

Method of Designing, Partitioning, and Printing 3D Objects with Specified Printing Direction

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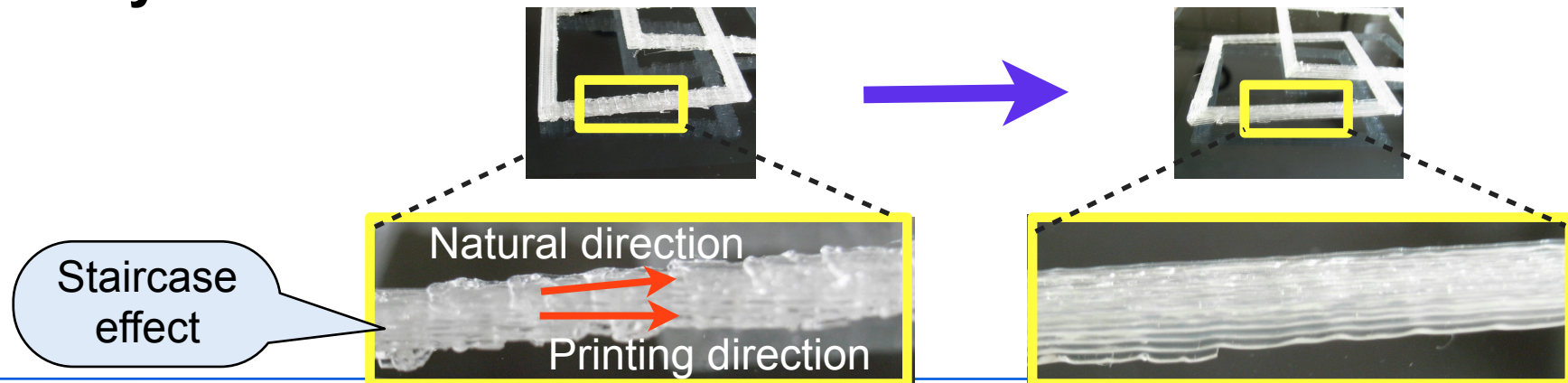
Two Problems in Conventional 3D Design & Printing Methods

► Conventional 3D printing/modeling methods cannot express “direction”.

- Objects may have natural or artificial directions.



► The printing direction of “FDM” 3D printing methods may contradict with the “natural direction”.

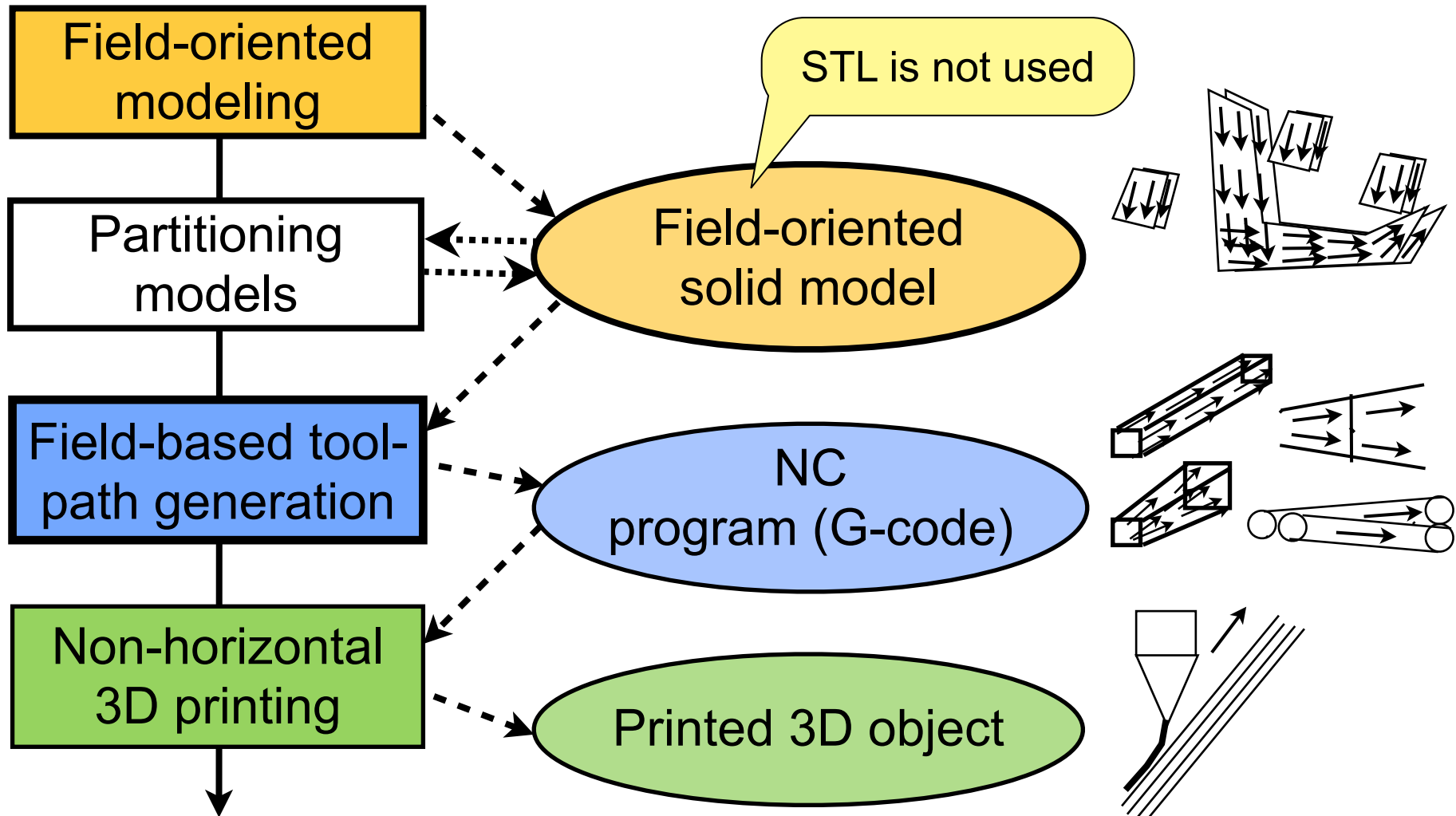


Proposal: Direction-specified Methodology and Methods

- ▶ **1. A direction-specified 3D design and printing methodology is proposed.**
- ▶ **2. Concrete methods that implements this methodology are proposed.**

Direction-specified Methodology

- ▶ A methodology for modeling and printing “directed” 3D models using four abstract steps are proposed.



Methodology: Four Abstract Steps

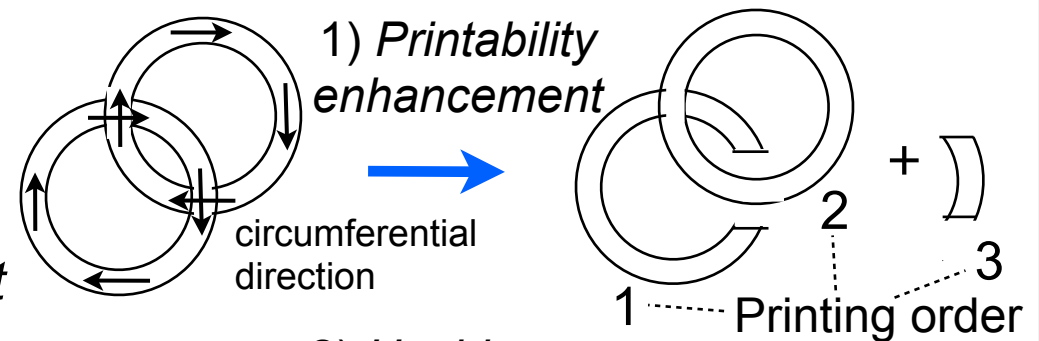
- ▶ **1. Field-oriented modeling:** A model with directions or a “vector field” is designed.



- Two methods: *Field-oriented 3D CAD*, *Field-oriented 3D painting*
- *Field-oriented 3D CAD*: *Parts combination*, *Magnetization*

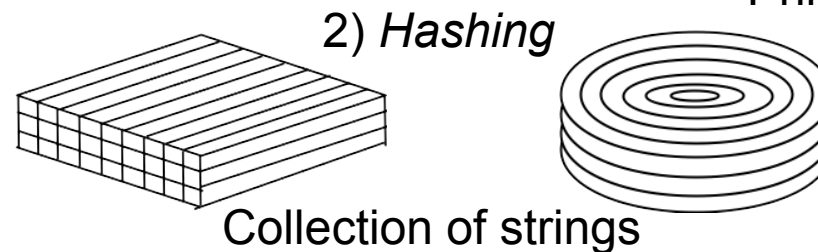
- ▶ **2. Model partitioning:** Objects are partitioned into parts by two steps.

- 1) *Printability enhancement*
- 2) *Hashing (peeling)*

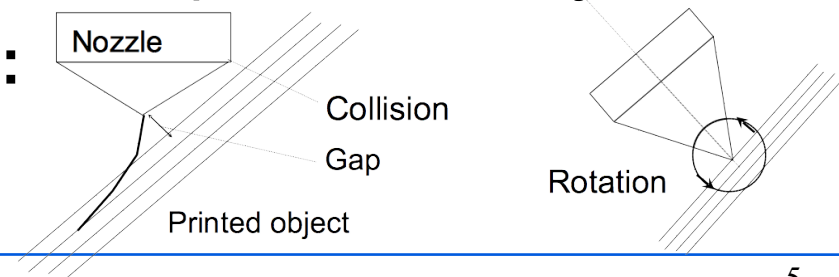


- ▶ **3. Field-oriented tool-path generator:**

A tool-path is generated from a set of partitioned objects.



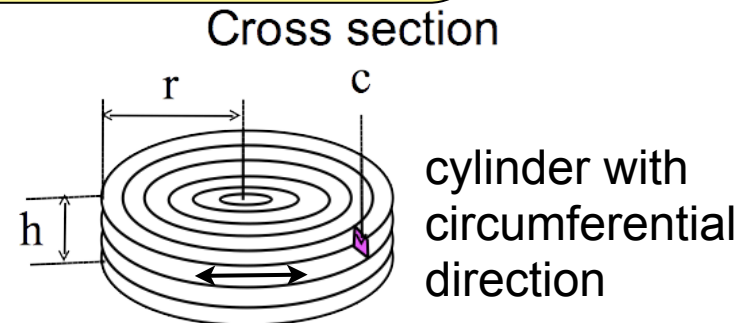
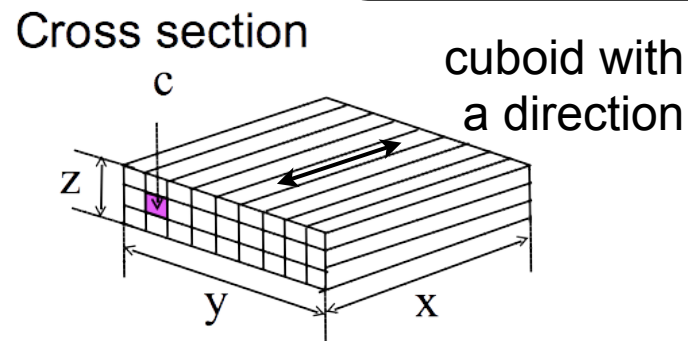
- ▶ **4. Non-horizontal 3D printing:** A 3D printer prints the object using the tool-path.



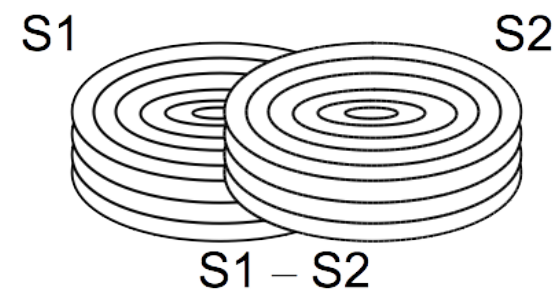
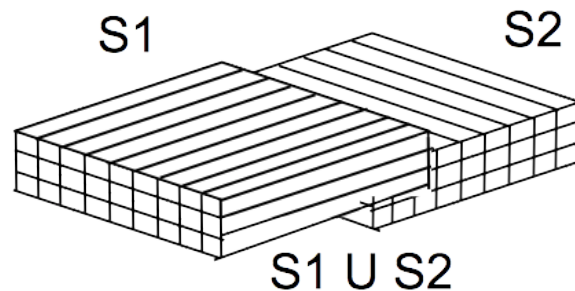
Concrete Method for Direction-aware 3D Design

- ▶ **Parts for 3D CAD are “pre-hashed” (or “pre-peeled”) in this method.**

Not just a field-oriented solid model

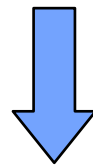
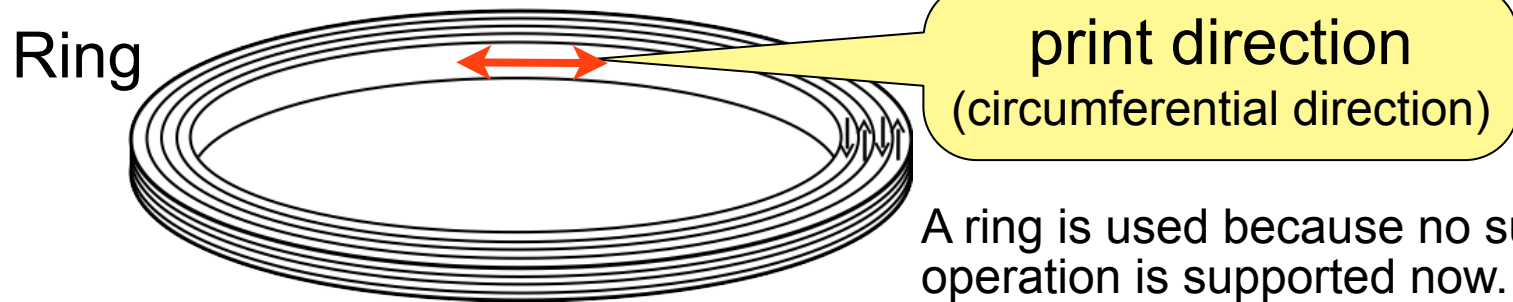


- ▶ **Parts are combined by using operations such as union or intersection (i.e., extended set operations).**



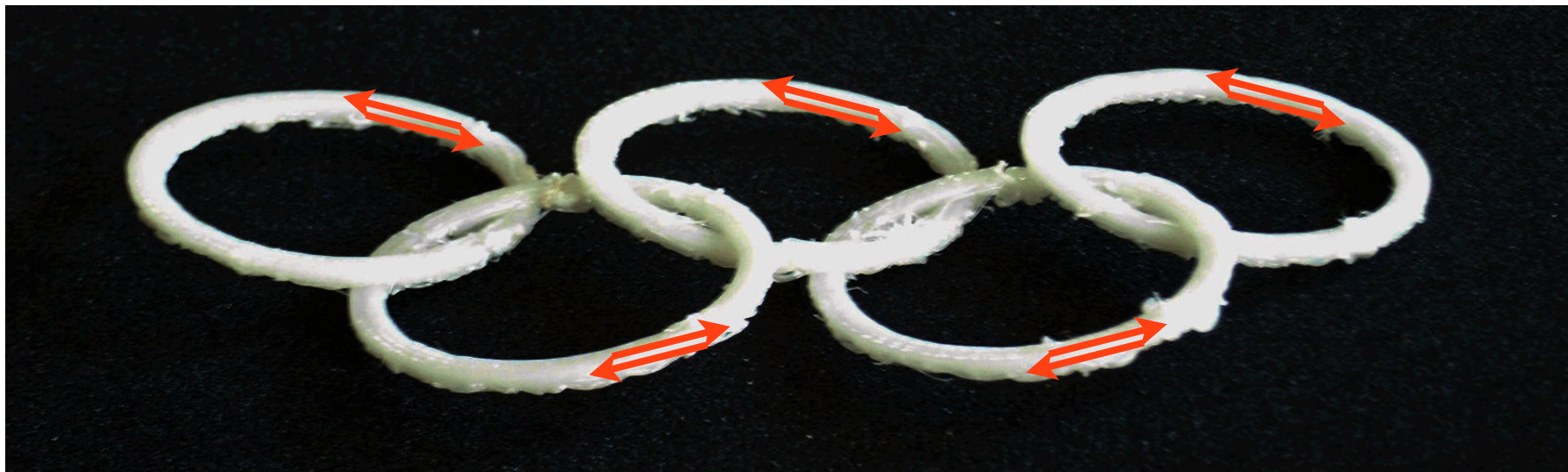
Example of Direction-aware Design and Non-horizontal Printing

- ▶ An olympic symbol was designed and printed.



partition, rotation, etc.

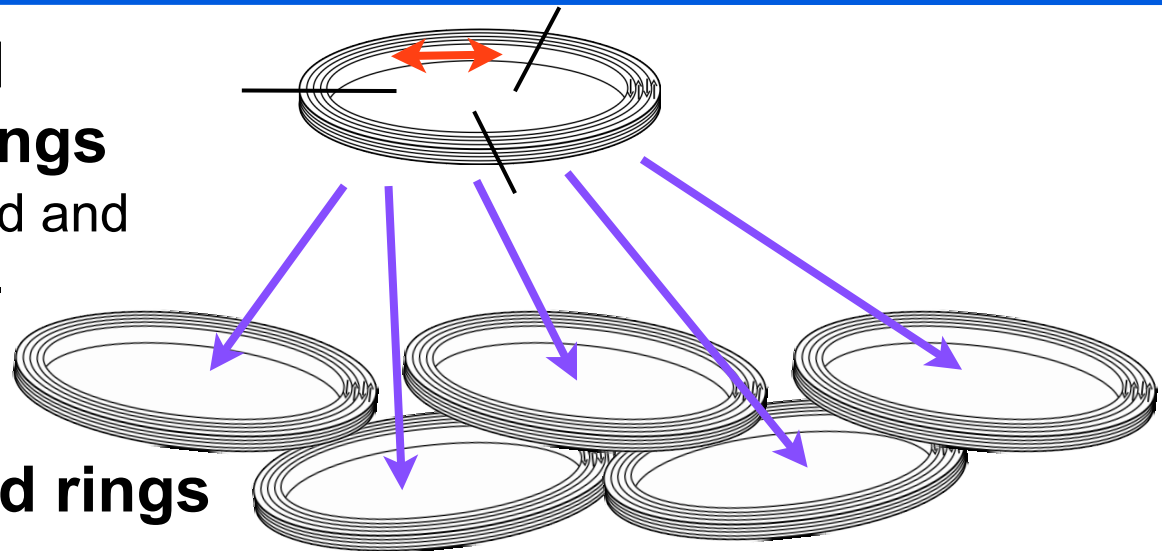
The design process is embedded in a Python program because no CAD tool is available now.



Example of Direction-aware Design and Non-horizontal Printing (cont'd)

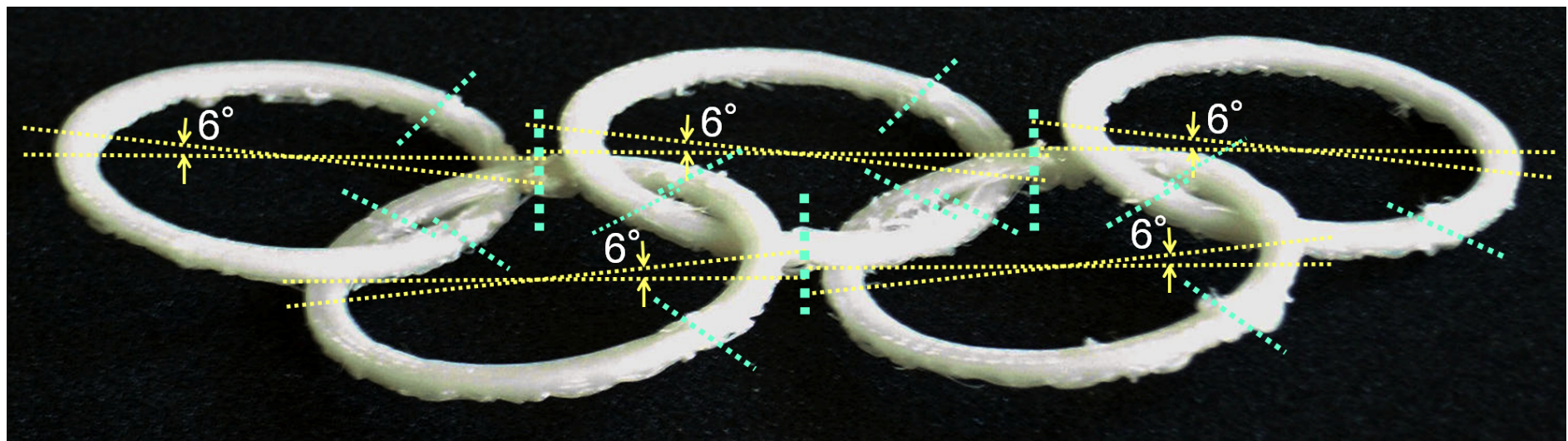
► Designing directed (and partitioned) rings

- Rings are pre-hashed and manually partitioned.

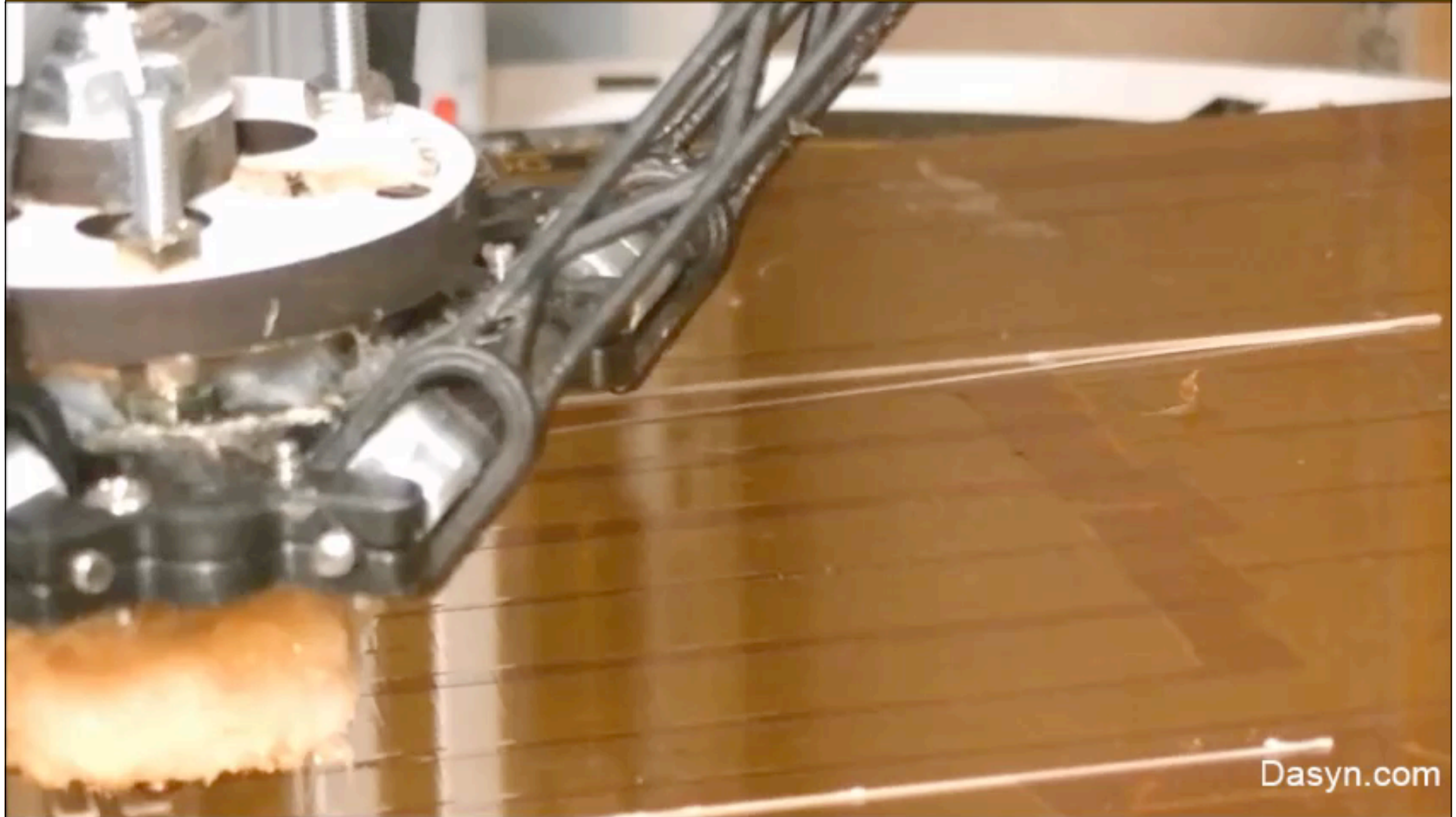


► Rotating partitioned rings

► Specifying order of parts and print them in order.



Printing Process and Result: Direction-aware Design and Non-horizontal Printing



YouTube, <http://youtu.be/saMdaqdlcxo> (1x ver), FZZj6fGLIs0 (8x ver)

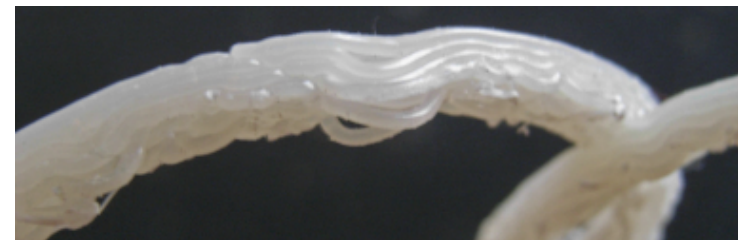
Evaluation

► Printed olympic symbol was measured.

Item	Design (mm)	Measured value (mm)	Ratio (M/D)
Outer diameter	40.4	39.9 ± 0.4	0.988
Inner diameter	34.0	34.0 ± 0.3	1.0
Ring height	1.6	2.3 ± 0.2	1.44

► Observation

- The ring height is too large because the lower layers of the rings were not completely supported.
- The rings looked mostly good, but sometimes defects were found.



Potential Applications

► Potential artistic application: 3D calligraphy

- Artworks using conventional methods



► Generative art (Algorithmic art)



Conclusion

► Proposals

- An abstract methodology for direction-specified 3D printing is proposed.
- Concrete methods for designing, partitioning, and printing directed 3D objects using an “FDM” printer are proposed.

► Evaluation

- A chained olympic rings were used for testing and evaluating the proposed method.
- The evaluation result is satisfiable except the object height and several defects.