

Fade2.5D

v1.82

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1 Main Page

1.1 C++ Constrained Delaunay Triangulation Fade2.5D

- Very fast multithreaded Delaunay triangulation library ([benchmark](#))
- Well documented and with easy to use `example source codes`
- 2D Delaunay with `Polygon support` and Constraint Edges
- 2.5D Delaunay for Surfaces and Digital Elevation Models
- Earthwork Volume Computations: `Cut And Fill`
- `Segment Intersection Test Software`
- `Grid Mesher and Delaunay Mesh Generator`
- Supports Windows, MacOS, Linux on PC and Raspberry PI
- Student license. Evaluation license. Commercial licenses and support available
- Fade is actively developed and maintained. If you miss a feature please get in [contact](#)

1.1.1 Getting started with Delaunay triangulations:

Download. Unzip. Start to play with the included example source codes. It works without installation. [The first example is described here.](#)

Fade comes as two separate libraries, Fade2D and Fade2.5D. Fade2.5D can do everything that Fade2D can do. But Fade2.5D offers a z-coordinate and additional functionality for Digital Elevation Models (DEM) and surfaces. A collection of 2D and 2.5D example source codes is contained in the download. The examples go step by step over the concepts of Fade. New Fade2.5D users are advised to start with the 2D examples because the basics are described there and these apply also to Fade2.5D.

1.1.2 For Windows users:

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 Fade with your own software you can use the settings from the example solutions or use the table below:

Visual Studio	IDE version	Platform Toolset
VS2010	version 10	toolset v100 or Windows7.1SDK
VS2012	version 11	toolset v110
VS2013	version 12	toolset v120
VS2015	version 14	toolset v140
VS2017	version 15	toolset v141
VS2019	version 16	toolset v142

1.1.3 For Linux and Apple users:

1. Edit the Makefile (choose Apple, your Linux distro or Raspberry PI) and type make to compile the example source code.
2. Make sure GMP is installed:
\$ sudo apt-get install libgmp10 (works on Ubuntu/Debian/Mint/Raspbian, on other systems search for libgmp or gmp)

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

1.1.4 Directory Contents

- **include_fade2d** and **include_fade25d**
Header files of the two libraries.
- **Win32** and **x64**
This directory contains the DLL's for Windows 32-bit and 64-bit and it is the target directory for the executables of example code compiled with Visual Studio.
- **lib_\${DISTRO}_\${ARCHITECTURE}**
The shared libs (*.so) for Linux/Apple developers.
- **examples_2D**
Example source code and Visual Studio projects using Fade2D
- **examples_25D**
Example source code and Visual Studio projects using Fade2.5D
- **doc**
PDF Documentation

1.1.5 Troubleshooting

- Mixing multiple Visual Studio versions won't work. Use the right dll.
- Compare your settings with the ones from the example projects.
- In rare cases you might need to increase Properties->ConfigurationProperties->Linker->System->Stack←ReserveSize in your Visual Studio project settings.
- If your problem persists, don't hesitate to [send](#) a minimal example that reproduces it and it will be fixed asap.

1.1.6 Release notes / History

Version 1.82, Nov. 15th, 2020:

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

Version 1.81, 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.

Version 1.80, 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

Version 1.79, January 20th, 2020:

Internal version. Revision.

Version 1.78, November 15th, 2019:

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

Version 1.77, 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.

Version 1.75 and 1.76

- Non-public test versions.

Version 1.74, 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 Fade 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 Fade 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.

Version 1.73, January 14th, 2019:

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

Version 1.71 and 1.72, October 24th, 2018:

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

Version 1.70, October 17th, 2018:

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

Version 1.69, October 15th, 2018:

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

Version 1.68, September 14th, 2018:

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

Version 1.67, September 4th, 2018:

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

Version 1.66, August 25th, 2018:

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

Version 1.65, July 29th, 2018:

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

Version 1.64, 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.

Version 1.63, 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.

Version 1.62, June 3rd, 2018:

3D Point Cloud Reconstruction considerably improved. Unofficial demo.

Version 1.61, May 1st, 2018:

3D Point Cloud Reconstruction: Unofficial demo.

Version 1.60, February 26th, 2018:

Accurate computation of glancing segment intersections. Additional parameter for Advanced Meshing: bool `b←KeepExistingSteinerPoints=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.

Version 1.59, January 14th, 2018:

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

Version 1.58, October 23th, 2017:

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

Version 1.57, October 9th, 2017:

Nonpublic test version.

Version 1.56, September 24th, 2017:

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

Version 1.55, August 12th, 2017:

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

Version 1.54beta, August 8th, 2017:

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

Version 1.53, July 15th, 2017:

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

Version 1.53 beta, June 2nd, 2017:

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

Version 1.51 beta, May 27th, 2017:

Non-public test version

Version 1.50, April 5th, 2017:

After three internal test versions (that concentrated on refactoring and rare bugs) this is again a stable public release version: 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 versions: 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.

Version 1.49, March 2nd, 2017:

Constraint insertion subsystem improved. Mesh generator revised.

Version 1.48, February 15th, 2017:

Corrections of yesterday's v1.47 version.

Version 1.47, 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.

Version 1.46a, January 14th, 2017:

+++ Raspberry PI is supported now +++ // Appart from RPI support version 1.46a is equal to v1.46. Raspberry PI users: Please give feedback, do you have everything you need for RPI development now?

Version 1.46, 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.

Version 1.43, 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.

Version 1.42, 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.

Version 1.41, July 24th, 2016:

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

Version 1.40 beta, June 14th, 2016:

Non public intermediate test version. 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=Z \leftarrow L_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.

Version 1.39, May 31st, 2016:

Non public intermediate test version.

Version 1.37, March 15th, 2016:

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

Version 1.37, 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 where the barycenter of a triangle for which the algorithm determines if it must be refined. The change is that x and y have been replaced by the triangle itself to give client code even more control (x and y can still be computed from the triangle).

Version 1.36, 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.

Version 1.34, February 14th, 2016:

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

Version 1.33 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 version 1.33.14: 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 version 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 version it is recommended that you remove any previous Fade DLL's to avoid unintended linking to an old version.

Version 1.31 and 1.32, December 1st, 2015:

Non public intermediate release, improves the CDT.

Version 1.30, November 18th, 2015:

Non public intermediate release, improves the refineExtended method.

Version 1.29, 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.

Version 1.28, 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.

Version 1.27, October 5th, 2015:

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

Version 1.26, September 8th, 2015:

New functions of the last unofficial version 1.25 have been revised. Constraint segments may intersect now.

Version 1.25, August 18th, 2015:

Intermediate pre-release with new features: importTriangles() imports arbitrary triangles into a triangulation, cut←Triangles() 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.

Version 1.24, July 22nd, 2015:

Public release of version 1.23'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.

Version 1.23, July 9th, 2015:

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

Version 1.22, 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.

Version 1.21, May 17th, 2015:

Unofficial intermediate release. Testing new features.

Version 1.20, 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 have been reengineered and are included in the present documentation pages.

Version 1.19, October 26th, 2014:

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

Version 1.18.3, June 9th, 2014:

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

Version 1.16.1, 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.

Version 1.16, February 3rd, 2014:

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

Version 1.14, November 2013 and version 1.15, December 2013:

Non-public intermediate releases (test versions with experimental features).

Version 1.13, 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.

Version 1.12, June 30th, 2013:

Starting with version 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 version: 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.

Version 1.11, June 14th, 2013:

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

Version 1.10, March 30th, 2013:

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

Version 1.03, Nov. 4th, 2012:

A critical bug has been fixed, please switch to the current version. 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 version 1.03.

Version 1.02, 9/2012:

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

Version 1.01, 9/2012:

This is a stable public release. Since version 0.9 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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5 Module Documentation

5.1 Tools

Functions

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

Points-to-Polyline.
- bool **GEOM_FADE25D::isSimplePolygon** (std::vector< **Segment2** > &vSegments)

isSimplePolygon
- **Vector2 GEOM_FADE25D::getNormalVector** (const **Point2** &p0, const **Point2** &p1, const **Point2** &p2, bool &bOK)

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

Get directed edge The directed edges of vT are returned vDirectedEdgesOut. Directed means that each edge (a,b) with two adjacent triangles in vT is returned twice, as edge(a,b) and edge(b,a).
- void **GEOM_FADE25D::getUndirectedEdges** (std::vector< **Triangle2** *> &vT, std::vector< **Edge2** > &vUndirectedEdgesOut)

Get undirected edges.
- bool **GEOM_FADE25D::fillHole** (std::vector< std::pair< **Segment2**, **Vector2** > > &vPolygonSegments, bool bWithRefine, bool bVerbose, std::vector< **Point2** > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- bool **GEOM_FADE25D::fillHole** (std::vector< **Point2** > &vMeshCorners, std::vector< **Segment2** > &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, std::vector< **Edge2** > &vPolygonEdges, bool bWithRefine, bool bVerbose, std::vector< **Point2** > &vCornersOut)

Fill a hole in a 3D mesh with triangles (deprecated)
- void **GEOM_FADE25D::edgesToPolygons** (std::vector< **Edge2** > &vEdgesIn, std::vector< std::vector< **Edge2** > > &vvPolygonsOut, std::vector< **Edge2** > &vRemainingOut)

Create polygons from a set of edges.
- void **GEOM_FADE25D::getBorders** (const std::vector< **Triangle2** *> &vT, std::vector< **Segment2** > &vBorderSegmentsOut)

Get Borders.
- 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.

- FUNC_DECLSPEC Orientation2 GEOM_FADE25D::getOrientation2 (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get the orientation of three points.

- FUNC_DECLSPEC Orientation2 GEOM_FADE25D::getOrientation2_mt (const Point2 *p0, const Point2 *p1, const Point2 *p2)

Get Orientation2 (MT)

5.1.1 Detailed Description

5.1.2 Function Documentation

5.1.2.1 edgesToPolygons()

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

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

Parameters

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

The present function adds one vector<Edge2> to vvPolygonsOut for each polygon found in vEdgesIn. Each such polygon starts with the leftmost vertex (and when two or more vertices share the smallest x-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.

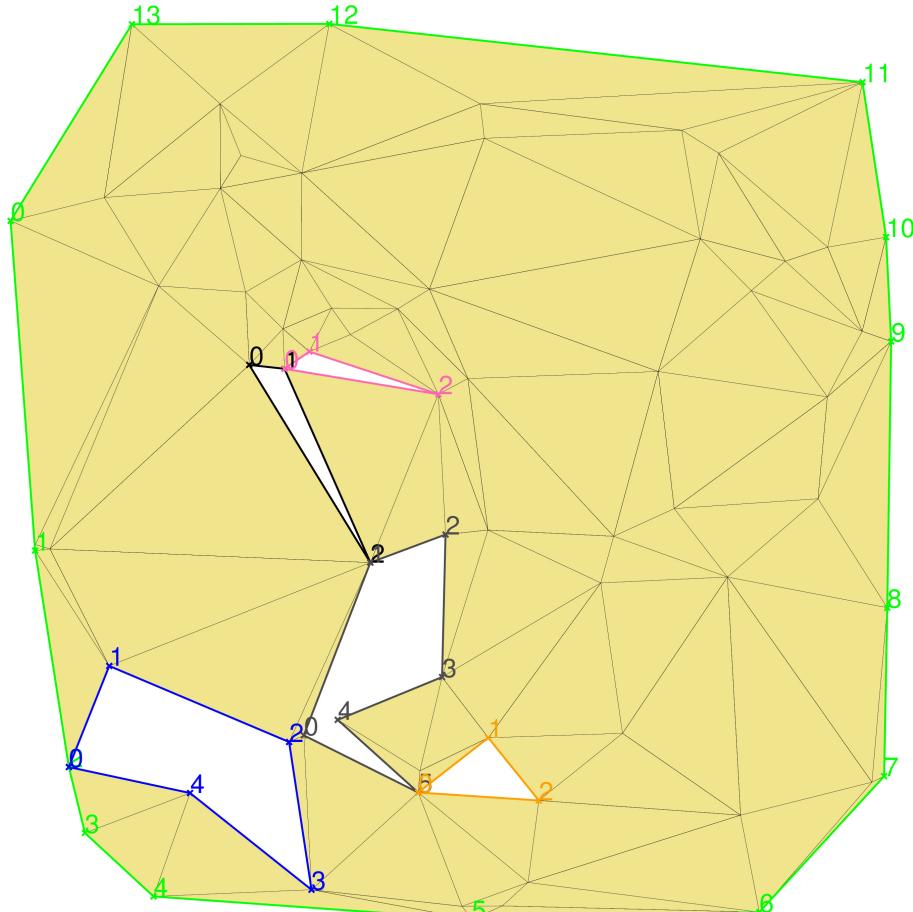


Figure 1 Polygons created by `edgesToPolygons`

5.1.2.2 `fillHole()` [1/3]

```
bool GEOM_FADE25D::fillHole (
    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.

5.1.2.3 *fillHole()* [2/3]

```
bool GEOM_FADE25D::fillHole (
    std::vector< Point2 > & vMeshCorners,
    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 (<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.

5.1.2.4 *fillHole()* [3/3]

```
bool GEOM_FADE25D::fillHole (
    Mesh3 * pMesh,
    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.

5.1.2.5 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	<i>vT</i>	are the input triangles
out	<i>vBorderSegmentsOut</i>	is used to return all border segments

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

5.1.2.7 getOrientation2()

```
FUNC_DECLSPEC 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

5.1.2.8 getOrientation2_mt()

```
FUNC_DECLSPEC 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.

5.1.2.9 getUndirectedEdges()

```
void GEOM_FADE25D::getUndirectedEdges (
    std::vector< Triangle2 *> & vT,
    std::vector< Edge2 > & vUndirectedEdgesOut )
```

A unique set of edges of vT is returned.

5.1.2.10 isSimplePolygon()

```
bool GEOM_FADE25D::isSimplePolygon (
    std::vector< Segment2 > & vSegments )
```

Parameters

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

Returns

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

5.1.2.11 pointsToPolyline()

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

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

Parameters

in	<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

5.1.2.12 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.

5.1.2.13 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

- std::string [GEOM_FADE25D::getFade2DVersion \(\)](#)
Get the Fade2D version string.
- FUNC_DECLSPEC int [GEOM_FADE25D::getMajorVersionNumber \(\)](#)
Get the major version number.
- FUNC_DECLSPEC int [GEOM_FADE25D::getMinorVersionNumber \(\)](#)
Get the minor version number.
- FUNC_DECLSPEC int [GEOM_FADE25D::getRevisionNumber \(\)](#)
Get the revision version number.
- FUNC_DECLSPEC 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

- FUNC_DECLSPEC 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.
- FUNC_DECLSPEC bool [GEOM_FADE25D::readXY](#) (const char *filename, std::vector< [Point2](#) > &vPointsOut)
Read (x y) points.
- FUNC_DECLSPEC bool [GEOM_FADE25D::readXYZ](#) (const char *filename, std::vector< [Point2](#) > &vPointsOut)
Read (x y z) points.
- 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::readPointsBIN](#) (const char *filename, std::vector< [Point2](#) > &vPointsIn)
Read points from a binary file.
- bool [GEOM_FADE25D::writeSegmentsBIN](#) (const char *filename, std::vector< [Segment2](#) > &vSegmentsIn)
Write segments to a binary file.
- bool [GEOM_FADE25D::readSegmentsBIN](#) (const char *filename, std::vector< [Segment2](#) > &vSegmentsOut)
Read segments from 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 )
```

Reads points from a binary file.

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()`

```
FUNC_DECLSPEC 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()`

```
FUNC_DECLSPEC 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]

```
FUNC_DECLSPEC 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 )
```

Writes 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 )
```

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.

5.3.2.8 writePointsBIN() [2/2]

```
bool GEOM_FADE25D::writePointsBIN (
    const char * filename,
    std::vector< Point2 *> & vPointsIn )
```

Writes points to a binary file

See also

[readPointsBIN\(\)](#)

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

- FUNC_DECLSPEC void `GEOM_FADE25D::generateRandomNumbers` (size_t num, double min, double max, std::vector<double> &vRandomNumbersOut, unsigned int seed=0)
Generate random numbers.
- FUNC_DECLSPEC void `GEOM_FADE25D::generateRandomPoints` (size_t numRandomPoints, double min, double max, std::vector<`Point2`> &vRandomPointsOut, unsigned int seed=0)
Generate random points.
- FUNC_DECLSPEC void `GEOM_FADE25D::generateRandomPoints3D` (size_t numRandomPoints, double min, double max, std::vector<`Point2`> &vRandomPointsOut, unsigned int seed=0)
Generate random points with height.
- FUNC_DECLSPEC void `GEOM_FADE25D::generateRandomPolygon` (size_t numSegments, double min, double max, std::vector<`Segment2`> &vPolygonOut, unsigned int seed=0)
Generate a random simple polygon.
- FUNC_DECLSPEC void `GEOM_FADE25D::generateRandomSegments` (size_t numSegments, double min, double max, double maxLen, std::vector<`Segment2`> &vSegmentsOut, unsigned int seed)
Generate random line segments.
- FUNC_DECLSPEC void `GEOM_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.
- FUNC_DECLSPEC void `GEOM_FADE25D::generateCircle` (int numPoints, double x, double y, double z, double radiusX, double radiusY, std::vector<`Point2`> &vCirclePointsOut)
Generate a circle.
- FUNC_DECLSPEC 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.
- FUNC_DECLSPEC void `GEOM_FADE25D::shear` (std::vector<`Point2`> &vPointsInOut, double shearX, double shearY)

5.4.1 Detailed Description

Generate random polygons and other test objects

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

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

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

5.4.2 Function Documentation

5.4.2.1 generateCircle()

```
FUNC_DECLSPEC 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

5.4.2.2 generateRandomNumbers()

```
FUNC_DECLSPEC 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.

5.4.2.3 generateRandomPoints()

```
FUNC_DECLSPEC 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)
<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)

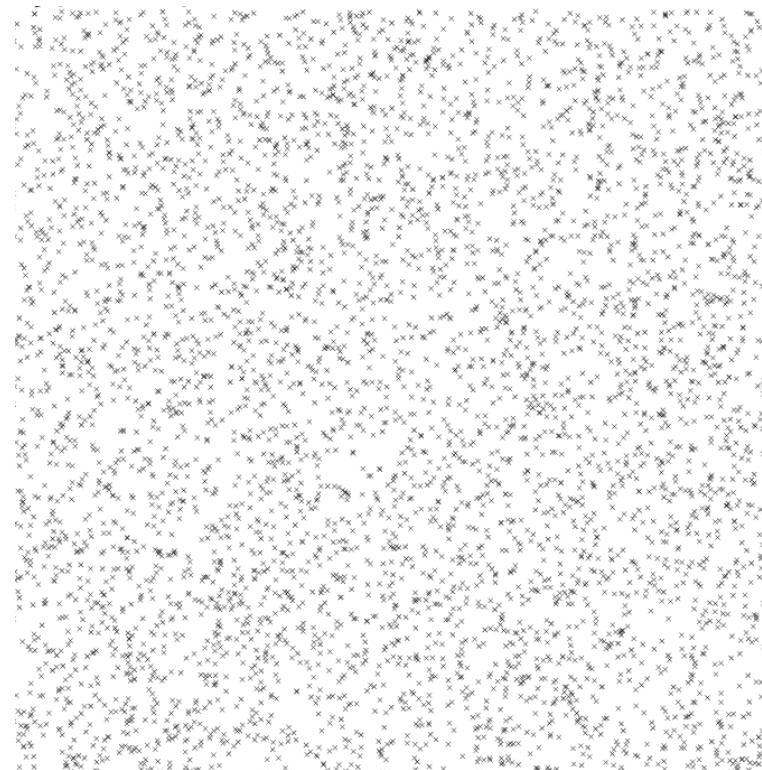


Figure 2 Point generator

5.4.2.4 generateRandomPoints3D()

```
FUNC_DECLSPEC 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)
	<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)

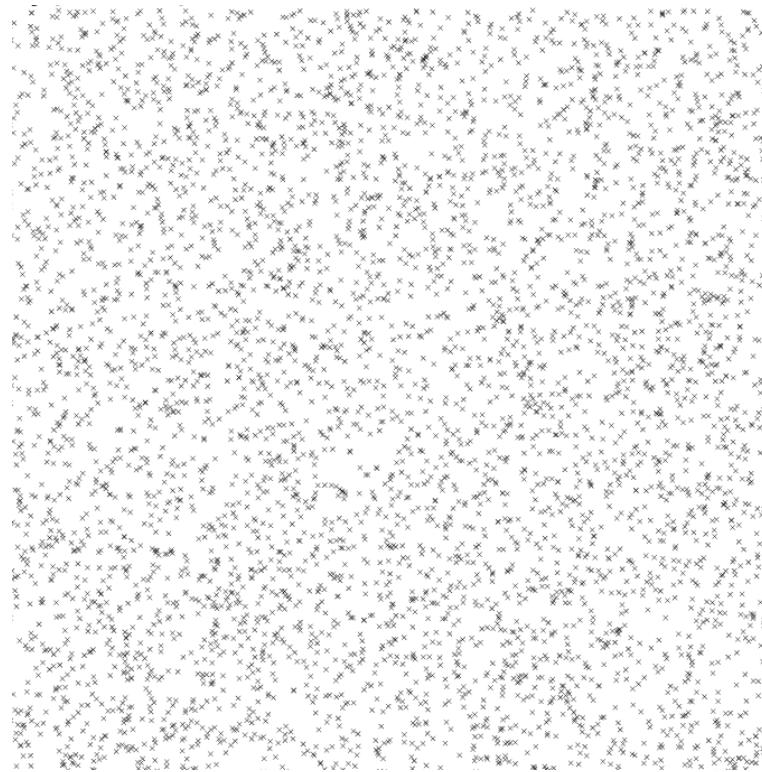


Figure 3 Point generator

5.4.2.5 generateRandomPolygon()

```
FUNC_DECLSPEC 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)
out	<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

5.4.2.6 generateRandomSegments()

```
FUNC_DECLSPEC 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

5.4.2.7 generateRandomSurfacePoints()

```
FUNC_DECLSPEC 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

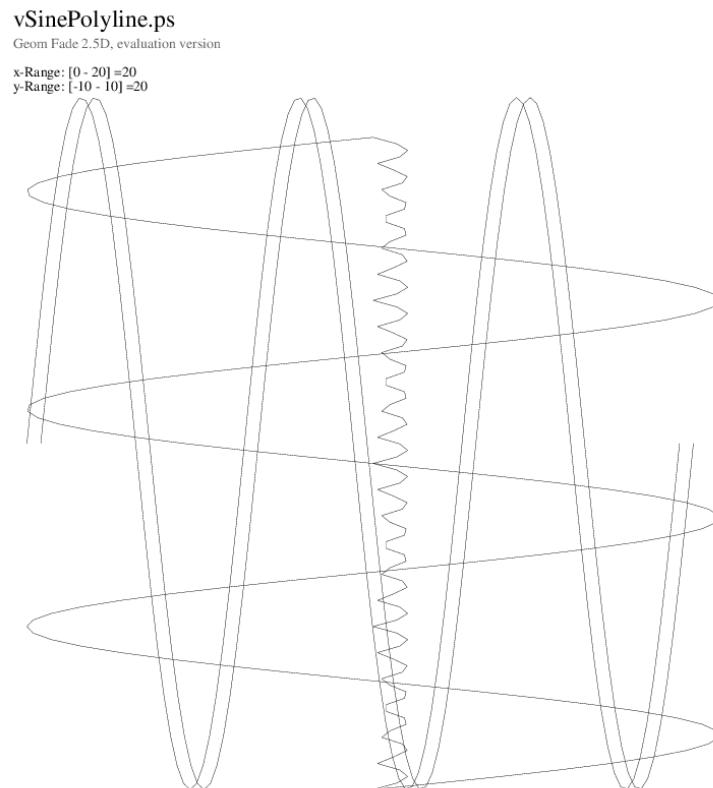
	<i>numX,numY</i>	specifies the grid size and must be >1. numX*numY points are created
	<i>numCenters</i>	defines the number of extreme points (must be >0)
	<i>xmin,ymin,zmin,xmax,ymax,zmax</i>	specifies the geometric bounds
<i>out</i>	<i>vSurfacePointsOut</i>	is the output vector
	<i>seed</i>	initializes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

5.4.2.8 generateSineSegments()

```
FUNC_DECLSPEC 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
<i>out</i>	<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.
- `Bbox2 (std::vector< Point2 >::const_iterator start_it, std::vector< Point2 >::const_iterator end_it, GeomTest *pGeomTest_=NULL)`

Constructor.
- `bool isValid () const`

Check if the bounds are valid.
- `void get Corners (std::vector< Point2 > &vBoxCorners) const`

Get corners.
- `void getOffsetCorners (double offset, std::vector< Point2 > &vBoxCorners) const`

Get offset corners.
- `bool doIntersect (const Bbox2 &other) const`

Check intersection.
- `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.
- `bool add (size_t numPoints, double *coordinates)`

Add points.
- `bool add (const Point2 &p)`

Add a point.
- `bool isInBox (const Point2 &p) const`

Point-in-Box Test.
- `Point2 computeCenter () const`

Compute the 2D midpoint.
- `Bbox2 operator+ (const Bbox2 &b)`

Add a bounding box.
- `Point2 getMinPoint () const`

Get the min point.
- `Point2 getMaxPoint () const`

Get the max point.
- `double getMinCoord () const`

Get minimum coordinate.
- `double getMaxCoord () const`

Get maximum coordinate.
- `double getRangeX () const`

Get x-range.
- `double getRangeY () const`

Get y-range.
- `double getMaxRange () const`

- double `get_minX () const`
Get minX.
- double `get_minY () const`
Get minY.
- double `get_maxX () const`
Get maxX.
- double `get_maxY () const`
Get maxY.
- void `getBounds (double &minX_, double &maxX_, double &minY_, double &maxY_) const`
Get bounds.
- void `doubleTheBox ()`
Double the box.
- void `setMinX (double val)`
Set minX.
- void `setMaxX (double val)`
Set maxX.
- void `setMinY (double val)`
Set minY.
- void `setMaxY (double val)`
Set maxY.
- void `enlargeRanges (double factor)`
- void `inflateIfDegenerate (double val)`
Inflate if Degenerate.

Protected Member Functions

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

Protected Attributes

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

Friends

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

6.1.1 Detailed Description

6.1.2 Constructor & Destructor Documentation

6.1.2.1 Bbox2() [1/2]

```
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

6.1.2.2 Bbox2() [2/2]

```
GEOM_FADE25D::Bbox2::Bbox2 (
    std::vector< Point2 >::const_iterator start_it,
    std::vector< Point2 >::const_iterator end_it,
    GeomTest * pGeomTest_ = NULL ) [inline]
```

Bounds initialized to the minimal bounding box of the iterator range of points.

6.1.3 Member Function Documentation

6.1.3.1 add() [1/4]

```
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

6.1.3.2 add() [2/4]

```
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

6.1.3.3 add() [3/4]

```
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

6.1.3.4 add() [4/4]

```
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

6.1.3.5 computeCenter()

```
Point2 GEOM_FADE25D::Bbox2::computeCenter () const
```

6.1.3.6 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.

6.1.3.7 doubleTheBox()

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

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

6.1.3.8 get_maxX()

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

Returns

maxX

6.1.3.9 `get_maxY()`

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

Returns

`maxY`

6.1.3.10 `get_minX()`

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

Returns

`minX`

6.1.3.11 `get_minY()`

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

Returns

`minY`

6.1.3.12 `getBounds()`

```
void GEOM_FADE25D::Bbox2::getBounds (
    double & minX_,
    double & maxX_,
    double & minY_,
    double & maxY_ ) const
```

6.1.3.13 `getCorners()`

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

Convenience function: Returns the 4 corners of the bounding box

6.1.3.14 `getMaxCoord()`

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

Returns

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

6.1.3.15 getMaxPoint()

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

Returns

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

6.1.3.16 getMaxRange()

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

Returns

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

6.1.3.17 getMinCoord()

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

Returns

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

6.1.3.18 getMinPoint()

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

Returns

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

6.1.3.19 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

6.1.3.20 getRangeX()

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

Returns

$\text{maxX} - \text{minX}$

6.1.3.21 getRangeY()

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

Returns

$\text{maxY} - \text{minY}$

6.1.3.22 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 .

6.1.3.23 isInBox()

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

Returns

true if $\text{minX} \leq p.x() \leq \text{maxX}$ and $\text{minY} \leq p.y() \leq \text{maxY}$ or false otherwise.

6.1.3.24 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 $\text{minX} \leq \text{maxX}$ and $\text{minY} \leq \text{maxY}$

6.1.3.25 operator+()

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

Extends the 2D bounding box if required.

Returns

the resulting bounding box

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_)
- **CAFTYP getCAFType** () const
Get Cut&Fill-Type.
- double **getVolume** () const
Get the volume.
- int **getLabel** () const
Get label.
- void **getTriangles** (std::vector< [Triangle2](#) *> &vTrianglesOut) const
Get Triangles.
- void **getBorder** (std::vector< [Segment2](#) > &vBorderSegments) const
Get border.

Protected Member Functions

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

Protected Attributes

- std::vector< [Triangle2](#) *> *pVT
- **CAFTYP caftype**
- double **volume**
- int **label**

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

<code>out</code>	<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.

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

Public Member Functions

- [Circle2 \(double x, double y, double sqRadius_\)](#)
Constructor.
- [Circle2 \(const Point2 ¢er_, double sqRadius_\)](#)
Constructor.
- double [getRadius \(\)](#)
Get the radius of the circle.
- double [getSqRadius \(\)](#)
Get the squared radius of the circle.
- Point2 [getCenter \(\)](#)
Get the center of the circle.

Protected Attributes

- `Point2 center`
- double `sqRadius`

Friends

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

6.3.1 Detailed Description

6.3.2 Constructor & Destructor Documentation

6.3.2.1 Circle2() [1/2]

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

Parameters

<code>x</code>	is x-coordinate of the center
<code>y</code>	is y-coordinate of the center
<code>sqRadius_</code>	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

<code>center_</code>	center of the circle
<code>sqRadius_</code>	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::Color Class Reference

[Color.](#)

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

Public Member Functions

- `Color (double r_, double g_, double b_, double width_, bool bFill_=false)`
- `Color (Colorname c, float width_=0.001, 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 r`
Red.
- `float g`
Green.
- `float b`
Blue.
- `float width`
Linewidth.
- `bool bFill`
Fill the shape or not.

Static Public Attributes

- static `size_t currentColorName`

Friends

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

6.4.1 Detailed Description

See also

[Visualizer2](#)

6.4.2 Constructor & Destructor Documentation

6.4.2.1 Color() [1/2]

```
GEOM_FADE25D::Color::Color (
    double r_,
    double g_,
    double b_,
    double width_,
    bool bFill_ = false )
```

Parameters

<i>r_</i>	red
<i>g_</i>	green
<i>b_</i>	blue
<i>width</i> ↵	linewidth
—	
<i>bFill</i> ↵	fill (default: <i>false</i>)
—	

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.

6.4.2.2 Color() [2/2]

```
GEOM_FADE25D::Color::Color (
    Colorname c,
    float width_ = 0.001,
    bool bFill_ = false )
```

For convenience predefined colors can be used.

Parameters

<i>c</i>	is a predefined color name
<i>width</i> ↵	linewidth (default: 0.001)
—	
<i>bFill</i> ↵	fill (default: <i>false</i>)

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](#)

6.5 GEOM_FADE25D::ConstraintGraph2 Class Reference

[ConstraintGraph2](#) is a set of Constraint Edges ([ConstraintSegment2](#))

```
#include <ConstraintGraph2.h>
```

Public Member Functions

- bool **isPolygon** () const
Does the constraint graph form a closed polygon?
- bool **isOriented** () const
Are the segments of the constraint graph oriented?
- void **getPolygonVertices** (std::vector< **Point2** *> &vVertices_)
Get the vertices of the constraint segments.
- **ConstraintInsertionStrategy getInsertionStrategy** () const
Get the constraint insertion strategy.
- bool **isConstraint** (**Point2** *p0, **Point2** *p1) const
Check if an edge is a constraint.
- bool **isConstraint** (**ConstraintSegment2** *pCSeg) const
*Check if a **ConstraintSegment2** is a member.*
- void **show** (const std::string &name)
Visualization.
- void **show** (**Visualizer2** *pVis, const **Color** &color)
Visualization.
- void **getOriginalConstraintSegments** (std::vector< **ConstraintSegment2** *> &vConstraintSegments_) const
*Get the original **ConstraintSegment2** objects.*
- void **getChildConstraintSegments** (std::vector< **ConstraintSegment2** *> &vConstraintSegments_) const
*Get child **ConstraintSegment2** objects.*
- **Dt2 * getDt2** ()
- void **getDirectChildren** (**ConstraintSegment2** *pParent, **ConstraintSegment2** *&pChild0, **ConstraintSegment2** *&pChild1)
Get direct children.
- bool **isReverse** (**ConstraintSegment2** *pCSeg) const
- bool **makeDelaunay** (double minLength)

Protected Attributes

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

6.5.1 Detailed Description

See also

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

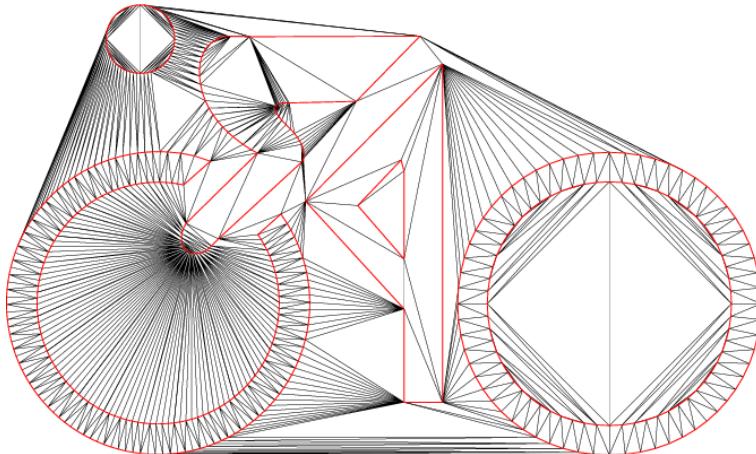


Figure 7 Constraint Delaunay triangulation

6.5.2 Member Function Documentation

6.5.2.1 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.

6.5.2.2 getDirectChildren()

```
void GEOM_FADE25D::ConstraintGraph2::getDirectChildren (
    ConstraintSegment2 * pParent,
    ConstraintSegment2 *& pChild0,
    ConstraintSegment2 *& pChild1 )
```

Parameters

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

The children are returned in the correct order of the present [ConstraintGraph2](#).

6.5.2.3 getDt2()

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

Returns

the Delaunay class it belongs to

6.5.2.4 getInsertionStrategy()

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

Returns

CIS_CONFORMING_DELAUNAY, CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL or
CIS_CONSTRAINED_DELAUNAY

6.5.2.5 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...)

6.5.2.6 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\(\)](#) ?

6.5.2.7 isConstraint() [1/2]

```
bool GEOM_FADE25D::ConstraintGraph2::isConstraint (
    Point2 * p0,
    Point2 * p1 ) const
```

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

6.5.2.8 isConstraint() [2/2]

```
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.

6.5.2.9 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.

6.5.2.10 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).

6.5.2.11 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.

6.5.2.12 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	<i>minLength</i>	specifies a lower bound. Constraint segments smaller than <i>minLength</i> are not subdivided. This parameter avoids excessive subdivision in narrow settings.
----	------------------	--

Returns

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

6.5.2.13 show() [1/2]

```
void GEOM_FADE25D::ConstraintGraph2::show (
    const std::string & name )
```

6.5.2.14 show() [2/2]

```
void GEOM_FADE25D::ConstraintGraph2::show (
    Visualizer2 * pVis,
    const Color & color )
```

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

- ConstraintGraph2.h

6.6 GEOM_FADE25D::ConstraintSegment2 Class Reference

A [ConstraintSegment2](#) represents a Constraint Edge.

```
#include <ConstraintSegment2.h>
```

Public Member Functions

- [`Point2 * getSrc \(\) const`](#)
Get the first endpoint.
- [`Point2 * getTrg \(\) const`](#)
Get the second endpoint.
- [`bool isAlive \(\) const`](#)
Check if the present `ConstraintSegment2` is alive.
- [`ConstraintInsertionStrategy getCIS \(\) const`](#)
Get the Constraint Insertion Strategy (CIS)
- [`bool operator< \(const ConstraintSegment2 &pOther\) const`](#)
operator<(..) Compares the vertex pointers of the endpoints, not the length
- [`Point2 * insertAndSplit \(const Point2 &splitPoint\)`](#)
Split a constraint segment.
- [`bool split_combinatorialOnly \(Point2 *pSplit\)`](#)
Split a constraint segment.
- [`void getChildrenRec \(std::vector< ConstraintSegment2 *> &vChildConstraintSegments\)`](#)
Get all children Recursively retrieve all children of the current `ConstraintSegment2`.
- [`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.

Public Attributes

- int **label**

Protected Attributes

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

Static Protected Attributes

- static int **runningLabel**

Friends

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

6.6.1 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.

6.6.2 Member Function Documentation

6.6.2.1 get CIS()

```
ConstraintInsertionStrategy GEOM_FADE25D::ConstraintSegment2::getCIS ( ) const
```

Returns

the constraint insertion strategy (CIS) of the present object

6.6.2.2 get Src()

```
Point2* GEOM_FADE25D::ConstraintSegment2::getSrc ( ) const
```

Returns

the first vertex

6.6.2.3 getTrg()

```
Point2* GEOM_FADE25D::ConstraintSegment2::getTrg ( ) const
```

Returns

the second vertex

6.6.2.4 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.

6.6.2.5 isAlive()

```
bool GEOM_FADE25D::ConstraintSegment2::isAlive ( ) const
```

Returns

TRUE when the object is alive, FALSE otherwise

6.6.2.6 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](#)

6.7 GEOM_FADE25D::CutAndFill Class Reference

Cut-And-Fill.

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

Public Member Functions

- **CutAndFill (Zone2 *pZoneBefore, Zone2 *pZoneAfter, double ignoreThreshold=1e-3)**
Constructor.
- **bool getDiffZone (Zone2 *&pDiffZone, std::map< Point2 *, std::pair< double, double >> &mVtx2BeforeAfter)**
Get the difference zone.
- **void subscribe (MsgType msgType, MsgBase *pMsg)**
Register a progress bar object.
- **void unsubscribe (MsgType msgType, MsgBase *pMsg)**
Unregister a progress bar object.
- **size_t getNumberOfComponents () const**
Get the number of components.
- **CAF_Component * getComponent (size_t ith) const**
*Get component *ith*.*
- **bool go ()**
Start the computation.
- **void show (Visualizer2 *pVis) const**
Draw a postscript visualization.

Protected Attributes

- CutAndFillImpl * pCAFI

6.7.1 Detailed Description

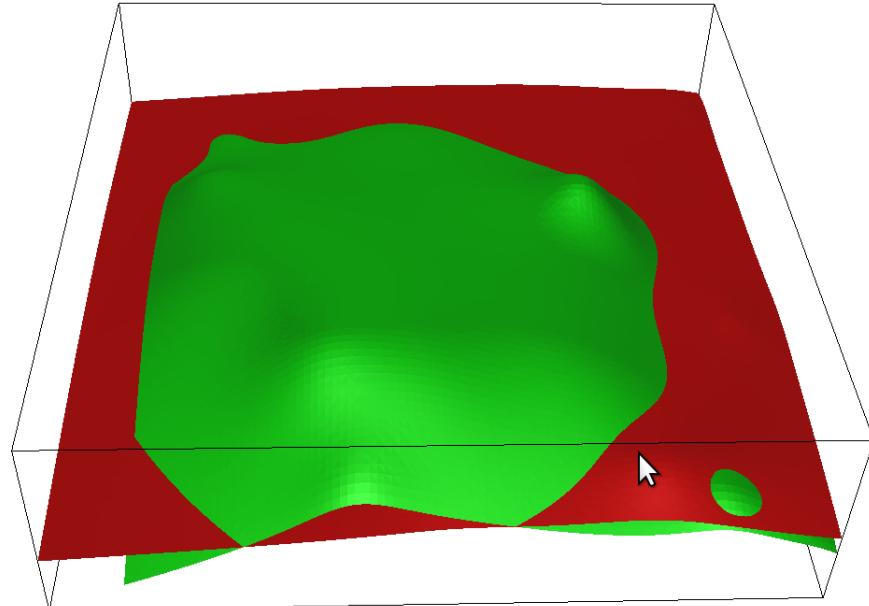


Figure 8 Overlapping input surfaces for Cut-And-Fill: RED=before, GREEN=after. The surfaces do not need to match exactly, the overlapping area is used

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

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

6.7.2 Constructor & Destructor Documentation

6.7.2.1 CutAndFill()

```
GEOM_FADE25D::CutAndFill::CutAndFill (
    Zone2 * pZoneBefore,
    Zone2 * pZoneAfter,
    double ignoreThreshold = 1e-3 )
```

Parameters

<i>pZoneBefore</i>	represents the surface before the earthworks
<i>pZoneAfter</i>	is the surface afterwards
<i>ignoreThreshold</i>	(default: 1e-3) can be used to ignore insignificant height differences

6.7.3 Member Function Documentation

6.7.3.1 getComponent()

```
CAF_Component* GEOM_FADE25D::CutAndFill::getComponent (
    size_t ith ) const
```

Returns

the *ith* CAF_Component.

6.7.3.2 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.

6.7.3.3 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)

6.7.3.4 go()

```
bool GEOM_FADE25D::CutAndFill::go ( )
```

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.

6.7.3.5 show()

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

For a quick overview a postscript visualization can be created.

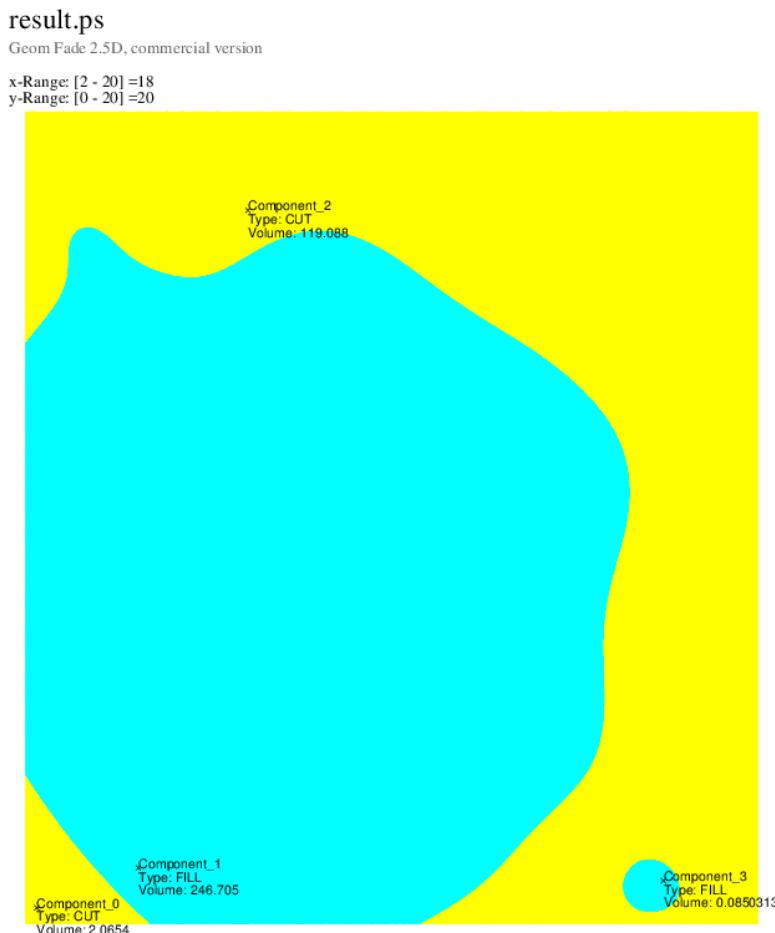


Figure 9 Cut&Fill-Result: YELLOW area CUT, CYAN area: FILL

6.7.3.6 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

<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 .

6.7.3.7 unsubscribe()

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

Parameters

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

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

- CutAndFill.h

6.8 GEOM_FADE25D::Edge2 Class Reference

Directed Edge.

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

Public Member Functions

- [Edge2 \(const Edge2 &e_\)](#)
Constructor.
- [Edge2 \(Triangle2 *pT, int oppIdx_\)](#)
Constructor.
- [Edge2 & operator= \(const Edge2 &other\)](#)
- [bool operator< \(const Edge2 &e\) const](#)
operator<()
- [bool operator== \(const Edge2 &e\) const](#)
operator==()
- [bool operator!= \(const Edge2 &e\) const](#)
operator!=()
- [Point2 * getSrc \(\) const](#)
Get the source point.
- [Point2 * getTrg \(\) const](#)
Get the target point.
- [void getPoints \(Point2 *&p1, Point2 *&p2\) const](#)
Get the endpoints.
- [double getLength2D \(\) const](#)
- [double getLength25D \(\) const](#)
- [Triangle2 * getTriangle \(\) const](#)
- [void getTriangles \(Triangle2 *&pT0, Triangle2 *&pT1, int &idx0, int &idx1\) const](#)

Protected Attributes

- [Triangle2 * pT](#)
- [int oppIdx](#)

Friends

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

6.8.1 Constructor & Destructor Documentation

6.8.1.1 Edge2()

```
GEOM_FADE25D::Edge2::Edge2 (
    Triangle2 * pT,
    int oppIdx_ )
```

Parameters

<i>pT</i>	is the triangle from which the edge is constructed
<i>oppIdx_</i>	is intra-triangle-index of the opposite vertex (of the edge) in pT

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

6.8.2 Member Function Documentation

6.8.2.1 getLength25D()

```
double GEOM_FADE25D::Edge2::getLength25D ( ) const
```

Get the 2.5D length

Returns

the 2.5D length of the edge

6.8.2.2 getLength2D()

```
double GEOM_FADE25D::Edge2::getLength2D ( ) const
```

Get the 2D length

Returns

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

6.8.2.3 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

6.8.2.4 getSrc()

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

Returns

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

6.8.2.5 getTrg()

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

Returns

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

6.8.2.6 getTriangle()

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

Get the triangle

Returns

the triangle whose directed edge the present edge is

6.8.2.7 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

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

6.8.2.8 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 edge.

6.8.2.9 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.

6.8.2.10 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.

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

- Edge2.h

6.9 GEOM_FADE25D::EfficientModel Class Reference

[EfficientModel](#).

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

Public Member Functions

- **EfficientModel** (const std::vector<[Point2](#)> &vPoints)
- void **zSmoothing** (int numIterations, double maxDifferencePerIteration, [SmoothingStrategy](#) sms)
Smoothing.
- void **extract** (double maxError, std::vector<[Point2](#)> &vEfficientPointsOut)
Extract a subset of points.

Protected Member Functions

- void **solveCand** (Candidate *pCand, double maxErr)
- void **go** ()
- void **part1_extractFC** ()
- void **part2_setWeights** ()
- void **sortVtx** (std::vector< Point2 *> &vVtx)
- int **insertKeepError** (double factor, double err, std::vector< Point2 *> &vIn, std::vector< Point2 *> &vNeedlessBigError, std::vector< Point2 *> &vNeedlessSmallError)
- void **insertMinHull** ()
- void **show** (const std::string &name)

6.9.1 Detailed Description

Point clouds from terrains are often oversampled. The present class aims to smooth and to reduce these point clouds in a controlled way such that the resulting surface keeps a certain user specified quality.

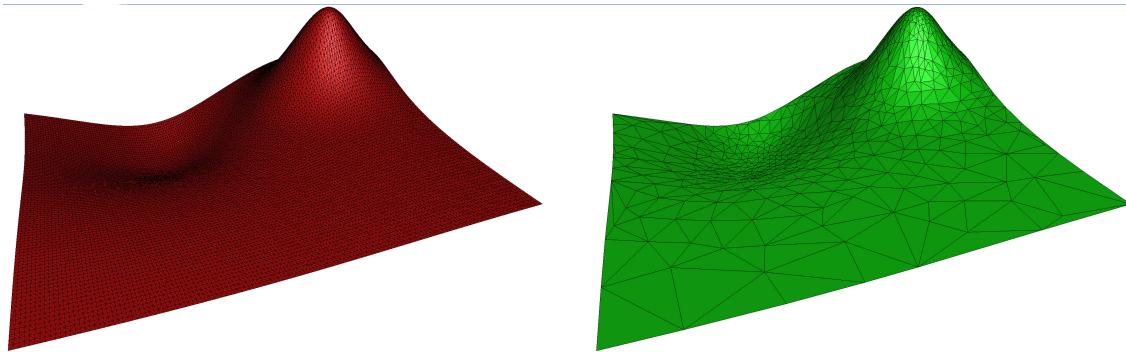


Figure 10 Point Cloud Reduction: Left original, right reduced

6.9.2 Member Function Documentation

6.9.2.1 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.

6.9.2.2 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

<code>numIterations</code>	Number of iterations
<code>maxDifferencePerIteration</code>	is the maximum change of any z-value
<code>sms</code>	is one of SMS_MINIMUM, SMS_MAXIMUM, SMS_MEDIAN, SMS_AVERAGE

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

- `EfficientModel.h`

6.10 GEOM_FADE25D::Fade_2D Class Reference

Delaunay triangulation - the main class.

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

Public Member Functions

- `Fade_2D` (`unsigned numExpectedVertices=3`)

Constructor of the main triangulation class.
- `bool checkValidity` (`bool bCheckEmptyCircleProperty, const std::string &msg`) `const`

Checks if a triangulation is valid.
- `int setNumCPU` (`int numCPU`)

Set the number CPU cores for multithreading.
- `void statistics` (`const std::string &s`) `const`

Statistics.
- `void show` (`const std::string &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 std::string &filename`)

Draws the triangulation in 3D.
- `void showGeomview (Visualizer3 *pVis)`

- Draws the triangulation in 3D.
- void `remove (Point2 *pVertex)`
Remove a single vertex.
- void `getConvexHull (bool bAllVertices, std::vector< Point2 *> &vConvexHullPointsOut)`
Compute the convex hull.
- `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.
- double `measureTriangulationTime (std::vector< Point2 > &vPoints)`
Measure the Delaunay triangulation time.
- `Triangle2 * locate (const Point2 &p)`
Locate a triangle which contains p.
- bool `getHeight (double x, double y, double &heightOut, Triangle2 *pApproxT=NULL, double tolerance=0)`
const
Compute the height of a certain point.
- void `refine (Zone2 *pZone, double minAngleDegree, double minEdgeLength, double maxEdgeLength, bool bAllowConstraintSplitting)`
Delaunay refinement.
- void `refineAdvanced (MeshGenParams *pParameters)`
Delaunay refinement and grid meshing.
- size_t `numberOfPoints () const`
Number of points.
- size_t `numberOfTriangles () const`
Number of triangles.
- void `getTrianglePointers (std::vector< Triangle2 *> &vAllTriangles) const`
Get pointers to all triangles.
- void `getVertexPointers (std::vector< Point2 *> &vAllPoints) const`
Get pointers to all vertices.
- `Triangle2 * getAdjacentTriangle (Point2 *p0, Point2 *p1) const`
Get adjacent triangle.
- bool `is2D () const`
Check if the triangulation contains triangles (which is the case if at least 3 non-collinear points exist in the triangulation).
- `ConstraintGraph2 * createConstraint (std::vector< Segment2 > &vSegments, ConstraintInsertionStrategy cis, bool bOrientedSegments=false)`
Add constraint edges (edges, polyline, polygon).
- `Zone2 * createZone (ConstraintGraph2 *pConstraintGraph, ZoneLocation zoneLoc, bool bVerbose=true)`
Create a zone.
- `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, 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.
- void `deleteZone (Zone2 *pZone)`

- Delete a `Zone2` object.
- void `applyConstraintsAndZones ()`

Apply conforming constraints and zones (deprecated!)
- `Bbox2 computeBoundingBox () const`

Compute the axis-aligned bounding box of the points.
- bool `isConstraint (Triangle2 *pT, int ith) const`

Check if an edge is a constraint edge.
- void `getAliveConstraintSegments (std::vector< ConstraintSegment2 *> &vAliveConstraintSegments) const`

Get active (alive) constraint segments.
- void `getAliveAndDeadConstraintSegments (std::vector< ConstraintSegment2 *> &vAllConstraintSegments) const`

Get all (alive and dead) constraint segments.
- `ConstraintSegment2 * getConstraintSegment (Point2 *p0, Point2 *p1) const`

Retrieve a `ConstraintSegment2`.
- void `getIncidentTriangles (Point2 *pVtx, std::vector< Triangle2 *> &vIncidentT) const`

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

Get incident vertices.
- void `writeObj (const std::string &filename) const`

Write the current triangulation to an `.obj` file.*
- void `writeObj (const std::string &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.*
- void `subscribe (MsgType msgType, MsgBase *pMsg)`

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

Unregister a message receiver.
- 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.
- void `printLicense () const`
- `Zone2 * importTriangles (std::vector< Point2 > &vPoints, bool bReorientIfNeeded, bool bCreateExtended BoundingBox)`

Import triangles.
- `Orientation2 getOrientation (const Point2 &p0, const Point2 &p1, const Point2 &p2)`

Compute the orientation of 3 points.
- 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.
- `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.
- bool `drape (std::vector< Segment2 > &vSegmentsIn, std::vector< Segment2 > &vSegmentsOut, double zTolerance) const`

Drape segments along a surface.
- void `enableMultithreading ()`

Enable multithreading (deprecated)

6.10.1 Detailed Description

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

6.10.2 Constructor & Destructor Documentation

6.10.2.1 Fade_2D()

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

Parameters

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

6.10.3 Member Function Documentation

6.10.3.1 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_CO←NFORMING_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

6.10.3.2 checkValidity()

```
bool GEOM_FADE25D::Fade_2D::checkValidity (
    bool bCheckEmptyCircleProperty,
    const std::string & 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 checkValidity call currently runs.

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

6.10.3.3 `computeBoundingBox()`

```
Bbox2 GEOM_FADE25D::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.

6.10.3.4 `createConstraint()`

```
ConstraintGraph2* GEOM_FADE25D::Fade_2D::createConstraint (
    std::vector< Segment2 > & vSegments,
    ConstraintInsertionStrategy cis,
    bool bOrientedSegments = 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>). To maintain backwards compatibility <code>bOrientedSegments</code> is a default parameter and it defaults to false. Fade will maintain the orientation of the segments only when <code>bOrientedSegments=true</code> . This regards functions like <code>ConstraintGraph2::getPolygonVertices()</code> when the order of the returned vertices is important. Another consequence is when later a <code>Zone2</code> object shall be constructed from this <code>ConstraintGraph2</code> . This is only possible if either this value is true (then the algorithm will assume that all segments exist in counterclockwise orientation) or when the value is false and the segments can be automatically reoriented and reordered such that they form one closed polygon.

Returns

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

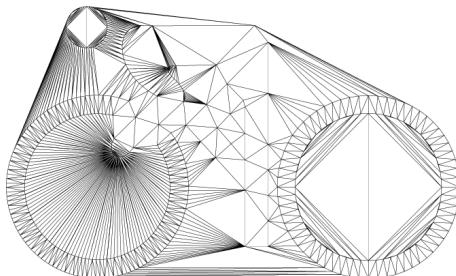


Figure 11 Delaunay triangulation without constraints

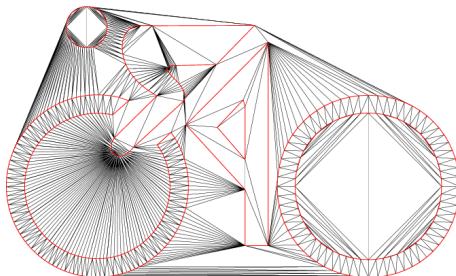


Figure 12 Constraint Delaunay triangulation

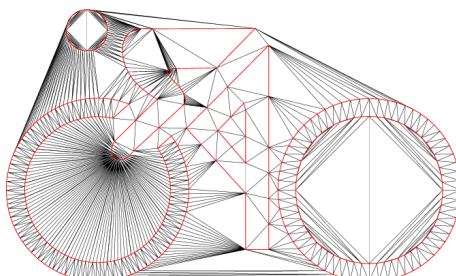


Figure 13 Conforming Delaunay triangulation through the [ConstraintGraph::makeDelaunay\(\)](#) method

6.10.3.5 [createZone\(\)](#) [1/4]

```
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

<i>zoneLoc</i>	is ZL_INSIDE, ZL_OUTSIDE or ZL_GLOBAL.
<i>pConstraintGraph</i>	points to a formerly created ConstraintGraph2 object (which must be oriented and contain a <i>simple</i> polygon) or is NULL in case of <i>zoneLoc==ZL_GLOBAL</i> .
Generated by Doxygen	
<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 no triangles exist or pConstraintGraph->isOriented() returns false.



Figure 14 Zones in a triangulation

6.10.3.6 [createZone\(\)](#) [2/4]

```
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 vConstraintGraphs 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)

6.10.3.7 [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

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

6.10.3.8 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

<i>vTriangles</i>	
<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 vTriangles is empty)

6.10.3.9 createZone_cookieCutter()

```
Zone2* GEOM_FADE25D::Fade_2D::createZone_cookieCutter (
    std::vector< Segment2 > & vSegments,
    bool bProtectEdges )
```

Parameters

in	<i>vSegments</i>	specifies a simple polygon.
in	<i>bProtectEdges</i>	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 could flip existing edges in the triangulation, this can be avoided using bProtectEdges=true. The operation may create constraint segments.

6.10.3.10 cutTriangles() [1/2]

```
void GEOM_FADE25D::Fade_2D::cutTriangles (
    const Point2 & knifeStart,
    const Point2 & knifeEnd,
    bool bTurnEdgesIntoConstraints )
```

Parameters

<i>knifeStart</i>	is one point of the knife segment
<i>knifeEnd</i>	is the second point of the knife segment
<i>bTurnEdgesIntoConstraints</i>	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.

6.10.3.11 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.

6.10.3.12 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.

6.10.3.13 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

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

Returns

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

Note

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

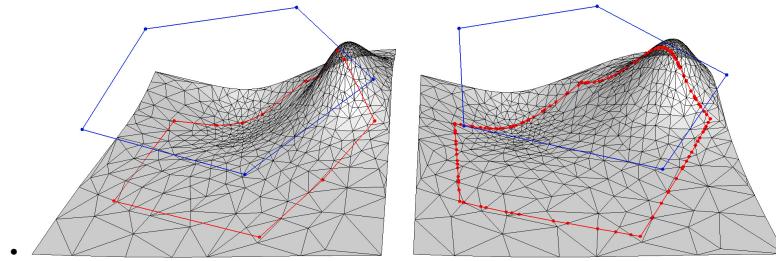


Figure 15 Drape: Input segments (blue) are draped (red) onto a TIN. Left with tolerance 1.0, right without tolerance

Note

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

6.10.3.14 enableMultithreading()

```
void GEOM_FADE25D::Fade_2D::enableMultithreading ( )
```

Deprecated: Use [setNumCPU\(\)](#) instead. This method is kept for compatibility with existing applications. Internally it calls setNumCPU(0) to automatically determine and use the number of available CPU cores.

6.10.3.15 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.

6.10.3.16 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)

6.10.3.17 getConvexHull()

```
void GEOM_FADE25D::Fade_2D::getConvexHull (
    bool bAllVertices,
    std::vector< Point2 *> & vConvexHullPointsOut )
```

Parameters

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

6.10.3.18 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

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

6.10.3.19 `getIncidentTriangles()`

```
void GEOM_FADE25D::Fade_2D::getIncidentTriangles (
    Point2 * pVtx,
    std::vector< Triangle2 *> & vIncidentT ) const
```

Stores pointers to all triangles around pVtx into vIncidentT

6.10.3.20 `getIncidentVertices()`

```
void GEOM_FADE25D::Fade_2D::getIncidentVertices (
    Point2 * pVtx,
    std::vector< Point2 *> & vIncidentVertices ) const
```

Stores pointers to all vertices around pVtx into vIncidentVertices

6.10.3.21 `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)

6.10.3.22 `getTrianglePointers()`

```
void GEOM_FADE25D::Fade_2D::getTrianglePointers (
    std::vector< Triangle2 *> & vAllTriangles ) const
```

This command fetches the existing triangles

Parameters

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

Note

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

6.10.3.23 getVertexPointers()

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

Parameters

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

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

Note

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

6.10.3.24 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\(\)](#).

6.10.3.25 insert() [1/4]

```
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.

6.10.3.26 insert() [2/4]

```
void GEOM_FADE25D::Fade_2D::insert (
    const std::vector< Point2 > & vInputPoints )
```

Parameters

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

Note

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

6.10.3.27 insert() [3/4]

```
void GEOM_FADE25D::Fade_2D::insert (
    const std::vector< Point2 > & vInputPoints,
    std::vector< Point2 *> & vHandles )
```

Parameters

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

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

Note

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

6.10.3.28 insert() [4/4]

```
void GEOM_FADE25D::Fade_2D::insert (
    int numPoints,
    double * aCoordinates,
    Point2 ** aHandles )
```

Parameters

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

Note

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

6.10.3.29 is2D()

```
bool GEOM_FADE25D::Fade_2D::is2D ( ) 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.

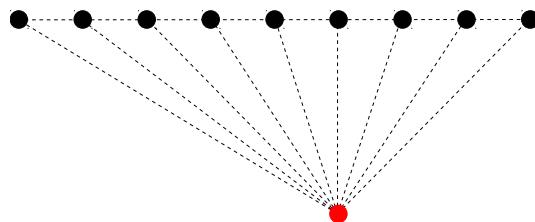


Figure 16 Triangles are generated as soon as the first non-collinear point is inserted.

Returns

true if at least one triangle exists
false otherwise

6.10.3.30 isConstraint() [1/3]

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

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

6.10.3.31 isConstraint() [2/3]

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

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

6.10.3.32 isConstraint() [3/3]

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

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

6.10.3.33 locate()

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

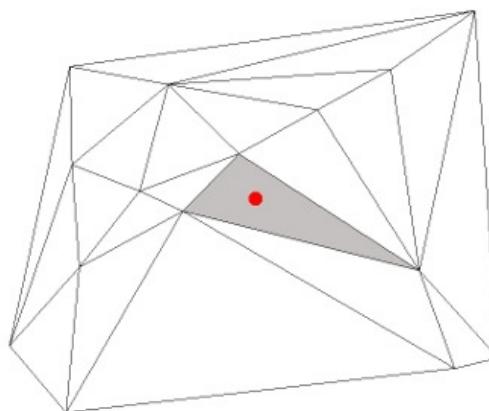


Figure 17 Point location

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

p	is the query point
-----	--------------------

Returns

a pointer to a [Triangle2](#) object (or NULL if `is2D() == false` or if p is outside the triangulation)

6.10.3.34 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	<code>vPoints</code>	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

6.10.3.35 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.

6.10.3.36 numberOfTriangles()

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

Returns

the number of triangles in the triangulation (or 0 as long as `is2D()` is false).

6.10.3.37 printLicense()

```
void GEOM_FADE25D::Fade_2D::printLicense ( ) const
```

Prints informations about the currently used license

6.10.3.38 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_BOUNDED.
<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_BOUNDED zones are accepted. But you can easily convert other types of zones to ZL_BOUNDED using [Zone2::convertToBoundedZone\(\)](#).

6.10.3.39 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.

6.10.3.40 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.

6.10.3.41 setNumCPU()

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

Parameters

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

Returns

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

Characteristics:

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

6.10.3.42 show() [1/2]

```
void GEOM_FADE25D::Fade_2D::show (
    const std::string & 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)

6.10.3.43 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\(\)](#).

6.10.3.44 showGeomview() [1/2]

```
void GEOM_FADE25D::Fade_2D::showGeomview (
    const std::string & filename )
```

Note

The free viewer Geomview can be used to view such files

6.10.3.45 showGeomview() [2/2]

```
void GEOM_FADE25D::Fade_2D::showGeomview (
    Visualizer3 * pVis )
```

Note

The free viewer Geomview can be used to view such files

6.10.3.46 statistics()

```
void GEOM_FADE25D::Fade_2D::statistics (
    const std::string & s ) const
```

Prints mesh statistics to stdout.

6.10.3.47 subscribe()

```
void GEOM_FADE25D::Fade_2D::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

6.10.3.48 unsubscribe()

```
void GEOM_FADE25D::Fade_2D::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

6.10.3.49 writeObj() [1/2]

```
void GEOM_FADE25D::Fade_2D::writeObj (
    const std::string & filename ) const
```

Visualizes the current triangulation. The *.obj format represents a 3D scene but can also be used with 2D triangles (all z-values are zero then).

6.10.3.50 writeObj() [2/2]

```
void GEOM_FADE25D::Fade_2D::writeObj (
    const std::string & filename,
    Zone2 * pZone ) const
```

Visualizes a [Zone2](#) object. The *.obj format represents a 3D scene but can also be used with 2D triangles (all z-values are zero then).

6.10.3.51 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.

6.10.3.52 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](#)

6.11 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

6.12 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

6.13 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

6.14 GEOM_FADE25D::Func_ItPointXYZ Struct Reference

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`

6.15 GEOM_FADE25D::Func_ItUndirected Struct Reference

Public Member Functions

- bool **operator()** (const `Edge2` &eA, const `Edge2` &eB) const

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

- `Edge2.h`

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

Protected Attributes

- `std::vector< Triangle2 * > vTriangles`

6.16.1 Detailed Description

See also

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

6.16.2 Constructor & Destructor Documentation

6.16.2.1 IsoContours()

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

Experimental feature

`IsoContours` can be used to create profiles (slices). This is a new and still experimental feature.

Parameters

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

6.16.3 Member Function Documentation**6.16.3.1 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

Polyline segments 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.

6.16.3.2 getMaxHeight()

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

The the maximum height

Returns the largest z-coordinate

6.16.3.3 getMinHeight()

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

Get the minimum height

Returns the smallest z coordinate

6.16.3.4 `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

6.17 GEOM_FADE25D::Label Class Reference

Text-Label.

```
#include <Label.h>
```

Public Member Functions

- `Label (const Point2 &p_, const std::string &s_, bool bWithMark_=true, int fontSize_=8)`
Constructs a Text-Label.

Public Attributes

- `Point2 p`
- `std::string s`
- `bool bWithMark`
- `int fontSize`

6.17.1 Detailed Description

See also

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

6.17.2 Constructor & Destructor Documentation

6.17.2.1 `Label()`

```
GEOM_FADE25D::Label::Label (
    const Point2 & p_,
    const std::string & s_,
    bool bWithMark_ = true,
    int fontSize_ = 8 )
```

Parameters

<i>p_</i>	is the point where the label appears
<i>s_</i>	is the text to be shown
<i>bWith←Mark_</i>	switches between text-only and text-with-mark
<i>fontSize_</i>	

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

- Label.h

6.18 GEOM_FADE25D::MeshGenParams Class Reference

Parameters for the mesh generator.

```
#include <MeshGenParams.h>
```

Public Member Functions

- **MeshGenParams** (*Zone2* **pZone_*)
getMaxTriangleArea(Triangle2 pT)*
- virtual double **getMaxEdgeLength** (*Triangle2* **pT*)
getMaxEdgeLength(Triangle2 pT)*
- void **addLockedConstraint** (*ConstraintSegment2* **pConstraintSegment*)
Constraint Segments that shall not be splitted.

Public Attributes

- *Fade_2D* * *pHeightGuideTriangulation*
pHeightGuideTriangulation
- double **maxHeightError**
maxHeightError
- *Zone2* * *pZone*
Zone to be meshed.
- double **minAngleDegree**
Minimum interior triangle angle.
- double **minEdgeLength**
Minimum edge length.
- double **maxEdgeLength**
Maximum edge length.
- double **maxTriangleArea**
maxTriangleArea
- bool **bAllowConstraintSplitting**
bAllowConstraintSplitting
- double **growFactor**
growFactor

- double `growFactorMinArea`
`growFactorMinArea`
- double `capAspectLimit`
`capAspectLimit`
- `Vector2 gridVector`
`gridVector`
- double `gridLength`
`gridLength`
- bool `bKeepExistingSteinerPoints`
Steiner points from previous refinements.
- int `command`
Command.

6.18.1 Detailed Description

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

See also

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

6.18.2 Member Function Documentation

6.18.2.1 addLockedConstraint()

```
void GEOM_FADE25D::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.

6.18.2.2 getMaxEdgeLength()

```
virtual double GEOM_FADE25D::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.

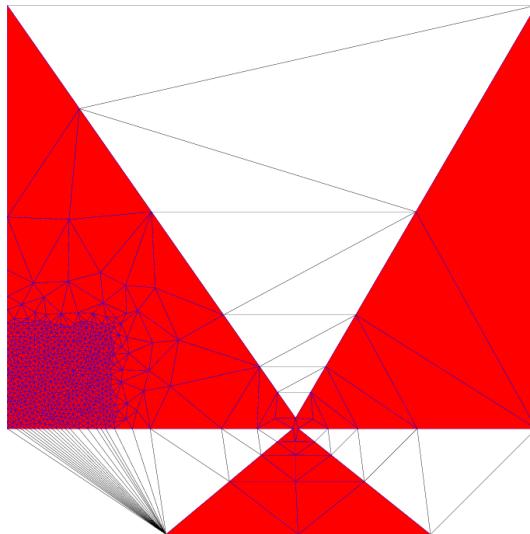


Figure 18 User Controlled Mesh Density, Edge Length

6.18.2.3 getMaxTriangleArea()

```
virtual double GEOM_FADE25D::MeshGenParams::getMaxTriangleArea (
    Triangle2 * pT ) [inline], [virtual]
```

Parameters

<i>pT</i>	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 $D \leftarrow BL_MAX$ if not changed by the user). This method can be overridden by the client software in order to control the local mesh density.

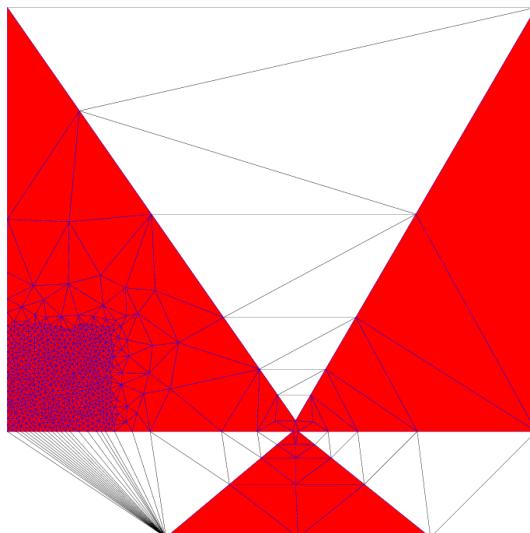


Figure 19 User Controlled Mesh Density, Area

6.18.3 Member Data Documentation

6.18.3.1 bAllowConstraintSplitting

```
bool GEOM_FADE25D::MeshGenParams::bAllowConstraintSplitting
```

Defines if constraint segments can be splitted. Default: yes

6.18.3.2 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.

6.18.3.3 capAspectLimit

```
double GEOM_FADE25D::MeshGenParams::capAspectLimit
```

Limits the quotient edgeLength / height. Default value: 10.0

6.18.3.4 command

```
int GEOM_FADE25D::MeshGenParams::command
```

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

6.18.3.5 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.

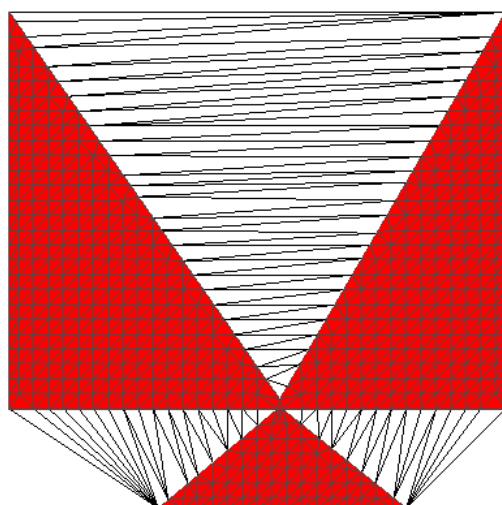


Figure 20 Grid Meshing axis aligned

6.18.3.6 gridVector

```
Vector2 GEOM_FADE25D::MeshGenParams::gridVector
```

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

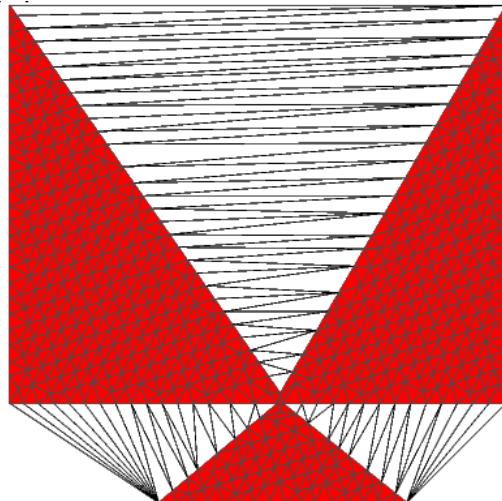


Figure 21 Grid Meshing along Vector2(1.0,0.3,0.0)

6.18.3.7 growFactor

```
double GEOM_FADE25D::MeshGenParams::growFactor
```

Limits the growth of adjacent triangles. The mesh is constructed such that for any two adjacent triangles t_0 and t_1 (where t_0 is the larger one) $\text{area}(t_0)/\text{area}(t_1) < \text{growFactor}$. Recommendation: `growFactor>5.0`, Default: `growFactor=DBL_MAX`

6.18.3.8 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

6.18.3.9 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`.

6.18.3.10 maxHeightError

```
double GEOM_FADE25D::MeshGenParams::maxHeightError
```

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

6.18.3.11 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`.

6.18.3.12 minAngleDegree

```
double GEOM_FADE25D::MeshGenParams::minAngleDegree
```

Minimum interior angle: Default: 20.0, maximum: 30.0

6.18.3.13 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

6.18.3.14 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

6.19 GEOM_FADE25D::MsgBase Class Reference

MsgBase

```
#include <MsgBase.h>
```

Public Member Functions

- virtual void `update` (MsgType msgType, const std::string &s, double d)=0
`update`

6.19.1 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/>

6.19.2 Member Function Documentation

6.19.2.1 update()

```
virtual void GEOM_FADE25D::MsgBase::update (
    MsgType msgType,
    const std::string & 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`

6.20 GEOM_FADE25D::Point2 Class Reference

Point.

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

Public Member Functions

- `Point2 (const double x_, const double y_, const double z_)`
Constructor.
- `Point2 ()`
Default constructor.
- `Point2 (const Point2 &p_)`
Copy constructor.
- `Point2 & operator= (const Point2 &other)`
- `void print ()`
Print.
- `double x () const`
Get the x-coordinate.
- `double y () const`
Get the y-coordinate.
- `double z () const`
Get the z-coordinate.
- `void xyz (double &x_, double &y_, double &z_) const`
Get the x-, y- and z-coordinate.
- `void xy (double &x_, double &y_) const`
Get the x- and y-coordinate.
- `void setHeight (double z)`
Set the z-coordinate.
- `double getMaxAbs () const`
Get max(abs(x),abs(y))
- `bool operator< (const Point2 &p) const`

- *Less than operator.*
• bool `operator>` (const `Point2` &p) const
Greater than operator.
- bool `operator==` (const `Point2` &p) const
Equality operator.
- bool `samePoint` (const `Point2` &p) const
Equality operator.
- bool `operator!=` (const `Point2` &p) const
Inequality operator.
- `Triangle2 * getIncidentTriangle () const`
Get the associated triangle.
- 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 `setCustomIndex` (int customIndex_)
Set a custom index.
- int `getCustomIndex () const`
Get the custom index.
- void `setIncidentTriangle (Triangle2 *pT)`
Associate a triangle with the point.
- `Vector2 operator- (const Point2 &other) const`
*Returns a vector from other to *this.*
- `Point2 operator+ (const Vector2 &vec) const`
Add vector and point.
- `Point2 operator- (const Vector2 &vec) const`
Subtract vector from point.

Protected Attributes

- double `coordX`
- double `coordY`
- double `coordZ`
- `Triangle2 * pAssociatedTriangle`
- int `customIndex`

Friends

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

6.20.1 Detailed Description

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

6.20.2 Constructor & Destructor Documentation

6.20.2.1 Point2() [1/3]

```
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

6.20.2.2 Point2() [2/3]

```
GEOM_FADE25D::Point2::Point2 ( ) [inline]
```

6.20.2.3 Point2() [3/3]

```
GEOM_FADE25D::Point2::Point2 (
    const Point2 & p_ ) [inline]
```

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

6.20.3 Member Function Documentation

6.20.3.1 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/>

6.20.3.2 getIncidentTriangle()

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

Returns

the associated triangle

6.20.3.3 getMaxAbs()

```
double GEOM_FADE25D::Point2::getMaxAbs ( ) const [inline]
```

6.20.3.4 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

6.20.3.5 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

6.20.3.6 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

6.20.3.7 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

6.20.3.8 print()

```
void GEOM_FADE25D::Point2::print () [inline]
```

Internal, prints the coordinates to stdout

6.20.3.9 samePoint()

```
bool GEOM_FADE25D::Point2::samePoint (
    const Point2 & p ) const [inline]
```

Compares the x,y,z coordinates while [operator==\(\)](#) compares only x,y

6.20.3.10 set() [1/2]

```
void GEOM_FADE25D::Point2::set (
    const double x_,
    const double y_,
    const double z_,
    int customIndex_ ) [inline]
```

Internal method

Parameters

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

6.20.3.11 set() [2/2]

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

Parameters

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

6.20.3.12 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/>

6.20.3.13 setHeight()

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

Allows to exchange the z-coordinate

6.20.3.14 setIncidentTriangle()

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

Parameters

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

6.20.3.15 x()

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

Returns

the x-coordinate

6.20.3.16 xy()

```
void GEOM_FADE25D::Point2::xy (
    double & x_,
    double & y_ ) const [inline]
```

Parameters

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

6.20.3.17 xyz()

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

Parameters

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

6.20.3.18 y()

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

Returns

the y-coordinate

6.20.3.19 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

6.21 GEOM_FADE25D::Segment2 Class Reference

Segment.

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

Public Member Functions

- [Segment2 \(const Point2 &src_, const Point2 &trg_\)](#)
Create a Segment2.
- [Segment2 \(\)](#)
- [Point2 getSrc \(\) const](#)
- [Point2 getTrg \(\) const](#)
- [double getSqLen2D \(\) const](#)
- [double getSqLen25D \(\) const](#)
- [void swapSrcTrg \(\)](#)
- [bool operator== \(const Segment2 &other\) const](#)

Protected Attributes

- [Point2 src](#)
- [Point2 trg](#)

Friends

- [std::ostream & operator<< \(std::ostream &stream, Segment2 seg\)](#)

6.21.1 Detailed Description

6.21.2 Constructor & Destructor Documentation

6.21.2.1 Segment2() [1/2]

```
GEOM_FADE25D::Segment2::Segment2 (
    const Point2 & src_,
    const Point2 & trg_ )
```

Parameters

<i>src</i> ↵	First endpoint (source)
<i>trg</i> ↵	Second endpoint (target)

6.21.2.2 Segment2() [2/2]

```
GEOM_FADE25D::Segment2::Segment2 ( )
```

Create a [Segment2](#) Default constructor

6.21.3 Member Function Documentation

6.21.3.1 getSqLen25D()

```
double GEOM_FADE25D::Segment2::getSqLen25D ( ) const
```

Get the squared length (2.5D version)

6.21.3.2 getSqLen2D()

```
double GEOM_FADE25D::Segment2::getSqLen2D ( ) const
```

Get the squared length

6.21.3.3 getSrc()

```
Point2 GEOM_FADE25D::Segment2::getSrc ( ) const
```

Get the source point

Returns

the source point

6.21.3.4 getTrg()

```
Point2 GEOM_FADE25D::Segment2::getTrg ( ) const
```

Get the target point

Returns

the target point

6.21.3.5 operator==()

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

operator==

Undirected equality operator

6.21.3.6 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

6.22 GEOM_FADE25D::SegmentChecker Class Reference

[SegmentChecker](#) identifies intersecting line segments.

```
#include <SegmentChecker.h>
```

Public Member Functions

- [SegmentChecker](#) (const std::vector< [Segment2](#) *> &vSegments_)
- [Segment2 * getSegment](#) (size_t i) const
- [size_t getNumberOfSegments](#) () const
- [int getIndex](#) ([Segment2](#) *pSeg) const
- [void subscribe](#) (MsgType msgType, [MsgBase](#) *pMsg)
- [void unsubscribe](#) (MsgType msgType, [MsgBase](#) *pMsg)
- [void showSegments](#) (const std::string &name) const
- [void showIllegalSegments](#) (bool bAlsoEndPointIntersections, const std::string &name) const
- [void getIllegalSegments](#) (bool bAlsoEndPointIntersections, std::vector< [Segment2](#) *> &vIllegalSegmentsOut) const
- [SegmentIntersectionType getIntersectionType](#) (const [Segment2](#) *pSeg1, const [Segment2](#) *pSeg2) const
- [void getIntersectors](#) ([Segment2](#) *pTestSegment, bool bAlsoEndPointIntersections, std::vector< std::pair< [Segment2](#) *, [SegmentIntersectionType](#) > > &vIntersectorsOut) 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
- [std::string getIntersectionTypeString](#) ([SegmentIntersectionType](#) sit) const

6.22.1 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.

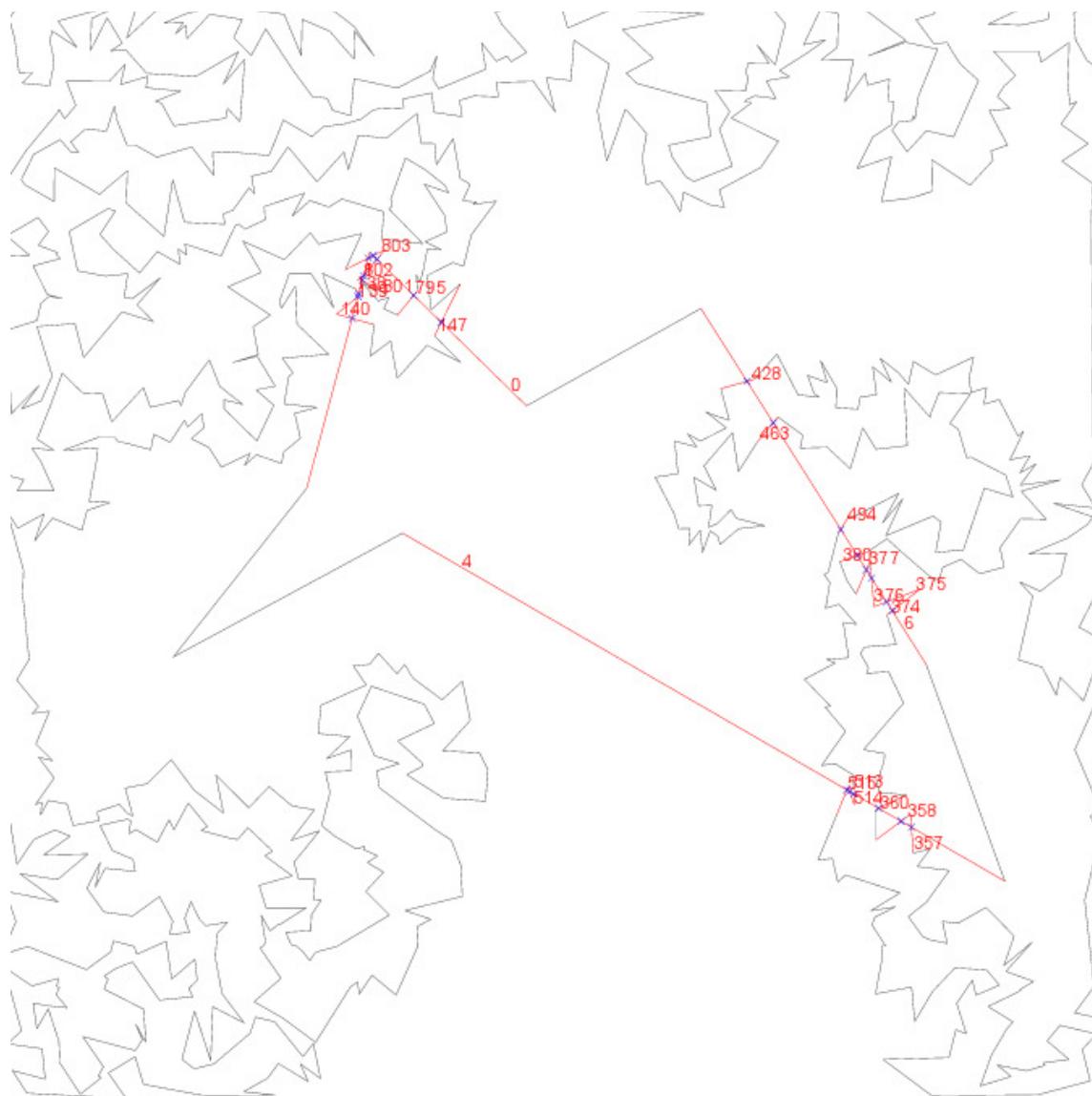


Figure 22 Polyline segments: Intersecting segments are automatically found

See also

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

6.22.2 Constructor & Destructor Documentation

6.22.2.1 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
--------------------------------------	-------------------------------------

6.22.3 Member Function Documentation**6.22.3.1 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

6.22.3.2 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
-------------	--

6.22.3.3 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.

6.22.3.4 [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.

6.22.3.5 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

6.22.3.6 getIntersectionTypeString()

```
std::string GEOM_FADE25D::SegmentChecker::getIntersectionTypeString (
    SegmentIntersectionType sit ) const
```

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
------------	---

6.22.3.7 getIntersectors()

```
void GEOM_FADE25D::SegmentChecker::getIntersectors (
    Segment2 * pTestSegment,
    bool bAlsoEndPointIntersections,
    std::vector< std::pair< Segment2 *, SegmentIntersectionType > > & vIntersectors<-
Out ) 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>vIntersectorsOut</i>	is the output vector. Segments intersecting <i>pTestSegment</i> are added to <i>vIntersectorsOut</i> along with their intersection type.
Generated by Doxygen	

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`.

6.22.3.8 `getNumberOfSegments()`

```
size_t GEOM_FADE25D::SegmentChecker::getNumberOfSegments ( ) const
```

Returns the number of segments contained in this [SegmentChecker](#) object

6.22.3.9 `getSegment()`

```
Segment2* GEOM_FADE25D::SegmentChecker::getSegment (
    size_t i ) const
```

Returns the i -th segment

Parameters

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

6.22.3.10 `showIllegalSegments()`

```
void GEOM_FADE25D::SegmentChecker::showIllegalSegments (
    bool bAlsoEndPointIntersections,
    const std::string & name ) const
```

Write a postscript file, highlight illegal segments

Parameters

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

showIllegalSegments.ps

Geom Fade 2.5D, student version

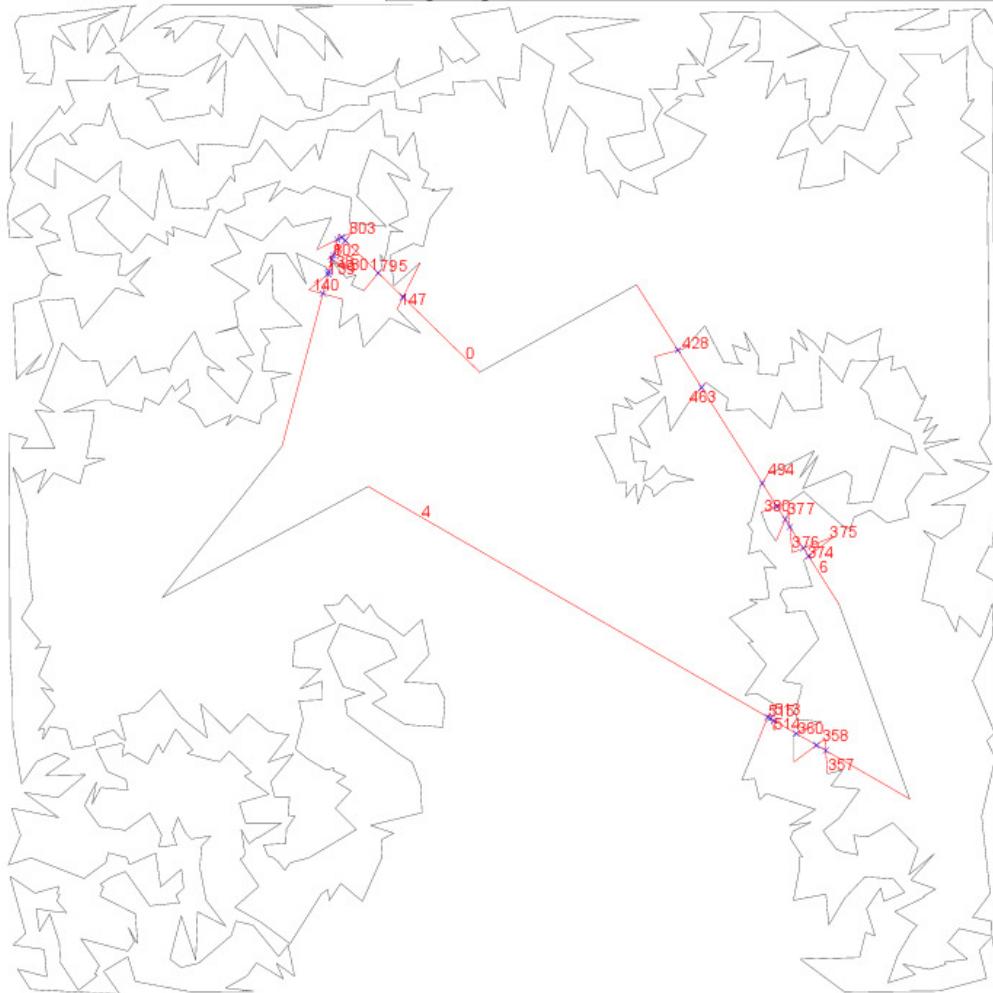
x-Range: [-99.8465 - 99.9001] = 199.747
y-Range: [-99.9906 - 99.9987] = 199.989

SegmentChecker::showIllegalSegments()

Number of segments: 1009

Legal segments: 983

Illegal segments: 26

**Figure 23 Visualization of polyline intersections****6.22.3.11 showSegments()**

```
void GEOM_FADE25D::SegmentChecker::showSegments (
    const std::string & name ) const
```

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

Parameters

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

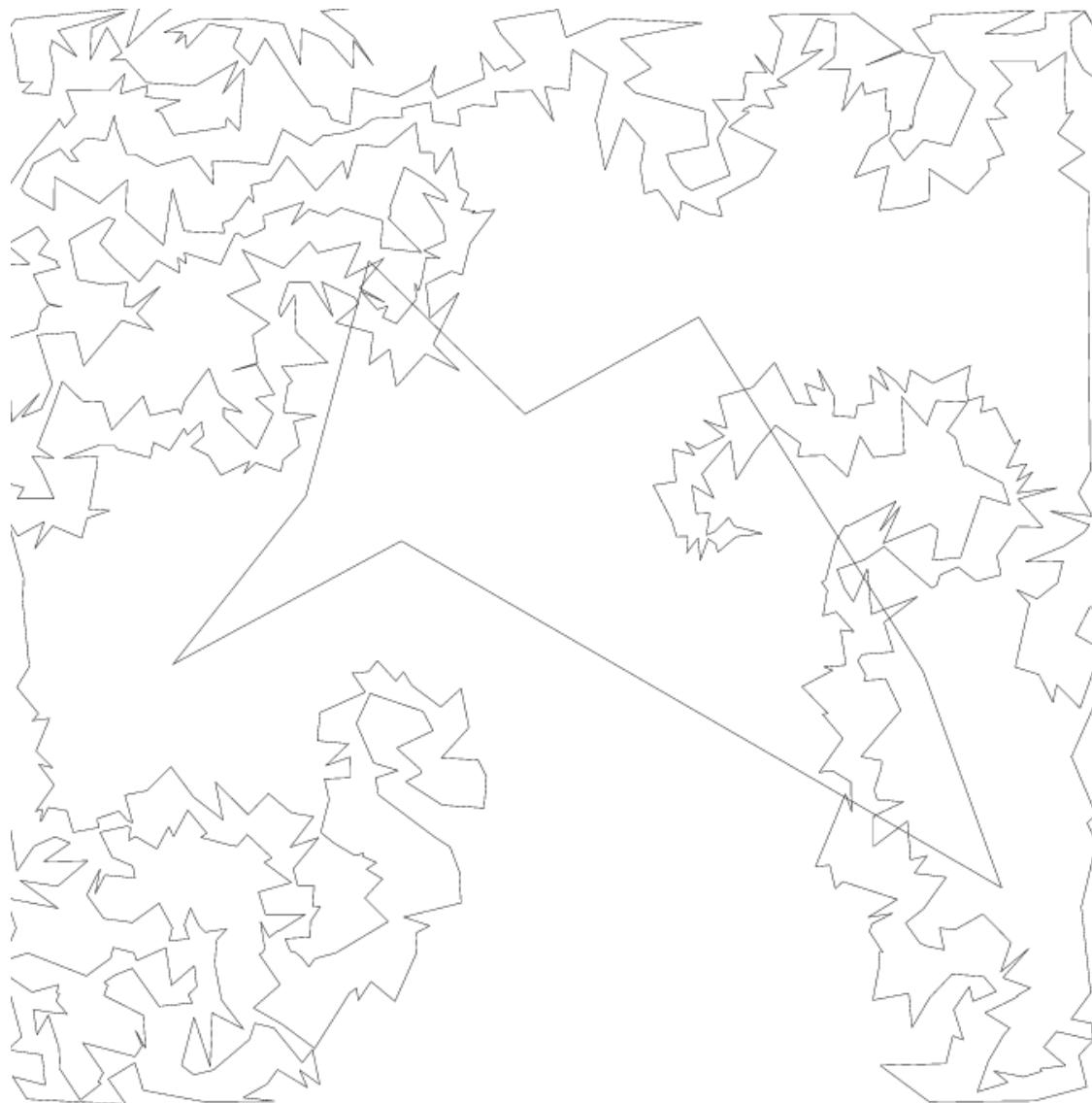


Figure 24 Line segments written to a postscript file

6.22.3.12 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 .

6.22.3.13 unsubscribe()

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

Unregister a progress bar object

Parameters

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

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

- [SegmentChecker.h](#)

6.23 GEOM_FADE25D::Triangle2 Class Reference

Triangle.

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

Public Member Functions

- [Triangle2 \(\)](#)
Constructor.
- [Point2 * getCorner \(const int ith\) const](#)
Get the i-th corner of the triangle.
- [std::pair< Point2, bool > getDual \(\) const](#)
Get the dual Voronoi vertex.
- [Point2 getBarycenter \(\) const](#)
Get the barycenter of a triangle.
- [Vector2 getNormalVector \(\) const](#)
Get the normal vector of a triangle.
- [double getInteriorAngle2D \(int ith\) const](#)
Get interior 2D angle.
- [double getInteriorAngle25D \(int ith\) const](#)
Get interior 2.5D angle.
- [double getArea2D \(\) const](#)
Get 2D Area.

- double `getArea25D () const`
Get 2.5D Area.
- `Triangle2 * getOppositeTriangle (const int ith) const`
Get the i-th neighbor triangle.
- int `getIntraTriangleIndex (const Point2 *p) const`
Get the index of p in the triangle.
- int `getIntraTriangleIndex (const Triangle2 *pTriangle) const`
Get the neighbor index of pTriangle.
- int `getIntraTriangleIndex (const Point2 *p0, const Point2 *p1) const`
Get the index of (p0,p1)
- double `getSquaredEdgeLength2D (int ith) const`
Method for internal use.
- double `getSquaredEdgeLength25D (int ith) const`
Squared edge length.
- 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 `clearProperties ()`
Clear all corners and neighbor pointers.
- 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.
- bool `hasVertex (Point2 *pVtx) const`
Has vertex.
- bool `hasVertex (const Point2 &vtx) const`
Has vertex.
- bool `hasOnEdge (int i, const Point2 &q) const`
Has point on edge.
- int `getMaxIndex () const`
Get the index of the largest edge.
- int `getMinIndex () const`
Get the index of the smallest edge.
- double `getMaxSqEdgeLen2D () const`
Get the maximum squared 2D edge length.

Protected Member Functions

- double `computeArea (double l0, double l1, double l2) const`
- bool `isAccurateCC (int maxIdx, const Point2 &cc) const`
- bool `getCC_strategy1 (double avgOffX, double avgOffY, Point2 &cc) const`
- void `getCC_strategy2 (int maxIdx, double avgOffX, double avgOffY, Point2 &cc) const`
- void `getCommonOffset (double &x, double &y) const`

Protected Attributes

- `Point2 * aVertexPointer [3]`
- `Triangle2 * aOppTriangles [3]`

Friends

- std::ostream & **operator<<** (std::ostream &stream, const Triangle2 &c)
- void **registerTriangles** (Triangle2 *fromTriangle, int ith, Triangle2 *toTriangle, int jth)

6.23.1 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.

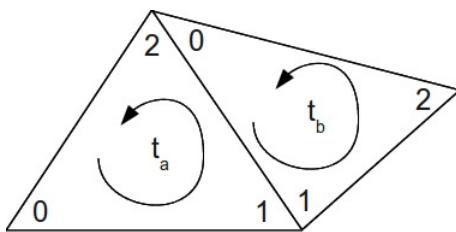


Figure 25 Indices and neighborships, t_b is the 0-th neighbor of t_a and t_a is the 2nd neighbor of t_b .

See also

[TriangleAroundVertexIterator](#) to find out how to access all triangles incident to a certain vertex.

6.23.2 Constructor & Destructor Documentation

6.23.2.1 Triangle2()

```
GEOM_FADE25D::Triangle2::Triangle2 ( ) [inline]
```

6.23.3 Member Function Documentation

6.23.3.1 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\(\)](#)

6.23.3.2 `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\(\)](#)

6.23.3.3 `getBarycenter()`

```
Point2 GEOM_FADE25D::Triangle2::getBarycenter ( ) const
```

Returns

the barycenter of the triangle.

6.23.3.4 `getCorner()`

```
Point2 * GEOM_FADE25D::Triangle2::getCorner (
    const int ith ) const [inline]
```

Returns

a pointer to the *i*-th corner point of the triangle.

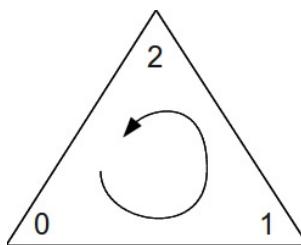


Figure 26 Intra triangle indices are ordered counterclockwise

Parameters

<i>ith</i>	is the intra-triangle-index, <i>ith</i> ={0,1,2}.
------------	---

6.23.3.5 `getDual()`

```
std::pair<Point2,bool> GEOM_FADE25D::Triangle2::getDual ( ) const
```

Returns

a std::pair<Point2,bool>, where the first component is the dual Voronoi vertex of the triangle and the second component is a boolean value which is true if the vertex is accurate. The z-coordinate of the returned point is always 0. Use [Fade_2D::getHeight\(..\)](#) to determine the height value.

Note

The true dual Voronoi vertex of an almost collinear Delaunay triangle can be outside the bounds of floating point arithmetic. In such cases this method returns a point with very large coordinates but still inside the range of double precision floating point arithmetic, and it will inform the user by setting the boolean return value to false.

Such cases can easily be avoided by insertion of four dummy vertices around the triangulation, e.g., at coordinates ten times larger than the domain of the data points. This will automatically restrict the Voronoi diagram of the data points to this range.

6.23.3.6 getInteriorAngle25D()

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

Returns

the interior 2.5D angle at the ith vertex

6.23.3.7 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

6.23.3.8 getIntraTriangleIndex() [1/3]

```
int GEOM_FADE25D::Triangle2::getIntraTriangleIndex (
    const Point2 * p ) const [inline]
```

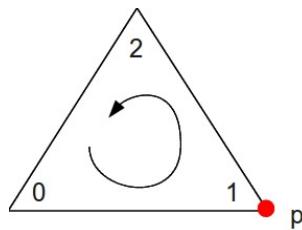


Figure 27 Intra triangle index of a vertex pointer

Parameters

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

Returns

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

6.23.3.9 getIntraTriangleIndex() [2/3]

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

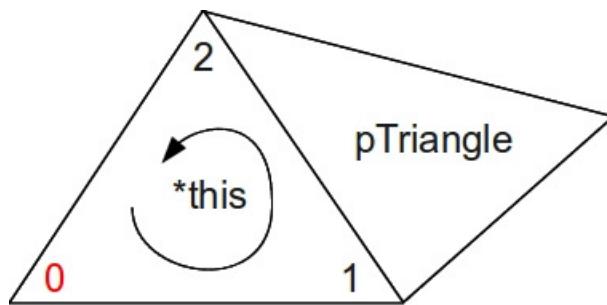


Figure 28 *pTriangle* is the 0-th neighbor of **this*

Parameters

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

Returns

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

6.23.3.10 getIntraTriangleIndex() [3/3]

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

Returns

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

6.23.3.11 getNormalVector()

```
Vector2 GEOM_FADE25D::Triangle2::getNormalVector ( ) const
```

Returns

the normalized normal vector

6.23.3.12 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.

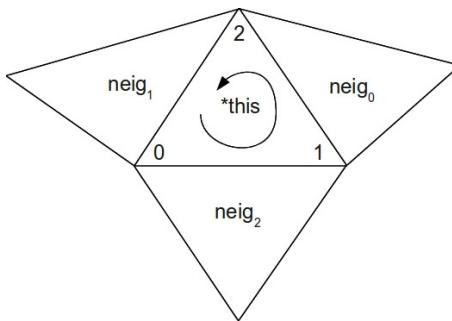


Figure 29 Neighbors of a triangle

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.

6.23.3.13 getSquaredEdgeLength25D()

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

Returns the squared length of the *ith* edge.

6.23.3.14 getSquaredEdgeLength2D()

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

Internal useSquared edge length

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

6.23.3.15 hasOnEdge()

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

Returns

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

6.23.3.16 hasVertex() [1/2]

```
bool GEOM_FADE25D::Triangle2::hasVertex (
    Point2 * pVtx ) const
```

Returns

if `pVtx` is a corner of the triangle

6.23.3.17 hasVertex() [2/2]

```
bool GEOM_FADE25D::Triangle2::hasVertex (
    const Point2 & vtx ) const
```

Returns

if `vtx` is a corner of the triangle

6.23.3.18 setOppTriangle()

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

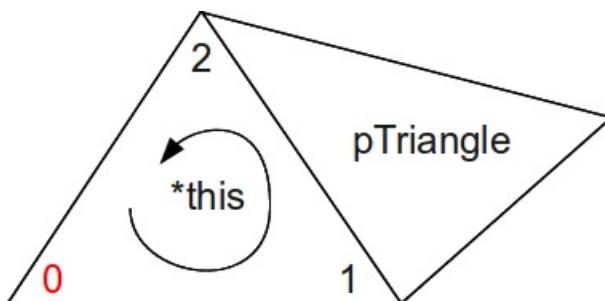


Figure 30 Make `pTriangle` the 0-th neighbor of `*this`

Parameters

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

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

- Triangle2.h

6.24 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 (Point2 *pPnt_, Triangle2 *pTr_)`
Constructor.
- `TriangleAroundVertexIterator (const TriangleAroundVertexIterator &it)`
Copy constructor.
- `TriangleAroundVertexIterator & operator= (const TriangleAroundVertexIterator &other)`
- `TriangleAroundVertexIterator & operator++ ()`
Proceed to the next triangle (the one in counterclockwise order)
- `TriangleAroundVertexIterator & operator-- ()`
Proceed to the previous triangle (the one in clockwise order)
- `bool operator== (const TriangleAroundVertexIterator &rhs)`
operator==()
- `bool operator!= (const TriangleAroundVertexIterator &rhs)`
operator!=()
- `Triangle2 * operator* ()`
Returns a pointer to the current triangle (or NULL)
- `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 * pTr`
- `Triangle2 * pSavedTr`

6.24.1 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.

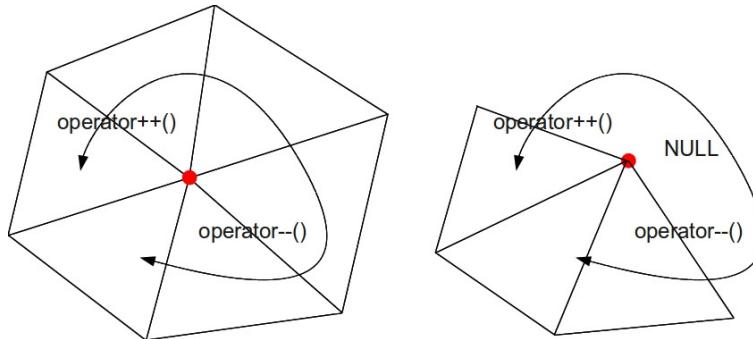


Figure 31 Left: the iterator visits the triangles around a vertex. **Right:** The iterator 'jumps' over the border edges of the triangulation

6.24.2 Constructor & Destructor Documentation

6.24.2.1 `TriangleAroundVertexIterator()` [1/3]

```
GEOM_FADE25D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (
    const Point2 * pPnt_ ) [inline], [explicit]
```

Parameters

p_{\leftarrow} Pnt_{\leftarrow} —	is the vertex whose incident triangles can be visited with the iterator
---	---

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

6.24.2.2 `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
pTr_{\leftarrow} —	is the triangle the iterator initially points to

6.24.2.3 TriangleAroundVertexIterator() [3/3]

```
GEOM_FADE25D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (
    const TriangleAroundVertexIterator & it ) [inline]
```

Copies the iterator `it`

6.24.3 Member Function Documentation

6.24.3.1 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

6.24.3.2 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.

6.24.3.3 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.

6.24.3.4 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.

6.24.3.5 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

6.24.3.6 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.

6.24.3.7 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](#)

6.25 GEOM_FADE25D::UserPredicateT Class Reference

User defined predicate.

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

Public Member Functions

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

6.25.1 Detailed Description

See also

<http://www.geom.at/remove-border-triangles/>

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

- UserPredicates.h

6.26 GEOM_FADE25D::Vector2 Class Reference

Vector.

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

Public Member Functions

- **Vector2** (const double x_, const double y_, const double z_)
Constructor.
- **Vector2** ()
Default constructor.
- **Vector2** (const **Vector2** &v_)
Copy constructor.
- **Vector2 orthogonalVector** () const
Get an orthogonal vector (CCW direction)
- bool **isDegenerate** () const
isDegenerate
- double **x** () const
Get the x-value.
- double **y** () const
Get the y-value.
- double **z** () const
Get the z-value.
- void **set** (const double x_, const double y_, const double z_)
Set the values.
- double **sqLength** () const
Get the squared length of the vector.

- int `getMaxIndex () const`
Get max index.
- double `length () const`
Get the length of the vector.
- double `operator* (const Vector2 &other) const`
Scalar product.
- `Vector2 operator* (double val) const`
Multiply by a scalar value.
- `Vector2 operator/ (double val) const`
Divide by a scalar value.

Protected Attributes

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

6.26.1 Detailed Description

This class represents a vector in 2D

6.26.2 Constructor & Destructor Documentation

6.26.2.1 Vector2() [1/3]

```
GEOM_FADE25D::Vector2::Vector2 (
    const double x_,
    const double y_,
    const double z_ )
```

6.26.2.2 Vector2() [2/3]

```
GEOM_FADE25D::Vector2::Vector2 ( )
```

The vector is initialized to (0,0,0)

6.26.2.3 Vector2() [3/3]

```
GEOM_FADE25D::Vector2::Vector2 (
    const Vector2 & v_ )
```

Create a copy of vector v_

6.26.3 Member Function Documentation

6.26.3.1 getMaxIndex()

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

Returns

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

6.26.3.2 isDegenerate()

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

Returns

true if the vector length is 0, false otherwise.

6.26.3.3 orthogonalVector()

```
Vector2 GEOM_FADE25D::Vector2::orthogonalVector ( ) const
```

Note

: Only (x,y) coordinates are computed, z=0

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

- Vector2.h

6.27 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 std::string &filename_)

Constructor.
- void **addObject** (const **Segment2** &seg, const **Color** &c)

*Add a **Segment2** object to the visualization.*
- void **addObject** (const **Edge2** &edge, const **Color** &c)

*Add an **Edge2** object 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< **Point2** *> &vPoints, const **Color** &c)

*Add a vector of **Point2*** 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< **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< **Triangle2** > &vT, const **Color** &c)

*Add a vector of **Triangle2** objects to the visualization.*
- void **addObject** (const **Circle2** &circ, const **Color** &c)

*Add a **Circle2** object to the visualization.*
- void **addObject** (const **Point2** &pnt, const **Color** &c)

*Add a **Point2** object to the visualization.*
- void **addObject** (const **Triangle2** &tri, const **Color** &c)

*Add a **Triangle2** object to the visualization.*
- void **addObject** (const std::vector< **Triangle2** *> &vT, const **Color** &c)

*Add a **Triangle2*** vector to the visualization.*
- void **addObject** (const **Label** &lab, const **Color** &c)

*Add a **Label** object to the visualization.*
- void **addHeaderLine** (const std::string &s)

Add a header line to the visualization.
- void **writeFile** ()

Finish and write the postscript file.

Protected Member Functions

- void **writeHeaderLines** ()
- **Point2 scaledPoint** (const **Point2** &p)
- double **scaledDouble** (const double &d)
- void **changeColor** (float r, float g, float b, float linewidth, bool bFill)
- void **changeColor** (const **Color** &c)
- void **writeHeader** (const std::string &title)
- void **writeFooter** ()
- void **writeLabel** (**Label** l)
- void **writeLine** (const **Point2** &pSource, const **Point2** &pTarget)
- 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 **writePoint** (**Point2** &p1_, float size)
- void **writeCircle** (const **Point2** &p1_, double radius, bool bFill)
- void **periodicStroke** ()
- void **setRange** ()

Protected Attributes

- std::ofstream **outFile**
- std::vector< std::pair< Segment2, Color > > **vSegments**
- std::vector< std::pair< Circle2, Color > > **vCircles**
- std::vector< std::pair< Point2, Color > > **vPoints**
- std::vector< std::pair< Triangle2, Color > > **vTriangles**
- std::vector< std::pair< Label, Color > > **vLabels**
- int **updateCtr**
- Bbox2 **bbox**
- bool **bFill**
- Color **lastColor**
- std::string **filename**
- std::vector< std::string > **vHeaderLines**
- bool **bFileClosed**

6.27.1 Detailed Description

See also

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

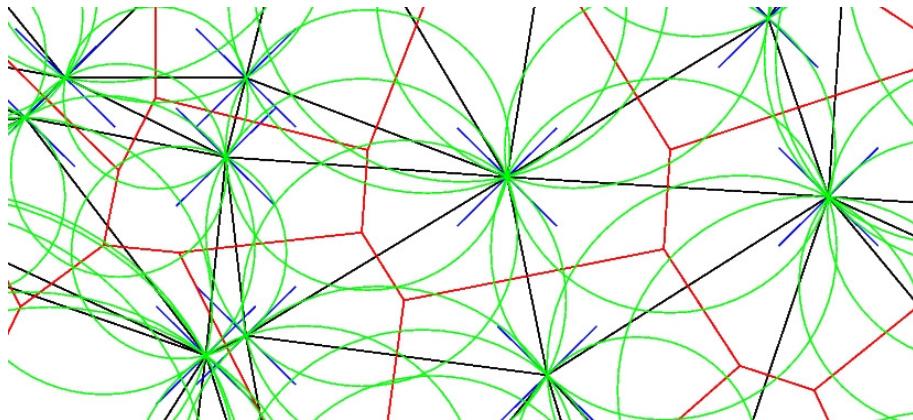


Figure 32 Example output of the Visualizer

6.27.2 Constructor & Destructor Documentation

6.27.2.1 Visualizer2()

```
GEOM_FADE25D::Visualizer2::Visualizer2 (
    const std::string & filename_ ) [explicit]
```

Parameters

<i>filename</i> ↞	is the name of the postscript file to be written
—	

6.27.3 Member Function Documentation

6.27.3.1 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

6.28 GEOM_FADE25D::Zone2 Class Reference

[Zone2](#) is an exactly defined area of a triangulation.

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

Public Member Functions

- ZoneLocation [getZoneLocation](#) () const
Get the zone location.
- Zone2 * [convertToBoundedZone](#) ()
Convert a zone to a bounded zone.
- void [show](#) (const std::string &postscriptFilename, bool bShowFull, bool bWithConstraints) const
Postscript visualization.
- void [show](#) (Visualizer2 *pVisualizer, bool bShowFull, bool bWithConstraints) const
Postscript visualization.
- void [showGeomview](#) (const std::string &filename, const std::string &color) const
Geomview visualization.
- void [showGeomview](#) (Visualizer3 *pVis, const std::string &color) const
Geomview visualization.
- void [analyzeAngles](#) ()
- void [slopeValleyRidgeOptimization](#) ()
- void [optimizeValleysAndRidges](#) (double tolerance2D, double lowerThreshold25D)
- void [unifyGrid](#) (double tolerance)
- 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.
- void [statistics](#) (const std::string &s) const
- ConstraintGraph2 * [getConstraintGraph](#) () const
Get the associated constraint.
- size_t [getNumberOfTriangles](#) () const
Get the number of triangles.

- void [getConstraintGraphs](#) (std::vector< ConstraintGraph2 *> &vConstraintGraphs_) const
Get the associated constraint graphs.
- size_t [numberOfConstraintGraphs](#) () const
Get a the number of `ConstraintGraph2` objects.
- void [debug](#) (std::string name="")
Development function.
- [Bbox2 getBoundingBox](#) () const
Compute the bounding box.
- void [getBoundaryEdges](#) (std::vector< Edge2 > &vEdges) const
Compute the boundary edges of the zone.
- void [getBoundarySegments](#) (std::vector< Segment2 > &vSegments) const
Compute the boundary segments of the zone.
- double [getArea2D](#) () const
Get 2D Area.
- double [getArea25D](#) () const
Get 2.5D Area.
- void [getBorderEdges](#) (std::vector< Edge2 > &vBorderEdgesOut) const
Get border edges.

Protected Attributes

- Dt2 * **pDt**
- ZoneLocation **zoneLoc**

Friends

- Zone2 * [zoneUnion](#) (Zone2 *pZone0, Zone2 *pZone1)
Compute the union of two zones.
- Zone2 * [zoneIntersection](#) (Zone2 *pZone0, Zone2 *pZone1)
Compute the intersection of two zones.
- Zone2 * [zoneDifference](#) (Zone2 *pZone0, Zone2 *pZone1)
Compute the difference of two zones.
- Zone2 * [zoneSymmetricDifference](#) (Zone2 *pZone0, Zone2 *pZone1)
Compute the symmetric difference of two zones.
- Zone2 * [peelOffIf](#) (Zone2 *pZone, UserPredicateT *pPredicate, bool bVerbose)

6.28.1 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

6.28.2 Member Function Documentation

6.28.2.1 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 *this* if this->[getZoneLocation\(\)](#) is ZL_INSIDE.

6.28.2.2 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\(\)](#)

6.28.2.3 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\(\)](#)

6.28.2.4 getBorderEdges()

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

Returns

: the CCW oriented border edges of the zone

6.28.2.5 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.

6.28.2.6 getConstraintGraphs()

```
void GEOM_FADE25D::Zone2::getConstraintGraphs (
    std::vector< ConstraintGraph2 *> & vConstraintGraphs_ ) const
```

6.28.2.7 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.

6.28.2.8 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.

6.28.2.9 getVertices()

```
void GEOM_FADE25D::Zone2::getVertices (
    std::vector< Point2 *> & vVertices_ ) const
```

6.28.2.10 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

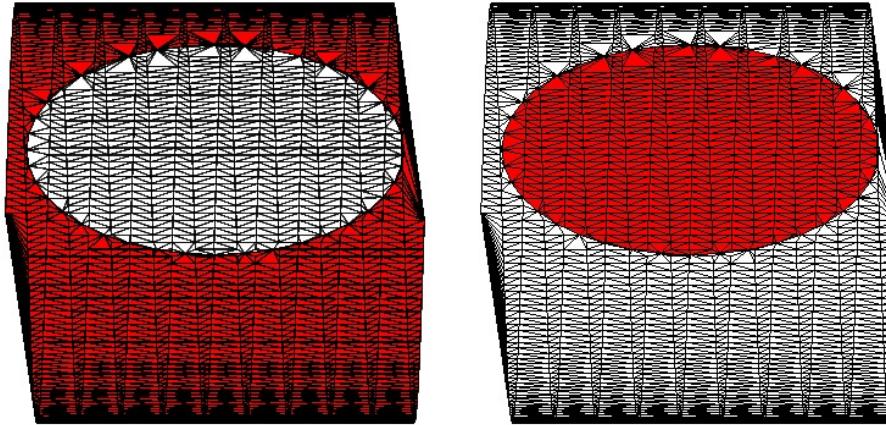


Figure 33 An outside zone and in inside zone

6.28.2.11 `numberOfConstraintGraphs()`

```
size_t GEOM_FADE25D::Zone2::numberOfConstraintGraphs ( ) const
```

A [Zone2](#) object might be defined by zero, one or more [ConstraintGraph2](#) objects.

6.28.2.12 `optimizeValleysAndRidges()`

```
void GEOM_FADE25D::Zone2::optimizeValleysAndRidges ( 
    double tolerance2D,
    double lowerThreshold25D )
```

Optimize Valleys and Ridges

A Delaunay triangulation not unique when when 2 or more triangles share a common circumcircle. As a consequence the four corners of a rectangle can be triangulated in two different ways: Either the diagonal proceeds from the lower left to the upper right corner or it connects the other two corners. Both solutions are valid and an arbitrary one is applied when points are triangulated. To improve the repeatability and for reasons of visual appearance this method unifies such diagonals such that they point from the lower left to the upper right corner (or in horizontal direction).

Moreover a Delaunay triangulation does not take the z-value into account and thus valleys and ridges may be disturbed. The present method flips diagonals such that they point from the lower left to the upper right corner of a quad. And if the 2.5D lengths of the diagonals are significantly different, then the shorter one is applied.

Parameters

<i>tolerance2D</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>tolerance2D</i> is an upper threshold to allow modification despite such tiny inaccuracies.
<i>lowerThreshold25D</i>	is used to take also the heights of the involved points into account. For example, the points Point_2 a(0,0,0); Point_2 b(10,0,0); Point_2 c(10,10,0); Point_2 d(0,10,1000); can form the triangles (a,b,c) and (a,c,d) or the triangles (a,b,d) and (d,b,c) but (a,c) is obviously the better diagonal because the points a,b,c share the same elevation while d is at z=1000. Technically spoken, the diagonal with the smaller 2.5D-length is applied if the both, the 2D error is below <i>tolerance2D</i> and the 2.5D error is above <i>lowerThreshold25D</i> . The 2.5D criterion has priority over the 2D criterion.

6.28.2.13 show() [1/2]

```
void GEOM_FADE25D::Zone2::show (
    const std::string & postscriptFilename,
    bool bShowFull,
    bool bWithConstraints ) const
```

Parameters

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

6.28.2.14 show() [2/2]

```
void GEOM_FADE25D::Zone2::show (
    Visualizer2 * pVisualizer,
    bool bShowFull,
    bool bWithConstraints ) const
```

Parameters

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

Note

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

Parameters

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

6.28.2.15 showGeomview() [1/2]

```
void GEOM_FADE25D::Zone2::showGeomview (
    const std::string & filename,
    const std::string & 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"*

6.28.2.16 showGeomview() [2/2]

```
void GEOM_FADE25D::Zone2::showGeomview (
    Visualizer3 * pVis,
    const std::string & 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"*

6.28.2.17 slopeValleyRidgeOptimization()

```
void GEOM_FADE25D::Zone2::slopeValleyRidgeOptimization ( )
```

Optimize Slopes, Valleys and Ridges

6.28.2.18 statistics()

```
void GEOM_FADE25D::Zone2::statistics (
    const std::string & s ) const
```

Statistics

Prints statistics to stdout.

6.28.2.19 unifyGrid()

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

Unify Grid

A Delaunay triangulation is not unique when two or more triangles share a common circumcircle. As a consequence the four corners of a rectangle can be triangulated in two different ways: Either the diagonal proceeds from the lower left to the upper right corner or it connects the other two corners. Both solutions are valid and an arbitrary one is applied when points are triangulated. To improve the repeatability and for reasons of visual appearance this method unifies such diagonals to point from the lower left to the upper right corner (or in horizontal direction).

Parameters

<code>tolerance</code>	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 <code>tolerance</code> 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.
------------------------	--

6.28.3 Friends And Related Function Documentation

6.28.3.1 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.

6.28.3.2 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.

6.28.3.3 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.

6.28.3.4 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 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`)

7.1.1 Enumeration Type Documentation

7.1.1.1 CAFTYP

`enum GEOM_FADE25D::CAFTYP`

enumerates the three possible Cut-And-Fill types

Enumerator

<code>CT_NULL</code>	the first surface corresponds to the second one
<code>CT_CUT</code>	the first surface is above the second one
<code>CT_FILL</code>	the first surface is below the second one

7.1.2 Function Documentation

7.1.2.1 operator<<()

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

Report

7.2 Color.h File Reference

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

Classes

- class `GEOM_FADE25D::Color`
Color.

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)`

7.3 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` {
 `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:

7.3.1 Enumeration Type Documentation

7.3.1.1 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_25D/terrain.cpp`.

Note

In former library versions the terms `CIS_IGNORE_DELAUNAY` and `CIS_KEEP_DELAUNAY` were used but these were misleading and are now deprecated. For backwards compatibility they are kept.

Enumerator

CIS_CONSTRAINED_DELAUNAY	Deprecated.
CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL	Deprecated.
CIS_KEEP_DELAUNAY	Deprecated name.
CIS_IGNORE_DELAUNAY	Deprecated.

7.4 EfficientModel.h File Reference

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

Classes

- class [GEOM_FADE25D::EfficientModel](#)
EfficientModel.

Enumerations

- enum [GEOM_FADE25D::SmoothingStrategy](#) { [GEOM_FADE25D::SMS_MINIMUM](#), [GEOM_FADE25D::SMS_MAXIMUM](#), [GEOM_FADE25D::SMS_MEDIAN](#), [GEOM_FADE25D::SMS_AVERAGE](#) }
SmoothingStrategy for EfficientModel::zSmoothing()

7.4.1 Enumeration Type Documentation**7.4.1.1 SmoothingStrategy**

```
enum GEOM\_FADE25D::SmoothingStrategy
```

Enumerator

SMS_MINIMUM	Assign the minimum height.
SMS_MAXIMUM	Assign the maximum height.
SMS_MEDIAN	Assign the median height.
SMS_AVERAGE	Assign the average height.

7.5 SegmentChecker.h File Reference

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

```
#include "MsgBase.h"
```

Classes

- class [GEOM_FADE25D::SegmentChecker](#)
SegmentChecker identifies intersecting line segments.

Enumerations

- enum [SegmentIntersectionType](#) {
 SIT_UNINITIALIZED, SIT_NONE, SIT_SEGMENT, SIT_POINT,
 SIT_ENDPOINT }

7.5.1 Enumeration Type Documentation

7.5.1.1 SegmentIntersectionType

```
enum SegmentIntersectionType
```

The Segment intersection type enumerates the way two line segments intersect each other

Enumerator

SIT_UNINITIALIZED	Invalid value
SIT_NONE	No intersection
SIT_SEGMENT	The intersection is a non-degenerate segment (collinear intersection)
SIT_POINT	The intersection is a single point differnt from the endpoints
SIT_ENDPOINT	The two segments share a common endpoint which is the only intersection

7.6 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.

Functions

- int [GEOM_FADE25D::inc1](#) (int num)
- int [GEOM_FADE25D::inc2](#) (int num)

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