GridTool

A Tool for Structured and Unstructured Grid Generation

GridTool is an interactive program for grid/geometry applications . Most grid generation programs represent geometry by a set of structured points which is not consistent with the Computer Aided Design (CAD) representation. The purpose of GridTool is to bridge the gap between the CAD and the grid generation systems. GridTool is designed primary for unstructured grid generation systems. Currently, GridTool supports VGRID and FELISA systems, and it can be easily extended to support other unstructured grid generation systems.

- Guest Book
- Documentation
- Examples
- Online Request form for **GridTool**

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GridTool is an interactive program for grid/geometry applications . Most grid generation programs represent geometry by a set of structured points which is not consistent with the Computer Aided Design (CAD) representation. The purpose of GridTool is to bridge the gap between the CAD and the grid generation systems. GridTool is designed primary for unstructured grid generation systems. Currently, GridTool supports VGRID and FELISA systems, and it can be easily extended to support other unstructured grid generation systems. GridTool is part of Tetrahedral Unstructured Software System (TetrUSS). TetrUSS is an unstructured-grid flow analysis and design computational fluid dynamic (CFD) software system developed at NASA Langley Research Center. The goal is to provide a validated capability to non-CFD expert users for performing rapid aerodynamic analysis and design of complex configurations. Capabilities include rapid grid generation and inviscid flow analysis, and an emerging Navier-Stokes viscous flow analysis.

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- I/O
  - Writing IGES file
  - In addition to the following IGES entities:
    - Copious data (entity 106),
    - Line (entity 110),
    - Parametric spline (entity 112),
    - Parametric surface spline (entity 114),
    - Matrix (entity 124),
    - NURBS curve (entity 126),
    - NURBS surface (entity 128).

    GridTool can read the following entities:
    - Circular Arc (entity 100),
    - Composite Curve (entity 102),
    - Curve on a Parameteric surface (entity 142).
    - Trimmed Surface (entity 144).

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Introduction

GridTool is an interactive program for grid/geometry applications . Most grid generation programs represent geometry by a set of structured points which is not consistent with the Computer Aided Design (CAD) representation. The purpose of GridTool is to bridge the gap between the CAD and the grid generation systems.

Computer Aided Design (CAD) tools store the geometry by set of NonUniform Rational B-Splines which allows to represent the geometry accurately. On other hand, most grid generation programs are designed around the concept that the surface grids are generated on a set of bi-linear patches (approximating the actual geometry). This type of grid generation is quite easy to implement, and it avoids the problems associated with complex CAD surface representations and associated surface parameterizations. However, the resulting surface grids are close to but not on the original CAD surfaces. Also the grid generator requires more information about the grid that can not be easily created in a CAD environment. GridTool bridges the gap between the CAD and grid generation systems by: (1) bringing the accurate CAD geometry to the grid generators, (2) creating the necessary information for grid generator such as patch definitions and spacing requirements, (3) providing a mechanism for checking the integrity and quality of the CAD geometry, (4) creating the missing information, and (5) providing an interactive environment to process very complex geometries. GridTool is designed primary for unstructured grid generation systems. Currently, GridTool supports VGRID [1] and FELISA [2] systems, and it can be easily extended to support other unstructured grid generation systems.

The data in GridTool is stored parametrically so that once the problem is set up, one can modify the surfaces and the entire set of points, curves and patches will be updated automatically. This is very useful in a multidisciplinary design and optimization process.

GridTool is written entirely in ANSI "C", the interface is based on the FORMS library [3], and the graphics is based on the GL library. The code has been tested successfully on IRIS workstations running IRIX4.0 and above. The memory is allocated dynamically, therefore, memory size will depend on the complexity of geometry/grid.

GridTool data structure is based on a link-list structure which allows the required memory to expand and contract dynamically according to the user's data size and action. Data structure contains several types of objects such as points, curves, patches, sources and surfaces. At any given time, there is always an active object which is drawn in magenta, or in their highlighted colors as defined by the resource file which will be discussed later.

FAQ

How can I get a copy of GridTool?

Fill out the online request form for **GridTool**

How do I report my comments/suggestions/questions?

Contact Jamshid Samareh at (J.A.SAMAREH@LaRC.NASA.GOV) (804-864-5776)

Where can I find the lastest version of this document?

Press here (http://geolab5.larc.nasa.gov/GridTool/GridTool_Doc.html)

What are the system requirements to run GridTool?

The code has been tested successfully on IRIS workstations running IRIX4.0 and above. The memory is allocated dynamically, therefore, memory size will depend on the complexity of geometry/grid.

Is there an on-line help for GridTool?

There is some limited on-line help which can be activated by pressing the **Help** button in the main panel which in turn will open a browser. As the user moves the cursor over any object in the panels, a description of that button will be given in the browser. Also, you use the **Help** button in each panel to access sections of this document.

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Surface Representation and Grid Projection

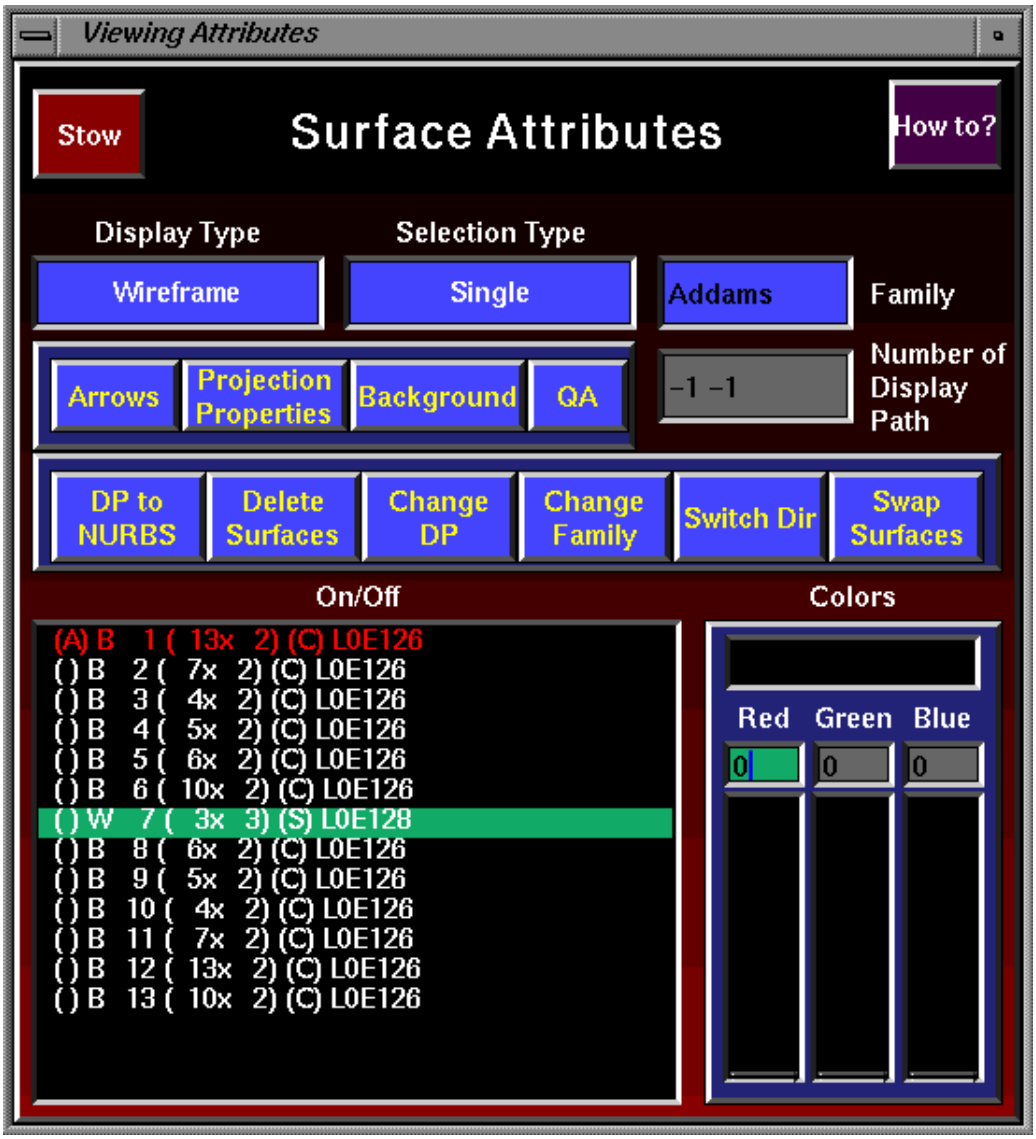
References [4]-[6] contain detailed descriptions of Surface Representation and Grid Projection. For completeness sake, a short summary will be provided here. In CAD systems, curves and surfaces are represented typically by NonUniform Rational B-Splines (NURBS) which is the most general mathematical representation for curves and surfaces. Most parametric curves and surfaces can be converted to an equivalent NURBS [7]-[8] representation without any loss of accuracy.

The surface-grid can be generated either in a parameter space or on approximated/simplified NURBS surfaces. Grids generated in a parameter space have two serious restrictions. The first restriction is that the choice of surface parameterization affects the CFD surface-grid. As shown in Refs. Ref. 6 and Ref. 9, a poor parameterization may cause the CFD surface-grid to be highly skewed. The second limitation is that a CFD surface-grid can not be generated over several overlapping NURBS surfaces which is the most serious restriction.

In the second method , the NURBS surfaces are approximated by a few bi-linear patches, then, the surface grids are generated based on these bi-linear patches. The resulting surface grids are close but they are not on the original NURBS surfaces. This problem can be alleviated by projecting the resulting grid points onto the original NURBS surfaces. This method is easy to implement, and it avoids the problems associated with surface parameterization. This method of grid generation will require a very robust and fast grid point projection. This method is implemented for structured and unstructured grid.

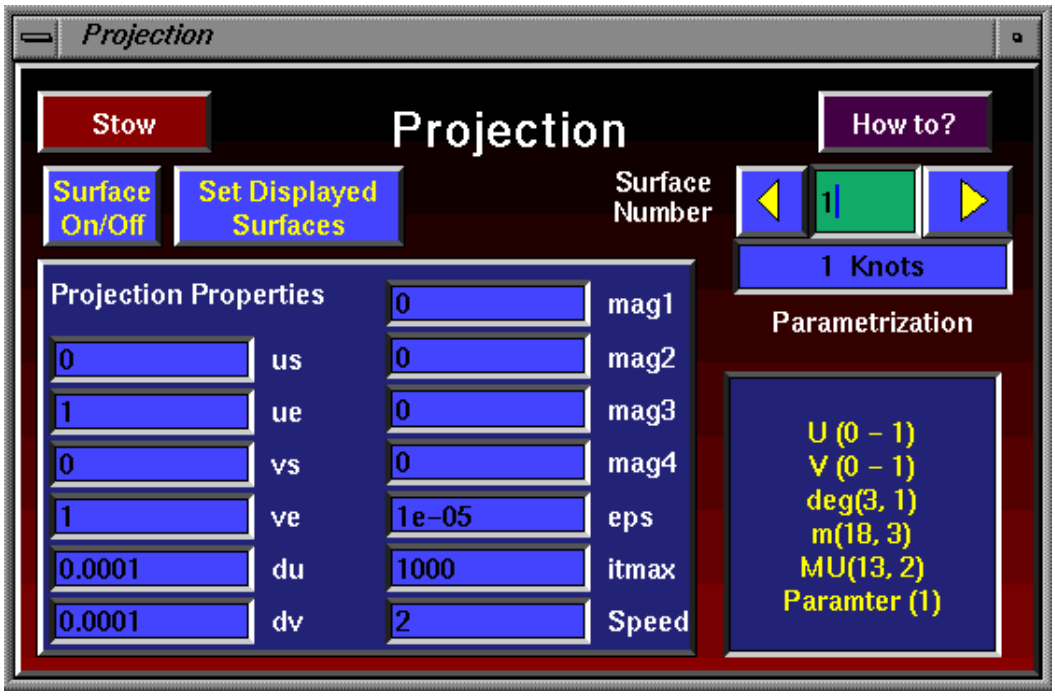
Surface Attributes

This panel is designed to allow the user to manipulate the surface properties. In order to change the background color of the display window, the "*Background*" button in the "*Attributes*" panel should be pressed. Then, the color can be changed by moving three sliders for the colors or by inputing the RGB color number (Red, Green, Blue) in the input-fields.



The surface properties such as color, direction and number of display paths can be changed in this panel. First, the "*Surfaces*" button in this panel should be pressed, and then "*On/Off*" browser will appear. In order to change the properties of some of the surfaces, first they must be turned on. This can be done either from the display window or from the "*On/Off*" browser by placing the cursor over the surface number and clicking with the left mouse. In order to turn a surface on/off from the display window, first the surface must become an active surface by placing the cursor over the surface and hitting the hot key "s". Then, the active surface can be turned on/off by hitting the hot key "w". Once the appropriate surfaces are turned on, then the properties can be changed. Surface colors can be changed by using the three sliders for colors or by inputing the RGB color number in the input-fields. The direction of surfaces can be changed by pressing the "*Directions*" button. The number of display paths can be changed by inputing the desired numbers of display paths in u and v coordinates in the input-field for "*number of display path*" and then pressing "*Change DP*" button.

Projection Properties



This panel is designed for modifying the projection parameters, and it displays the projection parameters for the active surface. For detail description of these properties, readers are referred to Refs. [4]-[6]. In this panel, it is also possible to change the parameters such that part of a surface is displayed and projected to. This can be done by changing the limits of the surface parameters, us (minimum u), ue (maximum u), vs (minimum v), and ve (maximum v). The "*Itmax*" is the number of iteration for the projection to converge. The "*EPS*" is the residual limit for the projection to converge. The "*du*" and "*dv*" are the step size in u and v directions, respectively. The "*magn*" are parameters used to pull grid points to boundaries, and their values range from 0-1.

1. "*mag1*" for minimum v
2. "*mag2*" for maximum u
3. "*mag3*" for maximum v
4. "*mag4*" for minimum u

FAQ

What is a display path?

In GridTool a surface is defined everywhere. In order to display it, lines are drawn on the surface.

How do I turn on/off surfaces?

Activate the Surface Panel from the Main panel. To turn off a single surface,

1. set selection type to single,
2. select the display type,
3. place the cursor over the surface number and click with the right mouse.

To turn off a family or all surfaces,

1. set selection type to family or all,
2. select the display type.

How do I make a surface active?

Either place the cursor over the desired surface in the display window, and then hit the "s" key. Or Activate the Surface Panel from the Main panel.

1. set selection type to single,
2. select "Active Surface" from the display type,
3. place the cursor over the surface number and click with the right mouse.

How do I group surfaces together?

1. Turn the surfaces that belong to the family on,
2. Select a family name,
3. push the "Change Family" button.

How do I change the directions on the surfaces?

1. Turn the desired surfaces on,
2. Push the "Direction" button.

How do I change the background color?

1. Push the "**Background**" button,
2. Then, the color can be changed by moving three sliders for the colors or by inputing the RGB color number (Red, Green, Blue) in the input-fields.

How do I change the surface color?

Turn the desired surfaces on. Surface colors can be changed by using the three sliders for colors or by inputing the RGB color number in the input-fields.

How do I change the number of display path?

Turn the desired surfaces on. Select the number of display path inputing the desired numbers of display paths in u and v coordinates in the input-field for "**number of display path**" and then pressing "**Change DP**" button.

How do I convert the existing display path to a NURBS surface?

1. Turn the desired surfaces on,
2. push the "DP to NURBS" button.

This will not delete the original surfaces.

How do I delete surfaces?

1. Turn the desired surfaces on,
2. push the "Delete Surfaces" button.

What are the projection properties for?

Some surfaces may have a bad parametrization and may be very complex. In order to project to these surfaces, the projection properties may need to be fine-turned.

How do I change the projection properties of a surface?

1. Activate the projection property panel from surface panel.
2. Make the surface active
3. Change the property

How do I change the projection properties of a displayed surfaces?

1. Activate the projection property panel from surface panel.
2. Turn the surfaces on
3. Change the property for one of them
4. Push Set Displayed Surfaces button

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Advancing Front Applications (VGRID System)

In this section, using GridTool for VGRID system is described. VGRID system is a robust and fast unstructured grid generator developed by VIGYAN Inc. for NASA Langley Research Center. The VGRID code is fully functional and supported and can be obtained from NASA Langley Research Center (contact: Dr. Neal Frink). The VGRID system is based on an advancing front technique, and readers are referred to an excellent and detailed report by Parikh, Pirzadeh and Lö hner VGRID[1]. A short description of advancing front technique will be given here for the sake of completeness.

The advancing front method is an unstructured grid generation method similar to parabolic and hyperbolic methods for structured grid generation. Grids are generated by marching from boundaries (front) towards the interior. First, the domain of interest is subdivided into a set of patches which cover the entire domain. Next, these patches are triangulated to form the "initial front". Finally, tetrahedral elements are generated based on the initial front. As tetrahedral elements are generated, the "initial front" is updated until the entire domain is covered with tetrahedral elements, and the front is emptied. The above process can be summarized in the following steps:

1. subdivide the domain of interest using GridTool,
2. specify grid spacings using GridTool,
3. generate the "initial front" using VGRID,
4. update the GridTool restart file to reflect the changes from VGRID using GridTool,
5. project the front onto the CAD surfaces using GridTool,
6. generate the volume grid using VGRID,
7. post-process the volume grid using VGRID.

The first step is to define the boundaries for the domain of interest. These boundaries are then subdivided into smaller patches using GridTool. In this paper, a patch is synonymous with a three-dimensional polygon. In the VGRID system, three types of patches are allowed: triangular Barnhill-Gregory-Nielson patches (three arbitrary sides), bilinear transfinite Coon’s patch (four arbitrary sides), and planar patches (defined by an arbitrary number of sides, all lying in one plane). Each patch consists of several sides, and each side consists of several curves. In step 2, the grid spacing is defined by nodal and linear sources. An excellent description of these sources can be found in Ref. [10]. In step 3, all patches are triangulated to form the "initial front" using the VGRID system. In this step, VGRID may change the patch orientation. If so, in step 4, the GridTool restart file must be updated to reflect the changes. In step 5, the "initial front" is projected back onto the original surfaces using GridTool. In step 6, the volume grid is generated in one run or several restart runs using VGRID. In step 7, the volume grid can be post-processed to enhance grid quality. The details for steps 3, 5 and 6 can be found in Ref. 1.

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GridTool Interface

The interface consists of a main panel and several sub-panels. The panels consist of a set of buttons, input-fields, sliders, dials, positioners, browsers and message boxes. This section describes the user interaction with the GridTool interface. The user interacts with GridTool program by pointing/clicking the mouse buttons and the keyboard while the cursor is over a panel or the display window. Panels can be activated by pressing their buttons from the main window. They can be stowed away either from the panel itself by pressing the "*Stow*" button or by pressing the panel's button in the main panel. Whenever a panel is activated, the color of its button in the main panel will be changed from blue to green. Here is a list of actions and how they can be accomplished in the panels.

- To press a button, place the the cursor over the button and click with any of the three mouse buttons.
- To change the value in an input-field, place the the cursor over the input-field, click with any of the three mouse buttons, enter the value in the input-field, and complete the input by entering the "Return" key. The "ESC" key can be used to delete the entire field, or the "BackSpace" key can be used to delete a portion of it.
- To change the position of a slider, dial or a positioner, hold and drag the right mouse while the cursor is over the object.
- To select an object from a browse, place the the cursor over the object in the browser and click the right mouse. The background color of the selected object in the browser will change from black to green when they are selected.

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Hot Keys

A series of hot keys are available in the display window which allow the user to accomplish some tasks without use of the panels. These keys can be activated by placing the cursor over the display window and clicking the hot key. The hot keys can be used to translate/rotate/zoom the object, to pick or to create an object.

List of Hot Keys

Keys	Action
Left Mouse	Translate (gridgen mode), rotate x, and y (PLOT3D mode)
Middle Mouse	Zoom, rotate z (PLOT3D)
Right Mouse	Translate (PLOT3D)
SHIFT + Mouse	Sparse Mode
b	Make a source active
c	Make a curve active
C	Move center of rotation to center of the active curve
f	Make a patch active
F	Move center of rotation to center of the active patch
g	Save the orientation
G	Restore the orientation
m	Move the active point to an existing point on a curve
n	Move the active source to an existing source and copy spacing
p	Make a point active
P	Move center of rotation to active point
ALT + P	Save the current display window as an RBG image in GridTool.rgb
r	Reset the image
s	Make a surface active
S	Move center of rotation to center of the active surface
t	Move the active point to an existing point on the active surface
w	Turn the active surface on/off
x	Turn axes on/off
F1	The same as "***Next Curve***" button
F2	The same as "***Next Point***" button
F5	The same as "***Next Patch***" button
F6	The same as "***Next Edge***" button
F7	The same as "***Find Edge***" button
F8	The same as "***Reverse the Active Patch***" button
F12	Turn Surfaces on/off

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GridTool Executions

GridTool can be executed by typing "GridTool" or "GridTool options filename", and here is a list of command line argument,

Command Line Arguments

Arguments		Action
-h		help
-d3m	d3m_filename	read a d3m file
-dat	dat_filename	read a dat file
-f	restart_filename	read a restart file
-gf	gridgen_filename	read a gridgen formatted file
-g	gridgen_filename	read a gridgen binary file
-pf	plot3d_filename	read a plot3d formatted file
-p	plot3d_filename	read a plot3d binary file
-IGES	IGES_filename	read an IGES file
-felisa		run GridTool in FELISA Mode

When GridTool starts, it looks for the resource file, ".GridTool". This file could be at either the user's root, the current directory or defined by "setenv" unix command as "setenv GridTool_resources my_resource_filename". Users may change the resource file by customizing it to their needs. If the resource file does not exist, GridTool will use the defaults values which are listed in the Sample Resource File section . The resource file may contain the preferred colors for displaying objects and the boundary conditions. A comment line can start either with a space or "#" in the first column. The default boundary conditions are based on the USM3D [11] code developed by Dr. Neal Frink at NASA/Langley Research Center. In the following sections, the application of GridTool for setting up data files for an advancing front technique (VGRID system) is described. One important feature of GridTool is that each operation is accomplished in one step only. Therefore users can create and manipulate objects randomly.

There is some limited on-line help which can be activated by pressing the "*Help*" button in the main panel which in turn will open a browser. As the user moves the cursor over any object in the panels, a description of that button will be given in the browser.

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I/O

GridTool is capable of reading geometry/grid definitions in ASCII or C-Binary formats.

File input/output formats

File Type	Options
IGES [12]	read
RESTART	read/write
GRIDGEN [13]	read/write (Binary as well)
PLOT3D [14]	read/write (Binary as well)
CURVES	read/write
LaWGS [15]	read/write
VGRID-NET [1]	read/write
VGRID-FRONT [1]	read/write
VGRID-FRONT (Update)[1]	read/write
VGRID-d3m [1]	read/write
VGRID-d3m (Update)[1]	read/write
FELISA system [2]	read/write

The IGES (Initial Graphics Exchange Standard) files are based on the industry standard as described in IGES manual [12]. GridTool is only capable of accepting the following entities: copious data (entity 106), lines (entity 110), parametric splines (entity 112), parametric surface spline (entity 114), NURBS curves (entity 126) and NURBS surfaces (entity 128). Surfaces defined by points can be read/written in GRIDGEN [13], PLOT3D [14], LaWGS [15] or VGRID-NET [1] formats.

The surface triangulation, "the initial front", can be read/written in a front format defined by the VGRID system [1] or FELISA system [2]. The necessary information for advancing front methods can be read/written either in a "d3m" input-file format for VGRID system [1] or in a "dat" input-file format FELISA system [2]. An ASCII "restart" file can be read/written at any time, which contains all created/modified/read objects. It is possible to combine several restart files to form one. This allows several people to work on the same configuration and combine all pieces at a later time. Before reading/writing a "d3m", "front" or a "dat" file, a "project name" must be selected. This name is used as the file name suffix for all necessary files (e.g. project.front). Once the file is read/written, the "*Files*" browser will be updated. To update the list displayed in "*Files*" browser, press the "*Update*" button.

FAQ

How can I read/write a file into/from GridTool?

1. Open the **I/O** panel,
2. Either type the file name in the **File Name** input field or select it from the **File** browser;
3. Select the file type;
4. Push read/write button.

How can I read/write a d3m file for VGRID system?

1. Type in the project name in the **Project** input field;
2. push read/write button.

How can I write the NURBS surfaces as GRIDGEN surfaces?

1. Turn the desired surfaces on;
2. Write a GRIDGEN file from IO panel

What IGES entities can GridTool read?

GridTool is only capable of accepting the following entities:

1. Copious data (entity 106),
2. Lines (entity 110),
3. Parametric splines (entity 112),
4. Parametric surface spline (entity 114),
5. Matrix (entity 124),
6. NURBS curves (entity 126),
7. NURBS surfaces (entity 128).

Is there any approximation involved in bringing IGES entities into GridTool?

There is no approximation involved in bringing IGES entities into GridTool.

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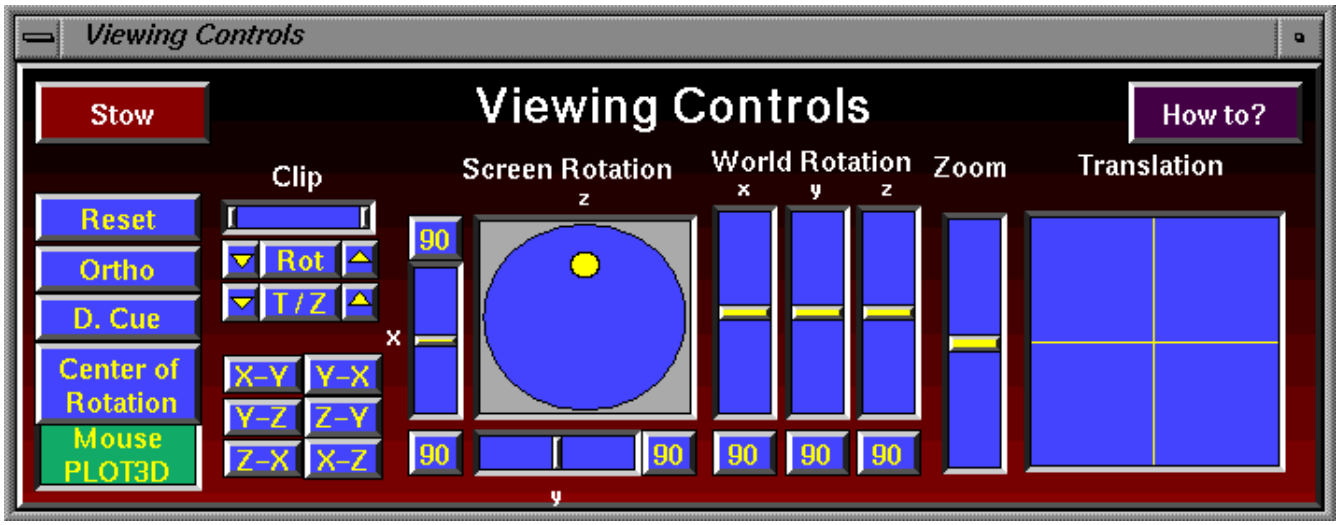
Display and Viewing Controls

The display can be controlled either from the display window using the mouse and the keyboard, or from the "*Viewing Controls*" panel. The mouse can be used either in a default mode or in a PLOT3D [14] mode. The mode can be changed by pressing the "*PLOT3D*" button which is located in the "*Viewing Controls*" panel. The default mouse mode is similar to the GRIDGEN system [13]. In the default mode, while pressing the left mouse button, left, right, up, and down mouse movements will cause the object to translate in the corresponding directions. By holding the middle mouse down, up and down mouse movements will cause the object to zoom out and in. The object can be rotated using the numeric keypad, and this will be explained later. In the PLOT3D mode, by holding the left mouse down, left/right and up/down mouse movements will cause the object to rotate about the x and y screen coordinates, respectively. By holding the middle mouse down, left/right mouse movements will cause the object to rotate about the z screen coordinate, up/down mouse movements will cause the object to zoom out and in, respectively. By holding the right mouse down, left, right, up, and down mouse movements will cause the object to translate in the corresponding directions.

Mouse Movements

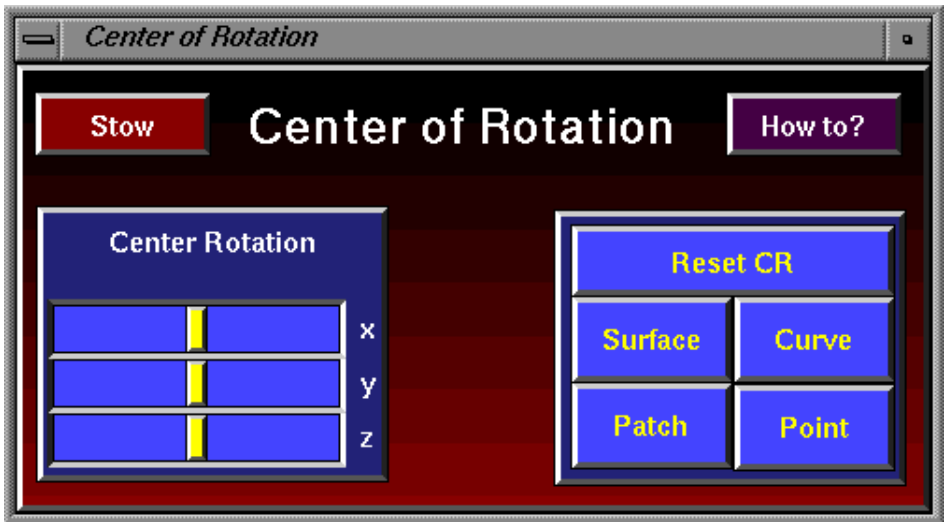
Mode	Movements	LM (down)	MM (down)	RM (down)
Default,	Right	Translate Right		N/A
Default,	Left	Translate Left		N/A
Default,	Up	Translate Up	Zoom out	N/A
Default,	Down	Translate Down	Zoom in	N/A
PLOT3D,	Right	Rotate Screen y	Rotate Screen z	Translate Right
PLOT3D,	Left	Rotate Screen -y	Rotate Screen -z	Translate Left
PLOT3D,	Up	Rotate Screen x	Zoom out	Translate Up
PLOT3D,	Down	Rotate Screen -x	Zoom in	Translate Down

In either modes, the object can be rotated using the numeric keypad. The object can be rotated about two sets of axes: screen coordinates and body coordinates (world). The top row of the numeric keypad, the "Num Lock", "/" and "*" keys control the rotation about the x, y and z world coordinates, respectively. The second row, the "7", "8" and "9" keys control the rotation about the x, y and z screen coordinates, respectively. The rotation continues as long as the keys are pressed down. The object can be rotated ninety degrees by holding the "PageUp" or "PageDown" key while pressing the appropriate key on the numeric keypad. The object can be rotated in the reverse direction by holding down the "-" key from numeric keypad and the appropriate rotation keys. The object orientation can be reinitialized by pressing the "r" key which is the hot keys for resetting the object. All object manipulations can be accomplished from the "*Viewing Controls*" panel as well.



Center of Rotation

This panel is designed to allow the user to move the center of rotation to an arbitrary point in space. The center of rotation can be moved to: an exiting point by using the three sliders, "*x*", " *y*", "z" to centers of the active surface/curve/patch/point by pressing the appropriate buttons. The center of rotation can be reset by pressing the "*Reset CR*" button. The hot keys, P, C, F, S can be used in the display window to move the center of rotation to the active point, active curve, active patch and active surface.



FAQ

How do I change the center rotation?

The center of rotation can be changed by using the center of rotation panel, or using hot keys

How do I reset the image?

Use either the hot key "r" or use the reset button in Viewing Control Panel

How do I translate/rotate/zoom?

Either the hot keys or Viewing Control Panel can be used to translate/rotate/zoom the object.

How do I change the rotation/translation rate?

The rotation rate can be increased/decreased by pushing the buttons to the left and right of the "Rot"/"T/Z" buttons in the Viewing Control Panel. This is the rate at which the display will be rotated in real time. Everytime the this button is pressed the rotation rate is changed by a factor of three. To reset the rate, press the "Rot"/"T/Z" buttons.

How do I change the mouse to PLOT3D mode?

Push the "PLOT3D" button in the Viewing Control Panel. Also this could be the default by having a line in resource file which contains the word "plot3d".

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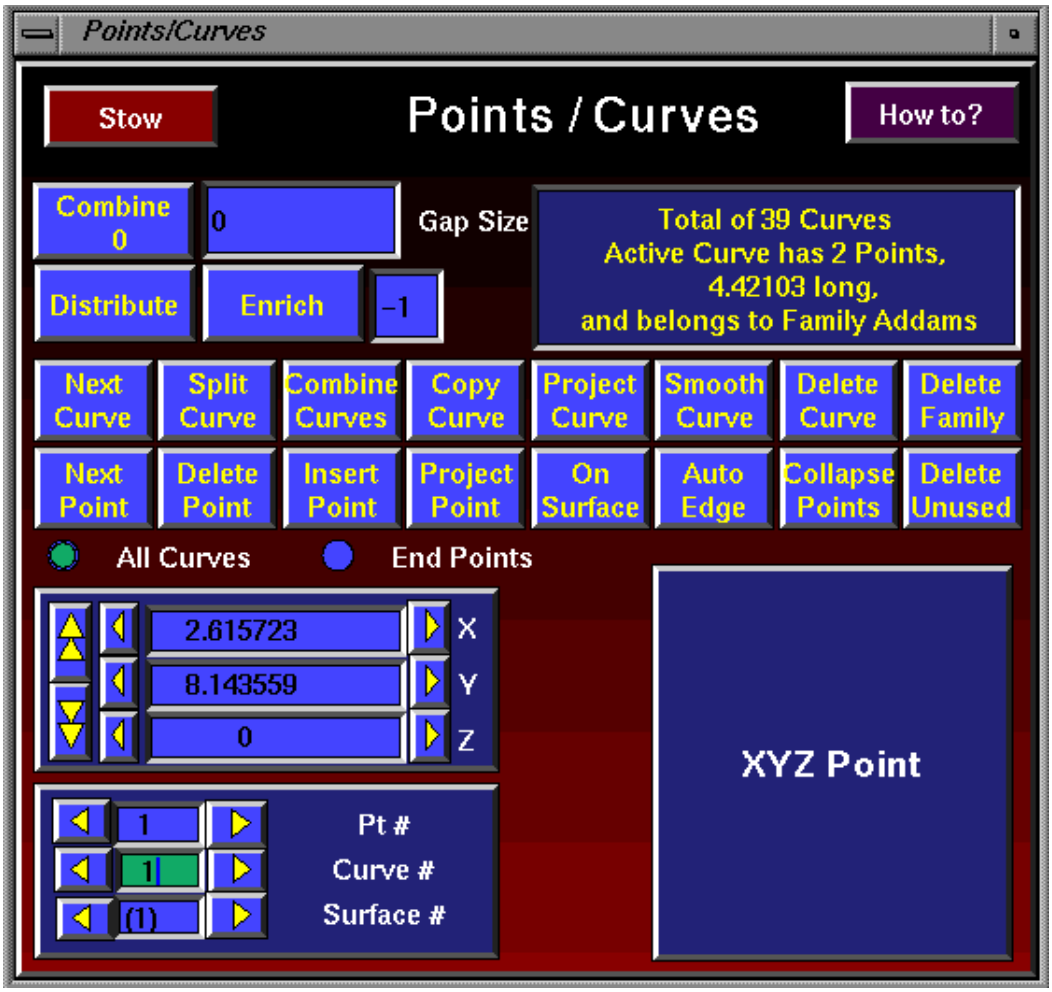
Points/Curves

This panel contains several buttons, input-fields and a positioner, and they are used to create/modify/delete points and curves. In GridTool, a curve is represented by a link-list of points. These points are either on a surface (surface points) or somewhere in space (XYZ points). For surface points, in addition to the x, y, z, the surface number and its parametric coordinates, u and v are stored in the data base. Curves can be created together as a family. For example, all curves associated with a wing could be created together as a "wing" family. The family name for curves is selected from the "*Patches*" panel which will be discussed later. To start a new curve, press the "*Next Curve*" button. To create a new point for a curve, the "*Next Point*" button should be pressed, and this newly created point becomes the active point. Since every operation is done in one step, the new point will be placed where the last point was, and then the user can move the new point, (the active point), to any location. The active point can be moved to an existing point on a curve by placing the cursor over the desired curve point and hitting the hot key "m". Similarly, the active point can be moved to an existing point on the active surface by placing the cursor over the surface point and hitting the hot key "t". Also, the active point can be moved to any location on the active surface by either: (1) typing the parametric coordinates in the "*U & V*" input box, (2) moving the "*U & V*" positioner, (3) moving the "*U & V*" sliders. In order to move the active point in space, first the point should be converted to an "XYZ" point by pressing "*On Surface*" button. Once the active point is an XYZ point, the "*x*", "*y*", and "z" sliders can be used to move the point to anywhere in the space. It is also possible to change the coordinate by typing the values in the input field boxes. A point can be inserted ahead of the active point on a curve by pressing the "*Insert Point*" button. The new point becomes the active, and if the two neighboring points are on the same surface, then the inserted point will also be on the same surface. The point or the active curve can be deleted by pressing the "*Delete Point*" or the "*Delete Curve*" buttons, respectively. A point or a curve can become active by placing the cursor over it and hitting the hot key "p" or "c", respectively.



Distribution

This panel is used to distribute points on the active curve. The distribution is determined either from curvature (optimum) and spacing at the curve ends. For optimimum spacing, the weight controls the spacing. For a zero weight, the distribution will be similar to the distribution for the active curve. For weight equal to one, the distribution is determined by the curvatue. For weight between zero and one, the distribution is linear combintation of the current distribution and curvature distribution. Points can be distributed based on the spacing on either or both ends. The method is based on techniques develop by Vinokur and implemented in GRIDGEN [13].

FAQ

How do I create a curve?

To start a new curve, press the "*Next Curve*" button.

How do I add a point to an existing curves?

To create a new point for a curve, the "*Next Point*" button should be pressed, and this newly created point becomes the active point. Since every operation is done in one step, the new point will be placed where the last point was, and then the user can move the new point, (the active point), to any location.

The active point can be moved to an existing point on a curve by placing the cursor over the desired curve point and hitting the hot key "m". Similarly, the active point can be moved to a display path on the active surface by placing the cursor over the display path and hitting the hot key hot key "t". Also, the active point can be moved to any location on the active surface by either: (1) typing the parametric coordinates in the "*U & V*" input box, (2) moving the "*U & V*" positioner, (3) moving the "*U & V*" sliders. In order to move the active point in space, first the point should be converted to an "XYZ" point by pressing "*On Surface*" button. Once the active point is an XYZ point, the "*x*", "*y*", and "*z*" sliders can beused to move the point to anywhere in the space. It is also possible to change the coordinate by typing the values in the input field boxes.

How do I make a point active?

Place the cursor over the point, and hit the hotkey p.

How do I delete/project a point?

Make the point active, then push the delete/project point from Points/Curves panel

How do I insert a point?

A point can be inserted ahead of the active point on a curve by pressing the "*Insert Point*" button. The new point becomes the active, and if the two neighboring points are on the same surface, then the inserted point will also be on the same surface.

How do I convert a surface point to an XYZ point?

In order to move the active point in space, first the point should be converted to an "XYZ" point by pressing "*On Surface*" button. Once the active point is an XYZ point, the "*x*", "*y*", and "*z*" sliders can be used to move the point to anywhere in the space. It is also possible to change the coordinate by typing the values in the input field boxes.

How do I change the coordinates of an existing point?

Also, the active point can be moved to any location on the active surface by either: (1) typing the parametric coordinates in the "*U & V*" input box, (2) moving the "*U & V*" positioner, (3) moving the "*U & V*" sliders. In order to move the active point in space, first the point should be converted to an "XYZ" point by pressing "*On Surface*" button. Once the active point is an XYZ point, the "*x*", "*y*", and "z" sliders can beused to move the point to anywhere in the space. It is also possible to change the coordinate by typing the values in the input field boxes.

How do I split a curve?

1. Make the curve active
2. Make the point at which the curve will split active
3. Push the split curve button

How do I combine two curves?

1. Make the first curve active
2. Push the combine button on the upper left of the Points/Curves
3. Make the second curve active
4. Push **Combine Curves**

How do I copy/project/smooth/delete a curve?

1. Make the curve active
2. Push the copy/project/smooth/delete button on the Points/Curves

How do I delete a family of curves?

1. Type in the family name **Family** input-field in the Patches panel
2. Push the **Delete Family** in the Patches Panel

How do extract edges of an existing surface?

1. Turn the desired surfaces on
2. Push the **Auto Edge** button

How do I collapse the endpoints of curves that are close?

1. Activate the point to which the nearby points (to within the gap size) should be collapsed
2. Input the **Gap size** the input-field
3. Push the **Collapse Points**

How do I delete unused curves?

Push the **Unused Curves** button.

How do I turn on/off curves?

Push the **All Curves** button.

How do I enrich points on an existing curve?

1. Make the curve active
2. Enter desired number of points between each existing points (e.g. -2, will put 2 points between each existing points)
3. Push the **Enrich** button

How do I redistribute points on an existing curve?

1. Make the curve active
2. Activate the **Distribute Panel** from **Points/Curves Panel**
3. Enter desired number of points for the curve
4. Enter the end spacings (-1 for default)
5. Push the **Distribute button**

How can I tell if I have defined the same curve (or patch) twice?

Place the cursor over the curve (or patch) in question, and hit the **c** key (**f** for patches). If there is more than one curve (or patch) at that location, different curve (or patch) numbers will appear in the **Curve Number** (or **Patch Number**) buffer in the **Points/Curves** menu (or the **Patches** menu for patches).

GridTool

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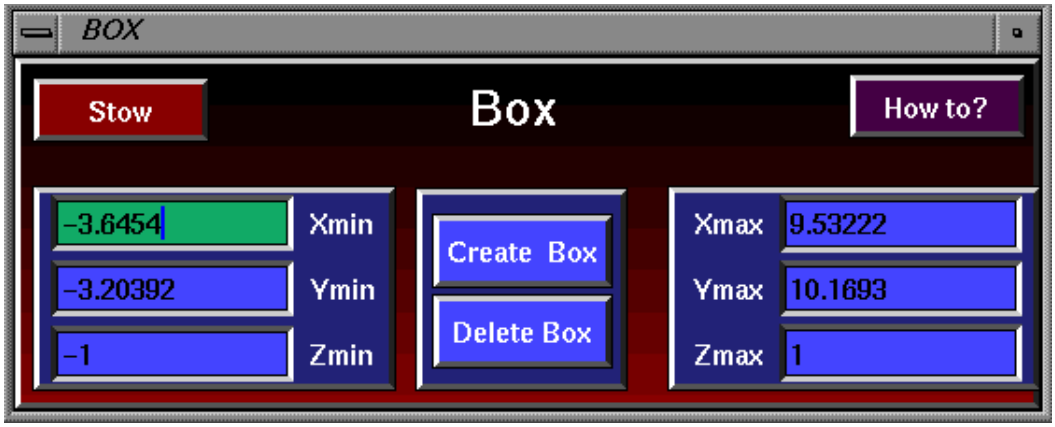
Patches

A patch is a closed three-dimensional polygon which is defined by a set of curves. Nonplanar patches should be 3- or 4-sided, and planar patches could be n-sided. Each side of a patch could consist of several curves. Each patch is stored as a link-list of curves. To create a patch, the "*Next Patch*" button should be pressed. Then, the first curve for the patch must be activated by the user, and then it can be accepted as the first curve by pressing "*Accept Edge*" button. The subsequent curves can be added by letting GridTool find them. This can be done by pressing "*Find Edge*" button until the correct curve is found. GridTool will find the next curve within the tolerance define in the " *tol*" input-field box. Once the correct curve is found, it should be accepted by pressing the "*Accept Edge*" button. Once a patch is created, its direction can be reversed by pressing the "*Reverse Patch*" button.

Box

This panel is designed to allow the user to create/delete a box. To create a box, press "*Create Box*" button which will create a box bounded by minmax in x, y, z coordinates defined in the six input-fields in the panel. The resulting curves and patches are grouped together as the "Box" family. To delete the box, press the "*Delete Box*" button which will delete all patches and curves in the "Box" family.



FAQ

How do I create a patch?

1. Select a family name
2. Select a boundary condition
3. Push the **Next Patch** button

How do I make an existing patch active?

Either enter the patch number in the **Patch #** input-field, or place the cursor over the patch and hit the f key

How do I select the patch boundary condition?

1. Put the cursor over the BC input-field
2. Use the right mouse to display and select the boundary condition
3. Every time a new patch is created, it will (by default) be associated with the values of the BC and family that were in the buffers at the time. In order to change the BC and/or family association of an existing patch, make the patch active and press the "Apply BC/Family" button after having entered the desired family and BC values.

How do I create patches automatically?

1. Turn the surfaces on
2. Select a family name (e.g. front-fuse)
3. Select a BC, use the right mouse
4. Select numbers of patches in each directions
5. Press the **Auto Patch** button

How do I reverse/delete an existing patch?

Make the patch active and press the **reverse** / **delete** button

How do I delete a family of patches?

Select the family name from **Family** input-field, the press **Delete Family** button

How do I associate a patch and a set of surfaces?

Make the patch active, turn the surfaces on, push the **Accept Surfaces** button

How do I split a patch?

1. Make the patch active

2. Create a curve that splits the patch
3. ake the curve at which to split the patch active
4. Press the **Split Patch** button

How do I add an edge to an existing patch?

Either make the curve active or use the **Find Edge** to find the next curve, then press **Accept Edge** button

How do I make an existing edge active?

Use the input-field **Edge #**

How do I find the next edge?

Push the **Find Edge** button

How do I reverse/delete/connect an edge?

Make the edge active, then press the button

How do I split an edge?

Make the splitting point active, the press the **Split Edge** button

How do I convert a 3 or 4 sided patch to a NURBS surface?

Make the patch active, and then push **Patch to Surface** button

How do I automatically create a box which covers the geometry?

Push the **Box** button which opens a panel, enter the minmax of the Box, press the **Create Box** button

How do I fix directions of all patches automatically?

Select one patch with the correct direction, then press **Fix Patches** button

How do I change a patch type?

Enter the type into the **Patch Type** input-field

How do I get more information for a patch?

Activate the help from main panel, press the **Bad Patches** button, then move the cursor over the **Bad Patches** button, the information for the active bad patch will be displayed

How do I turn on/off patches?

Use the **All Patches** button

How do I check to see if there are any bad patches?

Press the **Bad Patches** button, then the bad patches will be displayed

What are bad patches and how can I fix them?

A patch is bad if

1. a curve is used more than twice (this may not create a problem), or a curve is used twice in the same direction (to fix you can reverse the edge direction of the bad patch)
2. patch is not closed (either there is a gap between the edges or the tol is low, use collapse points in Points and Curves Panel to fix it)
3. the patch is n-sided and it is not a planar patch (the patch may be slightly off the plane, this depends on the tol)
4. no surface is associated with the patch (FELISA)
5. not enough points for the patch

What is the shrink panel for?

The patch can be shrunk for the display purposes. This will not effect the data.

How can I create a symmetry patch (two loops)??

1. make the patch on symmetry active (this is often one side of a box)
2. make one of the curves on the body/symmetry active (second loop)
3. accept that curve as a edge
4. make sure the direction is OPPOSITE to the patch boundary in this case. The final patch will have two loops: (1) outer loop from the box, (2) the inner loop from body/sysmmetry.

5. continue accepting all the curves on the symmetry until the second loop is closed as well.

GridTool

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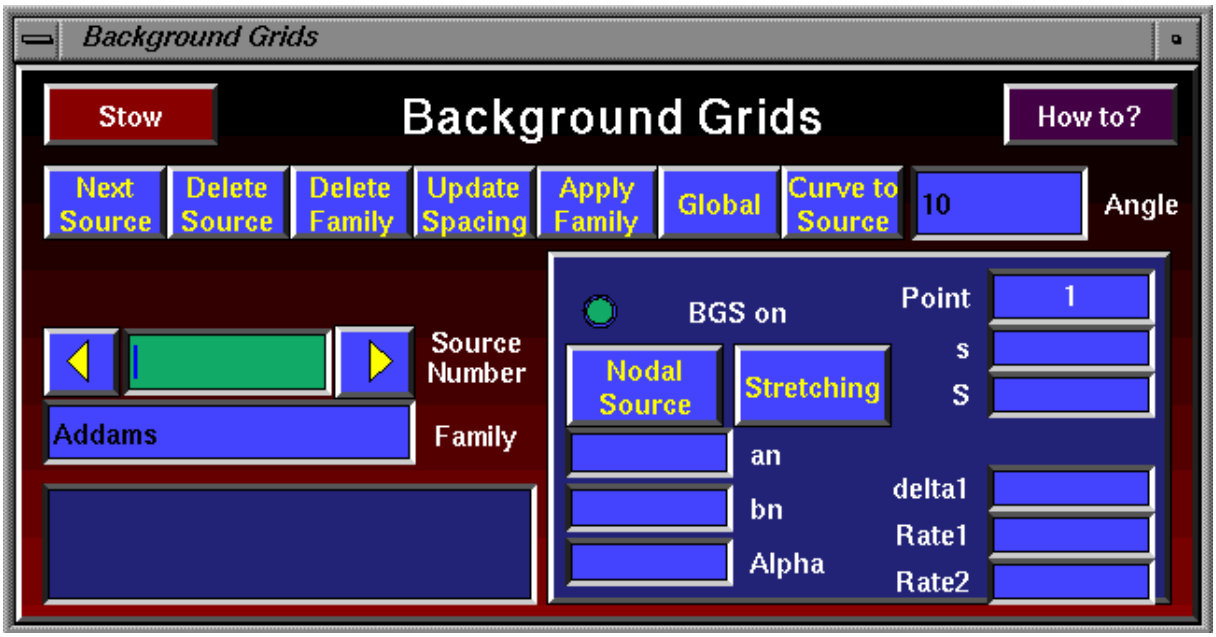
Background Grid

This panel contains several buttons and input-fields, and they are used to create/modify/delete nodal and linear sources. In order to define grid spacing, nodal and linear sources must be created and placed in the right locations. In order to create a source, the "*Bg Grid*" and "*Points/Curves*" panels must be activated. To create a source, press the "*Next Source*" button. This will create a source similar to the last source. If this is the first source, it will create a nodal source and place it in the middle of the domain. The location of a source can be moved by using the same techniques as described for moving points. The value spacings, "S1" and "S2", are the sizes of ideal tetrahedrals for the source locations. An excellent description of parameters "a_n, b_n, alpha" can be found in Ref. 10.



FAQ

How do I create a source?

Press **Next Source** button. This will create a source similar to the last source. If this is the first source, it will create a nodal source and place it in the middle of the domain. The location of a source can be moved by using the same techniques as described for moving points. The value spacings, "S1" and "S2", are the sizes of ideal tetrahedrals for the source locations. An excellent description of parameters "a_n, b_n, alpha" can be found in Ref. 10.

How do I make a source active? How do I make an end point of a linear source active?

Either place the cursor over the end points of the source, and press the **B** hotkey, or use **Source Number** input-field.

How do I delete a source?

Make the source active and hit the **Delete Source** button

How do I change a nodal source to linear and vs?

Make the source active and hit the **Nodal Source** button

How do I move a source location?

1. Active Backgound Grids Panel
2. Move the cursor over the source location and press "B" hotkey
3. Change the value in the **Points/Curves** panel
4. For linear sources, repeat above two steps for the other end.

How do I change the properties of a source?

Make the source active and enter the value in the Background Grids Panel

GridTool

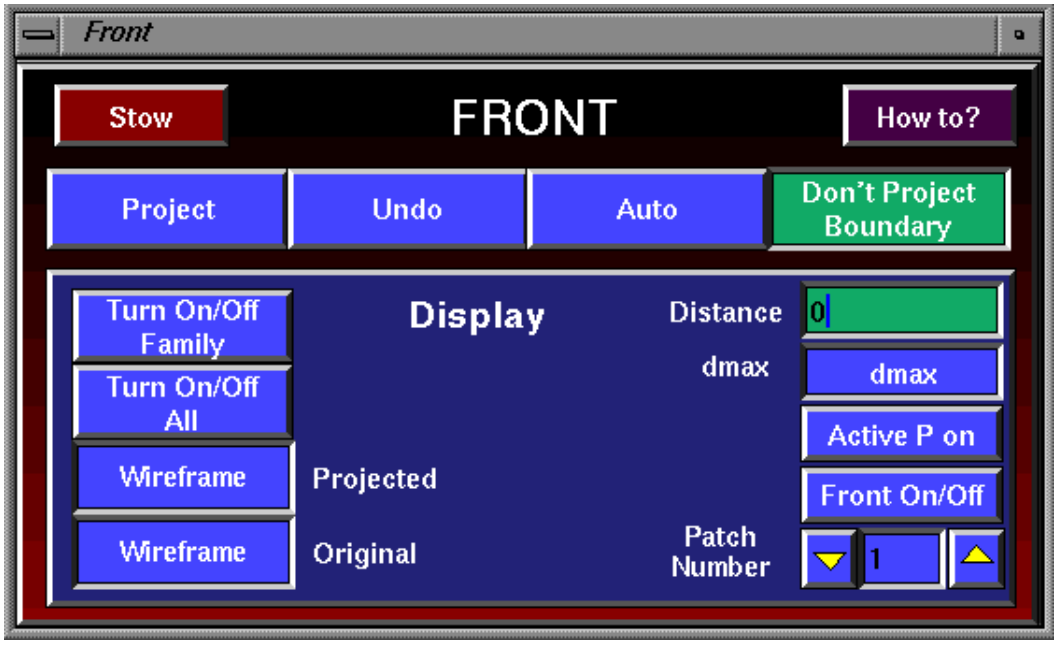
A Tool for Structured and Unstructured Grid Generation

Unstructured Grid

This panel is designed to manipulate the unstructured surface grid. The "*Front*" button is used to activate the "*Front*" from which a surface triangulation can be projected onto a set of surfaces.

Front

This panel is used to project the surface triangulation (front) onto a set of surfaces, and this process can be divided into five steps: (1) read the front using the "*IO*" panel, (2) turn the appropriate patches on, (3) turn associated surfaces on, (4) project the front onto the surfaces, and (5) check for the validity of the new triangulation. In order to have a successful projection, users are required to insure that: (1) the surface triangulation is close enough to the associated surfaces, and (2) the associated surfaces have sufficient display paths.



FAQ

How do I read an unstructured surface grid in?

Use the I/O panel to read the grid as VGRID front or a FELISA Front

How do I project the front?

Turn the desired surfaces and triangulated patches on, and press **Project** button

How do I undo a projection?

Turn the triangulated patches on, then press **Undo** button

How do I undo a projection after the front files are updates?

Read the projected front in and update the front from I/O panel.

How do I check the projected surface grid?

dmax shows the maximum distance the front has moved. Select a positive number, d < dmax, in the **Distance** input-field, this will display the triangles that have moved a distance between d and dmax (i.e., triangles that have vertices that have moved by at least a distance d).

How do I keep the boundaries from projection?

Push the **Project Boundary** button

How do I turn on/off an individual patch?

Select the patch by from **Patch Number** input-field, then press the **Front On/OFF** button

How do I turn on/off a family of patches?

Select the family, then press **Turn On/Off Family**

The project grid is messed up, how can I fix it?

Quality of surface projection depends on the surface parameterization. You can fix your problem by either

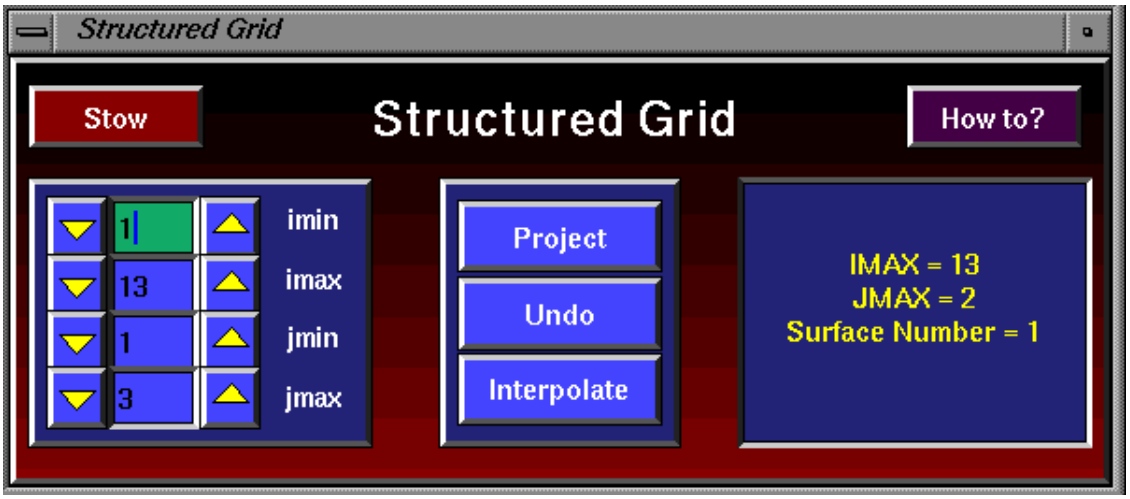
- increasing the display path of the NURBS surfaces
- changing the project speed
  - activate the **Projection Properties** panel
  - make the surfaces active (one at a time)
  - change the speed (input field speed) to 1

GridTool

A Tool for Structured and Unstructured Grid Generation

Structured Grid

This panel is used to project the entire or portion of a structured surface grid onto a set of surfaces, and this process can be divided into five steps: (1) read the surface definition and the surface grid using the "*IO*" panel, (2) turn on associated surfaces, (3) make the surface to be projected active, (4) project the surface grid onto the surfaces, and (5) check for the validity of the new surface grid. In order to have a successful projection, users are required to insure that: (1) the surface grid is close enough to the associated surfaces, and (2) the associated surfaces have sufficient display paths. User may undo the projection or reinterpolate a protion of the surface grid.



FAQ

How do I project a structured grid onto NURBS surfaces?

1. Read the grid as point definition (plot3d, gridgen, or lawgs)
2. Read the surface in
3. Turn the desires surfaces on
4. Make the grid active
5. Activate the Structured Grid Panel
6. Select the part of the grid that needs to be projected using imin, imax, jmin, jmax
7. Press the **Project** button

How do I write the grid out only?

turn only the grid on, and use the I/O panel to write it out

GridTool

A Tool for Structured and Unstructured Grid Generation

References

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16. Vinokur (1980).

GridTool

A Tool for Structured and Unstructured Grid Generation

Sample Resource File

When GridTool starts, it looks for the resource file, ".GridTool". This file could be at either the user's root, the current directory or defined by "setenv" unix command as "setenv GridTool_resources my_resource_filename". Users may change the resource file by customizing it to their needs. If the resource file does not exist, GridTool will use the defaults values which are listed here.

```
#
# This is a comment line
  This is also a comment line

# plot3d mouse movement
plot3d

#This line defines the web browser
#www mosaic
www netscape

#This line defines the location of the document
#GridTool_Doc $HOME/public_html/GridTool/GridTool_Doc.html
GridTool_Doc http://geolab5.larc.nasa.gov/GridTool/GridTool_Doc.html


#color  item                    R       G       B

#       Background Color for the Display
color   background              0       0       0       black

#       Color for the Active Surface
color   active_surface          199     21      133     medium violet red

#       Colors for the Points
color   xyz_pt                  67      110     238     royal blue
color   active_pt               255     0       0       red
color   surface_pt              34      139     34      forest green

#       Color for the Curves
color   xyz_curve                100     149     237     cornflower blue
color   active_curve            255     0       0       red
color   surface_curve           34      139     34      forest green

#       Color for the Patches
color   normal_patch            219     112     147     Pale violet red
color   active_edge             199     21      133     medium violet red
color   active_patch            199     21      133     medium violet red

#       Colors for the Background Grid
color   normal_bgs              255     255     0       yellow
color   active_bgs              255     0       0       red
color   active_bgs_pt           199     21      133     medium violet red
#
```

```
# BOUNDARY CONDITIONS Based on USM3D
#
bc      freestream              0
bc      reflection_plane        1
bc      extrapolation           2
bc      inflow/outflow          3
bc      viscous                 4
bc      inviscid                5
bc      nacelle_inlet         101
bc      nacelle_exit          102
bc      inlet_mass            110
bc      inlet_pressure        111
bc      inlet_mach            112
bc      inlet_velocity        113
bc      special_bc1           1001
bc      special_bc2           1002
bc      special_bc3           1003
bc      special_bc4           1004
bc      special_bc5           1005
```

GridTool

A Tool for Structured and Unstructured Grid Generation

Turtorial

This section covers some simple examples which are based on a geometry with a fuselage and a simple wing. The geometry file is distributed with the GridTool package (Class). The users are encouraged to follow at least steps A-G to get familiar with the code. Then, steps H-L can be followed.

```
A. To run:
   GridTool

B. Input / Output Panel
   Read an IGES file
     Select a project name (any name with no blank spaces)
     Select ASCII file format (use the right mouse)
     Select IGES file format (use the right mouse)
     Select Class.igs file name from "Files" browser
     Click on "Read" button to read Class.igs file
     Stow panel

C. Display Window / Viewing Controls panel
   To use hotkeys, the cursor must be in the display window
   To Make a surface active, select it from display window
       by using hotkey "s" (active surface is drawn in magenta)
   Turn active surface on/off by using hotkey "w"
   Turn axes on/off (x is hotkey)
   Turn all  surface/boundaries off/on by using hotkey "F12"
   Translate with left mouse Zoom with middle mouse
   Rotate world (key pad, x-rot num/lock, y-rot  /, z-rot *)
   Rotate screen (key pad, x-rot 7, y-rot 8, z-rot 9)
   Use "-" sign on key pad to reverse direction
   Do all above from Viewing Control Panel
     To active the Viewing Control Panel, push "Control" button
     on the main window
   Rotate the object 90 degrees
   Change the center of rotation to an active surface
   Try all buttons in Controls Panel

D. Surfaces (Background Color)
   change the display window's background color
      activate the Surface Panel from the main panel
      push the Background button in the Surface panel
      use sliders or numeric inputs fields to change the color

E. Attributes (Surface Properties)
   press "Surfaces" Button
   Turn surfaces on/off from "On / Off" browser
      change the "Selection Type" to single (use right mouse),
      change the "Display Type" (use right mouse), e.g. shaded.
      place the cursor over the surface number in the browers and press the
```

right mouse button

Change display paths of three surfaces (#2, #3 and 4)
turn the desired surfaces on
select the number of display paths, (-n change it to n*default)
(-2, 31)
press "Change DP" button

Change direction of a surface
press the "Arrow" button
turn the surfaces on
press "Switch Dir" button

Change directions of all surfaces to point outward

F. Points / Curves
Select a family from "Patches" panel
Create a curve on the active surface
press "Next Curve" button
press "next Point" button (the point will be in the middle of surface (red))
use uv panel to change u/v (sliders, positioner, change the rate, lock the direction)
Use hotkey "T" to move it to a display point on the active surface
Use hotkey "M" to move to an existing point on a curve
press "next Point" button" for the second point, the second, point will be on the top of the first, move to the right location
To put more point on this curve use enrich and Distribute buttons

G. Patches
press "Next Patch" button
Make first curve active
press "Next Edge" button
press "Find Edge" button to find the right curve
Repeat step 3-4

Note: Exit GridTool and start again

H. example (Class.igs)
Make sure all surfaces are pointing outward
Generate patches for surfaces 1, 3, 4, 5 automatically
Turn the surfaces on
select a family name (e.g. front-fuse)
select a BC, use the right mouse
select numbers of patches in each directions and number of points
press the "Auto Patch" button
Shrink the patches by 5%

I. Point / Curves
Turn surface #2 on
Generate the boundary edges automatically by pressing "Auto Edge" button
Create the necessary curves for mid-fuse

J. Patches
Create necessary patches for mid fuselage
Make the tip curve active
press "Next Patch" (hotkey F5)
press "Next Edge" (hotkey F6)
Connect the edge if necessary (hotkey F8)

press "Find Edge" (hotkey F7)
(till you find the correct curve)
go to step 3 (repeat till the patch is
finished)
check direction of the patch
(pointing into the flow field)
Make sure the patch has only four sides
(a circle marks the corner of each patch)
Create the box by pressing "Box" bottom
Connect the symmetry plane to the fuselage
Turn the surfaces / axes / curves / patches / curves off
Turn the "Bad Patches On"
Correct all Bad Patches
Turn all patches off and leave curves turned on

K. Bg Grids (Note: you need to have "Bg Grids" and
"Points / Curves" panels down).
Bring "Bg Grids" and "Points / Curves" panels down
Create a line source in the middle of fuselage
press "Next Source" button
press "Nodal Source" button (change to the linear source)
Move first and second points to the right locations
set the properties
repeat steps 1-4

L. Input / Output
Select a name for your restart file (e.g. my_rest1)
Write restart file
Write d3m file out (d3m file would be your
project name + d3m e.g., project.d3m)

GridTool Examples

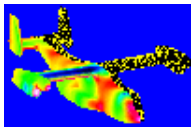
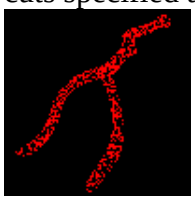

V-22 (Javier Garriz) Home Page


Image is a close-up of the unstructured surface mesh on the wing/pylon/nacelle of a transport aircraft. (Javier Garriz)


work performed for Dr. Robert Stark, David Taylor Naval Warfare Center. Image is of the unstructured surface mesh on a model of the human foot that was developed from cross-sectional cuts specified at different heights. (Javier Garriz)


Greg Burgreen and George Foutrakis, Univ. of Pittsburgh Medical Center. Image is of the unstructured surface mesh on a basilar-vertebral artery bifurcation of the intracranial circulation.


Greg Burgreen and George Foutrakis, Univ. of Pittsburgh Medical Center. Image is of the unstructured surface mesh on a blood pump impeller shape designed to mitigate any harmful fluid dynamic flow features related to blood trauma (e.g., hemolysis and thrombosis), while simultaneously improving hydrodynamic performance.

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