logarithmic expected time per operation. *Comput. Geom. Theory Appl.*, 2(2):55–80, 1992. [dmt-fddtl-92] *URL:* http://www-sop.inria.fr/prisme/publis/dmt-fddtl-92.ps.gz. *Keywords:* randomized algorithms, Delaunay triangulation, dynamizing datastructures. *Succeeds:* dmt-fddtl-91. *Precedes:* dmt-fddtl-91t. *Abstract:* The Delaunay Tree is a hierarchical data structure that has been introduced in [2219] and analyzed in [2188,2221]. For a given set of sites in the plane and an order of insertion for these sites, the Delaunay Tree stores allthe successive Delaunay triangulations. As proved before, the DelaunayTree allows the insertion of a site in logarithmic expected time andlinear expected space, when the insertion sequence is randomized. In thispaper, we describe an algorithm maintaining the Delaunay Tree underinsertions and deletions of sites. This can be done in $O(\log n)$expected time for an insertion and $O(\log \log n)$ expected time for adeletion, where n is the number of sites currently present in thestrucuture. For deletions, by expected time, we mean averaging over allalready inserted sites for the choice of the deleted sites. The algorithmhas been effectively coded and experimental results are given.

4041 Olivier Devillers, Stefan Meiser, and Monique Teillaud. The space of spheres, a geometric tool to unify duality results on Voronoi diagrams. Report 1620, INRIA Sophia-Antipolis, Valbonne, France, 1992. [dmt-ssgtu-92t] *URL:* http://www.inria.fr/RRRT/RR-1620. *Precedes:* dmt-ssgtu-92i.

4042 Olivier Devillers, Stefan Meiser, and Monique Teillaud. The space of spheres, a geometric tool to unify duality results on Voronoi diagrams. In *Abstracts 8th European Workshop Comput. Geom.*, pages 45–49. Utrecht University, 1992. [dmt-ssgtu-92]

4043 Olivier Devillers, Stefan Meiser, and Monique Teillaud. The space of spheres, a geometric tool to unify duality results on Voronoi diagrams. In *Proc. 4th Canad. Conf. Comput. Geom.*, pages 263–268, 1992. [dmt-ssgtu-92i] *Keywords:* duality results, generalized Voronoi diagrams, geometric transforms, upper/lower envelopes. *Succeeds:* dmt-ssgtu-92t.

4044 Olivier Devillers and Naji Mouawad. Guarding vertices versus guarding edges in a simple polygon. In *Proc. 4th Canad. Conf. Comput. Geom.*, pages 99–102, 1992. [dm-gvvge-92] *Cites:* c-ctpg-75, ll-ccagp-86, ea-lacvp-81, gj-cigtn-79, o-agta-87, ZZZ.

4045 Olivier Devillers and Asish Mukhopadhyay. Finding an ordinary conic and an ordinary hyperplane. *Nordic J. Comput.*, 6:422–428, 1999. [dm-focoh-99] *URL:* http://www-sop.inria.fr/prisme/biblio/. *Succeeds:* dm-focm-98.

4046 Olivier Devillers and Asish Mukhopadhyay. Finding an ordinary conic and more. Research Report 3517, INRIA, 1998. [dm-focm-98] *URL:* http://www-sop.inria.fr/prisme/biblio/. *Precedes:* dm-focoh-99. *Abstract:* Given a finite set of non-collinear points in the plane there exists a line that passes through exactly two points. Such a line is called an *ordinary line*. An efficient algorithm for computing such a line was proposed by Mukhopadhyay et al. In this note we extend this result in two directions. We first show how to use this algorithm to compute an *ordinary conic*, that is, a conic passing through exactly five points, assuming that all the points do not lie onthe same conic. Our proof of existence and the consequent algorithm is simpler than previous ones. We also show how to compute an ordinary hyperplane in three and higher dimensions.

4047 Olivier Devillers, Sylvain Pion, and Monique Teillaud. Walking in a triangulation. In *Proc. 17th Annu. ACM Sympos. Comput. Geom.*, pages 106–114, 2001. [dpt-wt-01]

4048 Olivier Devillers and Franco P. Preparata. A probabilistic analysis of the power of arithmetic filters. Technical Report CS-96-27, Center for Geometric Computing, Dept. Computer Science, Brown Univ., 1996. [dp-papaf-96] *URL:* ftp://ftp.cs.brown.edu/pub/techreports/96/cs96-27.ps.Z. *Keywords:* arithmetic filter, robustness, probabilistic analysis, geometric predicate, CGC, Brown. *Precedes:* dp-papaf-98.

4049 Olivier Devillers and Franco P. Preparata. A probabilistic analysis of the power of arithmetic filters. *Discrete Comput. Geom.*, 20:523–547, 1998. [dp-papaf-98] *URL:* http://www-sop.inria.fr/prisme/publis/dp-papaf-98.ps.gz. *Succeeds:* dp-papaf-96. *Cites:* b-g-87, bkmnsu-egcl-95, bms-hcvdl-94, fv-eeacg-93, lpt-rpqiv-96, mn-iga-94, y-tegc-97. *Abstract:* The assumption of real-number arithmetic, which is at the basis of conventional geometric algorithms, has been seriously challenged in recent years, since digital computers do not exhibit such capability. A geometric predicate usually consists of evaluating the sign of some algebraic expression. In most cases, rounded computations yield a reliable result, but sometimes rounded arithmetic introduces errors which may invalidate the algorithms. The rounded arithmetic may produce an incorrect result only if the exact absolute value of the algebraic expression is smaller than some (small) ε, which represents the largest error that may arise in the evaluation of the expression. The threshold ε depends on the structure of the expression and on the adopted computer arithmetic, assuming that the input operands are error-free. A pair (arithmetic engine,threshold) is an *arithmetic filter*. In this paper we develop a general technique for assessing the efficacy of an arithmetic filter. The analysis consists of evaluating both the threshold and the probability of failure of the filter. To exemplify the approach, under the assumption that the input points be chosen randomly in a unit ball or unit cube with uniform density, we analyze the two important predicates "which-side" and "in-sphere". We show that the probability that the absolute values of the corresponding determinants be no larger than some positive value V, with emphasis on small V, is $\Theta(V)$ for the which-side predicate, while for the insphere predicate it is $\Theta(V^{\frac{2}{3}})$ in dimension 1,$O(V^{\frac{1}{2}})$ in dimension 2, and $O(V^{\frac{1}{2}} \ln \frac{1}{V})$ in higher dimensions. Constants are small, and are given in the paper.

4050 Olivier Devillers and Franco P. Preparata. Evaluating the cylindricity of a nominally cylindrical point set. In *Proc. 11th ACM-SIAM Sympos. Discrete Algorithms*, pages 518–527, 2000. [dp-ecncp-00]

4051 Olivier Devillers and Franco P. Preparata. Further results on arithmetic filters for geometric predicates. In *Abstracts 15th European Workshop Comput. Geom.*, pages 113–116. INRIA Sophia-Antipolis, 1999. [dp-frafg-99i] *Precedes:* dp-frafg-99a.

4052 Olivier Devillers and Franco P. Preparata. Further results on arithmetic filters for geometric predicates. *Comput. Geom. Theory Appl.*, 13:141–148, 1999. [dp-frafg-99a] *URL:* http://www-sop.inria.fr/prisme/biblio/search.html. *Succeeds:* dp-frafg-99i. *Cites:* dp-papaf-98. *Abstract:* An efficient technique to solve precision problems consists in using exact computations. For geometric predicates, using systematically expensive exact computations can be avoided by the use of filters. The predicate is first evaluated using rounding computations, and an error estimation gives a certificate of the validity of the result. In this note, we studies the statistical efficiency of filters for cosphericity predicate with an assumption of regular distribution of the points. We prove that the expected value of the polynomial corresponding to the in sphere test is greater than ϵ with probability $O(\epsilon \log \frac{1}{\epsilon})$ improving the results of a previous paper [4049].

4053 Olivier Devillers, Monique Teillaud, and Mariette Yvinec. Dynamic location in an arrangement of line segments in the plane. *Algorithms Rev.*, 2(3):89–103, 1992. [dty-dlals-92] *Keywords:* randomized algorithms, arrangement of line-segments, dynamizing data structures.

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4055 L. Devroye. *Lecture Notes on Bucket Algorithms*. Birkhäuser Verlag, Boston, MA, 1986. [d-lnba-86] *Keywords:* book.

4056 L. Devroye. On the expected size of some graphs in computational geometry. *Comput. Math. Appl.*, 15:53–64, 1988. [d-essgc-88]

4057 L. Devroye. On the oscillation of the expected number of points on a random convex hull. *Statistics and Probability Letters*, 11:281–286, 1991. [d-oenpr-91]

4058 Luc Devroye, P. Epstein, and J.-R. Sack. On generating random intervals and hyperrectangles. *J. Computat. Graph. Statistics*, 2(3):291–307, 1993. [des-grih-93]

4059 L. Devroye and L. Laforest. An analysis of random d-dimensional quadtrees. *SIAM J. Comput.*, 19:821–832, 1990. [dl-arddq-90]

4060 Luc Devroye, Ernst Peter Mücke, and Binhai Zhu. A note on point location in Delaunay triangulations of random points. *Algorithmica*, 22:477–482, 1998. [dmz-npldt-98] *Comments:* replaces the old, wrong entry dmz-npldt-95.

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4062 L. Devroye and B. Zhu. Intersections of random line segments. *Internat. J. Comput. Geom. Appl.*, 4:261–274, 1994. [dz-irls-94] *Keywords:* probabilistic analysis, computational geometry, intersections of line segments, asymptotic analysis, algorithmic complexity, incidence graph.

L. Devroye. See also [1135–1137, 2302–2305, 12979].

4063 L. P. Devroye. A note on finding convex hulls via maximal vectors. *Inform. Process. Lett.*, 11:53–56, 1980. [d-nfchm-80]

4064 L. P. Devroye. A note on the expected time required to construct the outer layer. *Inform. Process. Lett.*, 20:255–257, 1985. [d-netrc-85]

4065 L. P. Devroye. Expected time analysis of algorithms in computational geometry. In G. T. Toussaint, editor, *Computational Geometry*, pages 135–151. North-Holland, Amsterdam, Netherlands, 1985. [d-etaac-85]

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4067 L. P. Devroye. Moment inequalities for random variables in computational geometry. *Computing*, 30:111–119, 1983. [d-mirvc-83]

4068 L. P. Devroye. On the average complexity of some bucketing algorithms. *Comput. Math. Appl.*, 7:407–412, 1981. [d-acsba-81]

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In this paper we present an algorithm that computes the Voronoi graph of a 2-D polygon (with holes) by generating the Voronoi diagram of a finite set of points on the polygon's boundary. Unlike algorithms for computing the Voronoi diagram of a polygon, our algorithm avoids manipulation of non-linear entities and is simple to implement. The operations used by the algorithm are line intersections and comparisons of distances between points and lines.

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We present two algorithms for constructing compatible star decompositions of two simple polygons. The first algorithm is optimal in the number of pieces in the decomposition, providing that such a decomposition exists without adding Steiner vertices. The second algorithm constructs compatible star decompositions with Steiner vertices, which are not minimal in the number of pieces but are worst case optimal in this number and in the number of added Steiner vertices. We prove that some pairs of polygons require $O(n^2)$ pieces, and that the decompositions computed by the second algorithm possess no more than $O(n^2)$ pieces.

In addition to the contributions regarding compatible star decompositions, the paper also corrects an error in the only previously published polynomial algorithm for constructing a minimal star decomposition of a simple polygon, an error which might lead to a non-minimal decomposition.

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We present algorithms for creating equivalent star-skeletons for the two polygons and for blending two star-skeletons by interpolating their skeletons and unfolding intermediate polygons from the skeletons. We also demonstrate the usage of the star-skeleton for blending multiple polygons and images. We show examples from a working system that demonstrate the improved blend sequences generated by the method.

The intrinsic reasons for the good results obtained are the fact that the interiors of the polygons are considered, not only the boundaries, and that the star-skeleton explicitly models an interdependence between all the vertices of the polygons.

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We present a variety of combinatorial and algorithmic results on this problem. In particular, we show that any finite set of at least 5 points allows a "pseudoconvex" tour, where all angles are nonnegative.

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8454 T. Lambert. *Empty-Shape Triangulation Algorithms.* Ph.D. thesis, Dept. Comput. Sci., Univ. of Manitoba, Winnipeg, MB, August 1994. [l-esta-94] *URL:* ftp://ftp.cse.unsw.edu.au/pub/users/lambert/thesis.ps.Z. *Keywords:* doctoral thesis. *Abstract:* The Delaunay triangulation of a set of sites (points in the plane) can be defined as the triangulation with the property that the circumcircle of each triangle is empty (contains no site). I generalize this to define *empty-shape triangulations*. An empty-shape triangulation is defined by a set of shapes with the property that any triangle has a unique circumscribing shape. The Delaunay triangulation is the empty-shape triangulation where the shapes consist of the set of all circles.

In this thesis I develop a taxonomy for triangulation algorithms, describe and implement a plane sweep algorithm for empty-shape triangulations, describe algorithms for constrained empty-shape triangulations and an algorithm for higher-dimensional empty-shape triangulations. I implement an algorithm for computing convex-distance-function Delaunay triangulations by extending them to empty-shape triangulations and then extracting the appropriate subtriangulation.

Two properties of the Delaunay triangulation are necessary for the correctness of the known efficient algorithms. I prove that the only triangulations with these properties are empty-shape triangulations.

I analyze, implement and measure the performance of Delaunay triangulation algorithms on random convex polygons.

There is no generally accepted definition of what a random convex polygon is. I give several operational definitions, design efficient algorithms and implement some of them.

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the algorithms and their complexity analysis are presented which yield both a surface representation of objects and a volume representation of free space. This goal is achieved by means of a simple visibility criterion. The method is intrinsically discontinuity- preserving and is useful for the integration of multiple viewpoints. 32 Refs.

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1. minimum rectilinear link paths, or shortest paths in the L_1 metric from any point in P to all vertices of P,
2. minimum rectilinear link paths from any segment inside P to all vertices of P,
3. the rectilinear window (histogram) partition of P,
4. both covering radii and vertex intervals for any diagonal of P,
5. a data structure to support rectilinear link distance queries between any two points in P (queries can be answered optimally in $O(\log n)$ time by a uniprocessor).

Our solution to 5 is based on a new linear-time sequential algorithm for this problem which is also provided here. (Independently, Schuierer [11807] obtained a linear-time sequential algorithm.) This improves on the previously best known sequential algorithm for this problem which used $O(n \log n)$ time and space. We develop techniques for solving link distance problems in parallel which are expected to find applications in the design of other parallel computational geometry algorithms. We employ these parallel techniques for example to optimally compute (on a CREW PRAM) the link diameter, the link center and the central diagonal of a rectilinear polygon.

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$$2\sqrt{3}\frac{|a \times b|}{a^2 + b^2 + c^2}$$

. Circumcircle algorithm for CDT. Keep track of non-Delaunay edges. Initially the boundary, edges of non-Delaunay triangles are added to this list, which is all that must be checked for intersections. *Abstract:* This paper investigates the possibility of integrating the two currently most popular mesh generation techniques, namely the method of advancing front and the Delaunay triangulation algorithm. The merits of the resulting scheme are its simplicity, efficiency and versatility. With the introduction of 'non-Delaunay' line segments, the concept of using Delaunay triangulation as a means of mesh generation is clarified. An efficient algorithm is proposed for the construction of Delaunay triangulations over non-convex planar domains. Interior nodes are first generated within the planar domain. These interior nodes and the boundary nodes are then linked up together to produce a valid triangulation. Through the study of numerous examples of various characteristics, it is found that high-quality triangular element meshes are obtained by the proposed algorithm, and the mesh generation time bears a linear relationship with the number of elements/nodes of the triangulation. (Edited author abstract) 37 Refs.

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From the V-Clip Collision Detection WWW page:

V-Clip is a low-level collision detection algorithm. The basic operation provided to the application is that of performing a collision check between two objects. The decisions of when to perform the checks between which object pairs are left to the application. In particular, the V-Clip library does not include facilities for higher level collision check culling, using bounding boxes or spheres, for example. If this is required, consider writing one yourself, or consider using a complete collision detection package such as I-Collide or V-Collide.

V-Clip is designed for objects that are bounded by closed surfaces, and not utterly nonconvex. If you need to detect collisions within polygon soup or between intricately intertwined objects, there are better alternatives: consider using Rapid.

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10335 J. O'Rourke. Computational geometry column 22. *Internat. J. Comput. Geom. Appl.*, 4:119–122, 1994. Also in SIGACT News 25:1 (1994), 31–33. [o-cgc22-94] *Annote:* n^2-hard problems.

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10337 J. O'Rourke. Computational geometry column 24. *Internat. J. Comput. Geom. Appl.*, 4:363–366, 1994. Also in SIGACT News 25:4 (1994), 12–14. [o-cgc24-94] *Annote:* Open problems from 10th SoCG and 6th CCCG.

10338 J. O'Rourke. Computational geometry column 25. *Internat. J. Comput. Geom. Appl.*, 5:215–218, 1995. Also in SIGACT News 26:1 (1995), 14–16. [o-cgc25-95] *Annote:* Lower envelope of surfaces: new complexity bounds.

10339 J. O'Rourke. Computational geometry column 26. *Internat. J. Comput. Geom. Appl.*, 5:339–341, 1995. Also in SIGACT News 26:2 (1995), 15–17. [o-cgc26-95] *Annote:* An advance on Conway's Thrackle conjecture.

10340 J. O'Rourke. Computational geometry column 27. *Internat. J. Comput. Geom. Appl.*, 6:123–125, 1996. Also in SIGACT News 26:4 (1995), 19–21. [o-cgc27-96] *Annote:* Perfect matching between edges of triangulations.

10341 J. O'Rourke. Computational geometry column 28. *Internat. J. Comput. Geom. Appl.*, 6:243–244, 1996. Also in SIGACT News 27:2 (1996) 18–19. [o-cgc28-96] *Annote:* Web directory of Computational Geometry Software.

10342 J. O'Rourke. Computational geometry column 29. *Internat. J. Comput. Geom. Appl.*, 6:507–511, 1996. Also in SIGACT News, 27(3):55–59 (1996), Issue 100. [o-cgc29-96] *Annote:* Past accomplishments of Computational Geometry are reviewed and future directions adumbrated.

10343 J. O'Rourke. Computational geometry column 30. *Internat. J. Comput. Geom. Appl.*, 7:165–166, 1997. Also in SIGACT News, 28(1):7–8 (1997), Issue 102. [o-cgc30-97] *Annote:* Several results from *Combinatorial Geometry* (J. Pach and P.K. Agarwal) are detailed.

10344 J. O'Rourke. Computational geometry column 31. *Internat. J. Comput. Geom. Appl.*, 7:379–382, 1997. Also in SIGACT News, 28(2):20–23 (1997), Issue 103. [o-cgc31-97] *Keywords:* packing, spheres. *Annote:* Sphere packing work of Neil Sloane et al.

10345 J. O'Rourke. Computational geometry column 32. *Internat. J. Comput. Geom. Appl.*, 7:509–513, 1997. Also in SIGACT News, 28(3):12–17 (1997), Issue 104. [o-cgc32-97] *Keywords:* k-sets, arrangements. *Annote:* Dey's new k-set bound is illustrated.

10346 J. O'Rourke. Computational geometry column 33. *Internat. J. Comput. Geom. Appl.*, 8:381–384, 1999. Also in SIGACT News, 29(2):12-16 (1998), Issue 107. [o-cgc33-98] *Annote:* Two results in "computational origami" are illustrated.

10347 J. O'Rourke. Computational geometry column 34. *Internat. J. Comput. Geom. Appl.*, ??:??–??, 1999. Also in SIGACT News, 29(3):27–32 (1998), Issue 108. [ao-cgc34-98] *Annote:* Problems presented at the open-problem session of the 14th Annual ACM Symposium on Computational Geometry are listed.

10348 J. O'Rourke. Computational geometry column 35. *Internat. J. Comput. Geom. Appl.*, ??:??–??, 1999. Also in SIGACT News, 30(2):31-32 (1999), Issue 111. [o-cgc35-99] *Keywords:* shortest paths. *Annote:* The subquadratic algorithm of Kapoor for finding shortest paths on a polyhedron is described.

10349 J. O'Rourke. Computational geometry column 36. *Internat. J. Comput. Geom. Appl.*, 9(6):615–618, 1999. Also in SIGACT News, 30(3):35–38 (1999), Issue 112. [o-cgc36-99] *Annote:* Two results in "computational origami" are illustrated.

10350 J. O'Rourke. Computational geometry column 38. *Internat. J. Comput. Geom. Appl.*, 10(2):221–223, 2000. Also in SIGACT News, 31(1):28–30 (2000), Issue 114. [o-cgc38-00] *Annote:* Recent results on curve reconstruction are described.

10351 J. O'Rourke. Computational geometry column 39. *Internat. J. Comput. Geom. Appl.*, 10(4):441–444, 2000. Also in SIGACT News, 31(3):47–49 (2000), Issue 116. [o-cgc39-00] *Annote:* The resolution of a decades-old open problem is described: polygonal chains cannot lock in the plane.

10352 J. O'Rourke. Computational geometry column 40. *Internat. J. Comput. Geom. Appl.*, 10(6):649–651, 2000. Also in SIGACT News, 31(4):62–64 (2000), Issue 117. [o-cgc40-00] *Annote:* It has recently been established by Below, De Loera, and Richter-Gebert that finding a minimum size (or even just a small) triangulation of a convex polyhedron is NP-complete. Their 3SAT-reduction proof is discussed.

10353 J. O'Rourke. Computational geometry column 41. *Internat. J. Comput. Geom. Appl.*, ??(??):??–??, 2001. Also in SIGACT News, 32(1):53-55 (2001), Issue 118. [o-cgc41-01] *Annote:* The recent result that n congruent balls in R^d have at most 4 distinct geometric permutations is described.

10354 J. O'Rourke. *Computational Geometry in C.* Cambridge University Press, 1st edition, 1994. [o-cgc-94] *Comments:* ISBN 0-521-44592-2/Pb $24.95, ISBN 0-521-44034-3/Hc $49.95. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211, 1-800-872-7423. 346+xi pages, 228 exercises, 200 figures, 219 references. C code and errata available by anonymous ftp from grendel.csc.smith.edu (131.229.222.23), in the directory /pub/compgeom. Third Printing: Dec. 1995. Chapter titles: 1. Polygon triangulation 2. Polygon partitioning 3. Convex hulls in two dimensions 4. Convex hulls in three dimensions 5. Voronoi diagrams 6. Arrangements 7. Search and intersection 8. Motion planning 9. Additional topics. *Annote:* Textbook.

10355 J. O'Rourke. *Computational Geometry in C.* Cambridge University Press, 2nd edition, 1998. [o-cgc-98] *URL:* http://cs.smith.edu/~orourke/books/compgeom.html. *Comments:* Printed 28 Sep 1998. *Annote:* Textbook.

10356 J. O'Rourke. Computing the relative neighborhood graph in the L_1 and L_∞ metrics. *Pattern Recogn.*, 15:189–192, 1982. [o-crngl-82] *Keywords:* geometric graphs.

10357 J. O'Rourke. Convex hulls, Voronoi diagrams, and terrain navigation. In *Proc. 9th Pecora Sympos. Spatial Inform. Tech.*, pages 358–361, 1984. [o-chvdt-84] *Keywords:* shortest paths.

10358 J. O'Rourke. Counterexamples to a minimal circumscription algorithm. *Comput. Vision Graph. Image Process.*, 30:364–366, June 1985. [o-cmca-85] *Keywords:* triangles, area, approximation.

10359 J. O'Rourke. Dynamically quantized spaces applied to motion analysis. Technical Report JHU-EE 81-1, Johns Hopkins Univ., Baltimore, MD, January 1981. [o-dqsam-81] *Keywords:* k-d trees, computer vision.

10360 J. O'Rourke. Dynamically quantized spaces for focusing the Hough transform. In *Proc. 7th Internat. Joint Conf. Artif. Intell.*, pages 737–739, 1981. [o-dqsfh-81] *Keywords:* cluster analysis.

10361 J. O'Rourke. Feature Review: The complexity of arrangements. *ACM Comput. Rev.*, 31(12):654–657, December 1990. [o-frca-90] *Keywords:* arrangements, combinatorial complexity, zones.

10362 J. O'Rourke. Finding a shortest ladder path: a special case. IMA Preprint Series 353, Inst. Math. Appl., Univ. Minnesota, Minneapolis, MN, 1987. [o-fslps-87] *Keywords:* motion planning, ladder.

10363 J. O'Rourke. Finding minimal enclosing boxes. Technical Report, Johns Hopkins Univ., Baltimore, MD, 1984. [o-fmeb-84]

10364 J. O'Rourke. Finding minimal enclosing boxes. *Internat. J. Comput. Inform. Sci.*, 14:183–199, June 1985. [o-fmeb-85] *Keywords:* approximation, volume.

10365 Joseph O'Rourke. Finding minimal enclosing boxes. *Internat. J. Comput. Info. Sci.*, 14(3):183–199, February 1986. [o-fmeb-86]

10366 J. O'Rourke. Folding and unfolding in computational geometry. In *Proc. Japan Conf. Discrete Comput. Geom. '98*, pages 142–147, December 1998. Revised version to appear in LNCS. [o-fucg-98]

10367 Joseph O'Rourke. Folding and unfolding in computational geometry. In *Discrete Comput. Geom.*, volume 1763 of *Lecture Notes Comput. Sci.*, pages 258–266. Springer-Verlag, 2000. Papers from the Japan Conf. Discrete Comput. Geom., Tokyo, Dec. 1998. [o-fucg-00] *Succeeds:* o-fucg-98.

10368 J. O'Rourke. Galleries need fewer mobile guards: a variation on Chvátal's theorem. *Geom. Dedicata*, 14:273–283, 1983. [o-gnfmg-83] *Keywords:* covering, star-shaped.

10369 J. O'Rourke. Guarding corpulent stars. In *Snapshots of Computational and Discrete Geometry*, volume 3, pages 63–71. School Comput. Sci., McGill Univ., Montreal, PQ, July 1994. Technical Report SOCS-94.50. [o-gcs-94] *Keywords:* visibility, art gallery theorems. *Comments:* Also Technical Report 032, Dept. Comput. Sci., Smith College. *Annote:* I've been informed of an error by H. Meijer, but haven't worked on it.

10370 J. O'Rourke. Minimum convex cover for polygons: some counterexamples. Report JHU-EE 82-1, Dept. Elect. Engrg. Comput. Sci., Johns Hopkins Univ., Baltimore, MD, 1982. [o-mccps-82]

10371 J. O'Rourke. Motion detection using Hough techniques. In *Proc. IEEE Internat. Conf. Pattern Recogn. Image Process.*, pages 82–87, 1981. [o-mduht-81] *Keywords:* computer vision, cluster analysis.

10372 J. O'Rourke. On the development of the intersection of a plane with a polytope. Technical Report 068, Dept. Comput. Sci., Smith College, Northampton, MA, June 2000. LANL arXiv cs.CG/0006035 v3, http://cs.smith.edu/~orourke/papers.html. [o-dipp-00] *URL:* http://cs.smith.edu/~orourke/papers.html. *Keywords:* polygonal chains, polytopes, polyhedra. *Cites:* c-cses-89, s-usedkkk-21.

10373 J. O'Rourke. On the scaling heuristic for reconstruction from slices. Technical Report 029, Dept. Comput. Sci., Smith College, Northampton, MA, June 1993. [o-shrs-93] *Keywords:* triangulations, polyhedra, surface reconstruction.

10374 J. O'Rourke. On the scaling heuristic for reconstruction from slices. *CVGIP: Graph. Models Image Process.*, 56:420–423, September 1994. [o-shrs-94] *Keywords:* triangulations, polyhedra, surface reconstruction. *Succeeds:* o-shrs-93.

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10380 J. O'Rourke. Recovery of convexity from visibility graphs. Technical Report 90.4.6, Dept. Comput. Sci., Smith College, Northampton, MA, April 1990. [o-rcvg-90] *Keywords:* visibility graphs, convexity.

10381 J. O'Rourke. The complexity of computing minimum convex covers for polygons. In *Proc. 20th Allerton Conf. Commun. Control Comput.*, pages 75–84, 1982. [o-ccmcc-82] *Keywords:* decomposition, covering.

10382 J. O'Rourke. The decidability of covering by convex polygons. Report JHU-EECS 82-4, Dept. Elect. Engrg. Comput. Sci., Johns Hopkins Univ., Baltimore, MD, 1982. [o-dccp-82]

10383 J. O'Rourke. The first ten computational geometry columns. Technical Report 4, Dept. Comput. Sci., Smith College, Northampton, MA, 1990. [o-ftcgc-90] *Annote:* Unedited copies of the first ten columns.

10384 J. O'Rourke. The signature of a plane curve. *SIAM J. Comput.*, 15:34–51, 1986. [o-spc-86] *Keywords:* length, pattern recognition.

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10386 J. O'Rourke. Uniqueness of orthogonal connected-the-dots. Technical report, Johns Hokins Univ., Baltimore, MD, 1986. [o-uocd-86]

10387 Joseph O'Rourke. Vertex π-lights for monotone mountains. In *Proc. 9th Canad. Conf. Comput. Geom.*, pages 1–5, 1997. [o-vplmm-97] *Keywords:* art gallery theorems, floodlights, monotone polygons.

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10396 J. O'Rourke and the Smith Problem Solving Group. PushPush is NP-hard in 3D. Technical Report 064, Smith College, Northampton, MA, November 1999. LANL XXX archive cs.CG/9911013. [os-ppnph3d-99] *Cites:* do-mpams-92.

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10412 J. O'Rourke and I. Streinu. The vertex-edge visibility graph of a polygon. Technical Report 047, Dept. Comput. Sci., Smith College, Northampton, MA, June 1996. Revised Feb. 1997. [os-vevgp-96]

10413 J. O'Rourke and I. Streinu. The vertex-edge visibility graph of a polygon. *Comput. Geom. Theory Appl.*, 8:1–17, 1997. [os-vevgp-97] *Keywords:* visibility, geometric graphs. *Succeeds:* os-pvgpp1-96. *Annote:* A new polygon visibility graph is introduced. It is demonstrated that it encodes more geometric information about the polygon than does the vertex visibility graph. For example, it determines the shortest path tree for each vertex.

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10424 J. O'Rourke and D. Xu. Illumination of polygons with 90° vertex lights. In *Snapshots of Computational and Discrete Geometry*, volume 3, pages 108–117. School Comput. Sci., McGill Univ., Montreal, PQ, July 1994. Technical Report SOCS-94.50. [ox-ip90v-94] *Keywords:* visibility, floodlights. *Annote:* Also Technical Report 034, Dept. Comput. Sci., Smith College.

J. O'Rourke. See also [138–140, 275, 276, 464, 465, 857–859, 1079, 1979–1982, 2319, 2423, 3386–3388, 3492–3494, 3948–3952, 3956–3959, 3961–3964, 3983, 4115, 4168–4174, 4380, 4731–4734, 5038, 5039, 5083, 5084, 5098, 5965, 5966, 6101, 7606, 7615, 7718, 7936–7944, 8290, 9009, 9371, 9372, 9522, 9733, 11701–11703, 12669–12672, 12742].

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S. A. Orszag. See also [1606].

Lidia Ortega. See also [6284, 6285].

R. Orti. See also [4498, 4499, 11282].

V. T. S ós. See also [8298].

D. O'Shea. See also [3572].

S. Osher. See also [13876].

G. A. Ososkov. See also [3135].

H. G. Osthof. See also [1562, 1563].

R. Ostrovsky. See also [2277, 2278, 8427].

others. See also [2719, 3009, 3010, 4403, 6807, 7128, 8532, 8979, 10004, 10014, 10843, 12426, 12429, 12746, 12779, 13096, 13370].

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This improves recent algorithms of Arora, which had used $N(\log N)^{O(s^{d-1})}$ time in fixed dimension d to produce a $(1 + 1/s)$ times optimal TST (or SMT, RSMT) with success probability 1/2. To verify success, however, Arora could only use a deterministic version of his algorithm that took a factor of N^d more time. The increase in running time for our deterministic version depends only on s.

Arora's approach can also be extended to produce other $(1+\epsilon)$-approximate geometrical graphs besides TSTs, e.g. the minimum matching (MM) and subgraph versions of the MST and TST problems. Our methods (at least at the moment) don't apply to those problems, but we can produce a $1.001 \exp(8 \cdot 2^{1-1/(d-1)}\sqrt{d})$-approximate MM in $O(N \log N)$ Monte Carlo time.

Our algorithms are based on using low-weight Euclidean *spanner graphs* (and generalizations of them) in conjunction with the hierarchical structure theorems that serve as the basis of Arora's work.

A "t-spanner" is a graph on N sites such that shortest path distance between two spanner vertices approximates the Euclidean distance to within a factor of t. By making work by Arya, Das, et al. more explicit, we show that a $(1+1/s)$-spanner of N sites in d-space is computable in $(sd)^{O(d)} N \log N$ time and $(sd)^{O(d)} N$ space, has maximum valence $(sd)^{O(d)}$, and is $(sd)^{O(d)}$ times longer than the MST. We show that spanners can in principle be made orders of magnitude shorter and simpler by allowing "Steiner points."

We introduce a remarkable generalization of the notion of "t-spanner," the "t-banyan," that t-approximates interconnection costs for site subsets of *any* cardinality, not just 2. If $d \geq 1$ and $\epsilon > 0$ are fixed, we show a $(1 + \epsilon)$-banyan of N sites in d-space exists, has $O(N)$ vertices and $O(N)$ edges, is only a constant factor longer than the MST, and is computable in $O(N \log N)$ time.

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11435 Peter J. Rousseeuw and Mia Hubert. Depth in an arrangement of hyperplanes. Manuscript, Dept. of Mathematics and Computer Science, University of Antwerp, Belgium, May 1998. [rh-dah-98] *Comments:* To appear, Discrete Comput. Geom. *Abstract:* A collection of n hyperplanes in Rp forms a hyperplane arrangement. The depth of any point θ in Rp is the smallest number of hyperplanes intersected by any halfline emanating from θ. For p=2 we prove that there always exists a point θ with depth at least n/3. For higher dimensions we conjecture that the maximal depth is at least n/(p+1). For arrangements in general position, also an upper bound on the maximal depth is established. Finally, we discuss algorithms to compute points with maximal depth.

11436 Peter J. Rousseeuw and Mia Hubert. Regression depth. Manuscript, Dept. of Mathematics and Computer Science, University of Antwerp, Belgium, 1996. [rh-rd-96] *Keywords:* breakdown value, deepest fit, depth envelopes, halfspace depth, robust regression, simplicial depth. *Comments:* to appear, journal ?? *Abstract:* In this paper we introduce a notion of depth in the regression setting. It provides the 'rank' of any line (plane), rather than ranks of observations or residuals. In simple regression we can compute the depth of any line by a fast algorithm. For any bivariate data set Zn of size n there exists a line with depth at least n/3. The largest depth in Zn can be used as a measure of linearity versus convexity. In both simple and multiple regression we introduce the deepest fit, which generalizes the univariate median and is equivariant for monotone transformations of the response. Throughout, the errors may be skewed and heteroskedastic. We also consider depth-based regression quantiles. They estimate the quantiles of y given x, as do the Koenker-Bassett regression quantiles, but with the advantage of being robust to leverage points. We explore the analogies between depth in regression and in location, where Tukey's halfspace depth is a special case of our general definition. Also Liu's simplicial depth can be extended to the regression framework.

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11439 Peter J. Rousseeuw and Ida Ruts. Constructing the bivariate Tukey median. Manuscript, Dept. of Mathematics and Computer Science, University of Antwerp, Belgium, 1997. [rh-dah-97] *Keywords:* halfplane depth, robustness, Tukey depth. *Comments:* Statistica Sinica, to appear. *Abstract:* The halfplane location depth of a point θ in R2 relative to a bivariate data set $X = \{x_1, x_2, ..., x_n\}$ is the minimal number of observations in any closed halfplane that contains θ (Tukey 1975). The halfplane median or Tukey median is the θ with maximal depth k* (Donoho and Gasko 1992). If this θ is not unique, the Tukey median is defined as the center of gravity of the set of points with depth k*. In this paper we construct two algorithms for computing the Tukey median. The first one is relatively straightforward but quite slow, whereas the second (called HALFMED) is much faster. A small simulation study is performed, and some examples are given.

11440 Peter J. Rousseeuw and Anja Struyf. Computing location depth and regression depth in higher dimensions. Manuscript, Dept. of Mathematics and Computer Science, University of Antwerp, Belgium, 1998. [rs-cldrd-98] *Keywords:* coordinate-free, multivariate ranks, robustness. *Comments:* to appear, Statistics and Computing. *Abstract:* The location depth (Tukey 1975) of a point θ relative to a p-dimensional data set Z of size n is defined as the smallest number of data points in a closed halfspace with boundary through θ;. For bivariate data, it can be computed in O(n log n) time (Rousseeuw and Ruts 1996). In this paper we construct an exact algorithm to compute the location depth in three dimensions in O(n2 log n) time. We also give an approximate algorithm to compute the location depth in p dimensions in O(m p3 + m p n) time, where m is the number of p-subsets used.

Recently, Rousseeuw and Hubert (1996) defined the depth of a regression fit. The depth of a hyperplane with coefficients $(\theta_1,...,\theta_p)$ is the smallest number of residuals that need to change sign to make $(\theta_1,...,\theta_p)$ a nonfit. For bivariate data (p=2) this depth can be computed in O(n log n) time as well. We construct an algorithm to compute the regression depth of a plane relative to a three-dimensional data set in $O(n^2 \log n)$ time, and another that deals with p=4 in $O(n^3 \log n)$ time. For data sets with large n and/or p we propose an approximate algorithm that computes the depth of a regression fit in $O(mp^3 + mpn + mn \log n)$ time. For all of these algorithms, actual implementations are made available.

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H. Todd Wareham. See also [5196].

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Z. U. A. Warsi. See also [12902].

R. Washington. See also [10393, 10394, 10422].

G. W. Wasilkowski. See also [7508–7510].

13396 Glen Y. Watabayishi and J. A. Galt. An optimized triangular mesh system from random points. In J. Häuser and C. Taylor, editors, *Numerical Grid Generation in Computational Fluid Dynamics*, pages 437–448, 1986. [wg-otmsr-86] *Annote:* Algorithm is generate initial triangulation and improve with flips. Flip criterion is to maximize minimum value of area over perimeter squared. One method of generating initial triangulation is straight insertion, join to visible points. Other method is to construct greedy triangulation by a rather involved $O(n^6)$ algorithm. (Authors make two mistakes in their analysis and claim $O((n!)^2)$.) This is a bit a slow so they compute an approximation to GT by only looking at $O(n)$ short lines, giving an $O(n^2)$ algorithm.

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13405 D. F. Watson. Natural neighbour sorting. *Australian Computer Journal*, 17(4):189–193, 1985. [w-nns-85] *Annote:* Survey of algorithms for DT.

13406 D. F. Watson. *nngridr: An implementation of natural neighbor interpolation*. David Watson, 1994. [w-ninni-94] *Comments:* source code and discussion about the natural neighbor gridding package nngridr, available from Watson at maths.uwa.edu.au.

13407 D. F. Watson and C. M. Philip. Survey: Systematic triangulations. *Comput. Vision Graph. Image Process.*, 26:217–223, 1984. [wp-sst-84] *Annote:* Compares Optimal, Greedy and Delaunay triangulations. Shows that they are different and suggests Delaunay is best because of the equiangular property and efficient implementation.

13408 D. F. Watson and G. M. Philip. Neighborhood-based interpolation. *Geobyte*, 2(2):12–16, 1987. [wp-nbi-87] *Annote:* Description of natural neighbor interpolation.

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E. Waupotitsch. See also [4778].

R. Waupotitsch. See also [4773, 4774, 4779, 4780].

B. M. Waxman. See also [7371].

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We are studying the problem of intelligent agent navigation in complex environments. The goal of our research is to develop a technique (and theoretical foundations) to solve the navigation problem. We assume that our algorithms must be applicable to the agents with significantly different locomotion capabilities that live (navigate) in *really* complex 3D environments, including natural landscapes with caves, stalactites/stalagmites, etc. Our characters (agents) are spiders, birds, hoppers, etc., so they have totally different 'walk algorithms'. Since we have to handle all these creature types motivated us to develop such 'universal' techniques that: - enables the agent to explore the environment off-line (it takes 5 to 30 minutes) and create a representative map; - navigate in the environment in real-time using the map.

The technology is not heuristic - it can be proved that the paths found in real-time do not differ much from the real optimal paths. Currently, our technology is practically implemented in a commercial 3D title scheduled this year.

We base our technology on accessibility graphs, not on road maps/visibility graphs since these methods prove to be inefficient in our context.

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