

Fade2.5D

v2.04

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1 Main Page

1.1 C++ Delaunay Triangulation and Voronoi library Fade2.5D

- Fast C++ Constrained Delaunay triangulation and Voronoi library , [see the benchmark](#).
- C++ examples for
 - [2D Delaunay triangulations](#),
 - [2D Voronoi C++ code examples](#) and
 - [2.5D triangulations](#).
- Free Student license. Commercial licenses and support are available.
- Support for Windows (Visual Studio), MacOS (Clang) and iOS (new), 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..** In addition it has a z-coordinate and a rich selection of 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_fade25**
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

- A supposed crash is often just an exception that has been thrown for a good reason. Use try.../catch() blocks to find out why.
 - Do 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.**
 - Don't mix multiple Visual Studio versions. 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 2.04, February 22nd, 2023:

- importTriangles(): Performance improved, multithreading added, progress counter added
- [copyFade\(\)](#) function added to copy a Fade instance and its zones.
- native VS2022 version added.

Version 2.03, January 9th, 2023:

- Grid meshing is much faster now
- Memory leak fixed, possible numerical problem fixed
- Multithreading improved, see [setGlobalNumCPU\(\)](#)
- Performance of Cut&Fill improved

Version 2.02, October 3rd, 2022:

- Cut&Fill revised for better reproducibility and robustness. The default value of ignoreThreshold has been reduced to 1e-6 to prevent null-components due to rounding.
- Numeric bug solved. This bug has not shown up for years but it is a critical one and upgrading to version 2.02 is recommended.

Version 2.01, September 19th, 2022:

- Reproducibility further improved.
- Note: For reproducibility pass the maximum number of vertices (including those created due to intersections and remeshing) to the Fade_2D constructor e.g., Fade_2D dt(1000000);

Version 2.00, September 15th, 2022:

- Fade v2.00 is simply the version number after v1.99. There are no fundamental or breaking changes in the library.
- Reproducibility of results for grid and quality meshing
- Minor fixes

Version 1.99, January 25th, 2022:

- Bugfix: In version 1.98 multithreading was not stable. Fixed.
- The function [offsetPolygonPoints\(\)](#) accounts for angles of the polygon now.

Version 1.98, January 15th, 2022:

- Large coordinates and other numerically difficult settings are now handled more efficiently. It depends on your data whether this gives a dramatic improvement in performance.
- CutAndFill prints warnings to stdout but this is not always desired, so CutAndFill::go() takes a new parameter *bool bWithMessages* now. Use *bWithMessages=false* to disable the messages.
- FadeExport offers the new function FadeExport::lexiSort(): It sorts the points stored in FadeExport lexicographically. Use it for better reproducibility.
- New function FadeExport::getCustomIndex() to retrieve the (optional) custom index of a vertex.
- New function FadeExport::getNormal() to compute the normal vector of a stored triangle.

Version 1.97, October 29th, 2021:

- Custom indices via CloudPrepare work now
- Voronoi diagram fixed (it had an endless loop)

Version 1.96, October 18th, 2021:

- Bug in CloudPrepare::adaptiveSimplification() fixed and other small bugfixes
- iOS support added (please report your experience)

Version 1.95, October 2nd:

- Internal test version, bugfixes, iOS

Version 1.94, September 7th, 2021:

- Fixed: When all points are horizontal or all points are vertical then multithreaded insertion failed.

Version 1.93, September 1st, 2021:

- Bug in the new Voronoi diagram module solved
- Voronoi diagram improved

Version 1.92, August 9th, 2021:

- Multithreading issue finally fixed.

Version 1.91, August 8th, 2021:

- Fixed multithreading issue when SegmentChecker is used in multiple threads
- New methods in Fade_2D: [getDirectedEdges\(\)](#), [getUndirectedEdges\(\)](#) and [getNearestNeighbor\(\)](#)
- Export of Zones to the FadeExport struct

Version 1.90, August 8th, 2021:

- Fixed stability issue when SegmentChecker is used in multiple threads
- Fixed rare bug in the Fade_2D::drape() method
- Added pZone2::getComponentPolygons() to retrieve oriented boundary polygons per connected component
- Added the free function [getSortedBoundaryPolygons\(\)](#)

Version 1.89, June 8th, 2021:

- Voronoi diagram: Numeric problems fixed.
- Visualizer: Scaling problem fixed.
- Circumcenter-computation improved.
- Segment intersection accuracy 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 convenient 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 concentrated on refactoring and rare bugs) this is again a stable public release:

- The constraint insertion subsystem has been rewritten 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 zoneLocation 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 `getMaxTriangleArea(double x,double y)` and `getMaxEdgeLength(double x,double y)` where x and y were 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(MeshGenParams* 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 were 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.
- Removal 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 `Fade2<-D::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.

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2.1 Modules

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3.1 Class List

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4 File Index

4.1 File List

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5 Module Documentation

5.1 Tools

Functions

- void `GEOM_FADE25D::edgesToPolygons` (const std::vector< `Edge2` > &vEdgesIn, std::vector< std::vector< `Edge2` > > &vvPolygonsOut, std::vector< `Edge2` > &vRemainingOut)

Create polygons from a set of edges.
- bool `GEOM_FADE25D::fillHole` (const 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)
- bool `GEOM_FADE25D::fillHole` (Mesh3 *pMesh, const std::vector< `Edge2` > &vPolygonEdges, bool bWithRefine, bool bVerbose, std::vector< `Point2` > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- bool `GEOM_FADE25D::fillHole` (std::vector< `Point2` > &vMeshCorners, const std::vector< `Segment2` > &vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< `Point2` > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- double `GEOM_FADE25D::getArea25D` (const `Point2` *p0, const `Point2` *p1, const `Point2` *p2)

Get 2.5D area of a triangle.
- double `GEOM_FADE25D::getArea2D` (const `Point2` *p0, const `Point2` *p1, const `Point2` *p2)

Get 2D area of a triangle.
- void `GEOM_FADE25D::getBorders` (const std::vector< `Triangle2` * > &vT, std::vector< std::vector< `Segment2` > &vBorderSegmentsOut)

Get Borders.
- void `GEOM_FADE25D::getConnectedComponents` (const std::vector< `Triangle2` * > &vT, std::vector< std::vector< `Triangle2` * > > &vvT)

Get connected components.
- void `GEOM_FADE25D::getDirectedEdges` (const std::vector< `Triangle2` * > &vT, std::vector< `Edge2` > &vDirectedEdgesOut)

Get directed edges The directed edges of vT are returned in 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).
- `Vector2 GEOM_FADE25D::getNormalVector` (const `Point2` &p0, const `Point2` &p1, const `Point2` &p2, bool &bOK)

Get normal vector.
- `Orientation2 GEOM_FADE25D::getOrientation2` (const `Point2` *p0, const `Point2` *p1, const `Point2` *p2)

Get the orientation of three points.
- `Orientation2 GEOM_FADE25D::getOrientation2_mt` (const `Point2` *p0, const `Point2` *p1, const `Point2` *p2)

Get Orientation2 (MT)
- void `GEOM_FADE25D::getUndirectedEdges` (const std::vector< `Triangle2` * > &vT, std::vector< `Edge2` > &vUndirectedEdgesOut)

Get undirected edges.
- bool `GEOM_FADE25D::isSimplePolygon` (std::vector< `Segment2` > &vSegments)

isSimplePolygon
- void `GEOM_FADE25D::pointsToPolyline` (std::vector< `Point2` > &vInPoints, bool bClose, std::vector< `Segment2` > &vOutSegments)

Points-to-Polyline.
- bool `GEOM_FADE25D::sortRing` (std::vector< `Segment2` > &vRing)

Sort a vector of Segments.
- bool `GEOM_FADE25D::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_FADE25D::edgesToPolygons (
    const 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	<i>vEdgesIn</i>	is a vector of oriented edges
out	<i>vvPolygonsOut</i>	contains one vector<Edge2> for each polygon found in the input data.
out	<i>vRemainingOut</i>	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-coordinate 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.

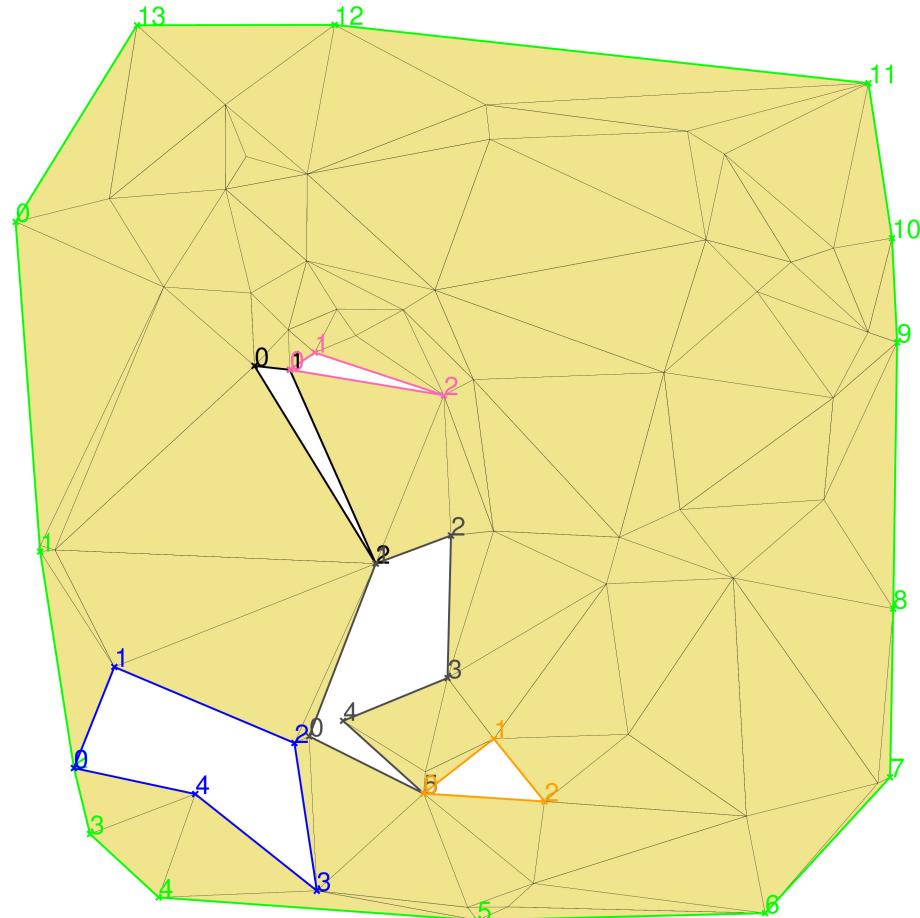


Figure 1 Polygons created by edgesToPolygons

5.1.2.2 **fillHole()** [1/3] `bool GEOM_FADE25D::fillHole (`

```
    const 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	<i>vPolygonSegments</i>	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 adjacent 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	<i>bWithRefine</i>	specifies if additional vertices shall be created. (<i>bWithRefine</i> =true is experimental, don't use currently)
in	<i>bVerbose</i>	specifies if warnings shall be printed to stdout
out	<i>vCornersOut</i>	contains the created fill triangles, 3 corners per triangle, counterclockwise oriented.

Note

This function is deprecated because all related functionality has been moved to the WOF project.

```
5.1.2.3 fillHole() [2/3] bool GEOM_FADE25D::fillHole (
    Mesh3 * pMesh,
    const std::vector< Edge2 > & vPolygonEdges,
    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	<i>pMesh</i>	
in	<i>vPolygonEdges</i>	are edges of the polygon to be triangulated. They must form a closed polygon in the mesh.
in	<i>bWithRefine</i>	specifies if additional vertices shall be created (Note: bWithRefine=true is experimental, don't use currently)
in	<i>bVerbose</i>	specifies if warnings shall be printed to stdout
out	<i>vCornersOut</i>	contains the created fill triangles, 3 corners per triangle, counterclockwise oriented.

Note

This function is deprecated because all related functionality has been moved to the WOF project.

```
5.1.2.4 fillHole() [3/3] bool GEOM_FADE25D::fillHole (
    std::vector< Point2 > & vMeshCorners,
    const std::vector< Segment2 > & 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	<i>vMeshCorners</i>	specifies the input mesh, 3 points per triangle in counterclockwise order.
in	<i>vPolygonSegments</i>	are the edges of the <i>closed</i> polygon to be triangulated.
in	<i>bWithRefine</i>	specifies if additional vertices shall be created (bWithRefine=true is experimental, don't use currently)
in	<i>bVerbose</i>	specifies if warnings shall be printed to stdout
out	<i>vCornersOut</i>	contains the created fill triangles, 3 corners per triangle, counterclockwise oriented.

Note

This function is deprecated because all related functionality has been moved to the WOF project.

```
5.1.2.5 getArea25D() double GEOM_FADE25D::getArea25D (
    const Point2 * p0,
```

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

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

Parameters

in	p0,p1,p2	are the corners of the triangle
----	----------	---------------------------------

```
5.1.2.6 getArea2D() double GEOM_FADE25D::getArea2D (
    const Point2 * p0,
    const Point2 * p1,
    const Point2 * p2 )
```

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

Note

The 2D area is returned i.e., the z-coordinate is ignored.

See also

[getArea25D\(\)](#)

Parameters

in	p0,p1,p2	are the corners of the triangle
----	----------	---------------------------------

```
5.1.2.7 getBorders() void GEOM_FADE25D::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

```
5.1.2.8 getConnectedComponents() void GEOM_FADE25D::getConnectedComponents (
    const std::vector< Triangle2 * > & vT,
    std::vector< std::vector< Triangle2 * > > & vvT )
```

This function partitions the triangles of vT into connected components i.e., connected sets of triangles. A connection between two triangles exists when they share a common edge.

Parameters

in	vT	Input triangles
out	vvT	Output components

```
5.1.2.9 getNormalVector() Vector2 GEOM_FADE25D::getNormalVector (
    const Point2 & p0,
    const Point2 & p1,
    const Point2 & p2,
    bool & bOK )
```

Returns the normalized normal vector of the triangle defined by the three input points `p0, p1, p2`.

Parameters

in	<code>p0,p1,p2</code>	When these points are counterclockwise (CCW) oriented then the resulting normal vector points towards the viewer.
out	<code>bOK</code>	returns true for valid results. When the plane defined by <code>p0, p1, p2</code> is degenerate, <code>bOK</code> returns false.

```
5.1.2.10 getOrientation2() Orientation2 GEOM_FADE25D::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

```
5.1.2.11 getOrientation2_mt() Orientation2 GEOM_FADE25D::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.

```
5.1.2.12 getUndirectedEdges() void GEOM_FADE25D::getUndirectedEdges (
```

```
    const std::vector< Triangle2 * > & vT,
    std::vector< Edge2 > & vUndirectedEdgesOut )
```

The undirected edges of `vT` are returned `vUndirectedEdgesOut`.

```
5.1.2.13 isSimplePolygon() bool GEOM_FADE25D::isSimplePolygon (
```

```
    std::vector< Segment2 > & vSegments )
```

Parameters

in	<code>vSegments</code>	specifies segments to be checked. Degenerate segments (0-length) are ignored.
----	------------------------	---

Returns

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

```
5.1.2.14 pointsToPolyline() void GEOM_FADE25D::pointsToPolyline (
```

```
    std::vector< Point2 > & vInPoints,
```

```
    bool bClose,
    std::vector< Segment2 > & vOutSegments )
```

Turns a vector of points ($p_0, p_1, p_2, \dots, p_m, p_n$) into a vector of segments ($(p_0, p_1), (p_1, p_2), \dots, (p_m, p_n)$). In case that $bClose$ is true an additional segment (p_n, p_0) is constructed. Degenerate segments are ignored. Selfintersections of the polyline are not checked.

Parameters

in	<i>vInPoints</i>	
in	<i>bClose</i>	specifies whether a closing segment shall be constructed
out	<i>vOutSegments</i>	is where the output segments are stored

5.1.2.15 sortRing() `bool GEOM_FADE25D::sortRing (`
 `std::vector< Segment2 > & vRing)`

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

5.1.2.16 sortRingCCW() `bool GEOM_FADE25D::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_FADE25D::getFade2DVersion ()`
Get the Fade2D version string.
- `int GEOM_FADE25D::getMajorVersionNumber ()`
Get the major version number.
- `int GEOM_FADE25D::getMinorVersionNumber ()`
Get the minor version number.
- `int GEOM_FADE25D::getRevisionNumber ()`
Get the revision version number.
- `bool GEOM_FADE25D::isRelease ()`
Check if a RELEASE or a DEBUG version is used.

5.2.1 Detailed Description

5.3 File I/O

Functions

- `bool GEOM_FADE25D::readPointsBIN (const char *filename, std::vector< Point2 > &vPointsIn, bool bWithHeader=true)`
Read points from a binary file.
- `bool GEOM_FADE25D::readSegmentsBIN (const char *filename, std::vector< Segment2 > &vSegmentsOut)`
Read segments from a binary file.
- `bool GEOM_FADE25D::readXY (const char *filename, std::vector< Point2 > &vPointsOut)`
Read (x y) points.
- `bool GEOM_FADE25D::readXYZ (const char *filename, std::vector< Point2 > &vPointsOut)`
Read (x y z) points.
- `bool GEOM_FADE25D::writePointsASCII (const char *filename, const std::vector< Point2 * > &vPointsIn)`

Write points to an ASCII file.

- bool [GEOM_FADE25D::writePointsASCII](#) (const char *filename, const std::vector< [Point2](#) > &vPointsIn)

Write points to an ASCII file.
- bool [GEOM_FADE25D::writePointsBIN](#) (const char *filename, std::vector< [Point2](#) * > &vPointsIn)

Write points to a binary file.
- bool [GEOM_FADE25D::writePointsBIN](#) (const char *filename, std::vector< [Point2](#) > &vPointsIn)

Write points to a binary file.
- bool [GEOM_FADE25D::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_FADE25D::readPointsBIN (

```
const char * filename,
std::vector< Point2 > & vPointsIn,
bool bWithHeader = true )
```

Reads points from a binary file.

Parameters

<i>filename</i>	is the input file
<i>vPointsIn</i>	is used to return the points
<i>bWithHeader</i>	specifies if the file contains a header (like the ones written by writePointsBIN()) or if the file contains just a sequence of double precision coordinates - use false in this case.

See also

[writePointsBIN\(\)](#)

5.3.2.2 [readSegmentsBIN\(\)](#) bool GEOM_FADE25D::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\(\)](#) bool GEOM_FADE25D::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. The z coordinate is set to 0.

5.3.2.4 [readXYZ\(\)](#) bool GEOM_FADE25D::readXYZ (

```
const char * filename,
std::vector< Point2 > & vPointsOut )
```

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

5.3.2.5 writePointsASCII() [1/2] `bool GEOM_FADE25D::writePointsASCII (`
 `const char * filename,`
 `const std::vector< Point2 * > & vPointsIn)`

Writes points to an ASCII file, three coordinates (x y z) 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\(\)](#))

5.3.2.6 writePointsASCII() [2/2] `bool GEOM_FADE25D::writePointsASCII (`
 `const char * filename,`
 `const std::vector< Point2 > & vPointsIn)`

Write points to an ASCII file

See also

[readPointsASCII\(\)](#)

5.3.2.7 writePointsBIN() [1/2] `bool GEOM_FADE25D::writePointsBIN (`
 `const char * filename,`
 `std::vector< Point2 * > & vPointsIn)`

Writes points to a binary file

See also

[readPointsBIN\(\)](#)

5.3.2.8 writePointsBIN() [2/2] `bool GEOM_FADE25D::writePointsBIN (`
 `const char * filename,`
 `std::vector< Point2 > & vPointsIn)`

File format:

```
int filetype (30)
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.

5.3.2.9 writeSegmentsBIN() `bool GEOM_FADE25D::writeSegmentsBIN (`
 `const char * filename,`
 `std::vector< Segment2 > & vSegmentsIn)`

Binary file format:

```
int filetype (31)
```

```

size_t numSegments (vSegmentsIn.size ())
double x0_source
double y0_source
double z0_source
double x0_target
double y0_target
double z0_target
...
double xn_source
double yn_source
double zn_source
double xn_target
double yn_target
double zn_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

- void [GEOM_FADE25D::generateCircle](#) (int numPoints, double x, double y, double z, double radiusX, double radiusY, std::vector< [Point2](#) > &vCirclePointsOut)

Generate a circle.
- void [GEOM_FADE25D::generateRandomNumbers](#) (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)

Generate random numbers.
- void [GEOM_FADE25D::generateRandomPoints](#) (size_t numRandomPoints, double min, double max, std::vector< [Point2](#) > &vRandomPointsOut, unsigned int seed=0)

Generate random points.
- void [GEOM_FADE25D::generateRandomPoints3D](#) (size_t numRandomPoints, double min, double max, std::vector< [Point2](#) > &vRandomPointsOut, unsigned int seed=0)

Generate random points with height.
- void [GEOM_FADE25D::generateRandomPolygon](#) (size_t numSegments, double min, double max, std::vector< [Segment2](#) > &vPolygonOut, unsigned int seed=0)

Generate a random simple polygon.
- void [GEOM_FADE25D::generateRandomSegments](#) (size_t numSegments, double min, double max, double maxLen, std::vector< [Segment2](#) > &vSegmentsOut, unsigned int seed)

Generate random line segments.
- void [GEOM_FADE25D::generateRandomSurfacePoints](#) (size_t numX, size_t numY, size_t numCenters, double xmin, double ymin, double zmin, double xmax, double ymax, double zmax, std::vector< [Point2](#) > &vSurfacePointsOut, unsigned int seed)

Generate a random surface.
- void [GEOM_FADE25D::generateSineSegments](#) (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< [Segment2](#) > &vSineSegmentsOut)

Generate segments from a sine function.
- void [GEOM_FADE25D::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. Fadé 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() void GEOM_FADE25D::generateCircle (
    int numPoints,
    double x,
    double y,
    double z,
    double radiusX,
    double radiusY,
    std::vector< Point2 > & vCirclePointsOut )
```

Returns points on a circle centered at the given coordinates

```
5.4.3.2 generateRandomNumbers() void GEOM_FADE25D::generateRandomNumbers (
    size_t num,
    double min,
    double max,
    std::vector< double > & vRandomNumbersOut,
    unsigned int seed = 0 )
```

Parameters

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

Note

Reproducible 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() void GEOM_FADE25D::generateRandomPoints (
    size_t numRandomPoints,
    double min,
    double max,
    std::vector< Point2 > & vRandomPointsOut,
    unsigned int seed = 0 )
```

Parameters

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

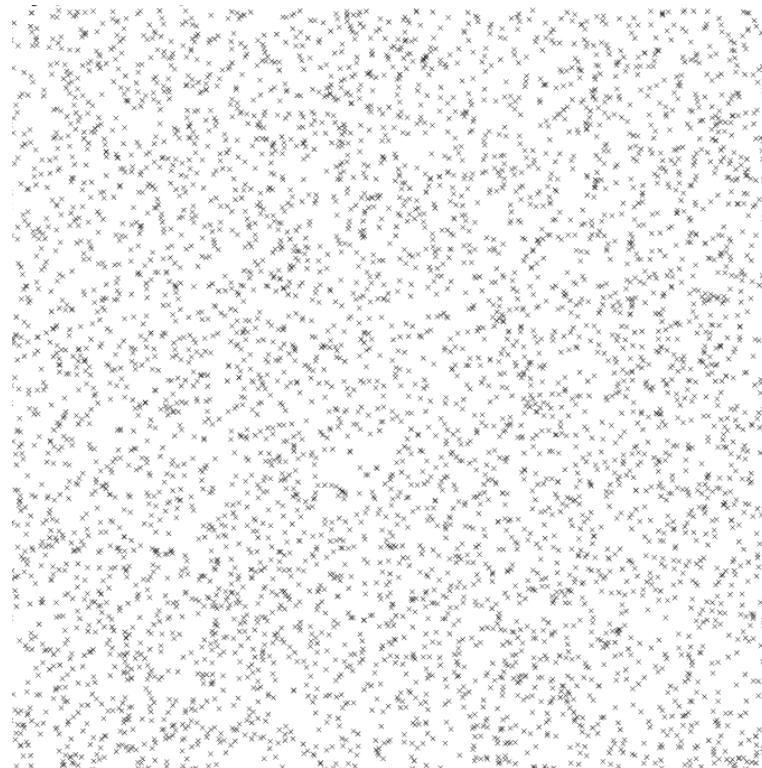


Figure 2 Point generator

```
5.4.3.4 generateRandomPoints3D() void GEOM_FADE25D::generateRandomPoints3D (
    size_t numRandomPoints,
    double min,
    double max,
    std::vector< Point3 > & vRandomPointsOut,
    unsigned int seed = 0 )
```

Parameters

	<i>numRandomPoints</i>	Number of points to be generated
	<i>min</i>	Lower bound (x,y)

Parameters

	<i>max</i>	Upper bound (x,y)
<i>out</i>	<i>vRandomPointsOut</i>	is the output vector
	<i>seed</i>	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

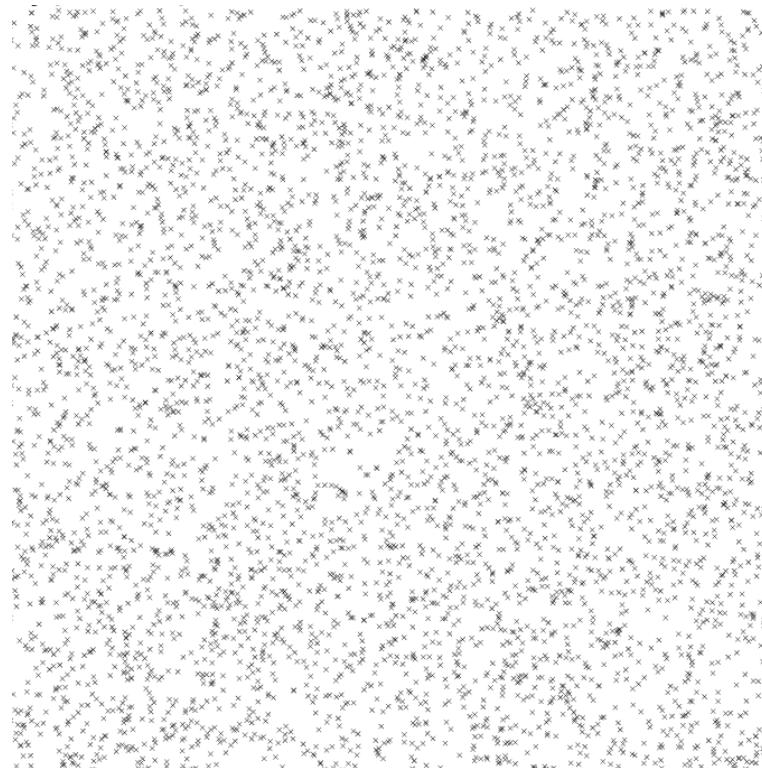


Figure 3 Point generator

```
5.4.3.5 generateRandomPolygon() void GEOM_FADE25D::generateRandomPolygon (
    size_t numSegments,
    double min,
    double max,
    std::vector< Segment2 > & vPolygonOut,
    unsigned int seed = 0 )
```

Parameters

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

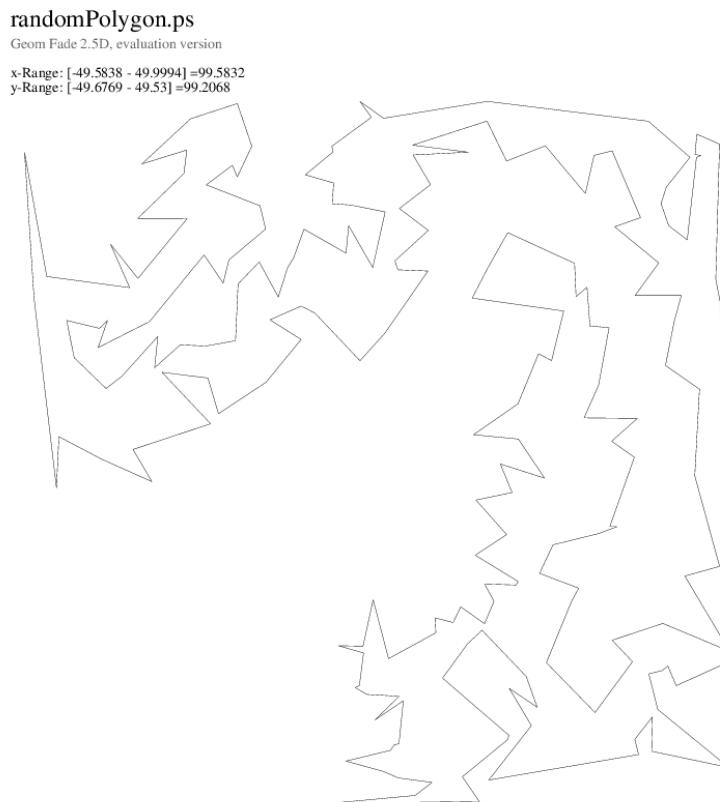


Figure 4 Polygon generator: Random simple polygon

5.4.3.6 generateRandomSegments() void GEOM_FADE25D::generateRandomSegments (size_t numSegments, double min, double max, double maxLen, std::vector< Segment2 > & vSegmentsOut, unsigned int seed)

Parameters

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



Figure 5 Segment generator: Random line segments

5.4.3.7 `generateRandomSurfacePoints()` `void GEOM_FADE25D::generateRandomSurfacePoints (`

```
size_t numX,
size_t numY,
size_t numCenters,
double xmin,
double ymin,
double zmin,
double xmax,
double ymax,
double zmax,
std::vector< Point2 > & vSurfacePointsOut,
unsigned int seed )
```

Parameters

	<code>numX,numY</code>	specifies the grid size and must be >1. numX*numY points are created
	<code>numCenters</code>	defines the number of extreme points (must be >0)
	<code>xmin,ymin,zmin,xmax,ymax,zmax</code>	specifies the geometric bounds
<code>out</code>	<code>vSurfacePointsOut</code>	is the output vector
	<code>seed</code>	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

5.4.3.8 `generateSineSegments()` `void GEOM_FADE25D::generateSineSegments (`

```
int numSegments,
```

```

int numPeriods,
double xOffset,
double yOffset,
double xFactor,
double yFactor,
bool bSwapXY,
std::vector< Segment2 > & vSineSegmentsOut )

```

Parameters

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

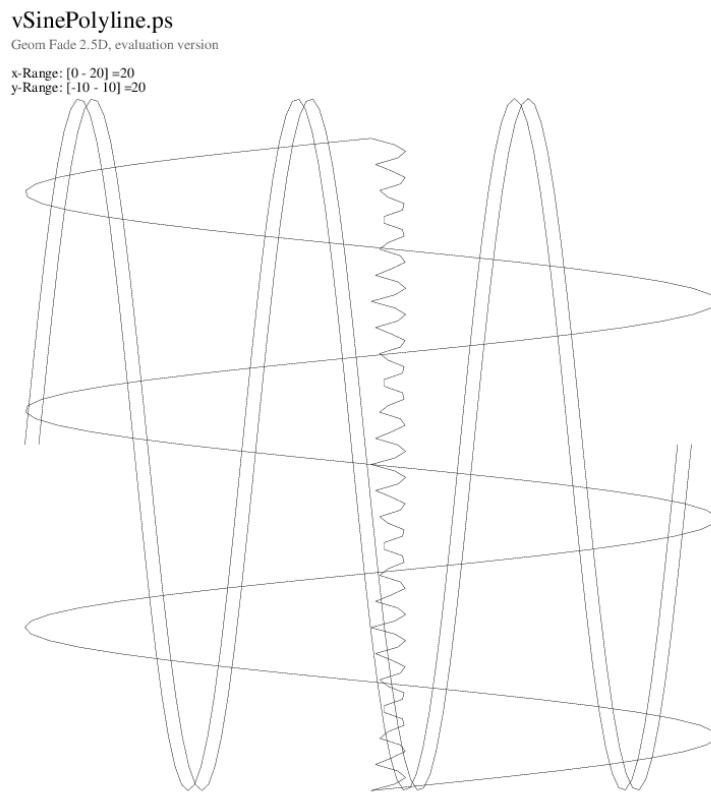


Figure 6 Polyline generator: Polylines from sine functions

6 Class Documentation

6.1 GEOM_FADE25D::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 Bbox2 &other)`
Add another bounding box.
- `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, bool bUseMaxRange, double minRange)`
Enlarge the x|y-ranges of a bounding box.
- `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 get Corners (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 **reset** ()
 - Reset the bounds.*
- 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)
- bool **updateMaxAbs** ()

Protected Attributes

- bool **bValid**
- double **maxAbsCoord**
- 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 Constructor & Destructor Documentation

6.1.1.1 Bbox2() GEOM_FADE25D::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

6.1.2 Member Function Documentation

6.1.2.1 add() [1/5] `bool GEOM_FADE25D::Bbox2::add (const Bbox2 & other) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.2 add() [2/5] `bool GEOM_FADE25D::Bbox2::add (const Point2 & p) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.3 add() [3/5] `bool GEOM_FADE25D::Bbox2::add (size_t numPoints, double * coordinates) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.4 add() [4/5] `bool GEOM_FADE25D::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

6.1.2.5 add() [5/5] `bool GEOM_FADE25D::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

6.1.2.6 doIntersect() `bool GEOM_FADE25D::Bbox2::doIntersect (const Bbox2 & other) const`

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

6.1.2.7 doubleTheBox() `void GEOM_FADE25D::Bbox2::doubleTheBox ()`

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

```
6.1.2.8 enlargeRanges() void GEOM_FADE25D::Bbox2::enlargeRanges (
    double factor,
    bool bUseMaxRange,
    double minRange )
```

This function updates `minX`, `minY`, `maxX` and `maxY` symmetrically to enlarge the x- and y-ranges of the bounding box.

Parameters

<code>factor</code>	is the factor by which the existing ranges <code>rangeX</code> and <code>rangeY</code> shall grow.
<code>bUseMaxRange</code>	specifies if a square bounding box with side length <code>factor * max(rangeX, rangeY)</code> shall be made.
<code>minRange</code>	is a lower bound on the new ranges and it can be used to avoid a degenerate box when the pre-existing box was degenerate.

```
6.1.2.9 get_maxX() double GEOM_FADE25D::Bbox2::get_maxX ( ) const [inline]
```

Returns

`maxX`

```
6.1.2.10 get_maxY() double GEOM_FADE25D::Bbox2::get_maxY ( ) const [inline]
```

Returns

`maxY`

```
6.1.2.11 get_minX() double GEOM_FADE25D::Bbox2::get_minX ( ) const [inline]
```

Returns

`minX`

```
6.1.2.12 get_minY() double GEOM_FADE25D::Bbox2::get_minY ( ) const [inline]
```

Returns

`minY`

```
6.1.2.13 getBoundary() void GEOM_FADE25D::Bbox2::getBoundary (
    std::vector< Segment2 > & vBoundary ) const
```

Convenience function: Returns 4 border segments

```
6.1.2.14 getorners() void GEOM_FADE25D::Bbox2::getCorners (
    std::vector< Point2 > & vBoxCorners ) const
```

Convenience function: Returns the 4 corners of the box

```
6.1.2.15 getMaxCoord() double GEOM_FADE25D::Bbox2::getMaxCoord ( ) const [inline]
```

Returns

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

6.1.2.16 `getMaxPoint()` `Point2 GEOM_FADE25D::Bbox2::getMaxPoint () const [inline]`

Returns

the 2D corner point with the maximum coordinates, the z-coordinate is set to 0

6.1.2.17 `getMaxRange()` `double GEOM_FADE25D::Bbox2::getMaxRange () const [inline]`

Returns

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

6.1.2.18 `getMinCoord()` `double GEOM_FADE25D::Bbox2::getMinCoord () const [inline]`

Returns

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

6.1.2.19 `getMinPoint()` `Point2 GEOM_FADE25D::Bbox2::getMinPoint () const [inline]`

Returns

the corner point with the minimum coordinates, the z-coordinate is set to 0

6.1.2.20 `getOffsetCorners()` `void GEOM_FADE25D::Bbox2::getOffsetCorners (`

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

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

6.1.2.21 `getRangeX()` `double GEOM_FADE25D::Bbox2::getRangeX () const [inline]`

Returns

`maxX-minX`

6.1.2.22 `getRangeY()` `double GEOM_FADE25D::Bbox2::getRangeY () const [inline]`

Returns

`maxY-minY`

6.1.2.23 `inflateIfDegenerate()` `void GEOM_FADE25D::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 undesirable. The present method inflates the `Bbox2` by adding /p `val` to `maxX` and/or `maxY`.

6.1.2.24 `isInBox()` `bool GEOM_FADE25D::Bbox2::isInBox (`
 `const Point2 & p) const`

Returns

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

6.1.2.25 isValid() `bool GEOM_FADE25D::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`

6.1.2.26 operator+() `Bbox2 GEOM_FADE25D::Bbox2::operator+ (const Bbox2 & b)`

Extends the 2D bounding box if required.

Returns

the resulting bounding box

6.1.2.27 reset() `void GEOM_FADE25D::Bbox2::reset () [inline]`

Resets the bounding box to default values

6.1.3 Friends And Related Function Documentation**6.1.3.1 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_FADE25D::CAF_Component Class Reference

[CAF_Component](#) stands for CUT AND FILL COMPONENT. It represents a connected area of the surface.

```
#include <CAF_Component.h>
```

Public Member Functions

- **CAF_Component** (`std::vector< Triangle2 * > &vT_, std::map< Point2 *, std::pair< double, double > > &mVtx2BeforeAfter_, int label_)`)
- void **getBorder** (`std::vector< Segment2 > &vBorderSegments`) const
Get border.
- **CAFTYP getCAFType** () const
Get Cut&Fill-Type.
- int **getLabel** () const
Get label.
- void **getTriangles** (`std::vector< Triangle2 * > &vTrianglesOut`) const
Get Triangles.
- double **getVolume** () const
Get the volume.

Protected Member Functions

- void **init** (`std::map< Point2 *, std::pair< double, double > > &mVtx2BeforeAfter`)
- void **setVolume** (`std::vector< Point2 > *pvBeforeT, std::vector< Point2 > *pvAfterT, std::vector< Point2 > *pvWallT`)
- void **showGeomview** (`const char *name, std::vector< Point2 > *pvBeforeT, std::vector< Point2 > *pvAfterT, std::vector< Point2 > *pvWallT`) const

Protected Attributes

- `CAFTYP caftype`
- int `label`
- std::vector< `Triangle2 *` > * `pVT`
- double `volume`

6.2.1 Detailed Description

A `CAF_Component` object represents a connected part of the surface such that:

- the first surface is below the second one (`CAFTYP=CT_FILL`) or
- the first surface is above the second one (`CAFTYP=CT_CUT`) or
- the first surface corresponds to the second one (`CAFTYP=CT_NULL`)

6.2.2 Member Function Documentation

6.2.2.1 `getBorder()` `void GEOM_FADE25D::CAF_Component::getBorder (std::vector< Segment2 > & vBorderSegments) const`

Returns

border segments of the present component in no particular order

6.2.2.2 `getCAFType()` `CAFTYP GEOM_FADE25D::CAF_Component::getCAFType () const`

Returns

`CT_CUT`, `CT_FILL` or `CT_NULL`

- `CT_CUT` means that earth must be digged off to turn the first surface into the second one,
- `CT_FILL` means that earth must be added.
- `CT_NULL` is returned when the first surface corresponds to the second one.

6.2.2.3 `getLabel()` `int GEOM_FADE25D::CAF_Component::getLabel () const`

Returns

the component label

Components are consecutively numbered.

6.2.2.4 `getTriangles()` `void GEOM_FADE25D::CAF_Component::getTriangles (std::vector< Triangle2 * > & vTrianglesOut) const`

Returns

the triangles of the present component. The z-coordinates of their corners correspond to the height differences between the two input surfaces.

Parameters

out	<code>vTrianglesOut</code>	is used to return the triangles
-----	----------------------------	---------------------------------

6.2.2.5 `getVolume()` double GEOM_FADE25D::CAF_Component::getVolume () const**Returns**

the volume of the present component.

Note

The volume is an absolute value. Use [getCAFType\(\)](#) to determine if it is a CUT, FILL or ZERO volume.

Warning

The computations are unitless but you must make sure that the x, y, and z-coordinate are given in the same unit.

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

- [CAF_Component.h](#)

6.3 GEOM_FADE25D::Circle2 Class Reference

Circle for visualization.

```
#include <Circle2.h>
```

Public Member Functions

- [Circle2 \(const Point2 ¢er_, double sqRadius_\)](#)
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<< \(std::ostream &stream, Circle2 b\)](#)

6.3.1 Detailed Description

See also

[Visualizer2](#)

6.3.2 Constructor & Destructor Documentation

6.3.2.1 `Circle2()` [1/2]

```
GEOM_FADE25D::Circle2::Circle2 (
    double x,
    double y,
    double sqRadius_ )
```

Parameters

<i>x</i>	is x-coordinate of the center
<i>y</i>	is y-coordinate of the center
<i>sqRadius_</i>	is the squared radius of the circle

Warning

The method expects the *squared* radius

6.3.2.2 Circle2() [2/2] `GEOM_FADE25D::Circle2::Circle2 (`
 `const Point2 & center_,`
 `double sqRadius_)`

Parameters

<i>center_</i>	center of the circle
<i>sqRadius_</i>	squared radius of the circle

Warning

The method expects the *squared* radius

6.3.3 Member Function Documentation

6.3.3.1 getCenter() `Point2 GEOM_FADE25D::Circle2::getCenter ()`

Returns

a `Point2` which represents the center

6.3.3.2 getRadius() `double GEOM_FADE25D::Circle2::getRadius ()`

Returns

the radius

6.3.3.3 getSqRadius() `double GEOM_FADE25D::Circle2::getSqRadius ()`

Returns

the squared radius

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

- `Circle2.h`

6.4 GEOM_FADE25D::CloudPrepare Class Reference

`CloudPrepare` simplifies overdense point clouds and helps to avoid memory-usage-peaks during data transfer.
`#include <CloudPrepare.h>`

Public Member Functions

- `size_t adaptiveSimplify (double maxDiffZ, SumStrategy sms, ConvexHullStrategy chs, bool bDryRun=false)`
Simplify the Point Cloud according to a tolerance z-value.
- `void add (const std::vector< Point2 > &vPoints)`
Add points to the `CloudPrepare` object (vector-version)
- `void add (double x, double y, double z, int customIndex=-1)`
Add a point to the `CloudPrepare` object.
- `void add (size_t numPoints, double *aCoordinates)`
Add points to the `CloudPrepare` object (array-version)
- `void clear ()`
Clear all stored data.
- `bool computeConvexHull (bool bAllPoints, std::vector< Point2 > &vConvexHull)`
Compute the 2.5D Convex Hull.
- `void getBounds (double &minX, double &minY, double &minZ, double &maxX, double &maxY, double &maxZ)`
Get the min/max bounds.
- `size_t getNumPoints () const`
Get the number of points.
- `void getPoints (std::vector< Point2 > &vPointsOut) const`
Get the simplified point cloud.
- `double getRangeX ()`
- `double getRangeY ()`
- `double getRangeZ ()`
- `size_t uniformSimplifyGrid (double gridLength, SumStrategy sms, ConvexHullStrategy chs, bool bDryRun=false)`
Simplify the point cloud according to grid resolution.
- `size_t uniformSimplifyNum (int approxNumPoints, SumStrategy sms, ConvexHullStrategy chs)`
Simplify the Point Cloud to a specific target size.

6.4.1 Detailed Description

This class has two applications:

1. **Simplification of over-dense point clouds** from areal and photogrammetry surveys. The reduction is either grid-based or z-adaptive with a tolerance threshold for the height error. Four strategies can be selected for grouping similar points: MIN, MAX, MEDIAN and AVG. MIN corresponds to simple ground filtering, since it favors ground measurement points over those on vegetation. MEDIAN stabilizes the point cloud because it removes outliers while AVG is well suited to reduce noise in the scan.
2. **Avoiding memory usage peaks** when triangulating a large point cloud: Usually you have all vertices in the data structures of your own software and when you then call `Fade_2D::insert()`, triangles are created immediately and only after that you have the possibility to remove the points from your own data structures. This means for a short time the vertices are duplicated in memory, and this creates an unnecessary memory peak. The solution is to give the points to the `CloudPrepare` class in advance (one-by-one or all at once) and to delete them from your own data structures while not a single triangle exists yet. Only then call `Fade_2D::insert(&CloudPrepare)`. This avoids duplicating memory usage for the vertices.

Have a look at the [Examples](#).

Note

This class replaces the [EfficientModel](#) class. It is much more memory-efficient and it is extremely fast.

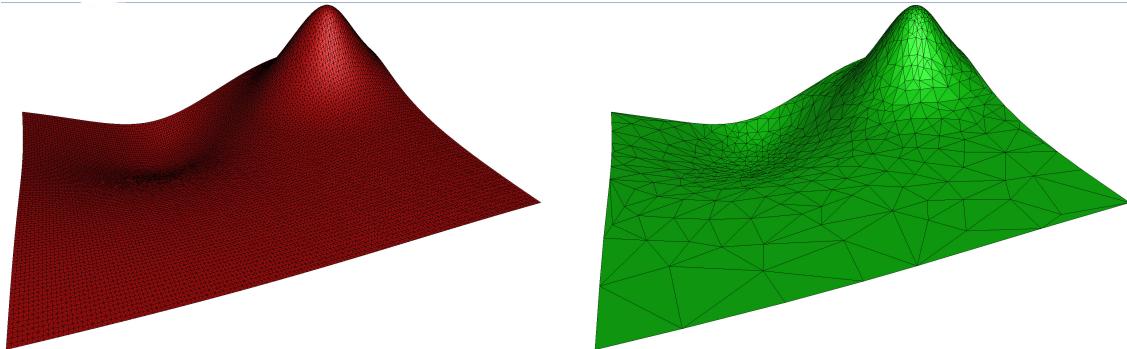


Figure 7 Point Cloud Reduction: Left original, right reduced

6.4.2 Member Function Documentation

6.4.2.1 adaptiveSimplify() `size_t GEOM_FADE25D::CloudPrepare::adaptiveSimplify (`
`double maxDiffZ,`
`SumStrategy sms,`
`ConvexHullStrategy chs,`
`bool bDryRun = false)`

This method simplifies the point cloud height-adaptively. This means that adjoining points with similar z-values (within the given tolerance `maxDiffZ`) are combined into one.

Parameters

<code>maxDiffZ</code>	[in] is the maximum height (z-coordinate) difference of points, so that these points are combined to one.
<code>sms</code>	[in] is the strategy used to summarize similar points into one. Possible values are <code>SMS_MINIMUM</code> , <code>SMS_MAXIMUM</code> , <code>SMS_MEDIAN</code> and <code>SMS_AVERAGE</code> .
<code>chs</code>	[in] is the ConvexHullStrategy: Use <code>CHS_MAXHULL</code> to keep all points of the convex hull unchanged. If only convex points but not collinear points of the convex hull are to be considered as convex hull points, then use <code>CHS_MINHULL</code> . If convex hull points should be treated like all other points, then use <code>CHS_NOHULL</code> .
<code>bDryRun</code>	is used to avoid point cloud simplification. This is used to determine the number of points that would result from simplification with certain parameters. By default <code>bDryRun=false</code> .

Returns

the resulting number of points

6.4.2.2 add() [1/3] `void GEOM_FADE25D::CloudPrepare::add (`
`const std::vector< Point2 > & vPoints)`

Parameters

<code>vPoints</code>	[in] are the input points
----------------------	---------------------------

```
6.4.2.3 add() [2/3] void GEOM_FADE25D::CloudPrepare::add (
    double x,
    double y,
    double z,
    int customIndex = -1 )
```

Parameters

	x,y,z	[in] are the coordinates
in	customIndex	is an optional index that you can use to relate the point to your own data structures.

Note

If you call [Point2::getCustomIndex\(\)](#) on this point at a later time, then exactly this index will be returned.

```
6.4.2.4 add() [3/3] void GEOM_FADE25D::CloudPrepare::add (
    size_t numPoints,
    double * aCoordinates )
```

Parameters

numPoints	[in] specifies the number of input points
aCoordinates	[in] an array that holds 3*numPoints coordinates (x0,y0,z0,x1,y1,z1,...,xn,yn,zn)

```
6.4.2.5 computeConvexHull() bool GEOM_FADE25D::CloudPrepare::computeConvexHull (
    bool bAllPoints,
    std::vector< Point2 > & vConvexHull )
```

Parameters

bAllPoints	If this parameter is <i>true</i> , then all convex hull points are returned. Otherwise, those points are omitted which lie on the convex hull but whose absence does not shrink the convex hull
vConvexHull	[out] is used to return the convex hull points

```
6.4.2.6 getBounds() void GEOM_FADE25D::CloudPrepare::getBounds (
    double & minX,
    double & minY,
    double & minZ,
    double & maxX,
    double & maxY,
    double & maxZ )
```

Parameters

minX,minY,minZ,maxX,maxY,maxZ	[out]
-------------------------------	-------

```
6.4.2.7 getNumPoints() size_t GEOM_FADE25D::CloudPrepare::getNumPoints ( ) const
```

Returns

the number of points

6.4.2.8 getPoints() void GEOM_FADE25D::CloudPrepare::getPoints (std::vector< Point2 > & vPointsOut) const

Parameters

vPointsOut	[out] is used to return the points
------------	------------------------------------

Note

The points of the [CloudPrepare](#) object can be inserted directly with [Fade_2D::insert\(CloudPrepare\)](#). This is more memory efficient than getting the points out first only to pass them to [insert\(\)](#).

See also

[Fade_2D::void insert\(CloudPrepare* pCloudPrepare, bool bClear=true\)](#)

6.4.2.9 getRangeX() double GEOM_FADE25D::CloudPrepare::getRangeX ()

Returns

the x-Range

6.4.2.10 getRangeY() double GEOM_FADE25D::CloudPrepare::getRangeY ()

Returns

the y-Range

6.4.2.11 getRangeZ() double GEOM_FADE25D::CloudPrepare::getRangeZ ()

Returns

the z-Range

6.4.2.12 uniformSimplifyGrid() size_t GEOM_FADE25D::CloudPrepare::uniformSimplifyGrid (

```
double gridLength,
SumStrategy sms,
ConvexHullStrategy chs,
bool bDryRun = false )
```

This method uses a thought grid in the xy plane and combines the points of each cell into a single point.

Parameters

gridLength	[in] determines the horizontal and vertical cell spacing in the grid.
sms	[in] is the SumStrategy used to combine similar points into one. Possible values are SMS_MINIMUM, SMS_MAXIMUM, SMS_MEDIAN and SMS_AVERAGE.
chs	[in] is the ConvexHullStrategy: Points of the convex hull can be kept unchanged. Use CHS_MAXHULL for this purpose. If only convex points but not collinear points of the convex hull are to be considered as convex hull points, then use CHS_MINHULL. If convex hull points should be treated like all other points, then use CHS_NOHULL.
bDryRun	is used to avoid point cloud simplification. This is used to determine the number of points that would result from simplification with certain parameters. By default bDryRun=false.

Returns

the resulting number of points

```
6.4.2.13 uniformSimplifyNum() size_t GEOM_FADE25D::CloudPrepare::uniformSimplifyNum (
    int approxNumPoints,
    SumStrategy sms,
    ConvexHullStrategy chs )
```

This method uses a thought grid in the xy plane and combines the points of each cell into a single point. The resolution of the grid is automatically determined such that the point cloud is reduced to approximately the desired number of points.

Parameters

<i>approxNumPoints</i>	[in] is the desired number of remaining points. The algorithm will reduce the point cloud to approximately that number of points.
<i>sms</i>	[in] is the SumStrategy used to combine similar points into one. Possible values are SMS_MINIMUM, SMS_MAXIMUM, SMS_MEDIAN and SMS_AVERAGE.
<i>chs</i>	[in] is the ConvexHullStrategy: Points of the convex hull can be kept unchanged. Use CHS_MAXHULL for this purpose. If only convex points but not collinear points of the convex hull are to be considered as convex hull points, then use CHS_MINHULL. If convex hull points should be treated like all other points, then use CHS_NOHULL.

Returns

the resulting number of points

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

- [CloudPrepare.h](#)

6.5 GEOM_FADE25D::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)

6.5.1 Detailed Description

See also

[Visualizer2](#)

6.5.2 Constructor & Destructor Documentation

6.5.2.1 Color() [1/2] GEOM_FADE25D::Color::Color (

<code>double r_</code> ,	
<code>double g_</code> ,	
<code>double b_</code> ,	
<code>double width_</code> ,	
<code>bool bFill_ = false</code>)	

Parameters

<code>r_</code>	red
<code>g_</code>	green
<code>b_</code>	blue
<code>width_</code>	linewidth
<code>bFill_</code>	fill (default: <code>false</code>)

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.

6.5.2.2 Color() [2/2] GEOM_FADE25D::Color::Color (

<code>Colorname c,</code>	
<code>float width_ = 0.001,</code>	
<code>bool bFill_ = false</code>) [explicit]	

For convenience predefined colors can be used.

Parameters

<code>c</code>	is a predefined color name
<code>width_</code>	linewidth (default: <code>0.001</code>)
<code>_</code>	

Parameters

<code>bFill</code>	fill (default: <code>false</code>)
_	

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](#)

6.6 GEOM_FADE25D::CompPolygon Struct Reference

Connected component with boundary- and hole polygons.

```
#include <Zone2.h>
```

Public Member Functions

- [CompPolygon](#) (const [CompPolygon](#) &other)
- [CompPolygon](#) & [operator=](#) (const [CompPolygon](#) &other)

Public Attributes

- `std::vector< Triangle2 * > * pvCC`
One connected component of triangles (connection is meant along edges, not just vertices)
- `std::vector< Edge2 > * pvOuterPolygon`
Sorted outer polygon.
- `std::vector< std::vector< Edge2 > > * pvvHolePolygons`
Sorted hole polygons.

6.6.1 Detailed Description

This helper struct holds the triangles that form a connected component as well as the outer boundary polygon and inner hole polygons, if any. Edges are represented by a triangle and by an index. They are always counterclockwise oriented around their triangle. Thus the outer polygon is also counterclockwise oriented while the hole polygons are clockwise.

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

- [Zone2.h](#)

6.7 GEOM_FADE25D::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_ItDerefPtr< `ConstraintSegment2` * > > `mCSegReverse`
- std::map< `Point2` *, size_t > `mSplitPointNum`
- Dt2 * `pDt2`
- GeomTest * `pGeomPredicates`
- std::vector< `ConstraintSegment2` * > `vCSegParents`

6.7.1 Detailed Description

See also

[Fade_2D::createConstraint\(\)](#)

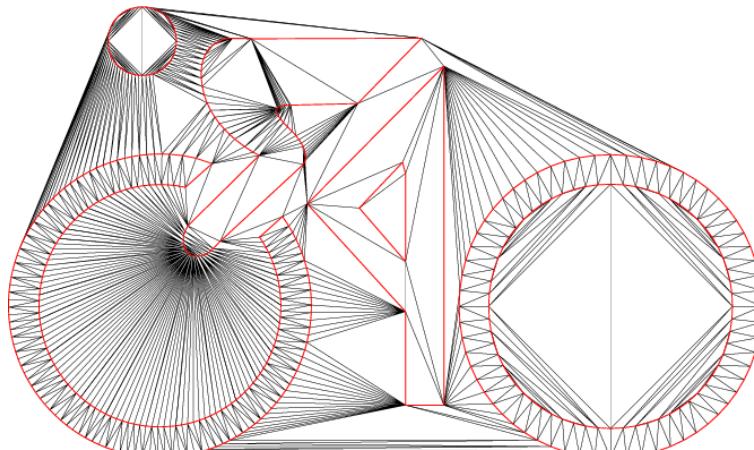


Figure 8 Constraint Delaunay triangulation

6.7.2 Member Function Documentation

6.7.2.1 getChildConstraintSegments() void GEOM_FADE25D::ConstraintGraph2::getChildConstraintSegments (std::vector< ConstraintSegment2 * > & vConstraintSegments_) const
 Returns the current constraint segments, i.e., the original ones or, if splitted, their child segments.

6.7.2.2 getDirectChildren() void GEOM_FADE25D::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](#).

6.7.2.3 getDt2() Dt2* GEOM_FADE25D::ConstraintGraph2::getDt2 ()

Returns

the Delaunay class it belongs to

6.7.2.4 getInsertionStrategy() ConstraintInsertionStrategy GEOM_FADE25D::ConstraintGraph2::getInsertionStrategy () const

Returns

CIS_CONFORMING_DELAUNAY, CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL or CIS_CONSTRAINED_DELAUNAY

6.7.2.5 getOriginalConstraintSegments() void GEOM_FADE25D::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...)

6.7.2.6 getPolygonVertices() void GEOM_FADE25D::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\(\)](#) ?

6.7.2.7 `isConstraint()` [1/2] `bool GEOM_FADE25D::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.

6.7.2.8 `isConstraint()` [2/2] `bool GEOM_FADE25D::ConstraintGraph2::isConstraint (Point2 * p0, Point2 * p1) const`

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

6.7.2.9 `isOriented()` `bool GEOM_FADE25D::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.

6.7.2.10 `isPolygon()` `bool GEOM_FADE25D::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).

6.7.2.11 `isReverse()` `bool GEOM_FADE25D::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.

6.7.2.12 `makeDelaunay()` `bool GEOM_FADE25D::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.

Note

This optimization considers the projection of the triangles to the xy plane.

Parameters

in	<code>minLength</code>	specifies a lower bound. Constraint segments smaller than <code>minLength</code> 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.

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

- [ConstraintGraph2.h](#)

6.8 GEOM_FADE25D::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**

Static Public Attributes

- static int **runningLabel**

Protected Attributes

- bool **bAlive**
- [ConstraintInsertionStrategy](#) **cis**
- [Point2](#) * **p0**
- [Point2](#) * **p1**
- std::vector<[ConstraintSegment2](#) * > **vChildren**

Friends

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

6.8.1 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.

6.8.2 Member Function Documentation

6.8.2.1 [getCIS\(\)](#) `ConstraintInsertionStrategy GEOM_FADE25D::ConstraintSegment2::getCIS () const`

Returns

the constraint insertion strategy (CIS) of the present object

6.8.2.2 [getSrc\(\)](#) `Point2* GEOM_FADE25D::ConstraintSegment2::getSrc () const`

Returns

the first vertex

6.8.2.3 [getTrg\(\)](#) `Point2* GEOM_FADE25D::ConstraintSegment2::getTrg () const`

Returns

the second vertex

6.8.2.4 [insertAndSplit\(\)](#) `Point2* GEOM_FADE25D::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.

6.8.2.5 [isAlive\(\)](#) `bool GEOM_FADE25D::ConstraintSegment2::isAlive () const`

Returns

TRUE when the object is alive, FALSE otherwise

6.8.2.6 [split_combinatorialOnly\(\)](#) `bool GEOM_FADE25D::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](#)

6.9 GEOM_FADE25D::CutAndFill Class Reference

[CutAndFill](#) computes the volume(s) between two overlapping surfaces.

```
#include <CutAndFill.h>
```

Public Member Functions

- [CutAndFill \(Zone2 *pZoneBefore, Zone2 *pZoneAfter, double ignoreThreshold=1e-6\)](#)
Constructor.
- [CAF_Component * getComponent \(size_t ith\) const](#)
*Get component *ith*.*
- [bool getDiffZone \(Zone2 *&pDiffZone, std::map< Point2 *, std::pair< double, double >> &mVtx2Before->After\)](#)
Get the difference zone.
- [size_t getNumberOfComponents \(\) const](#)
Get the number of components.
- [bool go \(bool bWithMessages=true\)](#)
Start the computation.
- [void show \(Visualizer2 *pVis\) const](#)
Draw a postscript visualization.
- [void subscribe \(MsgType msgType, MsgBase *pMsg\)](#)
Register a progress bar object.
- [void unsubscribe \(MsgType msgType, MsgBase *pMsg\)](#)
Unregister a progress bar object.

6.9.1 Detailed Description

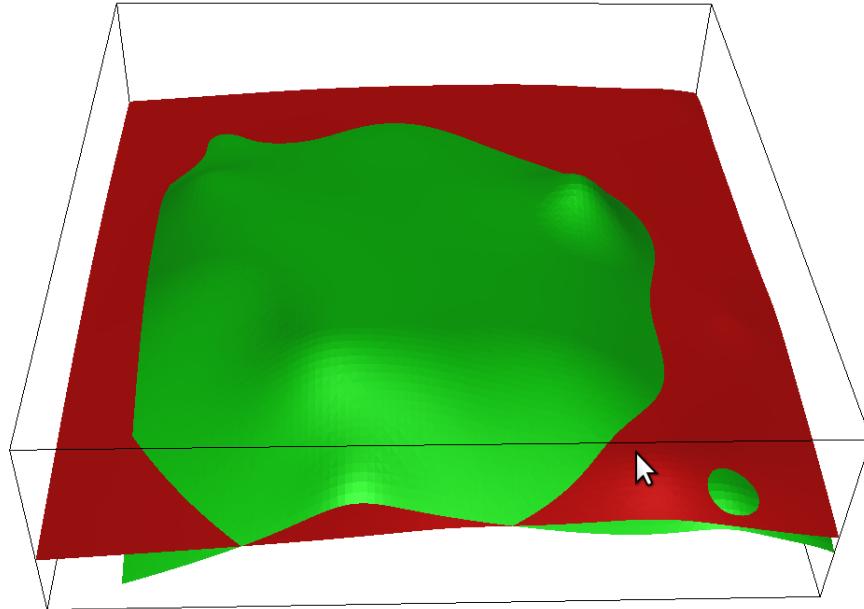


Figure 9 Overlapping input surfaces for Cut-And-Fill: RED=before, GREEN=after. The surfaces do not need to match exactly, the overlapping area is used

Given two overlapping surfaces with different elevations, [CutAndFill](#) partitions the surfaces into connected components and computes the volume that must be removed or added to turn one surface into the other.

See also

<https://www.geom.at/cut-and-fill/>

6.9.2 Constructor & Destructor Documentation

6.9.2.1 CutAndFill() GEOM_FADE25D::CutAndFill::CutAndFill (

```
Zone2 * pZoneBefore,  
Zone2 * pZoneAfter,  
double ignoreThreshold = 1e-6 )
```

Parameters

<i>pZoneBefore</i>	represents the surface before the earthworks
<i>pZoneAfter</i>	is the surface afterwards
<i>ignoreThreshold</i>	(default: 1e-6) can be used to ignore insignificant height differences

6.9.3 Member Function Documentation

6.9.3.1 getComponent() CAF_Component* GEOM_FADE25D::CutAndFill::getComponent (

```
size_t ith ) const
```

Returns

the *ith* CAF_Component.

6.9.3.2 getDiffZone() bool GEOM_FADE25D::CutAndFill::getDiffZone (

```
Zone2 *& pDiffZone,  
std::map< Point2 *, std::pair< double, double > > & mVtx2BeforeAfter )
```

This method gives access to the internal data structures, namely to a Zone2 object whose vertices have z-values that correspond to the height differences between the two input meshes (SurfaceBefore minus SurfaceAfter). And a map is returned that contains for each vertex the height in the first and in the second input mesh.

Returns

true in case of success, false otherwise.

Note

This method may set *pDiffZone*=NULL and return false when the two input surfaces do not share a common area. In this case the previous call to [CutAndFill::go\(\)](#) has already returned false.

6.9.3.3 getNumberOfComponents() size_t GEOM_FADE25D::CutAndFill::getNumberOfComponents ()

const

Returns

the number of components.

A CAF_Component object represents a connected part of the surface such that

- the first surface is below the second one (Type CT_FILL)
- the first surface is above the second one (Type CT_CUT)
- the first surface corresponds to the second one (Type CT_NULL)

```
6.9.3.4 go() bool GEOM_FADE25D::CutAndFill::go (
    bool bWithMessages = true )
```

Parameters

<i>bWithMessages</i>	is used to allow or suppress any warnings.
----------------------	--

Returns

true in case of success, false otherwise.

Note

When an input zone is empty or when the two input zones do not overlap then there is no common area on which the algorithm could operate. In this case the present method returns false.

```
6.9.3.5 show() void GEOM_FADE25D::CutAndFill::show (
    Visualizer2 * pVis ) const
```

For a quick overview a postscript visualization can be created.

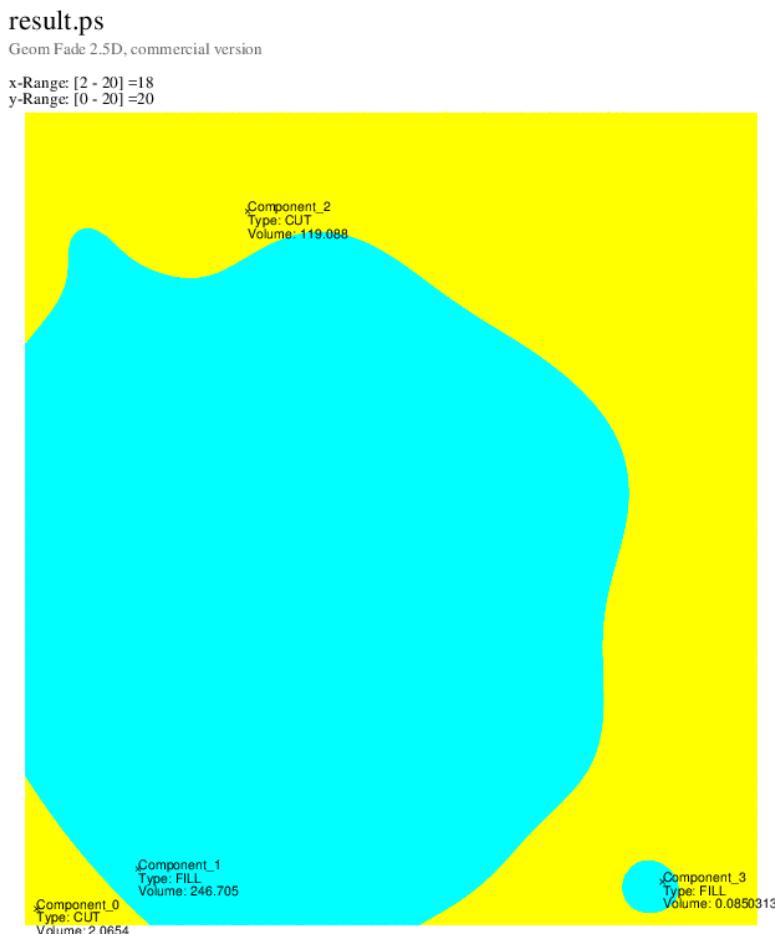


Figure 10 Cut&Fill-Result: YELLOW area CUT, CYAN area: FILL

6.9.3.6 subscribe() void GEOM_FADE25D::CutAndFill::subscribe (

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

A user defined message receiver object (for example your own progress-bar class) can be registered to get progress updates. This step is optional.

Parameters

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

6.9.3.7 unsubscribe() void GEOM_FADE25D::CutAndFill::unsubscribe (

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

Parameters

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

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

- [CutAndFill.h](#)

6.10 GEOM_FADE25D::Edge2 Class Reference

[Edge2](#) is a directed edge.

```
#include <Edge2.h>
```

Public Member Functions

- [Edge2 \(const Edge2 &e_\)](#)
Constructor.
- [Edge2 \(Triangle2 *pT, int oppIdx_\)](#)
Get the endpoints.
- [int getIndex \(\) const](#)
- [double getLength25D \(\) const](#)
- [double getLength2D \(\) const](#)
- [void getPoints \(Point2 *&p1, Point2 *&p2\) const](#)
Get the source point.
- [Point2 * getSrc \(\) const](#)
Get the target point.
- [Point2 * getTrg \(\) const](#)
- [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)

6.10.1 Constructor & Destructor Documentation**6.10.1.1 Edge2()** `GEOM_FADE25D::Edge2::Edge2 (`

```
    Triangle2 * pT,
    int oppIdx_ )
```

Parameters

<code>pT</code>	is the triangle from which the edge is constructed
<code>opp← Idx_</code>	is intra-triangle-index of the opposite vertex (of the edge) in <code>pT</code>

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)`.

6.10.2 Member Function Documentation**6.10.2.1 getIndex()** `int GEOM_FADE25D::Edge2::getIndex () const`
Get the opposite index**Returns**

the intra-triangle-index of the opposite vertex

6.10.2.2 getLength25D() `double GEOM_FADE25D::Edge2::getLength25D () const`
Get the 2.5D length**Returns**

the 2.5D length of the edge

6.10.2.3 getLength2D() `double GEOM_FADE25D::Edge2::getLength2D () const`
Get the 2D length**Returns**

the 2D length of the edge, the z-coordinate is ignored

6.10.2.4 getPoints() `void GEOM_FADE25D::Edge2::getPoints (`
 `Point2 *& p1,`
 `Point2 *& p2) const`

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

6.10.2.5 `getSrc()` `Point2* GEOM_FADE25D::Edge2::getSrc () const`**Returns**

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

6.10.2.6 `getTrg()` `Point2* GEOM_FADE25D::Edge2::getTrg () const`**Returns**

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

6.10.2.7 `getTriangle()` `Triangle2* GEOM_FADE25D::Edge2::getTriangle () const`

Get the triangle

Returns

the triangle whose directed edge the present edge is

6.10.2.8 `getTriangles()` `void GEOM_FADE25D::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

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

6.10.2.9 `operator"!=()` `bool GEOM_FADE25D::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`.

6.10.2.10 `operator<()` `bool GEOM_FADE25D::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.

6.10.2.11 `operator==(())` `bool GEOM_FADE25D::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](#)

6.11 GEOM_FADE25D::EfficientModel Class Reference

[EfficientModel](#) (DEPRECATED in favor of the new [CloudPrepare](#) class)

```
#include <EfficientModel.h>
```

Public Member Functions

- [EfficientModel](#) (const std::vector< [Point2](#) > &vPoints)
- void [extract](#) (double maxError, std::vector< [Point2](#) > &vEfficientPointsOut)

Extract a subset of points.
- void [zSmoothing](#) (int numIterations, double maxDifferencePerIteration, [SmoothingStrategy](#) sms)

Smoothing.

Protected Member Functions

- void [go](#) ()
- int [insertKeepError](#) (double factor, double err, std::vector< [Point2](#) * > &vIn, std::vector< [Point2](#) * > &v←NeedlessBigError, std::vector< [Point2](#) * > &vNeedlessSmallError)
- void [insertMinHull](#) ()
- void [part1_extractFC](#) ()
- void [part2_setWeights](#) ()
- void [show](#) (const char *name)
- void [solveCand](#) (Candidate *pCand, double maxErr)
- void [sortVtx](#) (std::vector< [Point2](#) * > &vVtx)

6.11.1 Detailed Description

Note

This class is deprecated but is kept for backward compatibility with existing software. Please use the new [CloudPrepare](#) class which is much faster and also more memory efficient.

6.11.2 Member Function Documentation

6.11.2.1 extract() void GEOM_FADE25D::EfficientModel::extract (

```
    double maxError,
    std::vector< Point2 > & vEfficientPointsOut )
```

This method extracts a subset of the original point cloud that represents the model more efficiently. Thereby the original and the simplified model cover the same area.

Parameters

	<i>maxError</i>	is the maximum height difference between the original points and the simplified model.
out	<i>vEfficientPointsOut</i>	is used to return a subset of the original points that represents the model more efficiently.

Note

When *maxError* is tiny i.e., below the noise level of the point cloud, then processing can take quite some time. Consider using the [zSmoothing\(\)](#) method before.

```
6.11.2.2 zSmoothing() void GEOM_FADE25D::EfficientModel::zSmoothing (
    int numIterations,
    double maxDifferencePerIteration,
    SmoothingStrategy sms )
```

This method should be used before [extract\(\)](#). It adapts the z-values according to the chosen SmoothingStrategy sms.

Parameters

<i>numIterations</i>	Number of iterations
<i>maxDifferencePerIteration</i>	is the maximum change of any z-value
<i>sms</i>	is one of SMST_MINIMUM, SMST_MAXIMUM, SMST_MEDIAN, SMST_AVERAGE

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

- [EfficientModel.h](#)

6.12 GEOM_FADE25D::Fade_2D Class Reference

[Fade_2D](#) is the Delaunay triangulation class.

```
#include <Fade_2D.h>
```

Public Member Functions

- [Fade_2D](#) (unsigned numExpectedVertices=3)
Constructor of the 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, bool bUseHeightOfLatest=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*, double *zTolerance*) 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 **getDirectedEdges** (*std::vector< Edge2 >* &*vDirectedEdgesOut*) const
 - Get directed edges Edges are counterclockwise oriented around their triangle. The present method returns directed edges. That means each edge(a,b) is returned twice, as edge(a,b) and as edge(b,a).*
- bool **getHeight** (double *x*, double *y*, double &*heightOut*, *Triangle2* **pApproxT=NULL*, double *tolerance=0*) const
 - Compute the height of a certain point.*
- void **getIncidentTriangles** (*Point2* **pVtx*, *std::vector< Triangle2 * >* &*vIncidentT*) const
 - Get incident triangles.*
- void **getIncidentVertices** (*Point2* **pVtx*, *std::vector< Point2 * >* &*vIncidentVertices*) const
 - Get incident vertices.*
- *Point2* * **getNearestNeighbor** (const *Point2* &*p*)
 - Get nearest neighbor.*
- 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 **getUndirectedEdges** (*std::vector< Edge2 >* &*vUndirectedEdgesOut*) const
 - Get undirected edges.*
- 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.*
- void **insert** (*CloudPrepare* **pCloudPrepare*, bool *bClear=true*)
 - Insert points from a CloudPrepare object.*
- *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.
 - void **reset** ()
Reset.
 - 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 (deprecated)
 - 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 **showGeomview** (const char *filename, const char *color="1 1 1 0.5") const

- `void showGeomview (Visualizer3 *pVis, const char *color="1 1 1 0.5") const`
Draws the triangulation in 3D.
- `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.*

6.12.1 Detailed Description

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

6.12.2 Constructor & Destructor Documentation

6.12.2.1 `Fade_2D()` `GEOM_FADE25D::Fade_2D::Fade_2D (`
`unsigned numExpectedVertices = 3) [inline], [explicit]`

Parameters

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

Remarks

There is no copy constructor. Use `copyFade()` to copy `Fade_2D` objects along with their `Zone2` objects.

6.12.3 Member Function Documentation

6.12.3.1 `applyConstraintsAndZones()` `void GEOM_FADE25D::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 compatibility. 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

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

Checks the validity of the data structure.

Parameters

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

6.12.3.3 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.

6.12.3.4 createConstraint() `ConstraintGraph2* GEOM_FADE2D::Fade_2D::createConstraint (`
`std::vector< Segment2 > & vSegments,`
`ConstraintInsertionStrategy cis,`
`bool bOrientedSegments = false,`
`bool bUseHeightOfLatest = false)`

Parameters

<code>vSegments</code>	are segments which shall appear as edges of the triangulation. The segments may be automatically reordered and reoriented, see <code>bOrientedSegments</code> below.
<code>cis</code>	is the Constraint-Insertion-Strategy. Use always <code>CIS_CONSTRAINED_DELAUNAY</code> . This mode inserts the constraint segments at their original level (no projection onto the surface) and without subdivision unless existing vertices or existing constraint segments are crossed. When subdivision (e.g., to achieve better triangle shapes) is desired then use <code>ConstraintGraph2::makeDelaunay()</code> after insertion. When the segments shall be adapted to the elevation of the existing surface then use <code>Fade_2D::drape()</code> . See the example code in <code>examples_25D/terrain.cpp</code>
<code>bOrientedSegments</code>	specifies whether the segments in <code>vSegments</code> are oriented (<i>oriented, not ordered!</i>). If later a zone is to be made with the returned <code>ConstraintGraph2</code> object this is only possible if the value is true (then it is assumed that all segments are counterclockwise oriented) or if the <code>ConstraintGraph2</code> represents exactly one closed polygon. The value affects also the order of the returned vertices when later <code>ConstraintGraph2::getPolygonVertices()</code> is called. This is a default parameter and it defaults to false.
<code>bUseHeightOfLatest</code>	specifies that the height z of the last inserted segment is to be used. This is used in conflict case only, e.g. if the endpoint of an inserted segment already exists with a different height, or if an existing constraint segment is cut. By default, the height of the existing elements is used for the intersection point.

Returns

a pointer to the new [ConstraintGraph2](#) object

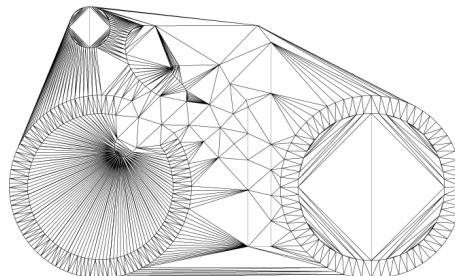


Figure 11 Delaunay triangulation without constraints

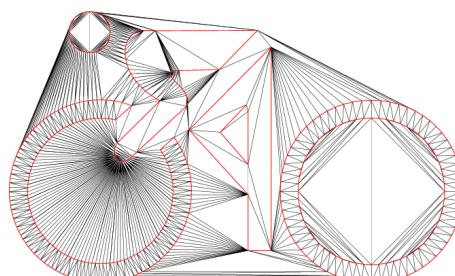


Figure 12 Constraint Delaunay triangulation

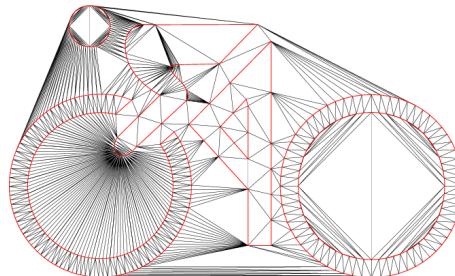


Figure 13 Conforming Delaunay triangulation through the [ConstraintGraph::makeDelaunay\(\)](#) method

```
6.12.3.5 createZone() [1/4] Zone2* GEOM_FADE25D::Fade_2D::createZone (
    const std::vector< ConstraintGraph2 * > & vConstraintGraphs,
    ZoneLocation zoneLoc,
    const Point2 & startPoint,
    bool bVerbose = true )
```

A [Zone2](#) object is an area of the triangulation, see [createZone](#)

Parameters

<i>vConstraintGraphs</i>	is a vector of ConstraintGraph objects
<i>zoneLoc</i>	must be ZL_GROW
<i>startPoint</i>	is the point from which the area is grown until the borders specified in <i>vConstraintGraphs</i> are reached
<i>bVerbose</i>	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)

6.12.3.6 createZone() [2/4] `Zone2* GEOM_FADE25D::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

<code>zoneLoc</code>	is ZL_INSIDE, ZL_OUTSIDE or ZL_GLOBAL.
<code>pConstraintGraph</code>	points to a formerly created ConstraintGraph2 object (which must be oriented and contain a <i>simple</i> polygon) or is NULL in case of zoneLoc==ZL_GLOBAL.
<code>bVerbose</code>	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 14 Zones in a triangulation

6.12.3.7 createZone() [3/4] `Zone2* GEOM_FADE25D::Fade_2D::createZone (`

```
    ConstraintGraph2 * pConstraintGraph,
    ZoneLocation zoneLoc,
    const Point2 & startPoint,
    bool bVerbose = true )
```

A [Zone2](#) object is an area of the triangulation, see [createZone](#)

Parameters

<code>pConstraintGraph</code>	is a constraint whose edges specify the area's border
<code>zoneLoc</code>	must be ZL_GROW
<code>startPoint</code>	is the point from which the area is grown until the borders specified in pConstraint are reached
<code>bVerbose</code>	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)

6.12.3.8 createZone() [4/4] `Zone2* GEOM_FADE25D::Fade_2D::createZone (`

```
    std::vector< Triangle2 * > & vTriangles,
    bool bVerbose = true )
```

A [Zone2](#) object is an area of the triangulation, see [createZone](#)

Parameters

<code>vTriangles</code>	
<code>bVerbose</code>	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)

6.12.3.9 createZone_cookieCutter() `Zone2* GEOM_FADE25D::Fade_2D::createZone_cookieCutter (`

```
    std::vector< Segment2 > & vSegments,
    bool bProtectEdges )
```

Parameters

in	<code>vSegments</code>	specifies a simple polygon.
in	<code>bProtectEdges</code>	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.

6.12.3.10 cutTriangles() [1/2] `void GEOM_FADE25D::Fade_2D::cutTriangles (`

```
    const Point2 & knifeStart,
    const Point2 & knifeEnd,
    bool bTurnEdgesIntoConstraints )
```

Parameters

<code>knifeStart</code>	is one point of the knife segment
<code>knifeEnd</code>	is the second point of the knife segment
<code>bTurnEdgesIntoConstraints</code>	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\(std::vector<Segment2>& vSegments, bool bTurnEdgesIntoConstraints\)](#) 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.

6.12.3.11 [cutTriangles\(\)](#) [2/2]

```
void GEOM_FADE25D::Fade_2D::cutTriangles (
    std::vector< Segment2 > & vSegments,
    bool bTurnEdgesIntoConstraints )
```

Parameters

<i>vSegments</i>	are the knife segments
<i>bTurnEdgesIntoConstraints</i>	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.

6.12.3.12 [deleteZone\(\)](#)

```
void GEOM_FADE25D::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.

6.12.3.13 [drape\(\)](#)

```
bool GEOM_FADE25D::Fade_2D::drape (
    std::vector< Segment2 > & vSegmentsIn,
    std::vector< Segment2 > & vSegmentsOut,
    double zTolerance ) 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.

The heights (z-values) of the result segments are adapted to the surface.

Parameters

<i>in</i>	<i>zTolerance</i>	is used to avoid excessive subdivision of segments. Use some positive value to define the acceptable geometric error or use <i>zTolerance</i> =-1.0 to split the segments at all intersections with triangulation-edges.
<i>in</i>	<i>vSegmentsIn</i>	Input segments
<i>out</i>	<i>vSegmentsOut</i>	Output segments

Returns

TRUE if 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.

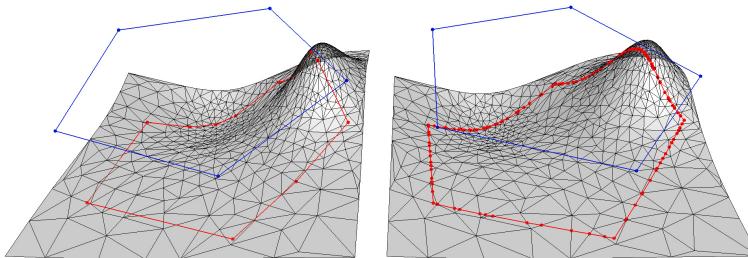


Figure 15 Drape: Input segments (blue) are draped (red) onto a TIN. Left with tolerance 1.0, right without tolerance

Note

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

```
6.12.3.14 exportTriangulation() void GEOM_FADE25D::Fade_2D::exportTriangulation (
    FadeExport & fadeExport,
    bool bWithCustomIndices,
    bool bClear )
```

Parameters

<i>fadeExport</i>	is a struct that will hold the requested triangulation data
<i>bWithCustomIndices</i>	determines whether the custom indices of the points are also stored
<i>bClear</i>	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.

```
6.12.3.15 getAdjacentTriangle() Triangle2* GEOM_FADE25D::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.

6.12.3.16 getConstraintSegment() `ConstraintSegment2* GEOM_FADE25D::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)

6.12.3.17 getConvexHull() `void GEOM_FADE25D::Fade_2D::getConvexHull (`

```
    bool bAllVertices,
    std::vector< Point2 * > & vConvexHullPointsOut )
```

Parameters

	<code>bAllVertices</code>	determines if all convex hull points are returned or if collinear ones shall be removed.
<code>out</code>	<code>vConvexHullPointsOut</code>	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.

6.12.3.18 getHeight() `bool GEOM_FADE25D::Fade_2D::getHeight (`

```
    double x,
    double y,
    double & heightOut,
    Triangle2 * pApproxT = NULL,
    double tolerance = 0 ) const
```

Computes the height (z) at the coordinates x and y, assigns it to heightOut and returns true if successful.

Parameters

<code>in</code>	<code>x,y</code>	are the input coordinates
<code>out</code>	<code>heightOut</code>	is the computed height
<code>in</code>	<code>pApproxT</code>	can be set to a nearby triangle. If unknown, use NULL.
<code>in</code>	<code>tolerance</code>	is by default 0, see below

Note

`pApproxT` is an optional parameter to speed up the search in case that you know a nearby triangle. But point location is very fast anyway and if you are not sure, using NULL is probably faster.

Due to rounding errors your query point may lie slightly outside the convex hull of the triangulation and in such a case the present method would correctly return false. But you can use the optional `tolerance` parameter (default: 0): If your query point is not farther outside the convex hull than `tolerance` then the height of the closest point of the convex hull is returned.

6.12.3.19 getIncidentTriangles() void GEOM_FADE25D::Fade_2D::getIncidentTriangles (
`Point2 * pVtx,`
`std::vector< Triangle2 * > & vIncidentT) const`
Stores pointers to all triangles around pVtx into vIncidentT

6.12.3.20 getIncidentVertices() void GEOM_FADE25D::Fade_2D::getIncidentVertices (
`Point2 * pVtx,`
`std::vector< Point2 * > & vIncidentVertices) const`
Stores pointers to all vertices around pVtx into vIncidentVertices

6.12.3.21 getNearestNeighbor() `Point2* GEOM_FADE25D::Fade_2D::getNearestNeighbor (`
`const Point2 & p)`
This method returns the closest vertex of p.

Parameters

in	<i>p</i>	is the query point
----	----------	--------------------

Returns

a pointer to the closest vertex

6.12.3.22 getOrientation() Orientation2 GEOM_FADE25D::Fade_2D::getOrientation (
`const Point2 & p0,`
`const Point2 & p1,`
`const Point2 & p2)`

Returns

ORIENTATION2_COLLINEAR, ORIENTATION2_CW (clockwise) or ORIENTATION2_CCW (counterclockwise)

6.12.3.23 getTrianglePointers() void GEOM_FADE25D::Fade_2D::getTrianglePointers (
`std::vector< Triangle2 * > & vAllTriangles) const`
This command fetches the existing triangles

Parameters

out	<i>vAllTriangles</i>	is used to return the triangles
-----	----------------------	---------------------------------

Note

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

6.12.3.24 getUndirectedEdges() void GEOM_FADE25D::Fade_2D::getUndirectedEdges (
`std::vector< Edge2 > & vUndirectedEdgesOut) const`

Parameters

<i>vUndirectedEdgesOut</i>	is used to return a unique set of undirected edges.
----------------------------	---

6.12.3.25 `getVertexPointers()` `void GEOM_FADE25D::Fade_2D::getVertexPointers (std::vector< Point2 * > & vAllPoints) const`

Parameters

<code>vAllPoints</code>	is an empty vector of <code>Point2</code> 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.

6.12.3.26 `getVoronoiDiagram()` `Voronoi2* GEOM_FADE25D::Fade_2D::getVoronoiDiagram ()`

Returns

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

6.12.3.27 `hasArea()` `bool GEOM_FADE25D::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.

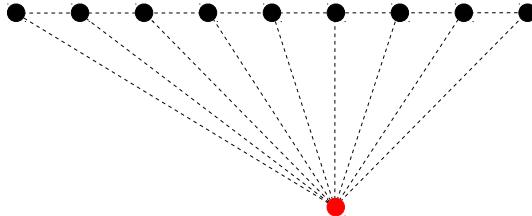


Figure 16 Triangles are generated as soon as the first non-collinear point is inserted.

Returns

true if at least one triangle exists
false otherwise

6.12.3.28 `importTriangles()` `Zone2* GEOM_FADE25D::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

<code>vPoints</code>	contains the input vertices (3 subsequent ones per triangle)
<code>bReorientIfNeeded</code>	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.
<code>bCreateExtendedBoundingBox</code>	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\(\)](#).

6.12.3.29 insert() [1/5] `void GEOM_FADE25D::Fade_2D::insert (`

```
CloudPrepare * pCloudPrepare,
bool bClear = true )
```

Parameters

in	<i>pCloudPrepare</i>	is a CloudPrepare object that contains a point cloud
in	<i>bClear</i>	determines whether <i>pCloudPrepare</i> shall be cleared during the operation in order to save memory. Always use <i>bClear</i> =true unless you plan to use <i>pCloudPrepare</i> also for other triangulations.

Note

There's a difference in peak memory conversion compared to the other [insert\(\)](#) methods: You can pre-give the vertices to the [CloudPrepare](#) object and delete them from your own software's data structures while not a single triangle has been created yet. Only after that you call this [insert\(\)](#) function with the [CloudPrepare](#) object and the vertices are triangulated.

6.12.3.30 insert() [2/5] `Point2* GEOM_FADE25D::Fade_2D::insert (`

```
const Point2 & p )
```

Parameters

<i>p</i>	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.

6.12.3.31 insert() [3/5] `void GEOM_FADE25D::Fade_2D::insert (`

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

Parameters

<code>vInputPoints</code>	contains the points to be inserted.
---------------------------	-------------------------------------

Note

Use [Fade_2D::setNumCPU\(\)](#) to activate multithreading

```
6.12.3.32 insert() [4/5] void GEOM_FADE25D::Fade_2D::insert (
    const std::vector< Point2 > & vInputPoints,
    std::vector< Point2 * > & vHandles )
```

Parameters

<code>vInputPoints</code>	contains the points to be inserted.
<code>vHandles</code>	(empty) is used by Fade to return <code>Point2</code> 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 occurrence.

Note

Use [Fade_2D::setNumCPU\(\)](#) to activate multithreading

```
6.12.3.33 insert() [5/5] void GEOM_FADE25D::Fade_2D::insert (
    int numPoints,
    double * aCoordinates,
    Point2 ** aHandles )
```

Parameters

<code>numPoints</code>	is the number of points to be inserted
<code>aCoordinates</code>	is an array of $3n$ double values, e.g. $\{x_0, y_0, z_0, x_1, y_1, z_1, \dots, x_n, y_n, z_n\}$
<code>aHandles</code>	is an array with size n where pointers to the inserted points will be stored

Note

Use [Fade_2D::setNumCPU\(\)](#) to activate multithreading

```
6.12.3.34 isConstraint() [1/3] bool GEOM_FADE25D::Fade_2D::isConstraint (
    Point2 * p0,
    Point2 * p1 ) const
```

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

```
6.12.3.35 isConstraint() [2/3] bool GEOM_FADE25D::Fade_2D::isConstraint (
    Point2 * pVtx ) const
```

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

```
6.12.3.36 isConstraint() [3/3] bool GEOM_FADE25D::Fade_2D::isConstraint (
    Triangle2 * pT,
    int ith ) const
```

Returns whether the edge in triangle pT which is opposite to the i th vertex is a constraint edge.

6.12.3.37 load() [1/2] `bool GEOM_FADE25D::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	<code>filename</code>	is the name of the input file
out	<code>vZones</code>	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

6.12.3.38 load() [2/2] `bool GEOM_FADE25D::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

	<code>stream</code>	is an input stream
out	<code>vZones</code>	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

6.12.3.39 locate() `Triangle2* GEOM_FADE25D::Fade_2D::locate (`
`const Point2 & p)`

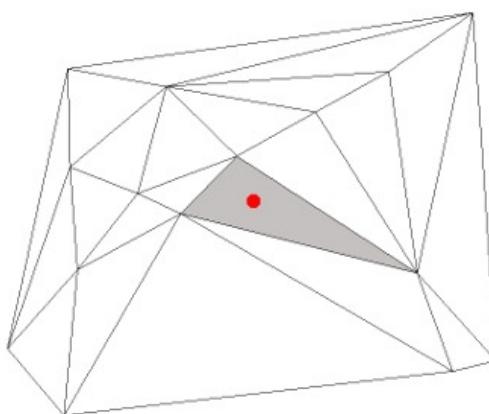


Figure 17 Point location

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

in	<i>p</i>	is the query point
----	----------	--------------------

Returns

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

6.12.3.40 measureTriangulationTime() `double GEOM_FADE25D::Fade_2D::measureTriangulationTime (std::vector< Point2 > & vPoints)`

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

Parameters

in	<i>vPoints</i>	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

6.12.3.41 numberOfPoints() `size_t GEOM_FADE25D::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 advised to avoid calling this method over-frequently in a loop. Duplicate point insertions count only once.

6.12.3.42 numberOfTriangles() `size_t GEOM_FADE25D::Fade_2D::numberOfTriangles () const`

Returns

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

6.12.3.43 refine() `void GEOM_FADE25D::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

<i>pZone</i>	is the zone whose triangles are refined. Allowed zoneLocation values are ZL_INSIDE and ZL_BOUNDDED.
<i>minAngleDegree</i>	(up to 30) is the minimum interior triangle angle
<i>minEdgeLength</i>	is a lower threshold on the edge length. Triangles with smaller edges are not refined.
<i>maxEdgeLength</i>	is an upper threshold on the edge length. Triangles with larger edges are always refined.
<i>bAllowConstraintSplitting</i>	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_BOUNDDED zones are accepted. But you can easily convert other types of zones to ZL_BOUNDDED using [Zone2::convertToBoundedZone\(\)](#).

6.12.3.44 refineAdvanced() `void GEOM_FADE25D::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.

6.12.3.45 remove() `void GEOM_FADE25D::Fade_2D::remove (Point2 * pVertex)`

Parameters

<i>pVertex</i>	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.

6.12.3.46 reset() `void GEOM_FADE25D::Fade_2D::reset ()`

Resets the triangulation and makes it re-usable.

6.12.3.47 saveTriangulation() [1/2] `bool GEOM_FADE25D::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

<i>in</i>	<i>filename</i>	is the name of the output file
<i>out</i>	<i>vSaveZones</i>	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

6.12.3.48 [saveTriangulation\(\)](#) [2/2] `bool GEOM_FADE25D::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

	<i>stream</i>	is the output stream
out	<i>vSaveZones</i>	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

6.12.3.49 [saveZones\(\)](#) [1/2] `bool GEOM_FADE25D::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	<i>filename</i>	is the name of the output file
out	<i>vSaveZones</i>	(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.

6.12.3.50 saveZones() [2/2] `bool GEOM_FADE25D::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

	<i>stream</i>	is the name of output stream
out	<i>vSaveZones</i>	(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.

6.12.3.51 setFastMode() `void GEOM_FADE25D::Fade_2D::setFastMode (`

```
    bool bFast )
```

By default, numerically perfect calculations are performed to compute a 100% perfect Delaunay triangulation. However, the quality difference to using double precision arithmetic is hardly noticeable. It is often 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

<i>bFast</i>	use true to avoid using multiple precision arithmetic in favor of better performance.
--------------	---

6.12.3.52 setNumCPU() `int GEOM_FADE25D::Fade_2D::setNumCPU (`

```
    int numCPU )
```

Warning

This method is deprecated in favor of the free function [int setGlobalNumCPU\(\)](#). It is kept for backwards compatibility and it internally forwards the call to [setGlobalNumCPU\(\)](#).

6.12.3.53 show() [1/2] void GEOM_FADE25D::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

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

6.12.3.54 show() [2/2] void GEOM_FADE25D::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

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

Note

The postscript file must be finalized with [Visualizer2::writeFile\(\)](#).

6.12.3.55 showGeomview() [1/2] void GEOM_FADE25D::Fade_2D::showGeomview (

```
const char * filename,
const char * color = "1 1 1 0.5" ) const
```

Parameters

<i>filename</i>	is the output filename
<i>color</i>	is by default white (red:1,green:1,blue:1,alpha:0.5)

Note

The free viewer Geomview can be used to view such files

6.12.3.56 showGeomview() [2/2] void GEOM_FADE25D::Fade_2D::showGeomview (

```
Visualizer3 * pVis,
const char * color = "1 1 1 0.5" ) const
```

Parameters

<i>pVis</i>	points to a Visualizer3 object
<i>color</i>	is by default white (red:1,green:1,blue:1,alpha:0.5)

Note

The free viewer Geomview can be used to view such files

6.12.3.57 statistics() `void GEOM_FADE25D::Fade_2D::statistics (const char * s) const`

Prints mesh statistics to stdout.

6.12.3.58 subscribe() `void GEOM_FADE25D::Fade_2D::subscribe (MsgType msgType, MsgBase * pMsg)`

Parameters

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

6.12.3.59 unsubscribe() `void GEOM_FADE25D::Fade_2D::unsubscribe (MsgType msgType, MsgBase * pMsg)`

Parameters

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

6.12.3.60 writeObj() [1/2] `void GEOM_FADE25D::Fade_2D::writeObj (const char * filename) const`

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

6.12.3.61 writeObj() [2/2] `void GEOM_FADE25D::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.

6.12.3.62 writeWebScene() [1/2] `void GEOM_FADE25D::Fade_2D::writeWebScene (const char * path) const`

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

6.12.3.63 writeWebScene() [2/2] `void GEOM_FADE25D::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](#)

6.13 GEOM_FADE25D::FadeExport Struct Reference

[FadeExport](#) is a simple struct to export triangulation data.

```
#include <FadeExport.h>
```

Public Member Functions

- **FadeExport** (const [FadeExport](#) &other)
- void **copy** (const [FadeExport](#) &other)
- void **extractTriangleNeighborhoods** (std::vector< std::pair< int, int > > &vNeigs) const
 - Determine index-pairs of adjacent triangles.*
- void **getCoordinates** (int vtxIdx, double &x, double &y, double &z) const
 - Get the coordinates for a certain vertex index.*
- void **getCornerIndices** (int trlIdx, int &vtxIdx0, int &vtxIdx1, int &vtxIdx2) const
 - Get the corner indices of a certain triangle.*
- int **getCustomIndex** (int vtxIdx) const
 - Get the custom vertex index.*
- void **getNormal** (int trlIdx, double &x, double &y, double &z) const
 - Get the normal vector of a triangle.*
- void **lexiSort** ()
 - Sort the points lexicographically.*
- **FadeExport** & **operator=** (const [FadeExport](#) &other)
- bool **operator==** (const [FadeExport](#) &other) const
- void **print** () const
 - Print data for demonstration purposes.*
- void **reset** ()
 - Reset the object.*
- 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*

6.13.1 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](#).

6.13.2 Member Function Documentation

```
6.13.2.1 getCoordinates() void GEOM_FADE25D::FadeExport::getCoordinates (
    int vtxIdx,
    double & x,
    double & y,
    double & z ) const [inline]
```

Parameters

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

```
6.13.2.2 getCornerIndices() void GEOM_FADE25D::FadeExport::getCornerIndices (
    int triIdx,
    int & vtxIdx0,
    int & vtxIdx1,
    int & vtxIdx2 ) const [inline]
```

Parameters

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

```
6.13.2.3 getCustomIndex() int GEOM_FADE25D::FadeExport::getCustomIndex (
    int vtxIdx ) const [inline]
```

Returns

the (optional) custom index of the vertex with the index `vtxIdx` or -1 if the vertex indices have not been exported.

```
6.13.2.4 lexiSort() void GEOM_FADE25D::FadeExport::lexiSort ( )
```

This method sorts the points lexicographically to provide better reproducibility.

```
6.13.2.5 reset() void GEOM_FADE25D::FadeExport::reset ( ) [inline]
```

This method deletes all contained data

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

- [FadeExport.h](#)

6.14 GEOM_FADE25D::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](#)

6.15 GEOM_FADE25D::Func_ItEdge25D Struct Reference

Functor to sort edges by 2.5d 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](#)

6.16 GEOM_FADE25D::Func_ItEdge2D 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](#)

6.17 GEOM_FADE25D::Func_ItPointXYZ Struct Reference

Functor to sort points lexicographically.

```
#include <Point2.h>
```

Public Member Functions

- bool **operator()** (const [Point2](#) &p0, const [Point2](#) &p1) const

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

- [Point2.h](#)

6.18 GEOM_FADE25D::IsoContours Class Reference

[IsoContours](#) uses a fast datastructure to compute intersections of horizontal planes with a given list of triangles.

```
#include <IsoContours.h>
```

Public Member Functions

- [IsoContours](#) (std::vector<[Point2](#)> &vCorners, const [Vector2](#) &dirVec)
- [IsoContours](#) (std::vector<[Triangle2](#)*> &vTriangles)
- bool [getContours](#) (double height, std::vector<std::vector<[Segment2](#)>> &vvContours, bool bVerbose, bool bAutoPerturbate=true)
- double [getMaxHeight](#) ()
- double [getMinHeight](#) ()
- void [getProfile](#) (const [Point2](#) &p, std::vector<[Segment2](#)> &vSegmentsOut)

Protected Member Functions

- [IsoContours](#) (const [IsoContours](#) &other)
- [IsoContours](#) & [operator=](#) (const [IsoContours](#) &other)

Protected Attributes

- std::vector<[Triangle2](#)*> [vTriangles](#)

6.18.1 Detailed Description

See also

<http://www.geom.at/terrain-triangulation/>

6.18.2 Constructor & Destructor Documentation

```
6.18.2.1 IsoContours() GEOM_FADE25D::IsoContours::IsoContours (
    std::vector< Point2 > & vCorners,
    const Vector2 & dirVec )
```

Experimental feature

IsoContours can be used to create profiles (slices).

Parameters

vCorners	contains 3*n points to specify n triangles, i.e. it is a corners-list where 3 subsequent points define a triangle.
dirVec	specifies the slice direction to compute profiles

6.18.3 Member Function Documentation

```
6.18.3.1 getContours() bool GEOM_FADE25D::IsoContours::getContours (
    double height,
    std::vector< std::vector< Segment2 > > & vvContours,
    bool bVerbose,
    bool bAutoPerturbate = true )
```

Get Contours

Computes the intersection of a horizontal plane at a certain height with all triangles and returns a vector of assembled polygons and polylines. The method works only for height values that do not occur as heights of any of the vertices. It returns false in such case except bAutoPerturbate=true. In this case a tiny offset is automatically added to height.

Note

Polylines that end in the middle of a terrain can not exist and if you see such lines in the output then these are not only individual line segments but extremely narrow polygons - enforced by your geometric setting. You can numerically inspect those lines to verify that.

```
6.18.3.2 getMaxHeight() double GEOM_FADE25D::IsoContours::getMaxHeight ( )
```

The the maximum height

Returns the largest z-coordinate

```
6.18.3.3 getMinHeight() double GEOM_FADE25D::IsoContours::getMinHeight ( )
```

Get the minimum height

Returns the smallest z coordinate

```
6.18.3.4 getProfile() void GEOM_FADE25D::IsoContours::getProfile (
    const Point2 & p,
    std::vector< Segment2 > & vSegmentsOut )
```

Get Profile

This is a new method to compute profiles i.e., to produce slices orthogonal to a direction specified in the constructor

`IsoContours(std::vector<Point2>& vCorners, const Vector2& dirVec)`

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

- `IsoContours.h`

6.19 GEOM_FADE25D::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`

6.19.1 Detailed Description

See also

[Visualizer2](#) where `Label` objects are used for visualizations

6.19.2 Constructor & Destructor Documentation

```
6.19.2.1 Label() GEOM_FADE25D::Label::Label (
    const Point2 & p_,
    const char * s_,
    bool bWithMark_ = true,
    int fontSize_ = 8 )
```

Parameters

<code>p_</code>	is the point where the label appears
<code>s_</code>	is the text to be shown
<code>bWithMark_</code>	switches between text-only and text-with-mark
<code>fontSize_</code>	

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

- `Label.h`

6.20 GEOM_FADE25D::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 **bGridMeshingLQ**
Low quality but high performance grid meshing.
- bool **bKeepExistingSteinerPoints**
Steiner points from previous refinements.
- bool **bReproducibleResults**
Reproducible results.
- double **capAspectLimit**
capAspectLimit
- int **command**
Command.
- double **gridLength**
gridLength
- **Vector2 gridVector**
gridVector
- double **growFactor**
growFactor
- double **growFactorMinArea**
growFactorMinArea
- double **maxEdgeLength**
Maximum edge length.
- double **maxHeightError**
maxHeightError
- double **maxTriangleArea**
maxTriangleArea
- double **minAngleDegree**
Minimum interior triangle angle.
- double **minEdgeLength**
Minimum edge length.
- **Fade_2D * pHeightGuideTriangulation**
pHeightGuideTriangulation
- **Zone2 * pZone**
Zone to be meshed.

6.20.1 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. The meshing algorithm calls these functions to decide if a certain triangle must be refined.

See also

<http://www.geom.at/advanced-mesh-generation/>

6.20.2 Member Function Documentation

6.20.2.1 `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.

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

Parameters

<code>pT</code>	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.

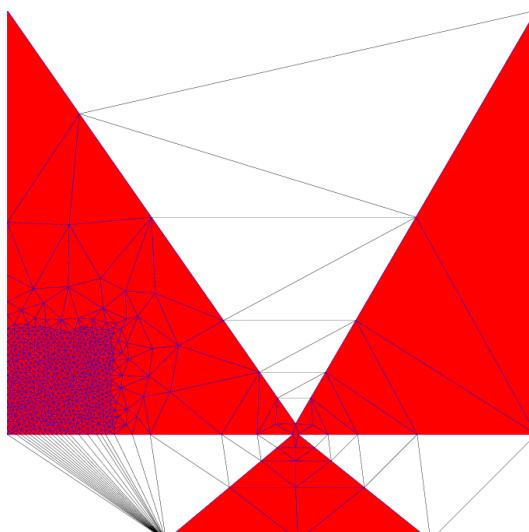


Figure 18 User Controlled Mesh Density, Edge Length

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

Parameters

<code>pT</code>	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.

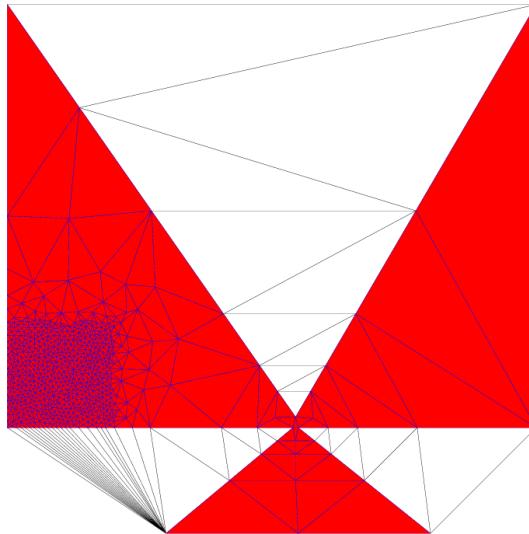


Figure 19 User Controlled Mesh Density, Area

6.20.3 Member Data Documentation

6.20.3.1 bAllowConstraintSplitting `bool GEOM_FADE25D::MeshGenParams::bAllowConstraintSplitting`
Defines if constraint segments can be splitted. Default: yes

6.20.3.2 bGridMeshingLQ `bool GEOM_FADE25D::MeshGenParams::bGridMeshingLQ`
By default bGridMeshingLQ=false in order to create high quality triangles everywhere. By using bGridMeshingLQ=true you can save time but a few bad shaped triangles may remain. This option works only together with grid-meshing.

6.20.3.3 bKeepExistingSteinerPoints `bool GEOM_FADE25D::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.

6.20.3.4 bReproducibleResults `bool GEOM_FADE25D::MeshGenParams::bReproducibleResults`
By default the algorithm generates reproducible triangulations. If not required you can disable that with bReproducibleResults=false to save time.

Note

Reproducible results are created *inside* pZone. If you need reproducible results outside also then create a global zone and call unifyGrid(0) once.

6.20.3.5 capAspectLimit `double GEOM_FADE25D::MeshGenParams::capAspectLimit`
Limits the quotient edgeLength / height. Default value: 10.0

6.20.3.6 command `int GEOM_FADE25D::MeshGenParams::command`
A command for development, not for public use. Will vanish soon.

6.20.3.7 gridLength double GEOM_FADE25D::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 $\sqrt{2} \cdot \text{gridLength}$ and the algorithm may automatically adapt the gridLength a bit such that the grid fits better into the shape.

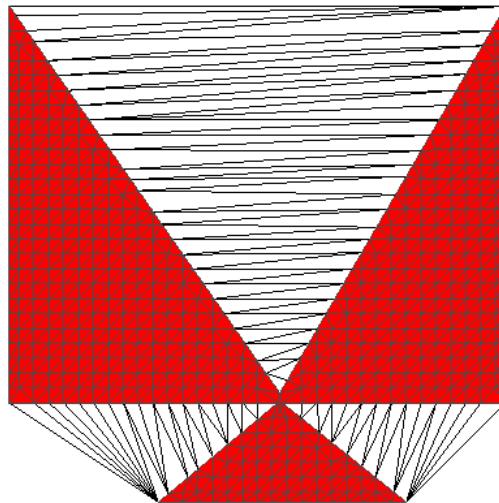


Figure 20 Grid Meshing axis aligned

6.20.3.8 gridVector Vector2 GEOM_FADE25D::MeshGenParams::gridVector

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

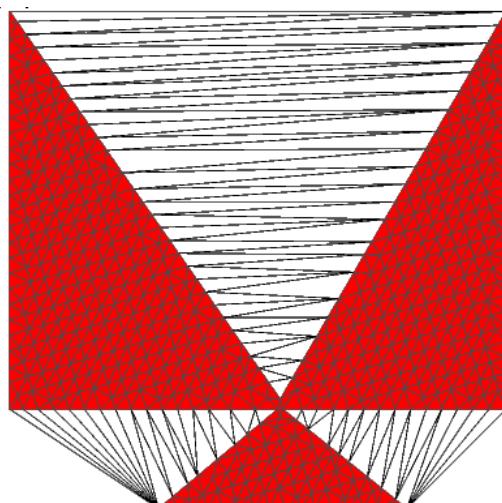


Figure 21 Grid Meshing along Vector2(1.0,0.3,0.0)

6.20.3.9 growFactor double GEOM_FADE25D::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) $\text{area}(t0)/\text{area}(t1) < \text{growFactor}$. Recommendation: growFactor>5.0, Default: growFactor=DBL_MAX

6.20.3.10 growFactorMinArea double GEOM_FADE25D::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

6.20.3.11 maxEdgeLength double GEOM_FADE25D::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.

6.20.3.12 maxHeightError double GEOM_FADE25D::MeshGenParams::maxHeightError

If pHeightGuideTriangulation is set and the height error exceeds locally maxHeightError then the triangulation is further refined.

6.20.3.13 maxTriangleArea double GEOM_FADE25D::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.

6.20.3.14 minAngleDegree double GEOM_FADE25D::MeshGenParams::minAngleDegree

Minimum interior angle: Default: 20.0, maximum: 30.0

6.20.3.15 minEdgeLength double GEOM_FADE25D::MeshGenParams::minEdgeLength

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

6.20.3.16 pHeightGuideTriangulation Fade_2D* GEOM_FADE25D::MeshGenParams::pHeightGuideTriangulation

When new vertices are created then their height (z-coordinate) is usually computed from the existing triangles. In a situation where an extra triangulation with more accurate heights exists this extra triangulation can be set as height guide triangulation. In this case the z-coordinates are computed from the triangles of the height guide triangulation. The documentation for this class was generated from the following file:

- [MeshGenParams.h](#)

6.21 GEOM_FADE25D::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

6.21.1 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/>

6.21.2 Member Function Documentation

```
6.21.2.1 update() virtual void GEOM_FADE25D::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](#)

6.22 GEOM_FADE25D::PeelPredicateTS Class Reference

User-defined peel predicate.

```
#include <UserPredicates.h>
```

Public Member Functions

- virtual bool [operator\(\)](#) (const [Triangle2](#) *, std::set< [Triangle2](#) * > *pCurrentSet)=0

6.22.1 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](#)

6.23 GEOM_FADE25D::Point2 Class Reference

Point.

```
#include <Point2.h>
```

Public Member Functions

- [Point2 \(\)](#)
Default constructor.
- [Point2 \(const double x_, const double y_, const double z_\)](#)
Constructor.
- [Point2 \(const Point2 &p_\)](#)
Copy constructor.
- 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.*
- bool `samePoint` (const `Point2` &p) const
 - Equality operator.*
- void `set` (const double x_, const double y_, const double z_, int customIndex_)
 - Set the coordinates.*
- void `set` (const `Point2` &pnt)
 - Set the coordinates.*
- void `setCoords` (const double x_, const double y_, const double z_)
 - Set the coordinates.*
- void `setCustomIndex` (int customIndex_)
 - Set a custom index.*
- void `setHeight` (double z)
 - Set the z-coordinate.*
- 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.*
- void `xyz` (double &x_, double &y_, double &z_) const
 - Get the x-, y- and z-coordinate.*
- double `y` () const
 - Get the y-coordinate.*
- double `z` () const
 - Get the z-coordinate.*

Protected Attributes

- double `coordX`
- double `coordY`
- double `coordZ`
- 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.*

6.23.1 Detailed Description

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

6.23.2 Constructor & Destructor Documentation

6.23.2.1 Point2() [1/2] GEOM_FADE25D::Point2::Point2 (

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

Parameters

$x \leftarrow$	x-coordinate
$y \leftarrow$	y-coordinate
$z \leftarrow$	z-coordinate

6.23.2.2 Point2() [2/2] GEOM_FADE25D::Point2::Point2 (

```
    const Point2 & p_ ) [inline]
```

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

6.23.3 Member Function Documentation

6.23.3.1 getCustomIndex() int GEOM_FADE25D::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/>

6.23.3.2 getIncidentTriangle() Triangle2* GEOM_FADE25D::Point2::getIncidentTriangle () const [inline]

Returns

the associated triangle

6.23.3.3 operator"!=() bool GEOM_FADE25D::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 are compared by this method

6.23.3.4 operator<() bool GEOM_FADE25D::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 are compared by this method

6.23.3.5 operator==(()) bool GEOM_FADE25D::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 are compared by this method

6.23.3.6 operator>() bool GEOM_FADE25D::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 are compared by this method

6.23.3.7 samePoint() bool GEOM_FADE25D::Point2::samePoint (const Point2 & p) const [inline]
 Compares the x,y,z coordinates while [operator==\(\)](#) compares only x,y

6.23.3.8 set() [1/2] void GEOM_FADE25D::Point2::set (const double x_, const double y_, const double z_, int customIndex_) [inline]

Internal method

Parameters

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

6.23.3.9 `set()` [2/2] void GEOM_FADE25D::Point2::set (const Point2 & pnt) [inline]

Parameters

<code>pnt</code>	is the point whose coordinates are assigned to the current point
------------------	--

6.23.3.10 `setCoords()` void GEOM_FADE25D::Point2::setCoords (const double x_, const double y_, const double z_) [inline]

Internal method

Parameters

<code>x</code> ↔	x-coordinate
<code>y</code> ↔	y-coordinate
<code>z</code> ↔	z-coordinate

Note

Does not adapt customIndex and pAssociatedTriangle.

6.23.3.11 `setCustomIndex()` void GEOM_FADE25D::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/>

6.23.3.12 `setHeight()` void GEOM_FADE25D::Point2::setHeight (double z) [inline]

Allows to exchange the z-coordinate

6.23.3.13 `setIncidentTriangle()` void GEOM_FADE25D::Point2::setIncidentTriangle (Triangle2 * pT) [inline]

Parameters

<code>pT</code>	will be associated with the triangle
-----------------	--------------------------------------

6.23.3.14 `x()` double GEOM_FADE25D::Point2::x () const [inline]

Returns

the x-coordinate

6.23.3.15 `xy()` void GEOM_FADE25D::Point2::xy (

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

Parameters

$x \leftarrow$ $_ \leftarrow \rightarrow$	x-coordinate
$y \leftarrow$ $_ \leftarrow \rightarrow$	y-coordinate

6.23.3.16 `xyz()` void GEOM_FADE25D::Point2::xyz (

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

Parameters

$x \leftarrow$ $_ \leftarrow$	x-coordinate
$y \leftarrow$ $_ \leftarrow$	y-coordinate
$z \leftarrow$ $_ \leftarrow$	z-coordinate

6.23.3.17 `y()` double GEOM_FADE25D::Point2::y () const [inline]

Returns

the y-coordinate

6.23.3.18 `z()` double GEOM_FADE25D::Point2::z () const [inline]

Returns

the z-coordinate

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

- [Point2.h](#)

6.24 GEOM_FADE25D::Segment2 Class Reference

Segment.

```
#include <Segment2.h>
```

Public Member Functions

- [Segment2 \(\)](#)
- [Segment2 \(const Point2 &src_, const Point2 &trg_\)](#)
Create a Segment2.
- [double getSqLen25D \(\) const](#)
- [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<< \(std::ostream &stream, Segment2 seg\)](#)

6.24.1 Constructor & Destructor Documentation

6.24.1.1 Segment2() [1/2] `GEOM_FADE25D::Segment2::Segment2 (`
 `const Point2 & src_,`
 `const Point2 & trg_)`

Parameters

<code>src</code> ↪	First endpoint (source)
<code>trg</code> ↪	Second endpoint (target)

6.24.1.2 Segment2() [2/2] `GEOM_FADE25D::Segment2::Segment2 ()`
Create a Segment2 Default constructor

6.24.2 Member Function Documentation

6.24.2.1 getSqLen25D() `double GEOM_FADE25D::Segment2::getSqLen25D () const`
Get the squared length (2.5D version)

6.24.2.2 getSqLen2D() `double GEOM_FADE25D::Segment2::getSqLen2D () const`
Get the squared length

6.24.2.3 getSrc() `Point2` `GEOM_FADE25D::Segment2::getSrc () const`
Get the source point

Returns

the source point

6.24.2.4 getTrg() `Point2` `GEOM_FADE25D::Segment2::getTrg () const`
Get the target point

Returns

the target point

6.24.2.5 operator==() `bool` `GEOM_FADE25D::Segment2::operator== (`
`const Segment2 & other) const`
operator==
Undirected equality operator

6.24.2.6 swapSrcTrg() `void` `GEOM_FADE25D::Segment2::swapSrcTrg ()`
Internally swaps the source and target point
The documentation for this class was generated from the following file:

- `Segment2.h`

6.25 GEOM_FADE25D::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 * > &vIllegalSegments<- Out) const`
- `int getIndex (Segment2 *pSeg) const`
- `void getIntersectionPoint (SegmentIntersectionType sit, const Segment2 &seg0, const Segment2 &seg1, Point2 &ispOut0, Point2 &ispOut1) const`
- `void getIntersectionSegment (const Segment2 &seg0, const Segment2 &seg1, Segment2 &issOut0, Segment2 &issOut1) const`
- `SegmentIntersectionType getIntersectionType (const Segment2 *pSeg1, const Segment2 *pSeg2) 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)`

Static Public Member Functions

- `static const char * getIntersectionTypeString (SegmentIntersectionType sit)`

6.25.1 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.

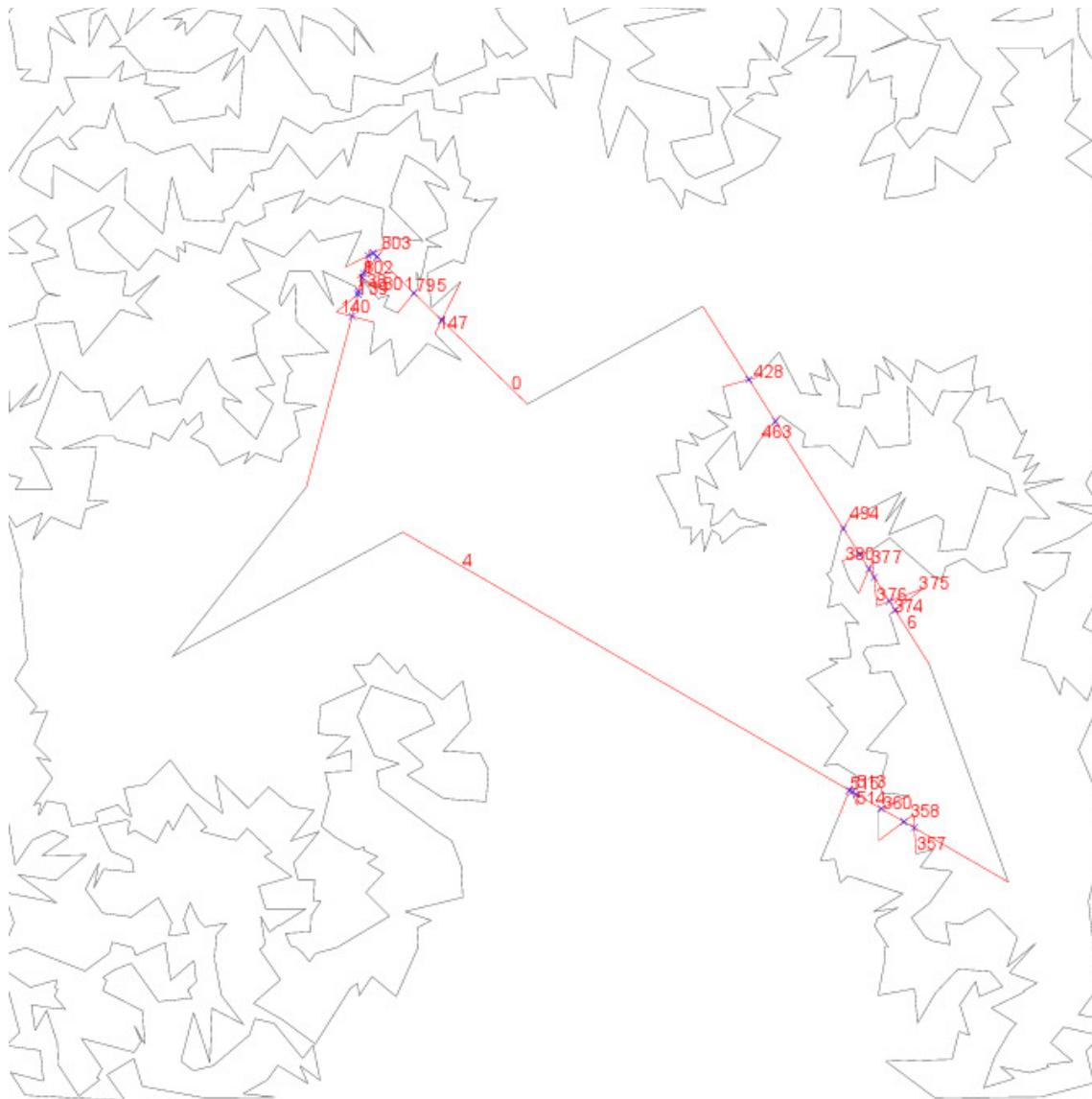


Figure 22 Polyline: Intersecting segments are automatically found

See also

<http://www.geom.at/segment-checker/>

6.25.2 Constructor & Destructor Documentation

6.25.2.1 SegmentChecker() `GEOm_FADE25D::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

<i>v</i> ↔ <i>Segments</i> ↔ —	contains the segments to be checked
--------------------------------------	-------------------------------------

6.25.3 Member Function Documentation

6.25.3.1 clipSegment() `ClipResult GEOM_FADE25D::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

<i>in,out</i>	<i>seg</i>	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 {;

6.25.3.2 getIllegalSegments() `void GEOM_FADE25D::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 `b`↔AlsoEndPointIntersections 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

	<i>bAlsoEndPointIntersections</i>	specifies if intersections at endpoints shall be detected
<i>out</i>	<i>vIllegalSegmentsOut</i>	is the output vector

6.25.3.3 getIndex() `int GEOM_FADE25D::SegmentChecker::getIndex (`

`Segment2 * pSeg) const`

Returns the index of a segment

Parameters

<i>pSeg</i>	is the segment whose index is returned
-------------	--

```
6.25.3.4 getIntersectionPoint() void GEOM_FADE25D::SegmentChecker::getIntersectionPoint (
    SegmentIntersectionType sit,
    const Segment2 & seg0,
    const Segment2 & seg1,
    Point2 & ispOut0,
    Point2 & ispOut1 ) const
```

Compute the intersection point(s) of two segments.

Use [getIntersectionType\(\)](#) to determine the segment intersection type `sit` before. Call this function only when the intersection type is SIT_POINT or SIT_ENDPOINT.

Parameters

	<code>sit</code>	is the segment intersection type (SIT_POINT or SIT_ENDPOINT for the present method)
	<code>seg0,seg1</code>	are the intersecting segments
out	<code>ispOut0</code>	output intersection point at <code>seg0</code>
out	<code>ispOut1</code>	output intersection point at <code>seg1</code>

The resulting two output intersection points `ispOut0` and `ispOut1` have always the same (x,y) coordinates but possibly different heights z.

Note

`pSeg1` and `pSeg2` do not need to be from the set of segments that have been used as argument for the constructor of the [SegmentChecker](#). You can use any segments.

```
6.25.3.5 getIntersectionSegment() void GEOM_FADE25D::SegmentChecker::getIntersectionSegment (
    const Segment2 & seg0,
    const Segment2 & seg1,
    Segment2 & issOut0,
    Segment2 & issOut1 ) const
```

Compute the intersection segment(s) of two collinear intersecting segments.

Use [getIntersectionType\(\)](#) to determine the segment intersection type `sit` before. Call this function only when the intersection type is SIT_SEGMENT.

Parameters

	<code>seg0,seg1</code>	are intersecting segments such that their SegmentIntersectionType is SIT_SEGMENT
out	<code>issOut0</code>	intersection segment at <code>seg0</code>
out	<code>issOut1</code>	intersection segment at <code>seg1</code>

The two output segments have always the same (x,y) coordinates but possibly diffent heights z.

Note

`pSeg1` and `pSeg2` do not need to be from the set of segments that have been used as argument for the constructor of the [SegmentChecker](#). You can use any segments.

```
6.25.3.6 getIntersectionType() SegmentIntersectionType GEOM_FADE25D::SegmentChecker::getIntersectionType (
    const Segment2 * pSeg1,
    const Segment2 * pSeg2 ) const
```

Get the intersection type of two segments

Parameters

<i>pSeg1,pSeg2</i>	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

6.25.3.7 getIntersectionTypeString() static const char* GEOM_FADE25D::SegmentChecker::getIntersectionTypeString (

SegmentIntersectionType sit) [static]

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

Parameters

<i>sit</i>	is an intersection type to be converted to a string
------------	---

6.25.3.8 getIntersectors() void GEOM_FADE25D::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

	<i>pTestSegment</i>	is the segment to be analyzed
	<i>bAlsoEndPointIntersections</i>	specifies if intersections of type SIT_ENDPOINT shall also be reported.
<i>out</i>	<i>vIntersectorsOut</i>	is the output vector. Segments intersecting <i>pTestSegment</i> are added to <i>vIntersectorsOut</i> 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*.

6.25.3.9 getLimit() *Bbox2* GEOM_FADE25D::SegmentChecker::getLimit () const
 Get Limit

Returns

the bounding box that has been set before using [setLimit\(\)](#)

6.25.3.10 `getNumberOfSegments()` `size_t GEOM_FADE25D::SegmentChecker::getNumberOfSegments () const`
Returns the number of segments contained in this [SegmentChecker](#) object

6.25.3.11 `getSegment()` `Segment2* GEOM_FADE25D::SegmentChecker::getSegment (size_t i) const`
Returns the i-th segment

Parameters

<code>i</code>	is the index of the segment to be returned
----------------	--

6.25.3.12 `setLimit()` `void GEOM_FADE25D::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

6.25.3.13 `showIllegalSegments()` `void GEOM_FADE25D::SegmentChecker::showIllegalSegments (bool bAlsoEndPointIntersections, const char * name) const`
Write a postscript file, highlight illegal segments

Parameters

<code>bAlsoEndPointIntersections</code>	specifies if intersections at endpoints are also illegal
<code>name</code>	is the output filename

showIllegalSegments.ps

Geom Fade 2.5D, student version

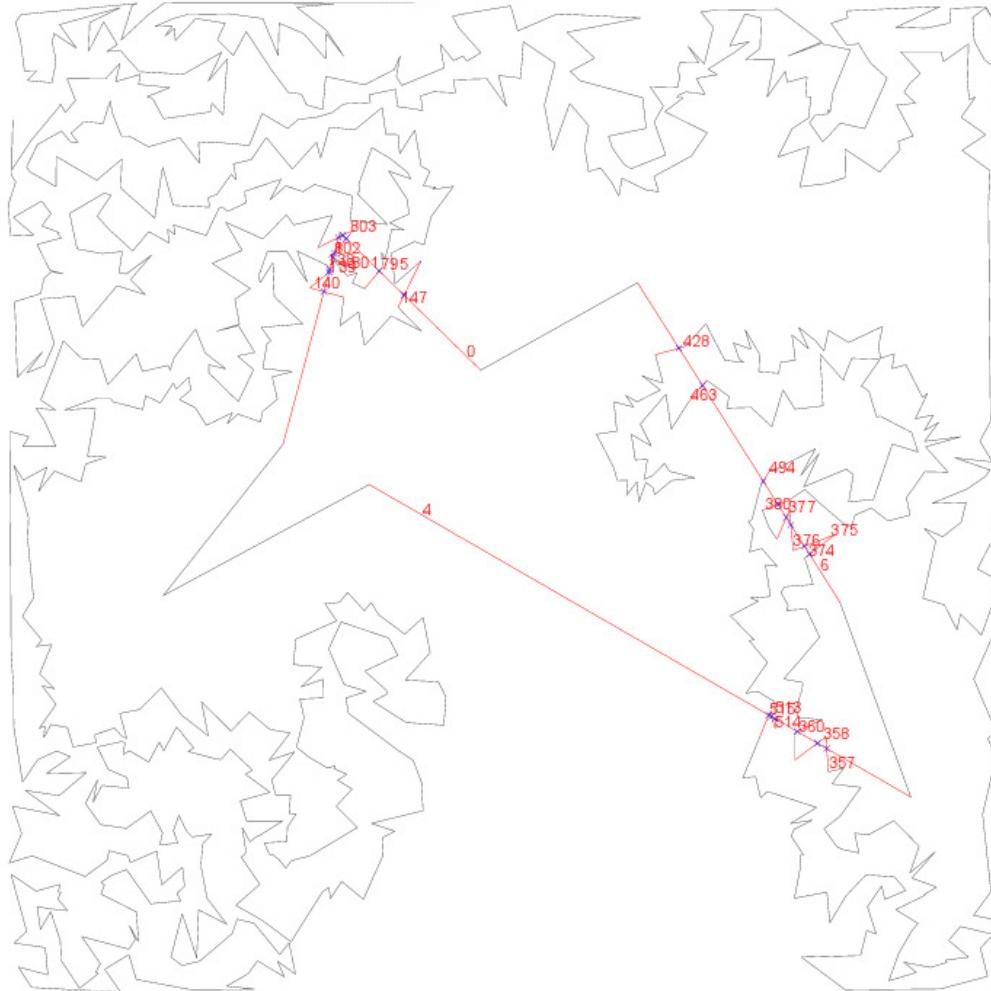
x-Range: [-99.8465 - 99.9001] = 199.747
y-Range: [-99.9906 - 99.9987] = 199.989

SegmentChecker::showIllegalSegments()

Number of segments: 1009

Legal segments: 983

Illegal segments: 26

**Figure 23 Visualization of polyline intersections**

```
6.25.3.14 showSegments() void GEOM_FADE25D::SegmentChecker::showSegments (
    const char * name ) const
```

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

Parameters

<i>name</i>	is the output filename
-------------	------------------------

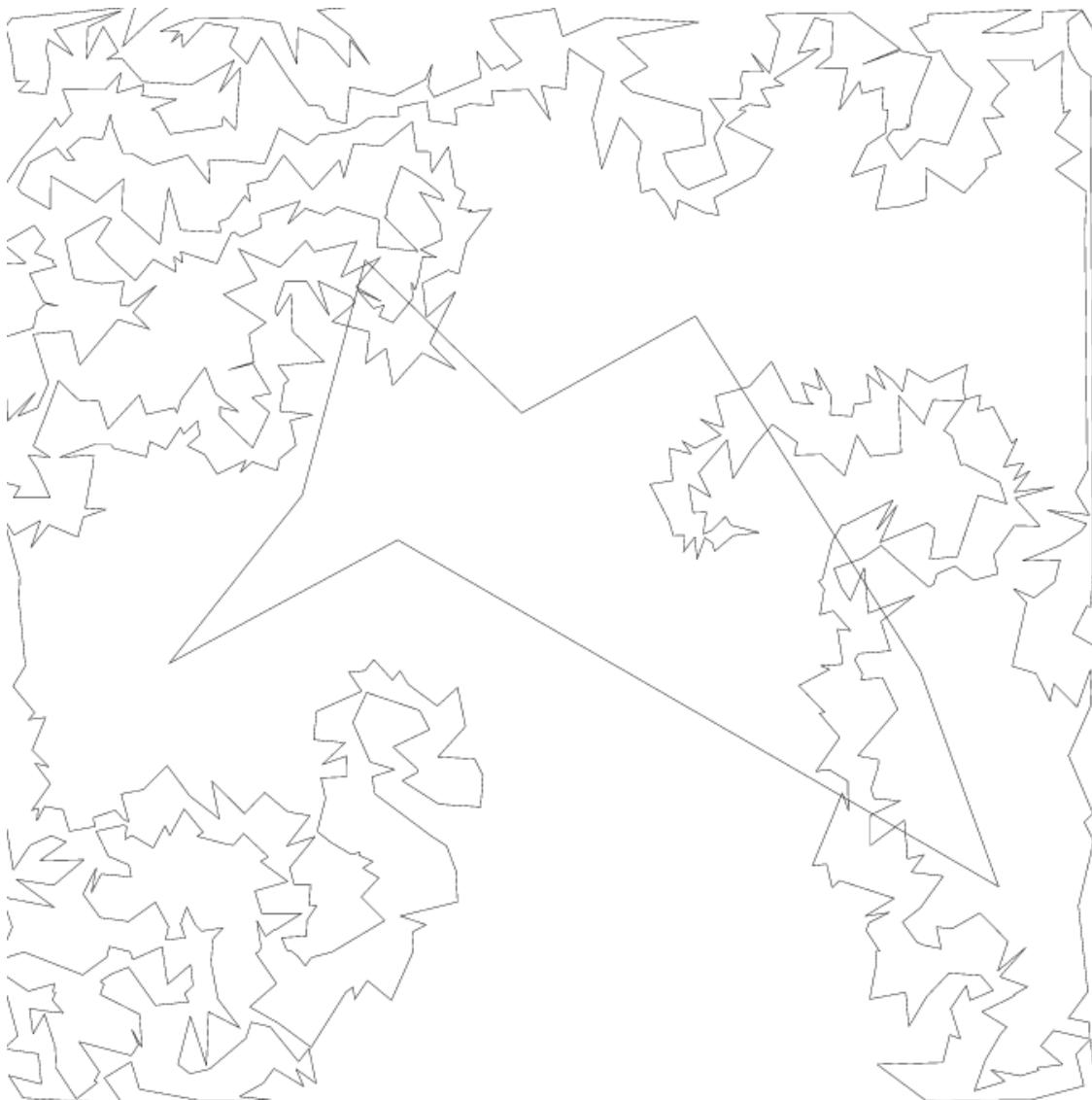


Figure 24 Line segments written to a postscript file

```
6.25.3.15 subscribe() void GEOM_FADE25D::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

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

```
6.25.3.16 unsubscribe() void GEOM_FADE25D::SegmentChecker::unsubscribe (
    MsgType msgType,
```

`MsgBase * pMsg)`
Unregister a progress bar object

Parameters

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

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

- [SegmentChecker.h](#)

6.26 GEOM_FADE25D::Triangle2 Class Reference

Triangle.

```
#include <Triangle2.h>
```

Public Member Functions

- [Triangle2 \(\)](#)
Constructor.
- [void clearProperties \(\)](#)
Clear all corners and neighbor pointers.
- [double getArea25D \(\) const](#)
Get 2.5D Area.
- [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.
- [void get Corners \(Point2 *&p0, Point2 *&p1, Point2 *&p2\) const](#)
Get the 3 triangle corners.
- [std::pair< Point2, bool > getDual \(bool bForceExact=false\) const](#)
- [double getInteriorAngle25D \(int ith\) const](#)
Get interior 2.5D angle.
- [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.
- [Vector2 getNormalVector \(\) const](#)
Get the normal vector of a triangle.
- [Triangle2 * getOppositeTriangle \(const int ith\) const](#)

- Get the i-th neighbor triangle.*
- double `getSquaredEdgeLength25D` (int ith) const
Squared edge length.
 - 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` (const `Point2` *pVtx) const
Has vertex.
 - void `setOppTriangle` (const int ith, `Triangle2` *pTriangle)
Set the i-th neighbor triangle.
 - void `setProperties` (`Point2` *pl, `Point2` *pj, `Point2` *pk)
Set all corners.
 - void `setPropertiesAndOppT` (`Point2` *pl, `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)

6.26.1 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.

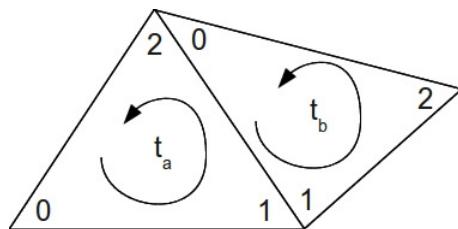


Figure 25 Indices and neighborships, t_b is the 0-th neighbor of t_a and t_a is the 2nd neighbor of t_b .

See also

`TriangleAroundVertexIterator` to find out how to access all triangles incident to a certain vertex.

6.26.2 Member Function Documentation

6.26.2.1 `getArea25D()` double GEOM_FADE25D::Triangle2::getArea25D () const
 Returns the 2.5D area of the triangle.

Note: The `getArea()` method is deprecated and replaced by [getArea2D\(\)](#) and [getArea25D\(\)](#)

6.26.2.2 `getArea2D()` double GEOM_FADE25D::Triangle2::getArea2D () const
 Returns the 2D area of the triangle.

Note: The `getArea()` method is deprecated and replaced by [getArea2D\(\)](#) and [getArea25D\(\)](#)

6.26.2.3 `getBarycenter()` [Point2](#) GEOM_FADE25D::Triangle2::getBarycenter () const

Returns

the barycenter of the triangle.

6.26.2.4 `getCircumcenter()` [Point2](#) GEOM_FADE25D::Triangle2::getCircumcenter (
CircumcenterQuality & *ccq*,
bool bForceExact = false) const

Parameters

<i>out</i>	<i>ccq</i>	returns the quality of the computed point and is one of CCQ_INEXACT, CCQ_EXACT and CCQ_OUT_OF_BOUNDS.
<i>in</i>	<i>bForceExact</i>	forces exact computation with multiple-precision arithmetic. When <i>bForceExact</i> =false, then the faster double-precision arithmetic is used for good shaped triangles.

Returns

the circumcenter of the triangle. The z-coordinate is 0.0. You can use [Fade_2D::getHeight\(..\)](#) to determine the height.

Attention

Attention: The circumcenter of a nearly collinear triangle can have extremely large coordinates. Fade computes the circumcenter with multiple-precision arithmetic 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.

6.26.2.5 `getInteriorAngle25D()` double GEOM_FADE25D::Triangle2::getInteriorAngle25D (
int ith) const

Returns

the interior 2.5D angle at the *ith* vertex

6.26.2.6 `getInteriorAngle2D()` double GEOM_FADE25D::Triangle2::getInteriorAngle2D (
int ith) const

Note: The `getInteriorAngle()` method is deprecated and replaced by [getInteriorAngle2D\(\)](#) and [getInteriorAngle25D\(\)](#)

Returns

the interior 2D angle at the ith vertex

6.26.2.7 getIntraTriangleIndex() [1/3] `int GEOM_FADE25D::Triangle2::getIntraTriangleIndex (const Point2 * p) const [inline]`

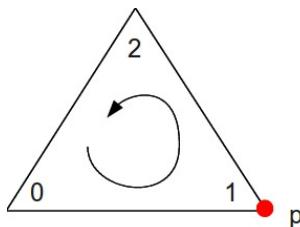


Figure 26 Intra triangle index of a vertex pointer

Parameters

<code>p</code>	is a pointer to a vertex in <code>*this</code>
----------------	--

Returns

the intra-triangle-index 0,1 or 2 of `p` in `*this`

6.26.2.8 getIntraTriangleIndex() [2/3] `int GEOM_FADE25D::Triangle2::getIntraTriangleIndex (const Point2 * p0, const Point2 * p1) const [inline]`

Returns

the index of the edge (`p0,p1`) in the triangle

6.26.2.9 getIntraTriangleIndex() [3/3] `int GEOM_FADE25D::Triangle2::getIntraTriangleIndex (const Triangle2 * pTriangle) const [inline]`

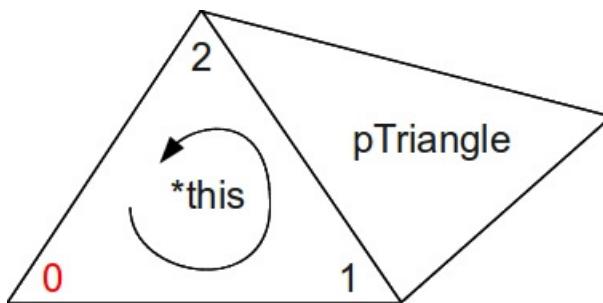


Figure 27 pTriangle is the 0-th neighbor of *this

Parameters

<code>pTriangle</code>	is a neighbor triangle of <code>*this</code> .
------------------------	--

Returns

the intra-triangle-index of the vertex in **this* which is opposite (i.e., does not touch the neighbor) *pTriangle*.

6.26.2.10 getNormalVector() `Vector2` GEOM_FADE25D::Triangle2::getNormalVector () const**Returns**

the normalized normal vector

6.26.2.11 getOppositeTriangle() `Triangle2 *` GEOM_FADE25D::Triangle2::getOppositeTriangle (const int *ith*) const [inline]

Returns the *i-th* neighbor triangle, i.e. the one opposite to the *i-th* corner.

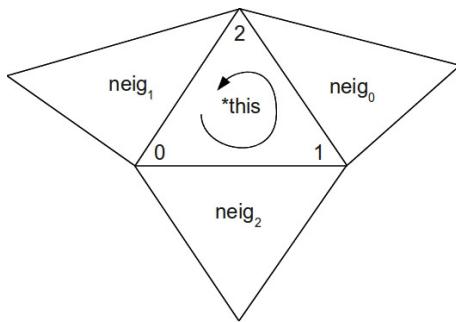


Figure 28 Neighbors of a triangle

Parameters

<i>ith</i>	is the intra-triangle-index of the opposite corner of <i>*this</i>
------------	--

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.

6.26.2.12 getSquaredEdgeLength25D() `double` GEOM_FADE25D::Triangle2::getSquaredEdgeLength25D (int *ith*) const

Returns the squared length of the *ith* edge.

6.26.2.13 getSquaredEdgeLength2D() `double` GEOM_FADE25D::Triangle2::getSquaredEdgeLength2D (int *ith*) const

Method for internal use

Squared edge length

Returns the squared length of the *ith* edge. This method ignores the z-coordinate.

6.26.2.14 hasOnEdge() `bool` GEOM_FADE25D::Triangle2::hasOnEdge (int *i*, const `Point2` & *q*) const**Returns**

if *q* is exactly on the *i-th* edge

6.26.2.15 hasVertex() [1/2] `bool GEOM_FADE25D::Triangle2::hasVertex (`
`const Point2 & vtx) const`

Returns

if `vtx` is a corner of the triangle

6.26.2.16 hasVertex() [2/2] `bool GEOM_FADE25D::Triangle2::hasVertex (`
`const Point2 * pVtx) const`

Returns

if `pVtx` is a corner of the triangle

6.26.2.17 setOppTriangle() `void GEOM_FADE25D::Triangle2::setOppTriangle (`
`const int ith,`
`Triangle2 * pTriangle) [inline]`

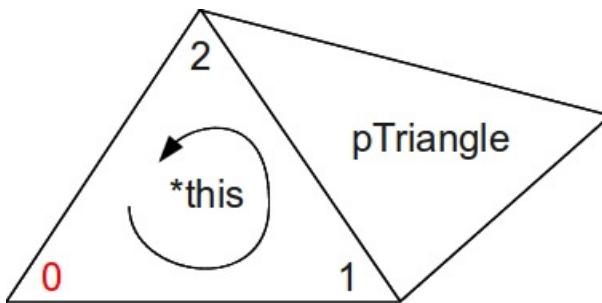


Figure 29 Make `pTriangle` the 0-th neighbor of `*this`

Parameters

<code>ith</code>	is the index of the corner of <code>*this</code> which does not touch <code>pTriangle</code>
<code>pTriangle</code>	is a pointer to the triangle which shares two corners with <code>*this</code>

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

- `Triangle2.h`

6.27 GEOM_FADE25D::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`

6.27.1 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.

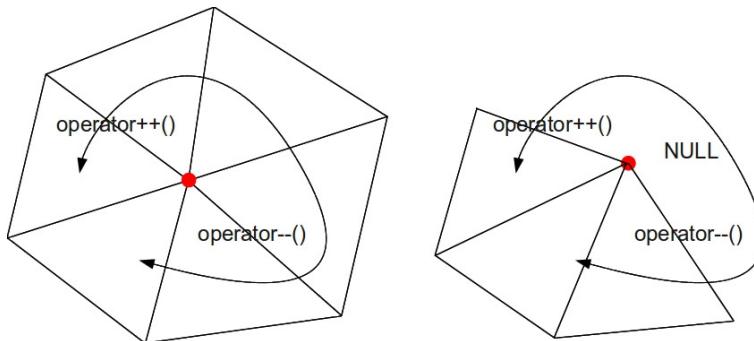


Figure 30 Left: the iterator visits the triangles around a vertex. Right: The iterator 'jumps' over the border edges of the triangulation

6.27.2 Constructor & Destructor Documentation

6.27.2.1 `TriangleAroundVertexIterator()` [1/3] `GEOM_FADE25D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (const Point2 * pPnt_) [inline], [explicit]`

Parameters

<code>pPnt_</code>	is the vertex whose incident triangles can be visited with the iterator
--------------------	---

Initially the iterator points to an arbitrary triangle (not NULL)

6.27.2.2 TriangleAroundVertexIterator() [2/3] GEOM_FADE25D::TriangleAroundVertexIterator::
 TriangleAroundVertexIterator (Point2 * pPnt_, Triangle2 * pTr_) [inline]

Parameters

$p_{\leftarrow} Pnt_{\leftarrow}$	is the vertex whose incident triangles can be visited with the iterator
$p_{\leftarrow} Tr_{\leftarrow}$	is the triangle the iterator initially points to

6.27.2.3 TriangleAroundVertexIterator() [3/3] GEOM_FADE25D::TriangleAroundVertexIterator::
 TriangleAroundVertexIterator (const TriangleAroundVertexIterator & it) [inline]
 Copies the iterator it

6.27.3 Member Function Documentation

6.27.3.1 operator"!=" bool GEOM_FADE25D::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

6.27.3.2 operator*() Triangle2* GEOM_FADE25D::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.

6.27.3.3 operator++() TriangleAroundVertexIterator& GEOM_FADE25D::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.

6.27.3.4 operator--() `TriangleAroundVertexIterator& GEOM_FADE25D::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.

6.27.3.5 operator==() `bool GEOM_FADE25D::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

6.27.3.6 previewNextTriangle() `Triangle2* GEOM_FADE25D::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.

6.27.3.7 previewPrevTriangle() `Triangle2* GEOM_FADE25D::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`

6.28 GEOM_FADE25D::UserPredicateT Class Reference

User-defined predicate (deprecated)

```
#include <UserPredicates.h>
```

Public Member Functions

- virtual bool `operator()` (const `Triangle2 *`)=0

6.28.1 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`

6.29 GEOM_FADE25D::Vector2 Class Reference

Vector.

```
#include <Vector2.h>
```

Public Member Functions

- `Vector2 ()`
Default constructor.
- `Vector2 (const double x_, const double y_, const double z_)`
Constructor.
- `Vector2 (const Vector2 &v_)`
Copy constructor.
- `int getMaxIndex () const`
Get max index.
- `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`
Get an orthogonal vector (CCW direction)
- `void set (const double x_, const double y_, const double z_)`
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.
- `double z () const`
Get the z-value.

Protected Attributes

- `double valX`
- `double valY`
- `double valZ`

6.29.1 Detailed Description

This class represents a vector in 2D

6.29.2 Constructor & Destructor Documentation

6.29.2.1 Vector2() [1/2] `GEOM_FADE25D::Vector2::Vector2 ()`
The vector is initialized to (0,0,0)

6.29.2.2 Vector2() [2/2] `GEOM_FADE25D::Vector2::Vector2 (const Vector2 & v_)`
Create a copy of vector `v_`

6.29.3 Member Function Documentation

6.29.3.1 getMaxIndex() `int GEOM_FADE25D::Vector2::getMaxIndex () const`

Returns

the index of the largest component (0,1 or 2)

6.29.3.2 isDegenerate() `bool GEOM_FADE25D::Vector2::isDegenerate () const`

Returns

true if the vector length is 0, false otherwise.

6.29.3.3 operator*() [1/2] `double GEOM_FADE25D::Vector2::operator* (const Vector2 & other) const`

Scalar product

6.29.3.4 operator*() [2/2] `Vector2 GEOM_FADE25D::Vector2::operator* (double val) const`

Multiply by a scalar value

6.29.3.5 operator/() `Vector2 GEOM_FADE25D::Vector2::operator/ (double val) const`

Divide by a scalar value

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

- `Vector2.h`

6.30 GEOM_FADE25D::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

- `Visualizer2` (const `Visualizer2` &)
- void `changeColor` (const `Color` &c)
- void `changeColor` (float r, float g, float b, float linewidth, bool bFill)
- `Visualizer2` & `operator=` (const `Visualizer2` &)
- 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` (const `Point2` &p1_, float size)
- void `writePoint` (const `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`

6.30.1 Detailed Description

See also

<http://www.geom.at/example2-traversing/>

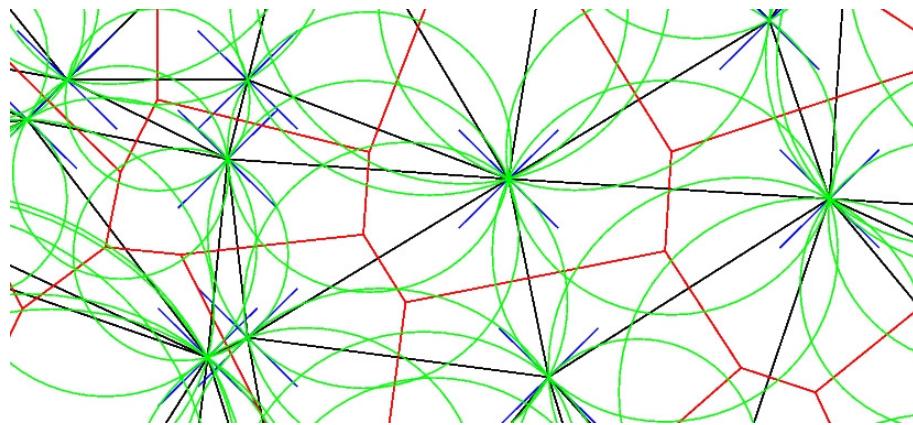


Figure 31 Example output of the Visualizer

6.30.2 Constructor & Destructor Documentation

6.30.2.1 Visualizer2() `GEOM_FADE25D::Visualizer2::Visualizer2 (`
`const char * filename_) [explicit]`

Parameters

<code>filename_</code>	is the name of the postscript file to be written
------------------------	--

6.30.3 Member Function Documentation

6.30.3.1 computeRange() `Bbox2 GEOM_FADE25D::Visualizer2::computeRange (`
`bool bWithVoronoi)`

Parameters

<code>bWithVoronoi</code>	specifies if the Voronoi cells shall be incorporated.
---------------------------	---

Returns

a bounding box of currently contained objects

6.30.3.2 `writeFile()` `void GEOM_FADE25D::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](#)

6.31 GEOM_FADE25D::Visualizer3 Class Reference

[Visualizer3](#) is a 3D scene writer for the Geomview viewer.

```
#include <Visualizer3.h>
```

Public Member Functions

- **Visualizer3** (const char *name)
- void **closeFile** ()
- void **setBackfaces** (bool bWithBackfaces_)
- void **writeBall** (const [Point2](#) &p, double radius)
- void **writeCubes** (const std::vector< [Point2](#) > &vPoints, const char *color)
- void **writeNormals** (const std::vector< [Triangle2](#) * > &vT, double scale)
- void **writePoint** (const [Point2](#) &p, unsigned linewidth, const char *color)
- void **writePoints** (const std::vector< [Point2](#) * > &vPoints, unsigned linewidth, const char *color)
- void **writePoints** (const std::vector< [Point2](#) > &vPoints, unsigned linewidth, const char *color)
- void **writeSegment** (const [Point2](#) &src, const [Point2](#) &trg, const char *color, bool bWithEndPoints=false)
- void **writeSegments** (const std::vector< [Edge2](#) > &vSegments, const char *color, bool bWithEndPoints=false)
- void **writeSegments** (const std::vector< [Segment2](#) > &vSegments, const char *color, bool bWithEndPoints=false)
- void **writeTriangle** (const [Point2](#) &p0, const [Point2](#) &p1, const [Point2](#) &p2, const char *color)
- void **writeTriangle** (const [Triangle2](#) &t, const char *color)
- void **writeTriangles** (const std::vector< [Point2](#) > &vTriangleCorners, const char *color, bool bWithNNV)
- void **writeTriangles** (const std::vector< [Triangle2](#) * > &vT, const char *color, bool bWithNormals=false)
- void **writeVertexPairs** (const std::vector< [VertexPair2](#) > &vVertexPairs, const char *color)

Static Public Member Functions

- static const char * **getColor** (int i)
- static const char * **getNextColor** ()
- static const char * **getNextColorAndName** (const char *&)

Static Public Attributes

- static const char *const **CBLACK**
- static const char *const **CCYAN**
- static const char *const **CDARKBLUE**
- static const char *const **CDARKBROWN**
- static const char *const **CDARKORANGE**
- static const char *const **CGOLDENROD**
- static const char *const **CGRAY**
- static const char *const **CGREEN**
- static const char *const **CGREENYELLOW**
- static const char *const **CLAWNGREEN**
- static const char *const **CLIGHTBLUE**
- static const char *const **CLIGHTBROWN**
- static const char *const **CLIGHTGRAY**
- static const char *const **CLIGHTSEAGREAN**
- static const char *const **CMEDSPRINGGREEN**
- static const char *const **COLIVE**
- static const char *const **CORANGE**
- static const char *const **CPALEGREEN**
- static const char *const **CPINK**
- static const char *const **CPURPLE**
- static const char *const **CRED**
- static const char *const **CRIMSON**
- static const char *const **CSTEELBLUE**
- static const char *const **CWHEAT**
- static const char *const **CWHITE**
- static const char *const **CYELLOW**
- static const char *const **MIDNIGHTBLUE**

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

- [Visualizer3.h](#)

6.32 GEOM_FADE25D::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.
- [`void exportZone \(FadeExport &fadeExport, bool bWithCustomIndices\) const`](#)
Export triangles from a zone.
- [`double getArea25D \(\) const`](#)
Get 2.5D Area.
- [`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.

- void `getBoundarySegments` (std::vector< `Segment2` > &vSegments) const
Compute the boundary segments.
- `Bbox2 getBoundingBox` () const
Compute the bounding box.
- void `getComponentPolygons` (std::vector< `CompPolygon` > &vCompPolygons) const
Get connected components and their boundary polygons.
- `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 `showGeomview` (const char *filename, const char *color) const
Geomview visualization.
- void `showGeomview` (`Visualizer3` *pVis, const char *color) const
Geomview visualization.
- void `slopeValleyRidgeOptimization` (`OptimizationMode` om=OPTMODE_BETTER)
Optimize Slopes, Valleys and Ridges.
- void `smoothing` (int numIterations=2)
Smoothing.
- 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).*

Protected Member Functions

- `Zone2 & operator=` (const `Zone2` &)

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.

6.32.1 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

6.32.2 Member Function Documentation**6.32.2.1 convertToBoundedZone()** `Zone2* GEOM_FADE25D::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_BOUNDDED or a pointer to the present zone if this->[getZoneLocation\(\)](#) is ZL_INSIDE.

6.32.2.2 exportZone() `void GEOM_FADE25D::Zone2::exportZone (`

```
FadeExport & fadeExport,
bool bWithCustomIndices ) const
```

Parameters

<code>fadeExport</code>	is a struct that will hold the requested triangulation data
<code>bWithCustomIndices</code>	determines whether the custom indices of the points are also stored

6.32.2.3 getArea25D() `double GEOM_FADE25D::Zone2::getArea25D () const`

Returns the 2.5D area of the zone.

Note: The [getArea\(\)](#) method is deprecated and replaced by [getArea2D\(\)](#) and [getArea25D\(\)](#)

6.32.2.4 getArea2D() `double GEOM_FADE25D::Zone2::getArea2D () const`

Returns the 2D area of the zone.

Note: The [getArea\(\)](#) method is deprecated and replaced by [getArea2D\(\)](#) and [getArea25D\(\)](#)

```
6.32.2.5 getBorderEdges() void GEOM_FADE25D::Zone2::getBorderEdges (
    std::vector< Edge2 > & vBorderEdgesOut ) const
```

Returns

: the CCW oriented border edges of the zone

```
6.32.2.6 getBoundaryEdges() void GEOM_FADE25D::Zone2::getBoundaryEdges (
    std::vector< Edge2 > & vEdges ) const
```

Outputs the boundary edges of the zone. `Edge2` elements are always ccw-oriented but the edges are not returned in any specific order.

```
6.32.2.7 getBoundarySegments() void GEOM_FADE25D::Zone2::getBoundarySegments (
    std::vector< Segment2 > & vSegments ) const
```

Outputs the boundary segments of the zone. These are ccw-oriented but not returned in any specific order.

```
6.32.2.8 getComponentPolygons() void GEOM_FADE25D::Zone2::getComponentPolygons (
    std::vector< CompPolygon > & vCompPolygons ) const
```

This method subdivides the zone into connected components. For each connected components it then returns a `CompPolygon` object consisting of the triangles, their outer boundary polygon and the hole polygons. Edges are represented by a triangle and an index and they are always counterclockwise (ccw) around their triangle. Thus the outer boundary polygon is also ccw-oriented while the polygons of inner holes are cw-oriented.

```
6.32.2.9 getConstraintGraph() ConstraintGraph2* GEOM_FADE25D::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.

```
6.32.2.10 getNumberOfTriangles() size_t GEOM_FADE25D::Zone2::getNumberOfTriangles ( ) const
```

Warning

This method is fast but O(n), so don't call it frequently in a loop.

```
6.32.2.11 getTriangles() void GEOM_FADE25D::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.

```
6.32.2.12 getZoneLocation() ZoneLocation GEOM_FADE25D::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

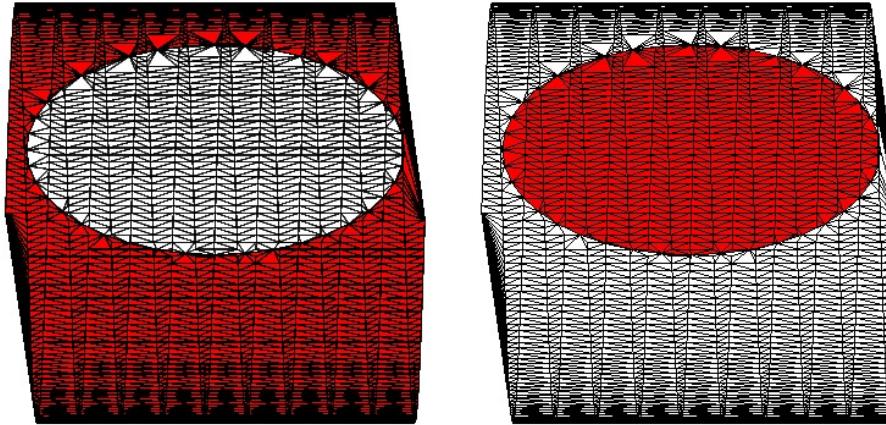


Figure 32 An outside zone and an inside zone

6.32.2.13 `numberOfConstraintGraphs()` `size_t GEOM_FADE25D::Zone2::numberOfConstraintGraphs () const`
 A [Zone2](#) object might be defined by zero, one or more [ConstraintGraph2](#) objects.

6.32.2.14 `save()` [1/2] `bool GEOM_FADE25D::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	<i>filename</i>	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.

6.32.2.15 `save()` [2/2] `bool GEOM_FADE25D::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

<code>stream</code>	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.

6.32.2.16 `show()` [1/2] `void GEOM_FADE25D::Zone2::show (`

```
const char * postscriptFilename,
bool bShowFull,
bool bWithConstraints ) const
```

Parameters

<code>postscriptFilename</code>	is the name of the output file.
<code>bShowFull</code>	specifies if only the zone or the full triangulation shall be drawn
<code>bWithConstraints</code>	specifies if constraint edges shall be drawn

6.32.2.17 `show()` [2/2] `void GEOM_FADE25D::Zone2::show (`

```
Visualizer2 * pVisualizer,
bool bShowFull,
bool bWithConstraints ) const
```

Parameters

<code>pVisualizer</code>	is a pointer to an existing Visualizer2 object.
--------------------------	---

Note

You must call `pVisualizer->writeFile()` before program end

Parameters

<code>bShowFull</code>	specifies if only the zone or the full triangulation shall be drawn
<code>bWithConstraints</code>	specifies if constraint edges shall be drawn

```
6.32.2.18 showGeomview() [1/2] void GEOM_FADE25D::Zone2::showGeomview (
    const char * filename,
    const char * color ) const
```

Parameters

<i>filename</i>	is the name of the output file.
<i>color</i>	is a string ("red green blue alpha"), e.g., "1.0 0.0 0.0 1.0"*

```
6.32.2.19 showGeomview() [2/2] void GEOM_FADE25D::Zone2::showGeomview (
    Visualizer3 * pVis,
    const char * color ) const
```

Parameters

<i>pVis</i>	points to a Visualizer3 object
<i>color</i>	is a string ("red green blue alpha"), e.g., "1.0 0.0 0.0 1.0"*

```
6.32.2.20 slopeValleyRidgeOptimization() void GEOM_FADE25D::Zone2::slopeValleyRidgeOptimization
(
    OptimizationMode om = OPTMODE_BETTER )
```

A pure Delaunay triangulation takes only the x and y coordinates into account. However, for terrain scans, it is important to consider the z coordinate as well, otherwise ridges, valleys and rivers will look unnatural. This method leaves the points constant, but uses edge flips to change the connectivity, making the surface smoother overall.

Parameters

<i>om</i>	is the optimization mode: OPTMODE_NORMAL is the fastest. OPTMODE_BETTER provides significantly better results while still taking a moderate amount of time. OPTMODE_BEST delivers the best results, but also has a significantly higher time requirement. This method supports the progress-bar mechanism.
-----------	--

Note

Flipping edges makes the triangulation non-delaunay, i.e. the empty-circle-property is then no longer given. Improving the smoothness of the surface by edge flips also means degrading the interior angles of the triangles (to a certain degree).

```
6.32.2.21 smoothing() void GEOM_FADE25D::Zone2::smoothing (
    int numIterations = 2 )
```

This method applies weighted laplacian smoothing to the vertices. It keeps boundary points and internal points belonging to constraint-edges constant. Nevertheless it is guaranteed that moving the vertices does not lead to self-intersections. This method is very fast, but for larger models it still supports the progress bar mechanism.

Parameters

<i>numIterations</i>	specifies the number of smoothing passes.
----------------------	---

6.32.2.22 statistics() void GEOM_FADE25D::Zone2::statistics (const char * s) const

Statistics

Prints statistics to stdout.

6.32.2.23 subscribe() void GEOM_FADE25D::Zone2::subscribe (MsgType msgType, MsgBase * pMsg)

Parameters

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

6.32.2.24 unifyGrid() void GEOM_FADE25D::Zone2::unifyGrid (double tolerance)

Unify Grid

A Delaunay triangulation is not unique when 2 or more triangles lie on a common circle. 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

<i>tolerance</i>	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 <i>tolerance</i> 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.
------------------	---

6.32.2.25 unsubscribe() void GEOM_FADE25D::Zone2::unsubscribe (MsgType msgType, MsgBase * pMsg)

Parameters

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

6.32.2.26 writeObj() void GEOM_FADE25D::Zone2::writeObj (const char * outFilename) const

Parameters

<i>outFilename</i>	is the output filename
--------------------	------------------------

6.32.3 Friends And Related Function Documentation

6.32.3.1 peelOffIf [1/2] `Zone2* peelOffIf (Zone2 * pZone, bool bAvoidSplit, PeelPredicateTS * pPredicate) [friend]`

Parameters

<code>pZone</code>	is the input zone
<code>bAvoidSplit</code>	if true, then the algorithm removes a triangle only if it does not break the zone into independent components.
<code>pPredicate</code>	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!

6.32.3.2 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

<code>pZone</code>	
<code>pPredicate</code>	
<code>bVerbose</code>	

Returns

a new zone containing a subset of the triangles of `pZone` or NULL when no triangles remain.

6.32.3.3 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.

6.32.3.4 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.

6.32.3.5 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.

6.32.3.6 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_FADE25D::Bbox2](#)
Bbox2 is an axis aligned 2D bounding box.

Functions

- Bbox2 [GEOM_FADE25D::getBox](#) (`std::vector< Point2 * > &vP)`
Compute the bounding box.
- Bbox2 [GEOM_FADE25D::getBox](#) (`std::vector< Point2 > &vP)`
Compute the bounding box.
- `std::ostream & GEOM_FADE25D::operator<<` (`std::ostream &stream, const Bbox2 &pC)`
Print the box.

7.1.1 Function Documentation

7.1.1.1 getBox() [1/2] Bbox2 GEOM_FADE25D::getBox (std::vector< Point2 * > & vP)

Computes the bounding box of points

7.1.1.2 getBox() [2/2] Bbox2 GEOM_FADE25D::getBox (std::vector< Point2 > & vP)

Computes the bounding box of points

7.1.1.3 operator<<() std::ostream& GEOM_FADE25D::operator<< (std::ostream & stream, const Bbox2 & pC) [inline]

Prints the box coordinates to stream

7.2 CAF_Component.h File Reference

```
#include <map>
#include "common.h"
#include "Segment2.h"
```

Classes

- class [GEOM_FADE25D::CAF_Component](#)

CAF_Component stands for CUT AND FILL COMPONENT. It represents a connected area of the surface.

Enumerations

- enum [GEOM_FADE25D::CAFTYP](#) { [GEOM_FADE25D::CT_NULL](#) , [GEOM_FADE25D::CT_CUT](#) , [GEOM_FADE25D::CT_FILL](#) }

Functions

- std::ostream & [GEOM_FADE25D::operator<<](#) (std::ostream &stream, const CAF_Component &c)

7.2.1 Enumeration Type Documentation

7.2.1.1 CAFTYP enum [GEOM_FADE25D::CAFTYP](#)
enumerates the three possible Cut-And-Fill types

Enumerator

CT_NULL	the first surface corresponds to the second one
CT_CUT	the first surface is above the second one
CT_FILL	the first surface is below the second one

7.2.2 Function Documentation

7.2.2.1 operator<<() std::ostream& GEOM_FADE25D::operator<< (std::ostream & stream, const CAF_Component & c) [inline]

Report

7.3 Circle2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Circle2](#)

Circle for visualization.

7.4 CloudPrepare.h File Reference

```
#include "common.h"
#include "Point2.h"
```

Classes

- class [GEOM_FADE25D::CloudPrepare](#)

CloudPrepare simplifies overdense point clouds and helps to avoid memory-usage-peaks during data transfer.

Enumerations

- enum [GEOM_FADE25D::ConvexHullStrategy](#) { [GEOM_FADE25D::CHS_NOHULL](#), [GEOM_FADE25D::CHS_MAXHULL](#), [GEOM_FADE25D::CHS_MINHULL](#) }
ConvexHullStrategy for CloudPrepare.
- enum [GEOM_FADE25D::SumStrategy](#) { [GEOM_FADE25D::SMS_MINIMUM](#), [GEOM_FADE25D::SMS_MAXIMUM](#), [GEOM_FADE25D::SMS_MEDIAN](#), [GEOM_FADE25D::SMS_AVERAGE](#) }
SumStrategy for CloudPrepare.

7.4.1 Enumeration Type Documentation

7.4.1.1 ConvexHullStrategy enum [GEOM_FADE25D::ConvexHullStrategy](#)

Enumerator

CHS_NOHULL	No special treatment for convex hull points.
CHS_MAXHULL	Use all points from the convex hull.
CHS_MINHULL	Use only convex points of the convex hull (no collinear ones)

7.4.1.2 SumStrategy enum [GEOM_FADE25D::SumStrategy](#)

Enumerator

SMS_MINIMUM	Assign the minimum height.
SMS_MAXIMUM	Assign the maximum height.

Enumerator

SMS_MEDIAN	Assign the median height.
SMS_AVERAGE	Assign the average height.

7.5 Color.h File Reference

```
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Color](#)
Color for visualization.

Enumerations

- enum [GEOM_FADE25D::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_FADE25D::operator<<](#) (std::ostream &stream, const Color &c)

7.6 ConstraintGraph2.h File Reference

```
#include "Segment2.h"
#include "ConstraintSegment2.h"
#include "Edge2.h"
#include <map>
#include "common.h"
```

Classes

- class [GEOM_FADE25D::ConstraintGraph2](#)
ConstraintGraph2 is a set of Constraint Edges ([ConstraintSegment2](#))

7.7 ConstraintSegment2.h File Reference

```
#include <set>
#include "common.h"
```

Classes

- class [GEOM_FADE25D::ConstraintSegment2](#)
A [ConstraintSegment2](#) represents a Constraint Edge.

Enumerations

- enum `GEOM_FADE25D::ConstraintInsertionStrategy` {
 `GEOM_FADE25D::CIS_CONFORMING_DELAUNAY` =0 , `GEOM_FADE25D::CIS_CONSTRAINED_DELAUNAY` =1 , `GEOM_FADE25D::CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL` =2 , `GEOM_FADE25D::CIS_KEEP_DELAUNAY` =0 ,
 `GEOM_FADE25D::CIS_IGNORE_DELAUNAY` =1 }

Constraint Insertion Strategy determines how a constraint edge shall be inserted:

7.7.1 Enumeration Type Documentation

7.7.1.1 ConstraintInsertionStrategy enum `GEOM_FADE25D::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_25-D/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

<code>CIS_CONFORMING_DELAUNAY</code>	Deprecated.
<code>CIS_CONSTRAINED_DELAUNAY</code>	The recommended insertion strategy.
<code>CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL</code>	Deprecated.
<code>CIS_KEEP_DELAUNAY</code>	Deprecated name.
<code>CIS_IGNORE_DELAUNAY</code>	Deprecated.

7.8 CutAndFill.h File Reference

```
#include "common.h"
#include "MsgBase.h"
#include "CAF_Component.h"
```

Classes

- class `GEOM_FADE25D::CutAndFill`

CutAndFill computes the volume(s) between two overlapping surfaces.

7.9 Edge2.h File Reference

```
#include "common.h"
```

Classes

- class `GEOM_FADE25D::Edge2`

Edge2 is a directed edge.

- struct `GEOM_FADE25D::Func_gtEdge2D`
Functor to sort edges by 2d length (descending)
- struct `GEOM_FADE25D::Func_ltEdge2D`
Functor to sort edges by 2.5d length (ascending)
- struct `GEOM_FADE25D::Func_ltEdge2D`
Functor to sort edges by 2d length (ascending)

7.10 EfficientModel.h File Reference

```
#include "common.h"
#include "Point2.h"
```

Classes

- class `GEOM_FADE25D::EfficientModel`
EfficientModel (DEPRECATED in favor of the new CloudPrepare class)

Enumerations

- enum `SmoothingStrategy` { `SMST_MINIMUM` , `SMST_MAXIMUM` , `SMST_MEDIAN` , `SMST_AVERAGE` }

7.10.1 Enumeration Type Documentation

7.10.1.1 SmoothingStrategy enum `SmoothingStrategy`

Enumerator

<code>SMST_MINIMUM</code>	Assign the minimum height.
<code>SMST_MAXIMUM</code>	Assign the maximum height.
<code>SMST_MEDIAN</code>	Assign the median height.
<code>SMST_AVERAGE</code>	Assign the average height.

7.11 Fade_2D.h File Reference

```
#include "common.h"
#include "freeFunctions.h"
#include "Licensee.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 "FadeExport.h"
#include "Voronoi2.h"
#include "IsoContours.h"
#include "EfficientModel.h"
```

```
#include "CutAndFill.h"
#include "CloudPrepare.h"
```

Classes

- class [GEOM_FADE25D::Fade_2D](#)

Fade_2D is the Delaunay triangulation class.

Functions

- void [GEOM_FADE25D::copyFade](#) (Fade_2D &dt0, std::vector< Zone2 * > &vZones0, Fade_2D &dt1, std::vector< Zone2 * > &vZones1)
Copy a Fade_2D object and selected Zone2 objects.

7.11.1 Detailed Description

[Fade_2D.h](#) is the main API file of the Fade library

7.11.2 Function Documentation

```
7.11.2.1 copyFade() void GEOM_FADE25D::copyFade (
    Fade_2D & dt0,
    std::vector< Zone2 * > & vZones0,
    Fade_2D & dt1,
    std::vector< Zone2 * > & vZones1 ) [inline]
```

Parameters

in	<i>dt0</i>	is the source triangulation
out	<i>dt1</i>	is the target triangulation
in	<i>vZones0</i>	(possibly empty) contains the source zones
out	<i>vZones1</i>	returns the target zones in the same order

7.12 FadeExport.h File Reference

```
#include <vector>
#include <algorithm>
#include "common.h"
```

Classes

- struct [GEOM_FADE25D::FadeExport](#)

FadeExport is a simple struct to export triangulation data.

7.13 freeFunctions.h File Reference

```
#include "Point2.h"
#include "Segment2.h"
#include "Edge2.h"
#include <vector>
```

Functions

- void **GEOM_FADE25D::edgesToPolygons** (const std::vector< Edge2 > &vEdgesIn, std::vector< std::vector< Edge2 > > &vvPolygonsOut, std::vector< Edge2 > &vRemainingOut)

Create polygons from a set of edges.
- bool **GEOM_FADE25D::fillHole** (const 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)
- bool **GEOM_FADE25D::fillHole** (Mesh3 *pMesh, const std::vector< Edge2 > &vPolygonEdges, bool bWithRefine, bool bVerbose, std::vector< Point2 > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- bool **GEOM_FADE25D::fillHole** (std::vector< Point2 > &vMeshCorners, const std::vector< Segment2 > &vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< Point2 > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- double **GEOM_FADE25D::getArea25D** (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get 2.5D area of a triangle.
- double **GEOM_FADE25D::getArea2D** (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get 2D area of a triangle.
- void **GEOM_FADE25D::getBorders** (const std::vector< Triangle2 * > &vT, std::vector< Segment2 > &vBorderSegmentsOut)

Get Borders.
- void **GEOM_FADE25D::getConnectedComponents** (const std::vector< Triangle2 * > &vT, std::vector< std::vector< Triangle2 * > > &vvT)

Get connected components.
- void **GEOM_FADE25D::getDirectedEdges** (const std::vector< Triangle2 * > &vT, std::vector< Edge2 > &vDirectedEdgesOut)

Get directed edges The directed edges of vT are returned in 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_FADE25D::getFade2DVersion** ()

Get the Fade2D version string.
- int **GEOM_FADE25D::getGlobalNumCPU** ()

Get the global number of threads to be used.
- int **GEOM_FADE25D::getMajorVersionNumber** ()

Get the major version number.
- int **GEOM_FADE25D::getMinorVersionNumber** ()

Get the minor version number.
- Vector2 **GEOM_FADE25D::getNormalVector** (const Point2 &p0, const Point2 &p1, const Point2 &p2, bool &bOK)

Get normal vector.
- Orientation2 **GEOM_FADE25D::getOrientation2** (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get the orientation of three points.
- Orientation2 **GEOM_FADE25D::getOrientation2_mt** (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get Orientation2 (MT)
- int **GEOM_FADE25D::getRevisionNumber** ()

Get the revision version number.
- void **GEOM_FADE25D::getSortedBoundaryPolygons** (std::vector< Triangle2 * > &vConnectedComponent, std::vector< Edge2 > &vOutsidePolygon, std::vector< std::vector< Edge2 > > &vHolePolygons)

Get sorted boundary polygons.
- void **GEOM_FADE25D::getUndirectedEdges** (const std::vector< Triangle2 * > &vT, std::vector< Edge2 > &vUndirectedEdgesOut)

Get undirected edges.
- bool **GEOM_FADE25D::isRelease** ()

Check if a RELEASE or a DEBUG version is used.

- bool **GEOM_FADE25D::isSimplePolygon** (std::vector< Segment2 > &vSegments)
isSimplePolygon
- void **GEOM_FADE25D::offsetPolygonPoints** (double offset, const std::vector< Point2 > &vOrgPoints, std::vector< Point2 > &vOffsetPoints, double maxCorrectionFactor=1.0)
Create an offset polygon.
- void **GEOM_FADE25D::pointsToPolyline** (std::vector< Point2 > &vInPoints, bool bClose, std::vector< Segment2 > &vOutSegments)
Points-to-Polyline.
- bool **GEOM_FADE25D::readPointsBIN** (const char *filename, std::vector< Point2 > &vPointsIn, bool bWithHeader=true)
Read points from a binary file.
- bool **GEOM_FADE25D::readSegmentsBIN** (const char *filename, std::vector< Segment2 > &vSegmentsOut)
Read segments from a binary file.
- bool **GEOM_FADE25D::readXY** (const char *filename, std::vector< Point2 > &vPointsOut)
Read (x y) points.
- bool **GEOM_FADE25D::readXYZ** (const char *filename, std::vector< Point2 > &vPointsOut)
Read (x y z) points.
- int **GEOM_FADE25D::setGlobalNumCPU** (int numCPU)
Set the global number of threads to be used.
- bool **GEOM_FADE25D::sortRing** (std::vector< Segment2 > &vRing)
Sort a vector of Segments.
- bool **GEOM_FADE25D::sortRingCCW** (std::vector< Segment2 > &vRing)
Sort a vector of Segments.
- bool **GEOM_FADE25D::writePointsASCII** (const char *filename, const std::vector< Point2 * > &vPointsIn)
Write points to an ASCII file.
- bool **GEOM_FADE25D::writePointsASCII** (const char *filename, const std::vector< Point2 > &vPointsIn)
Write points to an ASCII file.
- bool **GEOM_FADE25D::writePointsBIN** (const char *filename, std::vector< Point2 * > &vPointsIn)
Write points to a binary file.
- bool **GEOM_FADE25D::writePointsBIN** (const char *filename, std::vector< Point2 > &vPointsIn)
Write points to a binary file.
- bool **GEOM_FADE25D::writeSegmentsBIN** (const char *filename, std::vector< Segment2 > &vSegmentsIn)
Write segments to a binary file.

7.13.1 Function Documentation

7.13.1.1 **getGlobalNumCPU()** int GEOM_FADE25D::getGlobalNumCPU ()

Note

Fade is by default *single-threaded* to avoid nested multithreading when Fade runs in multiple threads of your application but you can change the number of threads using [setGlobalNumCPU\(\)](#)

7.13.1.2 **getSortedBoundaryPolygons()** void GEOM_FADE25D::getSortedBoundaryPolygons (

```
std::vector< Triangle2 * > & vConnectedComponent,
std::vector< Edge2 > & vOutsidePolygon,
std::vector< std::vector< Edge2 > > & vHolePolygons )
```

This function takes ONE connected component of triangles. It returns the outer polygon as well as the inner hole polygons if any.

Parameters

in	<i>vConnectedComponent</i>	is a connected component of triangles where the term "connected" means adjacency on edges. It is important that just one connected component is passed!
out	<i>vOutsidePolygon</i>	is the outside boundary of the connected component.
out	<i>vHolePolygons</i>	contains the hole polygons (if any)

Edges in output polygons are sorted and CCW-oriented with respect to their triangle. Thus the outer polygon is always CCW oriented and holes are always CW oriented. This is sometimes a useful property.

Attention

Pass only one connected component.

7.13.1.3 `offsetPolygonPoints()`

```
void GEOM_FADE25D::offsetPolygonPoints (
    double offset,
    const std::vector< Point2 > & vOrgPoints,
    std::vector< Point2 > & vOffsetPoints,
    double maxCorrectionFactor = 1.0 )
```

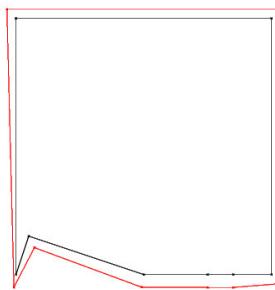


Figure 33 Offset polygon without angle correction

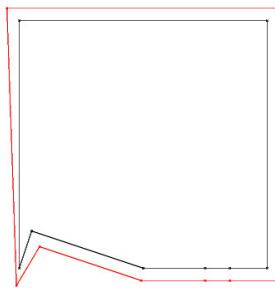


Figure 34 Offset polygon with angle correction factor 1.414 (down to 90 degrees)

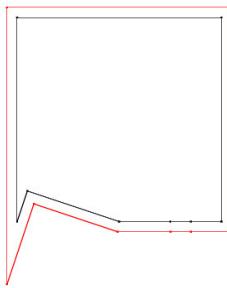


Figure 35 Offset polygon with angle correction factor 6.25 (for angles as low as 18.4 degrees)

Parameters

	<i>offset</i>	specifies the offset distance (positive or negative)
in	<i>vOrgPoints</i>	are ordered points of a <i>counterclockwise</i> polygon (no point repeated)
out	<i>vOffsetPoints</i>	returns points moved outside/inside by a positive/negative offset distance (times the angle correction factor)
in	<i>maxCorrectionFactor</i>	is the maximum angle correction factor that may be applied to the <i>offset</i> value. Its default value is 1.0 (no angle correction), lower values are ignored. The angle that can be corrected with a certain <i>maxCorrectionFactor</i> is computed according to $2 * \text{asin}(1.0/\text{maxCorrectionFactor})$. This means, a <i>maxCorrectionFactor</i> =1.4143 can account for angles down to 90 degrees while 2.6132 is required to correct angles as low as 45 degrees.

Warning

An offset polygon can selfintersect!

7.13.1.4 `setGlobalNumCPU()` `int GEOM_FADE25D::setGlobalNumCPU (int numCPU)`

Parameters

<i>numCPU</i>	is the number of CPU cores to be used and is 0 (means autodetect) or greater.
---------------	---

Returns

the number of CPU cores that will be used

Note

Fade is by default *single-threaded* to avoid nested multithreading when Fade runs in multiple threads of your application.

Characteristics:

- For technical reasons you should insert points into a triangulation before you insert constraint segments. Then 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.

7.14 IsoContours.h File Reference

```
#include "Segment2.h"
#include <map>
#include "common.h"
```

Classes

- class [GEOM_FADE25D::IsoContours](#)

IsoContours uses a fast datastructure to compute intersections of horizontal planes with a given list of triangles.

7.15 Label.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Label](#)

Label is a Text-Label for Visualization.

7.16 MeshGenParams.h File Reference

```
#include "common.h"
#include "Vector2.h"
```

Classes

- class [GEOM_FADE25D::MeshGenParams](#)

Parameters for the mesh generator.

Functions

- template<typename T >
void [GEOM_FADE25D::unusedParameter](#) (const T &)

Unused parameter.

7.16.1 Function Documentation

7.16.1.1 [unusedParameter\(\)](#) template<typename T >

```
void GEOM_FADE25D::unusedParameter (
    const T & ) [inline]
```

Empty template to avoid compiler warnings about unused function parameters

7.17 MsgBase.h File Reference

```
#include "common.h"
```

Classes

- class [GEOM_FADE25D::MsgBase](#)

MsgBase, a base class for message subscriber classes.

Enumerations

- enum **MsgType** { **MSG_PROGRESS** , **MSG_WARNING** }

7.18 Performance.h File Reference

```
#include "common.h"
```

Functions

- double [GEOM_FADE25D::timer](#) (const char *cstr)

Timer.

7.18.1 Function Documentation

7.18.1.1 timer() double GEOM_FADE25D::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.

7.19 Point2.h File Reference

```
#include "common.h"
#include "Vector2.h"
```

Classes

- struct [GEOM_FADE25D::Func_ItPointXYZ](#)
Functor to sort points lexicographically.
- class [GEOM_FADE25D::Point2](#)
Point.

Functions

- Point2 [GEOM_FADE25D::center](#) (const Point2 &p0, const Point2 &p1)
Compute the midpoint of p0 and p1.
- Point2 [GEOM_FADE25D::centerWithShift](#) (const Point2 &p0, const Point2 &p1)
Compute the midpoint of p0 and p1 and adapt it.
- std::ostream & [GEOM_FADE25D::operator<<](#) (std::ostream &stream, const Point2 &pnt)
Print to stream.
- std::istream & [GEOM_FADE25D::operator>>](#) (std::istream &stream, Point2 &pnt)
Stream-to-Point.
- double [GEOM_FADE25D::sqDistance25D](#) (const double x0, const double y0, const double z0, const Point2 &p1)
Get the squared distance between two points in 2D.
- double [GEOM_FADE25D::sqDistance25D](#) (const Point2 &p0, const Point2 &p1)
Get the squared distance between two points.
- double [GEOM_FADE25D::sqDistance2D](#) (const double x0, const double y0, const Point2 &p1)
Get the squared distance between two points in 2D.
- double [GEOM_FADE25D::sqDistance2D](#) (const Point2 &p0, const Point2 &p1)
Get the squared distance between two points in 2D.

7.19.1 Function Documentation

7.19.1.1 center() Point2 GEOM_FADE25D::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.

```
7.19.1.2 centerWithShift() Point2 GEOM_FADE25D::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.

```
7.19.1.3 sqDistance25D() [1/2] double GEOM_FADE25D::sqDistance25D (
    const double x0,
    const double y0,
    const double z0,
    const Point2 & p1 ) [inline]
```

Note

In contrast to [sqDistance2D](#) this method uses also the z-coordinate of the points

```
7.19.1.4 sqDistance25D() [2/2] double GEOM_FADE25D::sqDistance25D (
    const Point2 & p0,
    const Point2 & p1 ) [inline]
```

Note

In contrast to [sqDistance2D](#) this method uses also the z-coordinate of the points

```
7.19.1.5 sqDistance2D() [1/2] double GEOM_FADE25D::sqDistance2D (
    const double x0,
    const double y0,
    const Point2 & p1 ) [inline]
```

Note

This method does not use the z-coordinate

```
7.19.1.6 sqDistance2D() [2/2] double GEOM_FADE25D::sqDistance2D (
    const Point2 & p0,
    const Point2 & p1 ) [inline]
```

Note

This method does not use the z-coordinate

7.20 Segment2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Segment2](#)
Segment.

7.21 SegmentChecker.h File Reference

```
#include <map>
#include "common.h"
#include "License.h"
#include "Segment2.h"
#include "MsgBase.h"
#include "Bbox2.h"
```

Classes

- class [GEOM_FADE25D::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 }

7.21.1 Enumeration Type Documentation

7.21.1.1 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

7.21.1.2 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 different from the endpoints
SIT_ENDPOINT	The two segments share a common endpoint which is the only intersection

7.22 testDataGenerators.h File Reference

```
#include "Point2.h"
#include "Segment2.h"
#include <vector>
```

Functions

- void [GEOM_FADE25D::generateCircle](#) (int numPoints, double x, double y, double z, double radiusX, double radiusY, std::vector< Point2 > &vCirclePointsOut)

Generate a circle.
- void [GEOM_FADE25D::generateRandomNumbers](#) (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)

Generate random numbers.
- void [GEOM_FADE25D::generateRandomPoints](#) (size_t numRandomPoints, double min, double max, std::vector< Point2 > &vRandomPointsOut, unsigned int seed=0)

Generate random points.
- void [GEOM_FADE25D::generateRandomPoints3D](#) (size_t numRandomPoints, double min, double max, std::vector< Point2 > &vRandomPointsOut, unsigned int seed=0)

Generate random points with height.
- void [GEOM_FADE25D::generateRandomPolygon](#) (size_t numSegments, double min, double max, std::vector< Segment2 > &vPolygonOut, unsigned int seed=0)

Generate a random simple polygon.
- void [GEOM_FADE25D::generateRandomSegments](#) (size_t numSegments, double min, double max, double maxLen, std::vector< Segment2 > &vSegmentsOut, unsigned int seed)

Generate random line segments.
- void [GEOM_FADE25D::generateRandomSurfacePoints](#) (size_t numX, size_t numY, size_t numCenters, double xmin, double ymin, double zmin, double xmax, double ymax, double zmax, std::vector< Point2 > &vSurfacePointsOut, unsigned int seed)

Generate a random surface.
- void [GEOM_FADE25D::generateSineSegments](#) (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< Segment2 > &vSineSegmentsOut)

Generate segments from a sine function.
- void [GEOM_FADE25D::shear](#) (std::vector< Point2 > &vPointsInOut, double shearX, double shearY)

7.23 Triangle2.h File Reference

```
#include "Point2.h"
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Triangle2](#)

Triangle.

Enumerations

- enum [GEOM_FADE25D::CircumcenterQuality](#) { [GEOM_FADE25D::CCQ_INIT](#) , [GEOM_FADE25D::CCQ_INEXACT](#) , [GEOM_FADE25D::CCQ_EXACT](#) , [GEOM_FADE25D::CCQ_OUT_OF_BOUNDS](#) }

CircumcenterQuality.

7.23.1 Enumeration Type Documentation

7.23.1.1 CircumcenterQuality enum `GEOM_FADE25D::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.

7.24 TriangleAroundVertexIterator.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Triangle2.h"
```

Classes

- class [GEOM_FADE25D::TriangleAroundVertexIterator](#)
Iterator for all triangles around a given vertex.

7.25 UserPredicates.h File Reference

```
#include "common.h"
#include "Triangle2.h"
```

Classes

- class [GEOM_FADE25D::PeelPredicateTS](#)
User-defined peel predicate.
- class [GEOM_FADE25D::UserPredicateT](#)
User-defined predicate (deprecated)

7.26 Vector2.h File Reference

```
#include "common.h"
```

Classes

- class [GEOM_FADE25D::Vector2](#)
Vector.

Functions

- Vector2 [GEOM_FADE25D::crossProduct](#) (const Vector2 &vec0, const Vector2 &vec1)
Cross product.
- Vector2 [GEOM_FADE25D::normalize](#) (const Vector2 &other)
Normalize a vector.
- Vector2 [GEOM_FADE25D::operator*](#) (double d, const Vector2 &vec)
Multiplication with a scalar.
- Vector2 [GEOM_FADE25D::operator+](#) (const Vector2 &vec0, const Vector2 &vec1)
Addition.
- Vector2 [GEOM_FADE25D::operator-](#) (const Vector2 &in)

- Opposite vector.*
- Vector2 `GEOM_FADE25D::operator-` (const Vector2 &vec0, const Vector2 &vec1)
- Subtraction.*
- std::ostream & `GEOM_FADE25D::operator<<` (std::ostream &stream, const Vector2 &vec)
- Print to stream.*

7.26.1 Function Documentation

7.26.1.1 `crossProduct()` Vector2 `GEOM_FADE25D::crossProduct` (

```
    const Vector2 & vec0,
    const Vector2 & vec1 ) [inline]
```

Cross product of two vectors

7.26.1.2 `operator*()` Vector2 `GEOM_FADE25D::operator*` (

```
    double d,
    const Vector2 & vec ) [inline]
```

Multiplication with a scalar

7.26.1.3 `operator+()` Vector2 `GEOM_FADE25D::operator+` (

```
    const Vector2 & vec0,
    const Vector2 & vec1 ) [inline]
```

Addition

7.26.1.4 `operator-() [1/2]` Vector2 `GEOM_FADE25D::operator-` (

```
    const Vector2 & in ) [inline]
```

Returns

a vector that points in the opposite direction

7.26.1.5 `operator-() [2/2]` Vector2 `GEOM_FADE25D::operator-` (

```
    const Vector2 & vec0,
    const Vector2 & vec1 ) [inline]
```

Subtraction

7.26.1.6 `operator<<()` std::ostream& `GEOM_FADE25D::operator<<` (

```
    std::ostream & stream,
    const Vector2 & vec ) [inline]
```

Print to stream

7.27 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_FADE25D::Visualizer2](#)

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

7.28 Visualizer3.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Segment2.h"
#include "VertexPair2.h"
#include "Edge2.h"
```

Classes

- class [GEOM_FADE25D::Visualizer3](#)

Visualizer3 is a 3D scene writer for the Geomview viewer.

7.29 Zone2.h File Reference

```
#include "common.h"
#include "freeFunctions.h"
#include "FadeExport.h"
#include "Bbox2.h"
#include "Edge2.h"
#include "Segment2.h"
#include "UserPredicates.h"
#include "MsgBase.h"
```

Classes

- struct [GEOM_FADE25D::CompPolygon](#)

Connected component with boundary- and hole polygons.

- class [GEOM_FADE25D::Zone2](#)

Zone2 is a certain defined area of a triangulation.

Enumerations

- enum [GEOM_FADE25D::OptimizationMode](#) { [GEOM_FADE25D::OPTMODE_STANDARD](#) , [GEOM_FADE25D::OPTMODE_BEST](#) }

Functions

- [Zone2 * GEOM_FADE25D::zoneDifference](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the difference of two zones.
- [Zone2 * GEOM_FADE25D::zoneIntersection](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the intersection of two zones.
- [Zone2 * GEOM_FADE25D::zoneSymmetricDifference](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the symmetric difference of two zones.
- [Zone2 * GEOM_FADE25D::zoneUnion](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the union of two zones.

7.29.1 Enumeration Type Documentation

7.29.1.1 OptimizationMode enum GEOM_FADE25D::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.

7.29.2 Function Documentation

7.29.2.1 zoneDifference() Zone2* GEOM_FADE25D::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.

7.29.2.2 zoneIntersection() Zone2* GEOM_FADE25D::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.

7.29.2.3 zoneSymmetricDifference() Zone2* GEOM_FADE25D::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.

7.29.2.4 zoneUnion() Zone2* GEOM_FADE25D::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.

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