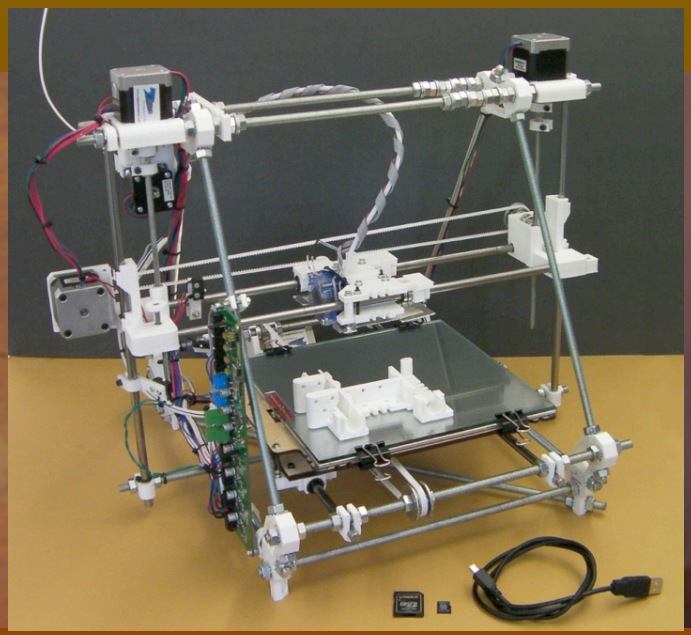
3D-printing of Generative Art by using Combination and Deformation of Direction-specified 3D Parts

Yasusi Kanada
Dasyn.com, Japan



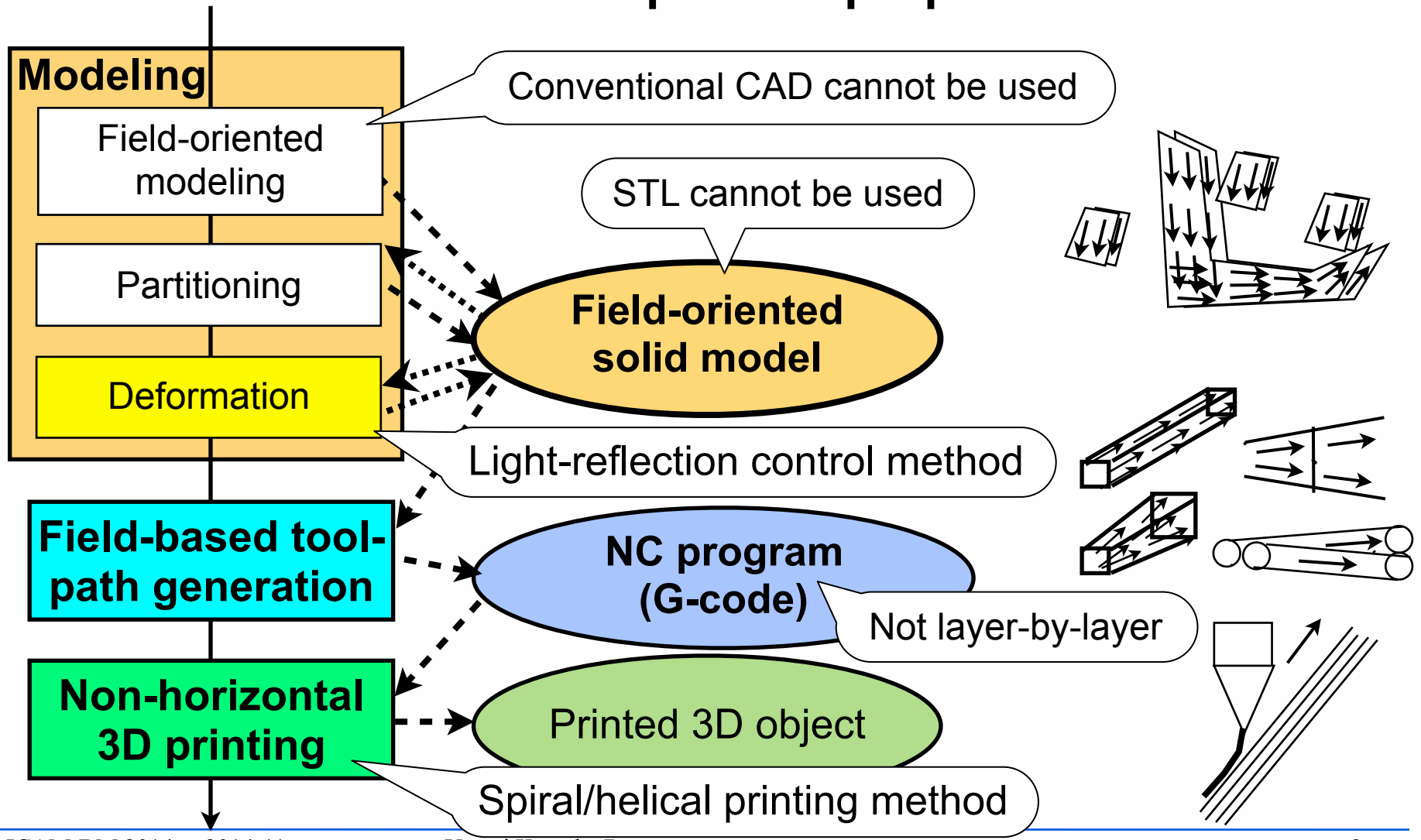
Introduction

- ***Direction-specified*** **3D modeling method and FDM-based printing method for directed models were proposed.**
  - These methods enable expression of natural or artificial directions, such as hairs, fabric, or other directed textures, in modeled objects.

- **Based on these methods, a method for creating various shapes using the following techniques is proposed.**
  - **Deformation** enables transforming simple 3D models to create varieties of shapes by generative design.
  - **Spiral/helical printing method** enables seamless print results by making filament directions of the surface & interior portion consistent.
  - **Light-reflection control method** for the spiral/helical printing with transparent filament.

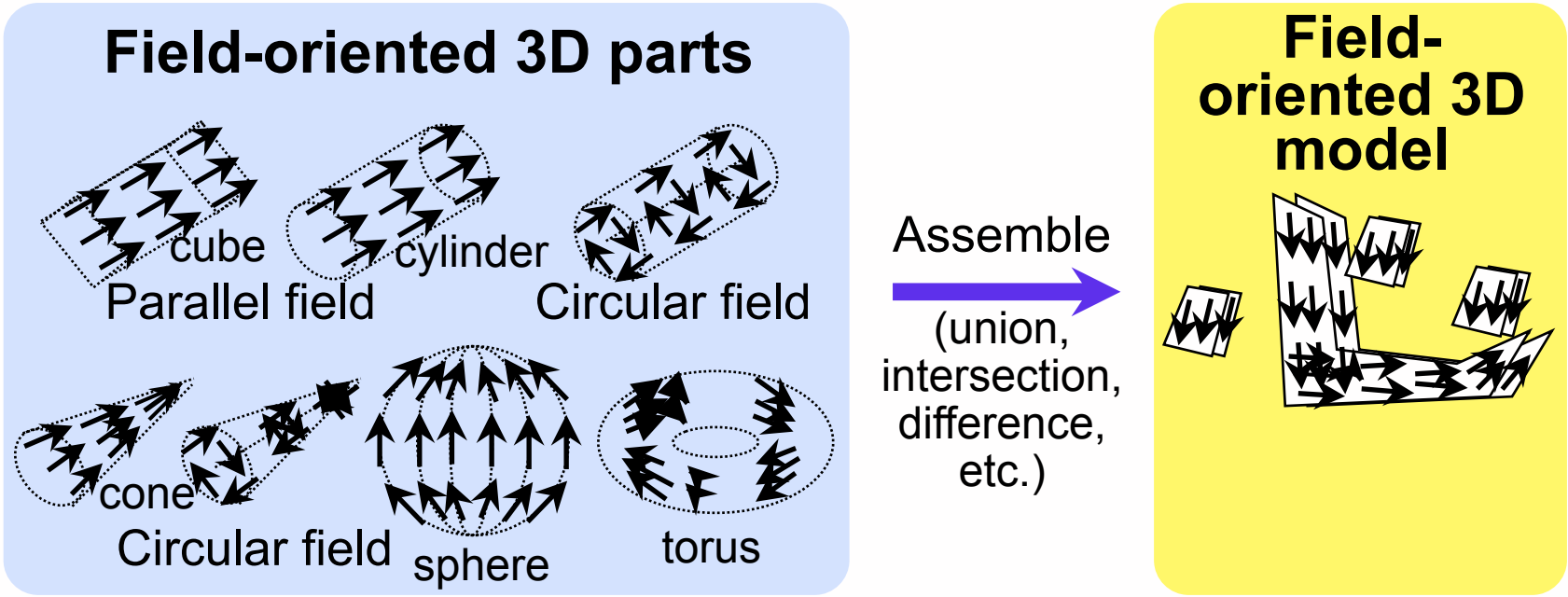
Outline of Direction-specified Methods

► **A methodology for modeling and printing "directed" 3D models with three steps were proposed.**

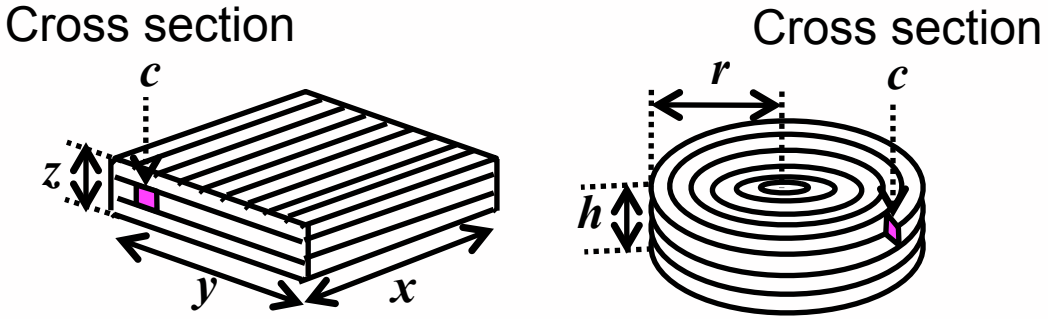


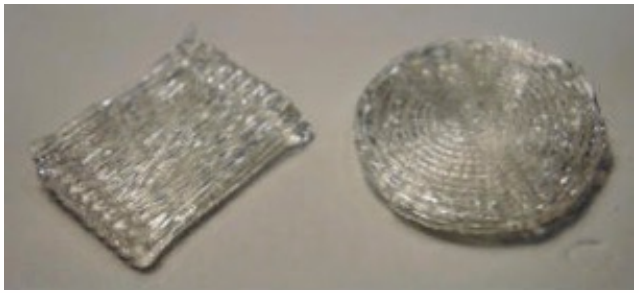
Field-oriented Modeling and Partitioning

▶ Field-oriented modeling method



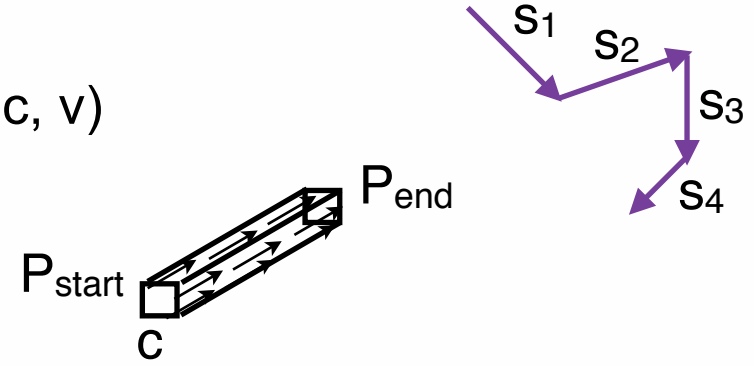
▶ Partitioning into a sequence of strings





Representation of Models

- **This model is suited for deformation.**
- **A model is represented by a sequence of directed strings.**
  - Directed string: (P_{start}, P_{end}, c, v)
  - P_{start} : tail
  - P_{end} : head
  - c : cross section of string
  - v : printing speed

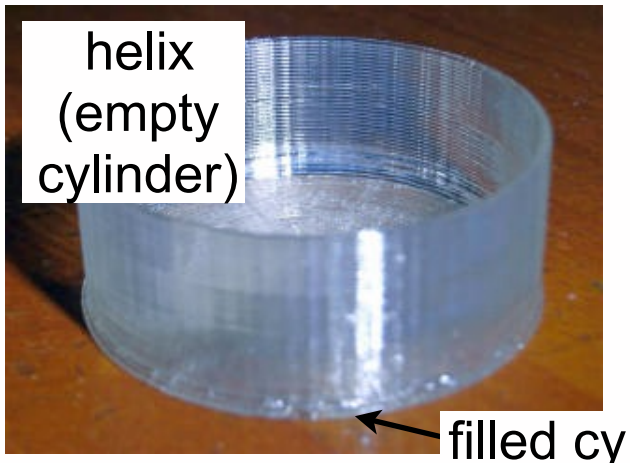


- **Models must be printable.**
  - Printing directions must be properly designed.

Deformation: Method

- **Purpose:**
  To generate various (artistic) shapes and directions in a generative way while preserving printability.

- **Original shape and Deformed shapes**



deformation

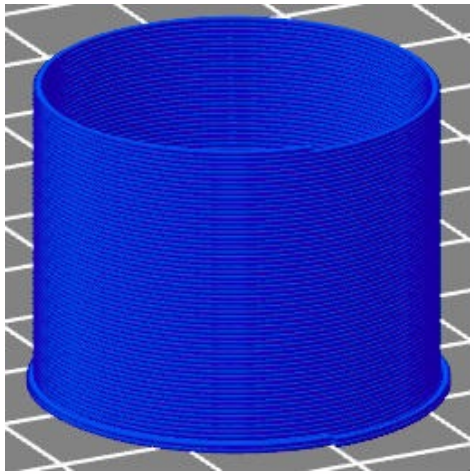
Description of Deformations

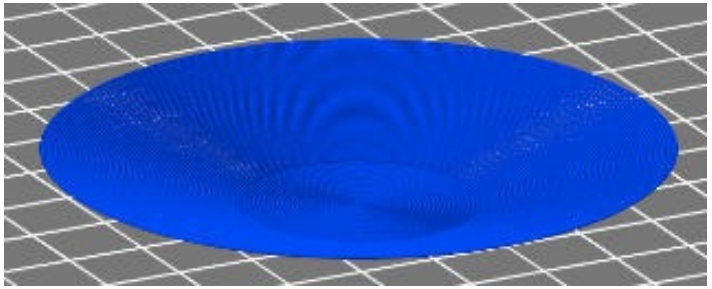
- **Deformation using Descartes coordinates**
  deform_xyz(*fd*(*x*, *y*, *z*), *fc*(*c*, *x*, *y*, *z*), *fv*(*v*, *x*, *y*, *z*))
  - *fd* maps a location (x, y, z) to a new location (x', y', z').
  - *fc* maps a cross section at (x, y, z) to a new cross section at (x', y', z').
  - *fv* maps a printing speed at (x, y, z) to a new speed at (x', y', z').
- **Deformation using cylinder coordinates**
  deform_cylinder(*fd*(*r*, *θ*, *z*), *fc*(*c*, *r*, *θ*, *z*), *fv*(*v*, *r*, *θ*, *z*))
  - *fd* maps a location (r, θ, z), which is expressed in cylinder coordinates, to a new location (r', θ', z').
  - *fc* maps a cross section at location (r, θ, z) to a new cross section at (r', θ', z').
  - *fv* maps a head speed at location (r, θ, z) to a new speed at (r', θ', z').

Deformation: Axisymmetric Examples

- **Dish:**

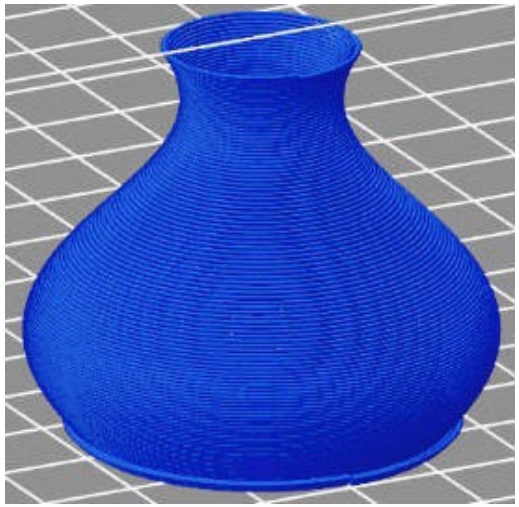
  deform_cylinder(
  fdd(*r*, *θ*, *z*), *fcd*(*c*, *r*, *θ*, *z*), *fvd*(*v*, *r*, *θ*, *z*))
  where *fdd*(*r*, *θ*, *z*) = (*r* + 1.05 *z*, *θ*, 0.3 *z*).





- **Vase:**

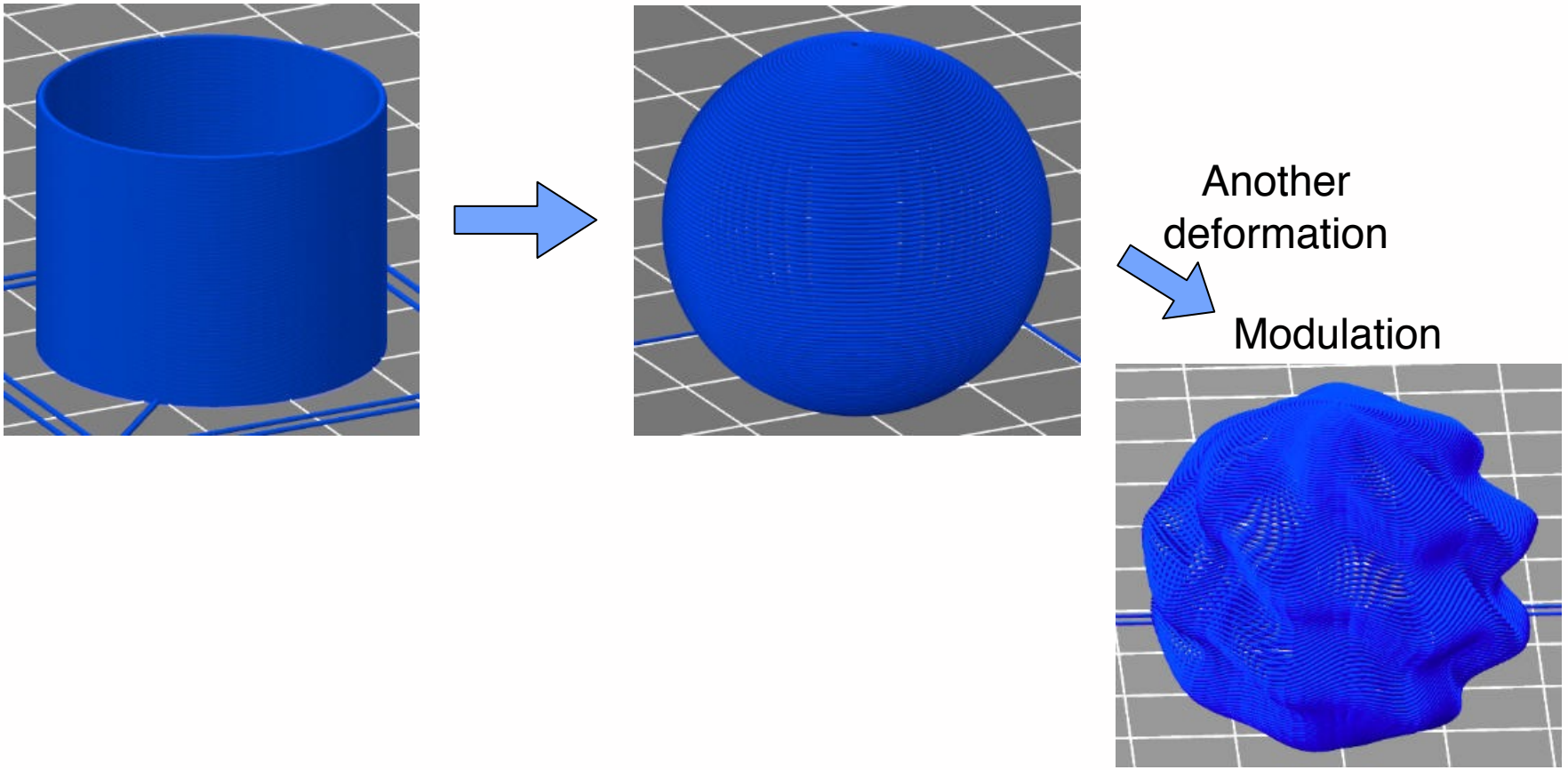
  deform_cylinder(
  fdp(*r*, *θ*, *z*), *fcp*(*c*, *r*, *θ*, *z*), *fvp*(*v*, *r*, *θ*, *z*))
  where *fdp*(*r*, *θ*, *z*) =
  (*r* (0.8 + 0.4 sin(*z* / 8 + 6.5)), *θ*, *z*)



Deformation: Axisymmetric Examples (cont'd)*

- **Sphere:**

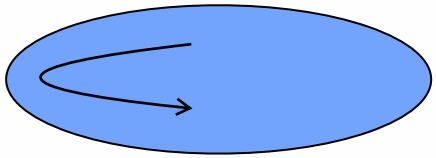
  deform_cylinder(*fds*(*r*, *θ*, *z*), *fvs*(*v*, *r*, *θ*, *z*), *fcs*(*c*, *r*, *θ*, *z*))
  where *fds*(*r*, *θ*, *z*) =
  (*Radius* * sin(*z* / *cylinderHeight*), *θ*, *r* – *Radius* * cos(*z* / *cylinderHeight*))



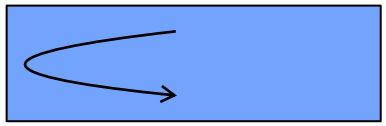
Spiral/helical Printing Method

► Printing parts spirally or helically in this method.

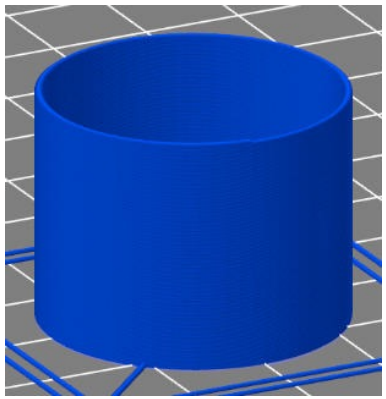
- A (mostly) horizontal surface can be printed spirally.



disk

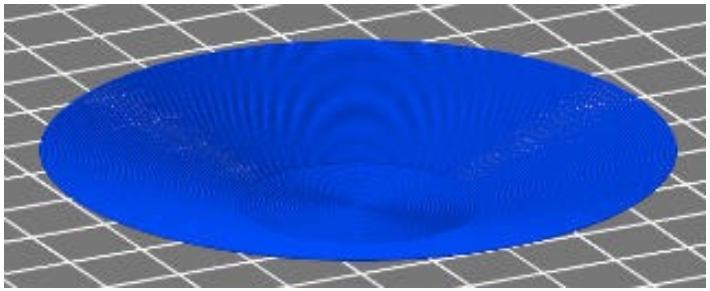


- A horizontally-closed surface can be printed helically.



► Advantages of spiral/helical printing method

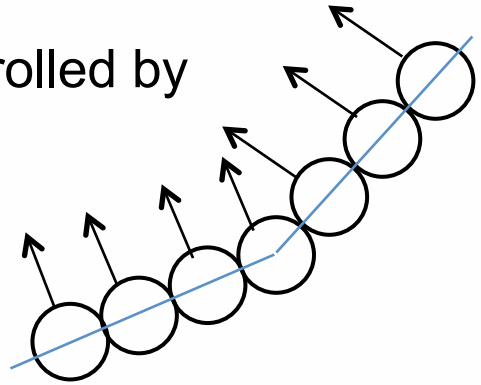
- Seams (non-printing head motions) can be reduced by this method.
- Low-angle overhang without support is allowed by this method.



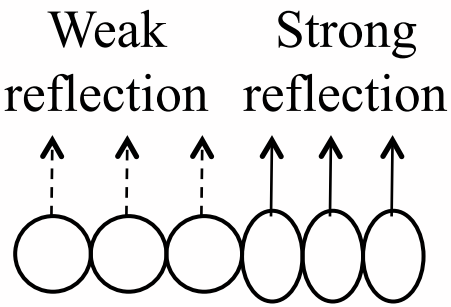
Light-reflection Control Method

- **Brilliantly shining objects can be generated by transparent filaments such as clear PLA.**

- **The amount and the direction of reflection can be controlled.**
  - Reflection controlled by overhang angle

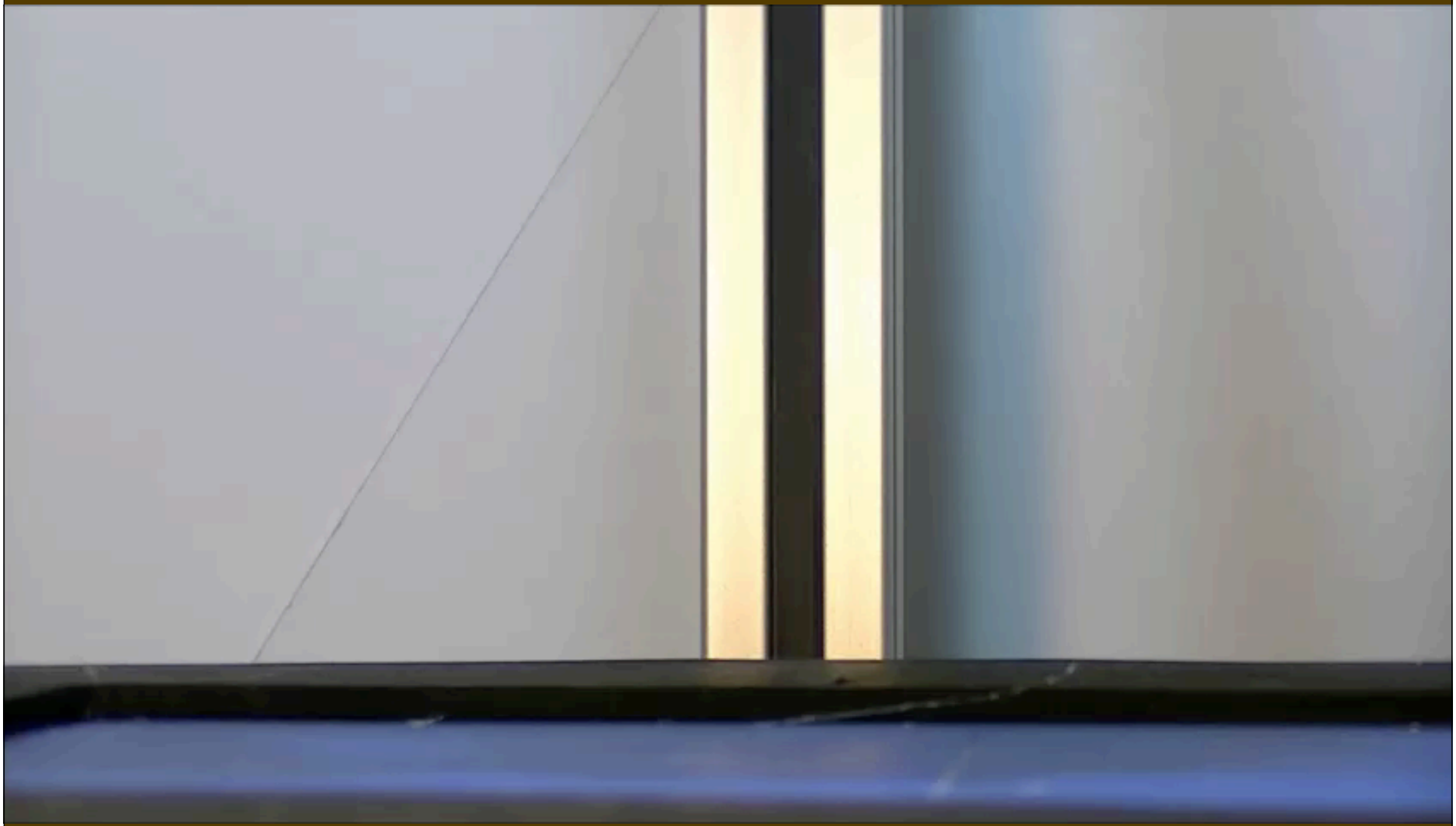


  - Reflection controlled by filament density



Print Results

Printing Process of Dish and Result



YouTube http://youtu.be/5P1vaahzW98

Summary and Conclusion

► Summary

- A method for creating various shapes by using the following three techniques was developed:
  - Deformation
  - Spiral/helical printing method
  - Light reflection control method.
- This method was implemented and evaluated.

► Conclusion

- The proposed method works well for thin axisymmetric shapes.
- Object with variety of (artistic) shapes and attractive attributes such as brilliant reflection can be obtained by deforming thin axisymmetric shapes.