# Problem to Solve

- An object to be printed, such as a collection of fibers, may have "natural direction" in shape.
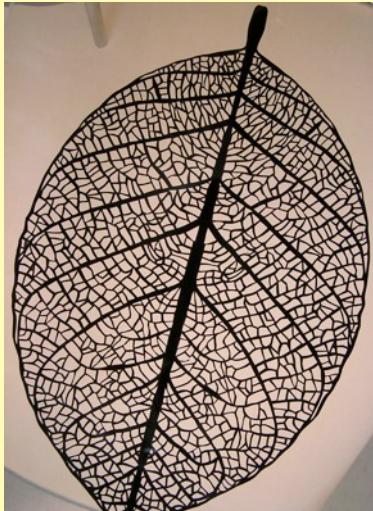


- The printing direction of FDM 3D printers may contradict with the "natural direction".

Natural direction

Printing direction
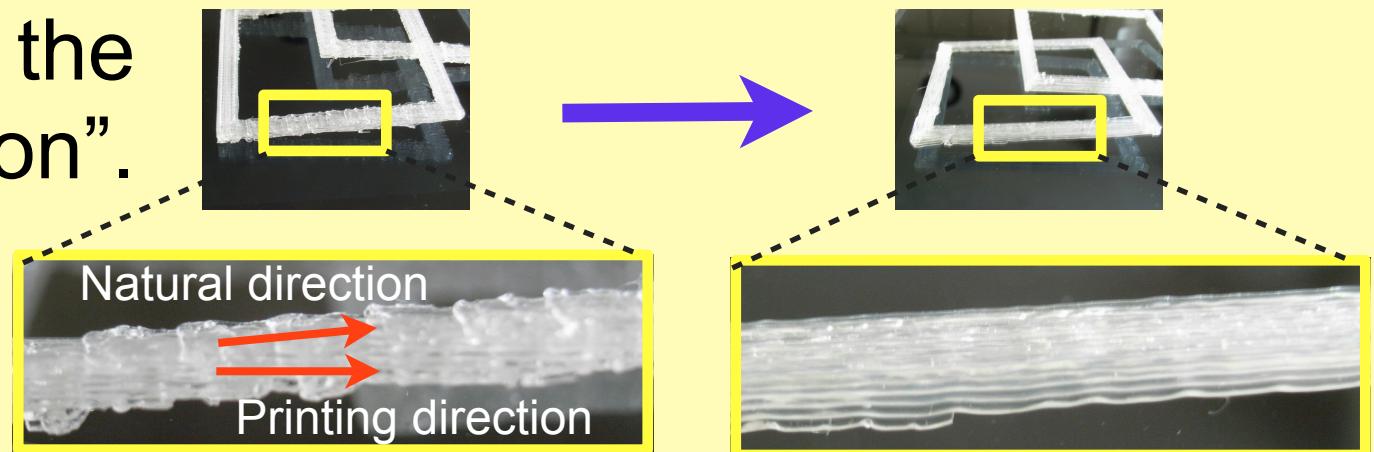
"Field" Based Solution

- To model objects with "natural directions," and to slice and to print objects in the "natural direction."
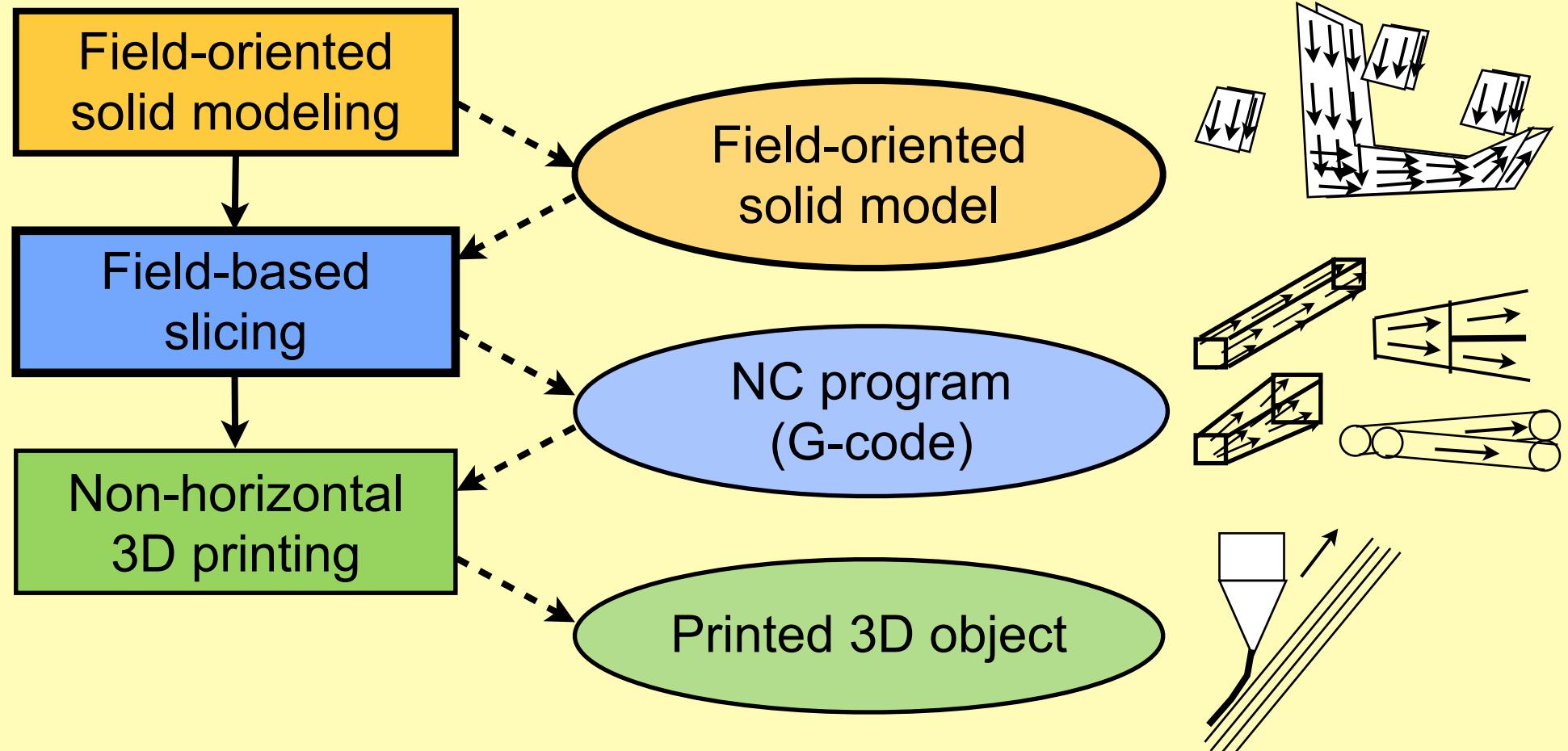
Modeling Methods

- **Two methods**
  - Field-oriented 3D CAD
 - Field-oriented 3D painting

• Field-oriented 3D CAD

– Parts combination

Field-oriented 3D parts

cube

cylinder

Parallel field

Spiral field

cone

Spiral field

sphere

torus

Combine

(union, intersection, difference, etc.)

Field-oriented 3D model

– Magnetization

Conventional solid model

Put in field

Field

Copy field

Field-oriented solid model
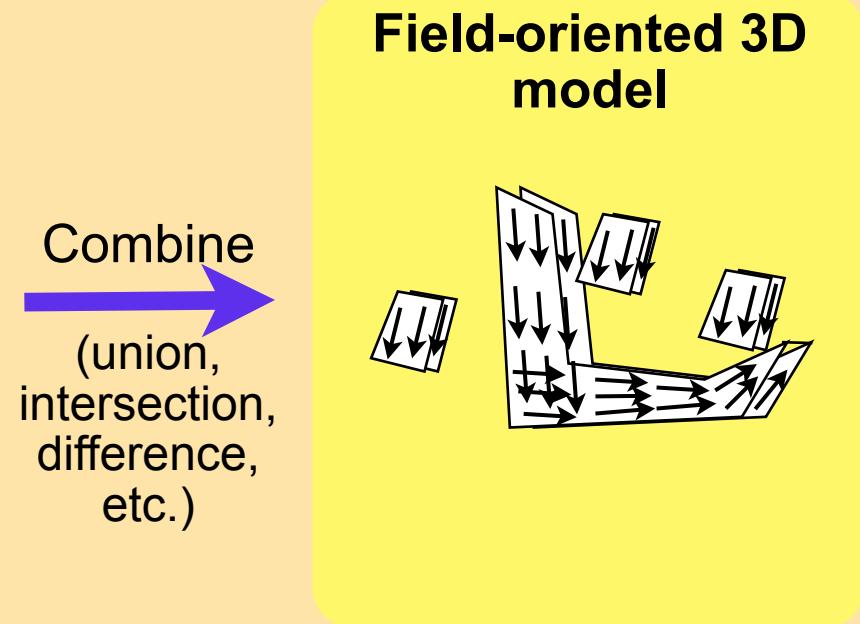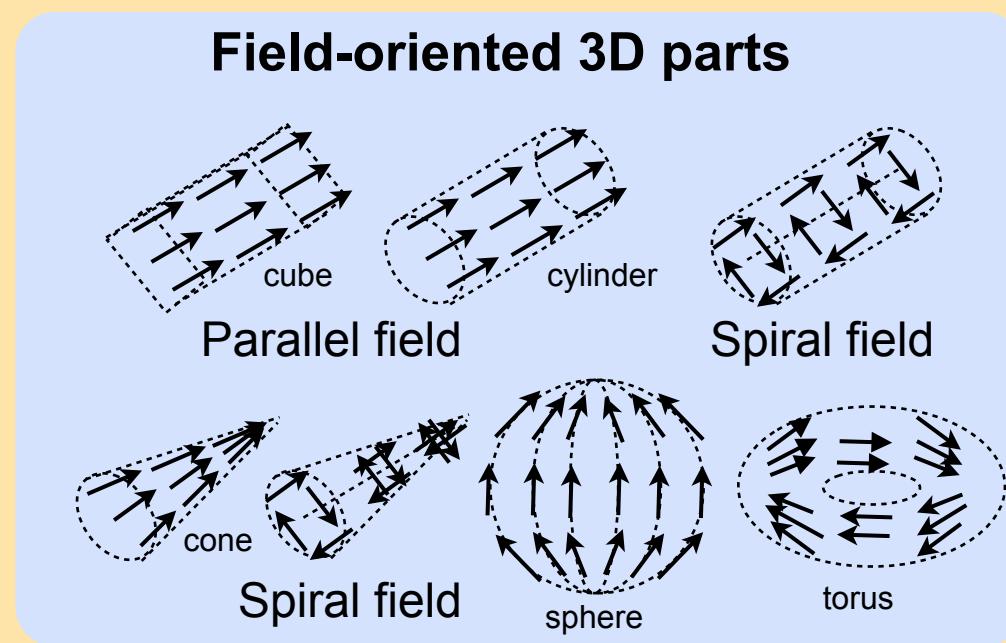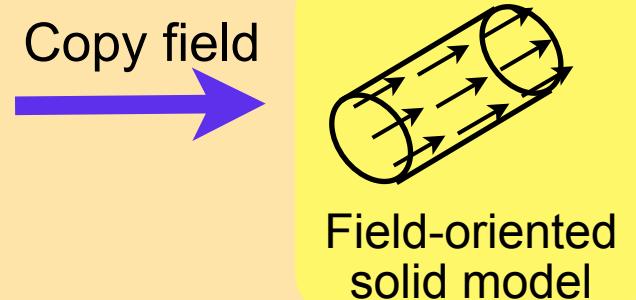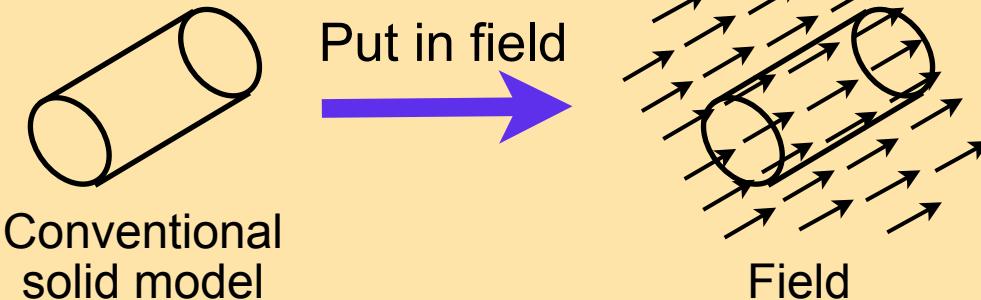
- **Field-oriented 3D painting**

- By using human body tracking

Tracking fingers

Motion

Dynamically changing width and shape

Sense width, shape, and direction

KINECT
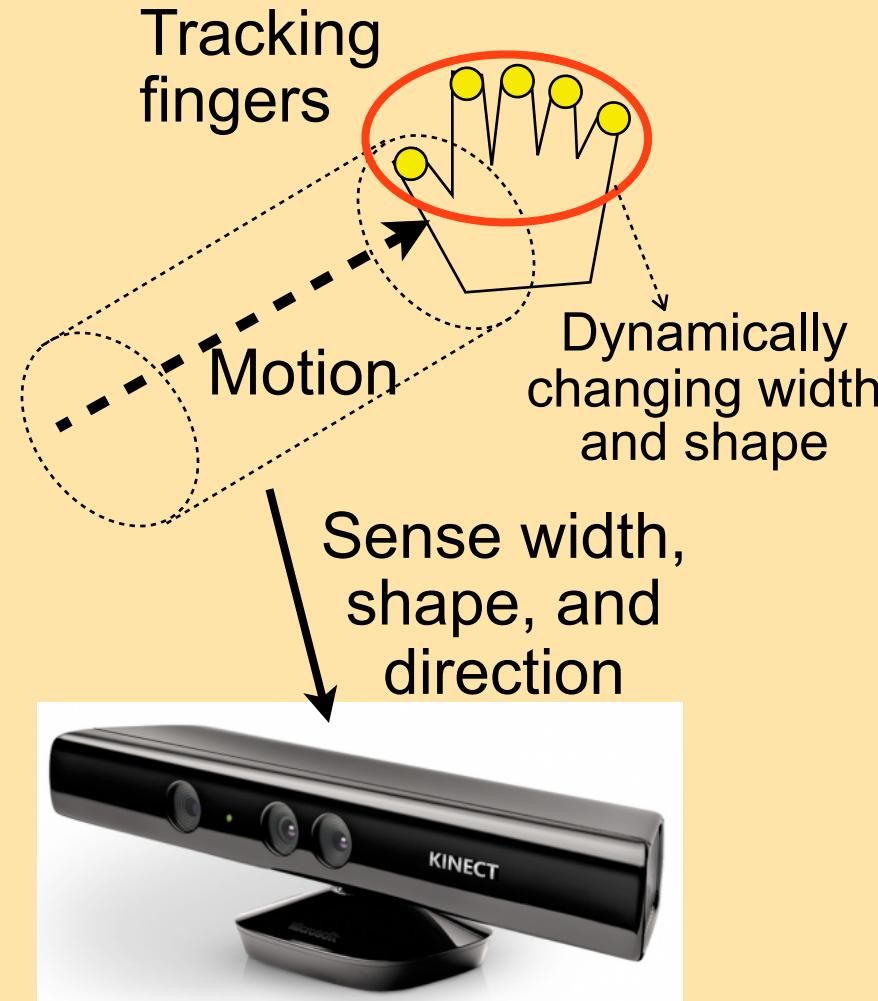
- By using sensors (accelerometers, etc.)

Pressure sensors

Motion

Sense width, shape, and direction

Wii
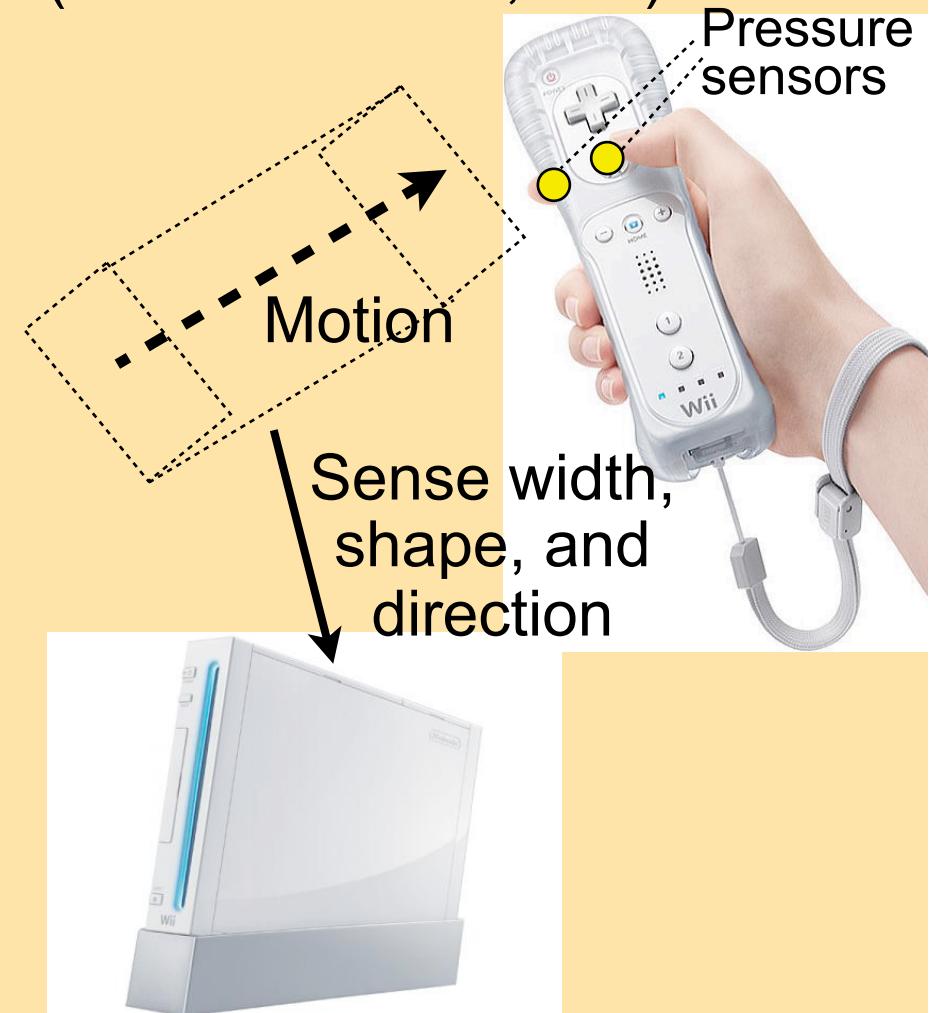
Slicing Methods

- ## Basic field-based slicing method

- Parallel slicing
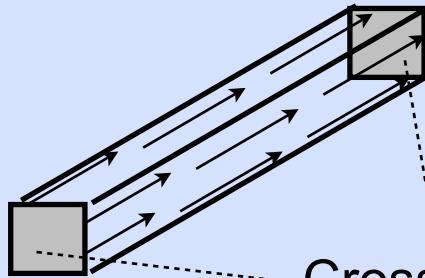
Cross sections
(constant extrusion)

- Widening / narrowing
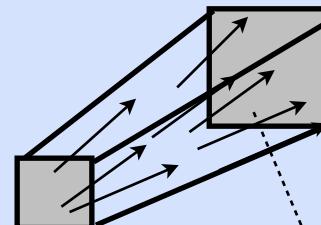
Increasing cross
section and extrusion
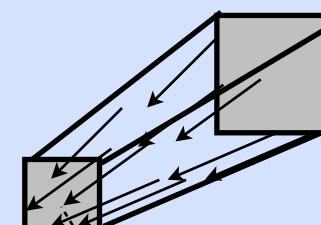
Decreasing cross
section and extrusion

- ## Slicing techniques

- Splitting / merging
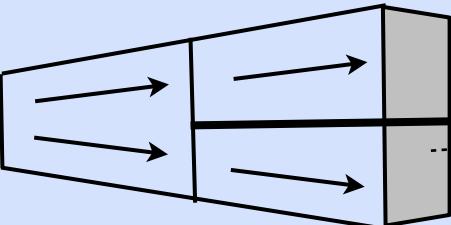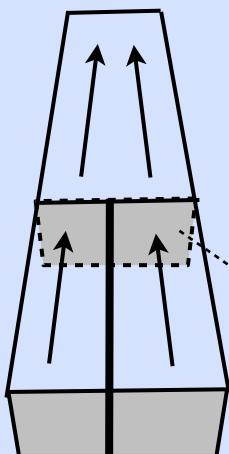
Splitting
large slices

Merging
small slices
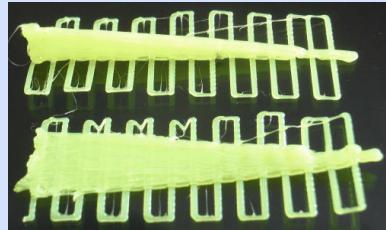
- Twisting
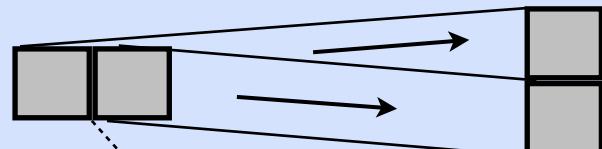
Horizontally
contacted

Vertically
contacted

- **Method for making unprintable objects printable**
  - Objects which cannot be printed may become printable by dividing them and by changing printing order.
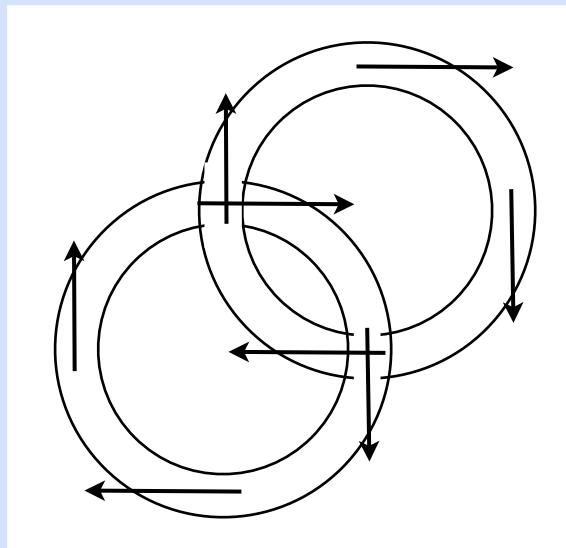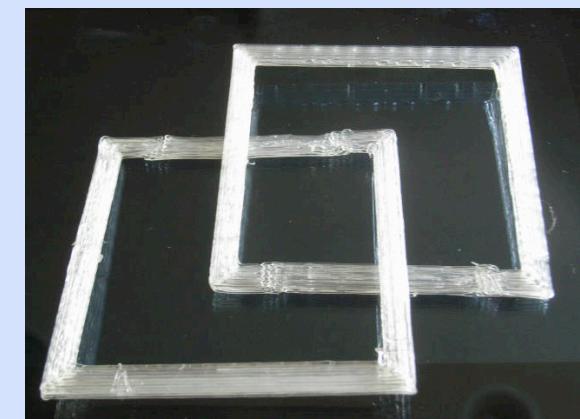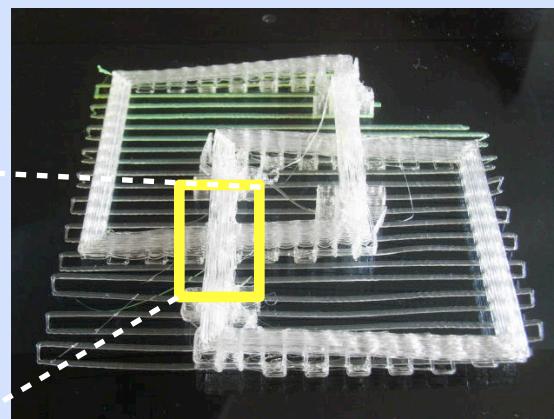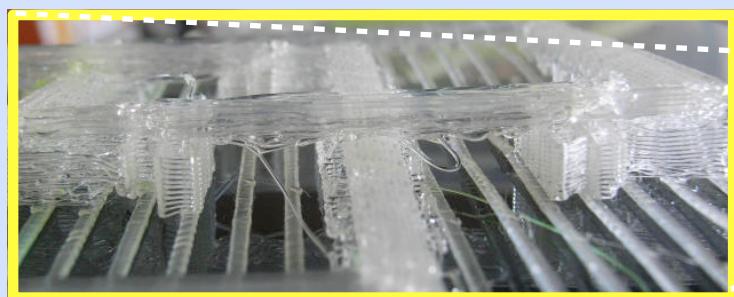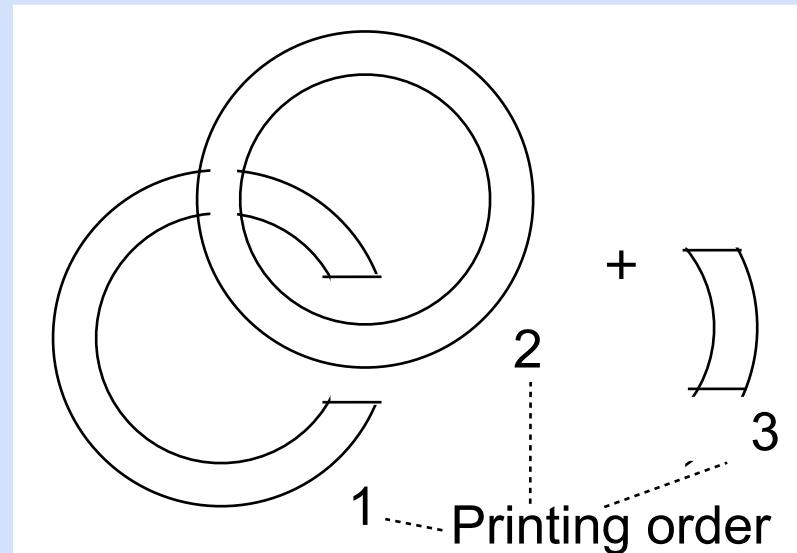
Printing Techniques

- **Problem in steep printing**

Nozzle

Collision

Gap

Printed object
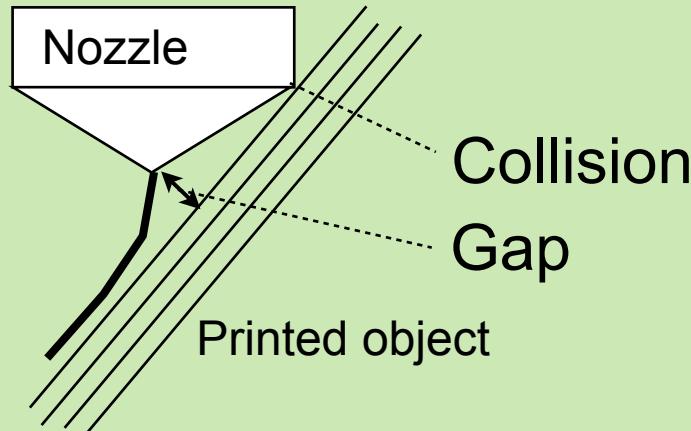
- **Two solutions**

  - Needle-shaped nozzle

  filament

 Insulator
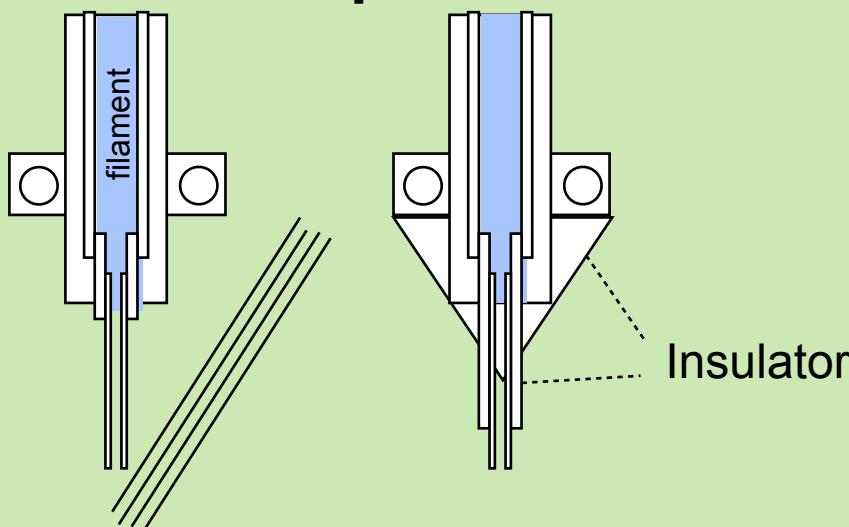
  - Five-axis print-head
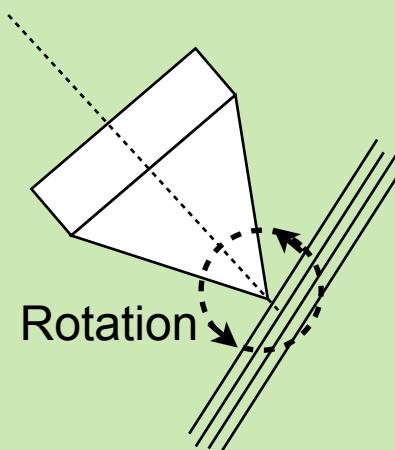
  Rotation

Implementation Status

- **Field-oriented modeling**
  - Kinect-based modeler is being designed.

- **Field-based slicing**
  - Slicing algorithms are being tested.
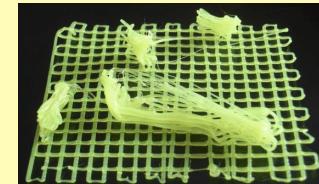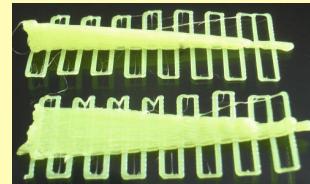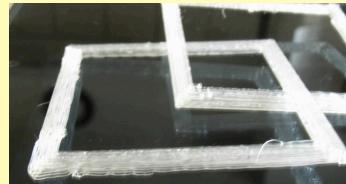
- **Non-horizontal 3D printing**
  - Printing methods are being tested using Rostock MAX (and printrbot) 3D printers.
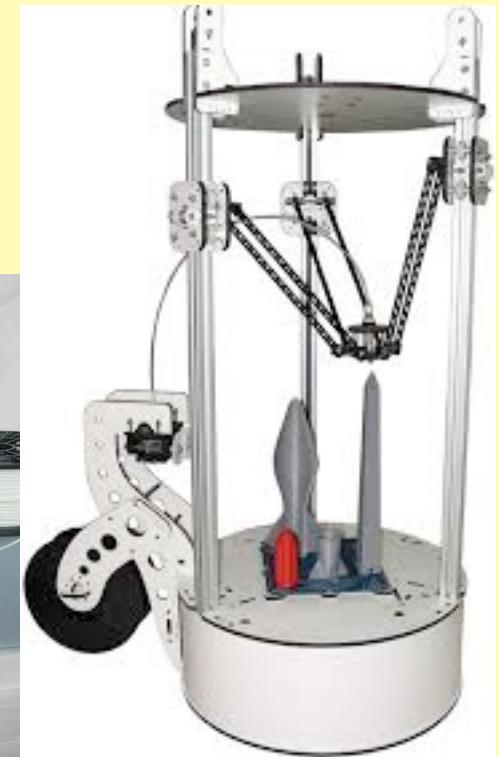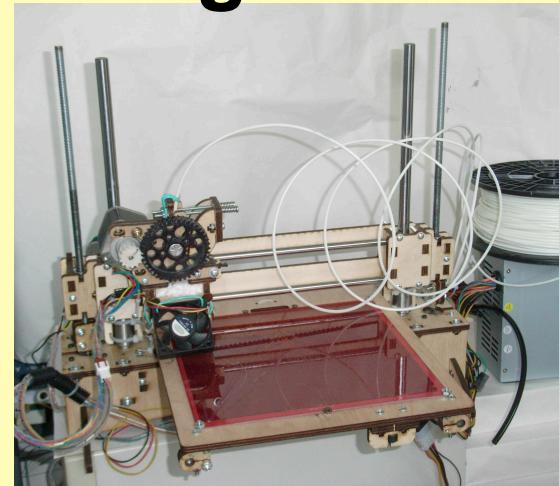
Applications

- **Art: 3D calligraphy**

  - Solid 3D calligraphy

Julien Breton

立体象書研究会

- Directed 3D calligraphy

  3D printing based

  ?

 Iron based

Shishu
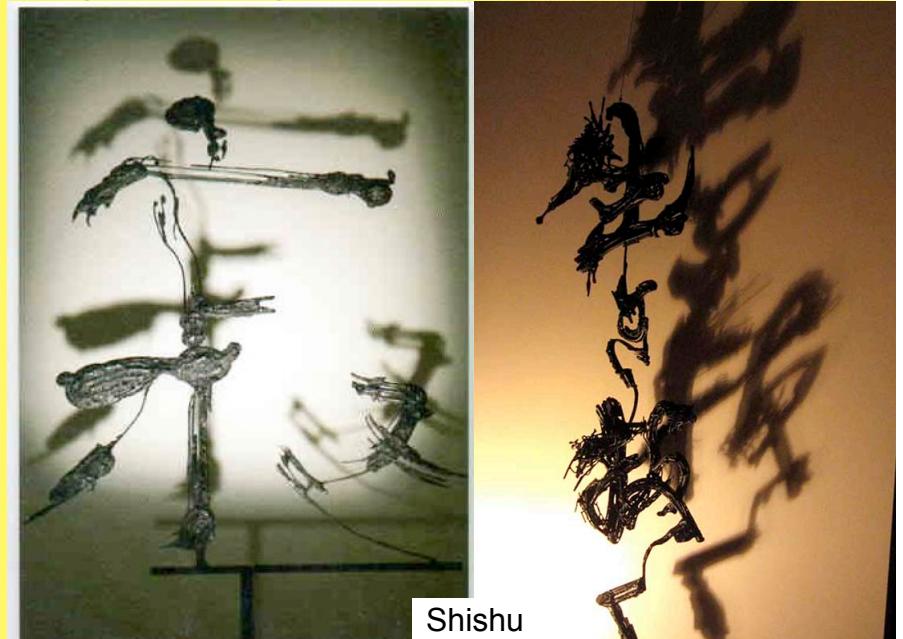
- **Hobby**

→ **?**
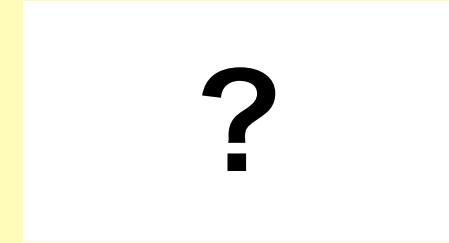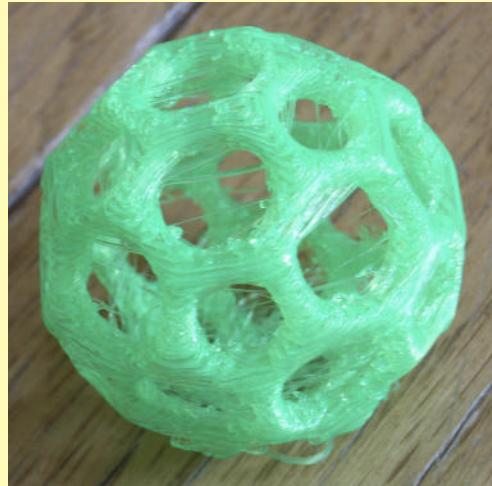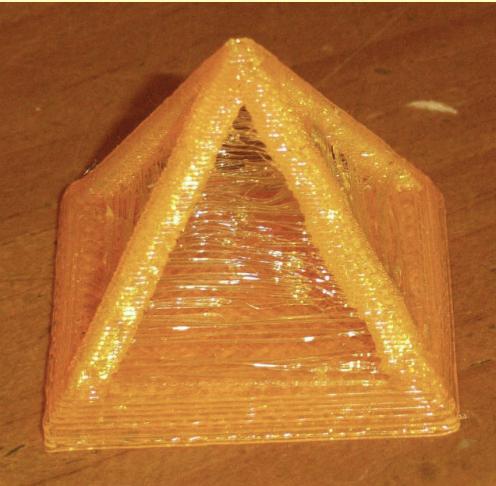
- **Industry**

→ **?**
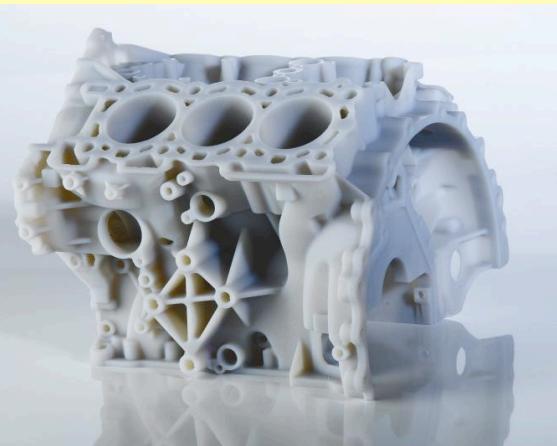
Concluding Remarks

- Natural direction of 3D objects can be expressed by FDM 3D printing using field-oriented/based modeling, slicing, and printing methods.

- The developments of field-oriented/based algorithms and applications are in early stages.