About Freeform Origami (0.2.x Alpha)

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1 Overview

Freeform Origami is a Win32 software written by Tomohiro Tachi for enabling interactive design of three-dimensional origami based on continuously modifying origami shapes under several geometric constraints.

The now-released or lower version of the software is a proprietary freeware applying the following terms of use.

1.1 Terms of Use

Freeform Origami (the software) are proprietary software provided under the following license.

1. The user is allowed to use the software if and only if both of the following conditions are satisfied. Before using the softwere, please contact me in advance.
   - (Non-Commercial Use) The use of the software is non-commercial.
   - (Attribution): The resulting works achieved using the software, e.g., research publications, exhibitions, educational workshops, etc. acknowledge the usage of the software and cite at least one of references [1, 2, 3, 4].
2. Any other type of usage, e.g., commercial use, is by default prohibited. For this type of usage, please contact the author.

References

[1] Tomohiro Tachi, "Freeform Origami", www.tsg.ne.jp/TT/software/

[2] Tomohiro Tachi, "Generalization of Rigid-Foldable Quadrilateral-Mesh Origami," Journal of the International Association for Shell and Spatial Structures (IASS), 50(3), pp. 173–179, December 2009.

[3] Tomohiro Tachi, "Freeform Variations of Origami", in Proceedings of The 14th International Conference on Geometry and Graphics (ICGG 2010), Kyoto, Japan, pp. 273–274, August 5-9, 2010.

[4] Tomohiro Tachi, "Freeform Rigid-Foldable Structure using Bidirectionally Flat-Foldable Planar Quadrilateral Mesh", Advances in Architectural Geometry 2010, pp. 87–102, September 2010.

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1.2 URLs

- The software is downloadable from `http://www.tsg.ne.jp/TT/software/#ffo`.
- Any questions and bug reports are planned to be responded at freeform origami group at curvedfolding.com (`http://www.curvedfolding.com/group/freeformorigami/`).

For technical details of the software, references [2, 3, 4] can help.

2 Basic User Interface

2.1 Screens

FreeformOrigami.exe shows the screen like Figure 1.

Left pane 3D View. Shows 3D view of the model when the model is loaded. Most of manipulation is done on this screen.

Right Upper pane Crease pattern. Shows the developed pattern of the form when "developable" constraint is activated (check Sytem→developable).

Right Down pane Flat-folded pattern. Shows the X-ray view of the form in the completely flat-folded state if "flat-foldable" constraint is activated (check Sytem→flat-foldable).

2.2 Coloring Scheme

The edges are colored according to the crease property. These assignment can be changed using Tool→assign.

Red	Mountain
Blue	Valley
Dark Gray	General Crease
Light Gray	Triangulation

2.3 Changing View

In order to change view, use mouse:

Rotate View : Use **Right Button Drag** for 3D rotation (for 3D view) and 2D rotation (for crease pattern and flat-folded pattern views).

Pan View : use **Middle Button Drag** or **Shift + Right Button Drag** for panning.

Zoom View : use **Wheel** to zoom up and down.

Most of other operations are done by left click/drag, selecting menu, or pressing key, and their combination depending which tool you are using.

2.4 Simulation Mode vs. Edit Mode

The software runs in two different mode "Simulation Mode" and "Design Mode." The default mode is defined by "System → Simulation First" check list. Only while you press **Tab** key, the software runs in the opposite mode.

Simulation Mode When the background color of Crease Pattern and Flat-Folded Pattern windows is **gray**, CP and FF are fixed, and the system runs in simulation mode. In this mode, the software does a rigid origami simulation using truss elements.

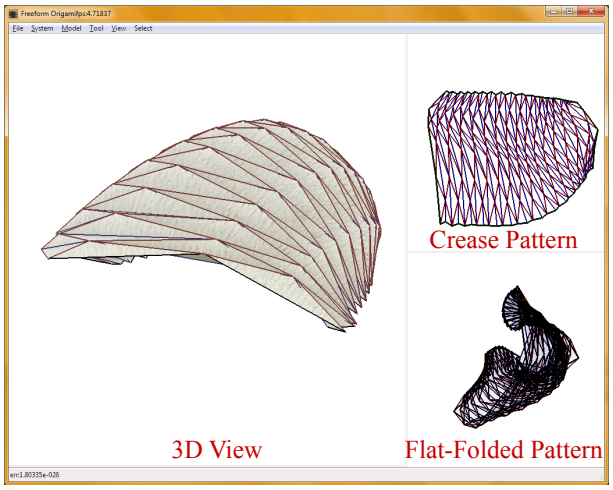

Figure 1: Screen shot of the software.

Edit Mode When the background color of Crease Pattern and Flat-Folded Pattern windows is **white** (CP and FF are fixed), the system runs in simulation mode. In this mode, manipulation to the 3D object affects the crease pattern and flat-folded pattern. The deformation of the object follows the constraints checklist in System menu.

3 File Menu

3.1 Open

This operation opens files of ***.dxf (2d drawing, i.e., crease pattern) or ***.obj (3d mesh folded form). You can drag and drop the files to the window to open. The files must be prepared very very carefully so that it works.

DXF Two dimensional crease pattern must be prepared in dxf format.

- Only LINES and POLYLINES in 2D are used.
- Color scheme: Red=Mountain, Blue=Valley, Black=Crease.
- The software cannot recognize Group, Block Instance.
- All the line data should be ungrouped.
- The lines can intersect but cannot overlap (bad double line).

OBJ Three-dimensional surface must be imported as a polyhedral mesh in obj file format.

- Surface must be singly covered and must be an orientable manifold, i.e., the edges must be shared by one or two facets (if one, the edge is on the boundary).
- The constraints are now only supporting disk topology, so you should import a mesh homeomorphic to a disk.
- The shared vertices must be shared in the obj files also. For example, in **Rhinoceros**, every edge should be welded.
- OBJ file is without crease information. If you want to assign Mountain and Valley according to the current state, use Model→Re-Assign MV.

3.2 Save

Save 3D mesh in OBJ or crease pattern in DXF.

3.3 Add Reference

This operation appends point data from ***.dxf (2d drawing, i.e., crease pattern) or ***.obj (3d mesh folded form). File preparation is the same as the open command. This is intended to be used for reading reference geometry such as boundary condition and existing shapes, using *stitch command*.

4 System Menu

System menu controls the constraints and the background calculation of the software.

Simulation First This check item set either the simulation mode or edit mode as default. See Section 2.4 for the difference between modes.

Constraints

Rigid Rigidize the edges marked as rigid bars displayed as green segments. Rigid bars are specified using Tool→Rigid.

Developable Forces the pattern developable, i.e., foldable from a piece of flat paper.

BoundaryDev Forces the angles of the boundary unchanged.

BoundaryRigid Forces the model to be folded from the same size of piece of paper.

Flat-Foldable Forces the pattern to be flat-foldable. Activate this constraints only after you assign proper Mountain and Valleys.

Angle Ineq Solves angle inequality condition for flat-foldability.

Planar This forces each mesh to be planar (triangulation lines have the folding angle of 0).

No Overfold This forces mountain to be folded in mountain-wise, and valley in valley-wise.

Stitch This enables the stitch constraint (stitch constraints are created using Tool→Stitch)

Constraint On/Off Background calculation is enabled or disabled. Default: ON.

Adaptive Mesh Enables or disables adaptive mesh by merging close vertices.

5 Model

Model menu is for performing action to the entire model. Undo/Redo is supported.

Set Length This command sets the length of the selected edges to the specified value, and make these edges rigid bars.

Stitch Verts This command operates Tool→Stitch for close vertices and reference points so that they won't separate. Stitch constraint is activated by System→Stitch.

Re-Assign MV This command assigns Mountains and Valleys to the edges according to the current folding angles.

6 Tool

Select Used for selecting elements. Rectangle region selection is possible. (Left to Right and Right to Left has different selection, following conventional 3D CAD interface.)

Assign This is for assigning mountain and valley to the edges. Chose the assignment from the palette and then click or region select edges that you want to "color."

Complementary foldlines try to unfold when foldlines fold, and fold when foldlines unfold. It is completely folded in the developed state, and is completely unfolded in flat-folded state. Using complementary foldlines along with normal foldlines with Planarity, Developability, Flat-foldability constraints is useful for making Bi-directionally Flat-foldable one-DOF rigid foldable surface such as egg-box surface or discrete Voss surface. See Tomohiro Tachi "Freeform Rigid-Foldable Structure using Bidirectionally Flat-Foldable Planar Quadrilateral Mesh" in Advances in Architectural Geometry 2010.

Ground Set the selected vertices on the ground ($z = 0$ plane).

Stitch This tool is for "stitching" two vertices or reference points, so that their coordinates are the same. Select the first point and then select the second point. The segment between vertices represent the stitch constraint, clicking of which results in eliminating the constraint. Stitch constraint is activated by System→Stitch.

Rigid This tool is for specifying which edges are rigid.

Move This tool is for translating selected vertices by dragging. Following keyboard shortcut can be combined.

Shift Adding points to the selection.

x, y, z The transformation is constrained in x, y, and z directions.

Move Sticky / Move Magnet This tool is similar to Move tool, but also affects neighbor vertices (in geodesic sense). Sticky uses the dragging speed and Magnet uses the size of the window for the unit distance for defining the decay of effect.

7 View

This menu changes the visibility of elements.

8 Keyboard Shortcuts

This section lists the implicit keyboard commands.

Tab Key Temporarily switches Simulation mode and Edit Mode.

Space Key Fold the model

'B' Unfold the model

'N' Add random white noise to the vertices.

9 Acknowledgement

The development of the software is supported by a Grant in Aid for JSPS fellows (2008 April - 2010 March).