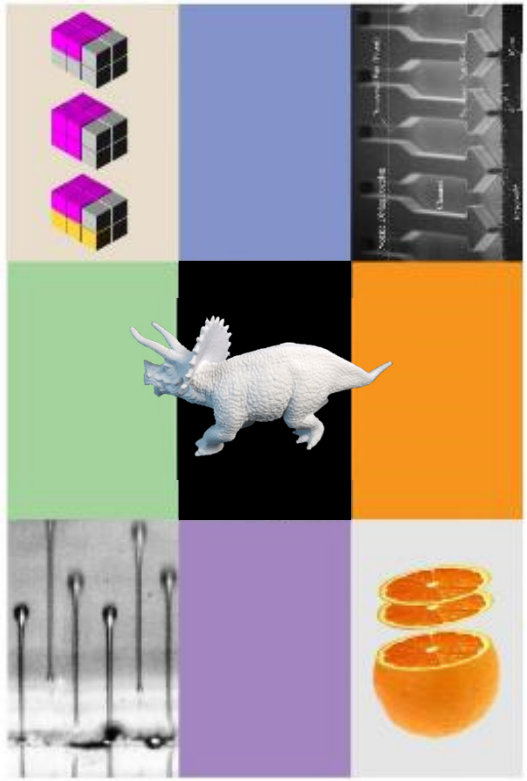
New Voxel-Based Data Format FAV for Seamless 3D Data Flow to 3D Printers



November 25, 2016

FUJI XEROX Co., Ltd.
Marking Technology Laboratory
FUJII, Masahiko

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Agenda

1. Motivation of Research on 3D Data Format
2. Introduction of New 3D Data Format FAV
3. Expectation to FAV and Future Activities

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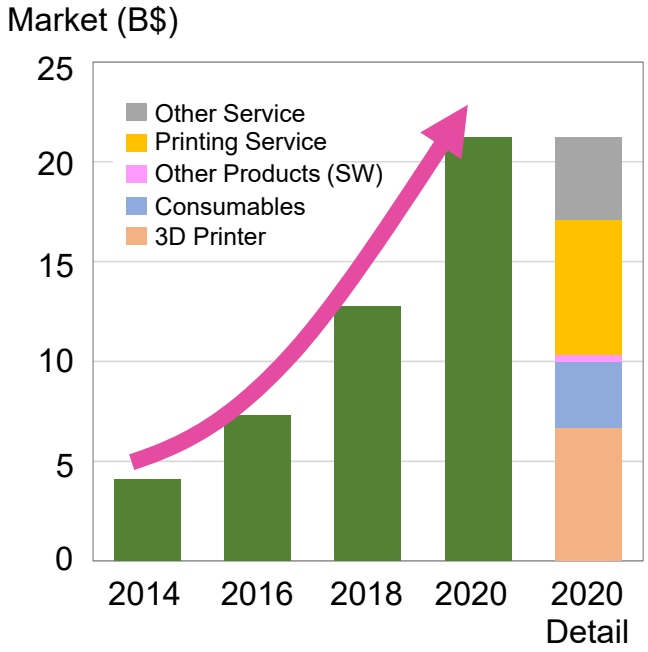
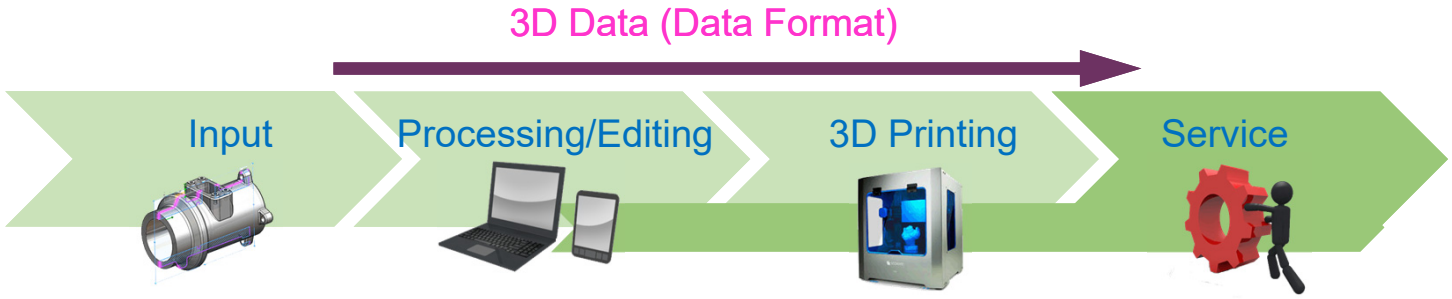
Motivation of Research on 3D Data Format

- 3D Printing markets has been growing rapidly, and world wide market size is expected to surpass $20B in 2020.
- However there are many issues to slow down this growth and one of solutions to the issues is improving 3D printers' performances. (productivity, variety of material, accuracy, material cost)
- Fuji Xerox and Keio University (Prof. Hiroya Tanaka) found current data format cannot make full use of advanced 3D printers' abilities and applications of 3D data.
- Fuji Xerox started to research a new 3D data format jointly with Keio University and announced the first specifications of new voxel-based 3D data format FAV on this July.





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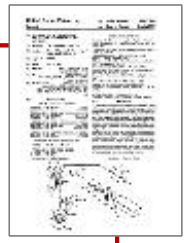
Introduction of New 3D Data Format FAV

History of 3D Printers and Current Data Format

1890 Blanther
1902 Baese
1937 Prerera
1972 Matsubara

Ideas of Additive Manufacturing

1980 Vat Photo-polymerization (Kodama)
1986 Powder Bed Fusion (Deckard)
1987 Sheet Lamination (Feygin)
1989 Material Extrusion (Housholder)
1989 Binder Jetting (Sachs)
1989 Material Jetting (Sakai)
1995 Directed Energy Deposition (Lewis)



Basic Patents for Current 3D Printers

1988 **STL was Proposed** by 3D Systems

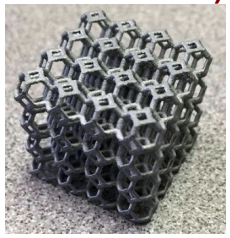
1987 SLA 1 [3D Systems]
1989 LOM ([Helisys]
1991 3D-Modeler [Stratasys]
1995 EOSINT [EOS]
1996 Z402 [Z Corp.]
1998 LENS [Optomec]
2001 EDEN [Objet]

The First Products of 3D Printer

Full Color (Outside/Inside)

Evolution

Mixing Materials



Internal Structure

Circuit Implementation

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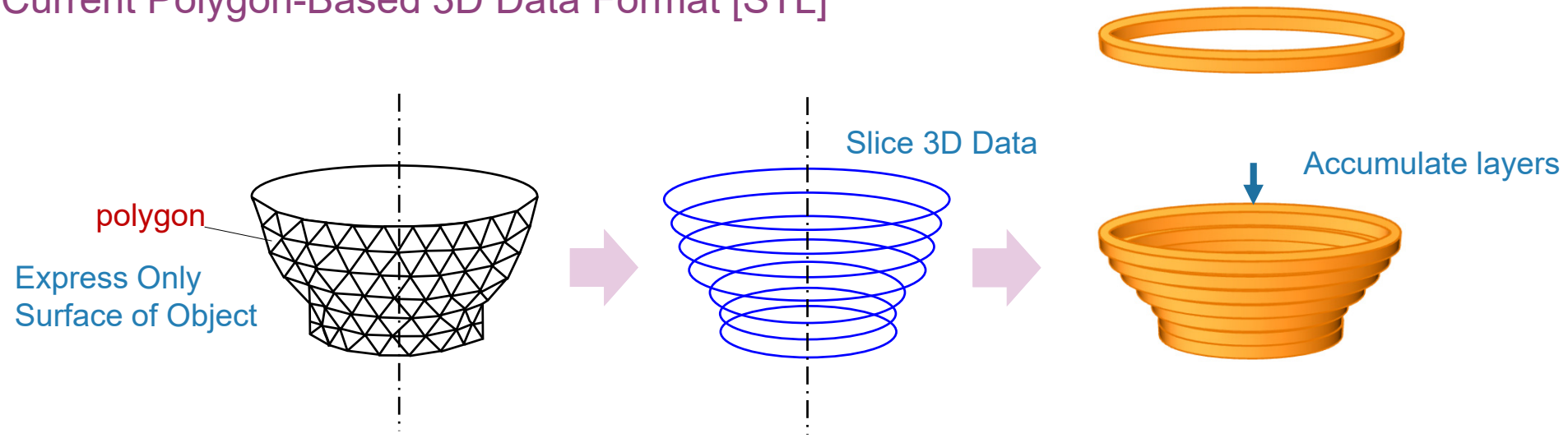
Current Polygon-Based 3D Data Format [STL]



STL

(Stereolithography / Standard Triangulated Language
/ Structural Triangle Language)

STL was proposed 30 years ago by 3D Systems.

- No Color information
- No Material Information
- No Internal Structure Information

To realize functional 3D inkjet printing, information for function have to be transmitted to 3D Printers.

AMF

(Additive Manufacturing File Format)

3MF

(3D Manufacturing Format)

New data format are proposed but still polygon-based same as STL. These can express color or material partially and can NOT express internal structure yet.
It is NOT suitable for functional printing.

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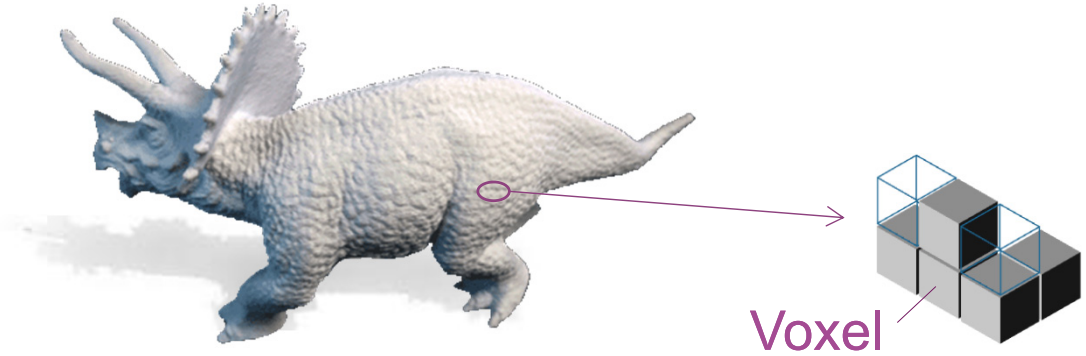
Pixel (2D) & Voxel (3D)

2D Image
(Document)

(Base Configuration Element for 2D Images)

3D Object



(Base Configuration Element for 3D Objects)

Voxel = Volume + Pixel

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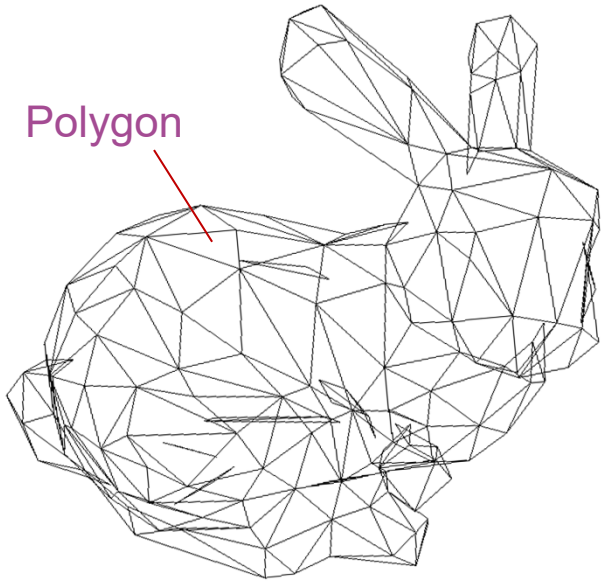
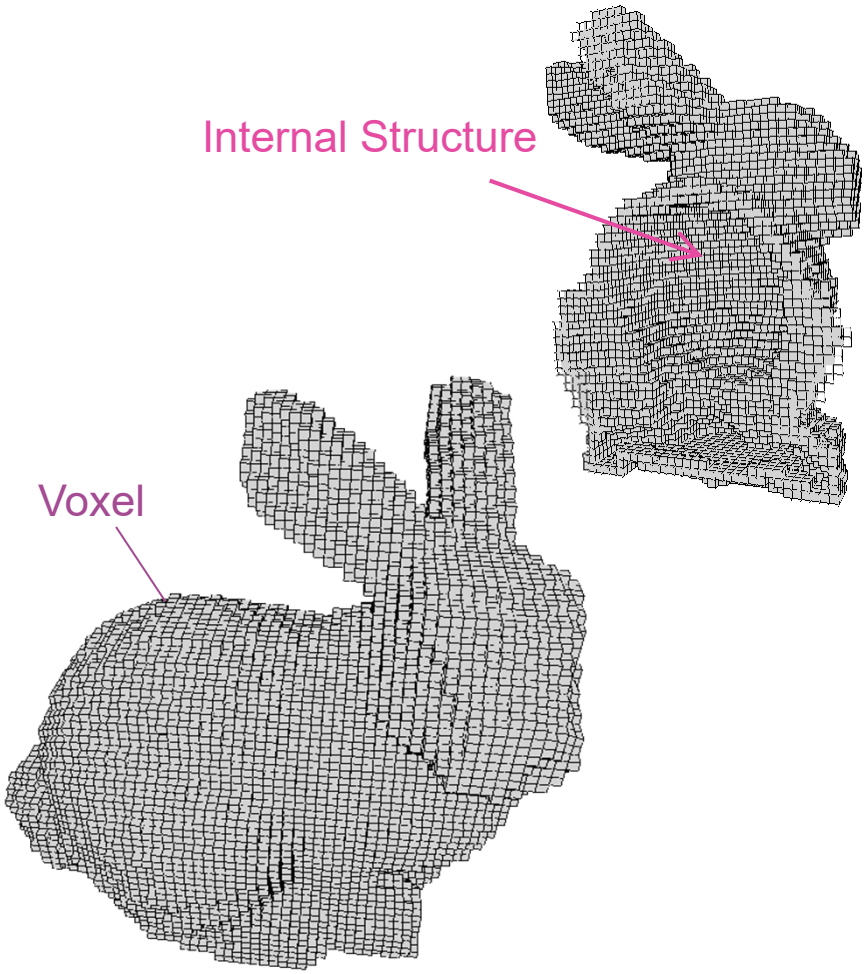
Polygon and Voxel Expression of 3D Object





Surface Expression by Polygon

STL

Object Expression by Voxel

FAV

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3D Object Expression by Voxel

Examples of Voxel

Color: Green
Material: ABS

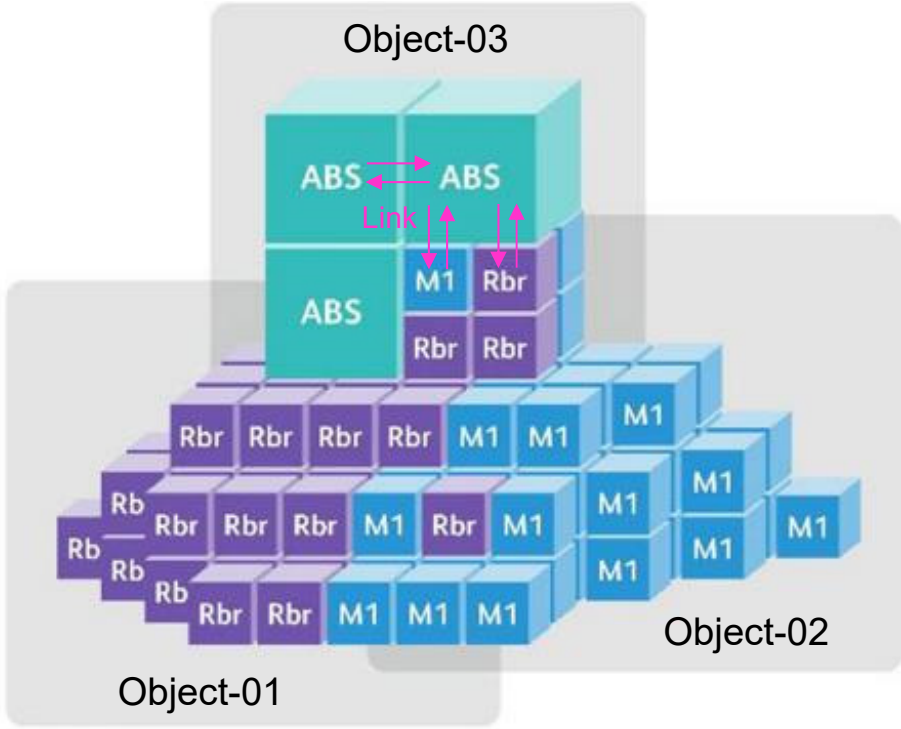
Voxel-01

Color: Violet
Material: Rubber

Voxel-02

Color: Cyan
Material: User Definitior

Voxel-03



FAV= Fabricatable Voxel

- Each voxel keeps color information, material information and link information.
- Link means interactions between each voxel. (e.g. joint strength)
  (3D Printer has anisotropy of joint strength fundamentally, FAV can manage these characteristic originated from 3D Printer.)
- Some example of voxel figures (cube, sphere, cylinder) are prepared. User can define voxel figure or size uniquely.

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Introduction of New 3D Data Format FAV

Structure of FAV

metadata
ID, Name, Author's Information, License(Creative Commons) Information

palette
Basic Voxel Information (Geometry, Size, Material)

Table 8: Example voxel shapes that can be defined in <geometry>

						
(id)	01	02	03	04	05	06
(name)	Cube01	Cube02	Plate	Big Sphere	Small Sphere	Cylinder
<shape>	cube	cube	cube	sphere	sphere	User_defined
<scale>	2×2×2	1×1×1	1×1×0.3	1.5×1.5×1.5	0.25×0.25×0.25	3×1×1

FAV has elemental geometries but users can define others. Product name or ID resisterd in ISO can be stored in *Material*

voxel
Voxel geometry or magnification ratio is assigned from Palette ID.

object
Spatial Arrangement of Voxels

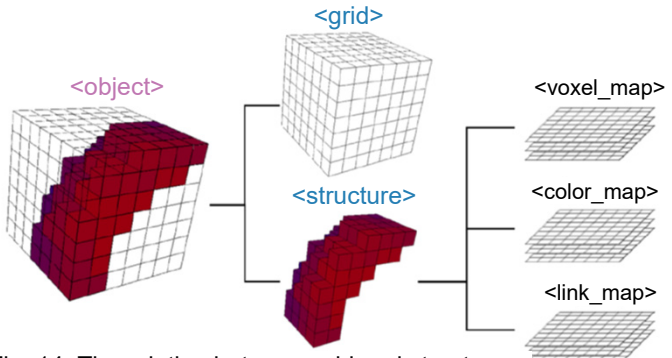

Fig. 14: The relation between grid and structure

grid: Definition 3D Space
structure: Arrangement of voxel (voxel_map), Arrangement of color information (color_map), Arrangement of Link Information (link_map)

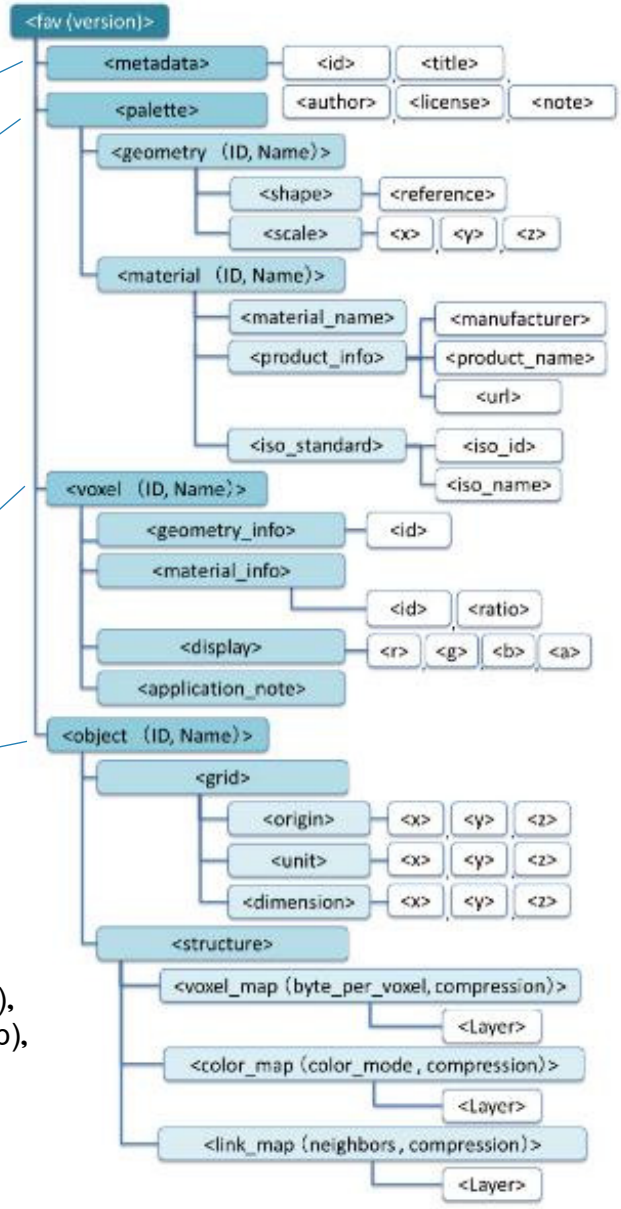

Fig. 5 : The tree structure of elements that constitute a FAV file [XML]

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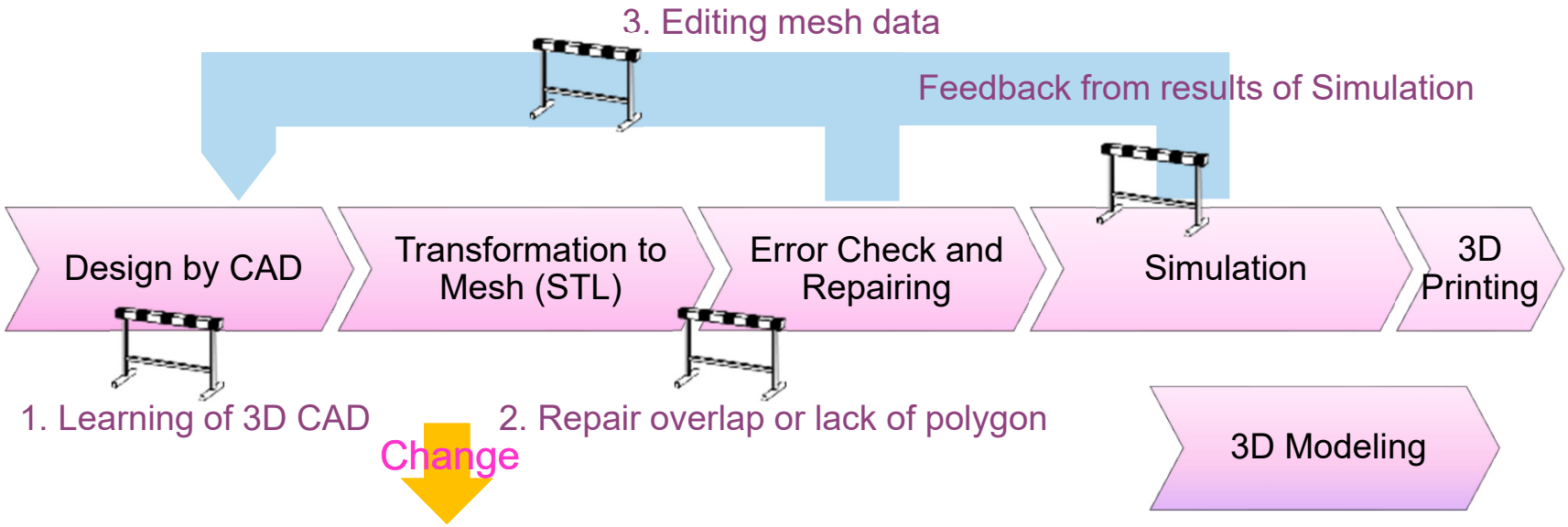
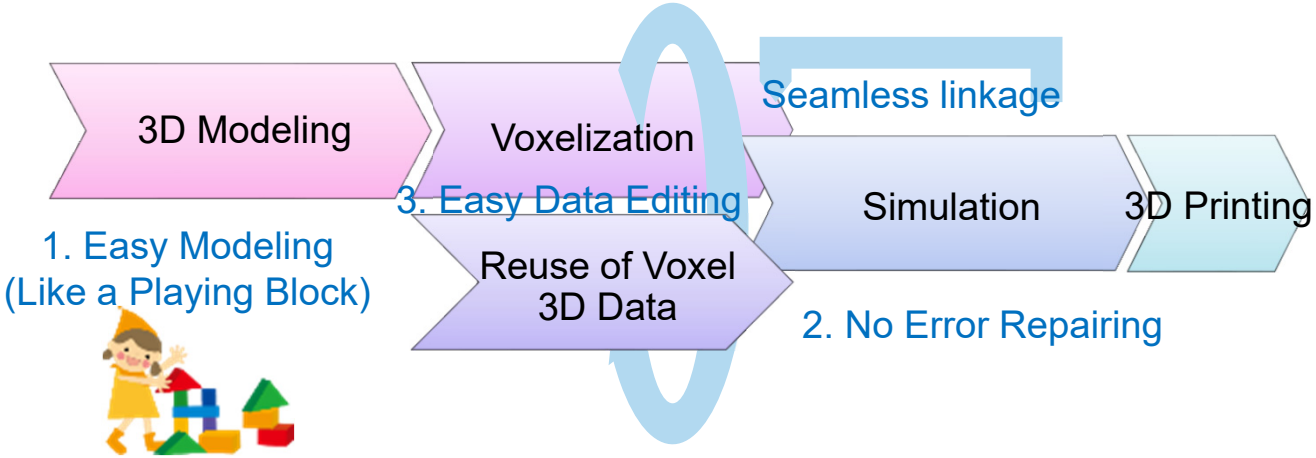
Introduction of New 3D Data Format FAV

Rectifying 3D Data Flow by Using FAV

Polygon-Based Format (STL)



Voxel-Based Format (FAV)



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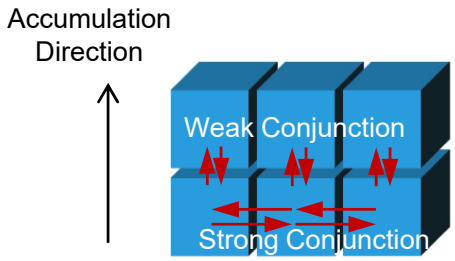
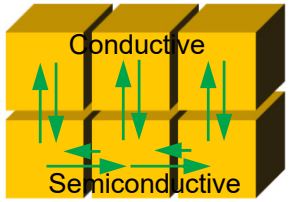
Expectation to FAV and Future Activities

FAV Scalability into Functional 3D Printing

- The first specification of FAV was released in this July and aimed to pull out abilities of current 3D Printers. Anyone can use or install FAV into their products for free.
- FAV may be useful for functional 3D printing by applying link and material information to not only 3D object but also electrical characteristics.
- In the first version (1.0) of FAV, we have no consideration for functional 3D printing to make electric device admittedly. Fuji Xerox and Keio University are going to draw up next version of FAV with considering requests from people with interests on FAV.



Link as Joint Strength in Objects



Link as Conductive Property in Electric Devices

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Expectation to FAV and Future Activities

Expectation to FAV

- ✓ FAV can make full use of current and potential 3D Printer's abilities (Full Color, Multi-Material and Internal Structure) easily.
- ✓ FAV can express not only shape but also complex internal structure with materials, colors and link information, can provide new design environments where designs and simulations work together.

Future Activities

- ✓ Fuji Xerox is proposing FAV as a standard of 3D data format in ISO and ASTM[*1] jointly with Keio University.
- ✓ Fuji Xerox is contacting with players in the business area of 3D data input (3D CAD, CG, Scanner), 3D data processing and 3D printers and explain advantages of FAV to be introduced into their products.
- ✓ Fuji Xerox will expand FAV though projects in ISO/TC261 and COI[*2]. Fuji Xerox also contacted with TRAFAM[*3] and encourage FAV to be adopted in their systems.

*1 ASTM: American Society for Testing and Materials

*2 COI: Projects supported by Ministry of Education, Culture, Sports, Science and Technology.

*3 TRAFAM: National 3D Printer Project of Ministry of International Trade and Industry.

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