Mirroring

Introduction

This report surveyed mainly FDM slicers on how they store mirrored objects and how they store copies of objects or object instances.

Tested applications

- Autodesk Fusion 360
- Cura
- ideaMaker
- Microsoft 3D Builder
- Microsoft Paint 3D
- PrusaSlicer
- Simplify3D

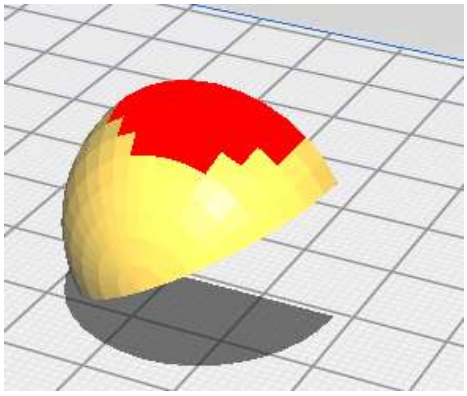
Autodesk Fusion 360

- It does not store any transformation matrices at all.
- The mirroring operation creates a new object.
- It stores separated mesh for every copy of the object.
- Grouping of objects does not create a tree structure.
- It does not support loading 3MF files.

Cura

- It stores a matrix with negative determinant for mirrored objects.
- For mirrored objects, Cura flips the 2nd and 3rd vertex index of each triangle to produce a mesh with a negative volume.
- Cura does not use object instancing, at least we were not able to find a way to produce such a 3MF. If an object is copied in Cura, it is stored into 3MF twice.
- Cura allows creating a tree structure of objects using object grouping. Cura also allows creating a floating object (object levitating over a build plate) through grouping. (PrusaSlicer can load these tree structures of objects without any problem, including applying transformation matrices, however PrusaSlicer forces these levitating objects to a build plate during the flattening of Cura's groups.
- Cura can load and display 3MF files with mirroring (negative determinant matrices) from Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer without any problem, including the correct application of transformations.

- Bug in Cura: Load an STL, apply mirroring, export 3MF. The exported 3MF mesh references invalid vertices. If the 3MF is exported after slicing, everything is OK.
- Cura slices mirrored objects from Cura, IdeaMaker, PrusaSlicer, Microsoft Paint 3D without any problems. Supports are generated correctly in all cases. However, 3MF files with mirroring created using ideaMaker have incorrectly shown overhangs. These overhangs are shown on the top of the object.



ideaMaker

- IdeaMaker works the same as Cura. It stores a matrix with negative determinant for mirrored objects.
- For mirrored objects, IdeaMaker flips the 1st and 3rd vertex index of each triangle to produce a mesh with a negative volume. Cura flips the 2nd and 3rd vertex index.
- IdeaMaker does not support grouping through UI.
- IdeaMaker does not use object instancing, at least we were not able to find a way to produce such a 3MF.
- It can load and display 3MF files with mirroring from Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer without any problems, including the correct application of transformations. IdeaMaker uses an Even / Odd polygon filling rule when slicing, Even / Odd rule leads to the same slicing independent of orientation of faces.
- ideaMaker can slice 3MF with mirroring from Cura, IdeaMaker, PrusaSlicer, and Microsoft Paint 3D. Supports are generated correctly only for 3MF with mirroring produced by Cura and ideaMaker. 3MF files with mirroring produced by PrusaSlicer have incorrectly generated supports. Cur operation produces for 3MF files with mirroring objects with holes in all cases (even for 3MF from ideaMaker). But these objects are sliced correctly.

Microsoft 3D Builder

- Mirroring is available through UI, but negative determinant matrices are never produced. If mirrored is applied, the mesh vertices are mirrored in the mesh object.
- It does not support grouping through UI.

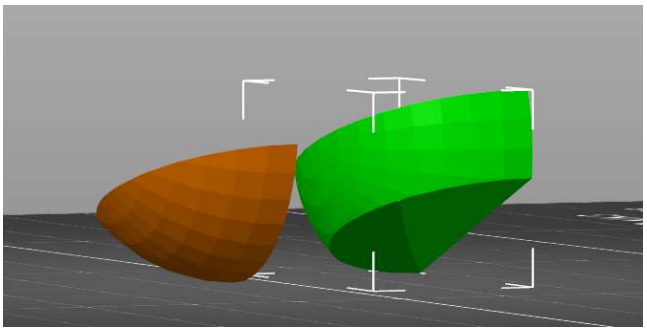
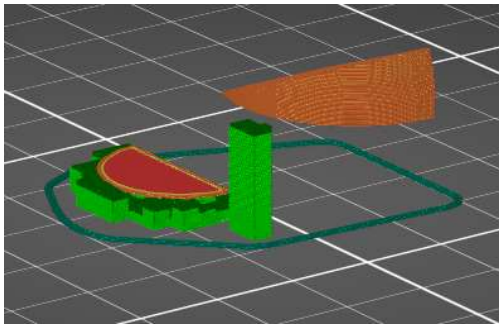
- It supports instancing. Copied objects are stored as a reference to the original object.
- It can load and display 3MF files with mirroring from Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer without any problems, including the correct application of transformations.
- Microsoft 3D Builder 3D has no problem with 3MF with mirroring produced by Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer, even with the following operations: painting, cutting, union, and rotations.

Microsoft Paint 3D

- Paint 3D produces matrices with negative determinant for mirrored objects.
- After the mirroring operation, the order of the vertices of each triangle does NOT change, the model is unmodified and it has a positive volume.
- The grouping is supported through the UI, but lost when stored into a 3MF.
- Paint 3D does not use object instancing, copied objects are stored as copies into 3MF.
- It can load and display 3MF files with mirroring from Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer without any problems, including the correct application of transformations.
- Microsoft Paint 3D has no problem with 3MF with mirroring produced by Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer, even with the following operations: painting, stickers, and rotations.

PrusaSlicer

- PrusaSlicer produces matrices with negative determinant for mirrored objects.
- After the mirroring operation, the order of the vertices of each triangle does NOT change, the model is unmodified and it has a positive volume.
- The copied objects are saved with copied mesh, but objects created via **Add instance** are saved as references to the original mesh without copying it.
- Compared to the other applications tested, the zero value in transformation matrices is stored, both as a positive zero (0) and a negative zero (-0).
- It can load and display 3MF files with mirroring from Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer without any problems, including the correct application of transformations. PrusaSlicer flips meshes with negative volume.
- PrusaSlicer can slice 3MF with mirroring from Cura, IdeaMaker, PrusaSlicer, and Microsoft Paint 3D without problems. Supports are also generated correctly in all cases. But if the cut operation is applied to mirrored objects from Cura and ideaMaker, then cut objects are shown with holes. And also, there is an issue with slicing these cut objects.

Simplify3D

- It can only load 3MF files, and it is not possible to export to 3MF.
- It can load and display 3MF files with mirroring from Cura and ideaMaker without any problems, including the correct application of transformations. 3MF files with mirroring from PrusaSlicer and Microsoft Paint 3D are displayed incorrectly due to flipped normals after the mirroring, but they are sliced correctly. Simplify3D uses an Even / Odd polygon filling rule when slicing, Even / Odd rule leads to the same slicing independent of orientation of faces.
- Simplify3D can slice 3MF with mirroring from Cura, IdeaMaker, PrusaSlicer, and Microsoft Paint 3D. Supports are generated correctly only for 3MF with mirroring produced by Cura and ideaMaker. 3MF files with mirroring produced by PrusaSlicer have incorrectly generated supports.

Conclusion

Cura, ideaMaker, Microsoft Paint 3D, and PrusaSlicer generate negative determinant transformation matrices if an object was mirrored.
Cura and ideaMaker stores mirrored models in 3MF with changed the vertex order of triangles of objects stored in 3MF and transformation matrices with mirroring.
In contrast, Microsoft Paint 3D and PrusaSlicer save in 3MF the original models without changed vertex order, and mirroring is represented only by a transformation matrix with mirroring.
Except for Simplify3D, other tested tools have no issue with either of these two mirroring representations mentioned above. Simplify3D only has an issue with displaying objects from Microsoft Paint 3D and PrusaSlicer, but it can slice it without any issue.

Positive/negative mesh

Cura

Positive Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	Yes
Box (mirrored)	no errors, positive volume	Yes

Comment

Both objects are sliced correctly. Supports are generated correctly for both of them.

Negative Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	Yes
Box (mirrored)	no errors, positive volume	Yes

Comment

Both objects are sliced correctly. Supports are generated correctly for both of them, but overhangs are shown incorrectly. These overhangs are shown on the top of the object instead of the bottom of the object.

ideaMaker

Positive Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	Yes
Box (mirrored)	object is missing	No

Comment

Only one object is displayed. The other object is missing. Supports are not generated at all, so the missing object is probably unmirrored. Because based on previous findings, ideaMaker has an issue only with mirrored objects. The cut operation produced objects with holes, but these objects were sliced correctly.

Negative Mesh	Displayed?	Printed?/Sliced?

Box	no errors, positive volume	Yes
Box (mirrored)	object is missing	No

Comment

Only one object is displayed. The other object is missing. Supports are generated correctly. The cut operation also works correctly.

Microsoft Paint 3D

Positive Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	???
Box (mirrored)	no errors, positive volume	???

Comment

Both objects are displayed correctly. Painting, stickers, and rotations work without any issues on these objects.

Negative Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	???
Box (mirrored)	no errors, positive volume	???

Comment

Both objects are displayed correctly. Painting, stickers, and rotations work without any issues on these objects.

Microsoft 3D Builder

Positive Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	???
Box (mirrored)	rendered with holes	???

Comment

The mirrored object is displayed with holes. Therefore, it is not possible to paint on this object. But after applying cut or union operation, objects are displayed with any issues. Also, these operations are performed on both objects performed without any issue.

Negative Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	???
Box (mirrored)	no errors, positive volume	???

Comment

Cut and union operation works on both objects without any issue.

Simplify3D

Positive Mesh	Displayed?	Printed?/Sliced?
Box	no errors, positive volume	Yes
Box (mirrored)	rendered with holes	Yes

Comment

Supports are not generated for the mirrored object.

Negative Mesh	Displayed?	Printed?/Sliced?
Box	rendered with holes	Yes
Box (mirrored)	no errors, positive volume	Yes

Comment

Supports are not generated for the unmirrored object.

PrusaSlicer

Positive Mesh	Displayed?	Printed?/Sliced?

Box	no errors, positive volume	Yes
Box (mirrored)	no errors, positive volume	Yes

Comment

Both objects are sliced correctly. Supports are generated correctly for both of them. Cut operation produced objects with holes for the mirrored object.

Negative Mesh	**Displayed?**	**Printed?/Sliced?**
Box	no errors, positive volume	Yes
Box (mirrored)	no errors, positive volume	Yes

Comment

Both objects are sliced correctly. Supports are generated correctly for both of them. Cut operation produced objects with holes for the mirrored object.