

Fade2D

v1.93

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1 Main Page

1.1 C++ Delaunay Triangulation and Voronoi library Fade2D

- Fast C++ Constrained Delaunay triangulation and Voronoi library , [see the benchmark](#).
- C++ examples for
 - [2D Delaunay triangulations](#),

- 2D Voronoi C++ code examples and
- 2.5D triangulations.
- Free Student license. Commercial licenses and support are available.
- Support for Windows (Visual Studio), MacOS (Clang), Linux (GCC) on PC and Raspberry PI

1.1.1 Using the C++ Constrained Delaunay triangulation library:

- Download.
- Unzip.
- Start to play with the included C++ example source codes: [The first example is described here.](#)

Fade comes as two separate libraries:

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

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

1.1.2 Compiling and Linking the Library under Windows:

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

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

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

1.1.3 Compiling and Linking the Library under Linux and Mac:

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

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

1.1.4 Directory Contents

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

1.1.5 Troubleshooting

- A supposed crash is often just an exception that has been thrown for a good reason. Use try.../catch() blocks to find out why.
- Do the examples work on your computer? Then compare their settings with your project settings.
- When updating from an earlier version: **UPDATE ALSO THE HEADER FILES.**
- Don't mix multiple Visual Studio versions. Use the right dll.
- In rare cases you might need to increase Properties->ConfigurationProperties->Linker->System->Stack↔ ReserveSize in your Visual Studio project settings.
- If your problem persists, don't hesitate to **send** a minimal example that reproduces it and it will be fixed asap.

1.1.6 Release notes / History

Version 1.93, September 1st, 2021:

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

Version 1.92, August 9th, 2021:

- Multithreading issue finally fixed.

Version 1.91, August 8th, 2021:

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

Version 1.90, August 8th, 2021:

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

Version 1.89, June 8th, 2021:

- Voronoi diagram: Numeric problems fixed.
- Visualizer: Scaling problem fixed.
- Circumcenter-computation improved.
- Segment intersection accuracy improved.

Version 1.88, June 4th, 2021:

- Voronoi diagram.
- Accuracy of Triangle::getDual() improved with multiple-precision arithmetic.

Version 1.87, May 5th., 2021:

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

Version 1.86, April 28th., 2021:

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

Version 1.85, March 8th., 2021:

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

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

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

v1.83, Dec. 30th, 2020:

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

v1.82, Nov. 15th, 2020:

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

v1.81, May 17th, 2020:

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

v1.80, March 25th, 2020:

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

v1.79, January 20th, 2020: Internal version. Revision.

v1.78, November 15th, 2019:

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

v1.77, October 21st, 2019

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

v1.75 and 1.76

- Non-public tests.

v1.74, March 19th, 2019:

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

v1.73, January 14th, 2019:

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

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

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

v1.70, October 17th, 2018:

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

v1.69, October 15th, 2018:

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

v1.68, September 14th, 2018:

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

v1.67, September 4th, 2018:

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

v1.66, August 25th, 2018:

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

v1.65, July 29th, 2018:

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

v1.64, July 21st, 2018:

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

v1.63, June 10th, 2018:

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

v1.62, June 3rd, 2018:

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

v1.61, May 1st, 2018:

- 3D Point Cloud Reconstruction: Unofficial demo.

v1.60, February 26th, 2018:

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

v1.59, January 14th, 2018:

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

v1.58, October 23th, 2017:

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

v1.57, October 9th, 2017:

- Nonpublic test code.

v1.56, September 24th, 2017:

- Bugfix: createConstraint() crashed in a rare case. Solved.

- Functions for binary file I/O added.

v1.55, August 12th, 2017:

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

v1.54beta, August 8th, 2017:

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

v1.53, July 15th, 2017:

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

v1.53 beta, June 2nd, 2017:

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

v1.51 beta, May 27th, 2017:

- Non-public test binary

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

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

v1.49, March 2nd, 2017:

- Constraint insertion subsystem improved.
- Mesh generator revised.

v1.48, February 15th, 2017:

- Corrections of yesterday's v1.47.

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

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

v1.46a, January 14th, 2017:

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

v1.46, January 8th, 2017:

- +++ MacOS is supported now +++ //

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

v1.43, November 20th, 2016:

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

v1.42, October 19th, 2016:

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

v1.41, July 24th, 2016:

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

v1.40 beta, June 14th, 2016:

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

v1.39, May 31st, 2016:

- Non public intermediate beta.

v1.37a, March 15th, 2016:

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

v1.37, March 10th, 2016:

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

v1.36, February 29th, 2016:

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

v1.34, February 14th, 2016:

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

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

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

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

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

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

- Non public intermediate release, improves the CDT.

v1.30, November 18th, 2015:

- Non public intermediate release, improves the `refineExtended` method.

v1.29, October 17th, 2015:

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

v1.28, October 10th, 2015:

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

v1.27, October 5th, 2015:

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

v1.26, September 8th, 2015:

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

v1.25, August 18th, 2015:

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

v1.24, July 22nd, 2015:

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

v1.23, July 9th, 2015:

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

v1.22, May 25th, 2015:

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

v1.21, May 17th, 2015:

- Unofficial intermediate release. Testing new features.

v1.20, April 5th, 2015:

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

v1.19, October 26th, 2014:

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

v1.18.3, June 9th, 2014:

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

v1.16.1, February 10th, 2014:

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

v1.16, February 3rd, 2014:

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

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

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

v1.13, August 4th, 2013:

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

v1.12, June 30th, 2013:

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

v1.11, June 14th, 2013:

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

v1.10, March 30th, 2013:

- Delaunay Refinement (already included as preview in the previous release) has been improved and is officially released now. Parts of the algorithm can use up to 8 CPUs under Linux if explicitly switched on using `Fade2↔D::enableMultithreading()`.
- There is a new insert method in the API which uses arrays.

v1.03, Nov. 4th, 2012:

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

v1.02, 9/2012:

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

v1.01, 9/2012:

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

2 Module Index

2.1 Modules

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3.1 Class List

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4 File Index

4.1 File List

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5 Module Documentation

5.1 Tools

Functions

- void [GEOM_FADE2D::edgesToPolygons](#) (std::vector< [Edge2](#) > &vEdgesIn, std::vector< std::vector< [Edge2](#) > > &vvPolygonsOut, std::vector< [Edge2](#) > &vRemainingOut)
Create polygons from a set of edges.
- bool [GEOM_FADE2D::fillHole](#) (std::vector< std::pair< [Segment2](#), [Vector2](#) > > vPolygonSegments, bool b↵WithRefine, bool bVerbose, std::vector< [Point2](#) > &vCornersOut)
Fill a hole in a 3D mesh with triangles (deprecated)
- double [GEOM_FADE2D::getArea2D](#) ([Point2](#) *p0, [Point2](#) *p1, [Point2](#) *p2)
Get 2D area of a triangle.
- void [GEOM_FADE2D::getBorders](#) (const std::vector< [Triangle2](#) * > &vT, std::vector< [Segment2](#) > &v↵BorderSegmentsOut)
Get Borders.
- void [GEOM_FADE2D::getConnectedComponents](#) (const std::vector< [Triangle2](#) * > &vT, std::vector< std↵::vector< [Triangle2](#) * > > &vvT)
Get connected components.
- void [GEOM_FADE2D::getDirectedEdges](#) (const std::vector< [Triangle2](#) * > &vT, std::vector< [Edge2](#) > &v↵DirectedEdgesOut)
Get directed edges The directed edges of vT are returned in vDirectedEdgesOut. Directed means that each edge (a,b) with two adjacent triangles in vT is returned twice, as edge(a,b) and edge(b,a).
- Orientation2 [GEOM_FADE2D::getOrientation2](#) (const [Point2](#) *p0, const [Point2](#) *p1, const [Point2](#) *p2)
Get the orientation of three points.
- Orientation2 [GEOM_FADE2D::getOrientation2_mt](#) (const [Point2](#) *p0, const [Point2](#) *p1, const [Point2](#) *p2)
Get Orientation2 (MT)
- void [GEOM_FADE2D::getUndirectedEdges](#) (const std::vector< [Triangle2](#) * > &vT, std::vector< [Edge2](#) > &vUndirectedEdgesOut)
Get undirected edges.
- bool [GEOM_FADE2D::isSimplePolygon](#) (std::vector< [Segment2](#) > &vSegments)
isSimplePolygon

- void `GEOM_FADE2D::pointsToPolyline` (std::vector< `Point2` > &vInPoints, bool bClose, std::vector< `Segment2` > &vOutSegments)
Points-to-Polyline.
- bool `GEOM_FADE2D::sortRing` (std::vector< `Segment2` > &vRing)
Sort a vector of Segments.
- bool `GEOM_FADE2D::sortRingCCW` (std::vector< `Segment2` > &vRing)
Sort a vector of Segments.

5.1.1 Detailed Description

5.1.2 Function Documentation

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

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

Parameters

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

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

Note

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

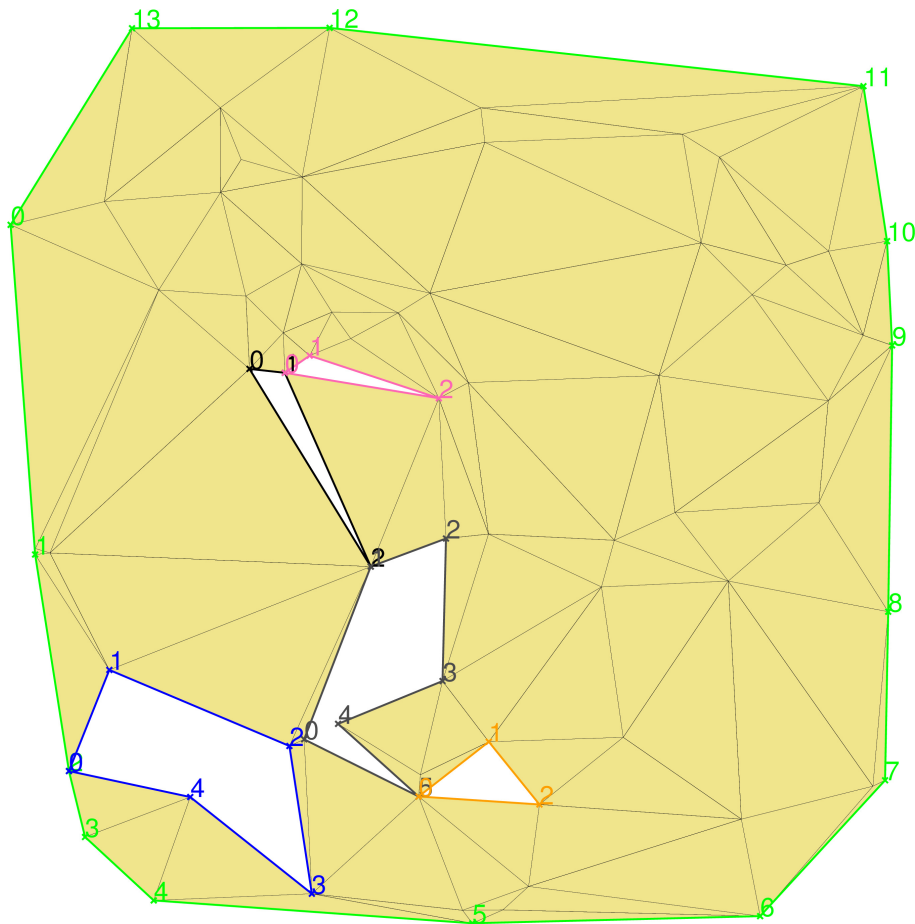


Figure 1 Polygons created by edgesToPolygons

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

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

Parameters

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

Note

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

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

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

Parameters

in	<i>p0,p1,p2</i>	are the corners of the triangle
----	-----------------	---------------------------------

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

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

Parameters

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

5.1.2.5 getConnectedComponents() `void GEOM_FADE2D::getConnectedComponents (`
`const std::vector< Triangle2 * > & vT,`
`std::vector< std::vector< Triangle2 * > > & vvT)`

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

Parameters

in	<i>vT</i>	Input triangles
out	<i>vvT</i>	Output components

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

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

5.1.2.7 getOrientation2_mt() `Orientation2 GEOM_FADE2D::getOrientation2_mt (`
`const Point2 * p0,`

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

See also

getOrientation2(const Point2* p0,const Point2* p1,const Point2* p2)

This version is thread-safe.

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

The undirected edges of vT are returned vUndirectedEdgesOut.

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

Parameters

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

Returns

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

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

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

Parameters

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

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

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

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

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

5.2 Version Information

Functions

- const char * GEOM_FADE2D::getFade2DVersion ()
Get the Fade2D version string.

- int [GEOM_FADE2D::getMajorVersionNumber](#) ()
Get the major version number.
- int [GEOM_FADE2D::getMinorVersionNumber](#) ()
Get the minor version number.
- int [GEOM_FADE2D::getRevisionNumber](#) ()
Get the revision version number.
- bool [GEOM_FADE2D::isRelease](#) ()
Check if a RELEASE or a DEBUG version is used.

5.2.1 Detailed Description

5.3 File I/O

Functions

- bool [GEOM_FADE2D::readPointsBIN](#) (const char *filename, std::vector< [Point2](#) > &vPointsIn)
Read points from a binary file.
- bool [GEOM_FADE2D::readSegmentsBIN](#) (const char *filename, std::vector< [Segment2](#) > &vSegmentsOut)
Read segments from a binary file.
- bool [GEOM_FADE2D::readXY](#) (const char *filename, std::vector< [Point2](#) > &vPointsOut)
Read (x y) points.
- bool [GEOM_FADE2D::writePointsASCII](#) (const char *filename, const std::vector< [Point2](#) * > &vPointsIn)
Write points to an ASCII file.
- bool [GEOM_FADE2D::writePointsASCII](#) (const char *filename, const std::vector< [Point2](#) > &vPointsIn)
Write points to an ASCII file.
- bool [GEOM_FADE2D::writePointsBIN](#) (const char *filename, std::vector< [Point2](#) * > &vPointsIn)
Write points to a binary file.
- bool [GEOM_FADE2D::writePointsBIN](#) (const char *filename, std::vector< [Point2](#) > &vPointsIn)
Write points to a binary file.
- bool [GEOM_FADE2D::writeSegmentsBIN](#) (const char *filename, std::vector< [Segment2](#) > &vSegmentsIn)
Write segments to a binary file.

5.3.1 Detailed Description

5.3.2 Function Documentation

5.3.2.1 readPointsBIN() bool [GEOM_FADE2D::readPointsBIN](#) (
const char * filename,
std::vector< [Point2](#) > & vPointsIn)

Reads points from a binary file.

See also

[writePointsBIN\(\)](#)

5.3.2.2 readSegmentsBIN() bool [GEOM_FADE2D::readSegmentsBIN](#) (
const char * filename,
std::vector< [Segment2](#) > & vSegmentsOut)

Reads segments from a binary file of type 21 or 31

See also

[writeSegmentsBIN\(\)](#)

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

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

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

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

Note

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

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

Write points to an ASCII file

See also

[readPointsASCII\(\)](#)

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

Writes points to a binary file

See also

[readPointsBIN\(\)](#)

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

File format:

int filetype (20)

size_t numPoints (vPointsIn.size())

double x0

double y0

double z0

...

double xn

double yn

double zn

Note

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

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

Binary file format:

```
int filetype (21)
size_t numSegments (vSegmentsIn.size())
double x0_source
double y0_source
double x0_target
double y0_target
...
double xn_source
double yn_source
double xn_target
double yn_target
```

Note

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

See also

[readSegmentsBIN\(\)](#)

5.4 Test Data Generators

Functions

- void [GEOM_FADE2D::generateCircle](#) (int numPoints, double x, double y, double radiusX, double radiusY, std::vector< [Point2](#) > &vCirclePointsOut)
Generate a circle.
- void [GEOM_FADE2D::generateRandomNumbers](#) (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)
Generate random numbers.
- void [GEOM_FADE2D::generateRandomPoints](#) (size_t numRandomPoints, double min, double max, std::vector< [Point2](#) > &vRandomPointsOut, unsigned int seed=0)
Generate random points.
- void [GEOM_FADE2D::generateRandomPolygon](#) (size_t numSegments, double min, double max, std::vector< [Segment2](#) > &vPolygonOut, unsigned int seed=0)
Generate a random simple polygon.
- void [GEOM_FADE2D::generateRandomSegments](#) (size_t numSegments, double min, double max, double maxLen, std::vector< [Segment2](#) > &vSegmentsOut, unsigned int seed)
Generate random line segments.
- void [GEOM_FADE2D::generateSineSegments](#) (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< [Segment2](#) > &vSineSegmentsOut)
Generate segments from a sine function.
- void [GEOM_FADE2D::shear](#) (std::vector< [Point2](#) > &vPointsInOut, double shearX, double shearY)

5.4.1 Detailed Description

5.4.2 Generate random polygons and other test objects

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

- Random simple polygons

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

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

5.4.3 Function Documentation

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

Returns points on a circle centered at the given coordinates

5.4.3.2 generateRandomNumbers() `void GEOM_FADE2D::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
out	<i>vRandomNumbersOut</i>	is the output vector
	<i>seed</i>	initializes the random number generator RNG (default: 0...mapped to a random seed, other values: constant initialization)

Note

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

5.4.3.3 generateRandomPoints() `void GEOM_FADE2D::generateRandomPoints (`
`size_t numRandomPoints,`
`double min,`
`double max,`
`std::vector< Point2 > & vRandomPointsOut,`
`unsigned int seed = 0)`

Parameters

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

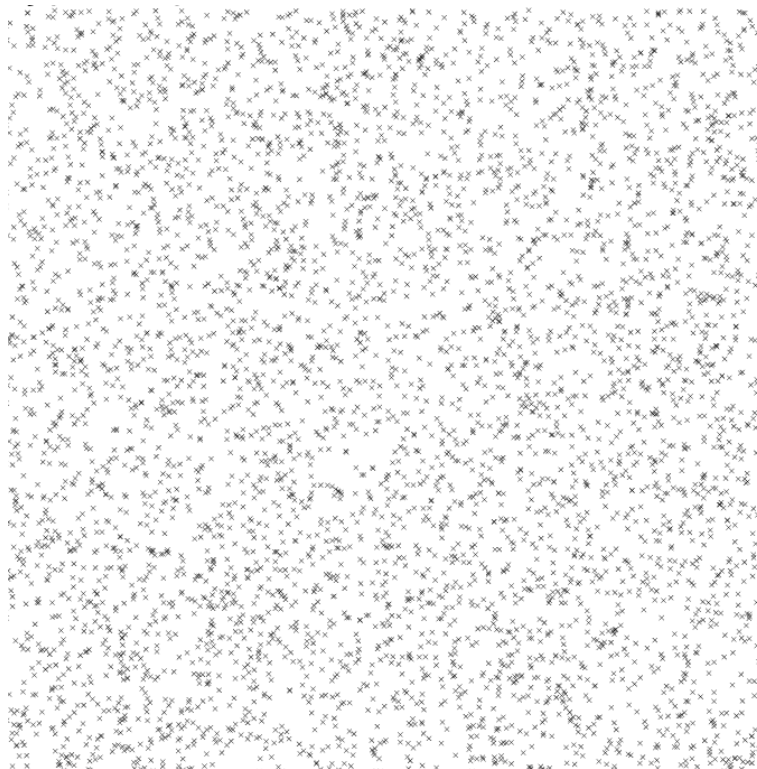


Figure 2 Point generator

5.4.3.4 generateRandomPolygon() `void GEOM_FADE2D::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 3 Polygon generator: Random simple polygon

5.4.3.5 generateRandomSegments() `void GEOM_FADE2D::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
out	<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 4 Segment generator: Random line segments

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

Parameters

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

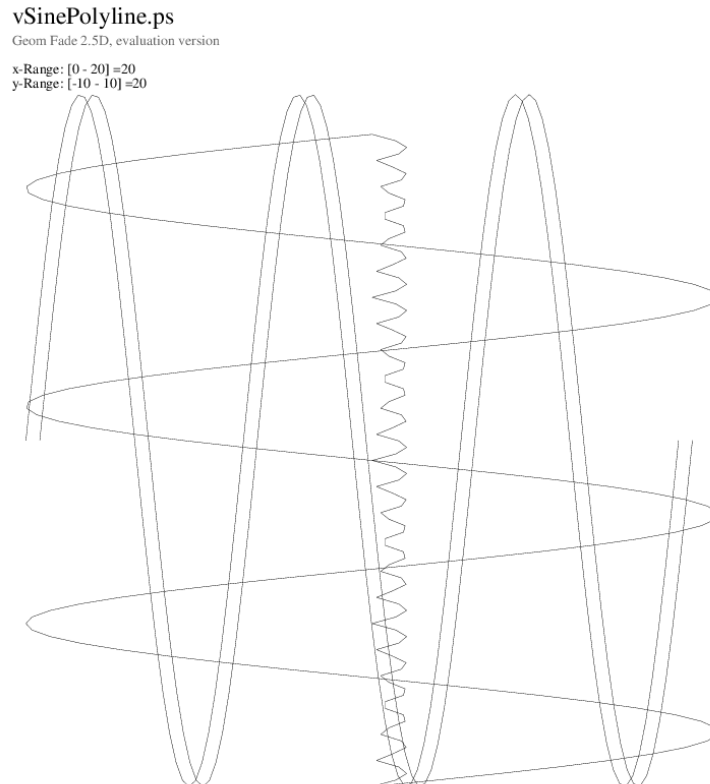


Figure 5 Polyline generator: Polylines from sine functions

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6 Class Documentation

6.1 GEOM_FADE2D::Bbox2 Class Reference

Bbox2 is an axis aligned 2D bounding box.

```
#include <Bbox2.h>
```

Public Member Functions

- **Bbox2** (GeomTest *pGeomTest_=NULL)
Constructor.
- bool **add** (const **Point2** &p)
Add a point.
- bool **add** (size_t numPoints, double *coordinates)
Add points.
- bool **add** (std::vector< **Point2** * >::const_iterator start_it, std::vector< **Point2** * >::const_iterator end_it)
Add points.
- bool **add** (std::vector< **Point2** >::const_iterator start_it, std::vector< **Point2** >::const_iterator end_it)
Add points.
- **Point2** **computeCenter** () const
Compute the 2D midpoint.
- bool **doIntersect** (const **Bbox2** &other) const
Check intersection.

- void `doubleTheBox` ()
Double the box.
- void `enlargeRanges` (double factor)
- double `get_maxX` () const
Get maxX.
- double `get_maxY` () const
Get maxY.
- double `get_minX` () const
Get minX.
- double `get_minY` () const
Get minY.
- void `getBoundary` (std::vector< `Segment2` > &vBoundary) const
Get boundary.
- void `getBounds` (double &minX_, double &maxX_, double &minY_, double &maxY_) const
Get bounds.
- void `getCorners` (std::vector< `Point2` > &vBoxCorners) const
Get corners.
- double `getMaxCoord` () const
Get maximum coordinate.
- `Point2` `getMaxPoint` () const
Get the max point.
- double `getMaxRange` () const
Get max range.
- double `getMinCoord` () const
Get minimum coordinate.
- `Point2` `getMinPoint` () const
Get the min point.
- void `getOffsetCorners` (double offset, std::vector< `Point2` > &vBoxCorners) const
Get offset corners.
- double `getRangeX` () const
Get x-range.
- double `getRangeY` () const
Get y-range.
- void `inflateIfDegenerate` (double val)
Inflate if Degenerate.
- bool `isInBox` (const `Point2` &p) const
Point-in-Box Test.
- bool `isValid` () const
Check if the bounds are valid.
- `Bbox2` `operator+` (const `Bbox2` &b)
Add a bounding box.
- void `setMaxX` (double val)
Set maxX.
- void `setMaxY` (double val)
Set maxY.
- void `setMinX` (double val)
Set minX.
- void `setMinY` (double val)
Set minY.

Protected Member Functions

- void **treatPointForInvalidBox** (const [Point2](#) &p)
- void **treatPointForValidBox** (const [Point2](#) &p)

Protected Attributes

- bool **bValid**
- double **maxX**
- double **maxY**
- double **minX**
- double **minY**
- [GeomTest](#) * **pGeomTest**

Friends

- [std::ostream](#) & **operator<<** ([std::ostream](#) &stream, const [Bbox2](#) &pC)
Print the box.

6.1.1 Constructor & Destructor Documentation

6.1.1.1 Bbox2() `GEOM_FADE2D::Bbox2::Bbox2 (
 GeomTest * pGeomTest_ = NULL) [inline], [explicit]`

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

6.1.2 Member Function Documentation

6.1.2.1 add() [1/4] `bool GEOM_FADE2D::Bbox2::add (
 const Point2 & p) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.2 add() [2/4] `bool GEOM_FADE2D::Bbox2::add (
 size_t numPoints,
 double * coordinates) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.3 add() [3/4] `bool GEOM_FADE2D::Bbox2::add (
 std::vector< Point2 * >::const_iterator start_it,
 std::vector< Point2 * >::const_iterator end_it) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.4 add() [4/4] `bool GEOM_FADE2D::Bbox2::add (`
 `std::vector< Point2 >::const_iterator start_it,`
 `std::vector< Point2 >::const_iterator end_it) [inline]`

Extends the 2D bounding box if required.

Returns

true if the bounding box changes, false otherwise

6.1.2.5 doIntersect() `bool GEOM_FADE2D::Bbox2::doIntersect (`
 `const Bbox2 & other) const`

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

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

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

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

Returns

maxX

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

Returns

maxY

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

Returns

minX

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

Returns

minY

6.1.2.11 getBoundary() `void GEOM_FADE2D::Bbox2::getBoundary (`
 `std::vector< Segment2 > & vBoundary) const`

Convenience function: Returns 4 border segments

6.1.2.12 getCorners() `void GEOM_FADE2D::Bbox2::getCorners (`
 `std::vector< Point2 > & vBoxCorners) const`

Convenience function: Returns the 4 corners of the box

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

Returns

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

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

Returns

the 2D corner point with the maximum coordinates

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

Returns

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

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

Returns

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

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

Returns

the 2D corner point with the minimum coordinates

6.1.2.18 getOffsetCorners() `void GEOM_FADE2D::Bbox2::getOffsetCorners (
double offset,
std::vector< Point2 > & vBoxCorners) const`

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

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

Returns

`maxX-minX`

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

Returns

`maxY-minY`

6.1.2.21 inflateIfDegenerate() `void GEOM_FADE2D::Bbox2::inflateIfDegenerate (
double val) [inline]`

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

6.1.2.22 isInBox() `bool GEOM_FADE2D::Bbox2::isInBox (
const Point2 & p) const`

Returns

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

6.1.2.23 isValid()

`bool GEOM_FADE2D::Bbox2::isValid () const [inline]`
The bounds are valid when at least one point has been added or when set-methods have been used to set $\text{minX} \leq \text{maxX}$ and $\text{minY} \leq \text{maxY}$

6.1.2.24 operator+()

`Bbox2 GEOM_FADE2D::Bbox2::operator+ (const Bbox2 & b)`
Extends the 2D bounding box if required.

Returns

the resulting bounding box

6.1.3 Friends And Related Function Documentation

6.1.3.1 operator<<

`std::ostream& operator<< (std::ostream & stream,`

`const Bbox2 & pC) [friend]`

Prints the box coordinates to `stream`

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

- [Bbox2.h](#)

6.2 GEOM_FADE2D::Circle2 Class Reference

Circle for visualization.

`#include <Circle2.h>`

Public Member Functions

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

Protected Attributes

- [Point2](#) [center](#)
- double [sqRadius](#)

Friends

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

6.2.1 Detailed Description

See also

[Visualizer2](#)

6.2.2 Constructor & Destructor Documentation

6.2.2.1 Circle2() [1/2] `GEOM_FADE2D::Circle2::Circle2 (`
`double x,`
`double y,`
`double sqRadius_)`

Parameters

<i>x</i>	is x-coordinate of the center
<i>y</i>	is y-coordinate of the center
<i>sq↔ Radius_</i>	is the squared radius of the circle

Warning

The method expects the *squared* radius

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

Parameters

<i>center_</i>	center of the circle
<i>sq↔ Radius_</i>	squared radius of the circle

Warning

The method expects the *squared* radius

6.2.3 Member Function Documentation

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

Returns

a [Point2](#) which represents the center

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

Returns

the radius

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

Returns

the squared radius

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

- [Circle2.h](#)

6.3 GEOM_FADE2D::Color Class Reference

[Color](#) for visualization.

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

Public Member Functions

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

Static Public Member Functions

- static [Colorname](#) getNextColorName ()

Public Attributes

- float [b](#)
Blue.
- bool [bFill](#)
Fill the shape or not.
- float [g](#)
Green.
- float [r](#)
Red.
- float [width](#)
Linewidth.

Static Public Attributes

- static size_t [currentColorName](#)

Friends

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

6.3.1 Detailed Description

See also

[Visualizer2](#)

6.3.2 Constructor & Destructor Documentation

6.3.2.1 Color() [1/2] `GEOM_FADE2D::Color::Color (`
 double r_,
 double g_,
 double b_,
 double width_,
 bool bFill_ = false)

Parameters

<i>r_</i>	red
<i>g_</i>	green

Parameters

<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.

6.3.2.2 Color() [2/2] `GEOM_FADE2D::Color::Color (`
 `Colorname c,`
 `float width_ = 0.001,`
 `bool bFill_ = false)`

For convenience predefined colors can be used.

Parameters

<i>c</i>	is a predefined color name
<i>width</i> ↔ —	linewidth (default: <i>0.001</i>)
<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](#)

6.4 GEOM_FADE2D::CompPolygon Struct Reference

Connected component with boundary- and hole polygons.

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

Public Member Functions

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

Public Attributes

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

6.4.1 Detailed Description

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

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

- [Zone2.h](#)

6.5 GEOM_FADE2D::ConstraintGraph2 Class Reference

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

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

Public Member Functions

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

Protected Attributes

- bool **blsOriented**
- bool **blsPolygon**
- [ConstraintInsertionStrategy](#) **cis**
- std::map< [ConstraintSegment2](#) *, bool, func_ltderefPtr< [ConstraintSegment2](#) * > > **mCsegReverse**
- std::map< [Point2](#) *, size_t > **mSplitPointNum**
- Dt2 * **pDt2**
- GeomTest * **pGeomPredicates**
- std::vector< [ConstraintSegment2](#) * > **vCsegParents**

6.5.1 Detailed Description

See also

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

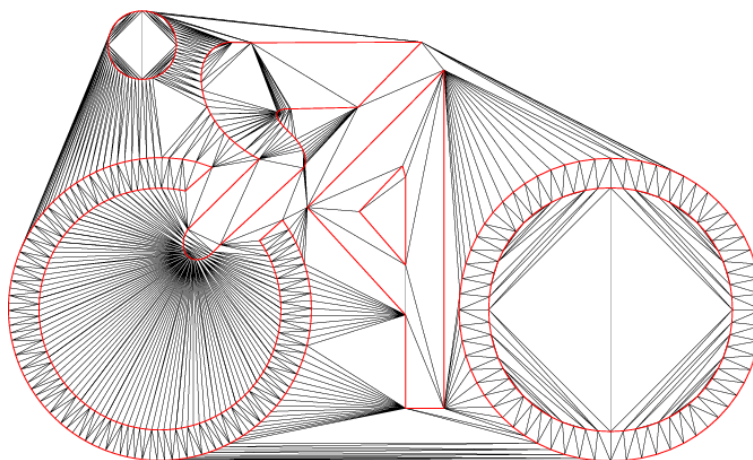


Figure 6 Constraint Delaunay triangulation

6.5.2 Member Function Documentation

6.5.2.1 getChildConstraintSegments() `void GEOM_FADE2D::ConstraintGraph2::getChildConstraintSegments (`

`std::vector< ConstraintSegment2 * > & vConstraintSegments_) const`

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

6.5.2.2 getDirectChildren() `void GEOM_FADE2D::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_FADE2D::ConstraintGraph2::getDt2 ()`

Returns

the Delaunay class it belongs to

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

Returns

CIS_CONFORMING_DELAUNAY or CIS_CONSTRAINED_DELAUNAY

6.5.2.5 getOriginalConstraintSegments() `void GEOM_FADE2D::ConstraintGraph2::getOriginalConstraintSegments (`

`std::vector< ConstraintSegment2 * > & vConstraintSegments_) const`

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

6.5.2.6 getPolygonVertices() `void GEOM_FADE2D::ConstraintGraph2::getPolygonVertices (`

`std::vector< Point2 * > & vVertices_)`

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

Note

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

See also

Do you already know [Zone2::getBorderEdges\(\)](#) and [edgesToPolygons\(\)](#) ?

6.5.2.7 isConstraint() [1/2] `bool GEOM_FADE2D::ConstraintGraph2::isConstraint (`

`ConstraintSegment2 * pCseg) const`

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

6.5.2.8 isConstraint() [2/2] `bool GEOM_FADE2D::ConstraintGraph2::isConstraint (`

`Point2 * p0,`

`Point2 * p1) const`

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

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

Returns

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

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

Returns

true when the present [ConstraintGraph](#) forms a closed polygon.

Note

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

6.5.2.11 isReverse() `bool GEOM_FADE2D::ConstraintGraph2::isReverse (
 ConstraintSegment2 * pCseg) const`

Get the orientation of a [ConstraintSegment2](#)

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

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

Improve the triangle quality (make Delaunay)

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

Parameters

in	<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 subdivisions have been carried out or FALSE when *minLength* has avoided further subdivision.

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

- [ConstraintGraph2.h](#)

6.6 GEOM_FADE2D::ConstraintSegment2 Class Reference

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

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

Public Member Functions

- void [getChildrenAndSplitPoint](#) ([ConstraintSegment2](#) *&pCseg0, [ConstraintSegment2](#) *&pCseg1, [Point2](#) *&pSplitPoint)
Get the children and the split point Retrieve the two direct children of the current [ConstraintSegment2](#) as well as the split point.
- void [getChildrenRec](#) (std::vector< [ConstraintSegment2](#) * > &vChildConstraintSegments)
Get all children Recursively retrieve all children of the current [ConstraintSegment2](#).
- [ConstraintInsertionStrategy](#) [getCIS](#) () const
Get the Constraint Insertion Strategy (CIS)
- [Point2](#) * [getSrc](#) () const
Get the first endpoint.
- [Point2](#) * [getTrg](#) () const
Get the second endpoint.
- [Point2](#) * [insertAndSplit](#) (const [Point2](#) &splitPoint)
Split a constraint segment.
- bool [isAlive](#) () const
Check if the present [ConstraintSegment2](#) is alive.
- bool [operator<](#) (const [ConstraintSegment2](#) &pOther) const
operator<(..) Compares the vertex pointers of the endpoints, not the length
- bool [split_combinatorialOnly](#) ([Point2](#) *pSplit)
Split a constraint segment.

Public Attributes

- int **label**

Protected Attributes

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

Static Protected Attributes

- static int **runningLabel**

Friends

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

6.6.1 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 [getCIS\(\)](#) [ConstraintInsertionStrategy](#) `GEOM_FADE2D::ConstraintSegment2::getCIS () const`

Returns

the constraint insertion strategy (CIS) of the present object

6.6.2.2 [getSrc\(\)](#) [Point2](#)* `GEOM_FADE2D::ConstraintSegment2::getSrc () const`

Returns

the first vertex

6.6.2.3 [getTrg\(\)](#) [Point2](#)* `GEOM_FADE2D::ConstraintSegment2::getTrg () const`

Returns

the second vertex

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

Splits the [ConstraintSegment2](#) (which must be alive) at `splitPoint`.

It may be impossible to represent a point on a certain line segment using floatingpoint arithmetic. Therefore it is highly recommended to split a [ConstraintSegment2](#) object not just by 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_FADE2D::ConstraintSegment2::isAlive () const`

Returns

TRUE when the object is alive, FALSE otherwise

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

internal use only (unless you do something very unusual)

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

- [ConstraintSegment2.h](#)

6.7 GEOM_FADE2D::Edge2 Class Reference

[Edge2](#) is a directed edge.

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

Public Member Functions

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

Protected Attributes

- int `opIdx`
- [Triangle2](#) * `pT`

Friends

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

6.7.1 Constructor & Destructor Documentation

6.7.1.1 `Edge2()` `GEOM_FADE2D::Edge2::Edge2 (
 Triangle2 * pT,
 int opIdx_)`

Parameters

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

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

6.7.2 Member Function Documentation

6.7.2.1 `getIndex()` `int GEOM_FADE2D::Edge2::getIndex () const`
Get the opposite index

Returns

the intra-triangle-index of the opposite vertex

6.7.2.2 `getLength2D()` `double GEOM_FADE2D::Edge2::getLength2D () const`
Get the length

Returns

the length of the edge

6.7.2.3 `getPoints()` `void GEOM_FADE2D::Edge2::getPoints (
 Point2 *& p1,
 Point2 *& p2) const`

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

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

Returns

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

6.7.2.5 getTrg() `Point2* GEOM_FADE2D::Edge2::getTrg () const`**Returns**

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

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

Get the triangle

Returns

the triangle whose directed edge the present edge is

6.7.2.7 getTriangles() `void GEOM_FADE2D::Edge2::getTriangles (Triangle2 *& pT0, Triangle2 *& pT1, int & idx0, int & idx1) const`

Get the triangles

Returns

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

Parameters

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

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

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

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

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

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

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

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

- [Edge2.h](#)

6.8 GEOM_FADE2D::Fade_2D Class Reference

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

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

Public Member Functions

- [Fade_2D](#) (unsigned numExpectedVertices=3)
Constructor of the main triangulation class.
- [~Fade_2D](#) ()
Destructor.
- void [applyConstraintsAndZones](#) ()
Apply conforming constraints and zones (deprecated!)
- bool [checkValidity](#) (bool bCheckEmptyCircleProperty, const char *msg) const
Checks if a triangulation is valid.
- [Bbox2 computeBoundingBox](#) () const
Compute the axis-aligned bounding box of the points.
- [ConstraintGraph2 * createConstraint](#) (std::vector< [Segment2](#) > &vSegments, [ConstraintInsertionStrategy](#) cis, bool bOrientedSegments=false)
Add constraint edges (edges, polyline, polygon) .
- [Zone2 * createZone](#) (const std::vector< [ConstraintGraph2](#) * > &vConstraintGraphs, [ZoneLocation](#) zoneLoc, const [Point2](#) &startPoint, bool bVerbose=true)
Create a zone limited by multiple [ConstraintGraph2](#) objects by growing from a start point.
- [Zone2 * createZone](#) ([ConstraintGraph2](#) *pConstraintGraph, [ZoneLocation](#) zoneLoc, bool bVerbose=true)
Create a zone.
- [Zone2 * createZone](#) ([ConstraintGraph2](#) *pConstraintGraph, [ZoneLocation](#) zoneLoc, const [Point2](#) &startPoint, bool bVerbose=true)
Create a zone limited by a [ConstraintGraph](#) by growing from a start point.
- [Zone2 * createZone](#) (std::vector< [Triangle2](#) * > &vTriangles, bool bVerbose=true)
Create a zone defined by a vector of triangles.
- [Zone2 * createZone_cookieCutter](#) (std::vector< [Segment2](#) > &vSegments, bool bProtectEdges)
Cookie Cutter The Cookie Cutter cuts out a part of a triangulation and returns it as a [Zone2](#) object.
- void [cutTriangles](#) (const [Point2](#) &knifeStart, const [Point2](#) &knifeEnd, bool bTurnEdgesIntoConstraints)
Cut through a triangulation.
- void [cutTriangles](#) (std::vector< [Segment2](#) > &vSegments, bool bTurnEdgesIntoConstraints)
Cut through a triangulation.
- void [deleteZone](#) ([Zone2](#) *pZone)
Delete a [Zone2](#) object.
- bool [drape](#) (std::vector< [Segment2](#) > &vSegmentsIn, std::vector< [Segment2](#) > &vSegmentsOut) const
Drape segments along a surface.
- void [exportTriangulation](#) ([FadeExport](#) &fadeExport, bool bWithCustomIndices, bool bClear)
Export triangulation data from Fade.
- [Triangle2 * getAdjacentTriangle](#) ([Point2](#) *p0, [Point2](#) *p1) const
Get adjacent triangle.
- void [getAliveAndDeadConstraintSegments](#) (std::vector< [ConstraintSegment2](#) * > &vAllConstraintSegments) const
Get all (alive and dead) constraint segments.
- void [getAliveConstraintSegments](#) (std::vector< [ConstraintSegment2](#) * > &vAliveConstraintSegments) const
Get active (alive) constraint segments.
- [ConstraintSegment2 * getConstraintSegment](#) ([Point2](#) *p0, [Point2](#) *p1) const
Retrieve a [ConstraintSegment2](#).
- void [getConvexHull](#) (bool bAllVertices, std::vector< [Point2](#) * > &vConvexHullPointsOut)
Compute the convex hull.
- void [getDirectedEdges](#) (std::vector< [Edge2](#) > &vDirectedEdgesOut) const

Get directed edges Edges are counterclockwise oriented around their triangle. The present method returns directed edges. That means each edge(a,b) is returned twice, as edge(a,b) and as edge(b,a).

- void `getIncidentTriangles` (`Point2` *pVtx, `std::vector`< `Triangle2` * > &vIncidentT) const
Get incident triangles.
- void `getIncidentVertices` (`Point2` *pVtx, `std::vector`< `Point2` * > &vIncidentVertices) const
Get incident vertices.
- `Point2` * `getNearestNeighbor` (const `Point2` &p)
Get nearest neighbor.
- `Orientation2` `getOrientation` (const `Point2` &p0, const `Point2` &p1, const `Point2` &p2)
Compute the orientation of 3 points.
- void `getTrianglePointers` (`std::vector`< `Triangle2` * > &vAllTriangles) const
Get pointers to all triangles.
- void `getUndirectedEdges` (`std::vector`< `Edge2` > &vUndirectedEdgesOut) const
Get undirected edges.
- void `getVertexPointers` (`std::vector`< `Point2` * > &vAllPoints) const
Get pointers to all vertices.
- `Voronoi2` * `getVoronoiDiagram` ()
Get the Voronoi diagram.
- bool `hasArea` () const
Check if the triangulation contains triangles (which is the case if at least 3 non-collinear points exist in the triangulation).
- `Zone2` * `importTriangles` (`std::vector`< `Point2` > &vPoints, bool bReorientIfNeeded, bool bCreateExtended↵
BoundingBox)
Import triangles.
- `Point2` * `insert` (const `Point2` &p)
Insert a single point.
- void `insert` (const `std::vector`< `Point2` > &vInputPoints)
Insert a vector of points.
- void `insert` (const `std::vector`< `Point2` > &vInputPoints, `std::vector`< `Point2` * > &vHandles)
Insert points from a std::vector and store pointers in vHandles.
- void `insert` (int numPoints, double *aCoordinates, `Point2` **aHandles)
Insert points from an array.
- bool `isConstraint` (`Point2` *p0, `Point2` *p1) const
Check if an edge is a constraint edge.
- bool `isConstraint` (`Point2` *pVtx) const
Check if a vertex is a constraint vertex.
- bool `isConstraint` (`Triangle2` *pT, int ith) const
Check if an edge is a constraint edge.
- bool `load` (const char *filename, `std::vector`< `Zone2` * > &vZones)
Load a triangulation.
- bool `load` (`std::istream` &stream, `std::vector`< `Zone2` * > &vZones)
Load a triangulation.
- `Triangle2` * `locate` (const `Point2` &p)
Locate a triangle which contains p.
- double `measureTriangulationTime` (`std::vector`< `Point2` > &vPoints)
Measure the Delaunay triangulation time.
- `size_t` `numberOfPoints` () const
Number of points.
- `size_t` `numberOfTriangles` () const
Number of triangles.
- void `printLicense` () const
Prints license information.

- void [refine](#) ([Zone2](#) *pZone, double minAngleDegree, double minEdgeLength, double maxEdgeLength, bool bAllowConstraintSplitting)
Delaunay refinement.
- void [refineAdvanced](#) ([MeshGenParams](#) *pParameters)
Delaunay refinement and grid meshing.
- void [remove](#) ([Point2](#) *pVertex)
Remove a single vertex.
- bool [saveTriangulation](#) (const char *filename, std::vector< [Zone2](#) * > &vSaveZones)
Save a triangulation.
- bool [saveTriangulation](#) (std::ostream &stream, std::vector< [Zone2](#) * > &vSaveZones)
Save a triangulation.
- bool [saveZones](#) (const char *filename, std::vector< [Zone2](#) * > &vSaveZones)
Save zones.
- bool [saveZones](#) (std::ostream &stream, std::vector< [Zone2](#) * > &vSaveZones)
Save zones.
- void [setFastMode](#) (bool bFast)
Set fast mode.
- int [setNumCPU](#) (int numCPU)
Set the number CPU cores for multithreading.
- void [show](#) (const char *postscriptFilename, bool bWithConstraints=true) const
Draws the triangulation as postscript file.
- void [show](#) ([Visualizer2](#) *pVis, bool bWithConstraints=true) const
Draws the triangulation as postscript file using an existing [Visualizer2](#) object.
- void [statistics](#) (const char *s) const
Statistics.
- void [subscribe](#) (MsgType msgType, [MsgBase](#) *pMsg)
Register a message receiver.
- void [unsubscribe](#) (MsgType msgType, [MsgBase](#) *pMsg)
Unregister a message receiver.
- void [writeObj](#) (const char *filename) const
*Write the current triangulation to an *.obj file.*
- void [writeObj](#) (const char *filename, [Zone2](#) *pZone) const
*Write a zone to an *.obj file.*
- void [writeWebScene](#) (const char *path) const
*Write the current triangulation to an *.obj file.*
- void [writeWebScene](#) (const char *path, [Zone2](#) *pZone) const
*Write a zone to an *.obj file.*

6.8.1 Detailed Description

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

6.8.2 Constructor & Destructor Documentation

6.8.2.1 Fade_2D() `GEOM_FADE2D::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.
----------------------------	---

6.8.3 Member Function Documentation

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

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

Note

The present function `applyConstraintsAndZones()` as well as the two constraint insertion strategies `CIS_CONFORMING_DELAUNAY` and `CIS_CONFORMING_DELAUNAY_SEGMENT_LEVEL` are deprecated. These are only kept for backwards 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`

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

Checks the validity of the data structure.

Parameters

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

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

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

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

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

Parameters

<i>vSegments</i>	are segments which shall appear as edges of the triangulation. The segments may be automatically reordered and reoriented, see <code>bOrientedSegments</code> below.
<i>cis</i>	is the Constraint-Insertion-Strategy. Use always <code>CIS_CONSTRAINED_DELAUNAY</code> . This mode inserts the constraint segments without subdivision unless existing vertices or existing constraint segments are crossed. When subdivision (e.g., to achieve better triangle shapes) is desired then use <code>ConstraintGraph2::makeDelaunay()</code> after insertion.

Parameters

<i>bOrientedSegments</i>	specifies whether the segments in vSegments are oriented (<i>oriented, not ordered!</i>). If later a zone is to be made with the returned ConstraintGraph2 object this is only possible if the value is true (then it is assumed that all segments are counterclockwise oriented) or if the ConstraintGraph2 represents exactly one closed polygon. The value affects also the order of the returned vertices when later ConstraintGraph2::getPolygonVertices() is called. This is a default parameter and it defaults to false.
--------------------------	--

Returns

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

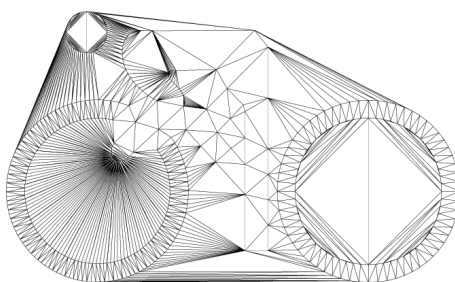


Figure 7 Delaunay triangulation without constraints

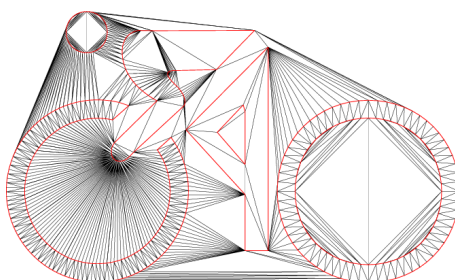


Figure 8 Constraint Delaunay triangulation

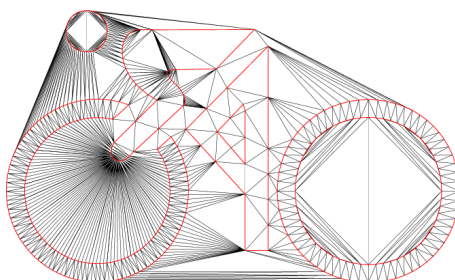


Figure 9 Conforming Delaunay triangulation through the [ConstraintGraph::makeDelaunay\(\)](#) method

```
6.8.3.5 createZone() [1/4] Zone2* GEOM_FADE2D::Fade_2D::createZone (
    const std::vector< ConstraintGraph2 * > & vConstraintGraphs,
    ZoneLocation zoneLoc,
    const Point2 & startPoint,
    bool bVerbose = true )
```

A [Zone2](#) object is an area of the 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)

6.8.3.6 createZone() [2/4] [Zone2*](#) GEOM_FADE2D::Fade_2D::createZone (
[ConstraintGraph2](#) * *pConstraintGraph*,
 ZoneLocation *zoneLoc*,
 bool *bVerbose* = true)

A [Zone2](#) object is an area of a triangulation, possibly bounded by a ConstraintGraph.

Parameters

<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 zoneLoc==ZL_GLOBAL.
<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.

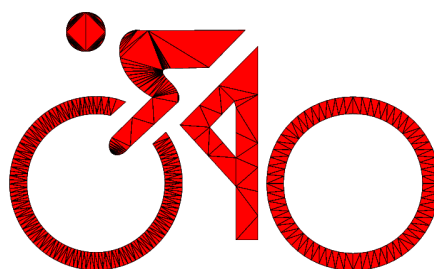


Figure 10 Zones in a triangulation

6.8.3.7 createZone() [3/4] [Zone2*](#) GEOM_FADE2D::Fade_2D::createZone (
[ConstraintGraph2](#) * *pConstraintGraph*,
 ZoneLocation *zoneLoc*,
 const [Point2](#) & *startPoint*,
 bool *bVerbose* = true)

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

Parameters

<i>pConstraintGraph</i>	is a constraint whose edges specify the area's border
-------------------------	---

Parameters

<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)

6.8.3.8 createZone() [4/4] [Zone2*](#) GEOM_FADE2D::Fade_2D::createZone (
 std::vector< [Triangle2](#) * > & vTriangles,
 bool bVerbose = true)

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

Parameters

<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)

6.8.3.9 createZone_cookieCutter() [Zone2*](#) GEOM_FADE2D::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 may flip existing edges in the triangulation but this can be avoided using bProtectEdges=true. In this case new constraint edges may be created.

6.8.3.10 cutTriangles() [1/2] void GEOM_FADE2D::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 `bTurnEdges↵IntoConstraints=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 bTurnEdges↵IntoConstraints)` 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.

6.8.3.11 cutTriangles() [2/2] `void GEOM_FADE2D::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 bTurnEdges↵IntoConstraints)` 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.

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

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

Note

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

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

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

Parameters

in	<i>vSegmentsIn</i>	Input segments
out	<i>vSegmentsOut</i>	Output segments

Returns

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

Note

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

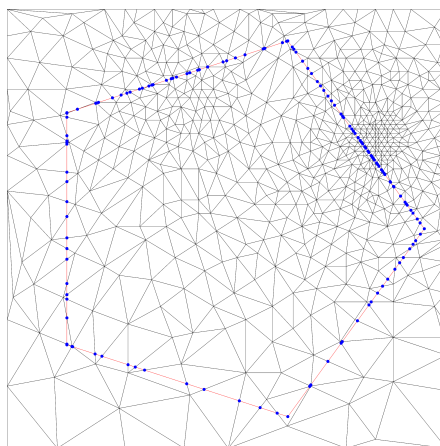


Figure 11 Drape: Input segments are draped (red) onto a TIN. They are subdivided (blue) at intersections with triangulation edges

•

Note

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

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

Parameters

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

Note

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

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

Returns

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

Note

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

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

Returns

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

6.8.3.17 getConvexHull() `void` GEOM_FADE2D::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.
out	<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.

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

Stores pointers to all triangles around pVtx into vIncidentT

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

Stores pointers to all vertices around pVtx into vIncidentVertices

6.8.3.20 getNearestNeighbor() `Point2*` GEOM_FADE2D::Fade_2D::getNearestNeighbor (
 `const Point2 & p)`

This method returns the closest vertex of p.

Parameters

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

Returns

a pointer to the closest vertex

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

Returns

ORIENTATION2_COLLINEAR, ORIENTATION2_CW (clockwise) or ORIENTATION2_CCW (counterclockwise)

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

This command fetches the existing triangles

Parameters

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

Note

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

6.8.3.23 getUndirectedEdges() `void GEOM_FADE2D::Fade_2D::getUndirectedEdges (`
`std::vector< Edge2 > & vUndirectedEdgesOut) const`

Parameters

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

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

Parameters

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

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

Note

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

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

Returns

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

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

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

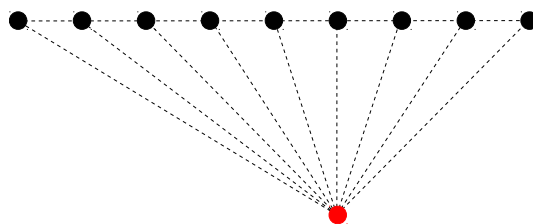


Figure 12 Triangles are generated as soon as the first non-collinear point is inserted.

Returns

true if at least one triangle exists
false otherwise

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

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

Parameters

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

6.8.3.28 insert() [1/4] `Point2* GEOM_FADE2D::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.

6.8.3.29 insert() [2/4] `void GEOM_FADE2D::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

6.8.3.30 insert() [3/4] `void GEOM_FADE2D::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

6.8.3.31 insert() [4/4] `void GEOM_FADE2D::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 $2n$ double values, e.g. {x0,y0,x1,y1,...,xn,yn}
<i>aHandles</i>	is an empty array with size n where pointers to the inserted points will be stored by Fade

Note

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

6.8.3.32 isConstraint() [1/3] `bool GEOM_FADE2D::Fade_2D::isConstraint (
 Point2 * p0,
 Point2 * p1) const`

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

6.8.3.33 isConstraint() [2/3] `bool GEOM_FADE2D::Fade_2D::isConstraint (
 Point2 * pVtx) const`

Returns whether the vertex pVtx belongs to a constraint edge.

6.8.3.34 isConstraint() [3/3] `bool GEOM_FADE2D::Fade_2D::isConstraint (
 Triangle2 * pT,
 int ith) const`

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

6.8.3.35 load() [1/2] `bool GEOM_FADE2D::Fade_2D::load (
 const char * filename,
 std::vector< Zone2 * > & vZones)`

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

Parameters

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

Returns

whether the operation was successful

6.8.3.36 load() [2/2] `bool GEOM_FADE2D::Fade_2D::load (
 std::istream & stream,
 std::vector< Zone2 * > & vZones)`

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

Parameters

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

Returns

whether the operation was successful

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

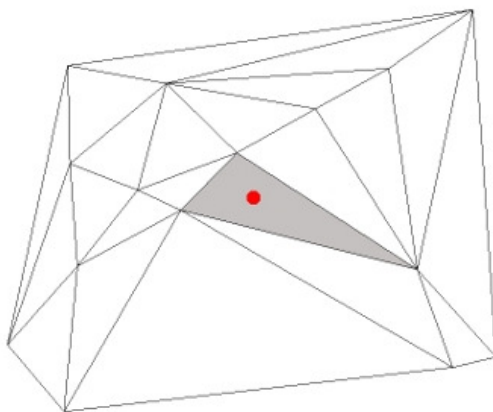


Figure 13 Point location

The [Fade_2D](#) class can be used as a data structure for point location. This method returns a pointer to a triangle which contains p .

Parameters

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

Returns

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

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

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

Parameters

in	$vPoints$	are the points to be inserted
----	-----------	-------------------------------

Returns

the total wall-time for point insertion in seconds

Note

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

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

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

Returns

the number of points in the triangulation

Note

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

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

Returns

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

6.8.3.41 refine() `void GEOM_FADE2D::Fade_2D::refine (`
`Zone2 * pZone,`
`double minAngleDegree,`
`double minEdgeLength,`
`double maxEdgeLength,`
`bool bAllowConstraintSplitting)`

Creates a mesh inside the area given by a [Zone2](#) object.

Parameters

<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\(\)](#).

6.8.3.42 refineAdvanced() `void GEOM_FADE2D::Fade_2D::refineAdvanced (`
`MeshGenParams * pParameters)`

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

6.8.3.43 remove() `void GEOM_FADE2D::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.

6.8.3.44 `saveTriangulation()` [1/2] `bool GEOM_FADE2D::Fade_2D::saveTriangulation (`
`const char * filename,`
`std::vector< Zone2 * > & vSaveZones)`

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

Parameters

in	<i>filename</i>	is the name of the output file
out	<i>vSaveZones</i>	is used specify zones that shall additionally be saved

See also

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

Returns

whether the operation was successful

6.8.3.45 `saveTriangulation()` [2/2] `bool GEOM_FADE2D::Fade_2D::saveTriangulation (`
`std::ostream & stream,`
`std::vector< Zone2 * > & vSaveZones)`

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

Parameters

	<i>stream</i>	is the output stream
out	<i>vSaveZones</i>	is used specify zones that shall additionally be saved

See also

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

Returns

whether the operation was successful

6.8.3.46 `saveZones()` [1/2] `bool GEOM_FADE2D::Fade_2D::saveZones (`
`const char * filename,`
`std::vector< Zone2 * > & vSaveZones)`

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

Note

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

Parameters

in	<i>filename</i>	is the name of the output file
out	<i>vSaveZones</i>	(non-empty) specifies the zones to be saved

Returns

whether the operation was successful

See also

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

6.8.3.47 saveZones() [2/2] `bool GEOM_FADE2D::Fade_2D::saveZones (`
`std::ostream & stream,`
`std::vector< Zone2 * > & vSaveZones)`

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

Note

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

Parameters

	<i>stream</i>	is the name of output stream
out	<i>vSaveZones</i>	(non-empty) specifies the zones to be saved

Returns

whether the operation was successful

See also

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

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

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

Parameters

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

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

Parameters

<i>numCPU</i>	is the number of CPU cores to be used. The special value <code>numCPU=0</code> 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.

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

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

Parameters

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

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

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

Parameters

<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\(\)](#).

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

Prints mesh statistics to stdout.

6.8.3.53 subscribe() `void GEOM_FADE2D::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

6.8.3.54 unsubscribe() `void GEOM_FADE2D::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

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

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

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

Visualizes a certain [Zone2](#) object of the present triangulation. The *.obj format represents a 3D scene.

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

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

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

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

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

- [Fade_2D.h](#)

6.9 GEOM_FADE2D::FadeExport Struct Reference

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

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

Public Member Functions

- void [extractTriangleNeighborships](#) (std::vector< std::pair< int, int > > &vNeigs) const
Determine index-pairs of adjacent triangles.
- void [getCoordinates](#) (int vtxIdx, double &x, double &y) const
Get the coordinates for a certain vertex index.
- void [getCornerIndices](#) (int triIdx, int &vtxIdx0, int &vtxIdx1, int &vtxIdx2) const
Get the corner indices of a certain triangle.
- void [lexiSort](#) ()
- void [print](#) () const
Print data for demonstration purposes.
- bool [writeObj](#) (const char *filename) const
*Write an *.obj file (supported by virtually any 3D viewer)*

Public Attributes

- double * [aCoords](#)
*Cartesian coordinates (dim*numPoints)*
- int * [aCustomIndices](#)
Custom indices of the points (only when exported)
- int * [aTriangles](#)
*3 counterclockwise oriented vertex-indices per triangle (3*numTriangles)*
- int [dim](#)
Dimension.
- int [numCustomIndices](#)
number of custom indices (same as numPoints when exported, otherwise 0)
- int [numPoints](#)
number of points
- int [numTriangles](#)
number of triangles

6.9.1 Detailed Description

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

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

6.9.2 Member Function Documentation

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

Parameters

<i>vtxIdx</i>	[in] vertex index
<i>x,y</i>	[out] coordinates

6.9.2.2 [getCornerIndices\(\)](#) void GEOM_FADE2D::FadeExport::getCornerIndices (
int triIdx,

```
int & vtxIdx0,
int & vtxIdx1,
int & vtxIdx2 ) const [inline]
```

Parameters

<i>trIdx</i>	[in] triangle index
<i>vtxIdx0, vtxIdx1, vtxIdx2</i>	[out] corner indices

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

- [FadeExport.h](#)

6.10 GEOM_FADE2D::Func_gtEdge2D Struct Reference

Functor to sort edges by 2d length (descending)

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

Public Member Functions

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

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

- [Edge2.h](#)

6.11 GEOM_FADE2D::Func_ltEdge2D Struct Reference

Functor to sort edges by 2d length (ascending)

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

Public Member Functions

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

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

- [Edge2.h](#)

6.12 GEOM_FADE2D::Label Class Reference

[Label](#) is a Text-Label for Visualization.

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

Public Member Functions

- **Label** (const [Label](#) &other)
- **Label** (const [Point2](#) &p_, const char *s_, bool bWithMark_=true, int fontSize_=8)
Constructs a Text-Label.
- const char * **getCS** () const
- [Label](#) & **operator=** (const [Label](#) &other)

Public Attributes

- bool **bWithMark**
- int **fontSize**
- [Point2](#) **p**
- LDat * **pDat**

6.12.1 Detailed Description

See also

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

6.12.2 Constructor & Destructor Documentation

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

Parameters

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

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

- [Label.h](#)

6.13 GEOM_FADE2D::MeshGenParams Class Reference

Parameters for the mesh generator.

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

Public Member Functions

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

Public Attributes

- bool **bAllowConstraintSplitting**
bAllowConstraintSplitting
- bool **bKeepExistingSteinerPoints**
Steiner points from previous refinements.
- double **capAspectLimit**
capAspectLimit
- int **command**
Command.
- double **gridLength**
gridLength
- [Vector2](#) **gridVector**
gridVector

- double [growFactor](#)
growFactor
- double [growFactorMinArea](#)
growFactorMinArea
- double [maxEdgeLength](#)
Maximum edge length.
- double [maxTriangleArea](#)
maxTriangleArea
- double [minAngleDegree](#)
Minimum interior triangle angle.
- double [minEdgeLength](#)
Minimum edge length.
- [Zone2](#) * [pZone](#)
Zone to be meshed.

6.13.1 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/>

6.13.2 Member Function Documentation

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

In case that some [ConstraintSegment2](#) can be splitted and others must not be splitted use `bAllow↔ConstraintSplitting=true` and add the ones that must not be splitted.

6.13.2.2 getMaxEdgeLength() `virtual double GEOM_FADE2D::MeshGenParams::getMaxEdgeLength (
 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 `maxEdgeLength` (which is `DBL_MAX` if not changed by the user). This method can be overridden by the client software in order to control the local mesh density.

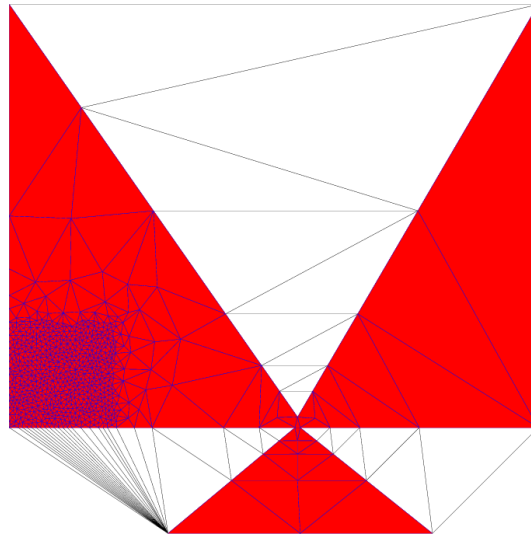


Figure 14 User Controlled Mesh Density, Edge Length

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

Parameters

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

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

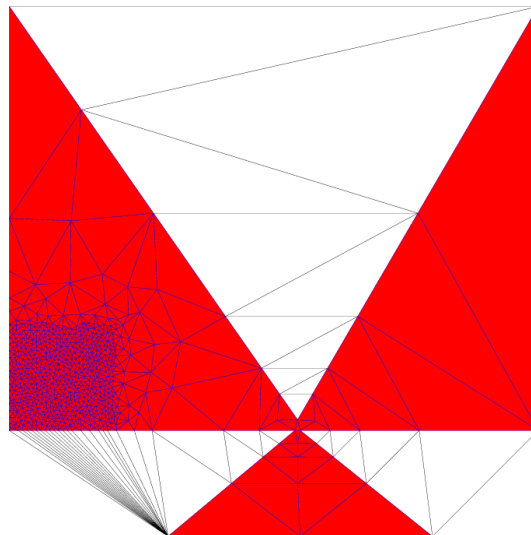


Figure 15 User Controlled Mesh Density, Area

6.13.3 Member Data Documentation

6.13.3.1 bAllowConstraintSplitting `bool GEOM_FADE2D::MeshGenParams::bAllowConstraintSplitting`
 Defines if constraint segments can be splitted. Default: yes

6.13.3.2 bKeepExistingSteinerPoints `bool GEOM_FADE2D::MeshGenParams::bKeepExistingSteinerPoints`

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

6.13.3.3 capAspectLimit `double GEOM_FADE2D::MeshGenParams::capAspectLimit`

Limits the quotient `edgeLength / height`. Default value: 10.0

6.13.3.4 command `int GEOM_FADE2D::MeshGenParams::command`

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

6.13.3.5 gridLength `double GEOM_FADE2D::MeshGenParams::gridLength`

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

Note

The length of the diagonals in the grid is $\sqrt{2} \cdot \text{gridLength}$ and the algorithm may automatically adapt the `gridLength` a bit such that the grid fits better into the shape.

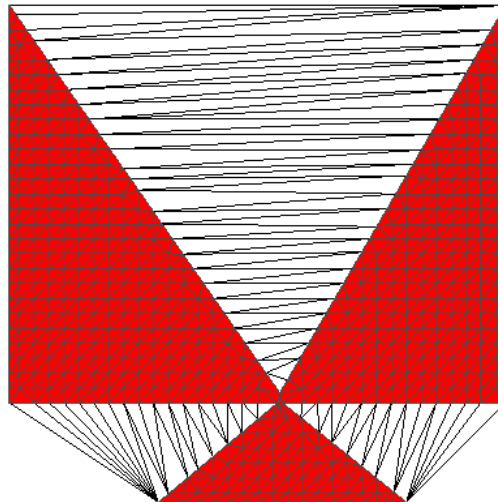


Figure 16 Grid Meshing axis aligned

6.13.3.6 gridVector `Vector2 GEOM_FADE2D::MeshGenParams::gridVector`

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

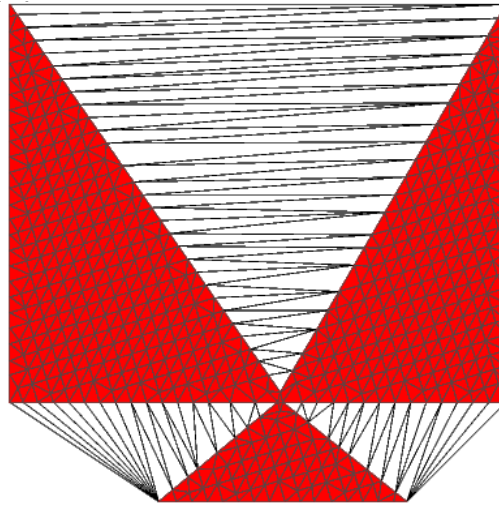


Figure 17 Grid Meshing along Vector2(1.0,0.3)

6.13.3.7 **growFactor** `double GEOM_FADE2D::MeshGenParams::growFactor`

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

6.13.3.8 **growFactorMinArea** `double GEOM_FADE2D::MeshGenParams::growFactorMinArea`

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

6.13.3.9 **maxEdgeLength** `double GEOM_FADE2D::MeshGenParams::maxEdgeLength`

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

6.13.3.10 **maxTriangleArea** `double GEOM_FADE2D::MeshGenParams::maxTriangleArea`

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

6.13.3.11 **minAngleDegree** `double GEOM_FADE2D::MeshGenParams::minAngleDegree`

Minimum interior angle: Default: 20.0, maximum: 30.0

6.13.3.12 **minEdgeLength** `double GEOM_FADE2D::MeshGenParams::minEdgeLength`

Edges below the minimum length are not subdivided. This parameter is useful to avoid tiny triangles. Default: 0.001
The documentation for this class was generated from the following file:

- [MeshGenParams.h](#)

6.14 GEOM_FADE2D::MsgBase Class Reference

[MsgBase](#), a base class for message subscriber classes.

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

Public Member Functions

- virtual void [update](#) (MsgType msgType, const char *s, double d)=0
update

6.14.1 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/>

6.14.2 Member Function Documentation

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

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

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

- [MsgBase.h](#)

6.15 GEOM_FADE2D::PeelPredicateTS Class Reference

User-defined peel predicate.

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

Public Member Functions

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

6.15.1 Detailed Description

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

See also

<https://www.geom.at/mesh-improvements/>

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

- [UserPredicates.h](#)

6.16 GEOM_FADE2D::Point2 Class Reference

Point.

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

Public Member Functions

- [Point2](#) ()
Default constructor.
- [Point2](#) (const double x_, const double y_)
Constructor.

- **Point2** (const **Point2** &p_)
Copy constructor.
- void **change** (const double x_, const double y_)
- int **getCustomIndex** () const
Get the custom index.
- **Triangle2** * **getIncidentTriangle** () const
Get the associated triangle.
- double **getMaxAbs** () const
Get max(abs(x),abs(y))
- bool **operator!=** (const **Point2** &p) const
Inequality operator.
- **Point2** **operator+** (const **Vector2** &vec) const
Add vector and point.
- **Vector2** **operator-** (const **Point2** &other) const
*Returns a vector from other to *this.*
- **Point2** **operator-** (const **Vector2** &vec) const
Subtract vector from point.
- bool **operator<** (const **Point2** &p) const
Less than operator.
- **Point2** & **operator=** (const **Point2** &other)
- bool **operator==** (const **Point2** &p) const
Equality operator.
- bool **operator>** (const **Point2** &p) const
Greater than operator.
- void **set** (const double x_, const double y_, int customIndex_)
Set the coordinates and customIndex.
- void **set** (const **Point2** &pnt)
Set the coordiantes.
- void **setCustomIndex** (int customIndex_)
Set a custom index.
- void **setIncidentTriangle** (**Triangle2** *pT)
Associate a triangle with the point.
- double **x** () const
Get the x-coordinate.
- void **xy** (double &x_, double &y_) const
Get the x- and y-coordinate.
- double **y** () const
Get the y-coordinate.

Protected Attributes

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

Friends

- class **Dt2**
- std::ostream & **operator<<** (std::ostream &stream, const **Point2** &pnt)
Print to stream.
- std::istream & **operator>>** (std::istream &stream, **Point2** &pnt)
Stream-to-Point.

6.16.1 Detailed Description

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

6.16.2 Constructor & Destructor Documentation

6.16.2.1 Point2() [1/3] `GEOM_FADE2D::Point2::Point2 (`
`const double x_,`
`const double y_) [inline]`

Parameters

$x \leftrightarrow$ _	x-coordinate
$y \leftrightarrow$ _	y-coordinate

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

The coordinates are initialized to -DBL_MAX

6.16.2.3 Point2() [3/3] `GEOM_FADE2D::Point2::Point2 (`
`const Point2 & p_) [inline]`

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

6.16.3 Member Function Documentation

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

Returns

the custom index.

Note

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

See also

void [setCustomIndex\(int customIndex_\)](#)

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

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

Returns

the associated triangle

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

Compares the x and y coordinates

Note

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

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

Compares the x and y coordinates

Note

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

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

Compares the x and y coordinates

Note

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

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

Compares the x and y coordinates

Note

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

6.16.3.7 set() [1/2] `void GEOM_FADE2D::Point2::set (`
`const double x_,`
`const double y_,`
`int customIndex_) [inline]`

Internal method

Parameters

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

6.16.3.8 set() [2/2] `void GEOM_FADE2D::Point2::set (`
`const Point2 & pnt) [inline]`

Parameters

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

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

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

Note

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

See also

int [getCustomIndex\(\)](#)

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

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

Parameters

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

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

Returns

the x-coordinate

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

Parameters

<i>x</i> ↔ _↔	x-coordinate
<i>y</i> ↔ _↔	y-coordinate

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

Returns

the y-coordinate

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

- [Point2.h](#)

6.17 GEOM_FADE2D::Segment2 Class Reference

Segment.

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

Public Member Functions

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

Protected Attributes

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

Friends

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

6.17.1 Constructor & Destructor Documentation

6.17.1.1 [Segment2\(\)](#) [1/2] `GEOM_FADE2D::Segment2::Segment2 (`
 const [Point2](#) & *src_*,
 const [Point2](#) & *trg_*)

Parameters

<i>src_</i> ↔ —	First endpoint (source)
<i>trg_</i> ↔ —	Second endpoint (target)

6.17.1.2 [Segment2\(\)](#) [2/2] `GEOM_FADE2D::Segment2::Segment2 ()`
 Create a [Segment2](#) Default constructor

6.17.2 Member Function Documentation

6.17.2.1 [getSqLen2D\(\)](#) `double GEOM_FADE2D::Segment2::getSqLen2D () const`
 Get the squared length

6.17.2.2 [getSrc\(\)](#) `Point2 GEOM_FADE2D::Segment2::getSrc () const`
 Get the source point

Returns

the source point

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

Get the target point

Returns

the target point

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

operator==

Undirected equality operator

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

Internally swaps the source and target point

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

- [Segment2.h](#)

6.18 GEOM_FADE2D::SegmentChecker Class Reference

[SegmentChecker](#) identifies intersecting line segments.

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

Public Member Functions

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

6.18.1 Detailed Description

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

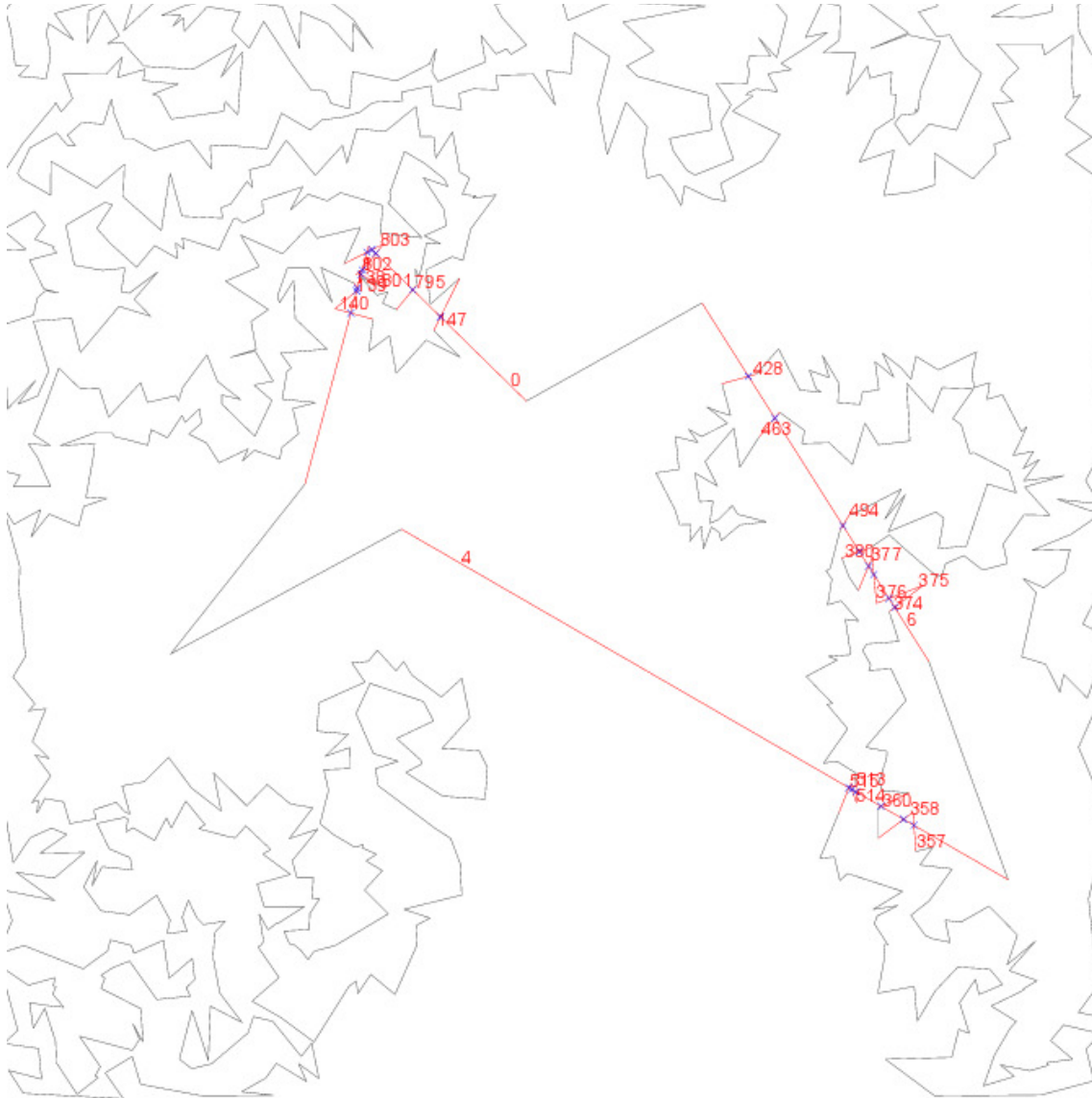


Figure 18 Polylines: Intersecting segments are automatically found

See also

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

6.18.2 Constructor & Destructor Documentation

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

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

Parameters

$V \leftrightarrow$ <i>Segments</i> \leftrightarrow —	contains the segments to be checked
---	-------------------------------------

6.18.3 Member Function Documentation

6.18.3.1 clipSegment() `ClipResult` GEOM_FADE2D::SegmentChecker::clipSegment (`Segment2` & *seg*)

Clip Segment

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

Parameters

<i>in, out</i>	<i>seg</i>	is the line segment to be clipped
----------------	------------	-----------------------------------

Returns

CR_INVALID, CR_EMPTY, CR_CLIPPED_DEGENERATE, CR_CLIPPED_NONDEGENERATE, $CR \leftrightarrow$ COMPLETE_DEGENERATE, CR_COMPLETE_NONDEGENERATE or CR_INVALID.

Note

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

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

Get illegal segments

Returns segments which are involved in intersections. Intersections at endpoints are only reported when $b \leftrightarrow$ 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

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

Returns the index of a segment

Parameters

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

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

Compute the intersection point of two segments

Use [getIntersectionType\(\)](#) to determine the segment intersection type sit.

Parameters

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

Note

pSeg1 and pSeg2 do not need to be from the set that has been used to initialize the [SegmentChecker](#).

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

Computes the intersection segment of two collinear intersecting segments

Parameters

	<i>seg0,seg1</i>	are intersecting segments such that their SegmentIntersectionType is SIT_SEGMENT
out	<i>issOut</i>	is the computed intersection of seg0 and seg1

Note

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

6.18.3.6 getIntersectionType() SegmentIntersectionType GEOM_FADE2D::SegmentChecker::getIntersection↔
 Type (
 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

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

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

Parameters

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

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

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

Parameters

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

Note

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

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

6.18.3.9 getLimit() `Bbox2 GEOM_FADE2D::SegmentChecker::getLimit () const`
Get Limit

Returns

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

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

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

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

Returns the i-th segment

Parameters

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

6.18.3.12 setLimit() `void GEOM_FADE2D::SegmentChecker::setLimit (`
`const Bbox2 & bbx)`

Set Limit

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

6.18.3.13 showIllegalSegments() `void GEOM_FADE2D::SegmentChecker::showIllegalSegments (`
`bool bAlsoEndPointIntersections,`
`const char * 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

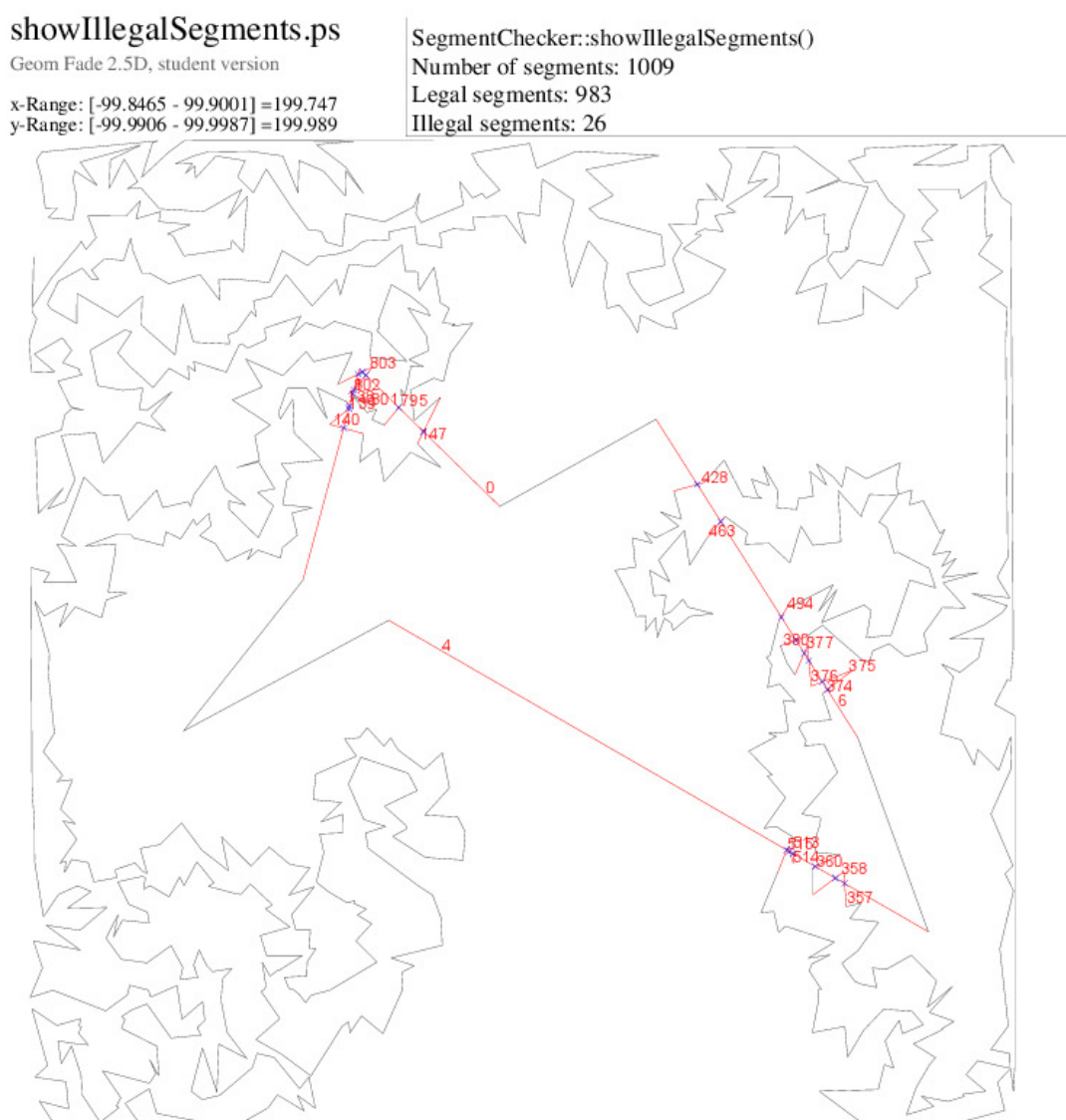


Figure 19 Visualization of polyline intersections

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

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

Parameters

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

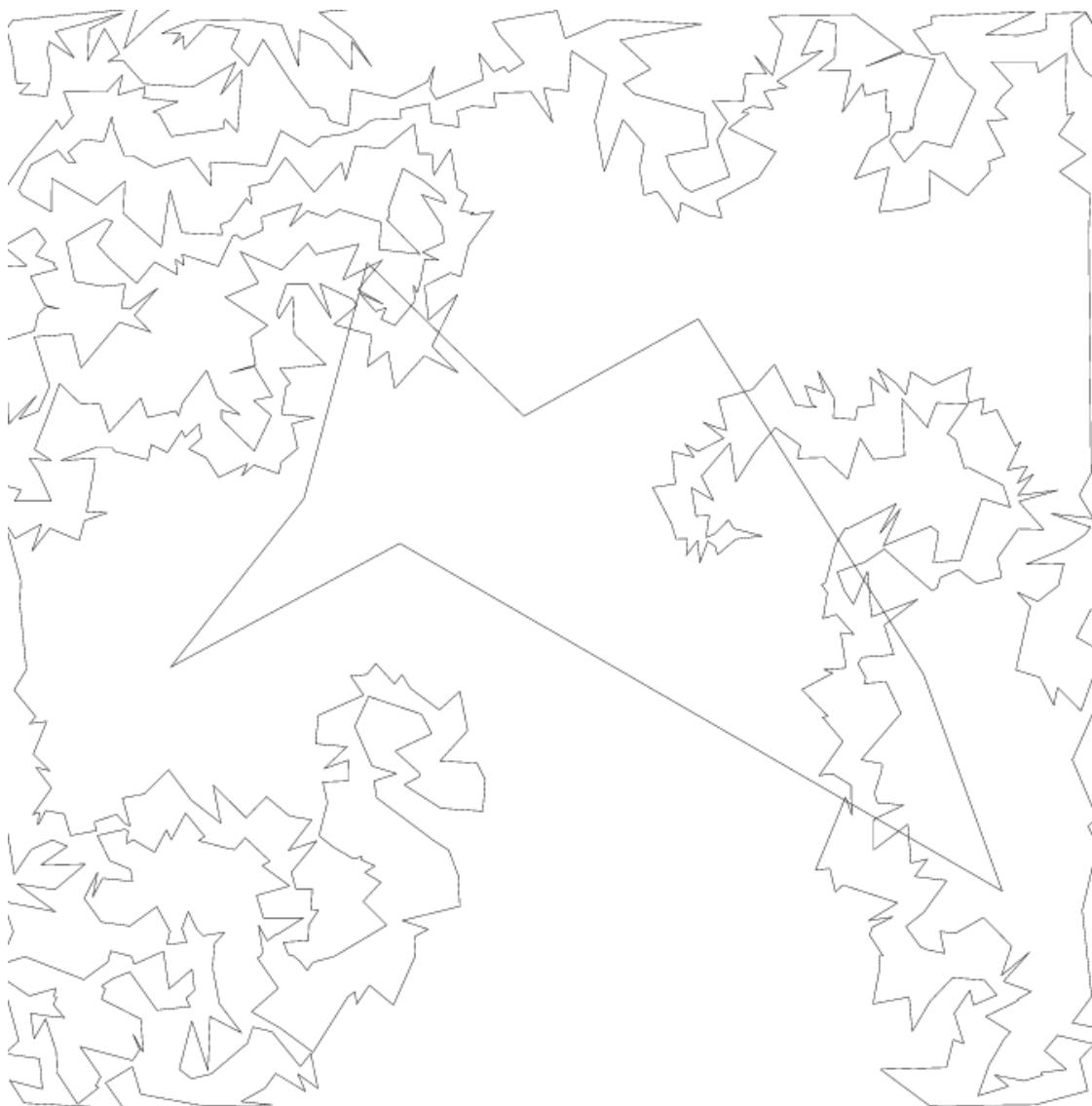


Figure 20 Line segments written to a postscript file

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

Register a progress bar object

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

Parameters

<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 .

6.18.3.16 unsubscribe() `void GEOM_FADE2D::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](#)

6.19 GEOM_FADE2D::Triangle2 Class Reference

Triangle.

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

Public Member Functions

- [Triangle2](#) ()
Constructor.
- void [clearProperties](#) ()
Clear all corners and neighbor pointers.
- double [getArea2D](#) () const
Get 2D Area.
- [Point2](#) [getBarycenter](#) () const
Get the barycenter of a triangle.
- [Point2](#) [getCircumcenter](#) ([CircumcenterQuality](#) &ccq, bool bForceExact=false) const
Get the circumcenter of the triangle.
- std::pair< [Point2](#), bool > [getDual](#) (bool bForceExact=false) const
- double [getInteriorAngle2D](#) (int ith) const
Get interior 2D angle.
- int [getIntraTriangleIndex](#) (const [Point2](#) *p) const
Get the index of p in the triangle.
- int [getIntraTriangleIndex](#) (const [Point2](#) *p0, const [Point2](#) *p1) const
Get the index of (p0,p1)
- int [getIntraTriangleIndex](#) (const [Triangle2](#) *pTriangle) const
Get the neighbor index of pTriangle.
- int [getMaxIndex](#) () const
Get the index of the largest edge.
- double [getMaxSqEdgeLen2D](#) () const
Get the maximum squared 2D edge length.
- int [getMinIndex](#) () const
Get the index of the smallest edge.
- [Triangle2](#) * [getOppositeTriangle](#) (const int ith) const
Get the i-th neighbor triangle.
- double [getSquaredEdgeLength2D](#) (int ith) const

- bool [hasOnEdge](#) (int i, const [Point2](#) &q) const
Has point on edge.
- bool [hasVertex](#) (const [Point2](#) &vtx) const
Has vertex.
- bool [hasVertex](#) ([Point2](#) *pVtx) const

- *Has vertex.*
- void **setOppTriangle** (const int ith, [Triangle2](#) *pTriangle)
Set the i-th neighbor triangle.
- void **setProperties** ([Point2](#) *pl, [Point2](#) *pJ, [Point2](#) *pK)
Set all corners.
- void **setPropertiesAndOppT** ([Point2](#) *pl, [Point2](#) *pJ, [Point2](#) *pK, [Triangle2](#) *pNeig0, [Triangle2](#) *pNeig1, [Triangle2](#) *pNeig2)
Set all corners and neighbor triangles.
- void **setVertexPointer** (const int ith, [Point2](#) *pp)
Set the i-th corner.

Protected Member Functions

- double **computeArea** (double l0, double l1, double l2) const
- bool **getCC_inexact** (double avgOffX, double avgOffY, [Point2](#) &cc) const

Protected Attributes

- [Triangle2](#) * **aOppTriangles** [3]
- [Point2](#) * **aVertexPointer** [3]

Friends

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

6.19.1 Detailed Description

[Triangle2](#) is a triangle in the [Fade_2D](#) triangulation. It holds three [Point2](#) pointers to its corners. The corners are numbered in counterclockwise order. We refer to these indices as intra-triangle-indices.

Each triangle has three neighbors which can be accessed through intra-triangle-indices: The i-th neighbor triangle of a certain triangle T is the one which shares an edge with T such that this edge does not include the i-th corner of T.

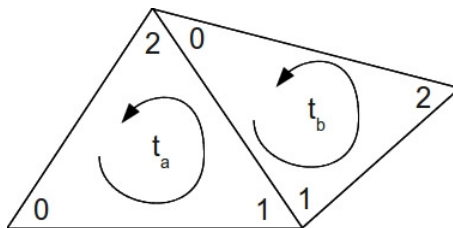


Figure 21 Indices and neighborships, *t_b* is the 0-th neighbor of *t_a* and *t_a* is the 2nd neighbor of *t_b*.

See also

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

6.19.2 Member Function Documentation

6.19.2.1 **getArea2D()** double GEOM_FADE2D::Triangle2::getArea2D () const

Returns the 2D area of the triangle.

Note: The `getArea()` method is deprecated and replaced by `getArea2D()` to keep the names consistent.

6.19.2.2 `getBarycenter()` `Point2` `GEOM_FADE2D::Triangle2::getBarycenter () const`**Returns**

the barycenter of the triangle.

6.19.2.3 `getCircumcenter()` `Point2` `GEOM_FADE2D::Triangle2::getCircumcenter (`
`CircumcenterQuality & ccq,`
`bool bForceExact = false) const`**Parameters**

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

Returns

the circumcenter of the triangle

Attention

Attention: The circumcenter of a nearly collinear triangle can have extremely large coordinates. Fade computes the circumcenter with multiple-precision arithmetic in this case but the result might nevertheless not be exact because it too large for double-precision coordinates. In such cases a finite point is returned and `ccq` returns CCQ_OUT_OF_BOUNDS. You can avoid such extreme numeric cases easily: Just insert four dummy vertices around the triangulation at coordinates 10 times larger than the domain of the data points because this restricts the Voronoi cells of the data points to this range.

6.19.2.4 `getInteriorAngle2D()` `double` `GEOM_FADE2D::Triangle2::getInteriorAngle2D (`
`int ith) const`

Note: The `getArea()` method is deprecated and replaced by `getInteriorAngle2D()` to keep the names consistent.

Returns

the interior 2D angle at the *ith* vertex

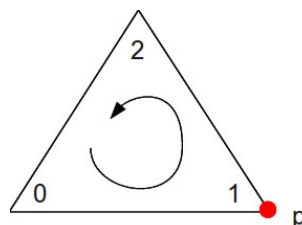
6.19.2.5 `getIntraTriangleIndex()` `[1/3]` `int` `GEOM_FADE2D::Triangle2::getIntraTriangleIndex (`
`const Point2 * p) const [inline]`

Figure 22 Intra triangle index of a vertex pointer

Parameters

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

Returns

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

6.19.2.6 `getIntraTriangleIndex()` [2/3] `int GEOM_FADE2D::Triangle2::getIntraTriangleIndex (`
`const Point2 * p0,`
`const Point2 * p1) const [inline]`

Returns

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

6.19.2.7 `getIntraTriangleIndex()` [3/3] `int GEOM_FADE2D::Triangle2::getIntraTriangleIndex (`
`const Triangle2 * pTriangle) const [inline]`

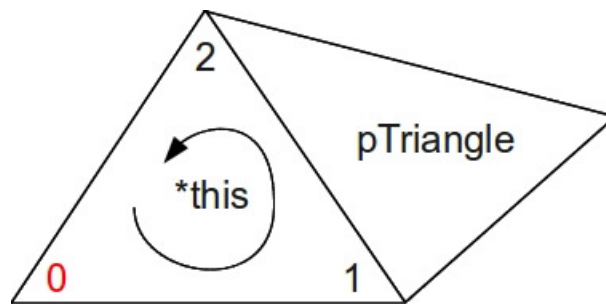


Figure 23 *pTriangle* is the 0-th neighbor of **this*

Parameters

<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*.

6.19.2.8 getOppositeTriangle() `Triangle2 * GEOM_FADE2D::Triangle2::getOppositeTriangle (const int ith) const [inline]`

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

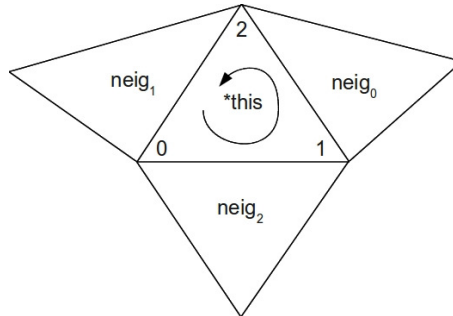


Figure 24 Neighbors of a triangle

Parameters

<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.

6.19.2.9 getSquaredEdgeLength2D() `double GEOM_FADE2D::Triangle2::getSquaredEdgeLength2D (int ith) const`

Method for internal use

Squared edge length

Returns the squared length of the *ith* edge.

6.19.2.10 hasOnEdge() `bool GEOM_FADE2D::Triangle2::hasOnEdge (int i, const Point2 & q) const`

Returns

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

6.19.2.11 hasVertex() `[1/2] bool GEOM_FADE2D::Triangle2::hasVertex (const Point2 & vtx) const`

Returns

if *vtx* is a corner of the triangle

6.19.2.12 hasVertex() [2/2] `bool GEOM_FADE2D::Triangle2::hasVertex (
 Point2 * pVtx) const`

Returns

if `pVtx` is a corner of the triangle

6.19.2.13 setOppTriangle() `void GEOM_FADE2D::Triangle2::setOppTriangle (
 const int ith,
 Triangle2 * pTriangle) [inline]`

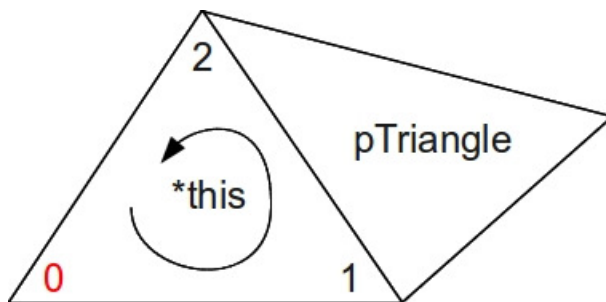


Figure 25 Make `pTriangle` the 0-th neighbor of `*this`

Parameters

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

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

- [Triangle2.h](#)

6.20 GEOM_FADE2D::TriangleAroundVertexIterator Class Reference

Iterator for all triangles around a given vertex.

```
#include <TriangleAroundVertexIterator.h>
```

Public Member Functions

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

- bool `operator==` (const [TriangleAroundVertexIterator](#) &rhs)
operator==()
- [Triangle2](#) * `previewNextTriangle` ()
Preview next triangle (CCW direction)
- [Triangle2](#) * `previewPrevTriangle` ()
Preview previous triangle (CW direction)

Protected Member Functions

- void `loop` ()

Protected Attributes

- const [Point2](#) * `pPnt`
- [Triangle2](#) * `pSavedTr`
- [Triangle2](#) * `pTr`

6.20.1 Detailed Description

The [TriangleAroundVertexIterator](#) iterates over all triangles incident to a given vertex of a [Fade_2D](#) instance. The advantage is that the incident triangles can be visited in a certain order, namely counterclockwise with `operator++()` or clockwise using `operator--()`. If the order is not important you can use [Fade_2D::getIncidentTriangles\(\)](#) instead.

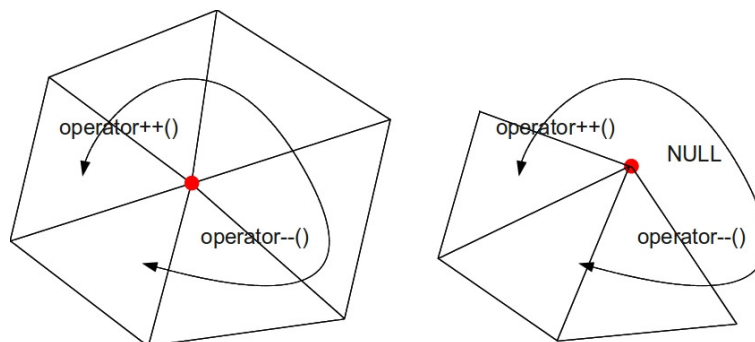


Figure 26 Left: the iterator visits the triangles around a vertex. Right: The iterator 'jumps' over the border edges of the triangulation

6.20.2 Constructor & Destructor Documentation

6.20.2.1 [TriangleAroundVertexIterator](#)() [1/3] `GEOM_FADE2D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (const Point2 * pPnt_) [inline], [explicit]`

Parameters

$p \leftrightarrow$ $Pnt \leftrightarrow$ —	is the vertex whose incident triangles can be visited with the iterator
---	---

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

6.20.2.2 [TriangleAroundVertexIterator](#)() [2/3] `GEOM_FADE2D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (Point2 * pPnt_, Triangle2 * pTr_) [inline]`

Parameters

$p \leftrightarrow$ $Pnt \leftrightarrow$ —	is the vertex whose incident triangles can be visited with the iterator
$pTr \leftrightarrow$ —	is the triangle the iterator initially points to

6.20.2.3 TriangleAroundVertexIterator() [3/3] `GEOM_FADE2D::TriangleAroundVertexIterator::TriangleAroundVertexIterator (`

`const TriangleAroundVertexIterator & it) [inline]`

Copies the iterator `it`

6.20.3 Member Function Documentation

6.20.3.1 operator!=() `bool GEOM_FADE2D::TriangleAroundVertexIterator::operator!= (`
`const TriangleAroundVertexIterator & rhs) [inline]`

Compares the center and the current triangle of `*this` and `rhs`

Returns

true when they are different, false otherwise

6.20.3.2 operator*() `Triangle2* GEOM_FADE2D::TriangleAroundVertexIterator::operator* () [inline]`
Dereferencing the iterator yields a pointer to the triangle to which the iterator points.

Warning

This method might yield NULL at the border of a triangulation.

6.20.3.3 operator++() `TriangleAroundVertexIterator& GEOM_FADE2D::TriangleAroundVertexIterator::operator++ () [inline]`

Moves the iterator to the next triangle in counterclockwise order.

Warning

At the border of a triangulation, two border edges exist which are incident to the center vertex. Consequently, the neighbor triangles are NULL there. If `operator++()` leads the iterator off the triangulation then the iterator will point to NULL. Another call to `operator++()` will set the iterator to the next triangle in counterclockwise order.

6.20.3.4 operator--() `TriangleAroundVertexIterator& GEOM_FADE2D::TriangleAroundVertexIterator::operator-- () [inline]`

Moves the iterator to the next triangle in clockwise order.

Warning

At the border of a triangulation, two border edges are incident to the center vertex. Consequently, the neighbor triangles are NULL there. If `operator--()` leads the iterator off the triangulation then the iterator will point to NULL. Another call to `operator--()` will set the iterator to the next triangle in clockwise order.

6.20.3.5 operator==() bool GEOM_FADE2D::TriangleAroundVertexIterator::operator==(const [TriangleAroundVertexIterator](#) & rhs) [inline]

Compares the center and the current triangle of *this and rhs

Returns

true when they are identically or false otherwise

6.20.3.6 previewNextTriangle() [Triangle2*](#) GEOM_FADE2D::TriangleAroundVertexIterator::preview↔NextTriangle () [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.

6.20.3.7 previewPrevTriangle() [Triangle2*](#) GEOM_FADE2D::TriangleAroundVertexIterator::preview↔PrevTriangle () [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](#)

6.21 GEOM_FADE2D::UserPredicateT Class Reference

User-defined predicate (deprecated)

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

Public Member Functions

- virtual bool **operator()** (const [Triangle2](#) *)=0

6.21.1 Detailed Description

This class is deprecated in favor of [PeelPredicateTS](#). It is kept for backwards compatibility.

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

- [UserPredicates.h](#)

6.22 GEOM_FADE2D::Vector2 Class Reference

Vector.

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

Public Member Functions

- [Vector2](#) ()
Default constructor.
- [Vector2](#) (const double x_, const double y_)
Constructor.
- [Vector2](#) (const [Vector2](#) &v_)
Copy constructor.
- bool [isDegenerate](#) () const
isDegenerate
- double [length](#) () const
Get the length of the vector.
- double [operator*](#) (const [Vector2](#) &other) const
Scalar product.
- [Vector2 operator*](#) (double val) const
Multiplication.
- [Vector2 operator/](#) (double val) const
Division.
- [Vector2 & operator=](#) (const [Vector2](#) &other)
Assignment operator.
- [Vector2 orthogonalVector](#) () const
- void [set](#) (const double x_, const double y_)
Set the values.
- double [sqLength](#) () const
Get the squared length of the vector.
- double [x](#) () const
Get the x-value.
- double [y](#) () const
Get the y-value.

Protected Attributes

- double **valX**
- double **valY**

6.22.1 Detailed Description

This class represents a vector in 2D

6.22.2 Constructor & Destructor Documentation

6.22.2.1 [Vector2\(\)](#) [1/2] `GEOM_FADE2D::Vector2::Vector2 ()`
The vector is initialized to (0,0)

6.22.2.2 [Vector2\(\)](#) [2/2] `GEOM_FADE2D::Vector2::Vector2 (const Vector2 & v_)`
Create a copy of vector v_

6.22.3 Member Function Documentation

6.22.3.1 isDegenerate() `bool GEOM_FADE2D::Vector2::isDegenerate () const`

Returns

true if the vector length is 0, false otherwise.

6.22.3.2 operator*() [1/2] `double GEOM_FADE2D::Vector2::operator* (const Vector2 & other) const`

Scalar product

6.22.3.3 operator*() [2/2] `Vector2 GEOM_FADE2D::Vector2::operator* (double val) const`

Multiply by a scalar value

6.22.3.4 operator/() `Vector2 GEOM_FADE2D::Vector2::operator/ (double val) const`

Divide by a scalar value

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

- [Vector2.h](#)

6.23 GEOM_FADE2D::Visualizer2 Class Reference

[Visualizer2](#) is a general Postscript writer. It draws the objects [Point2](#), [Segment2](#), [Triangle2](#), [Circle2](#) and [Label](#).

```
#include <Visualizer2.h>
```

Public Member Functions

- [Visualizer2](#) (const char *filename_)
Constructor.
- void [addHeaderLine](#) (const char *s)
Add a header line to the visualization.
- void [addObject](#) (const [Circle2](#) &circ, const [Color](#) &c)
Add a [Circle2](#) object to the visualization.
- void [addObject](#) (const [Edge2](#) &edge, const [Color](#) &c)
Add an [Edge2](#) object to the visualization.
- void [addObject](#) (const [Label](#) &lab, const [Color](#) &c)
Add a [Label](#) object to the visualization.
- void [addObject](#) (const [Point2](#) &pnt, const [Color](#) &c)
Add a [Point2](#) object to the visualization.
- void [addObject](#) (const [Segment2](#) &seg, const [Color](#) &c)
Add a [Segment2](#) object to the visualization.
- void [addObject](#) (const std::vector< [ConstraintSegment2](#) * > &vConstraintSegments, const [Color](#) &c)
Add a vector of [ConstraintSegment2](#) objects to the visualization.
- void [addObject](#) (const std::vector< [Edge2](#) > &vSegments, const [Color](#) &c)
Add a vector of [Edge2](#) objects to the visualization.
- void [addObject](#) (const std::vector< [Point2](#) * > &vPoints, const [Color](#) &c)
Add a vector of [Point2](#) to the visualization.*
- void [addObject](#) (const std::vector< [Point2](#) > &vPoints, const [Color](#) &c)
Add a vector of [Point2](#) objects to the visualization.
- void [addObject](#) (const std::vector< [Segment2](#) > &vSegments, const [Color](#) &c)
Add a vector of [Segment2](#) objects to the visualization.
- void [addObject](#) (const std::vector< [Triangle2](#) * > &vT, const [Color](#) &c)

- *Add a Triangle2* vector to the visualization.*
- void **addObject** (const std::vector< [Triangle2](#) > &vT, const [Color](#) &c)
- *Add a vector of Triangle2 objects to the visualization.*
- void **addObject** (const std::vector< [VoroCell2](#) * > &vT, const [Color](#) &c)
- *Add a vector of Voronoi Cells to the visualization.*
- void **addObject** (const [Triangle2](#) &tri, const [Color](#) &c)
- *Add a Triangle2 object to the visualization.*
- void **addObject** ([VoroCell2](#) *pVoroCell, const [Color](#) &c)
- *Add a Voronoi cell to the visualization.*
- **Bbox2 computeRange** (bool bWithVoronoi)
- *Compute the range.*
- void **writeFile** ()
- *Finish and write the postscript file.*

Protected Member Functions

- void **changeColor** (const [Color](#) &c)
- void **changeColor** (float r, float g, float b, float linewidth, bool bFill)
- void **periodicStroke** ()
- double **scaledDouble** (const double &d)
- [Point2](#) **scaledPoint** (const [Point2](#) &p)
- void **writeCircle** (const [Point2](#) &p1_, double radius, bool bFill)
- void **writeFooter** ()
- void **writeHeader** (const char *title)
- void **writeHeaderLines** ()
- void **writeLabel** ([Label](#) l)
- void **writeLine** (const [Point2](#) &pSource, const [Point2](#) &pTarget)
- void **writeMark** ([Point2](#) &p1_, float size)
- void **writePoint** ([Point2](#) &p1_, float size)
- void **writeTriangle** (const [Point2](#) &p0_, const [Point2](#) &p1_, const [Point2](#) &p2_, bool bFill, double width)
- void **writeTriangle** (const [Triangle2](#) *pT, bool bFill_, double width)
- void **writeVoroCell** ([VoroCell2](#) *pVoroCell, bool bFill, double width)

Protected Attributes

- [Bbox2](#) **bbox**
- bool **bFileClosed**
- bool **bFill**
- [Color](#) **lastColor**
- std::ofstream **outFile**
- Dat * **pDat**
- int **updateCtr**
- std::vector< std::pair< [Circle2](#), [Color](#) > > **vCircles**
- std::vector< std::pair< [Label](#), [Color](#) > > **vLabels**
- std::vector< std::pair< [Point2](#), [Color](#) > > **vPoints**
- std::vector< std::pair< [Segment2](#), [Color](#) > > **vSegments**
- std::vector< std::pair< [Triangle2](#), [Color](#) > > **vTriangles**
- std::vector< std::pair< [VoroCell2](#) *, [Color](#) > > **vVoroCells**

6.23.1 Detailed Description

See also

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

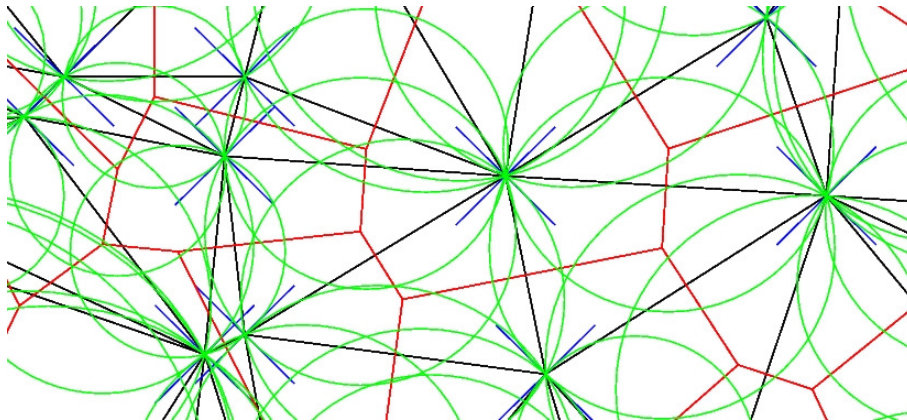


Figure 27 Example output of the Visualizer

6.23.2 Constructor & Destructor Documentation

6.23.2.1 Visualizer2() `GEOM_FADE2D::Visualizer2::Visualizer2 (const char * filename_) [explicit]`

Parameters

<i>filename_</i>	↔ is the name of the postscript file to be written
—	

6.23.3 Member Function Documentation

6.23.3.1 computeRange() `Bbox2 GEOM_FADE2D::Visualizer2::computeRange (bool bWithVoronoi)`

Parameters

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

Returns

a bounding box of currently contained objects

6.23.3.2 writeFile() `void GEOM_FADE2D::Visualizer2::writeFile ()`

Note

This method *must* be called at the end when all the objects have been added.

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

- [Visualizer2.h](#)

6.24 GEOM_FADE2D::VoroCell2 Class Reference

Voronoi cell.

```
#include <VoroCell2.h>
```

Public Member Functions

- bool [getAdjacentVCells](#) (std::vector< [VoroCell2](#) * > &vAdjacentCells) const
- double [getArea](#) () const
- bool [getBoundaryPoints](#) (std::vector< [Point2](#) > &vPoints, std::vector< [Vector2](#) > *pvInfiniteDirections=NULL) const
- double [getCentroid](#) ([Point2](#) ¢roid) const
- int [getCustomCellIndex](#) () const
- bool [getIncidentTriangles](#) (std::vector< [Triangle2](#) * > &vIncTriangles) const
- bool [getNeighborSites](#) (std::vector< [Point2](#) * > &vSites) const
- [Point2](#) * [getSite](#) () const
- bool [getVoronoiVertices](#) (std::vector< [VoroVertex2](#) * > &vVoroVertices) const
- bool [isFinite](#) () const
- void [setCustomCellIndex](#) (int customCellIndex_)

6.24.1 Detailed Description

This class represents a Voronoi cell. A Voronoi cell corresponds to a certain site which is also a vertex of the dual Delaunay triangulation.

6.24.2 Member Function Documentation

6.24.2.1 [getAdjacentVCells\(\)](#) bool GEOM_FADE2D::VoroCell2::getAdjacentVCells (std::vector< [VoroCell2](#) * > & vAdjacentCells) const

Get adjacent Voronoi cells

Parameters

<i>vAdjacentCells</i>	is used to return the neighbor cells in counterclockwise order.
-----------------------	---

Returns

whether the cell is finite.

6.24.2.2 [getArea\(\)](#) double GEOM_FADE2D::VoroCell2::getArea () const

Get the area

Returns

the area of the cell if it is finite or -1.0 for an infinite cell.

6.24.2.3 [getBoundaryPoints\(\)](#) bool GEOM_FADE2D::VoroCell2::getBoundaryPoints (std::vector< [Point2](#) > & vPoints, std::vector< [Vector2](#) > * pvInfiniteDirections = NULL) const

Get boundary points

Use this method to retrieve the Voronoi vertices of the present cell as [Point2](#).

Parameters

out	<i>vPoints</i>	contains the boundary points in counterclockwise order.
out	<i>pvInfiniteDirections</i>	can optionally be used to retrieve the directions of the infinite Voronoi edges: When a pointer to a vector is provided for <i>pvInfiniteDirections</i> and the cell is finite, then the first stored Vector2 describes the direction of the infinite edge at <i>vPoints</i> [0] and the second one the direction of the infinite edge at <i>vPoints</i> .back().

Returns

whether the cell is finite

See also

[getVoronoiVertices\(\)](#)

6.24.2.4 getCentroid() `double GEOM_FADE2D::VoroCell2::getCentroid (
 Point2 & centroid) const`

Get the centroid and area

Parameters

out	<i>centroid</i>	
-----	-----------------	--

Returns

the area of the cell if it is finite OR -1.0 for an infinite cell.

6.24.2.5 getCustomCellIndex() `int GEOM_FADE2D::VoroCell2::getCustomCellIndex () const`

Get custom cell-index

Returns

the custom cell index that has been set before or -1 when no custom cell index has been set.

See also

[setCustomCellIndex\(\)](#)

6.24.2.6 getIncidentTriangles() `bool GEOM_FADE2D::VoroCell2::getIncidentTriangles (
 std::vector< Triangle2 * > & vIncTriangles) const`

Get incident triangles

The site of the present Voronoi cell is also a vertex of the dual Delaunay triangulation.

Parameters

<i>vIncTriangles</i>	is used to return the the Delaunay triangles incident to the site of the cell in counterclockwise order.
----------------------	--

Returns

whether the cell is finite.

6.24.2.7 getNeighborSites() `bool GEOM_FADE2D::VoroCell2::getNeighborSites (
std::vector< Point2 * > & vSites) const`

Get neighbor sites

Parameters

<code>vSites</code>	is used to return the sites of the adjacent cells in counterclockwise order.
---------------------	--

Returns

whether the cell is finite.

6.24.2.8 getSite() `Point2* GEOM_FADE2D::VoroCell2::getSite () const`

Get site

Returns

the site of the cell, which is also a vertex of the dual Delaunay triangulation

6.24.2.9 getVoronoiVertices() `bool GEOM_FADE2D::VoroCell2::getVoronoiVertices (
std::vector< VoroVertex2 * > & vVoroVertices) const`

Get Voronoi vertices

Used to retrieve the Voronoi vertices of the cell.

Parameters

<code>out</code>	<code>vVoroVertices</code>	contains VoroVertex2 objects in counterclockwise order.
------------------	----------------------------	---

Returns

whether the cell is finite

See also

[getBoundaryPoints\(\)](#)

6.24.2.10 isFinite() `bool GEOM_FADE2D::VoroCell2::isFinite () const`

Is finite cell

Returns

whether the cell is finite

6.24.2.11 setCustomCellIndex() `void GEOM_FADE2D::VoroCell2::setCustomCellIndex (
int customCellIndex_)`

Set custom cell-index

Use this method to associate Voronoi cells with your own data structures or to assign labels for a visualization.

Parameters

<i>customCell↔ Index_</i>	is an arbitrary integer
-------------------------------	-------------------------

See also

[getCustomCellIndex\(\)](#)

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

- [VoroCell2.h](#)

6.25 GEOM_FADE2D::Voronoi2 Class Reference

Voronoi diagram.

```
#include <Voronoi2.h>
```

Public Member Functions

- bool [getVCellsAtVEdge](#) ([VoroVertex2](#) *pVoroVtx0, [VoroVertex2](#) *pVoroVtx1, [VoroCell2](#) *&pCell0, [VoroCell2](#) *&pCell1)
Get the Voronoi cells adjacent to a Voronoi edge.
- [VoroCell2](#) * [getVoronoiCell](#) ([Point2](#) *pSite)
Get Voronoi cell.
- void [getVoronoiCells](#) (std::vector< [VoroCell2](#) * > &vVoronoiCells)
Get all Voronoi cells.
- [VoroVertex2](#) * [getVoronoiVertex](#) ([Triangle2](#) *pT)
Get the Voronoi vertex of a triangle.
- bool [isValid](#) () const
Is valid.
- [VoroCell2](#) * [locateVoronoiCell](#) (const [Point2](#) &queryPoint)
Locate a Voronoi Cell.
- void [show](#) (const char *filename, bool bVoronoi=true, bool bCellColors=true, bool bSites=true, bool b↔Delaunay=true, bool bCellLabels=false)
Draw the Voronoi diagram.
- void [show](#) ([Visualizer2](#) *pVisualizer, bool bVoronoi=true, bool bCellColors=true, bool bSites=true, bool b↔Delaunay=true, bool bCellLabels=false)
Draw the Voronoi diagram.

Protected Attributes

- [Voronoi2Impl](#) * [pImpl](#)

6.25.1 Detailed Description

This class represents a Voronoi diagram. A Voronoi diagram is the dual graph of a Delaunay triangulation i.e.,

- Each Voronoi cell contains the area closest to its site which is a Delaunay vertex
- Each Voronoi edge has a dual edge in the Delaunay triangulation at an angle of 90 degrees to it.
- Each Voronoi vertex is the circumcenter of a Delaunay triangle

See also

https://en.wikipedia.org/wiki/Voronoi_diagram

6.25.2 Member Function Documentation

6.25.2.1 getVCellsAtVEdge() `bool GEOM_FADE2D::Voronoi2::getVCellsAtVEdge (`
`VoroVertex2 * pVoroVtx0,`
`VoroVertex2 * pVoroVtx1,`
`VoroCell12 *& pCell0,`
`VoroCell12 *& pCell1)`

Parameters

<code>pVoroVtx0,pVoroVtx1</code>	are the Voronoi vertices that define the Voronoi edge
<code>pCell0,pCell1</code>	are used to return the adjacent Voronoi cells or NULL if the command fails.

Returns

true when the command succeeds or false otherwise i.e., when (pVoroVtx0,pVoroVtx1) is not an edge of the Voronoi diagram.

6.25.2.2 getVoronoiCell() `VoroCell12* GEOM_FADE2D::Voronoi2::getVoronoiCell (`
`Point2 * pSite)`

Use this method to retrieve the Voronoi cell of a specific site.

Parameters

in	<code>pSite</code>	
----	--------------------	--

Returns

the `VoroCell2` of pSite.

6.25.2.3 getVoronoiCells() `void GEOM_FADE2D::Voronoi2::getVoronoiCells (`
`std::vector< VoroCell12 * > & vVoronoiCells)`

Use this method to retrieve all finite and infinite Voronoi cells.

Parameters

out	<code>vVoronoiCells</code>	
-----	----------------------------	--

6.25.2.4 getVoronoiVertex() `VoroVertex2* GEOM_FADE2D::Voronoi2::getVoronoiVertex (`
`Triangle2 * pT)`

Get the Voronoi vertex of a certain dual Delaunay triangle pT

Parameters

in	<code>pT</code>	
----	-----------------	--

Returns

the Voronoi vertex that corresponds to `pT`

6.25.2.5 isValid() `bool GEOM_FADE2D::Voronoi2::isValid () const`**Returns**

whether the Voronoi diagram is ready for use. This is the case as soon 3 sites exist which are not collinear.

6.25.2.6 locateVoronoiCell() `VoroCell2* GEOM_FADE2D::Voronoi2::locateVoronoiCell (const Point2 & queryPoint)`

This is a high performance method to locate the Voronoi cell of an arbitrary `queryPoint`

Parameters

in	<code>queryPoint</code>	
----	-------------------------	--

Returns

the Voronoi cell that contains `queryPoint` or NULL if the Voronoi diagram is invalid.

6.25.2.7 show() [1/2] `void GEOM_FADE2D::Voronoi2::show (const char * filename, bool bVoronoi = true, bool bCellColors = true, bool bSites = true, bool bDelaunay = true, bool bCellLabels = false)`**Parameters**

<code>filename</code>	is the output *.ps filename
<code>bVoronoi</code>	draw the edges of the Voronoi diagram (default: true)
<code>bCellColors</code>	use background colors for the Voronoi cells (default: true)
<code>bSites</code>	draw the sites (default: true)
<code>bDelaunay</code>	draw the Delaunay triangles (default: true)
<code>bCellLabels</code>	show cell labels (or -1 if not assigned) (default: false)

This method does automatically crop the viewport to twice the range of the sites. Thus very large and infinite cells appear clipped.

6.25.2.8 show() [2/2] `void GEOM_FADE2D::Voronoi2::show (Visualizer2 * pVisualizer, bool bVoronoi = true, bool bCellColors = true, bool bSites = true, bool bDelaunay = true, bool bCellLabels = false)`**Parameters**

<code>pVisualizer</code>	is the <code>Visualizer2</code> object to be used
--------------------------	---

Parameters

<i>bVoronoi</i>	draw the edges of the Voronoi diagram (default: true)
<i>bCellColors</i>	use background colors for the Voronoi cells (default: true)
<i>bSites</i>	draw the sites (default: true)
<i>bDelaunay</i>	draw the Delaunay triangles (default: true)
<i>bCellLabels</i>	show cell labels (or -1 if not assigned) (default: false)

Note

This method only clips infinite cells. But finite cells can also be very large. Call `Visualizer2::setLimit()` to specify the range of interest.

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

- [Voronoi2.h](#)

6.26 GEOM_FADE2D::VoroVertex2 Class Reference

Voronoi vertex.

```
#include <VoroVertex2.h>
```

Public Member Functions

- [Triangle2](#) * [getDualTriangle](#) () const
Get dual triangle.
- [Point2](#) [getPoint](#) ()
Get Point.
- bool [isAlive](#) () const
Is alive.

6.26.1 Detailed Description

This class represents a vertex of the Voronoi diagram. A Voronoi vertex is the circumcenter of a certain triangle of the dual Delaunay triangulation.

6.26.2 Member Function Documentation

6.26.2.1 [getDualTriangle\(\)](#) [Triangle2](#)* `GEOM_FADE2D::VoroVertex2::getDualTriangle () const`

A Voronoi vertex is the circumcenter of a certain triangle in the dual Delaunay triangulation.

Returns

the corresponding Delaunay triangle

6.26.2.2 [getPoint\(\)](#) [Point2](#) `GEOM_FADE2D::VoroVertex2::getPoint ()`

Returns

the Voronoi vertex as a [Point2](#)

6.26.2.3 isAlive() `bool GEOM_FADE2D::VoroVertex2::isAlive () const`

The Voronoi diagram changes dynamically when points are inserted or removed from the dual Delaunay triangulation.

Returns

whether the present Voronoi vertex is still valid

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

- [VoroVertex2.h](#)

6.27 GEOM_FADE2D::Zone2 Class Reference

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

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

Public Member Functions

- [Zone2](#) * [convertToBoundedZone](#) ()
Convert a zone to a bounded zone.
- void [debug](#) (const char *name="")
Development function.
- void [exportZone](#) ([FadeExport](#) &fadeExport, bool bWithCustomIndices) const
Export triangles from a zone.
- double [getArea2D](#) () const
Get 2D Area.
- void [getBorderEdges](#) (std::vector< [Edge2](#) > &vBorderEdgesOut) const
Get border edges.
- void [getBoundaryEdges](#) (std::vector< [Edge2](#) > &vEdges) const
Compute the boundary edges.
- void [getBoundarySegments](#) (std::vector< [Segment2](#) > &vSegments) const
Compute the boundary segments.
- [Bbox2](#) [getBoundingBox](#) () const
Compute the bounding box.
- void [getComponentPolygons](#) (std::vector< [CompPolygon](#) > &vCompPolygons) const
Get connected components and their boundary polygons.
- [ConstraintGraph2](#) * [getConstraintGraph](#) () const
Get the associated constraint.
- void [getConstraintGraphs](#) (std::vector< [ConstraintGraph2](#) * > &vConstraintGraphs_) const
Get the associated constraint graphs.
- size_t [getNumberOfTriangles](#) () const
Get the number of triangles.
- void [getTriangles](#) (std::vector< [Triangle2](#) * > &vTriangles_) const
Get the triangles of the zone.
- void [getVertices](#) (std::vector< [Point2](#) * > &vVertices_) const
Get the vertices of the zone.
- [ZoneLocation](#) [getZoneLocation](#) () const
Get the zone location.
- size_t [numberOfConstraintGraphs](#) () const
Get a the number of [ConstraintGraph2](#) objects.
- bool [save](#) (const char *filename)
Save the zone.
- bool [save](#) (std::ostream &stream)
Save the zone.

- void **show** (const char *postscriptFilename, bool bShowFull, bool bWithConstraints) const
Postscript visualization.
- void **show** (**Visualizer2** *pVisualizer, bool bShowFull, bool bWithConstraints) const
Postscript visualization.
- void **statistics** (const char *s) const
- void **subscribe** (MsgType msgType, **MsgBase** *pMsg)
Register a message receiver.
- void **unifyGrid** (double tolerance)
- void **unsubscribe** (MsgType msgType, **MsgBase** *pMsg)
Unregister a message receiver.
- void **writeObj** (const char *outFilename) const
*Write the zone to *.obj Writes the triangles of the present **Zone2** to an *.obj file (The *.obj format represents a 3D scene).*

Friends

- **Zone2** * **peelOfflf** (**Zone2** *pZone, bool bAvoidSplit, **PeelPredicateTS** *pPredicate)
Peel off border triangles.
- **Zone2** * **peelOfflf** (**Zone2** *pZone, **UserPredicateT** *pPredicate, bool bVerbose)
Peel off border triangles (deprecated)
- **Zone2** * **zoneDifference** (**Zone2** *pZone0, **Zone2** *pZone1)
Compute the difference of two zones.
- **Zone2** * **zoneIntersection** (**Zone2** *pZone0, **Zone2** *pZone1)
Compute the intersection of two zones.
- **Zone2** * **zoneSymmetricDifference** (**Zone2** *pZone0, **Zone2** *pZone1)
Compute the symmetric difference of two zones.
- **Zone2** * **zoneUnion** (**Zone2** *pZone0, **Zone2** *pZone1)
Compute the union of two zones.

6.27.1 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

6.27.2 Member Function Documentation

6.27.2.1 **convertToBoundedZone()** **Zone2*** **GEOM_FADE2D::Zone2::convertToBoundedZone** ()

The mesh generation algorithms **refine()** and **refineAdvanced()** require a zone object that is bounded by constraint segments. This is always the case for zones with **zoneLocation** **ZL_INSIDE** but other types of zones may be unbounded. For convenience this method is provided to create a bounded zone from a possibly unbounded one.

Returns

a pointer to a new **Zone2** object with **zoneLocation** **ZL_RESULT_BOUNDED** or a pointer to the present zone if this->**getZoneLocation()** is **ZL_INSIDE**.

6.27.2.2 **exportZone()** void **GEOM_FADE2D::Zone2::exportZone** (**FadeExport** & fadeExport, bool bWithCustomIndices) const

Parameters

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

6.27.2.3 getArea2D() `double GEOM_FADE2D::Zone2::getArea2D () const`

Returns the 2D area of the zone.

Note: The `getArea()` method is deprecated and replaced by `getArea2D()` to keep the names consistent.

6.27.2.4 getBorderEdges() `void GEOM_FADE2D::Zone2::getBorderEdges (std::vector< Edge2 > & vBorderEdgesOut) const`

Returns

: the CCW oriented border edges of the zone

6.27.2.5 getBoundaryEdges() `void GEOM_FADE2D::Zone2::getBoundaryEdges (std::vector< Edge2 > & vEdges) const`

Outputs the boundary edges of the zone. [Edge2](#) elements are always ccw-oriented but the edges are not returned in any specific order.

6.27.2.6 getBoundarySegments() `void GEOM_FADE2D::Zone2::getBoundarySegments (std::vector< Segment2 > & vSegments) const`

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

6.27.2.7 getComponentPolygons() `void GEOM_FADE2D::Zone2::getComponentPolygons (std::vector< CompPolygon > & vCompPolygons) const`

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

6.27.2.8 getConstraintGraph() `ConstraintGraph2* GEOM_FADE2D::Zone2::getConstraintGraph () const`

Returns

a pointer to the [ConstraintGraph2](#) object which defines the zone.
or NULL for ZL_RESULT-, ZL_GROW and ZL_GLOBAL_-zones.

6.27.2.9 getNumberOfTriangles() `size_t GEOM_FADE2D::Zone2::getNumberOfTriangles () const`

Warning

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

6.27.2.10 getTriangles() `void GEOM_FADE2D::Zone2::getTriangles (std::vector< Triangle2 * > & vTriangles_) const`

This command fetches the existing triangles of the zone.

Note

`Fade_2D::void applyConstraintsAndZones()` must be called after the last insertion of points and constraints.
that the lifetime of data from the `Fade2D` datastructures does exceed the lifetime of the `Fade2D` object.

6.27.2.11 getZoneLocation() `ZoneLocation GEOM_FADE2D::Zone2::getZoneLocation () const`

Returns

ZL_INSIDE if the zone applies to the triangles inside one or more [ConstraintGraph2](#) objects
 ZL_OUTSIDE if the zone applies to the outside triangles
 ZL_GLOBAL if the zone applies (dynamically) to all triangles
 ZL_RESULT if the zone is the result of a set operation
 ZL_GROW if the zone is specified by a set of constraint graphs and an inner point

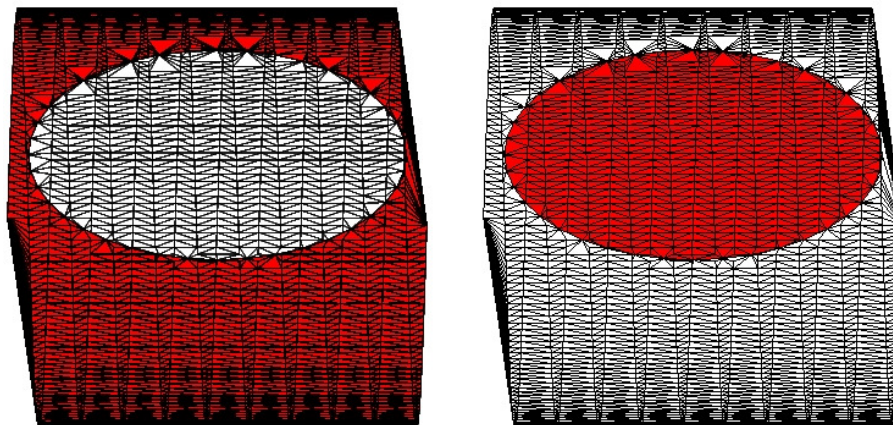


Figure 28 An outside zone and in inside zone

6.27.2.12 numberOfConstraintGraphs() `size_t GEOM_FADE2D::Zone2::numberOfConstraintGraphs () const`

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

6.27.2.13 save() `[1/2] bool GEOM_FADE2D::Zone2::save (const char * filename)`

This command saves the present [Zone2](#) to a binary file. Any constraint edges and custom indices in the domain are retained.

Parameters

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

Returns

whether the operation was successful

Note

A Delaunay triangulation is convex without holes but this may not hold for the zone to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the [Fade_2D](#) instance but not to the [Zone2](#) object when reloaded.

See also

[save\(std::ostream& stream\)](#). Use the similar command [Fade_2D::saveZones\(const char* file, std::vector<Zone2*> & vZones\)](#) to store more than just one zone. Use [Fade_2D::saveTriangulation\(\)](#) to store all triangles of the triangulation plus any specified zones. Use [Fade_2D::load\(\)](#) to reload the data from such files.

6.27.2.14 save() [2/2] `bool GEOM_FADE2D::Zone2::save (`
`std::ostream & stream)`

This command saves the present [Zone2](#) to an ostream. Any constraint edges and custom indices in the domain are retained.

Parameters

<i>stream</i>	is the output stream
---------------	----------------------

Returns

whether the operation was successful

Note

A Delaunay triangulation is convex without holes but this may not hold for the zone to be saved. Thus extra triangles may be saved to fill concavities. These extra-triangles will belong to the [Fade_2D](#) instance but not to the [Zone2](#) object when reloaded.

See also

Use the similar command [Fade_2D::saveZones\(const char* file, std::vector<Zone2*> &vZones\)](#) to store more than just one zone. Use [Fade_2D::saveTriangulation\(\)](#) to store all triangles of the triangulation plus any specified zones. Use [Fade_2D::load\(\)](#) to reload the data from such files.

6.27.2.15 show() [1/2] `void GEOM_FADE2D::Zone2::show (`
`const char * 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

6.27.2.16 show() [2/2] `void GEOM_FADE2D::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

6.27.2.17 statistics() `void GEOM_FADE2D::Zone2::statistics (`
`const char * s) const`

Statistics

Prints statistics to stdout.

6.27.2.18 subscribe() `void GEOM_FADE2D::Zone2::subscribe (`
`MsgType msgType,`
`MsgBase * pMsg)`

Parameters

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

6.27.2.19 unifyGrid() `void GEOM_FADE2D::Zone2::unifyGrid (`
`double tolerance)`

Unify Grid

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

Parameters

<i>tolerance</i>	is 0 when only exact cases of more than 3 points on a common circumcircle shall be changed. But in practice input data can be disturbed by noise and tiny rounding errors such that grid points are not exactly on a grid. The numeric error is computed as $error = \frac{abs(diagonalA - diagonalB)}{max(diagonalA, diagonalB)}$. and <i>tolerance</i> is an upper threshold to allow modification despite such tiny inaccuracies. Use with caution, such flips break the empty circle property and this may or may not fit your setting.
------------------	--

6.27.2.20 unsubscribe() `void GEOM_FADE2D::Zone2::unsubscribe (`
`MsgType msgType,`
`MsgBase * pMsg)`

Parameters

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

6.27.2.21 writeObj() `void GEOM_FADE2D::Zone2::writeObj (`
`const char * outFilename) const`

Parameters

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

6.27.3 Friends And Related Function Documentation

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

Parameters

<i>pZone</i>	is the input zone
<i>bAvoidSplit</i>	if true, then the algorithm removes a triangle only if it does not break the zone into independent components.
<i>pPredicate</i>	is a user-defined predicate that decides if a triangle shall be removed.

Returns

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

Attention

Check whether NULL is returned!

6.27.3.2 peelOffIf [2/2] `Zone2* peelOffIf (`
`Zone2 * pZone,`
`UserPredicateT * pPredicate,`
`bool bVerbose) [friend]`

This function is DEPRECATED but kept for backwards compatibility. The new and better function is↵
: `peelOffIf(Zone2* pZone, bool bAvoidSplit, PeelPredicateTS* pPredicate)`

Parameters

<i>pZone</i>	
<i>pPredicate</i>	
<i>bVerbose</i>	

Returns

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

6.27.3.3 zoneDifference `Zone2* zoneDifference (`
`Zone2 * pZone0,`
`Zone2 * pZone1) [friend]`

Returns

a new zone containing the triangles of `*pZone0` minus the ones of `*pZone1`

Note

`pZone0` and `pZone1` must belong to the same [Fade_2D](#) object.

6.27.3.4 zoneIntersection `Zone2* zoneIntersection (`
 `Zone2 * pZone0,`
 `Zone2 * pZone1) [friend]`

Returns

a new zone containing the intersection of *pZone0 and *pZone1

Note

pZone0 and pZone1 must belong to the same [Fade_2D](#) object.

6.27.3.5 zoneSymmetricDifference `Zone2* zoneSymmetricDifference (`
 `Zone2 * pZone0,`
 `Zone2 * pZone1) [friend]`

Returns

a new zone containing the triangles that are present in one of the zones but not in the other one.

Note

pZone0 and pZone1 must belong to the same [Fade_2D](#) object.

6.27.3.6 zoneUnion `Zone2* zoneUnion (`
 `Zone2 * pZone0,`
 `Zone2 * pZone1) [friend]`

Returns

a new zone containing the union of the triangles of *pZone0 and *pZone1

Note

pZone0 and pZone1 must belong to the same [Fade_2D](#) object.

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

- [Zone2.h](#)

7 File Documentation

7.1 Bbox2.h File Reference

```
#include "Segment2.h"  
#include "common.h"
```

Classes

- class [GEOM_FADE2D::Bbox2](#)
 Bbox2 is an axis aligned 2D bounding box.

Functions

- Bbox2 [GEOM_FADE2D::getBox](#) (std::vector< Point2 * > &vP)
 Compute the bounding box.
- Bbox2 [GEOM_FADE2D::getBox](#) (std::vector< Point2 > &vP)
 Compute the bounding box.
- std::ostream & [GEOM_FADE2D::operator<<](#) (std::ostream &stream, const Bbox2 &pC)
 Print the box.

7.1.1 Function Documentation

7.1.1.1 `getBox()` [1/2] `Bbox2 GEOM_FADE2D::getBox (`
`std::vector< Point2 * > & vP)`

Computes the bounding box of points

7.1.1.2 `getBox()` [2/2] `Bbox2 GEOM_FADE2D::getBox (`
`std::vector< Point2 > & vP)`

Computes the bounding box of points

7.1.1.3 `operator<<()` `std::ostream& GEOM_FADE2D::operator<< (`
`std::ostream & stream,`
`const Bbox2 & pC) [inline]`

Prints the box coordinates to stream

7.2 Circle2.h File Reference

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

Classes

- class [GEOM_FADE2D::Circle2](#)
Circle for visualization.

7.3 Color.h File Reference

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

Classes

- class [GEOM_FADE2D::Color](#)
Color for visualization.

Enumerations

- enum [GEOM_FADE2D::Colorname](#) {
CRED, **CGREEN**, **CBLUE**, **CBLACK**,
CPINK, **CGRAY**, **CORANGE**, **CLIGHTBLUE**,
CLIGHTBROWN, **CDARKBROWN**, **CPURPLE**, **COLIVE**,
CLAWNGREEN, **CPALEGREEN**, **CCYAN**, **CYELLOW**,
CWHITE }
Predefined colors for convenience.

Functions

- `std::ostream & GEOM_FADE2D::operator<< (std::ostream &stream, const Color &c)`

7.4 ConstraintGraph2.h File Reference

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

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

Classes

- class [GEOM_FADE2D::ConstraintGraph2](#)
ConstraintGraph2 is a set of Constraint Edges ([ConstraintSegment2](#))

7.5 ConstraintSegment2.h File Reference

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

Classes

- class [GEOM_FADE2D::ConstraintSegment2](#)
A [ConstraintSegment2](#) represents a Constraint Edge.

Enumerations

- enum [GEOM_FADE2D::ConstraintInsertionStrategy](#) { [CIS_CONFORMING_DELAUNAY](#) =0 , [GEOM_FADE2D::CIS_CONSTR](#)
=1 , [GEOM_FADE2D::CIS_KEEP_DELAUNAY](#) =0 , [GEOM_FADE2D::CIS_IGNORE_DELAUNAY](#) =1 }

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

7.5.1 Enumeration Type Documentation

7.5.1.1 ConstraintInsertionStrategy enum [GEOM_FADE2D::ConstraintInsertionStrategy](#)

- [CIS_CONSTRAINED_DELAUNAY](#) inserts a segment without subdivision unless required (which is the case if existing vertices or constraint segments are crossed).

All other constraint insertion strategies are deprecated and only kept for backwards compatibility. Their behavior can be achieved using [ConstraintGraph2::makeDelaunay\(\)](#) and/or [Fade_2D::drape\(\)](#). See also [examples_25↵D/terrain.cpp](#).

Note

In former library versions the terms [CIS_IGNORE_DELAUNAY](#) and [CIS_KEEP_DELAUNAY](#) were used but these were misleading and are now deprecated. For backwards compatibility they are kept.

Enumerator

CIS_CONSTRAINED_DELAUNAY	Deprecated.
CIS_KEEP_DELAUNAY	Deprecated name.
CIS_IGNORE_DELAUNAY	Deprecated.

7.6 Edge2.h File Reference

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

Classes

- class [GEOM_FADE2D::Edge2](#)

Edge2 is a directed edge.

- struct [GEOM_FADE2D::Func_gtEdge2D](#)
Functor to sort edges by 2d length (descending)
- struct [GEOM_FADE2D::Func_ltEdge2D](#)
Functor to sort edges by 2d length (ascending)

7.7 Fade_2D.h File Reference

```
#include "common.h"
#include "freeFunctions.h"
#include "License.h"
#include "Point2.h"
#include "Triangle2.h"
#include "TriangleAroundVertexIterator.h"
#include "Visualizer2.h"
#include "Zone2.h"
#include "ConstraintGraph2.h"
#include "Performance.h"
#include "MeshGenParams.h"
#include "MsgBase.h"
#include "SegmentChecker.h"
#include "testDataGenerators.h"
#include "FadeExport.h"
#include "Voronoi2.h"
```

Classes

- class [GEOM_FADE2D::Fade_2D](#)
Fade_2D is the Delaunay triangulation main class.

7.7.1 Detailed Description

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

7.8 FadeExport.h File Reference

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

Classes

- struct [GEOM_FADE2D::FadeExport](#)
FadeExport is a simple struct to export triangulation data.

7.9 freeFunctions.h File Reference

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

Functions

- void [GEOM_FADE2D::edgesToPolygons](#) (std::vector< Edge2 > &vEdgesIn, std::vector< std::vector< Edge2 > > &vvPolygonsOut, std::vector< Edge2 > &vRemainingOut)
Create polygons from a set of edges.
- bool [GEOM_FADE2D::fillHole](#) (std::vector< std::pair< Segment2, Vector2 > > vPolygonSegments, bool b↵WithRefine, bool bVerbose, std::vector< Point2 > &vCornersOut)
Fill a hole in a 3D mesh with triangles (deprecated)
- double [GEOM_FADE2D::getArea2D](#) (Point2 *p0, Point2 *p1, Point2 *p2)
Get 2D area of a triangle.
- void [GEOM_FADE2D::getBorders](#) (const std::vector< Triangle2 * > &vT, std::vector< Segment2 > &v↵BorderSegmentsOut)
Get Borders.
- void [GEOM_FADE2D::getConnectedComponents](#) (const std::vector< Triangle2 * > &vT, std::vector< std↵::vector< Triangle2 * > > &vvT)
Get connected components.
- void [GEOM_FADE2D::getDirectedEdges](#) (const std::vector< Triangle2 * > &vT, std::vector< Edge2 > &v↵DirectedEdgesOut)
Get directed edges The directed edges of vT are returned in vDirectedEdgesOut. Directed means that each edge (a,b) with two adjacent triangles in vT is returned twice, as edge(a,b) and edge(b,a).
- const char * [GEOM_FADE2D::getFade2DVersion](#) ()
Get the Fade2D version string.
- int [GEOM_FADE2D::getMajorVersionNumber](#) ()
Get the major version number.
- int [GEOM_FADE2D::getMinorVersionNumber](#) ()
Get the minor version number.
- Orientation2 [GEOM_FADE2D::getOrientation2](#) (const Point2 *p0, const Point2 *p1, const Point2 *p2)
Get the orientation of three points.
- Orientation2 [GEOM_FADE2D::getOrientation2_mt](#) (const Point2 *p0, const Point2 *p1, const Point2 *p2)
Get Orientation2 (MT)
- int [GEOM_FADE2D::getRevisionNumber](#) ()
Get the revision version number.
- void [GEOM_FADE2D::getSortedBoundaryPolygons](#) (std::vector< Triangle2 * > &vConnectedComponent, std::vector< Edge2 > &vOutsidePolygon, std::vector< std::vector< Edge2 > > &vHolePolygons)
Get sorted boundary polygons.
- void [GEOM_FADE2D::getUndirectedEdges](#) (const std::vector< Triangle2 * > &vT, std::vector< Edge2 > &vUndirectedEdgesOut)
Get undirected edges.
- bool [GEOM_FADE2D::isRelease](#) ()
Check if a RELEASE or a DEBUG version is used.
- bool [GEOM_FADE2D::isSimplePolygon](#) (std::vector< Segment2 > &vSegments)
isSimplePolygon
- void [GEOM_FADE2D::offsetPolygonPoints](#) (double offset, std::vector< Point2 > &vOrgPoints, std::vector< Point2 > &vOffsetPoints)
Create an offset polygon.
- void [GEOM_FADE2D::pointsToPolyline](#) (std::vector< Point2 > &vInPoints, bool bClose, std::vector< Seg↵ment2 > &vOutSegments)
Points-to-Polyline.
- bool [GEOM_FADE2D::readPointsBIN](#) (const char *filename, std::vector< Point2 > &vPointsIn)
Read points from a binary file.
- bool [GEOM_FADE2D::readSegmentsBIN](#) (const char *filename, std::vector< Segment2 > &vSegmentsOut)
Read segments from a binary file.
- bool [GEOM_FADE2D::readXY](#) (const char *filename, std::vector< Point2 > &vPointsOut)

- Read (x y) points.*
- bool `GEOM_FADE2D::sortRing` (std::vector< Segment2 > &vRing)
Sort a vector of Segments.
 - bool `GEOM_FADE2D::sortRingCCW` (std::vector< Segment2 > &vRing)
Sort a vector of Segments.
 - bool `GEOM_FADE2D::writePointsASCII` (const char *filename, const std::vector< Point2 * > &vPointsIn)
Write points to an ASCII file.
 - bool `GEOM_FADE2D::writePointsASCII` (const char *filename, const std::vector< Point2 > &vPointsIn)
Write points to an ASCII file.
 - bool `GEOM_FADE2D::writePointsBIN` (const char *filename, std::vector< Point2 * > &vPointsIn)
Write points to a binary file.
 - bool `GEOM_FADE2D::writePointsBIN` (const char *filename, std::vector< Point2 > &vPointsIn)
Write points to a binary file.
 - bool `GEOM_FADE2D::writeSegmentsBIN` (const char *filename, std::vector< Segment2 > &vSegmentsIn)
Write segments to a binary file.

7.9.1 Function Documentation

7.9.1.1 getSortedBoundaryPolygons() void `GEOM_FADE2D::getSortedBoundaryPolygons` (
 std::vector< `Triangle2` * > & `vConnectedComponent`,
 std::vector< `Edge2` > & `vOutsidePolygon`,
 std::vector< std::vector< `Edge2` > > & `vHolePolygons`)

This function takes ONE connected component of triangles. It returns the outer polygon as well as the inner hole polygons if any.

Parameters

in	<code>vConnectedComponent</code>	is a connected component of triangles where the term "connected" means adjacency on edges. It is important that just one connected component is passed!
out	<code>vOutsidePolygon</code>	is the outside boundary of the connected component.
out	<code>vHolePolygons</code>	contains the hole polygons (if any)

Edges in output polygons are sorted and CCW-oriented with respect to their triangle. Thus the outer polygon is always CCW oriented and holes are always CW oriented. This is sometimes a useful property.

Attention

Pass only one connected component.

7.9.1.2 offsetPolygonPoints() void `GEOM_FADE2D::offsetPolygonPoints` (
 double `offset`,
 std::vector< `Point2` > & `vOrgPoints`,
 std::vector< `Point2` > & `vOffsetPoints`)

Parameters

	<code>offset</code>	specifies the offset distance (positive or negative)
in	<code>vOrgPoints</code>	are ordered points of a counterclockwise polygon (no point repeated)
out	<code>vOffsetPoints</code>	contains points moved outside by the offset distance

Output polygon points do not care about selfintersections of the final offset polygon. The offset is constant independent of the angle at each vertex.

7.10 Label.h File Reference

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

Classes

- class [GEOM_FADE2D::Label](#)
Label is a Text-Label for Visualization.

7.11 MeshGenParams.h File Reference

```
#include "common.h"
#include "Vector2.h"
```

Classes

- class [GEOM_FADE2D::MeshGenParams](#)
Parameters for the mesh generator.

Functions

- `template<typename T >`
`void GEOM_FADE2D::unusedParameter (const T &)`
Unused parameter.

7.11.1 Function Documentation

7.11.1.1 `unusedParameter()` `template<typename T >`
`void GEOM_FADE2D::unusedParameter (`
`const T &) [inline]`

Empty template to avoid compiler warnings about unused function parameters

7.12 MsgBase.h File Reference

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

Classes

- class [GEOM_FADE2D::MsgBase](#)
MsgBase, a base class for message subscriber classes.

Enumerations

- enum `MsgType` { `MSG_PROGRESS` , `MSG_WARNING` }

7.13 Performance.h File Reference

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

Functions

- double [GEOM_FADE2D::timer](#) (const char *cstr)
Timer.

7.13.1 Function Documentation

7.13.1.1 timer() double GEOM_FADE2D::timer (
const char * cstr)

Call the timer function with a certain string to start time measurement. Call it a second time with the same string to finish the time measurement.

Returns

- 1 when the timer is started or the elapsed time in seconds when the timer is stopped.

7.14 Point2.h File Reference

```
#include "common.h"
#include "Vector2.h"
```

Classes

- class [GEOM_FADE2D::Point2](#)
Point.

Functions

- Point2 [GEOM_FADE2D::center](#) (const Point2 &p0, const Point2 &p1)
Compute the midpoint of p0 and p1.
- Point2 [GEOM_FADE2D::centerWithShift](#) (const Point2 &p0, const Point2 &p1)
Compute the midpoint of p0 and p1 and adapt it.
- std::ostream & [GEOM_FADE2D::operator<<](#) (std::ostream &stream, const Point2 &pnt)
Print to stream.
- std::istream & [GEOM_FADE2D::operator>>](#) (std::istream &stream, Point2 &pnt)
Stream-to-Point.
- double [GEOM_FADE2D::sqDistance2D](#) (const double x0, const double y0, const Point2 &p1)
Get the squared distance between two points in 2D.
- double [GEOM_FADE2D::sqDistance2D](#) (const Point2 &p0, const Point2 &p1)
Get the squared distance between two points in 2D.

7.14.1 Function Documentation

7.14.1.1 center() Point2 GEOM_FADE2D::center (
const [Point2](#) & p0,
const [Point2](#) & p1) [inline]

Note

: The exact midpoint of p0 and p1 may not exist in floating point numbers. Thus the returned point may not be collinear with p0 and p1.

7.14.1.2 centerWithShift() `Point2 GEOM_FADE2D::centerWithShift (`
`const Point2 & p0,`
`const Point2 & p1)`

Experimental new function that may change in the future. Thought for specific applications.

This function works like [center\(\)](#) but additionally it adapts the midpoint to the segment (p0,p1) such that it is 'as collinear as possible' with p0 and p1 in the x/y plane. Bounds for the shift are 0.01 and 1 % of the range in x- and y-direction.

7.15 Segment2.h File Reference

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

Classes

- class [GEOM_FADE2D::Segment2](#)
Segment.

7.16 SegmentChecker.h File Reference

```
#include <map>
#include "common.h"
#include "License.h"
#include "Segment2.h"
#include "MsgBase.h"
#include "Bbox2.h"
```

Classes

- class [GEOM_FADE2D::SegmentChecker](#)
SegmentChecker identifies intersecting line segments.

Enumerations

- enum [ClipResult](#) {
[CR_INVALID](#) , [CR_EMPTY](#) , [CR_CLIPPED_DEGENERATE](#) , [CR_CLIPPED_NONDEGENERATE](#) ,
[CR_COMPLETE_DEGENERATE](#) , [CR_COMPLETE_NONDEGENERATE](#) }
- enum [SegmentIntersectionType](#) {
[SIT_UNINITIALIZED](#) , [SIT_NONE](#) , [SIT_SEGMENT](#) , [SIT_POINT](#) ,
[SIT_ENDPOINT](#) }

7.16.1 Enumeration Type Documentation

7.16.1.1 ClipResult `enum ClipResult`

Enumerator

CR_INVALID	Can't compute a result, call setLimit() with a valid Bbox2 before!
CR_EMPTY	The result is empty (input completely outside the box)
CR_CLIPPED_DEGENERATE	The result has been clipped and is degenerate
CR_CLIPPED_NONDEGENERATE	The result has been clipped and is non-degenerate
CR_COMPLETE_DEGENERATE	The result is unclipped and degenerate (because the segment was already degenerate)
CR_COMPLETE_NONDEGENERATE	The result is unclipped and non-degenerate

7.16.1.2 SegmentIntersectionType enum [SegmentIntersectionType](#)

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

Enumerator

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

7.17 testDataGenerators.h File Reference

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

Functions

- void [GEOM_FADE2D::generateCircle](#) (int numPoints, double x, double y, double radiusX, double radiusY, std::vector< Point2 > &vCirclePointsOut)
Generate a circle.
- void [GEOM_FADE2D::generateRandomNumbers](#) (size_t num, double min, double max, std::vector< double > &vRandomNumbersOut, unsigned int seed=0)
Generate random numbers.
- void [GEOM_FADE2D::generateRandomPoints](#) (size_t numRandomPoints, double min, double max, std::vector< Point2 > &vRandomPointsOut, unsigned int seed=0)
Generate random points.
- void [GEOM_FADE2D::generateRandomPolygon](#) (size_t numSegments, double min, double max, std::vector< Segment2 > &vPolygonOut, unsigned int seed=0)
Generate a random simple polygon.
- void [GEOM_FADE2D::generateRandomSegments](#) (size_t numSegments, double min, double max, double maxLen, std::vector< Segment2 > &vSegmentsOut, unsigned int seed)
Generate random line segments.
- void [GEOM_FADE2D::generateSineSegments](#) (int numSegments, int numPeriods, double xOffset, double yOffset, double xFactor, double yFactor, bool bSwapXY, std::vector< Segment2 > &vSineSegmentsOut)
Generate segments from a sine function.
- void [GEOM_FADE2D::shear](#) (std::vector< Point2 > &vPointsInOut, double shearX, double shearY)

7.18 Triangle2.h File Reference

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

Classes

- class [GEOM_FADE2D::Triangle2](#)
Triangle.

Enumerations

- enum [GEOM_FADE2D::CircumcenterQuality](#) { [GEOM_FADE2D::CCQ_INIT](#), [GEOM_FADE2D::CCQ_INEXACT](#), [GEOM_FADE2D::CCQ_EXACT](#), [GEOM_FADE2D::CCQ_OUT_OF_BOUNDS](#) }
CircumcenterQuality.

7.18.1 Enumeration Type Documentation

7.18.1.1 CircumcenterQuality enum [GEOM_FADE2D::CircumcenterQuality](#)

Enumerator

CCQ_INIT	Init value.
CCQ_INEXACT	Double precision computation, the result is accurate enough.
CCQ_EXACT	Computation with multiple-precision arithmetic, the result is exact (apart from tiny quantization errors)
CCQ_OUT_OF_BOUNDS	Computation with multiple-precision arithmetic, but the result is not representable with double precision coordinates.

7.19 TriangleAroundVertexIterator.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Triangle2.h"
```

Classes

- class [GEOM_FADE2D::TriangleAroundVertexIterator](#)
Iterator for all triangles around a given vertex.

7.20 UserPredicates.h File Reference

```
#include "common.h"
#include "Triangle2.h"
```

Classes

- class [GEOM_FADE2D::PeelPredicateTS](#)
User-defined peel predicate.
- class [GEOM_FADE2D::UserPredicateT](#)
User-defined predicate (deprecated)

7.21 Vector2.h File Reference

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

Classes

- class [GEOM_FADE2D::Vector2](#)
Vector.

Functions

- Vector2 [GEOM_FADE2D::normalize](#) (const Vector2 &other)
Normalize a vector.
- Vector2 [GEOM_FADE2D::operator*](#) (double d, const Vector2 &vec)
Multiplication with a scalar.
- Vector2 [GEOM_FADE2D::operator+](#) (const Vector2 &vec0, const Vector2 &vec1)
Addition.
- Vector2 [GEOM_FADE2D::operator-](#) (const Vector2 &in)
Opposite vector.
- Vector2 [GEOM_FADE2D::operator-](#) (const Vector2 &vec0, const Vector2 &vec1)
Subtraction.
- std::ostream & [GEOM_FADE2D::operator<<](#) (std::ostream &stream, const Vector2 &vec)
Print to stream.

7.21.1 Function Documentation

7.21.1.1 [operator*\(\)](#) Vector2 GEOM_FADE2D::operator* (
double d,
const Vector2 & vec) [inline]

Multiplication with a scalar

7.21.1.2 [operator+\(\)](#) Vector2 GEOM_FADE2D::operator+ (
const Vector2 & vec0,
const Vector2 & vec1) [inline]

Addition

7.21.1.3 [operator-\(\)](#) [1/2] Vector2 GEOM_FADE2D::operator- (
const Vector2 & in) [inline]

Returns

a vector that points in the opposite direction

7.21.1.4 [operator-\(\)](#) [2/2] Vector2 GEOM_FADE2D::operator- (
const Vector2 & vec0,
const Vector2 & vec1) [inline]

Subtraction

7.21.1.5 [operator<<\(\)](#) std::ostream& GEOM_FADE2D::operator<< (
std::ostream & stream,
const Vector2 & vec) [inline]

Print to stream

7.22 Visualizer2.h File Reference

```
#include "Point2.h"
#include "Circle2.h"
#include "Segment2.h"
#include "Color.h"
#include "Label.h"
#include "Bbox2.h"
#include "Edge2.h"
#include "common.h"
```

Classes

- class [GEOM_FADE2D::Visualizer2](#)

Visualizer2 is a general Postscript writer. It draws the objects [Point2](#), [Segment2](#), [Triangle2](#), [Circle2](#) and [Label](#).

7.23 VoroCell2.h File Reference

```
#include "common.h"
#include "Point2.h"
#include "Bbox2.h"
```

Classes

- class [GEOM_FADE2D::VoroCell2](#)

Voronoi cell.

7.23.1 Detailed Description

Voronoi cell

7.24 Voronoi2.h File Reference

```
#include "common.h"
#include "VoroVertex2.h"
#include "VoroCell2.h"
```

Classes

- class [GEOM_FADE2D::Voronoi2](#)

Voronoi diagram.

7.24.1 Detailed Description

Voronoi diagram

7.25 VoroVertex2.h File Reference

```
#include "common.h"
#include "Triangle2.h"
```

Classes

- class [GEOM_FADE2D::VoroVertex2](#)

Voronoi vertex.

7.25.1 Detailed Description

Voronoi vertex

7.26 Zone2.h File Reference

```
#include "common.h"
#include "freeFunctions.h"
#include "FadeExport.h"
#include "Bbox2.h"
#include "Edge2.h"
```



```
#include "Segment2.h"
#include "UserPredicates.h"
#include "MsgBase.h"
```

Classes

- struct [GEOM_FADE2D::CompPolygon](#)
Connected component with boundary- and hole polygons.
- class [GEOM_FADE2D::Zone2](#)
Zone2 is a certain defined area of a triangulation.

Enumerations

- enum [GEOM_FADE2D::OptimizationMode](#) { [GEOM_FADE2D::OPTMODE_STANDARD](#), [GEOM_FADE2D::OPTMODE_BETTER](#), [GEOM_FADE2D::OPTMODE_BEST](#) }

Functions

- [Zone2 * GEOM_FADE2D::zoneDifference](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the difference of two zones.
- [Zone2 * GEOM_FADE2D::zoneIntersection](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the intersection of two zones.
- [Zone2 * GEOM_FADE2D::zoneSymmetricDifference](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the symmetric difference of two zones.
- [Zone2 * GEOM_FADE2D::zoneUnion](#) ([Zone2 *pZone0](#), [Zone2 *pZone1](#))
Compute the union of two zones.

7.26.1 Enumeration Type Documentation

7.26.1.1 OptimizationMode enum [GEOM_FADE2D::OptimizationMode](#)

Enumerates the possible modes for Valley/Ridge optimization through [Zone2::slopeValleyRidgeOptimization\(\)](#).

Enumerator

OPTMODE_STANDARD	Fastest optimization mode.
OPTMODE_BETTER	Considerably better quality and still fast.
OPTMODE_BEST	Best quality but quite time consuming.

7.26.2 Function Documentation

7.26.2.1 zoneDifference() [Zone2* GEOM_FADE2D::zoneDifference](#) ([Zone2 * pZone0](#), [Zone2 * pZone1](#))

Returns

a new zone containing the triangles of [*pZone0](#) minus the ones of [*pZone1](#)

Note

[pZone0](#) and [pZone1](#) must belong to the same [Fade_2D](#) object.

7.26.2.2 zoneIntersection() Zone2* GEOM_FADE2D::zoneIntersection (
 Zone2 * pZone0,
 Zone2 * pZone1)

Returns

a new zone containing the intersection of *pZone0 and *pZone1

Note

pZone0 and pZone1 must belong to the same Fade_2D object.

7.26.2.3 zoneSymmetricDifference() Zone2* GEOM_FADE2D::zoneSymmetricDifference (
 Zone2 * pZone0,
 Zone2 * pZone1)

Returns

a new zone containing the triangles that are present in one of the zones but not in the other one.

Note

pZone0 and pZone1 must belong to the same Fade_2D object.

7.26.2.4 zoneUnion() Zone2* GEOM_FADE2D::zoneUnion (
 Zone2 * pZone0,
 Zone2 * pZone1)

Returns

a new zone containing the union of the triangles of *pZone0 and *pZone1

Note

pZone0 and pZone1 must belong to the same Fade_2D object.

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