

Variable structure changing two-dimensional plane to three-dimensional solid
and its applications

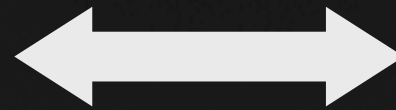
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Variable structure changing 2-D plane to 3-D solid

2-D mode



3-D mode



- Pulling the two endpoints (top and bottom), the solid is formed at once.
- Pulling the endpoints by stronger power, the solid becomes more robust.
- We can make curved surface structures such as a globe, an egg-shape, and a spheroid.

Background



It is difficult to make a globe by paper-crafting technique.

Is there a method to easily mold a globe?

Is it convenient if made foldable?

Background (2)

Problems of the conventional technique

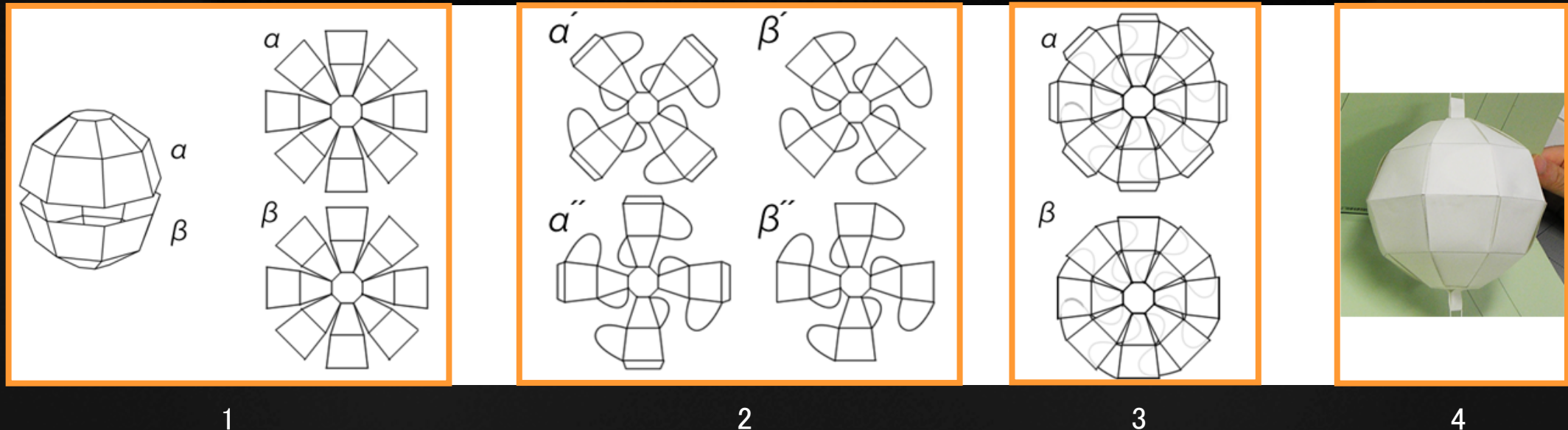
- Plural processes are necessary for assembling.
- It is difficult to return to 2D once the structure is built in 3D.
- Generally, the shapes are almost simple.
- It is difficult to form a curved surface body such as a globe.



【Example of the conventional technique : Cake box】

Procedure of the proposed technique

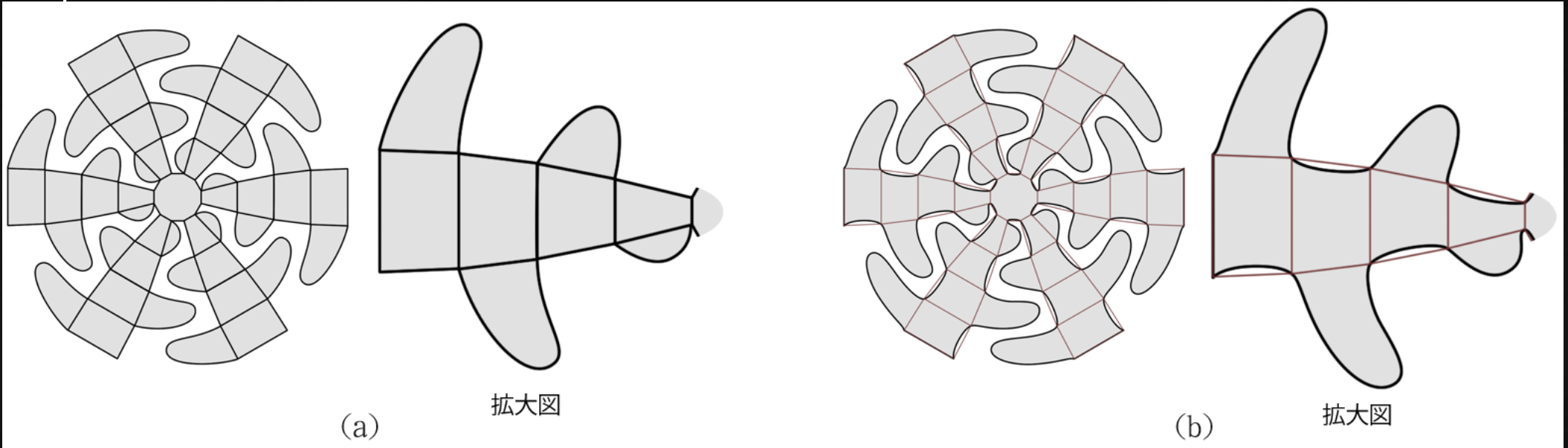
Making the developed figures and assembling them: An globe structure as the example.



1. A polyhedron similar to a globe is divided into the northern hemisphere (α) and the southern hemisphere (β).
2. The developed figures α and β are divided into two shapes (α' , α'' , and β' , β'' , respectively), and attach blades and margins as shown in Fig. 2.
3. The α' and α'' (β' and β'') are combined, where the blade overlaps at the back side of the neighboring folding aspect as shown in Fig. 3.
4. Finally, the northern and southern hemispheres are glued together.

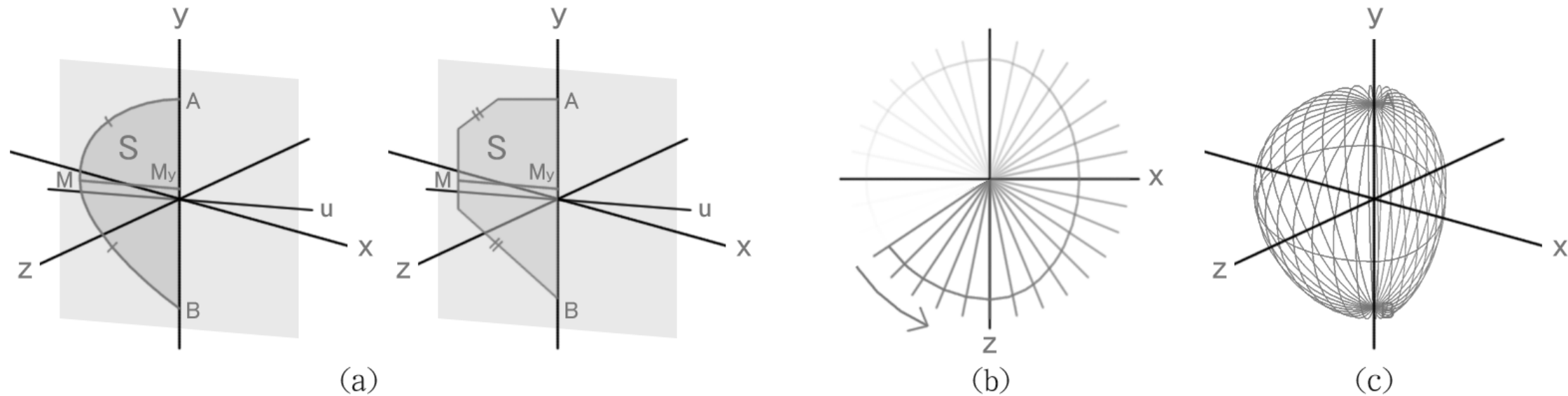
Procedure of the proposed technique (2)

Shape of the blade



Making the blade with a fluent shape like (b), the transformation between 2D and 3D is smooth.

Condition of the proposed method

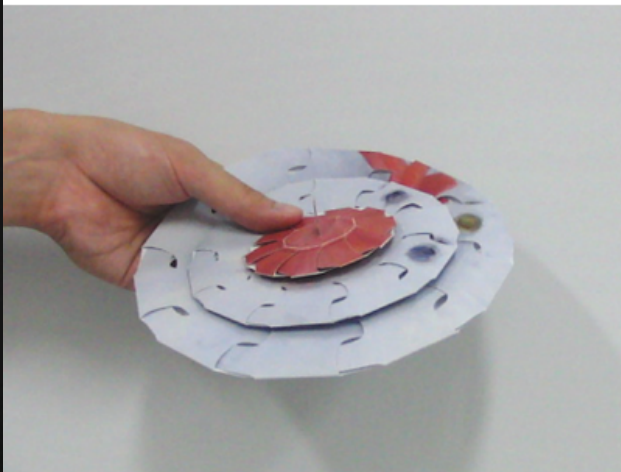


The 3D solid is foldable at the line which linked the middle point of each longitude line (Equatorial plane).

✂ The solid needs to be a convex structure.

Condition of the proposed method (2)

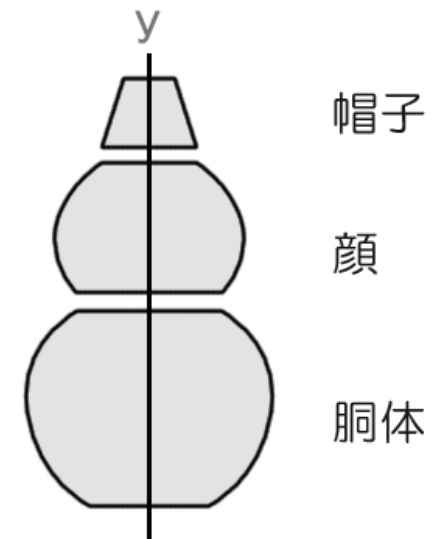
Exception: The formation of the dent structure by the combination of convex structures



(a)



(b)



(c)

Example of 3-D structures created using the proposed method



(a)



(b)



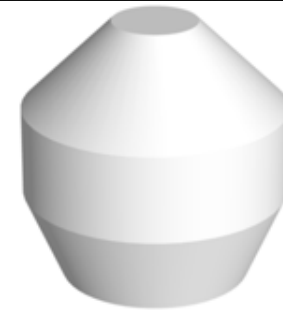
(c)



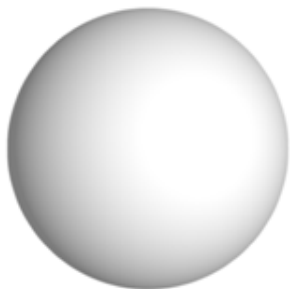
(d)



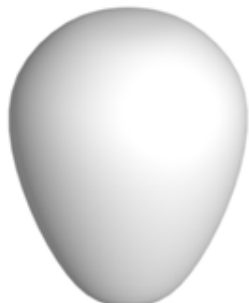
(e)



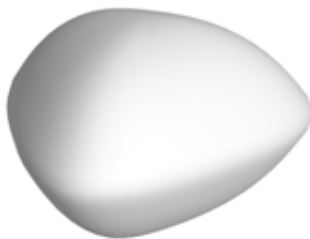
(f)



(g)



(h)



(i)



(j)

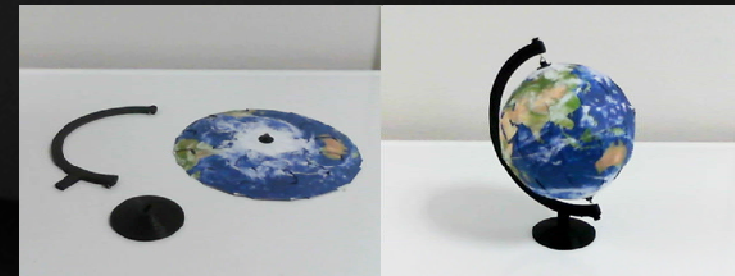
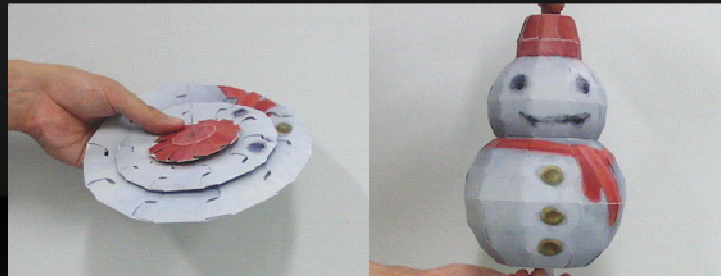
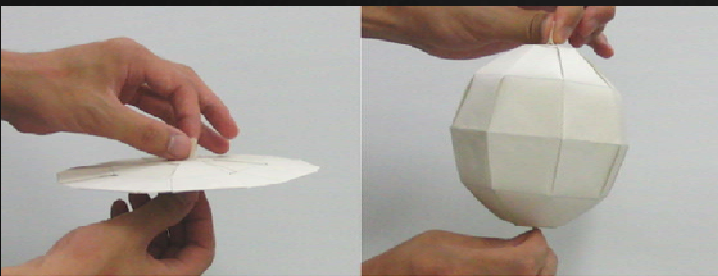
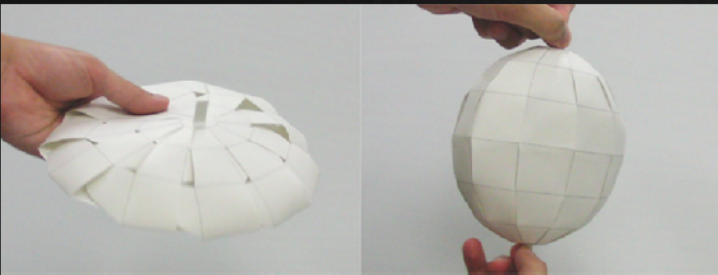
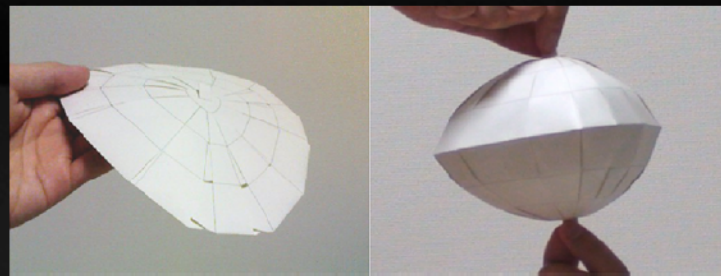
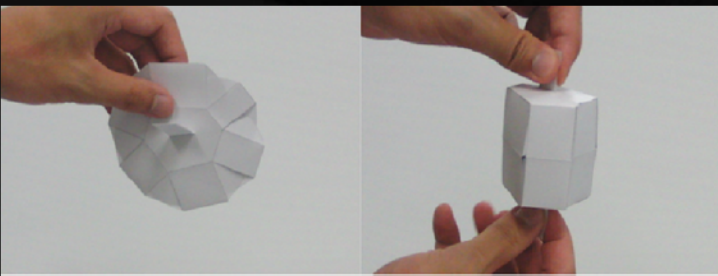


(k)



(l)

Trial models prepared by paper-crafting technique using this method

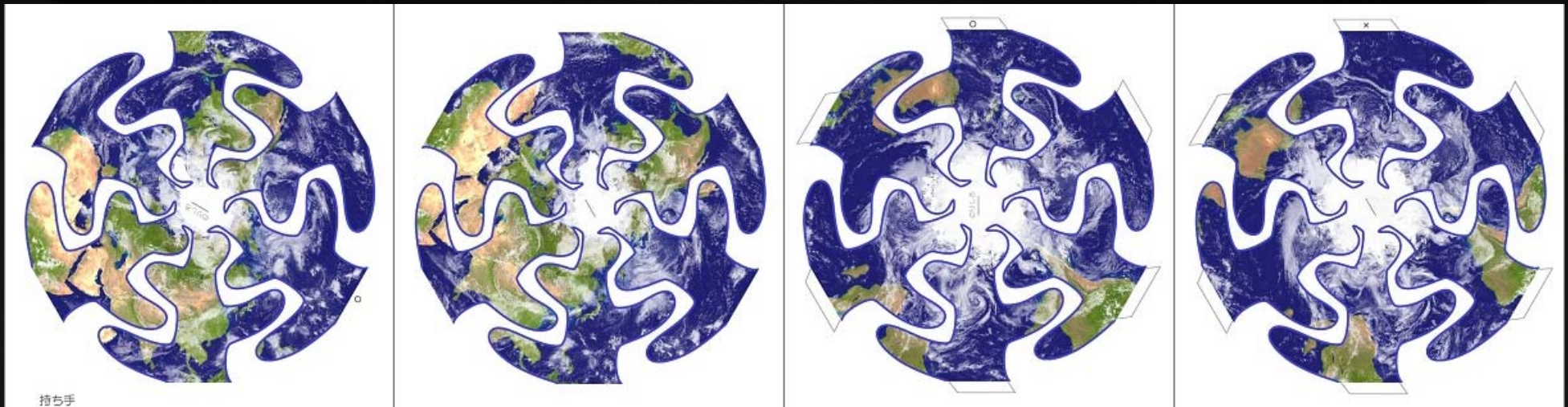


Expected applications

- Educational material
- Character goods
- Appendix of book
- lift-the-flap book (pop-up art)
- Chest for accessories
- Tent for emergency
- Movable large-scale screen

An unexpected reaction – It is interest from a clinician (surgeon).

Educational material 1: Making a solid from developed figures

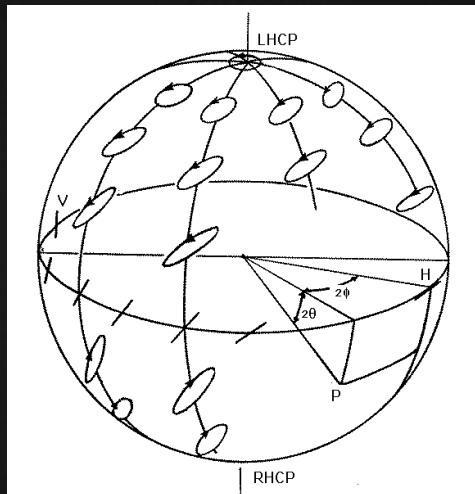


Four developments make a solid.

- Mass production is possible with a printer.
- We use scissors and paste only.

Educational material 2: Teaching by a 3D solid

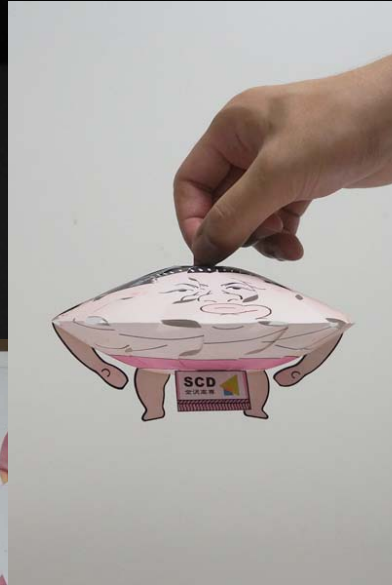
- Explanation is difficult when a teacher does not use the 3D solid.
- It is unsuitable as a teaching material to carry a 3D solid.



Example: Poincare sphere (tool explaining polarization)

- Experiment of two pieces of polarizing plates → OK
- Circular polarization and/or birefringence → ??
- Learning by Poincare sphere → Enough commentaries are difficult by the 2D figures on a black-board or a projection screen.

Character goods



Medical application: Space for laparoscopic surgery

— Difficulty of the securing of operation space —

Gravity

A patient is inclined and his/her organs such as intestinal tracts are moved.
The patient's burden is big depending on the posture.



リトラクタ (NITI-ON社)

Gas

Gas is injected into the body and expands it.
Gas dries a body filled with a liquid usually.

Balloon

It is difficult to operate for the rear of the balloon.



バルーン (COVIDIEN社)

Retractor

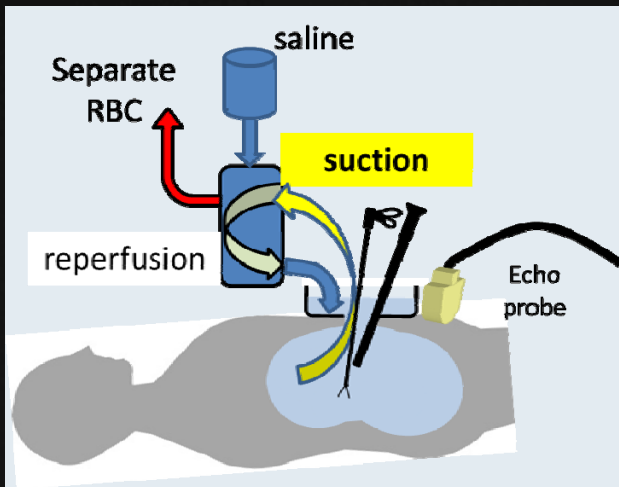
Since it is a wire, the pushing power is not strong and some danger exists that a healthy organ is damaged.

gauze

Since it moves by breathing, the organic surface is sometimes damaged, which causes an adhesion after operation.

It is sometimes left inside the body. Such an accident burdens operators.

Water filled laparo-endoscopic surgery (WaFLES) Frontier Medical Engineering in Chiba University



The vinyl ball which was filled with water: The control is difficult.

- Saline is used in substitution for gas to secure operation space.
- Good result has been obtained by slowing the speed of the circulating current.
- However, there is the disadvantage: It is difficult to secure the operating space.

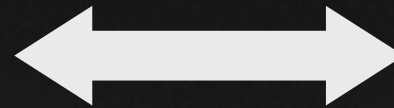
Technique to 3D structure aiming at securing of the operating space

Example of the trial model

2D mode



3D mode



- 2D plane mode is folded and inserted in the body.→3D structure is formed in the body.
- Advantages
 - Space is secured instantly.
 - Holding the organ with an aspect, the operating field is stable.
 - It is stable in water current.