Fade2D

v1.89

Generated by Doxygen 1.8.17

1 Main Page

1.1 C++ Constrained Delaunay Triangulation Fade2D

- Fast C++ Delaunay triangulation library , `see the benchmark`.
- C++ examples for `2D Delaunay triangulations` and `2.5D triangulations`.
- Free Student license. Commercial licenses and support are available.
- Support for Windows (Visual Studio), MacOS (Clang), Linux (GCC) on PC and Raspberry PI

1.1.1 Using the C++ Constrained Delaunay triangulation library:

Download. Unzip. Start to play with the included C++ example source codes: `The first example is described here`.

Fade comes as two separate libraries:

- Fade2D is a 2D Constrained Delaunay triangulation library with
  - Polygon support
  - Constraint edges
  - Grid Mesher and Delaunay Mesh Generator
  - Segment Intersection Test Software
- - **Fade2.5D is a C++ Constrained Delaunay triangulation library for 2.5D** and it can do **anything that the Fade2D library can do.**. But it has an additional z-coordinate and a rich selection of additional algorithms made for Digital Elevation Models (DEM) and surfaces like
  - Cut-and-Fill
  - Cookie Cutter
  - Valley-/Ridge-triangulations
  - Mesh smoothing
  - Point cloud simplification.

A collection of 2D and 2.5D example source codes (∗.cpp files) is contained in the download. The C++ examples go step by step over the concepts of the library. New Fade2.5D users are advised to check also the 2D examples because the basics are described there and these apply also to 2.5D.

1.1.2 Compiling and Linking the Library under Windows:

1. Open one of the Visual Studio example projects (currently supported: VS2010, VS2012, VS2013, VS2015, VS2017, VS2019)
2. Compile the example source code. The executable is written to the Win32 or x64 folder.

When you link the triangulation library with your own software you can use the settings from the example solutions or use the table below:

Visual Studio	IDE	Platform Toolset
VS2010	v10	toolset v100 or Windows7.1SDK
VS2012	v11	toolset v110
VS2013	v12	toolset v120
VS2015	v14	toolset v140
VS2017	v15	toolset v141
VS2019	v16	toolset v142

1.1.3 Compiling and Linking the Library under Linux and Mac:

1. Edit the Makefile (choose Apple, your Linux distro or Raspberry PI) and type make to compile the example source code.

2. Make sure GMP is installed:
   $ sudo apt-get install libgmp10 (works on Ubuntu/Debian/Mint/Raspbian, on other systems search for libgmp or gmp)

Work through the provided examples. They are small, well documented and they visualize the results.

1.1.4 Directory Contents

- **include_fade2d** and **include_fade25d**
  Header files of the two libraries.
- **Win32** and **x64**
  This directory contains the DLL's for Windows 32-bit and 64-bit and it is the target directory for the executables of example code compiled with Visual Studio.
- **lib_${DISTRO}_${ARCHITECTURE}**
  The shared library (∗.so) for Linux/Apple developers.
- **examples_2D**
  2D Example source code (∗.cpp files) and Visual Studio projects
- **examples_25D**
  2.5D Example source code (∗.cpp files) and Visual Studio projects
- **doc**
  Library Documentation in ∗.pdf format

1.1.5 Troubleshooting

- Check if the examples work on your computer. Then compare their settings with your project settings.
- When updating from an earlier version: UPDATE ALSO THE HEADER FILES.
- Mixing multiple Visual Studio versions won't work. Use the right dll.
- In rare cases you might need to increase Properties->ConfigurationProperties->Linker->System->Stack↩ ReserveSize in your Visual Studio project settings.
- If your problem persists, don't hesitate to `send` a minimal example that reproduces it and it will be fixed asap.

1.1.6 Release notes / History

Version 1.89, June 8th, 2021:

- Voronoi diagram: Numeric problems fixed. Visualizer: Scaling problem fixed. Circumcenter-computation improved.
  Version 1.88, June 4th, 2021:
- Voronoi diagram. Accuracy of Triangle::getDual() improved with multiple-precision arithmetic. Version 1.87, May 5th., 2021:
- Additional versions of the load() and save() commands to also accept std::ostream and std::istream.

- There is a new version of the peelOffIf() function that removes unwanted border-triangles. It can prevent a zone from breaking apart by deleting triangles. It takes the new predicate "PeelPredicateTS", which allows more precise decisions. The version of peelOffIf() that takes the old "UserPredicateT" remains valid for backwards compatibility.
- When Fade_2D::createConstraint() inserts a constraint segment that intersects an existing one or an existing point, then it needs to be subdivided. By default, the intersection point is then assigned the height of the existing element. But now this function has an additional parameter 'bool bUseHeightOfLatest=false' which can be used to enforce the height of the last inserted segment.

Version 1.86, April 28th., 2021:

- New commands Fade_2D::saveTriangulation(), Fade_2D::saveZones(), Zone2::save() and Fade_2D::load() to save and load triangulation data. The new example ex11_save_and_load.cpp demonstrates it.
- New dry-mode parameter for CloudPrepare::uniformSimplifyGrid() and for CloudPrepare::adaptiveSimplify() so that the size of the point cloud that would result from the reduction can be determined.

Version 1.85, March 8th., 2021:

- Bugfixes: A multithreading-bug has been solved and strings are now correctly passed to the Visualizer2 class.
- New method Fade_2D::setFastMode(true) to avoid expensive computations. This accelerates triangulation of raster data i.e., points on a regular grid.

v1.84, Jan. 7th., 2021:

- **IMPORTANT IF YOU UPGRADE FROM A PREVIOUS VERSION:** To avoid passing std::strings over the DLL boundary, some function parameters have been changed from std::string to const char∗. You will often not even notice this, but if your code should not compile anymore, then this is the reason. Instead of passing "yourString" please pass it as "yourString.c_str()". This change was unavoidable. Thank you for your understanding!
- New **CloudPrepare** class to simplify point clouds and also to avoid memory-usage-peaks. Have a look at the examples!
- New function **Fade_2D::exportTriangulation()** allows conventient transfer of triangulation data to your own data structures. The function was created with memory consumption in mind, i.e. while the data is exported, it frees memory from the library gradually.
- New function Zone2::smoothing() applies weighted **Laplacian smoothing** to the vertices of a zone.
- New **Valley/Ridge optimization**: With Zone2::slopeValleyRidgeOptimization() one can choose between 3 algorithms now to adapt the triangulation better to valleys and ridges. Have a look at the new examples.
- **Example codes** completely rewritten.
- Small bug fixes.

v1.83, Dec. 30th, 2020:

- Internal test release. Significant changes, thus it has not been released.

v1.82, Nov. 15th, 2020:

- Intermediate release to support CentOS/RedHat7.8. Minor improvements here and there.

v1.81, May 17th, 2020:

- Memory Leak in EfficientModel fixed. EfficientModel improved: Pruning the point cloud is much faster now and the new method zSmoothing() has been implemented. It provides minimum-, maximum-, median- and average-smoothing.

v1.80, March 25th, 2020:

- Bug in Cut&Fill solved: A foot point was computed in 3D while it should have been computed in 2D. The difference was in most cases insignificant and thus the problem did not become apparent earlier. Sorry. Fixed.
- Improvement in Cut&Fill: The algorithm checks now if the two input zones do overlap. If not, the CutAndFill::go() method returns false and the CutAndFill object shall not further be used.
- Example source codes adapted and -std=c++98 removed from their Makefiles
- Documentation improved

v1.79, January 20th, 2020: Internal version. Revision.
v1.78, November 15th, 2019:

- Bugfix: Multithreading did not work in Windows due to a CMake configuration error.
- A typo in the function name Fade_2D::measureTriangulationTime() has been corrected.

v1.77, October 21st, 2019

- Support for Visual Studio 2019.
- A bug has been fixed: In a rare case a self-intersecting constraint graph could generate an error.
- Improvements: The constraint-insertion-strategies CIS_CONFORMING_DELAUNAY and CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL are deprecated now.
- The fast and reliable replacement is CIS_CONSTRAINED_DELAUNAY along with the new methods ConstraintGraph::makeDelaunay() and Fade_2D::drape(). See the new example code in examples_25D/terrain.cpp.

v1.75 and 1.76

- Non-public tests.

v1.74, March 19th, 2019:

- Cleanup: The (until now experimental) surface reconstruction module has been moved into the separate WOF Point Cloud Meshing library (https://www.geom.at/products/wof-point-cloud-mesher/). This makes the binaries smaller and it improves the maintainability of the code.
- Cleanup: Support for VS2008 has been dropped (if you are a commercial user and still need VS2008 then contact the author please!).
- The build system has been migrated to CMake to reduce the manual work and to guarantee uniform flags for all builds.
- The HoleFiller class that has been developed for the removed surface reconstruction module is retained in the library because it has already users. Its code has been revised in order to provide repeatable results for identical inputs.
- According to a user request the MeshGenParams class (used for advanced Delaunay Meshing) offers now a method to lock certain constraint segments such that they are not splitted while all others can be splitted if required.

v1.73, January 14th, 2019:

- While all below mentioned releases after v1.63 were development versions the present v1.73 is again an official release
for all.
- The work of the below betas is included
- as well as a bugfix in the getProfile() method of the IsoContours class (this method was new and experimental in v1.63)

v1.71 and 1.72, October 24th, 2018:

- (internal) Hole-Filling (Polygon-Triangulation) improved.

v1.70, October 17th, 2018:

- (internal) Hole-Filling (Polygon-Triangulation) improved.

v1.69, October 15th, 2018:

- (internal) Hole-Filling (Polygon-Triangulation) improved.

v1.68, September 14th, 2018:

- (internal) Hole-Filling (Polygon-Triangulation) improved.

v1.67, September 4th, 2018:

- (internal) Hole-Filling (Polygon-Triangulation) is now offered via. an API call. Intermediate beta release.

v1.66, August 25th, 2018:

- (internal) Bugfix in Cut&Fill: An intersection point could be slightly off its expected range. Solved. Unofficial intermediate code.

v1.65, July 29th, 2018:

- (internal) Another bugfix in Cut&Fill. Unofficial intermediate binary.

v1.64, July 21st, 2018:

- (internal) Bugfix in the Cut&Fill module: In rare cases Cut&Fill crashed due to unexpected numeric deviation (fixed).
- The importTriangles() function has been reimplemented and is considerably faster now.
- And there is a change that affects only 32-bit users: Binary files written with the writePointsBIN() and writeSegmentsBIN() functions on 32-bit machines were not readable on 64-bit machines. The format on 32-bit machines (read/write) has been adapted to match exactly the one of 64-bit machines. But note that old 32-bit files are not readable anymore. This should affect next to nobody, thus this solution has been chosen.

v1.63, June 10th, 2018:

- Cookie-Cutter operation added. 3D Point Cloud Reconstruction added to the API (but is still under development, pls. take it as a preview).
- Raspberry PI support added again.

v1.62, June 3rd, 2018:

- 3D Point Cloud Reconstruction considerably improved. Unofficial demo.

v1.61, May 1st, 2018:

- 3D Point Cloud Reconstruction: Unofficial demo.

v1.60, February 26th, 2018:

- Accurate computation of glancing segment intersections.
- Additional parameter for Advanced Meshing: bool bKeepExistingSteinerPoints=true in MeshGenParams makes all Steiner points from previous refinement calls static, i.e. unremovable during subsequent refinement calls. This way Advanced Meshing can be carried out for several zones of a triangulation such that it does not destroy what has been meshed so far.

v1.59, January 14th, 2018:

- Performance upgrade: Multithreading is available now. Large point sets reach a speedup of 4.4 on a hexacore CPU (i7 6800K)

v1.58, October 23th, 2017:

- Mesh Generator refactored. Delaunay Meshing is +10x faster now.
- A function to create polygons from boundary edges has been added.

v1.57, October 9th, 2017:

- Nonpublic test code.

v1.56, September 24th, 2017:

- Bugfix: createConstraint() crashed in a rare case. Solved.
- Functions for binary file I/O added.

v1.55, August 12th, 2017:

- Access to internal Cut&Fill datastructures revised.
- Example source codes revised. Support for Visual Studio 2017 added.

v1.54beta, August 8th, 2017:

- Access to internal Cut&Fill datastructures. . This is a pre-released beta, code quality is good but final tests and documentation updates required.

v1.53, July 15th, 2017:

- Error corrections and performance upgrades in the still quite new Cut&Fill library module.

v1.53 beta, June 2nd, 2017:

- The new Cut&Fill library module has been added. Cut&Fill computes the volume between two surfaces.

v1.51 beta, May 27th, 2017:

- Non-public test binary

v1.50, April 5th, 2017: After three internal betas (that concetrated on refactoring and rare bugs) this is again a stable public release:

- The constraint insertion subsystem has been rewrittten and is faster now.
- Visualization improved.
- Exact orientation tests provided through the API.
- Improved progress bar support. Mesh generator improved.
- Users who upgrade from earlier Fade releases: The Zone2::getArea() and Triangle2::getArea() methods have been replaced by getArea2D() in Fade2D and by getArea2D() AND getArea25D() in Fade2.5D. The reason is that the old getArea() method was easily misunderstood in Fade2.5D (it returned the same result as getArea25D() now). We have decided to remove the old method to avoid confusion and a potential source of error. If necessary, please adapt your code.

v1.49, March 2nd, 2017:

- Constraint insertion subsystem improved.
- Mesh generator revised.

v1.48, February 15th, 2017:

- Corrections of yesterday's v1.47.

v1.47, February 14th, 2017: The focus of this (for now) non-public version is stability:

- Intersecting constraint segments must be subdivided although their exact intersection is not always representable with double precision coordinates. Thus tiny rounding errors are unavoidable and these caused trouble in very unlikely cases.
- The constraint insertion subsystem has now been re-implemented to behave robust also in such cases.

v1.46a, January 14th, 2017:

- +++ Raspberry PI is supported now +++ // Apart from RPI support v1.46a is equal to v1.46. Raspberry PI users: Please give feedback, do you have everything you need for RPI development now?

v1.46, January 8th, 2017:

- +++ MacOS is supported now +++ //
- A new class EfficientModel takes oversampled 2.5D point clouds and returns a subset that represents the model efficiently. The automatic pruning process runs in a controlled fashion such that a user specified maximum error is kept.
- The Delaunay Mesh Generator is now supported by a Grid Mesher, thus it creates more regular meshes.
- The Delaunay triangulation of specific point sets is not unique, for example when grid points are triangulated (4 points on a common circumcircle). To improve the repeatability and for reasons of visual appearance the new method Zone2::unifyGrid() has been implemented.
- A problem in the point location method Fade_2D::locate() when the query point was exactly on the convex hull of the triangulation has been solved.

v1.43, November 20th, 2016:

- Better example source code for the new SegmentChecker class.
- And the SegmentChecker of v1.42 returned false positives, this problem is solved now.

v1.42, October 19th, 2016:

- The new tool SegmentChecker takes a bunch of segments and fully automatically identifies intersecting segments. The underlying data structure makes the tool incredibly fast. Intersecting segments can be visualized. Intersections can be computed in 2D and 2.5D (with heights).
- A new module named TestDataGenerators creates random polygons, random segments, points, random numbers and polylines for automated software stress tests. Progress bar support added.

v1.41, July 24th, 2016:

- New constraint insertion strategy.
- Minor bug fixes.
- Performance slightly improved.

v1.40 beta, June 14th, 2016:

- Non public intermediate test code.
- Bounded zones introduced: Mesh generation algorithms require that zones are bounded by constraint segments. This is certainly the case for the most usual zones with zoneLocation=ZL_INSIDE. But other types of zones may be unbounded and in this case remeshing won't work well, so it was necessary to change the behavior: From now on calling refine() and refineAdvanced() is only allowed with zones whose zone↩ Location is ZL_INSIDE or ZL_BOUNDED. A bounded zone can easily be gained from any other zone using Zone2::convertToBoundedZone(). Also new: Fade_2D::createConstraintGraph(..) has now a third parameter 'bool bOrientedSegments=false'. By default it is false to provide backwards compatibility. This parameter allows you to specify that the provided segments are CCW oriented. This way more complex inside- and outside-zones can be formed.

- Performance of Fade_2D::createConstraint(..) drastically improved.

v1.39, May 31st, 2016:

- Non public intermediate beta.

v1.37a, March 15th, 2016:

- Small upgrade: The performance of the remove method has been improved.

v1.37, March 10th, 2016:

- Interface change in the MeshGenParams class. The class has been introduced two weeks before, so chances are good that the change does not affect you. Previously the class had the methods getMaxTriangle↩ Area(double x,double y) and getMaxEdgeLength(double x,double y) where x and y where the barycenter of a triangle for which the algorithm determines if it must be refined. The change is that x and y have been replaced by the triangle itself to give client code even more control (x and y can still be computed from the triangle).

v1.36, February 29th, 2016:

- Experimental method refineExtended(..) replaced by the (now permanent) method refineAdvanced(Mesh↩ GenParams∗ pParams). This method allows much more control over the mesh density.

v1.34, February 14th, 2016:

- Vertex management subsystem revised (sometimes Vertex removement did not work as expected). Performance improvement.

v1.33 PreRelease, January 17th, 2016: The previous official Fade version is Fade 1.24. It was released 6 months ago. Since then major developments have been made and now a big upgrade follows with v1.33.14:

- Constraint segments may intersect now and they are automatically subdivided at their intersection points.
- Import of existing triangles is supported and one can cut through static triangulations. This version is well tested. It also runs at two customers sites with no known problems. But due to the large amount of new code we call this one a pre-release. Please report if you find any problems and note that it is also helpful if you report that the library works well in your setting. The DLL names have been adapted to the safer and more convenient pattern

  fade[2D|25D]_$(Platform)_$(PlatformToolset)_$(Configuration).dll

  If you upgrade from an earlier release it is recommended that you remove any previous Fade DLL's to avoid unintended linking to an old binary.

v1.31 and 1.32, December 1st, 2015:

- Non public intermediate release, improves the CDT.

v1.30, November 18th, 2015:

- Non public intermediate release, improves the refineExtended method.

v1.29, October 17th, 2015:

- Non public intermediate release. The method importTriangles() detects invalid input data now and returns NULL to avoid an assertion or even an infinite loop when the input data is not clean. The possibly invalid input elements are written to stdout and a postscript file visualizes where the problem occurs.

v1.28, October 10th, 2015:

- Non public intermediate release. Customer specific code revised. Stress tests with random polygons and segments have been made. Heap checking to ensure proper memory handling.

v1.27, October 5th, 2015:

- Non public release, improvements of the recently implemented functions, especially of customer specific code Fade_2D::importTriangles() and Fade2D::cutTriangles().

v1.26, September 8th, 2015:

- New functions of the last unofficial v1.25 have been revised. Constraint segments may intersect now.

v1.25, August 18th, 2015:

- Intermediate pre-release with new features: importTriangles() imports arbitrary triangles into a triangulation, cutTriangles() allows to insert a constraint segment as if it where a knife, getOrientation() provides an exact orientation test. Zone2 objects can now also be made from a set of triangles. Constraint segments can intersect now. These features correspond to a large amount of new code: Please test v1.25 carefully before deploying it in a production environment.

v1.24, July 22nd, 2015:

- Public release of v1.23's improvements. And I'm sorry but we had a bug in Fade_2D::getVertexPointers(..). The method may have missed to return a few pointers after a call to refine() or remove(). This bug is fixed now.

v1.23, July 9th, 2015:

- Internal test release with the new refineExtended() method for the specific needs of a certain client software.

v1.22, May 25th, 2015:

- Code refactored, build system refactored and as a result improved Linux support: CentOS 6.4, Ubuntu 14.04, Ubuntu 15.04 and similar systems.
- Removement of points has been implemented
- Delaunay meshing has been reworked,
- sqDistance() has been replaced by sqDistance2D() and sqDistance25D() because both versions are useful in 2.5D.
- OpenMP has been removed, it was only used under Linux and currently I work on a better way to provide multithreading.

v1.21, May 17th, 2015:

- Unofficial intermediate release. Testing new features.

v1.20, April 5th, 2015:

- 3D scene Visualization for (up to date) web browsers added. Misleading enumeration values CIS_KEEP←_DELAUNAY and CIS_IGNORE_DELAUNAY have been replaced by CIS_CONFORMING_DELAUNAY and CIS_CONSTRAINED_DELAUNAY (the two deprecated names are kept for backward compatibility).
- Bug in the free function center(Point2&,Point2&) solved.
- Major revision of the documentation pages.
- The source codes of the examples has been reengineered and is included in the present documentation pages.

v1.19, October 26th, 2014:

- Support for Visual Studio 2013 (VC12) has been added.
- Only minor code changes.

v1.18.3, June 9th, 2014:

- Delaunay Mesh Generation has been improved: Better quality, better performance.
- API improved.
- Small bug fixes.

v1.16.1, February 10th, 2014:

- Small update: In rare cases it was possible that subdivided ConstraintSegments caused problems in combination with zone growing. This is fixed now.

v1.16, February 3rd, 2014:

- Constrained Delaunay triangulation improved,
- Delaunay meshing improved,
- aspect ratio meshing (experimental) added.
- Minor bug fixes.
- Added support for Visual Studio 2012.

v1.14, November 2013 and v1.15, December 2013:

- Non-public intermediate releases (betas with experimental features).

v1.13, August 4th, 2013:

- Mesh generation (Delaunay Meshing) has been improved and two bugfixes have been made in the new IsoContours class: A message can be suppressed now and a numeric problem has been fixed.

v1.12, June 30th, 2013:

- Starting with v1.12 the download consists of two separate libraries: The familiar full version of the 2D flavor as well as a 2.5D evaluation version. Two very fast new methods have been added to the 2.5D edition: One computes iso-contours, the other computes the height of a point with arbitrary (x,y) coordinates.
- Delaunay mesh generation has been improved.
- Support for VS2008, 32-bit and 64-bit, has been added.
- The performance has been improved.

v1.11, June 14th, 2013:

- Non-public intermediate release with VS2008 support and a first version of the iso-contour feature.

v1.10, March 30th, 2013:

- Delaunay Refinement (already included as preview in the previous release) has been improved and is officially released now. Parts of the algorithm can use up to 8 CPUs under Linux if explicitly switched on using Fade2D::enableMultithreading().
- There is a new insert method in the API which uses arrays.

v1.03, Nov. 4th, 2012:

- A critical bug has been fixed, please switch to v1.03.
- Performance upgrade: A first step towards multithreading has been made in the Linux version.
- In order to facilitate the installation for users without administrator privileges the installers have been replaced by a simple zipped directory that contains everything.
- Meshing through Delaunay Refinement is scheduled for the next release but it is pre-released as an experimental feature in the current v1.03.

v1.02, 9/2012:

- An additional debug library for Windows has been added and
- the directory structure has been reorganized.

v1.01, 9/2012:

- This is a stable public release. Since v0.9 we have introduced insertion of constraint edges and the zone concept. Moreover the API is under a namespace now. Boost types have been removed from the API to avoid this additional dependency. New demo software has been written and the library is now also available for 64-bit Windows.

2 Module Index

2.1 Modules

Here is a list of all modules:

3 Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

GEOM_FADE2D::Point2
Point 73

GEOM_FADE2D::Segment2
Segment 78

GEOM_FADE2D::SegmentChecker
SegmentChecker identifies intersecting line segments 79

GEOM_FADE2D::Triangle2
Triangle 87

GEOM_FADE2D::TriangleAroundVertexIterator
Iterator for all triangles around a given vertex 92

GEOM_FADE2D::UserPredicateT
User-defined predicate (deprecated) 95

GEOM_FADE2D::Vector2
Vector 96

GEOM_FADE2D::Visualizer2
Visualizer2 is a general Postscript writer. It draws the objects Point2, Segment2, Triangle2, Circle2 and Label 97

GEOM_FADE2D::VoroCell2
Voronoi cell 100

GEOM_FADE2D::Voronoi2
Voronoi diagram 103

GEOM_FADE2D::VoroVertex2
Voronoi vertex 106

GEOM_FADE2D::Zone2
Zone2 is a certain defined area of a triangulation 107

4 File Index

4.1 File List

Here is a list of all documented files with brief descriptions:

5 Module Documentation

5.1 Tools

Functions

- void GEOM_FADE2D::edgesToPolygons (std::vector< Edge2 > &vEdgesIn, std::vector< std::vector< Edge2 > > &vvPolygonsOut, std::vector< Edge2 > &vRemainingOut)

  Create polygons from a set of edges.
- bool GEOM_FADE2D::fillHole (std::vector< std::pair< Segment2, Vector2 > > vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< Point2 > &vCornersOut)

  Fill a hole in a 3D mesh with triangles (deprecated)
- double GEOM_FADE2D::getArea2D (Point2 *p0, Point2 *p1, Point2 *p2)

  Get 2D area of a triangle.
- void GEOM_FADE2D::getBorders (const std::vector< Triangle2 * > &vT, std::vector< Segment2 > &vBorderSegmentsOut)

  Get Borders.
- void GEOM_FADE2D::getDirectedEdges (std::vector< Triangle2 * > &vT, std::vector< Edge2 > &vDirectedEdgesOut)

  Get directed edge The directed edges of `vT` are returned `vDirectedEdgesOut`. Directed means that each edge (a,b) with two adjacent triangles in vT is returned twice, as edge(a,b) and edge(b,a).
- FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2 (const Point2 *p0, const Point2 *p1, const Point2 *p2)

  Get the orientation of three points.

- FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2_mt (const Point2 ∗p0, const Point2 ∗p1, const Point2 ∗p2)

  Get Orientation2 (MT)
- void GEOM_FADE2D::getUndirectedEdges (std::vector< Triangle2 ∗ > &vT, std::vector< Edge2 > &vUndirectedEdgesOut)

  Get undirected edges.
- bool GEOM_FADE2D::isSimplePolygon (std::vector< Segment2 > &vSegments)

  isSimplePolygon
- void GEOM_FADE2D::pointsToPolyline (std::vector< Point2 > &vInPoints, bool bClose, std::vector< Segment2 > &vOutSegments)

  Points-to-Polyline.
- bool GEOM_FADE2D::sortRing (std::vector< Segment2 > &vRing)

  Sort a vector of Segments.
- bool GEOM_FADE2D::sortRingCCW (std::vector< Segment2 > &vRing)

  Sort a vector of Segments.

5.1.1 Detailed Description

5.1.2 Function Documentation

5.1.2.1 edgesToPolygons()

```
void GEOM_FADE2D::edgesToPolygons (
        std::vector< Edge2 > & vEdgesIn,
        std::vector< std::vector< Edge2 > > & vvPolygonsOut,
        std::vector< Edge2 > & vRemainingOut )
```

A number of methods in Fade returns an unorganized set of edges that delimit a certain area. But sometimes it is more beneficial to have these edges organized as a set of one or more polygons. This is the purpose of the present method.

Parameters

`in`	*vEdgesIn*	is a vector of oriented edges
`out`	*vvPolygonsOut*	contains one vector<Edge2> for each polygon found in the input data.
`out`	*vRemainingOut*	is used to return unusable remaining edges

The present function adds one vector<Edge2> to `vvPolygonsOut` for each polygon found in `vEdgesIn`. Each such polygon starts with the leftmost vertex (and when two or more vertices share the smallest x-coordiante then the one of them with the smallest y-coordinate is chosen). Edges that do not form a closed polygon are returned in `vRemainingOut`.

Note

An Edge2 object represents an edge of a triangle. Triangle corners are always counterclockwise (CCW) oriented. Thus outer polygons are CCW-oriented while hole-polygons are CW-oriented, see the figure.

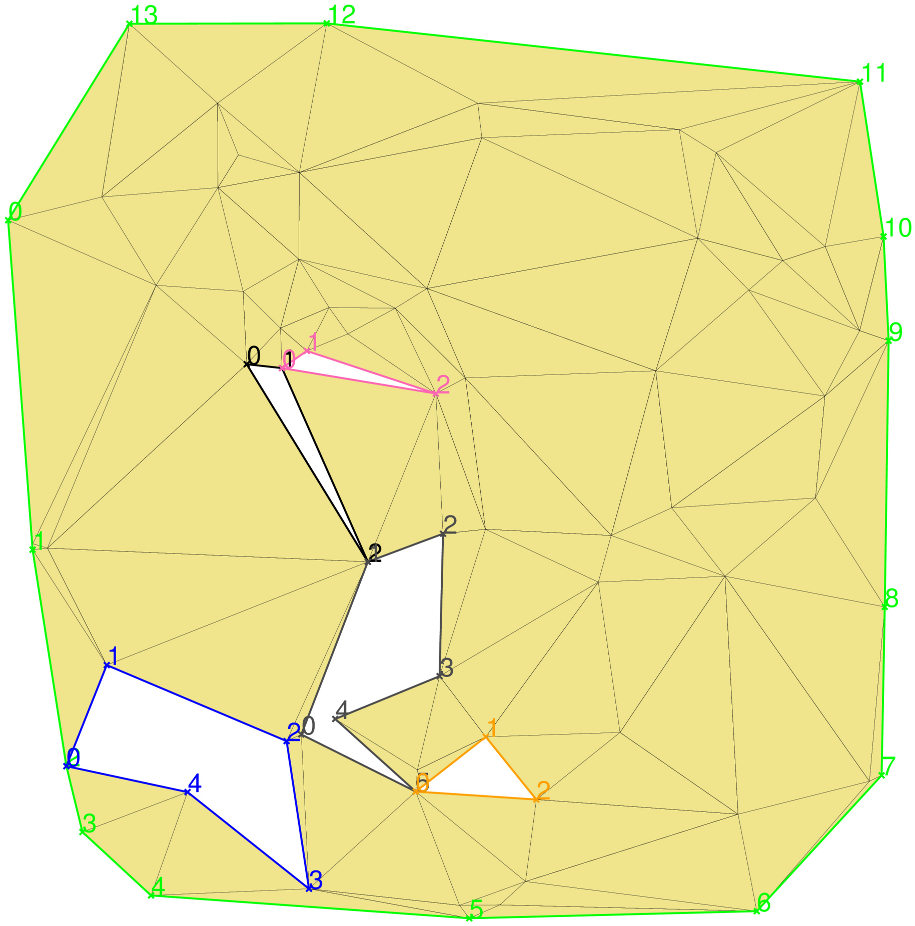


Figure 1 Polygons created by edgesToPolygons

5.1.2.2 fillHole() `bool GEOM_FADE2D::fillHole ( std::vector< std::pair< Segment2, Vector2 > > vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< Point2 > & vCornersOut )`

This function was experimental and is now deprecated because 3D point cloud meshing has been moved to the WOF library.

Parameters

`in`	*vPolygonSegments*	contains the segments of a closed, simple input polygon along with normal vectors. The segments are counterclockwise oriented and ordered with respect to the surface to be created. Check twice, the orientation is very important. The normal vectors point in the direction of the thought surface at the segment i.e., if a hole is filled, the normal vector of an adjecent triangle is taken but if a T-joint is filled the normal vector should be the average normal of the two triangles at the edge.
`in`	*bWithRefine*	specifies if additional vertices shall be created. (bWithRefine=true is experimental, don't use currently)

Parameters

`in`	*bVerbose*	specifies if warnings shall be printed to stdout
`out`	*vCornersOut*	contains the created fill triangles, 3 corners per triangle, counterclockwise oriented.

5.1.2.3 getArea2D()

```
double GEOM_FADE2D::getArea2D (
        Point2 * p0,
        Point2 * p1,
        Point2 * p2 )
```

Returns the 2D area of the triangle defined by the three input points `p0`, `p1`, `p2`.

Parameters

`in`	*p0,p1,p2*	are the corners of the triangle

5.1.2.4 getBorders()

```
void GEOM_FADE2D::getBorders (
        const std::vector< Triangle2 * > & vT,
        std::vector< Segment2 > & vBorderSegmentsOut )
```

Computes the border of the triangles in `vT`. The border consists of all edges having only one adjacent triangle in vT.

Parameters

`in`	*vT*	are the input triangles
`out`	*vBorderSegmentsOut*	is used to return all border segments

5.1.2.5 getOrientation2()

```
FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2 (
        const Point2 * p0,
        const Point2 * p1,
        const Point2 * p2 )
```

This function returns the *exact* orientation of the points `p0`, `p1`, `p2` Possible values are
ORIENTATION2_COLLINEAR if `p0`, `p1`, `p2` are located on a line,
ORIENTATION2_CCW if `p0`, `p1`, `p2` are counterclockwise oriented
ORIENTATION2_CW if `p0`, `p1`, `p2` are clockwise oriented
Not thread-safe but a bit faster than the thread-safe version

5.1.2.6 getOrientation2_mt()

```
FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2_mt (
        const Point2 * p0,
        const Point2 * p1,
        const Point2 * p2 )
```

See also

> getOrientation2(const Point2∗ p0,const Point2∗ p1,const Point2∗ p2)

This version is thread-safe.

5.1.2.7 getUndirectedEdges()

```
void GEOM_FADE2D::getUndirectedEdges (
        std::vector< Triangle2 * > & vT,
        std::vector< Edge2 > & vUndirectedEdgesOut )
```

A unique set of edges of `vT` is returned.

5.1.2.8 isSimplePolygon() `bool GEOM_FADE2D::isSimplePolygon ( std::vector< Segment2 > & vSegments )`

Parameters

`in`	*vSegments*	specifies segments to be checked. Degenerate segments (0-length) are ignored.

Returns

true when `vSegments` contains a closed polygon without selfintersections. False otherwise.

5.1.2.9 pointsToPolyline() `void GEOM_FADE2D::pointsToPolyline ( std::vector< Point2 > & vInPoints, bool bClose, std::vector< Segment2 > & vOutSegments )`

Turns a vector of points (p0,p1,p2,...pm,pn) into a vector of segments ((p0,p1),(p1,p2),...,(pm,pn)). In case that bClose is true an additional segment (pn,p0) is constructed. Degenerate segments are ignored. Selfintersections of the polyline are not checked.

Parameters

`in`	*vInPoints*	
`in`	*bClose*	specifies whether a closing segment shall be constructed
`out`	*vOutSegments*	is where the output segments are stored

5.1.2.10 sortRing() `bool GEOM_FADE2D::sortRing ( std::vector< Segment2 > & vRing )`

The segments in vRing are reoriented and sorted such that subsequent segments join at the endpoints.

5.1.2.11 sortRingCCW() `bool GEOM_FADE2D::sortRingCCW ( std::vector< Segment2 > & vRing )`

The segments in vRing are reoriented and sorted such that the resulting polygon is counterclockwise oriented and subsequent segments join at the endpoints.

5.2 Version Information

Functions

- const char ∗ GEOM_FADE2D::getFade2DVersion ()

  Get the Fade2D version string.
- FUNC_DECLSPEC int GEOM_FADE2D::getMajorVersionNumber ()

  Get the major version number.
- FUNC_DECLSPEC int GEOM_FADE2D::getMinorVersionNumber ()

  Get the minor version number.
- FUNC_DECLSPEC int GEOM_FADE2D::getRevisionNumber ()

  Get the revision version number.
- FUNC_DECLSPEC bool GEOM_FADE2D::isRelease ()

  Check if a RELEASE or a DEBUG version is used.

5.2.1 Detailed Description

5.3 File I/O

Functions

- bool GEOM_FADE2D::readPointsBIN (const char ∗filename, std::vector< Point2 > &vPointsIn)

  Read points from a binary file.
- bool GEOM_FADE2D::readSegmentsBIN (const char ∗filename, std::vector< Segment2 > &vSegmentsOut)

  Read segments from a binary file.
- FUNC_DECLSPEC bool GEOM_FADE2D::readXY (const char ∗filename, std::vector< Point2 > &vPoints↩ Out)

  Read (x y) points.
- FUNC_DECLSPEC bool GEOM_FADE2D::writePointsASCII (const char ∗filename, const std::vector< Point2 ∗ > &vPointsIn)

  Write points to an ASCII file.
- bool GEOM_FADE2D::writePointsASCII (const char ∗filename, const std::vector< Point2 > &vPointsIn)

  Write points to an ASCII file.
- bool GEOM_FADE2D::writePointsBIN (const char ∗filename, std::vector< Point2 ∗ > &vPointsIn)

  Write points to a binary file.
- bool GEOM_FADE2D::writePointsBIN (const char ∗filename, std::vector< Point2 > &vPointsIn)

  Write points to a binary file.
- bool GEOM_FADE2D::writeSegmentsBIN (const char ∗filename, std::vector< Segment2 > &vSegmentsIn)

  Write segments to a binary file.

5.3.1 Detailed Description

5.3.2 Function Documentation

5.3.2.1 readPointsBIN()

```
bool GEOM_FADE2D::readPointsBIN (
        const char * filename,
        std::vector< Point2 > & vPointsIn )
```

Reads points from a binary file.

See also

writePointsBIN()

5.3.2.2 readSegmentsBIN()

```
bool GEOM_FADE2D::readSegmentsBIN (
        const char * filename,
        std::vector< Segment2 > & vSegmentsOut )
```

Reads segments from a binary file of type 21 or 31

See also

writeSegmentsBIN()

5.3.2.3 readXY()

```
FUNC_DECLSPEC bool GEOM_FADE2D::readXY (
        const char * filename,
        std::vector< Point2 > & vPointsOut )
```

Reads points from an ASCII file. Expected file format: Two coordinates (x y) per line, whitespace separated.

5.3.2.4 writePointsASCII() [1/2] `FUNC_DECLSPEC bool GEOM_FADE2D::writePointsASCII ( const char * filename, const std::vector< Point2 * > & vPointsIn )`

Writes points to an ASCII file, two coordinates (x y) per line, whitespace separated.

Note

Data exchange through ASCII files is easy and convenient but floating point coordinates are not necessarily exact when represented as decimal numbers. If the tiny rounding errors can't be accepted in your setting you are advised to write binary files, (use writePointsBIN())

5.3.2.5 writePointsASCII() [2/2] `bool GEOM_FADE2D::writePointsASCII ( const char * filename, const std::vector< Point2 > & vPointsIn )`

Write points to an ASCII file

See also

readPointsASCII()

5.3.2.6 writePointsBIN() [1/2] `bool GEOM_FADE2D::writePointsBIN ( const char * filename, std::vector< Point2 * > & vPointsIn )`

Writes points to a binary file

See also

readPointsBIN()

5.3.2.7 writePointsBIN() [2/2] `bool GEOM_FADE2D::writePointsBIN ( const char * filename, std::vector< Point2 > & vPointsIn )`

File format:
int filetype (20)
size_t numPoints (`vPointsIn.size()`)
double x0
double y0
double z0
...
double xn
double yn
double zn

Note

Since version 1.64 the binary file format written by 32-bit machines is identical with the file format of x64 machines i.e., the numPoints value is always 8 bytes, not 4. This change affects only 32-bit programs.

5.3.2.8 writeSegmentsBIN() `bool GEOM_FADE2D::writeSegmentsBIN ( const char * filename, std::vector< Segment2 > & vSegmentsIn )`

Binary file format:
int filetype (21)

size_t numSegments (`vSegmentsIn.size()`)
double x0_source
double y0_source
double x0_target
double y0_target
...
double xn_source
double yn_source
double xn_target
double yn_target

Note

Since version 1.64 the binary file format written by 32-bit machines is identical with the file format of x64 machines i.e., the numSegments value is always 8 bytes, not 4. This change affects only 32-bit programs.

See also

readSegmentsBIN()

5.4 Test Data Generators

Functions

- FUNC_DECLSPEC void GEOM_FADE2D::generateCircle (int numPoints, double x, double y, double radiusX, double radiusY, std::vector< Point2 > &vCirclePointsOut)

  Generate a circle.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomNumbers (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)

  Generate random numbers.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPoints (size_t numRandomPoints, double min, double max, std::vector< Point2 > &vRandomPointsOut, unsigned int seed=0)

  Generate random points.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPolygon (size_t numSegments, double min, double max, std::vector< Segment2 > &vPolygonOut, unsigned int seed=0)

  Generate a random simple polygon.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomSegments (size_t numSegments, double min, double max, double maxLen, std::vector< Segment2 > &vSegmentsOut, unsigned int seed)

  Generate random line segments.
- FUNC_DECLSPEC void GEOM_FADE2D::generateSineSegments (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< Segment2 > &v↩SineSegmentsOut)

  Generate segments from a sine function.
- FUNC_DECLSPEC void **GEOM_FADE2D::shear** (std::vector< Point2 > &vPointsInOut, double shearX, double shearY)

5.4.1 Detailed Description

5.4.2 Generate random polygons and other test objects

Theory, careful programming and automated software stress tests. Neither of them can replace the other one. Testing with random data helps to discover errors early. Fade provides random object generators for your automated software stress tests:

- Random simple polygons
- Random segments
- Random point clouds
- Random numbers.
- Polylines from sine functions

If you discover an error in your software you must be able to reproduce the input data that has triggered your bug. For this reason the random object generators take a seed value to initialize the internal random number generators. A certain seed value always leads to the same sequence of objects. Only when the special seed value 0 is used then the random number generators are initialized from the system time.

5.4.3 Function Documentation

5.4.3.1 generateCircle()

```
FUNC_DECLSPEC void GEOM_FADE2D::generateCircle (
        int numPoints,
        double x,
        double y,
        double radiusX,
        double radiusY,
        std::vector< Point2 > & vCirclePointsOut )
```

Returns points on a circle centered at the given coordinates

5.4.3.2 generateRandomNumbers() `FUNC_DECLSPEC void GEOM_FADE2D::generateRandomNumbers (`

```
size_t num,
double min,
double max,
std::vector< double > & vRandomNumbersOut,
unsigned int seed = 0 )
```

Parameters

	num	Number of random numbers to be generated
	min	Lower bound
	max	Upper bound
`out`	*vRandomNumbersOut*	is the output vector
	seed	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

Note

> Reproducable random numbers are often desirable when software is tested with random geometric constructions. Thus each seed value different from *0* leads to its own, reproducible, output sequence. In contrast the `seed` value *0* is mapped to random initialization of the RNG. In this case the RNG will produce a different output sequence each time it is called.

5.4.3.3 generateRandomPoints() `FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPoints (`

```
size_t numRandomPoints,
double min,
double max,
std::vector< Point2 > & vRandomPointsOut,
unsigned int seed = 0 )
```

Parameters

	numRandomPoints	Number of points to be generated
	min	Lower bound (x,y)
	max	Upper bound (x,y)
`out`	*vRandomPointsOut*	is the output vector
	seed	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

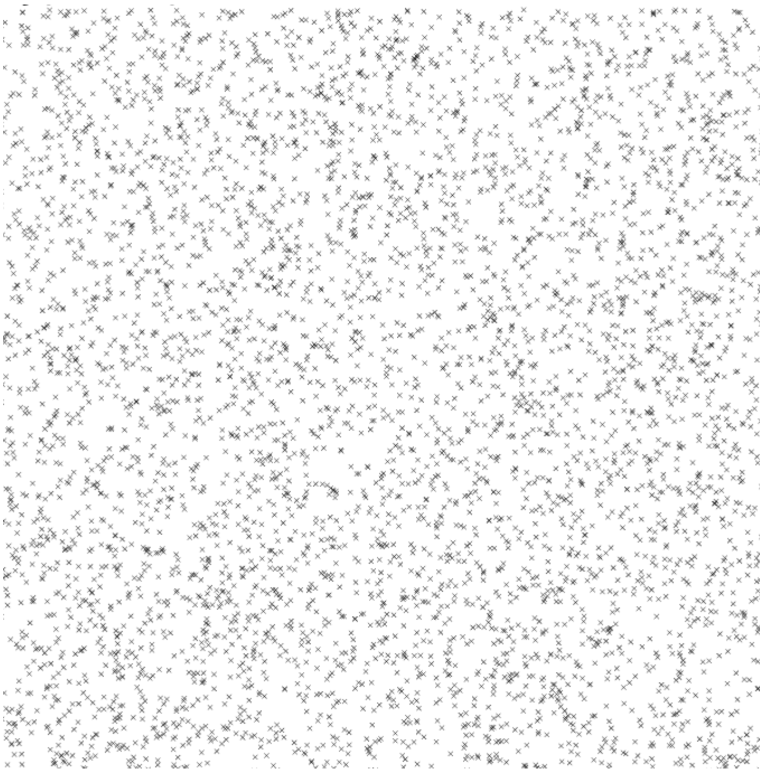


Figure 2 Point generator

5.4.3.4 generateRandomPolygon()

```
FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPolygon (
        size_t numSegments,
        double min,
        double max,
        std::vector< Segment2 > & vPolygonOut,
        unsigned int seed = 0 )
```

Parameters

	numSegments	Number of segments to be generated
	min	Lower bound (x,y)
	max	Upper bound (x,y)
`out`	*vPolygonOut*	is the output vector
	seed	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

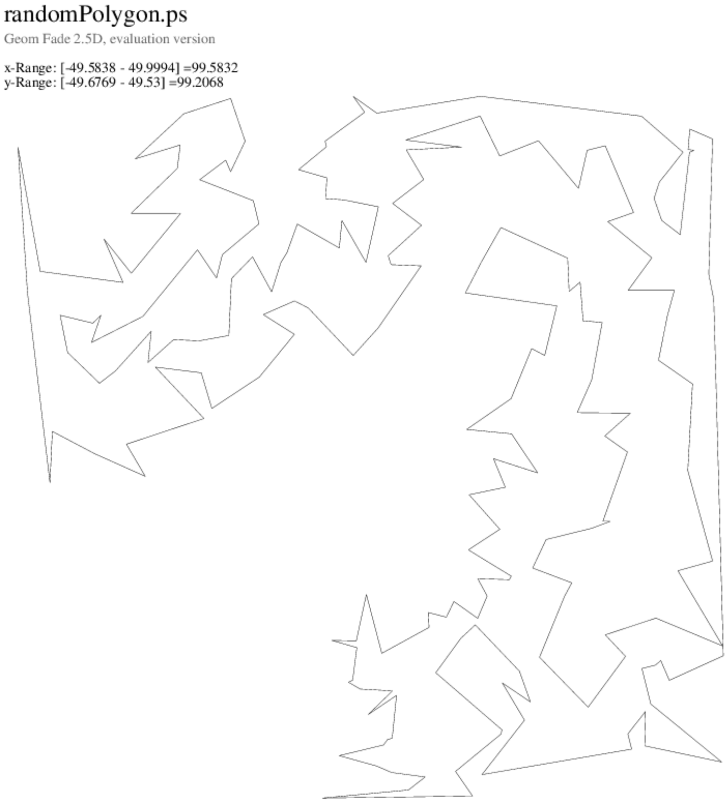

randomPolygon.ps
Geom Fade 2.5D, evaluation version
x-Range: [-49.5838 - 49.9994] =99.5832
y-Range: [-49.6769 - 49.53] =99.2068

Figure 3 Polygon generator: Random simple polygon

5.4.3.5 generateRandomSegments()

```
FUNC_DECLSPEC void GEOM_FADE2D::generateRandomSegments (
        size_t numSegments,
        double min,
        double max,
        double maxLen,
        std::vector< Segment2 > & vSegmentsOut,
        unsigned int seed )
```

Parameters

	numSegments	Number of segments to be generated
	min	Lower bound (x,y)
	max	Upper bound (x,y)
	maxLen	Maximal segment length
out	*vSegmentsOut*	is the output vector
	seed	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

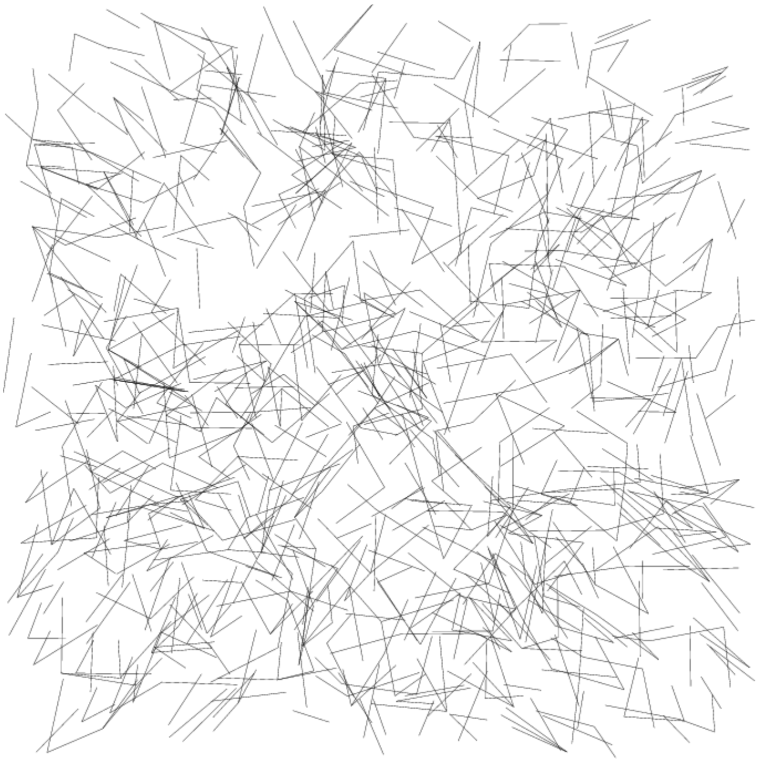


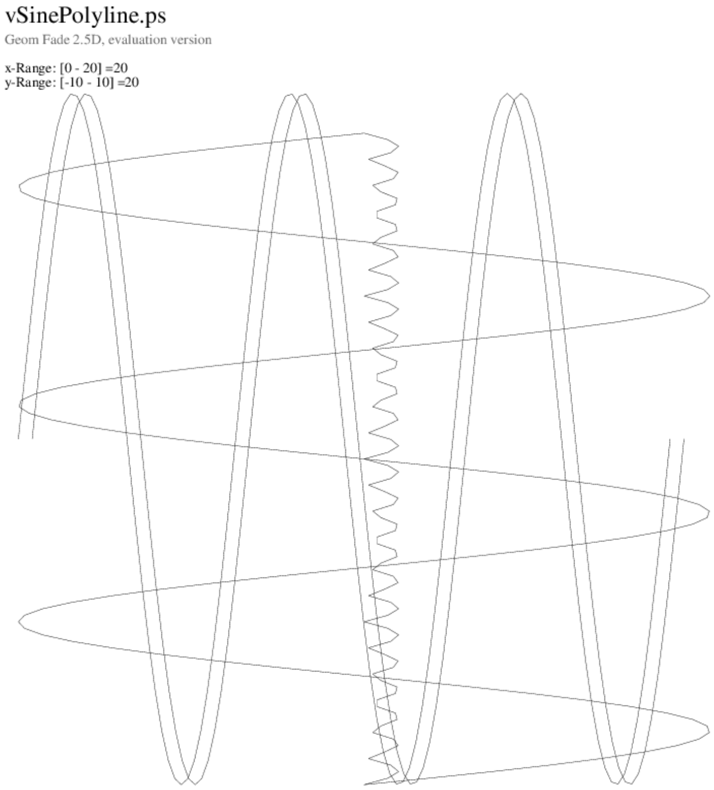
Figure 4 Segment generator: Random line segments

5.4.3.6 generateSineSegments()

```
FUNC_DECLSPEC void GEOM_FADE2D::generateSineSegments (
        int numSegments,
        int numPeriods,
        double xOffset,
        double yOffset,
        double xFactor,
        double yFactor,
        bool bSwapXY,
        std::vector< Segment2 > & vSineSegmentsOut )
```

Parameters

	numSegments	Number of segments to be generated
	numPeriods	Number of periods of the sine function
	xOffset	Offset of the output x-coordinates
	yOffset	Offset of the output y-coordinates
	xFactor	Factor to scale the sine function in x direction
	yFactor	Factor to scale the sine function in y direction
	bSwapXY	Swap the x and y coordinate of the function
`out`	*vSineSegmentsOut*	is the output vector



-

Figure 5 Polyline generator: Polylines from sine functions

6 Class Documentation

6.1 GEOM_FADE2D::Bbox2 Class Reference

Bbox2 is an axis aligned 2D bounding box.
`#include <Bbox2.h>`

Public Member Functions

- Bbox2 (GeomTest ∗pGeomTest_=NULL)

  Constructor.
- bool add (const Point2 &p)

  Add a point.
- bool add (size_t numPoints, double ∗coordinates)

  Add points.
- bool add (std::vector< Point2 ∗ >::const_iterator start_it, std::vector< Point2 ∗ >::const_iterator end_it)

  Add points.
- bool add (std::vector< Point2 >::const_iterator start_it, std::vector< Point2 >::const_iterator end_it)

  Add points.
- Point2 computeCenter () const

  Compute the 2D midpoint.
- bool doIntersect (const Bbox2 &other) const

  Check intersection.
- void doubleTheBox ()

  Double the box.
- void **enlargeRanges** (double factor)
- double get_maxX () const

  Get maxX.
- double get_maxY () const

  Get maxY.
- double get_minX () const

  Get minX.
- double get_minY () const

  Get minY.
- void getBoundary (std::vector< Segment2 > &vBoundary) const

  Get boundary.
- void getBounds (double &minX_, double &maxX_, double &minY_, double &maxY_) const

  Get bounds.
- void getCorners (std::vector< Point2 > &vBoxCorners) const

  Get corners.
- double getMaxCoord () const

  Get maximum coordinate.
- Point2 getMaxPoint () const

  Get the max point.
- double getMaxRange () const

  Get max range.
- double getMinCoord () const

  Get minimum coordinate.
- Point2 getMinPoint () const

  Get the min point.
- void getOffsetCorners (double offset, std::vector< Point2 > &vBoxCorners) const

  Get offset corners.

- double getRangeX () const

  Get x-range.
- double getRangeY () const

  Get y-range.
- void inflateIfDegenerate (double val)

  Inflate if Degenerate.
- bool isInBox (const Point2 &p) const

  Point-in-Box Test.
- bool isValid () const

  Check if the bounds are valid.
- Bbox2 operator+ (const Bbox2 &b)

  Add a bounding box.
- void setMaxX (double val)

  Set maxX.
- void setMaxY (double val)

  Set maxY.
- void setMinX (double val)

  Set minX.
- void setMinY (double val)

  Set minY.

Protected Member Functions

- void **treatPointForInvalidBox** (const Point2 &p)
- void **treatPointForValidBox** (const Point2 &p)

Protected Attributes

- bool **bValid**
- double **maxX**
- double **maxY**
- double **minX**
- double **minY**
- GeomTest ∗ **pGeomTest**

Friends

- std::ostream & operator<< (std::ostream &stream, const Bbox2 &pC)

  Print the box.

6.1.1 Detailed Description

6.1.2 Constructor & Destructor Documentation

6.1.2.1 Bbox2() `GEOM_FADE2D::Bbox2::Bbox2 (`

`GeomTest ∗ pGeomTest_ = NULL )  [inline], [explicit]`

Minimum bounds are initialized to DBL_MAX. Maximum bounds are initialized to -DBL_MAX. Box is not valid yet

6.1.3 Member Function Documentation

6.1.3.1 add() [1/4] `bool GEOM_FADE2D::Bbox2::add (`

`const Point2 & p ) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.3.2 add() [2/4] `bool GEOM_FADE2D::Bbox2::add (`

`size_t numPoints,`
`double * coordinates ) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.3.3 add() [3/4] `bool GEOM_FADE2D::Bbox2::add (`

`std::vector< Point2 * >::const_iterator start_it,`
`std::vector< Point2 * >::const_iterator end_it ) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.3.4 add() [4/4] `bool GEOM_FADE2D::Bbox2::add (`

`std::vector< Point2 >::const_iterator start_it,`
`std::vector< Point2 >::const_iterator end_it ) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.3.5 computeCenter() `Point2 GEOM_FADE2D::Bbox2::computeCenter ( ) const`

6.1.3.6 doIntersect() `bool GEOM_FADE2D::Bbox2::doIntersect (`

`const Bbox2 & other ) const`

Two valid bounding boxes intersect if they share at least one point in the XY plane.

6.1.3.7 doubleTheBox() `void GEOM_FADE2D::Bbox2::doubleTheBox ( )`

Changes the bounds such that the box grows in each direction by half the previous range

6.1.3.8 get_maxX() `double GEOM_FADE2D::Bbox2::get_maxX ( ) const [inline]`

Returns

maxX

6.1.3.9 get_maxY() `double GEOM_FADE2D::Bbox2::get_maxY ( ) const [inline]`

Returns

maxY

6.1.3.10 get_minX() `double GEOM_FADE2D::Bbox2::get_minX ( ) const [inline]`

Returns

minX

6.1.3.11 get_minY() `double GEOM_FADE2D::Bbox2::get_minY ( ) const [inline]`

Returns

minY

6.1.3.12 getBoundary() `void GEOM_FADE2D::Bbox2::getBoundary (`

```
std::vector< Segment2 > & vBoundary ) const
```

Convenience function: Returns 4 border segments

6.1.3.13 getBounds() `void GEOM_FADE2D::Bbox2::getBounds (`

```
double & minX_,
double & maxX_,
double & minY_,
double & maxY_ ) const
```

6.1.3.14 getCorners() `void GEOM_FADE2D::Bbox2::getCorners (`

```
std::vector< Point2 > & vBoxCorners ) const
```

Convenience function: Returns the 4 corners of the box

6.1.3.15 getMaxCoord() `double GEOM_FADE2D::Bbox2::getMaxCoord ( ) const [inline]`

Returns

the largest coordinate value, i.e. max(maxX,maxY)

6.1.3.16 getMaxPoint() `Point2 GEOM_FADE2D::Bbox2::getMaxPoint ( ) const [inline]`

Returns

the 2D corner point with the maximum coordinates

6.1.3.17 getMaxRange() `double GEOM_FADE2D::Bbox2::getMaxRange ( ) const [inline]`

Returns

the largest range, i.e. max(getRangeX(),getRangeY())

6.1.3.18 getMinCoord() `double GEOM_FADE2D::Bbox2::getMinCoord ( ) const [inline]`

Returns

the smallest coordinate value, i.e. min(minX,minY)

6.1.3.19 getMinPoint() `Point2 GEOM_FADE2D::Bbox2::getMinPoint ( ) const [inline]`

Returns

the 2D corner point with the minimum coordinates

6.1.3.20 getOffsetCorners() `void GEOM_FADE2D::Bbox2::getOffsetCorners (`

```
double offset,
std::vector< Point2 > & vBoxCorners ) const
```

Convenience function: Returns the 4 corners of an enlarged box. The box es enlarged by `offset` in each direction

6.1.3.21 getRangeX() `double GEOM_FADE2D::Bbox2::getRangeX ( ) const [inline]`

Returns

maxX-minX

6.1.3.22 getRangeY() `double GEOM_FADE2D::Bbox2::getRangeY ( ) const [inline]`

Returns

maxY-minY

6.1.3.23 inflateIfDegenerate() `void GEOM_FADE2D::Bbox2::inflateIfDegenerate (`

```
double val ) [inline]
```

When only one point has been added to Bbox2 or when all points have the same x- and/or y- coordinates then Bbox2 is degenerate. This is a valid state but sometimes undesireable. The present method inflates the Bbox2 by adding /p val to maxX and/or maxY.

6.1.3.24 isInBox() `bool GEOM_FADE2D::Bbox2::isInBox (`

```
const Point2 & p ) const
```

Returns

true if minX <= p.x() <=maxX and minY <= p.y() <=maxY or false otherwise.

6.1.3.25 isValid() `bool GEOM_FADE2D::Bbox2::isValid ( ) const [inline]`

The bounds are valid when at least one point has been added or when set-methods have been used to set minX<=maxX and minY<=maxY

6.1.3.26 operator+() `Bbox2 GEOM_FADE2D::Bbox2::operator+ (`

```
const Bbox2 & b )
```

Extends the 2D bounding box if required.

Returns

the resulting bounding box

6.1.4 Friends And Related Function Documentation

6.1.4.1 operator<< `std::ostream& operator<< (`

```
            std::ostream & stream,
            const Bbox2 & pC )  [friend]
```

Prints the box coordinates to `stream`

The documentation for this class was generated from the following file:

- Bbox2.h

6.2 GEOM_FADE2D::Circle2 Class Reference

Circle for visualization.

`#include <Circle2.h>`

Public Member Functions

- Circle2 (const Point2 &center_, double sqRadius_)

  Constructor.
- Circle2 (double x, double y, double sqRadius_)

  Constructor.
- Point2 getCenter ()

  Get the center of the circle.
- double getRadius ()

  Get the radius of the circle.
- double getSqRadius ()

  Get the squared radius of the circle.

Protected Attributes

- Point2 **center**
- double **sqRadius**

Friends

- std::ostream & **operator**<< (std::ostream &stream, Circle2 b)

6.2.1 Detailed Description

See also

Visualizer2

6.2.2 Constructor & Destructor Documentation

6.2.2.1 Circle2() [1/2] `GEOM_FADE2D::Circle2::Circle2 (`

```
            double x,
            double y,
            double sqRadius_ )
```

Parameters

x	is x-coordinate of the center
y	is y-coordinate of the center
*sq← Radius_*	is the squared radius of the circle

Warning

The method expects the *squared* radius

6.2.2.2 Circle2() `[2/2]` `GEOM_FADE2D::Circle2::Circle2 ( const Point2 & center_, double sqRadius_ )`

Parameters

*center_*	center of the circle
*sq↩ Radius_*	squared radius of the circle

Warning

The method expects the *squared* radius

6.2.3 Member Function Documentation

6.2.3.1 getCenter() `Point2 GEOM_FADE2D::Circle2::getCenter ( )`

Returns

a Point2 which represents the center

6.2.3.2 getRadius() `double GEOM_FADE2D::Circle2::getRadius ( )`

Returns

the radius

6.2.3.3 getSqRadius() `double GEOM_FADE2D::Circle2::getSqRadius ( )`

Returns

the squared radius

The documentation for this class was generated from the following file:

- Circle2.h

6.3 GEOM_FADE2D::Color Class Reference

Color for visualization.
`#include <Color.h>`

Public Member Functions

- Color (Colorname c, float width_=0.001, bool bFill_=false)
- Color (double r_, double g_, double b_, double width_, bool bFill_=false)
- bool **operator!=** (const Color &other) const
- bool **operator<** (const Color &other) const
- bool **operator==** (const Color &other) const

Static Public Member Functions

- static Colorname **getNextColorName** ()

Public Attributes

- float b

  Blue.
- bool bFill

  Fill the shape or not.
- float g

  Green.
- float r

  Red.
- float width

  Linewidth.

Static Public Attributes

- static size_t **currentColorName**

Friends

- std::ostream & **operator**<< (std::ostream &stream, const Color &c)

6.3.1 Detailed Description

See also

Visualizer2

6.3.2 Constructor & Destructor Documentation

6.3.2.1 Color() [1/2]

```
GEOM_FADE2D::Color::Color (
        double r_,
        double g_,
        double b_,
        double width_,
        bool bFill_ = false )
```

Parameters

*r_*	red
*g_*	green
*b_*	blue
*width_*	linewidth
*bFill_*	fill (default: *false*)

Note

bFill_=true has two meanings: Objects that can be filled (Triangle2, Circle2) are filled with the rgb-color but line segments get x-marks at their endpoints.

6.3.2.2 Color() [2/2]

```
GEOM_FADE2D::Color::Color (
        Colorname c,
        float width_ = 0.001,
        bool bFill_ = false )
```

For convenience predefined colors can be used.

Parameters

c	is a predefined color name
*width_*	linewidth (default: *0.001*)
*bFill_*	fill (default: *false*)

Note

> bFill_=true has two meanings: Objects that can be filled (Triangle2, Circle2) are filled with the rgb-color but line segments get x-marks at their endpoints.

The documentation for this class was generated from the following file:

- Color.h

6.4 GEOM_FADE2D::ConstraintGraph2 Class Reference

ConstraintGraph2 is a set of Constraint Edges (ConstraintSegment2)

`#include <ConstraintGraph2.h>`

Public Member Functions

- void getChildConstraintSegments (std::vector< ConstraintSegment2 ∗ > &vConstraintSegments_) const

  Get child ConstraintSegment2 objects.
- void getDirectChildren (ConstraintSegment2 ∗pParent, ConstraintSegment2 ∗&pChild0, ConstraintSegment2 ∗&pChild1)

  Get direct children.
- Dt2 ∗ getDt2 ()
- ConstraintInsertionStrategy getInsertionStrategy () const

  Get the constraint insertion strategy.
- void getOriginalConstraintSegments (std::vector< ConstraintSegment2 ∗ > &vConstraintSegments_) const

  Get the original ConstraintSegment2 objects.
- void getPolygonVertices (std::vector< Point2 ∗ > &vVertices_)

  Get the vertices of the constraint segments.
- bool isConstraint (ConstraintSegment2 ∗pCSeg) const

  Check if a ConstraintSegment2 is a member.
- bool isConstraint (Point2 ∗p0, Point2 ∗p1) const

  Check if an edge is a constraint.
- bool isOriented () const

  Are the segments of the constraint graph oriented?
- bool isPolygon () const

  Does the constraint graph form a closed polygon?
- bool isReverse (ConstraintSegment2 ∗pCSeg) const
- bool makeDelaunay (double minLength)
- void show (const char ∗name)

  Visualization.
- void show (Visualizer2 ∗pVis, const Color &color)

  Visualization.

Protected Attributes

- bool **bIsOriented**
- bool **bIsPolygon**
- ConstraintInsertionStrategy **cis**
- std::map< ConstraintSegment2 ∗, bool, func_ltDerefPtr< ConstraintSegment2 ∗ > > **mCSegReverse**
- std::map< Point2 ∗, size_t > **mSplitPointNum**
- Dt2 ∗ **pDt2**
- GeomTest ∗ **pGeomPredicates**
- std::vector< ConstraintSegment2 ∗ > **vCSegParents**

6.4.1 Detailed Description

See also

Fade_2D::createConstraint()

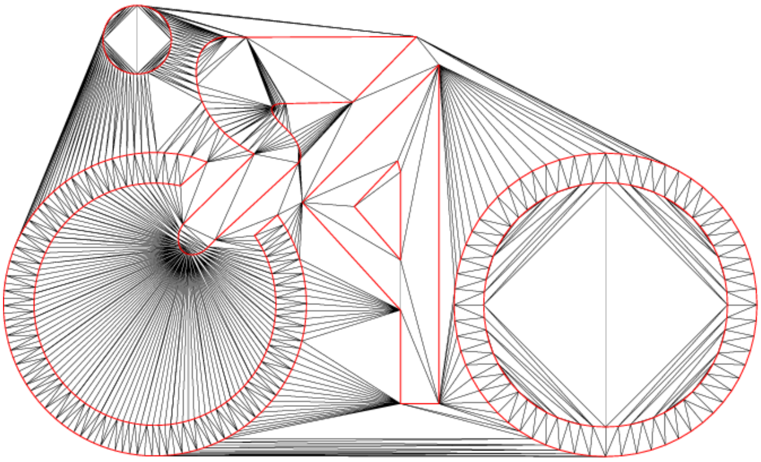


Figure 6 Constraint Delaunay triangulation

6.4.2 Member Function Documentation

6.4.2.1 getChildConstraintSegments() `void GEOM_FADE2D::ConstraintGraph2::getChildConstraintSegments ( std::vector< ConstraintSegment2 * > & vConstraintSegments_ ) const`

Returns the current constraint segments, i.e., the original ones or, if splitted, their child segments.

6.4.2.2 getDirectChildren() `void GEOM_FADE2D::ConstraintGraph2::getDirectChildren ( ConstraintSegment2 * pParent, ConstraintSegment2 *& pChild0, ConstraintSegment2 *& pChild1 )`

Parameters

in	*pParent*	is a ConstraintSegment that may have been splitted
out	*pChild0,pChild1*	are the direct child segments of `pParent`. They can be alive or dead (splitted).

The children are returned in the correct order of the present ConstraintGraph2.

6.4.2.3 getDt2() `Dt2* GEOM_FADE2D::ConstraintGraph2::getDt2 ( )`

Returns

> the Delaunay class it belongs to

6.4.2.4 getInsertionStrategy() `ConstraintInsertionStrategy GEOM_FADE2D::ConstraintGraph2::getInsertionStrategy ( ) const`

Returns

> CIS_CONFORMING_DELAUNAY or CIS_CONSTRAINED_DELAUNAY

6.4.2.5 getOriginalConstraintSegments() `void GEOM_FADE2D::ConstraintGraph2::getOriginalConstraintSegments ( std::vector< ConstraintSegment2 * > & vConstraintSegments_ ) const`

Get the original, ConstraintSegment2 objects. They are not subdivided but may be dead and have child segments (which may also be dead and have child segments...)

6.4.2.6 getPolygonVertices() `void GEOM_FADE2D::ConstraintGraph2::getPolygonVertices ( std::vector< Point2 * > & vVertices_ )`

Use this method to retrieve the vertices of the present ConstraintGraph2. If it forms ONE closed polygon, then the vertices are ordered and oriented in counterclockwise direction, e.g. (a,b,b,c,c,d,d,a). Otherwise they are returned in original order. Be aware that the order is only maintained if the ConstraintGraph2 has been created with Fade_2D::createConstraint(..,..,`bOrientedSegments=true`).

Note

> The segments of the present ConstraintGraph2 may have been splitted. In this case the split points are also contained in the result. If, in the above example, the ConstraintSegment2(a,b) has been subdivided at vertex x then the result is (a,x,x,b,b,c,c,d,d,a).

See also

> Do you already know Zone2::getBorderEdges() and edgesToPolygons() ?

6.4.2.7 isConstraint() [1/2] `bool GEOM_FADE2D::ConstraintGraph2::isConstraint ( ConstraintSegment2 * pCSeg ) const`

The present ConstraintGraph2 has been created using a set of edges and this method checks if the ConstraintSegment2 `pCSeg` is one of them. Original edges that have been splitted are not alive anymore and are no members. But their child segments are members.

6.4.2.8 isConstraint() [2/2] `bool GEOM_FADE2D::ConstraintGraph2::isConstraint ( Point2 * p0, Point2 * p1 ) const`

Checks if the edge (p0,p1) is a constraint of the present ConstraintGraph2 object.

6.4.2.9 isOriented() `bool GEOM_FADE2D::ConstraintGraph2::isOriented ( ) const`

Returns

> true if the constraint graph has been created with bOrientedSegments=true or if automatic reorientation was possible which is the case for simple polygons.

6.4.2.10 isPolygon() `bool GEOM_FADE2D::ConstraintGraph2::isPolygon ( ) const`

Returns

true when the present ConstraintGraph forms a closed polygon.

Note

This method won't check if it is a simple polygon (one without self-intersections).

6.4.2.11 isReverse() `bool GEOM_FADE2D::ConstraintGraph2::isReverse ( ConstraintSegment2 * pCSeg ) const`

Get the orientation of a ConstraintSegment2

A ConstraintSegment2 `pCSeg` is unoriented because it may participate (with different orientations) in more than just one ConstraintGraph2 and thus the vertices returned by pCSeg->getSrc() and pCSeg->getTrg() do not carry any orientation information. However, the orientation of `pCSeg` is stored in the ConstraintGraph2 objects where `pCSeg` is a member and this method returns if the source and target vertex must be exchanged to match the present graph's direction.

6.4.2.12 makeDelaunay() `bool GEOM_FADE2D::ConstraintGraph2::makeDelaunay ( double minLength )`

Improve the triangle quality (make Delaunay)

Constraint segments can make a triangulation locally non-delaunay i.e., the empty-circumcircle property is not maintained for all triangles. `makeDelaunay()` subdivides the constraint segments so that they appear naturally as part of the Delaunay triangulation. Use this function to create visually more appealing triangles with better aspect ratios.

Parameters

in	*minLength*	specifies a lower bound. Constraint segments smaller than `minLength` are not subdivided. This parameter avoids excessive subdivision in narrow settings.

Returns

TRUE when all required somedevisions have been carried out or FALSE when `minLength` has avoided further subdivision.

6.4.2.13 show() [1/2] `void GEOM_FADE2D::ConstraintGraph2::show ( const char * name )`

6.4.2.14 show() [2/2] `void GEOM_FADE2D::ConstraintGraph2::show ( Visualizer2 * pVis, const Color & color )`

The documentation for this class was generated from the following file:

- ConstraintGraph2.h

6.5 GEOM_FADE2D::ConstraintSegment2 Class Reference

A ConstraintSegment2 represents a Constraint Edge.

`#include <ConstraintSegment2.h>`

Public Member Functions

- void getChildrenAndSplitPoint (ConstraintSegment2 ∗&pCSeg0, ConstraintSegment2 ∗&pCSeg1, Point2 ∗&pSplitPoint)

  Get the children and the split point Retrieve the two direct children of the current ConstraintSegment2 as well as the split point.
- void getChildrenRec (std::vector< ConstraintSegment2 ∗ > &vChildConstraintSegments)

  Get all children Recursively retrieve all children of the current ConstraintSegment2.
- ConstraintInsertionStrategy getCIS () const

  Get the Constraint Insertion Strategy (CIS)
- Point2 ∗ getSrc () const

  Get the first endpoint.
- Point2 ∗ getTrg () const

  Get the second endpoint.
- Point2 ∗ insertAndSplit (const Point2 &splitPoint)

  Split a constraint segment.
- bool isAlive () const

  Check if the present ConstraintSegment2 is alive.
- bool operator< (const ConstraintSegment2 &pOther) const

  operator<(..) Compares the vertex pointers of the endpoints, not the length
- bool split_combinatorialOnly (Point2 ∗pSplit)

  Split a constraint segment.

Public Attributes

- int **label**

Protected Attributes

- bool **bAlive**
- ConstraintInsertionStrategy **cis**
- Point2 ∗ **p0**
- Point2 ∗ **p1**
- std::vector< ConstraintSegment2 ∗ > **vChildren**

Static Protected Attributes

- static int **runningLabel**

Friends

- class **ConstraintGraph2**
- class **ConstraintMgr**
- std::ostream & **operator**<< (std::ostream &stream, const ConstraintSegment2 &cSeg)

6.5.1 Detailed Description

A ConstraintSegment2 can belong to more than one ConstraintGraph2 object, thus it is unoriented. But the ConstraintGraph knows the orientation of its ConstraintSegment2's.

6.5.2 Member Function Documentation

6.5.2.1 getCIS() `ConstraintInsertionStrategy GEOM_FADE2D::ConstraintSegment2::getCIS ( ) const`

Returns

the constraint insertion strategy (CIS) of the present object

6.5.2.2 getSrc() `Point2* GEOM_FADE2D::ConstraintSegment2::getSrc ( ) const`

Returns

the first vertex

6.5.2.3 getTrg() `Point2* GEOM_FADE2D::ConstraintSegment2::getTrg ( ) const`

Returns

the second vertex

6.5.2.4 insertAndSplit() `Point2* GEOM_FADE2D::ConstraintSegment2::insertAndSplit ( const Point2 & splitPoint )`

Splits the ConstraintSegment2 (which must be alive) at `splitPoint`.
It may be impossible to represent a point on a certain line segment using floatingpoint arithmetic. Therefore it is highly recommended to split a ConstraintSegment2 object not just be inserting points into the triangulation but using the present method. It does not require that `splitPoint` is exactly on the segment.

Note

A splitted ConstraintSegment2 is dead and it has two child segments (which may also be dead and have children). The class is organized as a binary tree.

6.5.2.5 isAlive() `bool GEOM_FADE2D::ConstraintSegment2::isAlive ( ) const`

Returns

TRUE when the object is alive, FALSE otherwise

6.5.2.6 split_combinatorialOnly() `bool GEOM_FADE2D::ConstraintSegment2::split_combinatorialOnly ( Point2 * pSplit )`

internal use only (unless you do something very unusual)
The documentation for this class was generated from the following file:

- ConstraintSegment2.h

6.6 GEOM_FADE2D::Edge2 Class Reference

Edge2 is a directed edge.
`#include <Edge2.h>`

Public Member Functions

- **Edge2** (const Edge2 &e_)
- Edge2 (Triangle2 ∗pT, int oppIdx_)

  Constructor.
- int getIndex () const
- double getLength2D () const
- void getPoints (Point2 ∗&p1, Point2 ∗&p2) const

  Get the endpoints.
- Point2 ∗ getSrc () const

  Get the source point.
- Point2 ∗ getTrg () const

  Get the target point.
- Triangle2 ∗ getTriangle () const
- void getTriangles (Triangle2 ∗&pT0, Triangle2 ∗&pT1, int &idx0, int &idx1) const
- bool operator!= (const Edge2 &e) const

  operator!=()
- bool operator< (const Edge2 &e) const

  operator<()
- Edge2 & **operator=** (const Edge2 &other)
- bool operator== (const Edge2 &e) const

  operator==()

Protected Attributes

- int **oppIdx**
- Triangle2 ∗ **pT**

Friends

- std::ostream & **operator**<< (std::ostream &stream, const Edge2 &e)

6.6.1 Constructor & Destructor Documentation

6.6.1.1 Edge2()

```
GEOM_FADE2D::Edge2::Edge2 (
        Triangle2 ∗ pT,
        int oppIdx_ )
```

Parameters

pT	is the triangle from which the edge is constructed
*opp↩ Idx_*	is intra-triangle-index of the opposite vertex (of the edge) in pT

The orientation of the constructed Edge2 is counterclockwise (CCW) with respect to `pT`. Example: Edge2(pT,0) creates an edge from pT->getCorner(1) to pT->getCorner(2).

6.6.2 Member Function Documentation

6.6.2.1 getIndex() `int GEOM_FADE2D::Edge2::getIndex ( ) const`

Get the opposite index

Returns

the intra-triangle-index of the opposite vertex

6.6.2.2 getLength2D() `double GEOM_FADE2D::Edge2::getLength2D ( ) const`

Get the length

Returns

the length of the edge

6.6.2.3 getPoints() `void GEOM_FADE2D::Edge2::getPoints (`

```
Point2 *& p1,
Point2 *& p2 ) const
```

returns the source point of the edge as `p1` and the target point as `p2`

6.6.2.4 getSrc() `Point2* GEOM_FADE2D::Edge2::getSrc ( ) const`

Returns

the source point of the edge, i.e. pT->getCorner((oppIdx+1)%3)

6.6.2.5 getTrg() `Point2* GEOM_FADE2D::Edge2::getTrg ( ) const`

Returns

the target point of the edge, i.e. pT->getCorner((oppIdx+2)%3)

6.6.2.6 getTriangle() `Triangle2* GEOM_FADE2D::Edge2::getTriangle ( ) const`

Get the triangle

Returns

the triangle whose directed edge the present edge is

6.6.2.7 getTriangles() `void GEOM_FADE2D::Edge2::getTriangles (`

```
Triangle2 *& pT0,
Triangle2 *& pT1,
int & idx0,
int & idx1 ) const
```

Get the triangles

Returns

the two adjacent triangles of the present edge along with their intra-triangle-indices

Parameters

pT0	is used to return the triangle whose directed edge the present edge is
idx0	is the opposite intra-triangle-index in pT0 of the present edge
pT1	is the other adjacent triangle at the present edge (or NULL)
idx1	is the intra-triangle index of the present edge in pT1 (or -1)

6.6.2.8 operator"!=() `bool GEOM_FADE2D::Edge2::operator!= ( const Edge2 & e ) const [inline]`

operator!=() returns true if the compared edges are different. Be aware that edges are directed and therefore two adjacent triangles do not share the same Edge2.

6.6.2.9 operator<() `bool GEOM_FADE2D::Edge2::operator< ( const Edge2 & e ) const [inline]`

operator<() does NOT compare edge lengths but the associated triangle pointers and intra-triangle indices. This is useful when edges are used in STL containers.

6.6.2.10 operator==() `bool GEOM_FADE2D::Edge2::operator== ( const Edge2 & e ) const [inline]`

operator==() compares oriented edges, i.e., it returns only true when the two edges have been made from the same triangle and the same intra-triangle-index i.e., an edge with two adjacent triangles has two Edge2 objects, one in each direction.

The documentation for this class was generated from the following file:

- Edge2.h

6.7 GEOM_FADE2D::Fade_2D Class Reference

Fade_2D is the Delaunay triangulation main class.

`#include <Fade_2D.h>`

Public Member Functions

- Fade_2D (unsigned numExpectedVertices=3)

  Constructor of the main triangulation class.
- ∼Fade_2D ()

  Destructor.
- void applyConstraintsAndZones ()

  Apply conforming constraints and zones (deprecated!)
- bool checkValidity (bool bCheckEmptyCircleProperty, const char ∗msg) const

  Checks if a triangulation is valid.
- Bbox2 computeBoundingBox () const

  Compute the axis-aligned bounding box of the points.
- ConstraintGraph2 ∗ createConstraint (std::vector< Segment2 > &vSegments, ConstraintInsertionStrategy cis, bool bOrientedSegments=false)

  Add constraint edges (edges, polyline, polygon)
- Zone2 ∗ createZone (const std::vector< ConstraintGraph2 ∗ > &vConstraintGraphs, ZoneLocation zoneLoc, const Point2 &startPoint, bool bVerbose=true)

  Create a zone limited by multiple ConstraintGraph2 objects by growing from a start point.
- Zone2 ∗ createZone (ConstraintGraph2 ∗pConstraintGraph, ZoneLocation zoneLoc, bool bVerbose=true)

  Create a zone.
- Zone2 ∗ createZone (ConstraintGraph2 ∗pConstraintGraph, ZoneLocation zoneLoc, const Point2 &startPoint, bool bVerbose=true)

  Create a zone limited by a ConstraintGraph by growing from a start point.
- Zone2 ∗ createZone (std::vector< Triangle2 ∗ > &vTriangles, bool bVerbose=true)

  Create a zone defined by a vector of triangles.
- Zone2 ∗ createZone_cookieCutter (std::vector< Segment2 > &vSegments, bool bProtectEdges)

  Cookie Cutter The Cookie Cutter cuts out a part of a triangulation and returns it as a Zone2 object.
- void cutTriangles (const Point2 &knifeStart, const Point2 &knifeEnd, bool bTurnEdgesIntoConstraints)

Cut through a triangulation.

- void cutTriangles (std::vector< Segment2 > &vSegments, bool bTurnEdgesIntoConstraints)

    Cut through a triangulation.
- void deleteZone (Zone2 ∗pZone)

    Delete a Zone2 object.
- bool drape (std::vector< Segment2 > &vSegmentsIn, std::vector< Segment2 > &vSegmentsOut) const

    Drape segments along a surface.
- void exportTriangulation (FadeExport &fadeExport, bool bWithCustomIndices, bool bClear)

    Export triangulation data from Fade.
- Triangle2 ∗ getAdjacentTriangle (Point2 ∗p0, Point2 ∗p1) const

    Get adjacent triangle.
- void getAliveAndDeadConstraintSegments (std::vector< ConstraintSegment2 ∗ > &vAllConstraintSegments) const

    Get all (alive and dead) constraint segments.
- void getAliveConstraintSegments (std::vector< ConstraintSegment2 ∗ > &vAliveConstraintSegments) const

    Get active (alive) constraint segments.
- ConstraintSegment2 ∗ getConstraintSegment (Point2 ∗p0, Point2 ∗p1) const

    Retrieve a ConstraintSegment2.
- void getConvexHull (bool bAllVertices, std::vector< Point2 ∗ > &vConvexHullPointsOut)

    Compute the convex hull.
- void getIncidentTriangles (Point2 ∗pVtx, std::vector< Triangle2 ∗ > &vIncidentT) const

    Get incident triangles.
- void getIncidentVertices (Point2 ∗pVtx, std::vector< Point2 ∗ > &vIncidentVertices) const

    Get incident vertices.
- Orientation2 getOrientation (const Point2 &p0, const Point2 &p1, const Point2 &p2)

    Compute the orientation of 3 points.
- void getTrianglePointers (std::vector< Triangle2 ∗ > &vAllTriangles) const

    Get pointers to all triangles.
- void getVertexPointers (std::vector< Point2 ∗ > &vAllPoints) const

    Get pointers to all vertices.
- Voronoi2 ∗ getVoronoiDiagram ()

    Get the Voronoi diagram.
- bool hasArea () const

    Check if the triangulation contains triangles (which is the case if at least 3 non-collinear points exist in the triangulation.
- Zone2 ∗ importTriangles (std::vector< Point2 > &vPoints, bool bReorientIfNeeded, bool bCreateExtendedBoundingBox)

    Import triangles.
- Point2 ∗ insert (const Point2 &p)

    Insert a single point.
- void insert (const std::vector< Point2 > &vInputPoints)

    Insert a vector of points.
- void insert (const std::vector< Point2 > &vInputPoints, std::vector< Point2 ∗ > &vHandles)

    Insert points from a std::vector and store pointers in vHandles.
- void insert (int numPoints, double ∗aCoordinates, Point2 ∗∗aHandles)

    Insert points from an array.
- bool isConstraint (Point2 ∗p0, Point2 ∗p1) const

    Check if an edge is a constraint edge.
- bool isConstraint (Point2 ∗pVtx) const

    Check if a vertex is a constraint vertex.
- bool isConstraint (Triangle2 ∗pT, int ith) const

    Check if an edge is a constraint edge.

- bool load (const char ∗filename, std::vector< Zone2 ∗ > &vZones)

  Load a triangulation.
- bool load (std::istream &stream, std::vector< Zone2 ∗ > &vZones)

  Load a triangulation.
- Triangle2 ∗ locate (const Point2 &p)

  Locate a triangle which contains p.
- double measureTriangulationTime (std::vector< Point2 > &vPoints)

  Measure the Delaunay triangulation time.
- size_t numberOfPoints () const

  Number of points.
- size_t numberOfTriangles () const

  Number of triangles.
- void printLicense () const

  Prints license information.
- void refine (Zone2 ∗pZone, double minAngleDegree, double minEdgeLength, double maxEdgeLength, bool bAllowConstraintSplitting)

  Delaunay refinement.
- void refineAdvanced (MeshGenParams ∗pParameters)

  Delaunay refinement and grid meshing.
- void remove (Point2 ∗pVertex)

  Remove a single vertex.
- bool saveTriangulation (const char ∗filename, std::vector< Zone2 ∗ > &vSaveZones)

  Save a triangulation.
- bool saveTriangulation (std::ostream &stream, std::vector< Zone2 ∗ > &vSaveZones)

  Save a triangulation.
- bool saveZones (const char ∗filename, std::vector< Zone2 ∗ > &vSaveZones)

  Save zones.
- bool saveZones (std::ostream &stream, std::vector< Zone2 ∗ > &vSaveZones)

  Save zones.
- void setFastMode (bool bFast)

  Set fast mode.
- int setNumCPU (int numCPU)

  Set the number CPU cores for multithreading.
- void show (const char ∗postscriptFilename, bool bWithConstraints=true) const

  Draws the triangulation as postscript file.
- void show (Visualizer2 ∗pVis, bool bWithConstraints=true) const

  Draws the triangulation as postscript file using an existing Visualizer2 object.
- void statistics (const char ∗s) const

  Statistics.
- void subscribe (MsgType msgType, MsgBase ∗pMsg)

  Register a message receiver.
- void unsubscribe (MsgType msgType, MsgBase ∗pMsg)

  Unregister a message receiver.
- void writeObj (const char ∗filename) const

  Write the current triangulation to an ∗.obj file.
- void writeObj (const char ∗filename, Zone2 ∗pZone) const

  Write a zone to an ∗.obj file.
- void writeWebScene (const char ∗path) const

  Write the current triangulation to an ∗.obj file.
- void writeWebScene (const char ∗path, Zone2 ∗pZone) const

  Write a zone to an ∗.obj file.

6.7.1 Detailed Description

Fade_2D represents a Delaunay triangulation in 2D or 2.5D (depends on the used namespace)

6.7.2 Constructor & Destructor Documentation

6.7.2.1 Fade_2D() `GEOM_FADE2D::Fade_2D::Fade_2D ( unsigned numExpectedVertices = 3 ) [inline], [explicit]`

Parameters

numExpectedVertices	specifies the number of points that will be inserted. This is a default parameter that does not need to be specified.

6.7.3 Member Function Documentation

6.7.3.1 applyConstraintsAndZones() `void GEOM_FADE2D::Fade_2D::applyConstraintsAndZones ( )`

This method establishes conforming constraint segments and zones which depend on them. For technical reasons conforming constraint segments are not immediately established but inserted at the end of the triangulation process. This step must be triggered manually i.e., it is up to the user to call applyConstraintsAndZones() before the resulting triangulation is used. If afterwards the triangulation is changed in any way, applyConstraintsAndZones() must be called again.

Note

> The present function applyConstraintsAndZones() as well as the two constraint insertion strategies CIS_CONFORMING_DELAUNAY and CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL are deprecated. These are only kept for backwards compatibilty. The replacement is CIS_CONSTRAINED_DELAUNAY along with the methods Fade_2D::drape() and/or ConstraintGraph2::makeDelaunay(). See the example code in examples_25D/terrain.cpp

6.7.3.2 checkValidity() `bool GEOM_FADE2D::Fade_2D::checkValidity ( bool bCheckEmptyCircleProperty, const char * msg ) const`

Checks the validity of the data structure.

Parameters

bCheckEmptyCircleProperty	specifies if (slow!) multiprecision arithmetic shall be used to recheck the empty circle property
msg	is a debug string that will be shown in terminal output so that you know which checkValidity call currently runs.

This method is thought for development purposes. Don't call it method unless you assume that something is wrong with the code.

6.7.3.3 computeBoundingBox() `Bbox2 GEOM_FADE2D::Fade_2D::computeBoundingBox ( ) const`

If no points have been inserted yet, then the returned Bbox2 object is invalid and its member function *Bbox2::isValid()* returns false.

6.7.3.4 createConstraint() `ConstraintGraph2* GEOM_FADE2D::Fade_2D::createConstraint (`

```
std::vector< Segment2 > & vSegments,
ConstraintInsertionStrategy cis,
bool bOrientedSegments = false )
```

Parameters

vSegments	are segments which shall appear as edges of the triangulation. The segments may be automatically reordered and reoriented, see `bOrientedSegments` below.
cis	is the Constraint-Insertion-Strategy. Use always CIS_CONSTRAINED_DELAUNAY. This mode inserts the constraint segments without subdivision unless existing vertices or existing constraint segments are crossed. When subdivision (e.g., to achieve better triangle shapes) is desired then use ConstraintGraph2::makeDelaunay() after insertion.
bOrientedSegments	specifies whether the segments in vSegments are oriented (*oriented, not ordered!*). If later a zone is to be made with the returned ConstraintGraph2 object this is only possible if the value is true (then it is assumed that all segments are counterclockwise oriented) or if the ConstraintGraph2 represents exactly one closed polygon. The value affects also the order of the returned vertices when later ConstraintGraph2::getPolygonVertices() is called. This is a default parameter and it defaults to false.

Returns

a pointer to the new ConstraintGraph2 object

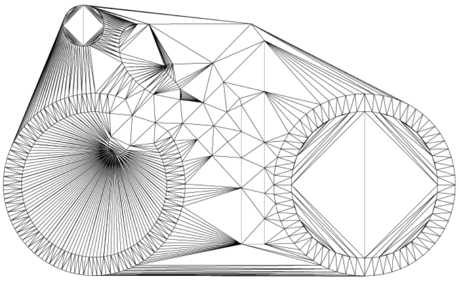


Figure 7 Delaunay triangulation without constraints

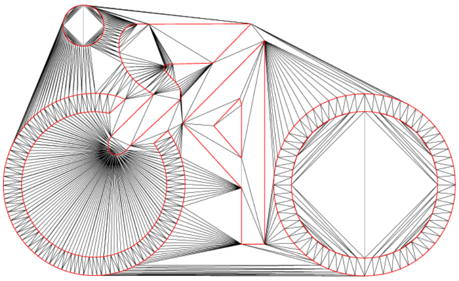


Figure 8 Constraint Delaunay triangulation

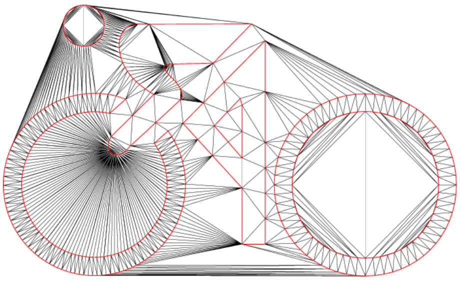


Figure 9 Conforming Delaunay triangulation through the ConstraintGraph::makeDelaunay() method

6.7.3.5 createZone() [1/4]

```
Zone2* GEOM_FADE2D::Fade_2D::createZone (
        const std::vector< ConstraintGraph2 * > & vConstraintGraphs,
        ZoneLocation zoneLoc,
        const Point2 & startPoint,
        bool bVerbose = true )
```

A Zone2 object is an area of the traingulation, see createZone

Parameters

vConstraintGraphs	is a vector of ConstraintGraph objects
zoneLoc	must be ZL_GROW
startPoint	is the point from which the area is grown until the borders specified in vConstraintGraphs are reached
bVerbose	is by default true and causes a warning if NULL is returned.

Returns

a pointer to the new Zone2 object (or NULL if zoneLoc!=ZL_GROW or no triangles exist)

6.7.3.6 createZone() [2/4]

```
Zone2* GEOM_FADE2D::Fade_2D::createZone (
        ConstraintGraph2 * pConstraintGraph,
        ZoneLocation zoneLoc,
        bool bVerbose = true )
```

A Zone2 object is an area of a triangulation, possibly bounded by a ConstraintGraph.

Parameters

zoneLoc	is ZL_INSIDE, ZL_OUTSIDE or ZL_GLOBAL.
pConstraintGraph	points to a formerly created ConstraintGraph2 object (which must be oriented and contain a *simple* polygon) or is NULL in case of zoneLoc==ZL_GLOBAL.
bVerbose	is by default true and causes a warning if NULL is returned.

Returns

a pointer to the new Zone2 object or NULL if no triangles exist or pConstraintGraph->isOriented() returns false.

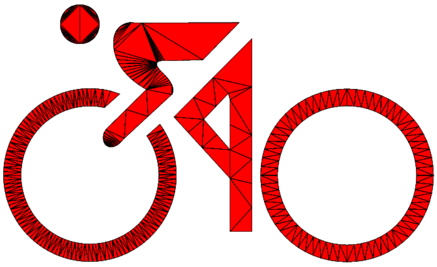


Figure 10 Zones in a triangulation

6.7.3.7 createZone() [3/4]

```
Zone2* GEOM_FADE2D::Fade_2D::createZone (
        ConstraintGraph2 * pConstraintGraph,
        ZoneLocation zoneLoc,
        const Point2 & startPoint,
        bool bVerbose = true )
```

A Zone2 object is an area of the traingulation, see createZone

Parameters

pConstraintGraph	is a constraint whose edges specify the area's border
zoneLoc	must be ZL_GROW
startPoint	is the point from which the area is grown until the borders specified in pConstraint are reached
bVerbose	is by default true and causes a warning if NULL is returned.

Returns

a pointer to the new Zone2 object (or NULL if zoneLoc!=ZL_GROW or no triangles exist)

6.7.3.8 createZone() [4/4]

```
Zone2* GEOM_FADE2D::Fade_2D::createZone (
        std::vector< Triangle2 * > & vTriangles,
        bool bVerbose = true )
```

A Zone2 object is an area of the traingulation, see createZone

Parameters

vTriangles	
bVerbose	is by default true and causes a warning if NULL is returned.

Returns

a pointer to the new Zone2 object (or NULL if vTriangles is empty)

6.7.3.9 createZone_cookieCutter()

```
Zone2* GEOM_FADE2D::Fade_2D::createZone_cookieCutter (
        std::vector< Segment2 > & vSegments,
        bool bProtectEdges )
```

Parameters

in	*vSegments*	specifies a simple polygon.
in	*bProtectEdges*	specifies if existing triangles shall be protected with constraint segments.

Returns

a Zone2 object consisting of all triangles inside the polygon or NULL when the operation has failed due to wrong preconditions.

Properties: The input polygon (`vSegments`) does not need to have certain height values, the z-coordinates are computed automatically. The input polygon is automatically trimmed when it is outside the convex hull of the triangulation. Insertion of intersection points may flip existing edges in the triangulation but this can be avoided using bProtectEdges=true. In this case new constraint edges may be created.

6.7.3.10 cutTriangles() [1/2]

```
void GEOM_FADE2D::Fade_2D::cutTriangles (
        const Point2 & knifeStart,
        const Point2 & knifeEnd,
        bool bTurnEdgesIntoConstraints )
```

Parameters

knifeStart	is one point of the knife segment
knifeEnd	is the second point of the knife segment
bTurnEdgesIntoConstraints	turns all 3 edges of each intersected triangle into constraint segments.

This method inserts a constraint edge *knife*(*knifeStart*,*knifeEnd*). If existing edges *E* are intersected by *knife*, then *knife* is subdivided at the intersection points *P*.
In any case *knife* will exist (in a possibly subdivided form) in the result. But a consequence of the insertion of the points *P* is that the edges *E* and even edges which are not intersected by *knife* may be flipped. Use bTurnEdgesIntoConstraints=true to avoid that.

Note

The intersection point of two line segments may not be exactly representable in double precision floating point arithmetic and thus tiny rounding errors may occur. As a consequence two very close intersection points may be rounded to the same coordinates.

When more than one knife segment is inserted then the method void cutTriangles(std::vector<Segment2>& vSegments,bool bTu
should be used. The reason is that each individual cut operation changes the triangulation and thus iterative calls to the present version of the method can lead to a different result.

6.7.3.11 cutTriangles() [2/2]

```
void GEOM_FADE2D::Fade_2D::cutTriangles (
        std::vector< Segment2 > & vSegments,
        bool bTurnEdgesIntoConstraints )
```

Parameters

vSegments	are the knife segments
bTurnEdgesIntoConstraints	specifies if intersected edges shall automatically be turned into constraints

Same method as void cutTriangles(const Point2& knifeStart,const Point2& knifeEnd,bool bTurnEdgesIntoConstraints) but it takes a vector of segments instead of a single segment. This is the recommended method to cut through a triangulation when more than one knife segment exists.

6.7.3.12 deleteZone() `void GEOM_FADE2D::Fade_2D::deleteZone ( Zone2 * pZone )`

Zone2 objects are automatically destroyed with their Fade_2D objects. In addition this method provides the possibility to eliminate Zone2 objects earlier.

Note

> Zones are designed transparently: When two zones Z1 and Z2 are combined to a new one Z3 (for example through a boolean operation) then Z1,Z2,Z3 form a tree such that changes in the leaf nodes Z1 and Z2 can propagate up to the root node Z3. For this reason Z1 and Z2 must be alive as long as Z3 is used.

6.7.3.13 drape() `bool GEOM_FADE2D::Fade_2D::drape ( std::vector< Segment2 > & vSegmentsIn, std::vector< Segment2 > & vSegmentsOut ) const`

Projects the segments from `vSegmentsIn` onto the triangulation. Thereby the segments are subdivided where they intersect edges of the triangulation. Segment parts outside the triangulation are cut off and ignored. Degenerate input segments are also ignored.

Parameters

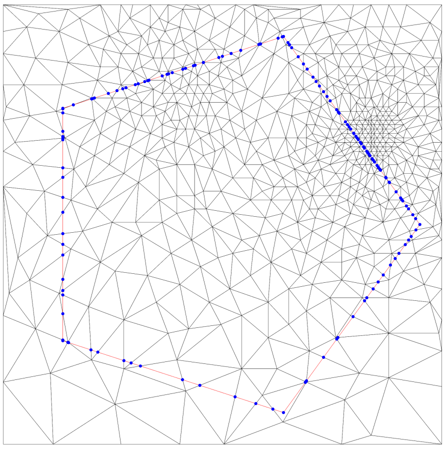
`in`	*vSegmentsIn*	Input segments
`out`	*vSegmentsOut*	Output segments

Returns

> TRUE when all input segments are inside the convex hull of the triangulation. Otherwise FALSE is returned and the result is still valid but it contains only the segment parts inside the convex hull.

Note

> The tiny rounding errors that occur when segment intersections are computed are largely theoretical. But be aware that subdivided segments are not always perfectly collinear. This can't be avoided because the exact split point is sometimes not even representable using floating point coordinates.



-

Figure 11 Drape: Input segments are draped (red) onto a TIN. They are subdivided (blue) at intersections with triangulation edges

Note

Draping segments onto a TIN does not insert them. Use Fade_2D::createConstraint() for that purpose.

6.7.3.14 exportTriangulation()

```
void GEOM_FADE2D::Fade_2D::exportTriangulation (
        FadeExport & fadeExport,
        bool bWithCustomIndices,
        bool bClear )
```

Parameters

fadeExport	is a struct that will hold the requested triangulation data
bWithCustomIndices	determines whether the custom indices of the points are also stored
bClear	determines whether the Fade instance is cleared **during** the export operation to save memory

Note

When bClear is true then all memory of the Fade object is deleted i.e., all existing pointers to its objects become invalid.

6.7.3.15 getAdjacentTriangle()

```
Triangle2* GEOM_FADE2D::Fade_2D::getAdjacentTriangle (
        Point2 * p0,
        Point2 * p1 ) const
```

Returns

the triangle that has the edge (p0,p1) or NULL if no such edge is present

Note

Recall the counter-clockwise enumeration of vertices in a triangle. If (p0,p1) is used, the unique triangle with the CCW oriented edge (p0,p1) is returned, using (p1,p0) one gets the other adjacent triangle.

6.7.3.16 getConstraintSegment()

```
ConstraintSegment2* GEOM_FADE2D::Fade_2D::getConstraintSegment
(
        Point2 * p0,
        Point2 * p1 ) const
```

Returns

a pointer to the ConstraintSegment2 between p0 and p1 or NULL if the segment is not a constraint edge (or dead because it has been splitted)

6.7.3.17 getConvexHull()

```
void GEOM_FADE2D::Fade_2D::getConvexHull (
        bool bAllVertices,
        std::vector< Point2 * > & vConvexHullPointsOut )
```

Parameters

	bAllVertices	determines if all convex hull points are returned or if collinear ones shall be removed.
out	*vConvexHullPointsOut*	is used to return the convex hull vertices in counterclockwise order. The start vertex is the leftmost vertex. If more than one leftmost vertex exists, the bottommost of them is the start vertex.

6.7.3.18 getIncidentTriangles()

```
void GEOM_FADE2D::Fade_2D::getIncidentTriangles (
        Point2 * pVtx,
        std::vector< Triangle2 * > & vIncidentT ) const
```

Stores pointers to all triangles around pVtx into vIncidentT

6.7.3.19 getIncidentVertices()

```
void GEOM_FADE2D::Fade_2D::getIncidentVertices (
        Point2 * pVtx,
        std::vector< Point2 * > & vIncidentVertices ) const
```

Stores pointers to all vertices around pVtx into vIncidentVertices

6.7.3.20 getOrientation()

```
Orientation2 GEOM_FADE2D::Fade_2D::getOrientation (
        const Point2 & p0,
        const Point2 & p1,
        const Point2 & p2 )
```

Returns

ORIENTATION2_COLLINEAR, ORIENTATION2_CW (clockwise) or ORENTATION2_CCW (counterclockwise)

6.7.3.21 getTrianglePointers()

```
void GEOM_FADE2D::Fade_2D::getTrianglePointers (
        std::vector< Triangle2 * > & vAllTriangles ) const
```

This command fetches the existing triangles

Parameters

out	*vAllTriangles*	is used to return the triangles

Note

that the lifetime of data from the Fade2D datastructures does exceed the lifetime of the Fade2D object.

6.7.3.22 getVertexPointers()

```
void GEOM_FADE2D::Fade_2D::getVertexPointers (
        std::vector< Point2 * > & vAllPoints ) const
```

Parameters

vAllPoints	is an empty vector of Point2 pointers.

Stores pointers to all vertices of the triangulation in vAllPoints. The order in which the points are stored is *not* necessarily the insertion order. For geometrically identical points which have been inserted multiple times, only one pointer exists. Thus vAllPoints.size() can be smaller than the number of inserted points.

Note

that the lifetime of data from the Fade2D datastructures does exceed the lifetime of the Fade2D object.

6.7.3.23 getVoronoiDiagram()

```
Voronoi2* GEOM_FADE2D::Fade_2D::getVoronoiDiagram ( )
```

Returns

a dual Voronoi diagram that changes dynamically when the triangulation changes.

6.7.3.24 hasArea() `bool GEOM_FADE2D::Fade_2D::hasArea ( ) const`

As long as all inserted points are collinear the triangulation does not contain triangles. This is clearly the case as long as less than three input points are present but it may also be the case when 3 or more points have been inserted when all these points are collinear. These points are then in a pending state, i.e. they will be triangulated as soon as the first non-collinear point is inserted.

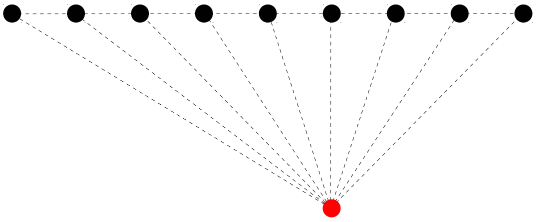


Figure 12 Triangles are generated as soon as the first non-collinear point is inserted.

Returns

true if at least one triangle exists
false otherwise

6.7.3.25 importTriangles() `Zone2* GEOM_FADE2D::Fade_2D::importTriangles ( std::vector< Point2 > & vPoints, bool bReorientIfNeeded, bool bCreateExtendedBoundingBox )`

This method imports triangles into an empty Fade object. The triangles do not need to satisfy the empty circle property.

Parameters

vPoints	contains the input vertices (3 subsequent ones per triangle)
bReorientIfNeeded	specifies if the orientations of the point triples shall be checked and corrected. If the point triples are certainly oriented in counterclockwise order then the orientation test can be skipped.
bCreateExtendedBoundingBox	can be used to insert 4 dummy points of an extended bounding box. This is convenient in some cases. Use false if you are unsure.

Returns

a pointer to a Zone2 object or NULL if the input data is invalid

Warning

This method requires 100% correct input. A frequent source of trouble is when client software reads points from an ASCII file. The ASCII format is convenient but it can **introduce rounding errors that cause intersections and flipped triangle orientations**. Thus it is highly recommended to transfer point coordinates with binary files. See also readPointsBIN() and writePointsBIN().

6.7.3.26 insert() [1/4]

```
Point2* GEOM_FADE2D::Fade_2D::insert (
            const Point2 & p )
```

Parameters

p	is the point to be inserted.

Returns

a pointer to the point in the triangulation

The triangulation keeps a copy of *p*. The return value is a pointer to this copy. If duplicate points are inserted, the triangulation does not create new copies but returns a pointer to the copy of the very first insertion.

Note

This method offers a very good performance but it is still faster if all points are passed at once, if possible.

6.7.3.27 insert() [2/4]

```
void GEOM_FADE2D::Fade_2D::insert (
        const std::vector< Point2 > & vInputPoints )
```

Parameters

vInputPoints	contains the points to be inserted.

Note

Use Fade_2D::setNumCPU() to activate multithreading

6.7.3.28 insert() [3/4]

```
void GEOM_FADE2D::Fade_2D::insert (
        const std::vector< Point2 > & vInputPoints,
        std::vector< Point2 * > & vHandles )
```

Parameters

vInputPoints	contains the points to be inserted.
vHandles	(empty) is used by Fade to return Point2 pointers

Internally, the triangulation keeps copies of the inserted points which are returned in *vHandles* (in the same order). If duplicate points are contained in vInputPoints then only one copy will be made and a pointer to this unique copy will be stored in vHandles for every occurance.

Note

Use Fade_2D::setNumCPU() to activate multithreading

6.7.3.29 insert() [4/4]

```
void GEOM_FADE2D::Fade_2D::insert (
        int numPoints,
        double * aCoordinates,
        Point2 ** aHandles )
```

Parameters

numPoints	is the number of points to be inserted
aCoordinates	is an array of $2n$ double values, e.g. {x0,y0,x1,y1,...,xn,yn}

Parameters

aHandles	is an empty array with size *n* where pointers to the inserted points will be stored by Fade

Note

Use Fade_2D::setNumCPU() to activate multithreading

6.7.3.30 isConstraint() [1/3]

```
bool GEOM_FADE2D::Fade_2D::isConstraint (
        Point2 * p0,
        Point2 * p1 ) const
```

Returns whether the edge (p0,p1) is a constraint edge.

6.7.3.31 isConstraint() [2/3]

```
bool GEOM_FADE2D::Fade_2D::isConstraint (
        Point2 * pVtx ) const
```

Returns whether the vertex `pVtx` belongs to a constraint edge.

6.7.3.32 isConstraint() [3/3]

```
bool GEOM_FADE2D::Fade_2D::isConstraint (
        Triangle2 * pT,
        int ith ) const
```

Returns whether the edge in triangle *pT* which is opposite to the *ith* vertex is a constraint edge.

6.7.3.33 load() [1/2]

```
bool GEOM_FADE2D::Fade_2D::load (
        const char * filename,
        std::vector< Zone2 * > & vZones )
```

Loads a triangulation together with any custom indices, constraint-edges and zones from a binary file

Parameters

`in`	*filename*	is the name of the input file
`out`	*vZones*	is used to return Zone2∗ pointers if any. The order of the pointers is the same as at the time of storage

Returns

whether the operation was successful

6.7.3.34 load() [2/2]

```
bool GEOM_FADE2D::Fade_2D::load (
        std::istream & stream,
        std::vector< Zone2 * > & vZones )
```

Loads a triangulation together with any custom indices, constraint-edges and zones from a stream

Parameters

	stream	is an input stream
`out`	*vZones*	is used to return Zone2∗ pointers if any. The order of the pointers is the same as at the time of storage

Returns

whether the operation was successful

6.7.3.35 locate() `Triangle2* GEOM_FADE2D::Fade_2D::locate ( const Point2 & p )`

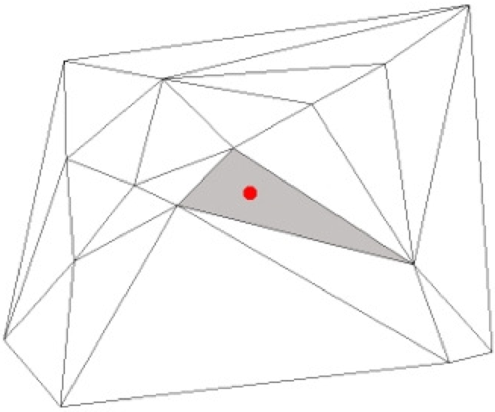


Figure 13 Point location

The Fade_2D class can be used as a data structure for point location. This method returns a pointer to a triangle which contains *p*.

Parameters

p	is the query point

Returns

a pointer to a Triangle2 object (or NULL if hasArea()==false or if *p* is outside the triangulation)

6.7.3.36 measureTriangulationTime() `double GEOM_FADE2D::Fade_2D::measureTriangulationTime ( std::vector< Point2 > & vPoints )`

This method evaluates the performance of single- and multithreaded point insertion into a Delaunay triangulation.

Parameters

in	*vPoints*	are the points to be inserted

Returns

the total wall-time for point insertion in seconds

Note

The method cleans up the triangulation (objects, memory) on exit. Thus the time measured outside this method may be slightly larger than the returned time that is exactly the time needed to triangulate the input points.

Use Fade_2D::setNumCPU() to activate multithreading

6.7.3.37 numberOfPoints() `size_t GEOM_FADE2D::Fade_2D::numberOfPoints ( ) const`

Returns

the number of points in the triangulation

Note

Due to possibly duplicate input points the number of points is not stored somewhere but freshly computed in O(n) time. This is fast but you are adviced to avoid calling this method over-frequently in a loop. Duplicate point insertions count only once.

6.7.3.38 numberOfTriangles() `size_t GEOM_FADE2D::Fade_2D::numberOfTriangles ( ) const`

Returns

the number of triangles in the triangulation (or 0 as long as hasArea() is false).

6.7.3.39 refine() `void GEOM_FADE2D::Fade_2D::refine (`

```
Zone2 * pZone,
double minAngleDegree,
double minEdgeLength,
double maxEdgeLength,
bool bAllowConstraintSplitting )
```

Creates a mesh inside the area given by a Zone2 object.

Parameters

pZone	is the zone whose triangles are refined. Allowed zoneLocation values are ZL_INSIDE and ZL_BOUNDED.
minAngleDegree	(up to 30) is the minimum interior triangle angle
minEdgeLength	is a lower threshold on the edge length. Triangles with smaller edges are not refined.
maxEdgeLength	is an upper threshold on the edge length. Triangles with larger edges are always refined.
bAllowConstraintSplitting	specifies if constraint edges may be splitted

Note

The behavior of the present method had to be changed in Fade v1.39: Only ZL_INSIDE and ZL_BO↩ UNDED zones are accepted. But you can easily convert other types of zones to ZL_BOUNDED using Zone2::convertToBoundedZone().

6.7.3.40 refineAdvanced() `void GEOM_FADE2D::Fade_2D::refineAdvanced (`

```
MeshGenParams * pParameters )
```

This method calls an advanced Delaunay mesh generator and grid mesher. The parameters are encapsulated in the MeshGenParams class. This class provides default parameters that can be used as is. Alternatively client code can derive from MeshGenParams and overwrite the methods and parameters to gain full control over the mesh generation process.

6.7.3.41 remove() `void GEOM_FADE2D::Fade_2D::remove (`

```
Point2 * pVertex )
```

Parameters

pVertex	shall be removed.

Note

> `pVertex` must not be a vertex of a ConstraintGraph2 or ConstraintSegment2 object. If this is the case, the vertex is not removed and a warning is issued.

6.7.3.42 saveTriangulation() [1/2]

```
bool GEOM_FADE2D::Fade_2D::saveTriangulation (
        const char * filename,
        std::vector< Zone2 * > & vSaveZones )
```

The saveTriangulation() command saves all triangles of the present triangulation to a binary file. Thereby it retains constraint edges and custom vertex indices, if any. If Zone2∗ pointers are specified, these zones will be saved also and their order will be retained.

Parameters

`in`	*filename*	is the name of the output file
`out`	*vSaveZones*	is used specify zones that shall additionally be saved

See also

> If you just want to store zones, use Zone2::save() or Fade_2D::saveTriangulation(). Use Fade_2D::load() to reload data from such files.

Returns

> whether the operation was successful

6.7.3.43 saveTriangulation() [2/2]

```
bool GEOM_FADE2D::Fade_2D::saveTriangulation (
        std::ostream & stream,
        std::vector< Zone2 * > & vSaveZones )
```

The saveTriangulation() command saves all triangles of the present triangulation to a stream. Thereby it retains constraint edges and custom vertex indices, if any. If Zone2∗ pointers are specified, these zones will be saved also and their order will be retained.

Parameters

	stream	is the output stream
`out`	*vSaveZones*	is used specify zones that shall additionally be saved

See also

> If you just want to store zones, use Zone2::save() or Fade_2D::saveTriangulation(). Use Fade_2D::load() to reload data from such files.

Returns

> whether the operation was successful

6.7.3.44 saveZones() [1/2]

```
bool GEOM_FADE2D::Fade_2D::saveZones (
        const char * filename,
        std::vector< Zone2 * > & vSaveZones )
```

The saveZones() command saves the triangles of the zones in `vSaveZones` to a binary file. Thereby it keeps the order of the zones and it retains any constraint edges and custom indices in the domain.

Note

A Delaunay triangulation is convex without holes and this may not hold for the zones to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the Fade_2D instance but not to any Zone2 when reloaded later.

Parameters

`in`	*filename*	is the name of the output file
`out`	*vSaveZones*	(non-empty) specifies the zones to be saved

Returns

whether the operation was successful

See also

The saveTriangulation() command can be used to store all triangles of a triangulation plus any specified zones. The Zone2::save() command is used to store just one zone. Use Fade_2D::load() to reload data from such files.

6.7.3.45 saveZones() [2/2]

```
bool GEOM_FADE2D::Fade_2D::saveZones (
        std::ostream & stream,
        std::vector< Zone2 * > & vSaveZones )
```

The saveZones() command saves the triangles of the zones in `vSaveZones` to stream. Thereby it keeps the order of the zones and it retains any constraint edges and custom indices in the domain.

Note

A Delaunay triangulation is convex without holes and this may not hold for the zones to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the Fade_2D instance but not to any Zone2 when reloaded later.

Parameters

	stream	is the name of output stream
`out`	*vSaveZones*	(non-empty) specifies the zones to be saved

Returns

whether the operation was successful

See also

The saveTriangulation() command can be used to store all triangles of a triangulation plus any specified zones. The Zone2::save() command is used to store just one zone. Use Fade_2D::load() to reload data from such files.

6.7.3.46 setFastMode() `void GEOM_FADE2D::Fade_2D::setFastMode ( bool bFast )`

By default, numerically perfect calculations are performed to compute a 100% perfect Delaunay triangulation. However, the difference to using double precision arithmetic is hardly noticeable. It is rather relevant in scientific applications while practical applications may want to skip the computationally expensive calculations. Depending on the position of the input points, the effect of FastMode can be zero or a quite considerable acceleration.

Parameters

bFast	use true to avoid using multiple precision arithmetic in favor of better performance.

6.7.3.47 setNumCPU() `int GEOM_FADE2D::Fade_2D::setNumCPU ( int numCPU )`

Parameters

numCPU	is the number of CPU cores to be used. The special value `numCPU=0` means: auto-detect and use the number of available CPU cores.

Returns

the number of CPU cores that will be used (useful in case of auto-detection)

Characteristics:

- This setting affects Fade_2D::measureTriangulationTime() and Fade_2D::insert() which is by default single-threaded to avoid undeliberate nested multithreading (an application may run Fade in a thread).
- For technical reasons points should be inserted before any constraint segments so that the algorithm can fully benefit from multithreading.
- Fade continues support for very old compilers but multithreading is not available for VS2010 and CentOS6.4 library versions.

6.7.3.48 show() [1/2] `void GEOM_FADE2D::Fade_2D::show ( const char * postscriptFilename, bool bWithConstraints = true ) const`

show() is a convenience function for quick outputs with a default look. It is also possible to use the Visualizer2 class directly to draw arbitrary circles, line segments, vertices and labels with custom colors.

Parameters

postscriptFilename	is the output name, i.e. "myFile.ps"
bWithConstraints	specifies if constraint segments shall be shown (default: true)

6.7.3.49 show() [2/2] `void GEOM_FADE2D::Fade_2D::show ( Visualizer2 * pVis, bool bWithConstraints = true ) const`

This overload of the show() method allows to add further geometric primitives to the Visualizer2 object before it is finally written.

Parameters

pVis	is the pointer of a Visualizer2 object that may already contain geometric primitives or that may later be used to draw further elements
bWithConstraints	specifies if constraint segments shall be shown (default: true)

Note

The postscript file must be finalized with Visualizer2::writeFile().

6.7.3.50 statistics() `void GEOM_FADE2D::Fade_2D::statistics ( const char * s ) const`

Prints mesh statistics to stdout.

6.7.3.51 subscribe() `void GEOM_FADE2D::Fade_2D::subscribe ( MsgType msgType, MsgBase * pMsg )`

Parameters

msgType	is the type of message the subscriber shall receive, e.g. MSG_PROGRESS or MSG_WARNING
pMsg	is a pointer to a custom class derived from MsgBase

6.7.3.52 unsubscribe() `void GEOM_FADE2D::Fade_2D::unsubscribe ( MsgType msgType, MsgBase * pMsg )`

Parameters

msgType	is the type of message the subscriber shall not receive anymore
pMsg	is a pointer to a custom class derived from MsgBase

6.7.3.53 writeObj() [1/2] `void GEOM_FADE2D::Fade_2D::writeObj ( const char * filename ) const`

Visualizes the current triangulation. The ∗.obj format represents a 3D scene.

6.7.3.54 writeObj() [2/2] `void GEOM_FADE2D::Fade_2D::writeObj ( const char * filename, Zone2 * pZone ) const`

Visualizes a certain Zone2 object of the present triangulation. The ∗.obj format represents a 3D scene.

6.7.3.55 writeWebScene() [1/2] `void GEOM_FADE2D::Fade_2D::writeWebScene ( const char * path ) const`

Made for terrain visualizations in 2.5D but will work also for 2D.

6.7.3.56 writeWebScene() [2/2] `void GEOM_FADE2D::Fade_2D::writeWebScene ( const char * path, Zone2 * pZone ) const`

Made for terrain visualizations in 2.5D but will work also for 2D.

The documentation for this class was generated from the following file:

- Fade_2D.h

6.8 GEOM_FADE2D::FadeExport Struct Reference

FadeExport is a simple struct to export triangulation data.
`#include <FadeExport.h>`

Public Member Functions

- void extractTriangleNeighborships (std::vector< std::pair< int, int > > &vNeigs) const

  Determine index-pairs of adjacent triangles.
- void getCoordinates (int vtxIdx, double &x, double &y) const

  Get the coorinates for a certain vertex index.
- void getCornerIndices (int triIdx, int &vtxIdx0, int &vtxIdx1, int &vtxIdx2) const

  Get the corner indices of a certain triangle.
- void print () const

  Print data for demonstration purposes.
- bool writeObj (const char ∗filename) const

  Write an ∗.obj file (supported by virtually any 3D viewer)

Public Attributes

- double ∗ aCoords

  Cartesian coordinates (dim∗numPoints)
- int ∗ aCustomIndices

  Custom indices of the points (only when exported)
- int ∗ aTriangles

  3 counterclockwise oriented vertex-indices per triangle (3∗numTriangles)
- int dim

  Dimension.
- int numCustomIndices

  number of custom indices (same as numPoints when exported, otherwise 0)
- int numPoints

  number of points
- int numTriangles

  number of triangles

6.8.1 Detailed Description

This data structure is there to get data out of Fade easily and memory efficiently. **The source code of this class is deliberately included in the header file** so that users can take over the code to their individual project.
Have a look at the `Examples`.

6.8.2 Member Function Documentation

6.8.2.1 getCoordinates()

```
void GEOM_FADE2D::FadeExport::getCoordinates (
        int vtxIdx,
        double & x,
        double & y ) const  [inline]
```

Parameters

vtxIdx	[in] vertex index
x,y	[out] coordinates

6.8.2.2 getCornerIndices()

```
void GEOM_FADE2D::FadeExport::getCornerIndices (
        int triIdx,
        int & vtxIdx0,
        int & vtxIdx1,
        int & vtxIdx2 ) const  [inline]
```

Parameters

triIdx	[in] triangle index
vtxIdx0,vtxIdx1,vtxIdx2	[out] corner indices

The documentation for this struct was generated from the following file:

- FadeExport.h

6.9 GEOM_FADE2D::Func_gtEdge2D Struct Reference

Functor to sort edges by 2d length (descending)

`#include <Edge2.h>`

Public Member Functions

- bool **operator()** (const Edge2 &e0, const Edge2 &e1) const

The documentation for this struct was generated from the following file:

- Edge2.h

6.10 GEOM_FADE2D::Func_ltEdge2D Struct Reference

Functor to sort edges by 2d length (ascending)

`#include <Edge2.h>`

Public Member Functions

- bool **operator()** (const Edge2 &e0, const Edge2 &e1) const

The documentation for this struct was generated from the following file:

- Edge2.h

6.11 GEOM_FADE2D::Label Class Reference

Label is a Text-Label for Visualization.

`#include <Label.h>`

Public Member Functions

- **Label** (const Label &other)
- Label (const Point2 &p_, const char ∗s_, bool bWithMark_=true, int fontSize_=8)

  Constructs a Text-Label.
- const char ∗ **getCS** () const
- Label & **operator=** (const Label &other)

Public Attributes

- bool **bWithMark**
- int **fontSize**
- Point2 **p**
- LDat ∗ **pDat**

6.11.1 Detailed Description

See also

Visualizer2 where Label objects are used for visualizations

6.11.2 Constructor & Destructor Documentation

6.11.2.1 Label()

```
GEOM_FADE2D::Label::Label (
    const Point2 & p_,
    const char * s_,
    bool bWithMark_ = true,
    int fontSize_ = 8 )
```

Parameters

*p_*	is the point where the label appears
*s_*	is the text to be shown
*bWith↩ Mark_*	switches between text-only and text-with-mark
*fontSize_*	

The documentation for this class was generated from the following file:

- Label.h

6.12 GEOM_FADE2D::MeshGenParams Class Reference

Parameters for the mesh generator.
`#include <MeshGenParams.h>`

Public Member Functions

- **MeshGenParams** (Zone2 ∗pZone_)
- void addLockedConstraint (ConstraintSegment2 ∗pConstraintSegment)

  Constraint Segments that shall not be splitted.
- virtual double getMaxEdgeLength (Triangle2 ∗pT)

  getMaxEdgeLength(Triangle2∗ pT)
- virtual double getMaxTriangleArea (Triangle2 ∗pT)

  getMaxTriangleArea(Triangle2∗ pT)

Public Attributes

- bool bAllowConstraintSplitting

  bAllowConstraintSplitting
- bool bKeepExistingSteinerPoints

  Steiner points from previous refinements.
- double capAspectLimit

  capAspectLimit

- int command

  Command.
- double gridLength

  gridLength
- Vector2 gridVector

  gridVector
- double growFactor

  growFactor
- double growFactorMinArea

  growFactorMinArea
- double maxEdgeLength

  Maximum edge length.
- double maxTriangleArea

  maxTriangleArea
- double minAngleDegree

  Minimum interior triangle angle.
- double minEdgeLength

  Minimum edge length.
- Zone2 ∗ pZone

  Zone to be meshed.

6.12.1 Detailed Description

This class serves as container for mesh generator parameters. Client code can provide a class which derives from MeshGenParams and which provides custom implementations of the getMaxTriangleArea(Triangle∗ pT) method or the getMaxEdgeLength(Triangle∗ pT) method in order to gain control over the local density of the generated mesh. When the meshing algorithm decides if a certain triangle T must be refined, then it calls these functions.

See also

`http://www.geom.at/advanced-mesh-generation/`

6.12.2 Member Function Documentation

6.12.2.1 addLockedConstraint() `void GEOM_FADE2D::MeshGenParams::addLockedConstraint ( ConstraintSegment2 * pConstraintSegment )`

In case that some ConstraintSegment2 can be splitted and others must not be splitted use `bAllowConstraintSplitting=true` and add the ones that must not be splitted.

6.12.2.2 getMaxEdgeLength() `virtual double GEOM_FADE2D::MeshGenParams::getMaxEdgeLength ( Triangle2 * pT ) [inline], [virtual]`

Parameters

pT	is a triangle for which the meshing algorithm checks if it must be refined.

The default implementation of the present class returns the value maxEdgeLength (which is DBL_MAX if not changed by the user). This method can be overridden by the client software in order to control the local mesh density.

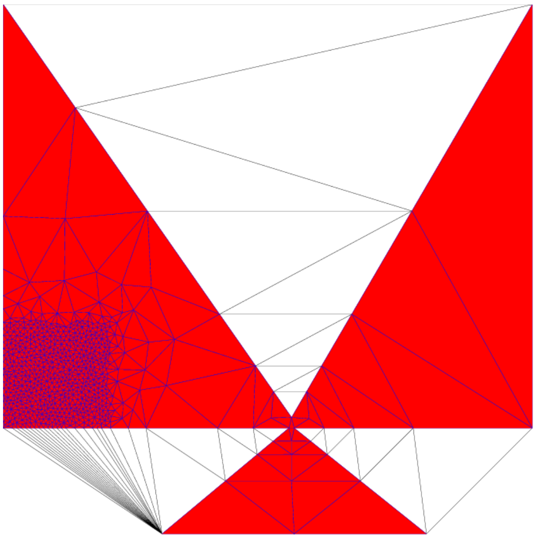


Figure 14 User Controlled Mesh Density, Edge Length

6.12.2.3 getMaxTriangleArea() `virtual double GEOM_FADE2D::MeshGenParams::getMaxTriangleArea ( Triangle2 * pT ) [inline], [virtual]`

Parameters

pT	is a triangle for which the meshing algorithm checks if it must be refined.

The default implementation of the present class returns the value maxTriangleArea (which is the default value DBL_MAX if not changed by the user). This method can be overridden by the client software in order to control the local mesh density.

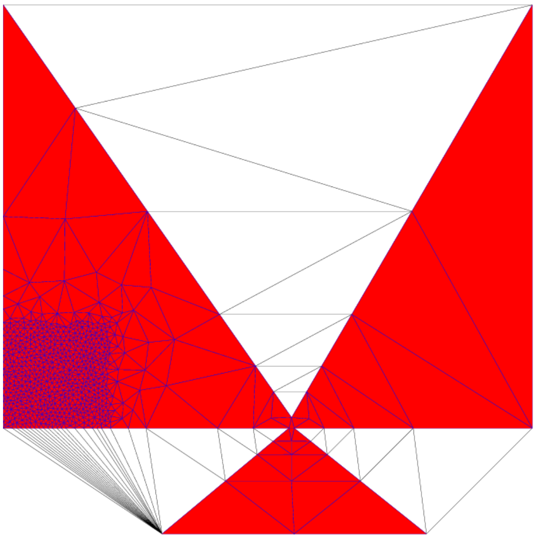


Figure 15 User Controlled Mesh Density, Area

6.12.3 Member Data Documentation

6.12.3.1 bAllowConstraintSplitting `bool GEOM_FADE2D::MeshGenParams::bAllowConstraintSplitting`

Defines if constraint segments can be splitted. Default: yes

6.12.3.2 bKeepExistingSteinerPoints `bool GEOM_FADE2D::MeshGenParams::bKeepExistingSteinerPoints`

A previous call to refine() or refineAdvanced() may have created Steiner points. These may be partially or entirely removed during a later refinement call, even (!) if this later refinement takes place in a different zone. It depends on your application if this behavior is desired or not. Usually you want to preserve the points, thus the default value of /p bKeepExistingSteinerPoints is true.

6.12.3.3 capAspectLimit `double GEOM_FADE2D::MeshGenParams::capAspectLimit`

Limits the quotient edgeLength / height. Default value: 10.0

6.12.3.4 command `int GEOM_FADE2D::MeshGenParams::command`

A command for development, not for public use. Will vanish soon.

6.12.3.5 gridLength `double GEOM_FADE2D::MeshGenParams::gridLength`

Set gridLength $>$ 0 to mesh large enough areas with grid points. Border areas and narrow stripes where a grid does not fit are automatically meshed using classic Delaunay methods. By default gridLength=0 (off).

Note

> The length of the diagonals in the grid is sqrt(2)$*$gridLength and the algorithm may automatically adapt the gridLength a bit such that the grid fits better into the shape.

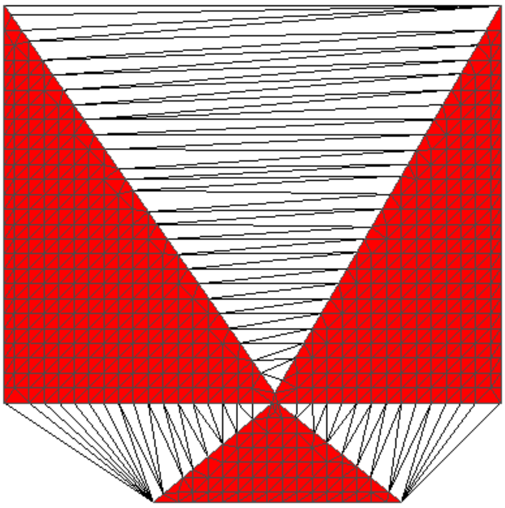


Figure 16 Grid Meshing axis aligned

6.12.3.6 gridVector `Vector2 GEOM_FADE2D::MeshGenParams::gridVector`

When grid-meshing is used the grid is aligned to the `gridVector`. By default `gridVector` is axis aligned.

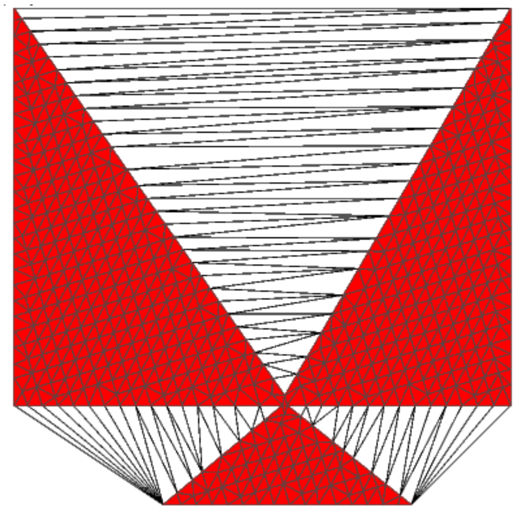


Figure 17 Grid Meshing along Vector2(1.0,0.3)

6.12.3.7 growFactor `double GEOM_FADE2D::MeshGenParams::growFactor`

Limits the growth of adjacent triangles. The mesh is constructed such that for any two adjacent triangles t0 and t1 (where t0 is the larger one) area(t0)/area(t1) < growFactor. Recommendation: growFactor>5.0, Default: growFactor=DBL_MAX

6.12.3.8 growFactorMinArea `double GEOM_FADE2D::MeshGenParams::growFactorMinArea`

The growFactor value is ignored for triangles with a smaller area than growFactorMinArea. This value prevents generation of hundreds of tiny triangles around one that is unusually small. Default: 0.001

6.12.3.9 maxEdgeLength `double GEOM_FADE2D::MeshGenParams::maxEdgeLength`

This value is returned by the default implementation of getMaxEdgeLength(Triangle∗ pT). Larger edges are automatically subdivided. If a custom implementation of getMaxEdgeLength(Triangle∗ pT) is provided then this value is ignored. Default value: DBL_MAX.

6.12.3.10 maxTriangleArea `double GEOM_FADE2D::MeshGenParams::maxTriangleArea`

This value is returned by the default implementation of getMaxTriangleArea(Triangle∗ pT). Larger triangles are automatically subdivided. If a custom implementation of getMaxTriangleArea(Triangle∗ pT) is provided then this value is ignored. Default value: DBL_MAX.

6.12.3.11 minAngleDegree `double GEOM_FADE2D::MeshGenParams::minAngleDegree`

Minimum interior angle: Default: 20.0, maximum: 30.0

6.12.3.12 minEdgeLength `double GEOM_FADE2D::MeshGenParams::minEdgeLength`

Edges below the minimum length are not subdivided. This parameter is useful to avoid tiny triangles. Default: 0.001

The documentation for this class was generated from the following file:

- MeshGenParams.h

6.13 GEOM_FADE2D::MsgBase Class Reference

MsgBase, a base class for message subscriber classes.

`#include <MsgBase.h>`

Public Member Functions

- virtual void update (MsgType msgType, const char ∗s, double d)=0

  update

6.13.1 Detailed Description

MsgBase is a base class from which message subscriber classes (for example widgets, progress bars, ...) can be derived which then receive messages (progress, warnings, ...) from Fade.

See also

`http://www.geom.at/progress-bar/`

6.13.2 Member Function Documentation

6.13.2.1 update()

```
virtual void GEOM_FADE2D::MsgBase::update (
        MsgType msgType,
        const char * s,
        double d ) [pure virtual]
```

This method must be defined in derived classes. It is automatically called everytime Fade has a message of type `msgType`.

The documentation for this class was generated from the following file:

- MsgBase.h

6.14 GEOM_FADE2D::PeelPredicateTS Class Reference

User-defined peel predicate.

`#include <UserPredicates.h>`

Public Member Functions

- virtual bool **operator()** (const Triangle2 ∗, std::set< Triangle2 ∗ > ∗pCurrentSet)=0

6.14.1 Detailed Description

This class is the successor of the deprecated (but still valid) UserPredicateT. In contrast to UserPredicateT the operator() receives also a set of current triangles to enable border-edge tests.

See also

`https://www.geom.at/mesh-improvements/`

The documentation for this class was generated from the following file:

- UserPredicates.h

6.15 GEOM_FADE2D::Point2 Class Reference

Point.

`#include <Point2.h>`

Public Member Functions

- Point2 ()

  Default constructor.
- Point2 (const double x_, const double y_)

  Constructor.

- Point2 (const Point2 &p_)

    Copy constructor.
- void **change** (const double x_, const double y_)
- int getCustomIndex () const

    Get the custom index.
- Triangle2 ∗ getIncidentTriangle () const

    Get the associated triangle.
- double getMaxAbs () const

    Get max(abs(x),abs(y))
- bool operator!= (const Point2 &p) const

    Inequality operator.
- Point2 operator+ (const Vector2 &vec) const

    Add vector and point.
- Vector2 operator- (const Point2 &other) const

    Returns a vector from other to ∗this.
- Point2 operator- (const Vector2 &vec) const

    Subtract vector from point.
- bool operator< (const Point2 &p) const

    Less than operator.
- Point2 & **operator=** (const Point2 &other)
- bool operator== (const Point2 &p) const

    Equality operator.
- bool operator> (const Point2 &p) const

    Greater than operator.
- void set (const double x_, const double y_, int customIndex_)

    Set the coordinates and customIndex.
- void set (const Point2 &pnt)

    Set the coordiantes.
- void setCustomIndex (int customIndex_)

    Set a custom index.
- void setIncidentTriangle (Triangle2 ∗pT)

    Associate a triangle with the point.
- double x () const

    Get the x-coordinate.
- void xy (double &x_, double &y_) const

    Get the x- and y-coordinate.
- double y () const

    Get the y-coordinate.

Protected Attributes

- double **coordX**
- double **coordY**
- int **customIndex**
- Triangle2 ∗ **pAssociatedTriangle**

Friends

- class **Dt2**
- std::ostream & operator<< (std::ostream &stream, const Point2 &pnt)

    Print to stream.
- std::istream & operator>> (std::istream &stream, Point2 &pnt)

    Stream-to-Point.

6.15.1 Detailed Description

This class represents a point in 2D with x- and y-coordinates and an additional pointer to an associated triangle.

6.15.2 Constructor & Destructor Documentation

6.15.2.1 Point2() `[1/3]` `GEOM_FADE2D::Point2::Point2 (`

`const double x_,`
`const double y_ ) [inline]`

Parameters

x↩_↩	x-coordinate
y↩_↩	y-coordinate

6.15.2.2 Point2() `[2/3]` `GEOM_FADE2D::Point2::Point2 ( ) [inline]`

The coordinates are initialized to -DBL_MAX

6.15.2.3 Point2() `[3/3]` `GEOM_FADE2D::Point2::Point2 (`

`const Point2 & p_ ) [inline]`

Create a point as a copy of p_. The associated triangle pointer is initialized to NULL

6.15.3 Member Function Documentation

6.15.3.1 getCustomIndex() `int GEOM_FADE2D::Point2::getCustomIndex ( ) const [inline]`

Returns

the custom index.

Note

The custom index defaults to -1. It is not the index of the point in the triangulation (such an index does not exist) but an arbitrary value which can be set by the user.

See also

void setCustomIndex(int customIndex_)

A best practices example that deals with indices: `http://www.geom.at/runtime/`

6.15.3.2 getIncidentTriangle() `Triangle2* GEOM_FADE2D::Point2::getIncidentTriangle ( ) const [inline]`

Returns

the associated triangle

6.15.3.3 getMaxAbs() `double GEOM_FADE2D::Point2::getMaxAbs ( ) const [inline]`

6.15.3.4 operator"!=() `bool GEOM_FADE2D::Point2::operator!= ( const Point2 & p ) const [inline]`

Compares the x and y coordinates

Note

Although a point has a z-coordinate in the 2.5D version only x and y a compared by this method

6.15.3.5 operator<() `bool GEOM_FADE2D::Point2::operator< ( const Point2 & p ) const [inline]`

Compares the x and y coordinates

Note

Although a point has a z-coordinate in the 2.5D version only x and y a compared by this method

6.15.3.6 operator==() `bool GEOM_FADE2D::Point2::operator== ( const Point2 & p ) const [inline]`

Compares the x and y coordinates

Note

Although a point has a z-coordinate in the 2.5D version only x and y a compared by this method

6.15.3.7 operator>() `bool GEOM_FADE2D::Point2::operator> ( const Point2 & p ) const [inline]`

Compares the x and y coordinates

Note

Although a point has a z-coordinate in the 2.5D version only x and y a compared by this method

6.15.3.8 set() [1/2]

```
void GEOM_FADE2D::Point2::set (
        const double x_,
        const double y_,
        int customIndex_ ) [inline]
```

Internal method

Parameters

*x_*	x-coordinate
*y_*	y-coordinate
*customIndex_*	Arbitrary index, use -1 if not required

6.15.3.9 set() [2/2]

```
void GEOM_FADE2D::Point2::set (
        const Point2 & pnt ) [inline]
```

Parameters

pnt	is the point whose coordinates are assigned to the current point

6.15.3.10 setCustomIndex() `void GEOM_FADE2D::Point2::setCustomIndex ( int customIndex_ ) [inline]`

An arbitrary index can be assigned to a point. Use getCustomIndex() to retrieve it later.

Note

This method is provided for the users' convenience. It has nothing to do with the internal data structures of Fade 2D and using this method is optional. By default this index is -1.

See also

int getCustomIndex()

A best practices example that deals with indices: http://www.geom.at/runtime/

6.15.3.11 setIncidentTriangle() `void GEOM_FADE2D::Point2::setIncidentTriangle ( Triangle2 * pT ) [inline]`

Parameters

pT	will be associated with the triangle

6.15.3.12 x() `double GEOM_FADE2D::Point2::x ( ) const [inline]`

Returns

the x-coordinate

6.15.3.13 xy() `void GEOM_FADE2D::Point2::xy ( double & x_, double & y_ ) const [inline]`

Parameters

*x_*	x-coordinate
*y_*	y-coordinate

6.15.3.14 y() `double GEOM_FADE2D::Point2::y ( ) const [inline]`

Returns

the y-coordinate

The documentation for this class was generated from the following file:

- Point2.h

6.16 GEOM_FADE2D::Segment2 Class Reference

Segment.
`#include <Segment2.h>`

Public Member Functions

- Segment2 ()
- Segment2 (const Point2 &src_, const Point2 &trg_)

  Create a Segment2.
- double getSqLen2D () const
- Point2 getSrc () const
- Point2 getTrg () const
- bool operator== (const Segment2 &other) const
- void swapSrcTrg ()

Protected Attributes

- Point2 **src**
- Point2 **trg**

Friends

- std::ostream & **operator**<< (std::ostream &stream, Segment2 seg)

6.16.1 Detailed Description

6.16.2 Constructor & Destructor Documentation

6.16.2.1 Segment2() [1/2] `GEOM_FADE2D::Segment2::Segment2 (`

```
const Point2 & src_,
const Point2 & trg_ )
```

Parameters

src← _	First endpoint (source)
trg← _	Second endpoint (target)

6.16.2.2 Segment2() [2/2] `GEOM_FADE2D::Segment2::Segment2 ( )`

Create a Segment2 Default constructor

6.16.3 Member Function Documentation

6.16.3.1 getSqLen2D() `double GEOM_FADE2D::Segment2::getSqLen2D ( ) const`

Get the squared length

6.16.3.2 getSrc() `Point2 GEOM_FADE2D::Segment2::getSrc ( ) const`

Get the source point

Returns

the source point

6.16.3.3 getTrg() `Point2 GEOM_FADE2D::Segment2::getTrg ( ) const`

Get the target point

Returns

the target point

6.16.3.4 operator==() `bool GEOM_FADE2D::Segment2::operator== ( const Segment2 & other ) const`

operator==
Undirected equality operator

6.16.3.5 swapSrcTrg() `void GEOM_FADE2D::Segment2::swapSrcTrg ( )`

Internally swaps the source and target point
The documentation for this class was generated from the following file:

- Segment2.h

6.17 GEOM_FADE2D::SegmentChecker Class Reference

SegmentChecker identifies intersecting line segments.
`#include <SegmentChecker.h>`

Public Member Functions

- SegmentChecker (const std::vector< Segment2 ∗ > &vSegments_)
- ClipResult clipSegment (Segment2 &seg)
- void getIllegalSegments (bool bAlsoEndPointIntersections, std::vector< Segment2 ∗ > &vIllegalSegmentsOut) const
- int getIndex (Segment2 ∗pSeg) const
- void getIntersectionPoint (SegmentIntersectionType typ, const Segment2 &seg0, const Segment2 &seg1, Point2 &ispOut) const
- void getIntersectionSegment (const Segment2 &seg0, const Segment2 &seg1, Segment2 &issOut) const
- SegmentIntersectionType getIntersectionType (const Segment2 ∗pSeg1, const Segment2 ∗pSeg2) const
- const char ∗ getIntersectionTypeString (SegmentIntersectionType sit) const
- void getIntersectors (Segment2 ∗pTestSegment, bool bAlsoEndPointIntersections, std::vector< std::pair< Segment2 ∗, SegmentIntersectionType > > &vIntersectorsOut) const
- Bbox2 getLimit () const
- size_t getNumberOfSegments () const
- Segment2 ∗ getSegment (size_t i) const
- void setLimit (const Bbox2 &bbx)
- void showIllegalSegments (bool bAlsoEndPointIntersections, const char ∗name) const
- void showSegments (const char ∗name) const
- void subscribe (MsgType msgType, MsgBase ∗pMsg)
- void unsubscribe (MsgType msgType, MsgBase ∗pMsg)

6.17.1 Detailed Description

SegmentChecker takes a bunch of line segments and fully automatically identifies illegal segment intersections. The intersection points can be computed in 2D and in 2.5D. Further this class offers visualization methods. Due to the underlying datastructure the search algorithm scales very well to large inputs.

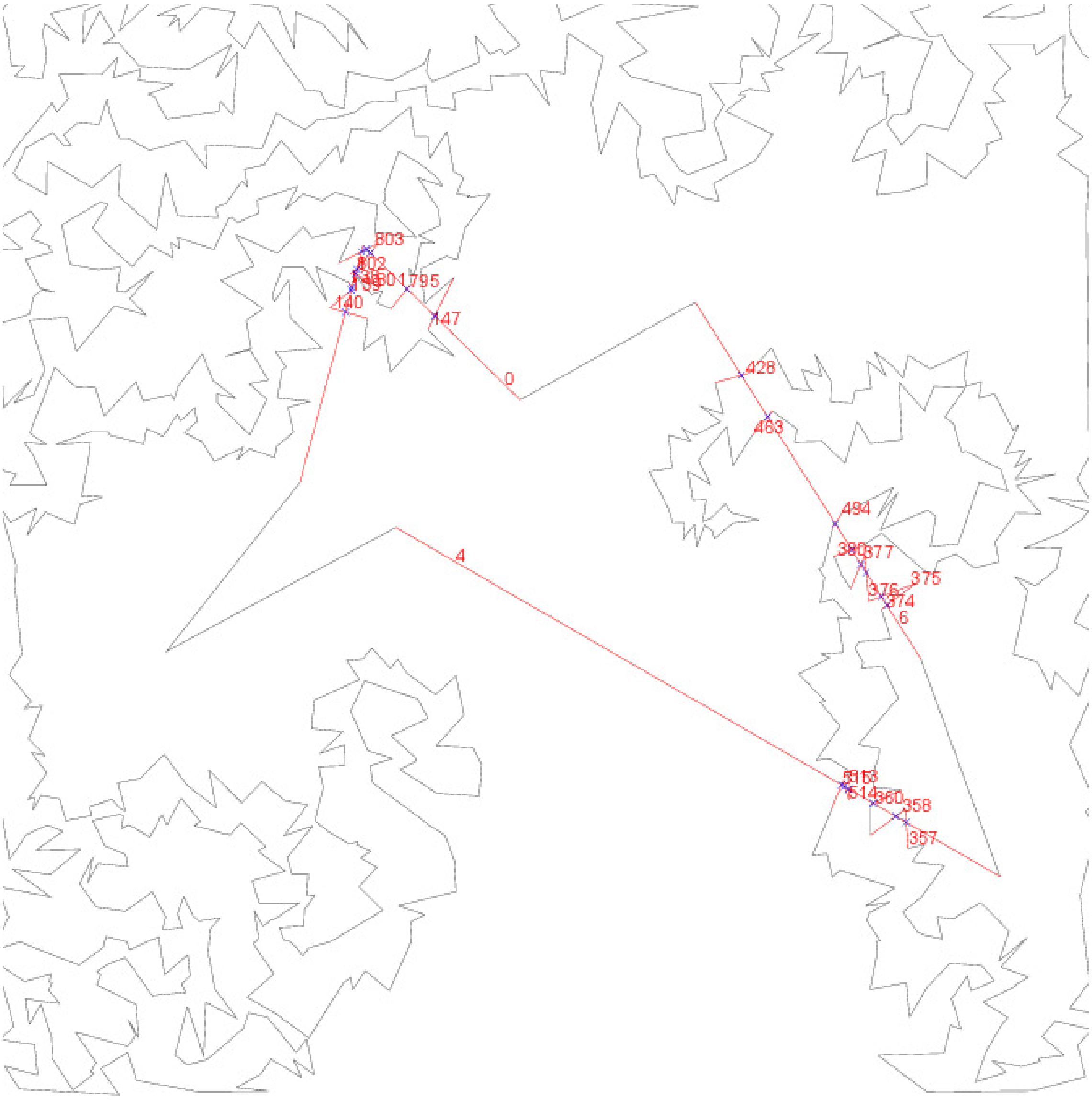


Figure 18 Polylines: Intersecting segments are automatically found

See also

`http://www.geom.at/segment-checker/`

6.17.2 Constructor & Destructor Documentation

6.17.2.1 SegmentChecker() `GEOM_FADE2D::SegmentChecker::SegmentChecker ( const std::vector< Segment2 * > & vSegments_ ) [explicit]`

Internally this constructor prepares a data structure from `vSegments` that enables efficient spatial searches. The time complexity is O(n∗log(n)).

Parameters

v↩ Segments↩ _	contains the segments to be checked

6.17.3 Member Function Documentation

6.17.3.1 clipSegment() `ClipResult GEOM_FADE2D::SegmentChecker::clipSegment ( Segment2 & seg )`

Clip Segment

Use this method to limit the length of a line-segment to its intersection with a box. The result can be the whole segment, a subsegment, a degenerate segment or the result can be empty. In the last case the segment is not changed but the method returns CR_EMPTY.

Parameters

`in,out`	*seg*	is the line segment to be clipped

Returns

CR_INVALID,CR_EMPTY, CR_CLIPPED_DEGENERATE, CR_CLIPPED_NONDEGENERATE, CR_COMPLETE_DEGENERATE, CR_COMPLETE_NONDEGENERATE or CR_INVALID.

Note

In case that you missed to call setLimit() with a valid bounding box before, the method returns CR_INVALID };

6.17.3.2 getIllegalSegments() `void GEOM_FADE2D::SegmentChecker::getIllegalSegments ( bool bAlsoEndPointIntersections, std::vector< Segment2 * > & vIllegalSegmentsOut ) const`

Get illegal segments

Returns segments which are involved in intersections. Intersections at endpoints are only reported when `bAlsoEndPointIntersections` is true. The asymptotic time consumption for the lookup per segment S is O(log(n)+k) where k is the number of segments that intersect the minimal bounding box of S. Thus, for n segments the method takes O(n∗(log(n)+k)) time.

Parameters

	bAlsoEndPointIntersections	specifies if intersections at endpoints shall be detected
`out`	*vIllegalSegmentsOut*	is the output vector

6.17.3.3 getIndex() `int GEOM_FADE2D::SegmentChecker::getIndex ( Segment2 * pSeg ) const`

Returns the index of a segment

Parameters

pSeg	is the segment whose index is returned

6.17.3.4 getIntersectionPoint()

```
void GEOM_FADE2D::SegmentChecker::getIntersectionPoint (
            SegmentIntersectionType typ,
            const Segment2 & seg0,
            const Segment2 & seg1,
            Point2 & ispOut ) const
```

Compute the intersection point of two segments
Use getIntersectionType() to determine the segment intersection type `sit`.

Parameters

	typ	is the intersection type (SIT_POINT or SIT_ENDPOINT for the present method)
	seg0,seg1	are the intersecting segments
`out`	*ispOut*	is the output intersection point.

Note

> `pSeg1` and `pSeg2` do not need to be from the set that has been used to initialize the SegmentChecker.

6.17.3.5 getIntersectionSegment()

```
void GEOM_FADE2D::SegmentChecker::getIntersectionSegment (
            const Segment2 & seg0,
            const Segment2 & seg1,
            Segment2 & issOut ) const
```

Computes the intersection segment of two collinear intersecting segments

Parameters

	seg0,seg1	are intersecting segments such that their SegmentIntersectionType is SIT_SEGMENT
`out`	*issOut*	is the computed intersection of `seg0` and `seg1`

Note

> `pSeg1` and `pSeg2` do not need to be from the set that has been used to initialize the present object

6.17.3.6 getIntersectionType()

```
SegmentIntersectionType GEOM_FADE2D::SegmentChecker::getIntersection↩
Type (
            const Segment2 * pSeg1,
            const Segment2 * pSeg2 ) const
```

Get the intersection type of two segments

Parameters

pSeg1,pSeg2	are the segments to be checked

Returns

> SIT_NONE (no intersection),
> SIT_SEGMENT (collinear intersection),
> SIT_POINT (intersection somewhere between the endpoints) or
> SIT_ENDPOINT (endpoint intersection)

Note

> `pSeg1` and `pSeg2` do not need to be from the set that has been used to initialize the present object

6.17.3.7 getIntersectionTypeString()

`const char* GEOM_FADE2D::SegmentChecker::getIntersectionTypeString ( SegmentIntersectionType sit ) const`

Return the intersection type as a human readable string. This is a convenience function

Parameters

sit	is an intersection type to be converted to a string

6.17.3.8 getIntersectors()

`void GEOM_FADE2D::SegmentChecker::getIntersectors ( Segment2 * pTestSegment, bool bAlsoEndPointIntersections, std::vector< std::pair< Segment2 *, SegmentIntersectionType > > & vIntersectorsOut ) const`

Return segments that intersect a certain segment along with their intersection type

Parameters

	pTestSegment	is the segment to be analyzed
	bAlsoEndPointIntersections	specifies if intersections of type SIT_ENDPOINT shall also be reported.
`out`	*vIntersectorsOut*	is the output vector. Segments intersecting `pTestSegment` are added to `vIntersectorsOut` along with their intersection type.

Note

> When vIntersectorsOut is non-empty, it is not cleared but the intersected segments are added.

The time complexity is O(log(n)+k) where n is the number of segments and k is the number of intersections for `pTestSegment`.

6.17.3.9 getLimit()

`Bbox2 GEOM_FADE2D::SegmentChecker::getLimit ( ) const`

Get Limit

Returns

> the bounding box that has been set before using setLimit()

6.17.3.10 getNumberOfSegments()

`size_t GEOM_FADE2D::SegmentChecker::getNumberOfSegments ( ) const`

Returns the number of segments contained in this SegmentChecker object

6.17.3.11 getSegment()

`Segment2* GEOM_FADE2D::SegmentChecker::getSegment ( size_t i ) const`

Returns the i-th segment

Parameters

i	is the index of the segment to be returned

6.17.3.12 setLimit() `void GEOM_FADE2D::SegmentChecker::setLimit (`

`const Bbox2 & bbx )`

Set Limit

Sets the bounding box `bbx` that is used by clipSegment() to limit the length of a line segment

6.17.3.13 showIllegalSegments() `void GEOM_FADE2D::SegmentChecker::showIllegalSegments (`

`bool bAlsoEndPointIntersections,`

`const char * name ) const`

Write a postscript file, highlight illegal segments

Parameters

bAlsoEndPointIntersections	specifies if intersections at endpoints are also illegal
name	is the output filename

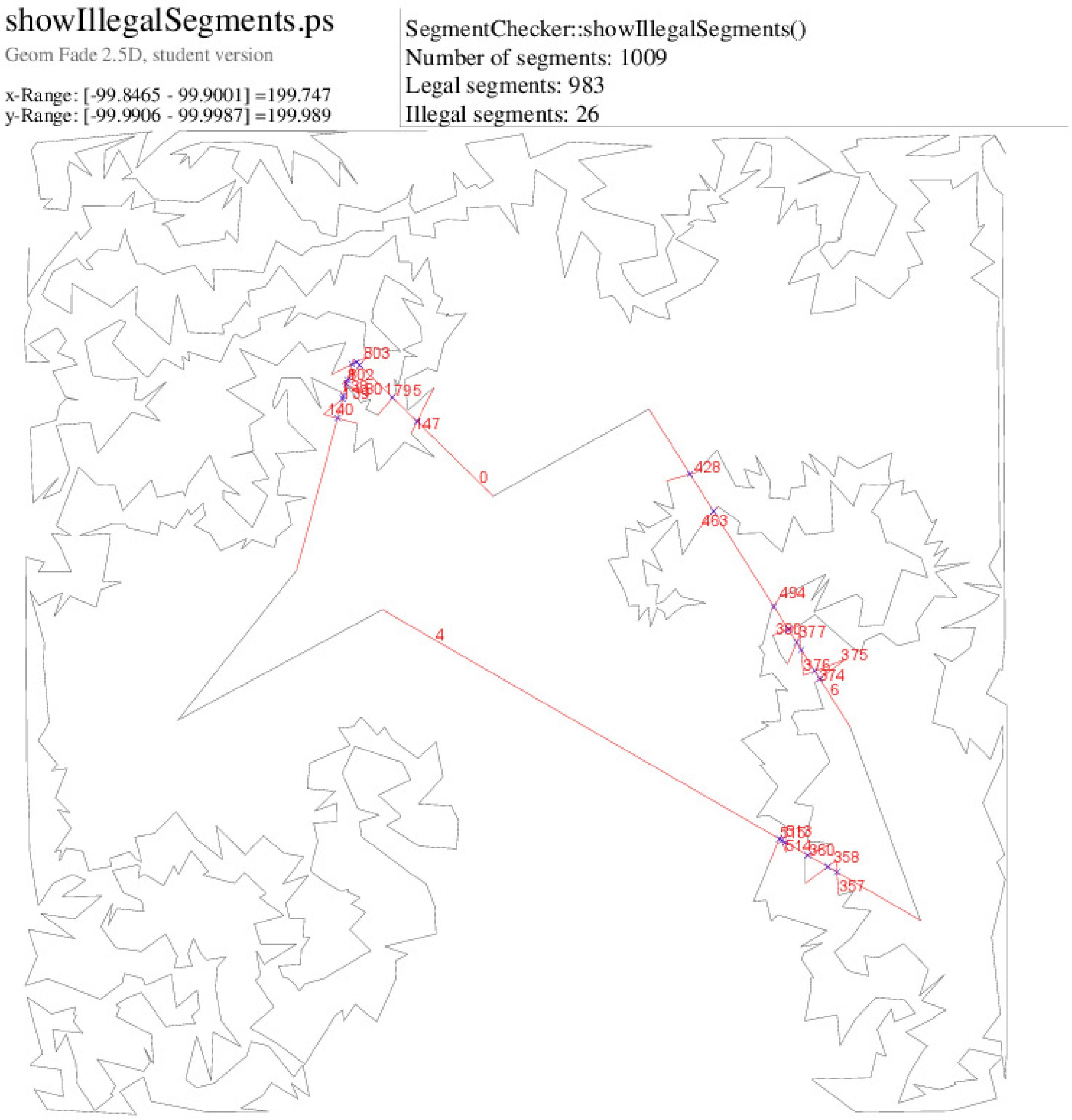

showIllegalSegments.ps
Geom Fade 2.5D, student version
x-Range: [-99.8465 - 99.9001] =199.747
y-Range: [-99.9906 - 99.9987] =199.989
SegmentChecker::showIllegalSegments()
Number of segments: 1009
Legal segments: 983
Illegal segments: 26
803
802
801
795
140
147
0
428
463
494
377
375
376
374
6
4
358
357

Figure 19 Visualization of polyline intersections

6.17.3.14 showSegments() `void GEOM_FADE2D::SegmentChecker::showSegments ( const char * name ) const`

Write all segments, with and without intersection, to a postscript file

Parameters

name	is the output filename

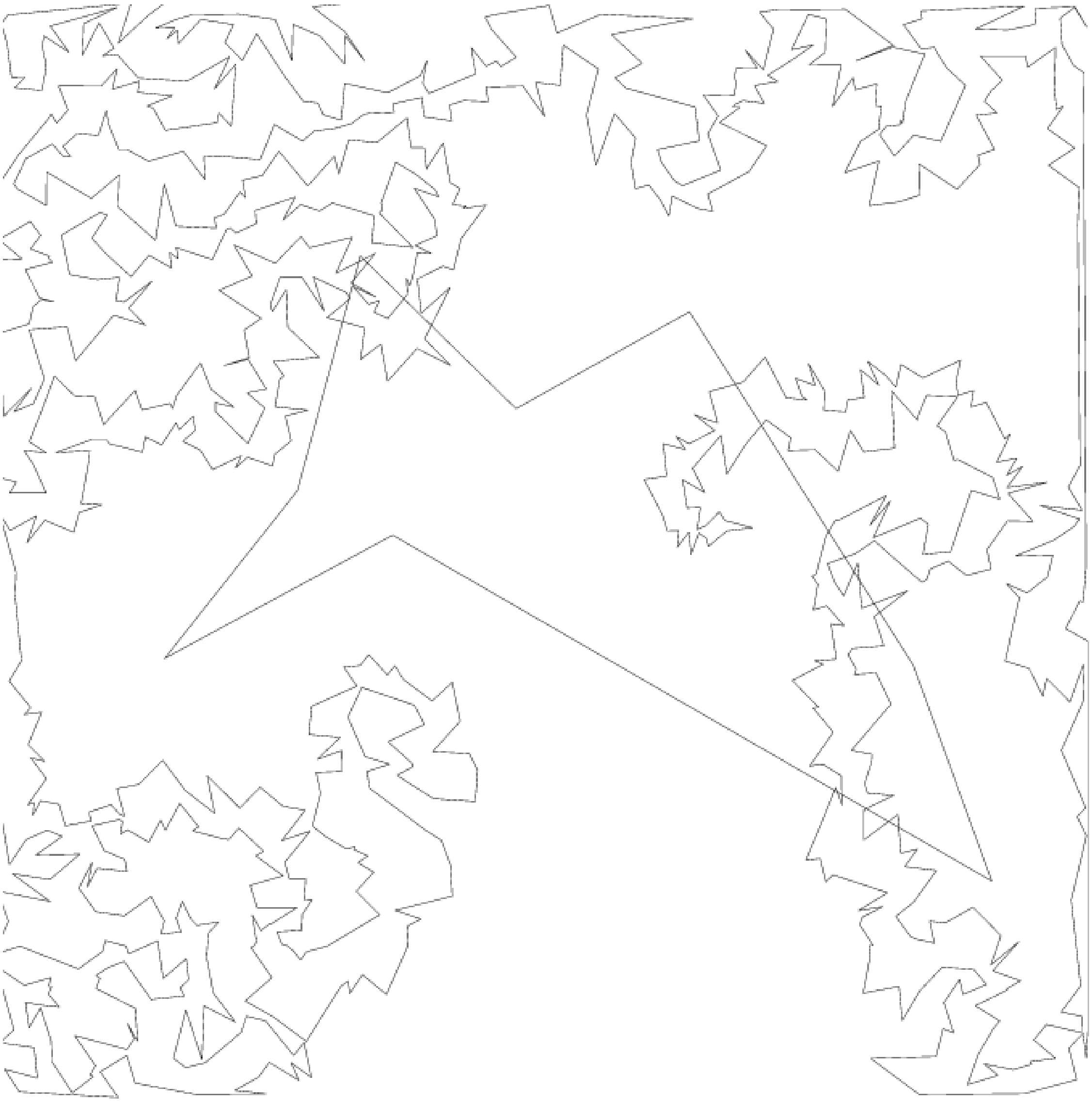


Figure 20 Line segments written to a postscript file

6.17.3.15 subscribe() `void GEOM_FADE2D::SegmentChecker::subscribe ( MsgType msgType, MsgBase * pMsg )`

Register a progress bar object

The SegmentChecker does its job typically in fractions of a second. But inputs may contain a quadratic number of intersections and such tasks take a while. Therefore a user defined message object (your own progress-bar class) can be registered in order to get progress updates. This step is optional.

Parameters

msgType	is the message type. For progress information the type is always MSG_PROGRESS
pMsg	is a user defined progress bar which derives from Fade's MsgBase.

6.17.3.16 unsubscribe() `void GEOM_FADE2D::SegmentChecker::unsubscribe (`

```
            MsgType msgType,
            MsgBase * pMsg )
```

Unregister a progress bar object

Parameters

msgType	is the message type. For progress information the type is always MSG_PROGRESS
pMsg	is a user defined class which derives from Fade's MsgBase

The documentation for this class was generated from the following file:

- SegmentChecker.h

6.18 GEOM_FADE2D::Triangle2 Class Reference

Triangle.

`#include <Triangle2.h>`

Public Member Functions

- Triangle2 ()

  Constructor.
- void clearProperties ()

  Clear all corners and neighbor pointers.
- double getArea2D () const

  Get 2D Area.
- Point2 getBarycenter () const

  Get the barycenter of a triangle.
- Point2 getCircumcenter (CircumcenterQuality &ccq, bool bForceExact=false) const

  Get the circumcenter of the triangle.
- std::pair< Point2, bool > **getDual** (bool bForceExact=false) const
- double getInteriorAngle2D (int ith) const

  Get interior 2D angle.
- int getIntraTriangleIndex (const Point2 ∗p) const

  Get the index of p in the triangle.
- int getIntraTriangleIndex (const Point2 ∗p0, const Point2 ∗p1) const

  Get the index of (p0,p1)
- int getIntraTriangleIndex (const Triangle2 ∗pTriangle) const

  Get the neighbor index of pTriangle.
- int getMaxIndex () const

  Get the index of the largest edge.
- double getMaxSqEdgeLen2D () const

  Get the maximum squared 2D edge length.
- int getMinIndex () const

  Get the index of the smallest edge.
- Triangle2 ∗ getOppositeTriangle (const int ith) const

  Get the i-th neighbor triangle.
- double getSquaredEdgeLength2D (int ith) const

  ∗∗
- bool hasOnEdge (int i, const Point2 &q) const

  Has point on edge.
- bool hasVertex (const Point2 &vtx) const

  Has vertex.

- bool hasVertex (Point2 ∗pVtx) const

  Has vertex.
- void setOppTriangle (const int ith, Triangle2 ∗pTriangle)

  Set the i-th neighbor triangle.
- void setProperties (Point2 ∗pI, Point2 ∗pJ, Point2 ∗pK)

  Set all corners.
- void setPropertiesAndOppT (Point2 ∗pI, Point2 ∗pJ, Point2 ∗pK, Triangle2 ∗pNeig0, Triangle2 ∗pNeig1, Triangle2 ∗pNeig2)

  Set all corners and neighbor triangles.
- void setVertexPointer (const int ith, Point2 ∗pp)

  Set the i-th corner.

Protected Member Functions

- double **computeArea** (double l0, double l1, double l2) const
- bool **getCC_inexact** (double avgOffX, double avgOffY, Point2 &cc) const

Protected Attributes

- Triangle2 ∗ **aOppTriangles** [3]
- Point2 ∗ **aVertexPointer** [3]

Friends

- std::ostream & **operator**<< (std::ostream &stream, const Triangle2 &c)
- void **registerTriangles** (Triangle2 ∗fromTriangle, int ith, Triangle2 ∗toTriangle, int jth)

6.18.1 Detailed Description

Triangle2 is a triangle in the Fade_2D triangulation. It holds three Point2 pointers to its corners. The corners are numbered in counterclockwise order. We refer to these indices as intra-triangle-indices.
Each triangle has three neighbors which can be accessed through intra-triangle-indices: The i-th neighbor triangle of a certain triangle T is the one which shares an edge with T such that this edge does not include the i-th corner of T.

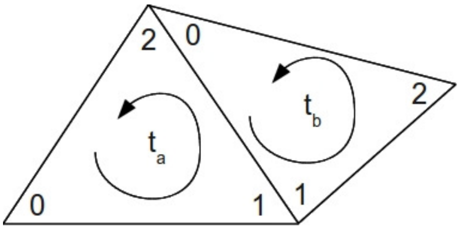


Figure 21 Indices and neighborships, *tb* is the 0-th neighbor of *ta* and *ta* is the 2nd neighbor of *tb*.

See also

TriangleAroundVertexIterator to find out how to access all triangles incident to a certain vertex.

6.18.2 Constructor & Destructor Documentation

6.18.2.1 Triangle2() `GEOM_FADE2D::Triangle2::Triangle2 ( ) [inline]`

6.18.3 Member Function Documentation

6.18.3.1 getArea2D() `double GEOM_FADE2D::Triangle2::getArea2D ( ) const`

Returns the 2D area of the triangle.
Note: The getArea() method is deprecated and replaced by getArea2D() to keep the names consistent.

6.18.3.2 getBarycenter() `Point2 GEOM_FADE2D::Triangle2::getBarycenter ( ) const`

Returns

the barycenter of the triangle.

6.18.3.3 getCircumcenter() `Point2 GEOM_FADE2D::Triangle2::getCircumcenter (`

```
CircumcenterQuality & ccq,
bool bForceExact = false ) const
```

Parameters

out	*ccq*	holds the quality of the computed point and is one of CCQ_INEXACT, CCQ_EXACT and CCQ_OUT_OF_BOUNDS.
in	*bForceExact*	forces exact computation with multiple-precision arithmetic. When bForceExact=false, then the faster double-precision arithmetic is used for good shaped triangles.

Returns

the circumcenter of the triangle

Attention

Attention: The circumcenter of a nearly collinear triangle can have extremely large coordinates. Fade computes the circumcenter with multiple-precision artihmetic in this case but the result might nevertheless not be exact because it too large for double-precision coordinates. In such cases a finite point is returned and `ccq` returns CCQ_OUT_OF_BOUNDS. You can avoid such extreme numeric cases easily: Just insert four dummy vertices around the triangulation at coordinates 10 times larger than the domain of the data points because this restricts the Voronoi cells of the data points to this range.

6.18.3.4 getInteriorAngle2D() `double GEOM_FADE2D::Triangle2::getInteriorAngle2D (`

```
int ith ) const
```

Note: The getArea() method is deprecated and replaced by getInteriorAngle2D() to keep the names consistent.

Returns

the interior 2D angle at the ith vertex

6.18.3.5 getIntraTriangleIndex() [1/3] `int GEOM_FADE2D::Triangle2::getIntraTriangleIndex (`

```
const Point2 * p ) const [inline]
```

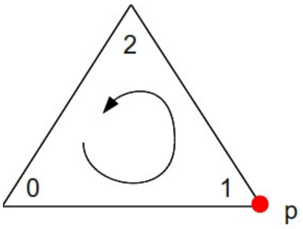


Figure 22 Intra triangle index of a vertex pointer

Parameters

p	is a pointer to a vertex in ∗*this*

Returns

the intra-triangle-index 0,1 or 2 of *p* in ∗*this*

6.18.3.6 getIntraTriangleIndex() [2/3] `int GEOM_FADE2D::Triangle2::getIntraTriangleIndex ( const Point2 * p0, const Point2 * p1 ) const [inline]`

Returns

the index of the edge (p0,p1) in the triangle

6.18.3.7 getIntraTriangleIndex() [3/3] `int GEOM_FADE2D::Triangle2::getIntraTriangleIndex ( const Triangle2 * pTriangle ) const [inline]`

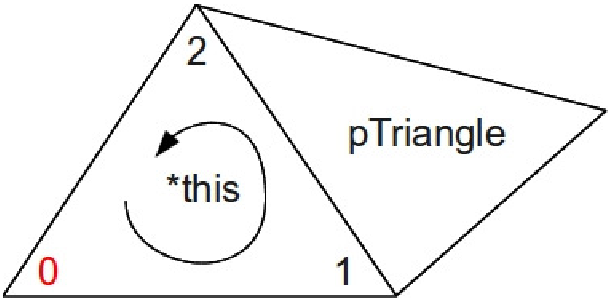


Figure 23 pTriangle is the 0-th neighbor of ∗this

Parameters

pTriangle	is a neighbor triangle of ∗this.

Returns

the intra-triangle-index of the vertex in ∗*this* which is opposite (i.e., does not touch the neighbor) *pTriangle*.

6.18.3.8 getOppositeTriangle() `Triangle2 * GEOM_FADE2D::Triangle2::getOppositeTriangle ( const int ith ) const [inline]`

Returns the *i-th* neighbor triangle, i.e. the one opposite to the *i-th* corner.

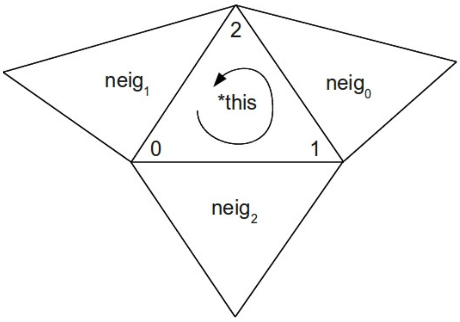


Figure 24 Neighbors of a triangle

Parameters

ith	is the intra-triangle-index of the opposite corner of ∗*this*

Returns

the i-th neighbor triangle, i.e. the one opposite to the i-th vertex or NULL if no neighbor triangle exists which is the case at the convex hull edges of the triangulation.

6.18.3.9 getSquaredEdgeLength2D() `double GEOM_FADE2D::Triangle2::getSquaredEdgeLength2D ( int ith ) const`

Method for internal use
Squared edge length
Returns the squared length of the *ith* edge.

6.18.3.10 hasOnEdge() `bool GEOM_FADE2D::Triangle2::hasOnEdge ( int i, const Point2 & q ) const`

Returns

if `q` is exactly on the i-th edge

6.18.3.11 hasVertex() [1/2] `bool GEOM_FADE2D::Triangle2::hasVertex ( const Point2 & vtx ) const`

Returns

if `vtx` is a corner of the triangle

6.18.3.12 hasVertex() [2/2] `bool GEOM_FADE2D::Triangle2::hasVertex ( Point2 * pVtx ) const`

Returns

if `pVtx` is a corner of the triangle

6.18.3.13 setOppTriangle() `void GEOM_FADE2D::Triangle2::setOppTriangle ( const int ith, Triangle2 * pTriangle ) [inline]`

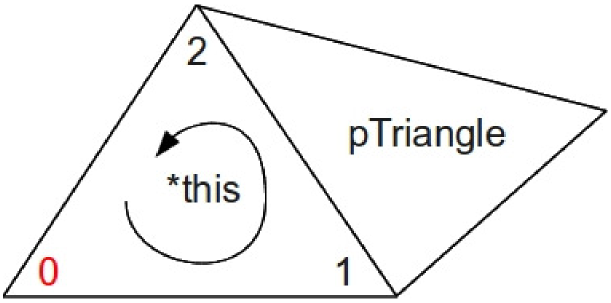


Figure 25 Make pTriangle the 0-th neighbor of $*$this

Parameters

ith	is the index of the corner of $*$*this* which does not touch *pTriangle*
pTriangle	is a pointer to the triangle which shares two corners with $*$*this*

The documentation for this class was generated from the following file:

- Triangle2.h

6.19 GEOM_FADE2D::TriangleAroundVertexIterator Class Reference

Iterator for all triangles around a given vertex.
`#include <TriangleAroundVertexIterator.h>`

Public Member Functions

- TriangleAroundVertexIterator (const Point2 ∗pPnt_)

  Constructor.
- TriangleAroundVertexIterator (const TriangleAroundVertexIterator &it)

  Copy constructor.
- TriangleAroundVertexIterator (Point2 ∗pPnt_, Triangle2 ∗pTr_)

  Constructor.
- bool operator!= (const TriangleAroundVertexIterator &rhs)

  operator!=()
- Triangle2 ∗ operator∗ ()

  Returns a pointer to the current triangle (or NULL)
- TriangleAroundVertexIterator & operator++ ()

  Proceed to the next triangle (the one in counterclockwise order)
- TriangleAroundVertexIterator & operator-- ()

  Proceed to the previous triangle (the one in clockwise order)

- TriangleAroundVertexIterator & **operator=** (const TriangleAroundVertexIterator &other)
- bool operator== (const TriangleAroundVertexIterator &rhs)

  operator==()
- Triangle2 ∗ previewNextTriangle ()

  Preview next triangle (CCW direction)
- Triangle2 ∗ previewPrevTriangle ()

  Preview previous triangle (CW direction)

Protected Member Functions

- void **loop** ()

Protected Attributes

- const Point2 ∗ **pPnt**
- Triangle2 ∗ **pSavedTr**
- Triangle2 ∗ **pTr**

6.19.1 Detailed Description

The TriangleAroundVertexIterator iterates over all triangles incident to a given vertex of a Fade_2D instance. The advantage is that the incident triangles can be visited in a certain order, namely counterclockwise with operator++() or clockwise using operator--(). If the order is not important you can use Fade_2D::getIncidentTriangles() instead.

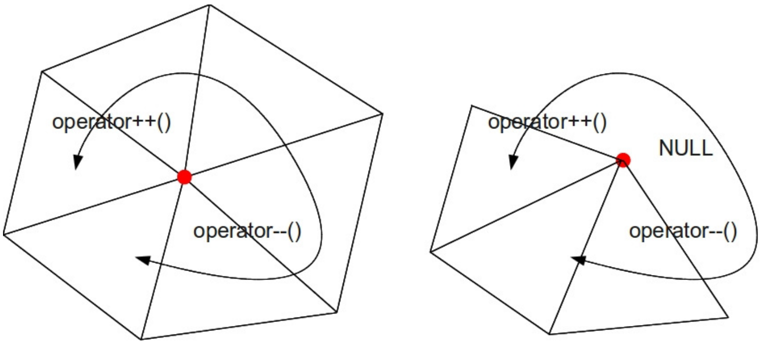


Figure 26 Left: the iterator visits the triangles around a vertex. Right: The iterator 'jumps' over the border edges of the triangulation

6.19.2 Constructor & Destructor Documentation

6.19.2.1 TriangleAroundVertexIterator() [1/3] GEOM_FADE2D::TriangleAroundVertexIterator::Triangle↩ AroundVertexIterator (const Point2 ∗ *pPnt_*) [inline], [explicit]

Parameters

p↩ Pnt↩ _	is the vertex whose incident triangles can be visited with the iterator

Initially the iterator points to an arbitrary triangle (not NULL)

6.19.2.2 TriangleAroundVertexIterator() [2/3] GEOM_FADE2D::TriangleAroundVertexIterator::Triangle↩ AroundVertexIterator (

```
Point2 * pPnt_,
Triangle2 * pTr_ )  [inline]
```

Parameters

p← Pnt← _	is the vertex whose incident triangles can be visited with the iterator
pTr← _	is the triangle the iterator initially points to

6.19.2.3 TriangleAroundVertexIterator() [3/3]

```
GEOM_FADE2D::TriangleAroundVertexIterator::Triangle←
AroundVertexIterator (
            const TriangleAroundVertexIterator & it )  [inline]
```

Copies the iterator `it`

6.19.3 Member Function Documentation

6.19.3.1 operator"!=()

```
bool GEOM_FADE2D::TriangleAroundVertexIterator::operator!= (
            const TriangleAroundVertexIterator & rhs )  [inline]
```

Compares the center and the current triangle of ∗this and `rhs`

Returns

true when they are different, false otherwise

6.19.3.2 operator∗()

```
Triangle2* GEOM_FADE2D::TriangleAroundVertexIterator::operator* ( )  [inline]
```

Dereferencing the iterator yields a pointer to the triangle to which the iterator points.

Warning

This method might yield NULL at the border of a triangulation.

6.19.3.3 operator++()

```
TriangleAroundVertexIterator& GEOM_FADE2D::TriangleAroundVertexIterator←
::operator++ ( )  [inline]
```

Moves the iterator to the next triangle in counterclockwise order.

Warning

At the border of a triangulation, two border edges exist which are incident to the center vertex. Consequently, the neighbor triangles are NULL there. If operator++() leads the iterator off the triangulation then the iterator will point to NULL. Another call to operator++() will set the iterator to the next triangle in counterclockwise order.

6.19.3.4 operator--()

```
TriangleAroundVertexIterator& GEOM_FADE2D::TriangleAroundVertexIterator←
::operator-- ( )  [inline]
```

Moves the iterator to the next triangle in clockwise order.

Warning

> At the border of a triangulation, two border edges are incident to the center vertex. Consequently, the neighbor triangles are NULL there. If operator--() leads the iterator off the triangulation then the iterator will point to NULL. Another call to operator--() will set the iterator to the next triangle in clockwise order.

6.19.3.5 operator==() `bool GEOM_FADE2D::TriangleAroundVertexIterator::operator== ( const TriangleAroundVertexIterator & rhs ) [inline]`

Compares the center and the current triangle of ∗this and `rhs`

Returns

> true when they are identically or false otherwise

6.19.3.6 previewNextTriangle() `Triangle2* GEOM_FADE2D::TriangleAroundVertexIterator::previewNextTriangle ( ) [inline]`

Returns

> the next triangle (the one in CCW direction) without changing the current position.

Warning

> This method might yield NULL at the border of a triangulation.

6.19.3.7 previewPrevTriangle() `Triangle2* GEOM_FADE2D::TriangleAroundVertexIterator::previewPrevTriangle ( ) [inline]`

Returns

> the previous triangle (the one in CW direction) without changing the current position.

Warning

> This method might yield NULL at the border of a triangulation.

The documentation for this class was generated from the following file:

- TriangleAroundVertexIterator.h

6.20 GEOM_FADE2D::UserPredicateT Class Reference

User-defined predicate (deprecated)
`#include <UserPredicates.h>`

Public Member Functions

- virtual bool **operator()** (const Triangle2 ∗)=0

6.20.1 Detailed Description

This class is deprecated in favor of PeelPredicateTS. It is kept for backwards compatibility.
The documentation for this class was generated from the following file:

- UserPredicates.h

6.21 GEOM_FADE2D::Vector2 Class Reference

Vector.

`#include <Vector2.h>`

Public Member Functions

- Vector2 ()

  Default constructor.
- Vector2 (const double x_, const double y_)

  Constructor.
- Vector2 (const Vector2 &v_)

  Copy constructor.
- bool isDegenerate () const

  isDegenerate
- double length () const

  Get the length of the vector.
- double operator∗ (const Vector2 &other) const

  Scalar product.
- Vector2 operator∗ (double val) const

  Multiplication.
- Vector2 operator/ (double val) const

  Division.
- Vector2 & operator= (const Vector2 &other)

  Assignment operator.
- Vector2 **orthogonalVector** () const
- void set (const double x_, const double y_)

  Set the values.
- double sqLength () const

  Get the squared length of the vector.
- double x () const

  Get the x-value.
- double y () const

  Get the y-value.

Protected Attributes

- double **valX**
- double **valY**

6.21.1 Detailed Description

This class represents a vector in 2D

6.21.2 Constructor & Destructor Documentation

6.21.2.1 Vector2() [1/3]

```
GEOM_FADE2D::Vector2::Vector2 (
        const double x_,
        const double y_ )
```

6.21.2.2 Vector2() [2/3]

```
GEOM_FADE2D::Vector2::Vector2 ( )
```

The vector is initialized to (0,0)

6.21.2.3 Vector2() [3/3] `GEOM_FADE2D::Vector2::Vector2 ( const Vector2 & v_ )`

Create a copy of vector v_

6.21.3 Member Function Documentation

6.21.3.1 isDegenerate() `bool GEOM_FADE2D::Vector2::isDegenerate ( ) const`

Returns

true if the vector length is 0, false otherwise.

6.21.3.2 operator∗() [1/2] `double GEOM_FADE2D::Vector2::operator* ( const Vector2 & other ) const`

Scalar product

6.21.3.3 operator∗() [2/2] `Vector2 GEOM_FADE2D::Vector2::operator* ( double val ) const`

Multiply by a scalar value

6.21.3.4 operator/() `Vector2 GEOM_FADE2D::Vector2::operator/ ( double val ) const`

Divide by a scalar value

The documentation for this class was generated from the following file:

- Vector2.h

6.22 GEOM_FADE2D::Visualizer2 Class Reference

Visualizer2 is a general Postscript writer. It draws the objects Point2, Segment2, Triangle2, Circle2 and Label.

`#include <Visualizer2.h>`

Public Member Functions

- Visualizer2 (const char ∗filename_)

  Constructor.
- void addHeaderLine (const char ∗s)

  Add a header line to the visualization.
- void addObject (const Circle2 &circ, const Color &c)

  Add a Circle2 object to the visualization.
- void addObject (const Edge2 &edge, const Color &c)

  Add an Edge2 object to the visualization.
- void addObject (const Label &lab, const Color &c)

  Add a Label object to the visualization.
- void addObject (const Point2 &pnt, const Color &c)

  Add a Point2 object to the visualization.
- void addObject (const Segment2 &seg, const Color &c)

  Add a Segment2 object to the visualization.
- void addObject (const std::vector< ConstraintSegment2 ∗ > &vConstraintSegments, const Color &c)

  Add a vector of ConstraintSegment2 objects to the visualization.
- void addObject (const std::vector< Edge2 > &vSegments, const Color &c)

  Add a vector of Edge2 objects to the visualization.

- void addObject (const std::vector< Point2 * > &vPoints, const Color &c)

  Add a vector of Point2 to the visualization.*
- void addObject (const std::vector< Point2 > &vPoints, const Color &c)

  Add a vector of Point2 objects to the visualization.
- void addObject (const std::vector< Segment2 > &vSegments, const Color &c)

  Add a vector of Segment2 objects to the visualization.
- void addObject (const std::vector< Triangle2 * > &vT, const Color &c)

  Add a Triangle2 vector to the visualization.*
- void addObject (const std::vector< Triangle2 > &vT, const Color &c)

  Add a vector of Triangle2 objects to the visualization.
- void addObject (const std::vector< VoroCell2 * > &vT, const Color &c)

  Add a vector of Voronoi Cells to the visualization.
- void addObject (const Triangle2 &tri, const Color &c)

  Add a Triangle2 object to the visualization.
- void addObject (VoroCell2 *pVoroCell, const Color &c)

  Add a Voronoi cell to the visualization.
- Bbox2 computeRange (bool bWithVoronoi)

  Compute the range.
- void writeFile ()

  Finish and write the postscript file.

Protected Member Functions

- void **changeColor** (const Color &c)
- void **changeColor** (float r, float g, float b, float linewidth, bool bFill)
- void **periodicStroke** ()
- double **scaledDouble** (const double &d)
- Point2 **scaledPoint** (const Point2 &p)
- void **writeCircle** (const Point2 &p1_, double radius, bool bFill)
- void **writeFooter** ()
- void **writeHeader** (const char *title)
- void **writeHeaderLines** ()
- void **writeLabel** (Label l)
- void **writeLine** (const Point2 &pSource, const Point2 &pTarget)
- void **writeMark** (Point2 &p1_, float size)
- void **writePoint** (Point2 &p1_, float size)
- void **writeTriangle** (const Point2 &p0_, const Point2 &p1_, const Point2 &p2_, bool bFill, double width)
- void **writeTriangle** (const Triangle2 *pT, bool bFill_, double width)
- void **writeVoroCell** (VoroCell2 *pVoroCell, bool bFill, double width)

Protected Attributes

- Bbox2 **bbox**
- bool **bFileClosed**
- bool **bFill**
- Color **lastColor**
- std::ofstream **outFile**
- Dat * **pDat**
- int **updateCtr**
- std::vector< std::pair< Circle2, Color > > **vCircles**
- std::vector< std::pair< Label, Color > > **vLabels**
- std::vector< std::pair< Point2, Color > > **vPoints**
- std::vector< std::pair< Segment2, Color > > **vSegments**
- std::vector< std::pair< Triangle2, Color > > **vTriangles**
- std::vector< std::pair< VoroCell2 *, Color > > **vVoroCells**

6.22.1 Detailed Description

See also

http://www.geom.at/example2-traversing/

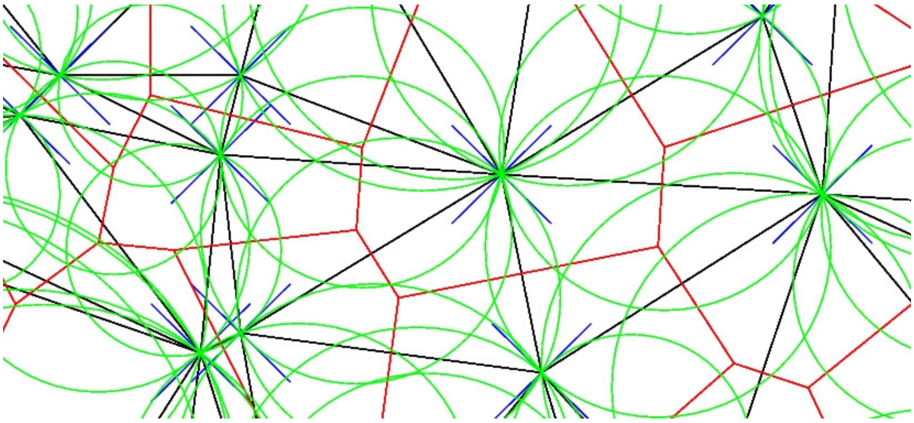


Figure 27 Example output of the Visualizer

6.22.2 Constructor & Destructor Documentation

6.22.2.1 Visualizer2() `GEOM_FADE2D::Visualizer2::Visualizer2 ( const char * filename_ ) [explicit]`

Parameters

*filename_*	is the name of the postscript file to be written

6.22.3 Member Function Documentation

6.22.3.1 computeRange() `Bbox2 GEOM_FADE2D::Visualizer2::computeRange ( bool bWithVoronoi )`

Parameters

bWithVoronoi	specifies if the Voronoi cells shall be incorporated.

Returns

a bounding box of currently contained objects

6.22.3.2 writeFile() `void GEOM_FADE2D::Visualizer2::writeFile ( )`

Note

This method *must* be called at the end when all the objects have been added.

The documentation for this class was generated from the following file:

- Visualizer2.h

6.23 GEOM_FADE2D::VoroCell2 Class Reference

Voronoi cell.
`#include <VoroCell2.h>`

Public Member Functions

- bool getAdjacentVCells (std::vector< VoroCell2 ∗ > &vAdjacentCells) const
- double getArea () const
- bool getBoundaryPoints (std::vector< Point2 > &vPoints, std::vector< Vector2 > ∗pvInfiniteDirections=NULL) const
- double getCentroid (Point2 &centroid) const
- int getCustomCellIndex () const
- bool getIncidentTriangles (std::vector< Triangle2 ∗ > &vIncTriangles) const
- bool getNeighborSites (std::vector< Point2 ∗ > &vSites) const
- Point2 ∗ getSite () const
- bool getVoronoiVertices (std::vector< VoroVertex2 ∗ > &vVoroVertices) const
- bool isFinite () const
- void setCustomCellIndex (int customCellIndex_)

6.23.1 Detailed Description

This class represents a Voronoi cell. A Voronoi cell corresponds to a certain site which is also a vertex of the dual Delaunay triangulation.

6.23.2 Member Function Documentation

6.23.2.1 getAdjacentVCells() `bool GEOM_FADE2D::VoroCell2::getAdjacentVCells ( std::vector< VoroCell2 ∗ > & vAdjacentCells ) const`

Get adjacent Voronoi cells

Parameters

vAdjacentCells	is used to return the neighbor cells in counterclockwise order.

Returns

whether the cell is finite.

6.23.2.2 getArea() `double GEOM_FADE2D::VoroCell2::getArea ( ) const`

Get the area

Returns

the area of the cell if it is finite or -1.0 for an infinite cell.

6.23.2.3 getBoundaryPoints() `bool GEOM_FADE2D::VoroCell2::getBoundaryPoints ( std::vector< Point2 > & vPoints, std::vector< Vector2 > ∗ pvInfiniteDirections = NULL ) const`

Get boundary points
Use this method to retrieve the Voronoi vertices of the present cell as Point2.

Parameters

`out`	*vPoints*	contains the boundary points in counterclockwise order.
`out`	*pvInfiniteDirections*	can optionally be used to retrieve the directions of the infinite Voronoi edges: When a pointer to a vector is provided for `pvInfiniteDirections` and the cell is finite, then the first stored Vector2 describes the direction of the infinite edge at vPoints[0] and the second one the direction of the infinite edge at vPoints.back().

Returns

whether the cell is finite

See also

getVoronoiVertices()

6.23.2.4 getCentroid() `double GEOM_FADE2D::VoroCell2::getCentroid ( Point2 & centroid ) const`

Get the centroid and area

Parameters

`out`	*centroid*	

Returns

the area of the cell if it is finite OR -1.0 for an infinite cell.

6.23.2.5 getCustomCellIndex() `int GEOM_FADE2D::VoroCell2::getCustomCellIndex ( ) const`

Get custom cell-index

Returns

the custom cell index that has been set before or -1 when no custom cell index has been set.

See also

setCustomCellIndex()

6.23.2.6 getIncidentTriangles() `bool GEOM_FADE2D::VoroCell2::getIncidentTriangles ( std::vector< Triangle2 * > & vIncTriangles ) const`

Get incident triangles

The site of the present Voronoi cell is also a vertex of the dual Delaunay triangulation.

Parameters

vIncTriangles	is used to return the the Delaunay triangles incident to the site of the cell in counterclockwise order.

Returns

whether the cell is finite.

6.23.2.7 getNeighborSites() `bool GEOM_FADE2D::VoroCell2::getNeighborSites ( std::vector< Point2 * > & vSites ) const`

Get neighbor sites

Parameters

vSites	is used to return the sites of the adjacent cells in counterclockwise order.

Returns

whether the cell is finite.

6.23.2.8 getSite() `Point2* GEOM_FADE2D::VoroCell2::getSite ( ) const`

Get site

Returns

the site of the cell, which is also a vertex of the dual Delaunay triangulation

6.23.2.9 getVoronoiVertices() `bool GEOM_FADE2D::VoroCell2::getVoronoiVertices ( std::vector< VoroVertex2 * > & vVoroVertices ) const`

Get Voronoi vertices

Used to retrieve the Voronoi vertices of the cell.

Parameters

`out`	*vVoroVertices*	contains VoroVertex2 objects in counterclockwise order.

Returns

whether the cell is finite

See also

getBoundaryPoints()

6.23.2.10 isFinite() `bool GEOM_FADE2D::VoroCell2::isFinite ( ) const`

Is finite cell

Returns

whether the cell is finite

6.23.2.11 setCustomCellIndex() `void GEOM_FADE2D::VoroCell2::setCustomCellIndex ( int customCellIndex_ )`

Set custom cell-index

Use this method to associate Voronoi cells with your own data structures or to assign labels for a visualization.

Parameters

*customCellIndex_*	is an arbitrary integer

See also

getCustomCellIndex()

The documentation for this class was generated from the following file:

- VoroCell2.h

6.24 GEOM_FADE2D::Voronoi2 Class Reference

Voronoi diagram.
`#include <Voronoi2.h>`

Public Member Functions

- VoroCell2 ∗ getVoronoiCell (Point2 ∗pSite)

  Get Voronoi cell.
- void getVoronoiCells (std::vector< VoroCell2 ∗ > &vVoronoiCells)

  Get all Voronoi cells.
- VoroVertex2 ∗ getVoronoiVertex (Triangle2 ∗pT)

  Get the Voronoi vertex of a triangle.
- bool isValid () const

  Is valid.
- VoroCell2 ∗ locateVoronoiCell (const Point2 &queryPoint)

  Locate a Voronoi Cell.
- void show (const char ∗filename, bool bVoronoi=true, bool bCellColors=true, bool bSites=true, bool bDelaunay=true, bool bCellLabels=false)

  Draw the Voronoi diagram.
- void show (Visualizer2 ∗pVisualizer, bool bVoronoi=true, bool bCellColors=true, bool bSites=true, bool bDelaunay=true, bool bCellLabels=false)

  Draw the Voronoi diagram.

Protected Attributes

- Voronoi2Impl ∗ **pImpl**

6.24.1 Detailed Description

This class represents a Voronoi diagram. A Voronoi diagram is the dual graph of a Delaunay triangulation i.e.,

- Each Voronoi cell contains the area closest to its site which is a Delaunay vertex
- Each Voronoi edge has a dual edge in the Delaunay triangulation at an angle of 90 degrees to it.
- Each Voronoi vertex is the circumcenter of a Delaunay triangle

See also

`https://en.wikipedia.org/wiki/Voronoi_diagram`

6.24.2 Member Function Documentation

6.24.2.1 getVoronoiCell() `VoroCell2* GEOM_FADE2D::Voronoi2::getVoronoiCell ( Point2 * pSite )`

Use this method to retrieve the Voronoi cell of a specific site.

Parameters

in	*pSite*	

Returns

the VoroCell2 of `pSite`.

6.24.2.2 getVoronoiCells() `void GEOM_FADE2D::Voronoi2::getVoronoiCells ( std::vector< VoroCell2 * > & vVoronoiCells )`

Use this method to retrieve all finite and infinite Voronoi cells.

Parameters

out	*vVoronoiCells*	

6.24.2.3 getVoronoiVertex() `VoroVertex2* GEOM_FADE2D::Voronoi2::getVoronoiVertex ( Triangle2 * pT )`

Get the Voronoi vertex of a certain dual Delaunay triangle `pT`

Parameters

in	*pT*	

Returns

the Voronoi vertex that corresponds to `pT`

6.24.2.4 isValid() `bool GEOM_FADE2D::Voronoi2::isValid ( ) const`

Returns

whether the Voronoi diagram is ready for use. This is the case as soon 3 sites exist which are not collinear.

6.24.2.5 locateVoronoiCell() `VoroCell2* GEOM_FADE2D::Voronoi2::locateVoronoiCell ( const Point2 & queryPoint )`

This is a high performance method to locate the Voronoi cell of an arbitrary `queryPoint`

Parameters

in	*queryPoint*	

Returns

the Voronoi cell that contains `queryPoint` or NULL if the Voronoi diagram is invalid.

6.24.2.6 show() [1/2] `void GEOM_FADE2D::Voronoi2::show ( const char * filename,`

```
bool bVoronoi = true,
bool bCellColors = true,
bool bSites = true,
bool bDelaunay = true,
bool bCellLabels = false )
```

Parameters

filename	is the output ∗.ps filename
bVoronoi	draw the edges of the Voronoi diagram (default: true)
bCellColors	use background colors for the Voronoi cells (default: true)
bSites	draw the sites (default: true)
bDelaunay	draw the Delaunay triangles (default: true)
bCellLabels	show cell labels (or -1 if not assigned) (default: false)

This method does automatically crop the viewport to twice the range of the sites. Thus very large and infinite cells appear clipped.

6.24.2.7 show() `[2/2]` `void GEOM_FADE2D::Voronoi2::show (`

```
Visualizer2 * pVisualizer,
bool bVoronoi = true,
bool bCellColors = true,
bool bSites = true,
bool bDelaunay = true,
bool bCellLabels = false )
```

Parameters

pVisualizer	is the Visualizer2 object to be used
bVoronoi	draw the edges of the Voronoi diagram (default: true)
bCellColors	use background colors for the Voronoi cells (default: true)
bSites	draw the sites (default: true)
bDelaunay	draw the Delaunay triangles (default: true)
bCellLabels	show cell labels (or -1 if not assigned) (default: false)

Note

> This method only clips infinite cells. But finite cells can also be very large. Call Visualizer2::setLimit() to specify the range of interest.

The documentation for this class was generated from the following file:

- Voronoi2.h

6.25 GEOM_FADE2D::VoroVertex2 Class Reference

Voronoi vertex.

`#include <VoroVertex2.h>`

Public Member Functions

- Triangle2 ∗ getDualTriangle () const

  Get dual triangle.
- Point2 getPoint ()

  Get Point.
- bool isAlive () const

  Is alive.

6.25.1 Detailed Description

This class represents a vertex of the Voronoi diagram. A Voronoi vertex is the circumcenter of a certain triangle of the dual Delaunay triangulation.

6.25.2 Member Function Documentation

6.25.2.1 getDualTriangle() `Triangle2* GEOM_FADE2D::VoroVertex2::getDualTriangle ( ) const`

A Voronoi vertex is the circumcenter of a certain triangle in the dual Delaunay triangulation.

Returns

the corresponding Delaunay triangle

6.25.2.2 getPoint() `Point2 GEOM_FADE2D::VoroVertex2::getPoint ( )`

Returns

the Voronoi vertex as a Point2

6.25.2.3 isAlive() `bool GEOM_FADE2D::VoroVertex2::isAlive ( ) const`

The Voronoi diagram changes dynamically when points are inserted or removed from the dual Delaunay triangulation.

Returns

whether the present Voronoi vertex is still valid

The documentation for this class was generated from the following file:

- VoroVertex2.h

6.26 GEOM_FADE2D::Zone2 Class Reference

Zone2 is a certain defined area of a triangulation.

`#include <Zone2.h>`

Public Member Functions

- Zone2 ∗ convertToBoundedZone ()

  Convert a zone to a bounded zone.
- void debug (const char ∗name="")

  Development function.
- double getArea2D () const

  Get 2D Area.
- void getBorderEdges (std::vector< Edge2 > &vBorderEdgesOut) const

  Get border edges.
- void getBoundaryEdges (std::vector< Edge2 > &vEdges) const

  Compute the boundary edges of the zone.
- void getBoundarySegments (std::vector< Segment2 > &vSegments) const

  Compute the boundary segments of the zone.
- Bbox2 getBoundingBox () const

  Compute the bounding box.
- ConstraintGraph2 ∗ getConstraintGraph () const

Get the associated constraint.
- void getConstraintGraphs (std::vector< ConstraintGraph2 ∗ > &vConstraintGraphs_) const

  Get the associated constraint graphs.
- size_t getNumberOfTriangles () const

  Get the number of triangles.
- void getTriangles (std::vector< Triangle2 ∗ > &vTriangles_) const

  Get the triangles of the zone.
- void getVertices (std::vector< Point2 ∗ > &vVertices_) const

  Get the vertices of the zone.
- ZoneLocation getZoneLocation () const

  Get the zone location.
- size_t numberOfConstraintGraphs () const

  Get a the number of ConstraintGraph2 objects.
- bool save (const char ∗filename)

  Save the zone.
- bool save (std::ostream &stream)

  Save the zone.
- void show (const char ∗postscriptFilename, bool bShowFull, bool bWithConstraints) const

  Postscript visualization.
- void show (Visualizer2 ∗pVisualizer, bool bShowFull, bool bWithConstraints) const

  Postscript visualization.
- void statistics (const char ∗s) const
- void subscribe (MsgType msgType, MsgBase ∗pMsg)

  Register a message receiver.
- void unifyGrid (double tolerance)
- void unsubscribe (MsgType msgType, MsgBase ∗pMsg)

  Unregister a message receiver.
- void writeObj (const char ∗outFilename) const

  Write the zone to ∗.obj Writes the triangles of the present Zone2 to an ∗.obj file (The ∗.obj format represents a 3D scene).

Friends

- Zone2 ∗ peelOffIf (Zone2 ∗pZone, bool bAvoidSplit, PeelPredicateTS ∗pPredicate)

  Peel off border triangles.
- Zone2 ∗ peelOffIf (Zone2 ∗pZone, UserPredicateT ∗pPredicate, bool bVerbose)

  Peel off border triangles (deprecated)
- Zone2 ∗ zoneDifference (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the difference of two zones.
- Zone2 ∗ zoneIntersection (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the intersection of two zones.
- Zone2 ∗ zoneSymmetricDifference (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the symmetric difference of two zones.
- Zone2 ∗ zoneUnion (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the union of two zones.

6.26.1 Detailed Description

See also

`http://www.geom.at/example4-zones-defined-areas-in-triangulations/`

`http://www.geom.at/boolean-operations/`

createZone in the Fade2D class

6.26.2 Member Function Documentation

6.26.2.1 convertToBoundedZone() `Zone2* GEOM_FADE2D::Zone2::convertToBoundedZone ( )`

The mesh generation algorithms refine() and refineAdvanced() require a zone object that is bounded by constraint segments. This is always the case for zones with zoneLocation ZL_INSIDE but other types of zones may be unbounded. For convenience this method is provided to create a bounded zone from a possibly unbounded one.

Returns

a pointer to a new Zone2 object with zoneLocation ZL_RESULT_BOUNDED or a pointer to the present zone if this->getZoneLocation() is ZL_INSIDE.

6.26.2.2 getArea2D() `double GEOM_FADE2D::Zone2::getArea2D ( ) const`

Returns the 2D area of the zone.
Note: The getArea() method is deprecated and replaced by getArea2D() to keep the names consistent.

6.26.2.3 getBorderEdges() `void GEOM_FADE2D::Zone2::getBorderEdges ( std::vector< Edge2 > & vBorderEdgesOut ) const`

Returns

: the CCW oriented border edges of the zone

6.26.2.4 getConstraintGraph() `ConstraintGraph2* GEOM_FADE2D::Zone2::getConstraintGraph ( ) const`

Returns

a pointer to the ConstraintGraph2 object which defines the zone.
or NULL for ZL_RESULT-, ZL_GROW and ZL_GLOBAL_-zones.

6.26.2.5 getConstraintGraphs() `void GEOM_FADE2D::Zone2::getConstraintGraphs ( std::vector< ConstraintGraph2 * > & vConstraintGraphs_ ) const`

6.26.2.6 getNumberOfTriangles() `size_t GEOM_FADE2D::Zone2::getNumberOfTriangles ( ) const`

Warning

This method is fast but O(n), so don't call it frequently in a loop.

6.26.2.7 getTriangles() `void GEOM_FADE2D::Zone2::getTriangles ( std::vector< Triangle2 * > & vTriangles_ ) const`

This command fetches the existing triangles of the zone.

Note

Fade_2D::void applyConstraintsAndZones() must be called after the last insertion of points and constraints.

that the lifetime of data from the Fade2D datastructures does exceed the lifetime of the Fade2D object.

6.26.2.8 getVertices() `void GEOM_FADE2D::Zone2::getVertices ( std::vector< Point2 * > & vVertices_ ) const`

6.26.2.9 getZoneLocation() `ZoneLocation GEOM_FADE2D::Zone2::getZoneLocation ( ) const`

Returns

ZL_INSIDE if the zone applies to the triangles inside one or more ConstraintGraph2 objects
ZL_OUTSIDE if the zone applies to the outside triangles
ZL_GLOBAL if the zone applies (dynamically) to all triangles
ZL_RESULT if the zone is the result of a set operation
ZL_GROW if the zone is specified by a set of constraint graphs and an inner point

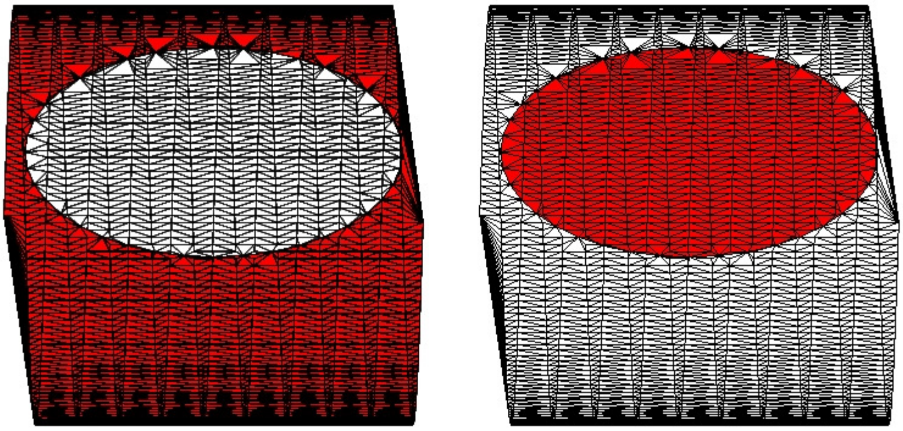


Figure 28 An ouside zone and in inside zone

6.26.2.10 numberOfConstraintGraphs() `size_t GEOM_FADE2D::Zone2::numberOfConstraintGraphs ( ) const`

A Zone2 object might be defined by zero, one or more ConstraintGraph2 objects.

6.26.2.11 save() [1/2] `bool GEOM_FADE2D::Zone2::save ( const char * filename )`

This command saves the present Zone2 to a binary file. Any constraint edges and custom indices in the domain are retained.

Parameters

in	*filename*	is the output filename

Returns

whether the operation was successful

Note

A Delaunay triangulation is convex without holes but this may not hold for the zone to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the Fade_2D instance but not to the Zone2 object when reloaded.

See also

save(std::ostream& stream). Use the similar command Fade_2D::saveZones(const char∗ file, std::vector<Zone2∗>& vZones) to store more than just one zone. Use Fade_2D::saveTriangulation() to store all triangles of the triangulation plus any specified zones. Use Fade_2D::load() to reload the data from such files.

6.26.2.12 save() `[2/2]` `bool GEOM_FADE2D::Zone2::save ( std::ostream & stream )`

This command saves the present Zone2 to an ostream. Any constraint edges and custom indices in the domain are retained.

Parameters

stream	is the output stream

Returns

whether the operation was successful

Note

A Delaunay triangulation is convex without holes but this may not hold for the zone to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the Fade_2D instance but not to the Zone2 object when reloaded.

See also

Use the similar command Fade_2D::saveZones(const char∗ file, std::vector<Zone2∗>& vZones) to store more than just one zone. Use Fade_2D::saveTriangulation() to store all triangles of the triangulation plus any specified zones. Use Fade_2D::load() to reload the data from such files.

6.26.2.13 show() `[1/2]`

```
void GEOM_FADE2D::Zone2::show (
        const char * postscriptFilename,
        bool bShowFull,
        bool bWithConstraints ) const
```

Parameters

postscriptFilename	is the name of the output file.
bShowFull	specifies if only the zone or the full triangulation shall be drawn
bWithConstraints	specifies if constraint edges shall be drawn

6.26.2.14 show() `[2/2]`

```
void GEOM_FADE2D::Zone2::show (
        Visualizer2 * pVisualizer,
        bool bShowFull,
        bool bWithConstraints ) const
```

Parameters

pVisualizer	is a pointer to an existing Visualizer2 object.

Note

You must call pVisualizer->writeFile() before program end

Parameters

bShowFull	specifies if only the zone or the full triangulation shall be drawn
bWithConstraints	specifies if constraint edges shall be drawn

6.26.2.15 statistics()

```
void GEOM_FADE2D::Zone2::statistics (
        const char * s ) const
```

Statistics

Prints statistics to stdout.

6.26.2.16 subscribe()

```
void GEOM_FADE2D::Zone2::subscribe (
        MsgType msgType,
        MsgBase * pMsg )
```

Parameters

msgType	is the type of message the subscriber shall receive, e.g. MSG_PROGRESS or MSG_WARNING
pMsg	is a pointer to a custom class derived from MsgBase

6.26.2.17 unifyGrid()

```
void GEOM_FADE2D::Zone2::unifyGrid (
        double tolerance )
```

Unify Grid

A Delaunay triangulation not unique when when 2 or more triangles share a common circumcircle. As a consequence the four corners of a rectangle can be triangulated in two different ways: Either the diagonal proceeds from the lower left to the upper right corner or it connects the other two corners. Both solutions are valid and an arbitrary one is applied when points are triangulated. To improve the repeatability and for reasons of visual appearance this method unifies such diagonals to point from the lower left to the upper right corner (or in horizontal direction).

Parameters

tolerance	is 0 when only exact cases of more than 3 points on a common circumcircle shall be changed. But in practice input data can be disturbed by noise and tiny rounding errors such that grid points are not exactly on a grid. The numeric error is computed as $error = \frac{abs(diagonalA-diagonalB)}{max(diagonalA,diagonalB)}$. and `tolerance` is an upper threshold to allow modification despite such tiny inaccuracies. Use with caution, such flips break the empty circle property and this may or may not fit your setting.

6.26.2.18 unsubscribe()

```
void GEOM_FADE2D::Zone2::unsubscribe (
        MsgType msgType,
        MsgBase * pMsg )
```

Parameters

msgType	is the type of message the subscriber shall not receive anymore
pMsg	is a pointer to a custom class derived from MsgBase

6.26.2.19 writeObj() `void GEOM_FADE2D::Zone2::writeObj (`

```
const char * outFilename ) const
```

Parameters

outFilename	is the output filename

6.26.3 Friends And Related Function Documentation

6.26.3.1 peelOffIf `[1/2]` `Zone2* peelOffIf (`

```
Zone2 * pZone,
bool bAvoidSplit,
PeelPredicateTS * pPredicate ) [friend]
```

Parameters

pZone	is the input zone
bAvoidSplit	if true, then the algorithm removes a triangle only if it does not break the zone into independent components.
pPredicate	is a user-defined predicate that decides if a triangle shall be removed.

Returns

a new zone containing a subset of the triangles of `pZone` or NULL when no triangles remain.

Attention

Check whether NULL is returned!

6.26.3.2 peelOffIf `[2/2]` `Zone2* peelOffIf (`

```
Zone2 * pZone,
UserPredicateT * pPredicate,
bool bVerbose ) [friend]
```

This function is DEPRECATED but kept for backwards compatibility. The new and better function is↩ : peelOffIf(Zone2∗ pZone, bool bAvoidSplit,PeelPredicateTS∗ pPredicate)

Parameters

pZone	
pPredicate	
bVerbose	

Returns

a new zone containing a subset of the triangles of `pZone` or NULL when no triangles remain.

6.26.3.3 zoneDifference `Zone2* zoneDifference (`

```
Zone2 * pZone0,
```

`Zone2 * pZone1 ) [friend]`

Returns

a new zone containing the triangles of ∗pZone0 minus the ones of ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

6.26.3.4 zoneIntersection

```
Zone2* zoneIntersection (
        Zone2 * pZone0,
        Zone2 * pZone1 ) [friend]
```

Returns

a new zone containing the intersection of ∗pZone0 and ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

6.26.3.5 zoneSymmetricDifference

```
Zone2* zoneSymmetricDifference (
        Zone2 * pZone0,
        Zone2 * pZone1 ) [friend]
```

Returns

a new zone containing the triangles that are present in one of the zones but not in the other one.

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

6.26.3.6 zoneUnion

```
Zone2* zoneUnion (
        Zone2 * pZone0,
        Zone2 * pZone1 ) [friend]
```

Returns

a new zone containing the union of the triangles of ∗pZone0 and ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

The documentation for this class was generated from the following file:

- Zone2.h

7 File Documentation

7.1 Bbox2.h File Reference

```
#include "Segment2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Bbox2

  Bbox2 is an axis aligned 2D bounding box.

Functions

- Bbox2 GEOM_FADE2D::getBox (std::vector< Point2 ∗ > &vP)

  Compute the bounding box.
- Bbox2 GEOM_FADE2D::getBox (std::vector< Point2 > &vP)

  Compute the bounding box.
- std::ostream & GEOM_FADE2D::operator<< (std::ostream &stream, const Bbox2 &pC)

  Print the box.

7.1.1 Function Documentation

7.1.1.1 getBox() [1/2]

```
Bbox2 GEOM_FADE2D::getBox (
        std::vector< Point2 * > & vP )
```

Computes the bounding box of points

7.1.1.2 getBox() [2/2]

```
Bbox2 GEOM_FADE2D::getBox (
        std::vector< Point2 > & vP )
```

Computes the bounding box of points

7.1.1.3 operator<<()

```
std::ostream& GEOM_FADE2D::operator<< (
        std::ostream & stream,
        const Bbox2 & pC ) [inline]
```

Prints the box coordinates to `stream`

7.2 Circle2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Circle2

  Circle for visualization.

7.3 Color.h File Reference

```
#include "common.h"
```

Classes

- class GEOM_FADE2D::Color

  Color for visualization.

Enumerations

- enum GEOM_FADE2D::Colorname {
  CRED, **CGREEN**, **CBLUE**, **CBLACK**,
  CPINK, **CGRAY**, **CORANGE**, **CLIGHTBLUE**,
  CLIGHTBROWN, **CDARKBROWN**, **CPURPLE**, **COLIVE**,
  CLAWNGREEN, **CPALEGREEN**, **CCYAN**, **CYELLOW**,
  CWHITE }

  Predefined colors for convenience.

Functions

- std::ostream & **GEOM_FADE2D::operator**<< (std::ostream &stream, const Color &c)

7.4 ConstraintGraph2.h File Reference

```
#include "Segment2.h"
#include "ConstraintSegment2.h"
#include "Edge2.h"
#include <map>
#include "common.h"
```

Classes

- class GEOM_FADE2D::ConstraintGraph2

  ConstraintGraph2 is a set of Constraint Edges (ConstraintSegment2)

7.5 ConstraintSegment2.h File Reference

```
#include <set>
#include "common.h"
```

Classes

- class GEOM_FADE2D::ConstraintSegment2

  A ConstraintSegment2 represents a Constraint Edge.

Enumerations

- enum GEOM_FADE2D::ConstraintInsertionStrategy { **CIS_CONFORMING_DELAUNAY** =0, GEOM_FADE2D::CIS_CONSTRA
  =1, GEOM_FADE2D::CIS_KEEP_DELAUNAY =0, GEOM_FADE2D::CIS_IGNORE_DELAUNAY =1 }

  Constraint Insertion Strategy determines how a constraint edge shall be inserted:

7.5.1 Enumeration Type Documentation

7.5.1.1 ConstraintInsertionStrategy `enum GEOM_FADE2D::ConstraintInsertionStrategy`

- CIS_CONSTRAINED_DELAUNAY inserts a segment without subdivision unless required (which is the case if existing vertices or constraint segments are crossed).

All other constraint insertion strategies are deprecated and only kept for backwards compatibility. Their behavior can be achieved using ConstraintGraph2::makeDelaunay() and/or Fade_2D::drape(). See also `examples_25D/terrain.cpp`.

Note

In former library versions the terms CIS_IGNORE_DELAUNAY and CIS_KEEP_DELAUNAY were used but these were misleading and are now deprecated. For backwards compatibility they are kept.

Enumerator

CIS_CONSTRAINED_DELAUNAY	Deprecated.
CIS_KEEP_DELAUNAY	Deprecated name.
CIS_IGNORE_DELAUNAY	Deprecated.

7.6 Edge2.h File Reference

```
#include "common.h"
```

Classes

- class GEOM_FADE2D::Edge2

  Edge2 is a directed edge.
- struct GEOM_FADE2D::Func_gtEdge2D

  Functor to sort edges by 2d length (descending)
- struct GEOM_FADE2D::Func_ltEdge2D

  Functor to sort edges by 2d length (ascending)

7.7 Fade_2D.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Triangle2.h"
#include "TriangleAroundVertexIterator.h"
#include "Visualizer2.h"
#include "Zone2.h"
#include "ConstraintGraph2.h"
#include "Performance.h"
#include "MeshGenParams.h"
#include "MsgBase.h"
#include "SegmentChecker.h"
#include "testDataGenerators.h"
#include "freeFunctions.h"
#include "FadeExport.h"
#include "Voronoi2.h"
#include "License.h"
```

Classes

- class GEOM_FADE2D::Fade_2D

  Fade_2D is the Delaunay triangulation main class.

7.7.1 Detailed Description

Fade_2D.h is the main API of the Fade library

7.8 FadeExport.h File Reference

```
#include <vector>
#include <algorithm>
#include "common.h"
#include "License.h"
```

Classes

- struct GEOM_FADE2D::FadeExport

    FadeExport is a simple struct to export triangulation data.

7.9 freeFunctions.h File Reference

```
#include "Point2.h"
#include "Segment2.h"
#include "Edge2.h"
#include <vector>
```

Functions

- void GEOM_FADE2D::edgesToPolygons (std::vector< Edge2 > &vEdgesIn, std::vector< std::vector< Edge2 > > &vvPolygonsOut, std::vector< Edge2 > &vRemainingOut)

    Create polygons from a set of edges.
- bool GEOM_FADE2D::fillHole (std::vector< std::pair< Segment2, Vector2 > > vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< Point2 > &vCornersOut)

    Fill a hole in a 3D mesh with triangles (deprecated)
- double GEOM_FADE2D::getArea2D (Point2 ∗p0, Point2 ∗p1, Point2 ∗p2)

    Get 2D area of a triangle.
- void GEOM_FADE2D::getBorders (const std::vector< Triangle2 ∗ > &vT, std::vector< Segment2 > &vBorderSegmentsOut)

    Get Borders.
- void GEOM_FADE2D::getDirectedEdges (std::vector< Triangle2 ∗ > &vT, std::vector< Edge2 > &vDirectedEdgesOut)

    Get directed edge The directed edges of `vT` are returned `vDirectedEdgesOut`. Directed means that each edge (a,b) with two adjacent triangles in vT is returned twice, as edge(a,b) and edge(b,a).
- const char ∗ GEOM_FADE2D::getFade2DVersion ()

    Get the Fade2D version string.
- FUNC_DECLSPEC int GEOM_FADE2D::getMajorVersionNumber ()

    Get the major version number.
- FUNC_DECLSPEC int GEOM_FADE2D::getMinorVersionNumber ()

    Get the minor version number.
- FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2 (const Point2 ∗p0, const Point2 ∗p1, const Point2 ∗p2)

    Get the orientation of three points.
- FUNC_DECLSPEC Orientation2 GEOM_FADE2D::getOrientation2_mt (const Point2 ∗p0, const Point2 ∗p1, const Point2 ∗p2)

    Get Orientation2 (MT)
- FUNC_DECLSPEC int GEOM_FADE2D::getRevisionNumber ()

    Get the revision version number.
- void GEOM_FADE2D::getUndirectedEdges (std::vector< Triangle2 ∗ > &vT, std::vector< Edge2 > &vUndirectedEdgesOut)

    Get undirected edges.

- FUNC_DECLSPEC bool GEOM_FADE2D::isRelease ()

  Check if a RELEASE or a DEBUG version is used.
- bool GEOM_FADE2D::isSimplePolygon (std::vector< Segment2 > &vSegments)

  isSimplePolygon
- void GEOM_FADE2D::pointsToPolyline (std::vector< Point2 > &vInPoints, bool bClose, std::vector< Segment2 > &vOutSegments)

  Points-to-Polyline.
- bool GEOM_FADE2D::readPointsBIN (const char *filename, std::vector< Point2 > &vPointsIn)

  Read points from a binary file.
- bool GEOM_FADE2D::readSegmentsBIN (const char *filename, std::vector< Segment2 > &vSegmentsOut)

  Read segments from a binary file.
- FUNC_DECLSPEC bool GEOM_FADE2D::readXY (const char *filename, std::vector< Point2 > &vPoints↩Out)

  Read (x y) points.
- bool GEOM_FADE2D::sortRing (std::vector< Segment2 > &vRing)

  Sort a vector of Segments.
- bool GEOM_FADE2D::sortRingCCW (std::vector< Segment2 > &vRing)

  Sort a vector of Segments.
- FUNC_DECLSPEC bool GEOM_FADE2D::writePointsASCII (const char *filename, const std::vector< Point2 * > &vPointsIn)

  Write points to an ASCII file.
- bool GEOM_FADE2D::writePointsASCII (const char *filename, const std::vector< Point2 > &vPointsIn)

  Write points to an ASCII file.
- bool GEOM_FADE2D::writePointsBIN (const char *filename, std::vector< Point2 * > &vPointsIn)

  Write points to a binary file.
- bool GEOM_FADE2D::writePointsBIN (const char *filename, std::vector< Point2 > &vPointsIn)

  Write points to a binary file.
- bool GEOM_FADE2D::writeSegmentsBIN (const char *filename, std::vector< Segment2 > &vSegmentsIn)

  Write segments to a binary file.

7.10 Label.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Label

  Label is a Text-Label for Visualization.

7.11 MeshGenParams.h File Reference

```
#include "common.h"
#include "Zone2.h"
```

Classes

- class GEOM_FADE2D::MeshGenParams

  Parameters for the mesh generator.

Functions

- template<typename T >
  void GEOM_FADE2D::unusedParameter (const T &)

  Unused parameter.

7.11.1 Function Documentation

7.11.1.1 unusedParameter() `template<typename T >`

```
void GEOM_FADE2D::unusedParameter (
             const T &  )  [inline]
```

Empty template to avoid compiler warnings about unused function parameters

7.12 MsgBase.h File Reference

`#include "common.h"`

Classes

- class GEOM_FADE2D::MsgBase

  MsgBase, a base class for message subscriber classes.

Enumerations

- enum **MsgType** { **MSG_PROGRESS**, **MSG_WARNING** }

7.13 Performance.h File Reference

`#include "common.h"`

Functions

- double GEOM_FADE2D::timer (const char ∗cstr)

  Timer.

7.13.1 Function Documentation

7.13.1.1 timer() `double GEOM_FADE2D::timer (`

```
             const char ∗ cstr )
```

Call the timer function with a certain string to start time measurement. Call it a second time with the same string to finish the time measurement.

Returns

-1 when the timer is started or the elapsed time in seconds when the timer is stopped.

7.14 Point2.h File Reference

```
#include "common.h"
#include "Vector2.h"
```

Classes

- class GEOM_FADE2D::Point2

  Point.

Functions

- Point2 GEOM_FADE2D::center (const Point2 &p0, const Point2 &p1)

  Compute the midpoint of p0 and p1.
- Point2 GEOM_FADE2D::centerWithShift (const Point2 &p0, const Point2 &p1)

  Compute the midpoint of p0 and p1 and adapt it.
- std::ostream & GEOM_FADE2D::operator<< (std::ostream &stream, const Point2 &pnt)

  Print to stream.
- std::istream & GEOM_FADE2D::operator>> (std::istream &stream, Point2 &pnt)

  Stream-to-Point.
- double GEOM_FADE2D::sqDistance2D (const double x0, const double y0, const Point2 &p1)

  Get the squared distance between two points in 2D.
- double GEOM_FADE2D::sqDistance2D (const Point2 &p0, const Point2 &p1)

  Get the squared distance between two points in 2D.

7.14.1 Function Documentation

7.14.1.1 center()

```
Point2 GEOM_FADE2D::center (
        const Point2 & p0,
        const Point2 & p1 )  [inline]
```

Note

: The exact midpoint of p0 and p1 may not exist in floating point numbers. Thus the returned point may not be collinear with p0 and p1.

7.14.1.2 centerWithShift()

```
Point2 GEOM_FADE2D::centerWithShift (
        const Point2 & p0,
        const Point2 & p1 )
```

Experimental new function that may change in the future. Thought for specific applications.

This function works like center() but additionally it adapts the midpoint to the segment (p0,p1) such that it is 'as collinear as possible' with p0 and p1 in the x/y plane. Bounds for the shift are 0.01 and 1 % of the range in x- and y-direction.

7.14.1.3 sqDistance2D() [1/2]

```
double GEOM_FADE2D::sqDistance2D (
        const double x0,
        const double y0,
        const Point2 & p1 )  [inline]
```

7.14.1.4 sqDistance2D() [2/2]

```
double GEOM_FADE2D::sqDistance2D (
        const Point2 & p0,
        const Point2 & p1 )  [inline]
```

7.15 Segment2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Segment2

  Segment.

7.16 SegmentChecker.h File Reference

```
#include <map>
#include "common.h"
#include "Segment2.h"
#include "MsgBase.h"
#include "Bbox2.h"
```

Classes

- class GEOM_FADE2D::SegmentChecker

  SegmentChecker identifies intersecting line segments.

Enumerations

- enum ClipResult {
  CR_INVALID, CR_EMPTY, CR_CLIPPED_DEGENERATE, CR_CLIPPED_NONDEGENERATE,
  CR_COMPLETE_DEGENERATE, CR_COMPLETE_NONDEGENERATE }
- enum SegmentIntersectionType {
  SIT_UNINITIALIZED, SIT_NONE, SIT_SEGMENT, SIT_POINT,
  SIT_ENDPOINT }

7.16.1 Enumeration Type Documentation

7.16.1.1 ClipResult `enum ClipResult`

Enumerator

CR_INVALID	Can't compute a result, call setLimit() with a valid Bbox2 before!
CR_EMPTY	The result is empty (input completely outside the box)
CR_CLIPPED_DEGENERATE	The result has been clipped and is degenerate
CR_CLIPPED_NONDEGENERATE	The result has been clipped and is non-degenerate
CR_COMPLETE_DEGENERATE	The result is unclipped and degenerate (because the segment was already degenerate)
CR_COMPLETE_NONDEGENERATE	The result is unclipped and non-degenerate

7.16.1.2 SegmentIntersectionType `enum SegmentIntersectionType`

The Segment intersection type enumerates the way two line segments intersect each other

Enumerator

SIT_UNINITIALIZED	Invalid value
SIT_NONE	No intersection
SIT_SEGMENT	The intersection is a non-degenerate segment (collinear intersection)
SIT_POINT	The intersection is a single point differnt from the endpoints
SIT_ENDPOINT	The two segments share a common endpoint which is the only intersection

7.17 testDataGenerators.h File Reference

```
#include "Point2.h"
#include "Segment2.h"
#include <vector>
```

Functions

- FUNC_DECLSPEC void GEOM_FADE2D::generateCircle (int numPoints, double x, double y, double radiusX, double radiusY, std::vector< Point2 > &vCirclePointsOut)

  Generate a circle.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomNumbers (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)

  Generate random numbers.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPoints (size_t numRandomPoints, double min, double max, std::vector< Point2 > &vRandomPointsOut, unsigned int seed=0)

  Generate random points.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomPolygon (size_t numSegments, double min, double max, std::vector< Segment2 > &vPolygonOut, unsigned int seed=0)

  Generate a random simple polygon.
- FUNC_DECLSPEC void GEOM_FADE2D::generateRandomSegments (size_t numSegments, double min, double max, double maxLen, std::vector< Segment2 > &vSegmentsOut, unsigned int seed)

  Generate random line segments.
- FUNC_DECLSPEC void GEOM_FADE2D::generateSineSegments (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< Segment2 > &v↩ SineSegmentsOut)

  Generate segments from a sine function.
- FUNC_DECLSPEC void **GEOM_FADE2D::shear** (std::vector< Point2 > &vPointsInOut, double shearX, double shearY)

7.18 Triangle2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Triangle2

  Triangle.

Enumerations

- enum GEOM_FADE2D::CircumcenterQuality { GEOM_FADE2D::CCQ_INIT, GEOM_FADE2D::CCQ_INEXACT, GEOM_FADE2D::CCQ_EXACT, GEOM_FADE2D::CCQ_OUT_OF_BOUNDS }

  CircumcenterQuality.

7.18.1 Enumeration Type Documentation

Enumerator

7.18.1.1 CircumcenterQuality `enum GEOM_FADE2D::CircumcenterQuality`

Enumerator

CCQ_INIT	Init value.
CCQ_INEXACT	Double precision computation, the result is accurate enough.
CCQ_EXACT	Computation with multiple-precision arithmetic, the result is exact (apart from tiny quantization errors)
CCQ_OUT_OF_BOUNDS	Computation with multiple-precision arithmetic, but the result is not representable with double precision coordinates.

7.19 TriangleAroundVertexIterator.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Triangle2.h"
```

Classes

- class GEOM_FADE2D::TriangleAroundVertexIterator

  Iterator for all triangles around a given vertex.

7.20 UserPredicates.h File Reference

```
#include "common.h"
#include "Triangle2.h"
```

Classes

- class GEOM_FADE2D::PeelPredicateTS

  User-defined peel predicate.
- class GEOM_FADE2D::UserPredicateT

  User-defined predicate (deprecated)

7.21 Vector2.h File Reference

```
#include "common.h"
```

Classes

- class GEOM_FADE2D::Vector2

  Vector.

Functions

- Vector2 GEOM_FADE2D::normalize (const Vector2 &other)

  Normalize a vector.
- Vector2 GEOM_FADE2D::operator* (double d, const Vector2 &vec)

  Multiplication with a scalar.

- Vector2 GEOM_FADE2D::operator+ (const Vector2 &vec0, const Vector2 &vec1)

  Addition.
- Vector2 GEOM_FADE2D::operator- (const Vector2 &in)

  Opposite vector.
- Vector2 GEOM_FADE2D::operator- (const Vector2 &vec0, const Vector2 &vec1)

  Subtraction.
- std::ostream & GEOM_FADE2D::operator<< (std::ostream &stream, const Vector2 &vec)

  Print to stream.

7.21.1 Function Documentation

7.21.1.1 operator∗()

```
Vector2 GEOM_FADE2D::operator* (
        double d,
        const Vector2 & vec ) [inline]
```

Multiplication with a scalar

7.21.1.2 operator+()

```
Vector2 GEOM_FADE2D::operator+ (
        const Vector2 & vec0,
        const Vector2 & vec1 ) [inline]
```

Addition

7.21.1.3 operator-() [1/2]

```
Vector2 GEOM_FADE2D::operator- (
        const Vector2 & in ) [inline]
```

Returns

a vector that points in the opposite direction

7.21.1.4 operator-() [2/2]

```
Vector2 GEOM_FADE2D::operator- (
        const Vector2 & vec0,
        const Vector2 & vec1 ) [inline]
```

Subtraction

7.21.1.5 operator<<()

```
std::ostream& GEOM_FADE2D::operator<< (
        std::ostream & stream,
        const Vector2 & vec ) [inline]
```

Print to stream

7.22 Visualizer2.h File Reference

```
#include "Point2.h"
#include "Circle2.h"
#include "Segment2.h"
#include "Color.h"
#include "Label.h"
#include "Bbox2.h"
#include "Edge2.h"
#include "common.h"
```

Classes

- class GEOM_FADE2D::Visualizer2

  Visualizer2 is a general Postscript writer. It draws the objects Point2, Segment2, Triangle2, Circle2 and Label.

7.23 VoroCell2.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Bbox2.h"
```

Classes

- class GEOM_FADE2D::VoroCell2

  Voronoi cell.

7.23.1 Detailed Description

Voronoi cell

7.24 Voronoi2.h File Reference

```
#include "common.h"
#include "VoroVertex2.h"
#include "VoroCell2.h"
```

Classes

- class GEOM_FADE2D::Voronoi2

  Voronoi diagram.

7.24.1 Detailed Description

Voronoi diagram

7.25 VoroVertex2.h File Reference

```
#include "common.h"
#include "Triangle2.h"
```

Classes

- class GEOM_FADE2D::VoroVertex2

  Voronoi vertex.

7.25.1 Detailed Description

Voronoi vertex

7.26 Zone2.h File Reference

```
#include "common.h"
#include "Bbox2.h"
#include "Edge2.h"
#include "Segment2.h"
#include "UserPredicates.h"
#include "MsgBase.h"
```

Classes

- class GEOM_FADE2D::Zone2

  Zone2 is a certain defined area of a triangulation.

Enumerations

- enum GEOM_FADE2D::OptimizationMode { GEOM_FADE2D::OPTMODE_STANDARD, GEOM_FADE2D::OPTMODE_BETT
  GEOM_FADE2D::OPTMODE_BEST }

Functions

- Zone2 ∗ GEOM_FADE2D::zoneDifference (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the difference of two zones.
- Zone2 ∗ GEOM_FADE2D::zoneIntersection (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the intersection of two zones.
- Zone2 ∗ GEOM_FADE2D::zoneSymmetricDifference (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the symmetric difference of two zones.
- Zone2 ∗ GEOM_FADE2D::zoneUnion (Zone2 ∗pZone0, Zone2 ∗pZone1)

  Compute the union of two zones.

7.26.1 Enumeration Type Documentation

7.26.1.1 OptimizationMode `enum GEOM_FADE2D::OptimizationMode`

Enumerates the possible modes for Valley/Ridge optimization through Zone2::slopeValleyRidgeOptimization().

Enumerator

OPTMODE_STANDARD	Fastest optimization mode.
OPTMODE_BETTER	Considerably better quality and still fast.
OPTMODE_BEST	Best quality but quite time consuming.

7.26.2 Function Documentation

7.26.2.1 zoneDifference()

```
Zone2* GEOM_FADE2D::zoneDifference (
        Zone2 * pZone0,
        Zone2 * pZone1 )
```

Returns

a new zone containing the triangles of ∗pZone0 minus the ones of ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

7.26.2.2 zoneIntersection()

```
Zone2* GEOM_FADE2D::zoneIntersection (
        Zone2 * pZone0,
        Zone2 * pZone1 )
```

Returns

a new zone containing the intersection of ∗pZone0 and ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

7.26.2.3 zoneSymmetricDifference()

```
Zone2* GEOM_FADE2D::zoneSymmetricDifference (
        Zone2 * pZone0,
        Zone2 * pZone1 )
```

Returns

a new zone containing the triangles that are present in one of the zones but not in the other one.

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

7.26.2.4 zoneUnion()

```
Zone2* GEOM_FADE2D::zoneUnion (
        Zone2 * pZone0,
        Zone2 * pZone1 )
```

Returns

a new zone containing the union of the triangles of ∗pZone0 and ∗pZone1

Note

`pZone0` and `pZone1` must belong to the same Fade_2D object.

Index