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GEOMETRICAL TEACHING MATERIALS FOR VISUALLY HANDICAPPED PERSON: THEY SEE FORMS BY TOUCHING

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Abstract: *We started the project "Development of 3D geometrical teaching materials for visually handicapped person" from 2006. Stone-blind person can recognize various shapes by touching. We are developing teaching materials which can enrich the world of observation by touching. This paper discusses a part of our teaching materials, which allows us to share the beauty of forms and symmetries with visually handicapped people.*

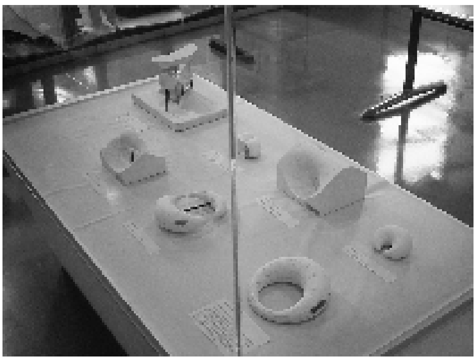
1 INTRODUCTION

Visually handicapped persons, especially stone-blind person can recognize 3-dimensional forms by touching. Unfortunately, they can not touch art pieces in art galleries, museums, and objects in many other situations in daily life. They can imagine forms by listening to explanations, but this is indirect observation. Touching is direct observation. Touching is seeing for them.
We started the five years project "Research on recognition mechanisms of 3D object of visually handicapped persons, and development of 3D geometrical teaching materials"

from 2006. One of our major goals is to develop teaching materials which can enrich the world of observation by touching.
How can this be done? One answer is to make models that visually handicapped person have never touched before. Of course, the subjects of such models can be infinite. However, we think that these subjects can be divided into the following two categories. One is “objects that we cannot touch in actual size”, that is, huge objects or microscopic objects. Another is “objects that do not exist naturally”, that is, products based on an abstract idea, for instance, mathematics curved surfaces, etc. As concrete examples in the first category, we are developing the globes of planets and satellites in the solar system (e.g. globes of the earth, Mars, Venus, and the moon, etc.). The globes have bumps on the spherical surface to visually handicapped persons. Models of microorganisms (e.g. skeleton of radiolarian and foraminifera) are also examples in the first category. This paper discusses our approach in the second category.

2 MATHEMATICAL CURVED SURFACES

The famous German mathematician F. Klein started the project of model production at the Martin Schilling company around 1870. All his models were plaster casts, elaborate and exquisite. Craftsmen and mathematicians in those days worked together in this project. The company stopped the manufacturing on 1932, and the models are valuable now. The Department of Mathematics of the University of Tokyo imported these models around 1910. Visitors can see them still now but cannot touch them, as they are displayed in glass showcase (Figure 1).



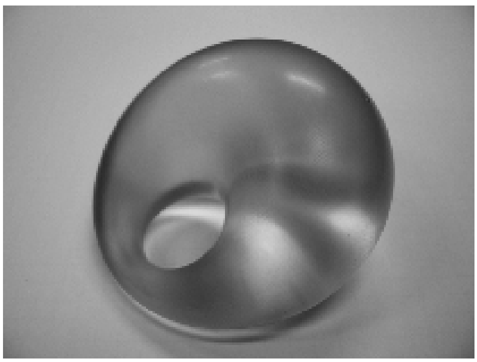


Figure 1 (left): Models of geometry at University of Tokyo. Produced in Germany around 1870 under the model production project by F. Klein.

Figure 2 (right): Dupin cyclide (stereolithography model). This is not a model kept in glass showcase but a model for touching.

In modern times, we can make such models without craftsmen. We can generate various mathematical curved surfaces by using CAD or the mathematics software like Maple or Mathematica. The shape data is preserved into STL (STereoLithography) file format. The STL is the standard file format for layered manufacturing or rapid prototyping. The craftsmen are not indispensable to Stereolithography nor 3D printing. In our study, we plan to create many other models of geometry (e.g.: some mathematical curved surfaces, Platonic solids, Archimedean solids, Catalan solids, etc.) as geometrical teaching materials for visually handicapped persons. The following model is one of mathematical curved surface: a Dupin cyclide which was discovered by Charles Dupin (Figure 2).

3 KLEIN BOTTLE

The Klein bottle is also named after F. Klein. He first described the bottle in 1882. Its surface has no distinction between the "inside" and "outside" surfaces. The sighted person can see the internal structure of the Klein bottle which is usually made of glass and transparent.

So what is a good model for the stone-blind person? We made a usual Klein bottle (left, Figure 3) and two chiral half models (right, Figure 3). One half enables visually handicapped persons to touch the intersecting part, which is the most important part of the Klein bottle. This is therefore insufficient for making 3D models. We need to use our brains to make models which are suitable for visually handicapped persons to touch.

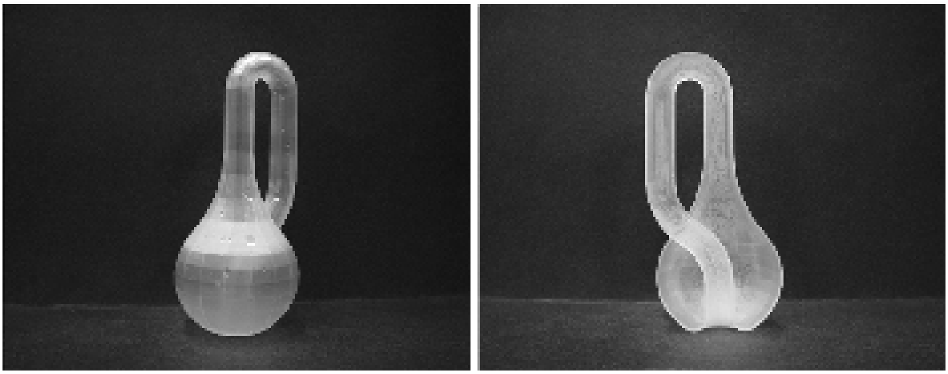


Figure 3
Left: Klein bottle. Its surface has no distinction between the "inside" and "outside" surfaces.
Right: Slitable Klein bottle. Two chiral forms are unified into a Klein bottle. (Stereolithography model)

4 ESCHER TESSELLATION

A tessellation of 2D plane is a gathering of 2D pieces that fills the plane without overlaps and gaps. A wallpaper group (or two-dimensional crystallographic group) is a mathematical classification of a two-dimensional repetitive pattern. There are 17 possible distinct patterns. We can see such patterns frequently in architecture and decorative art. M. C. Escher, Dutch graphic artist, studied the tessellation of 2D plane with same pieces. He produced many tessellation art.

Our "Seahorses" is an original Escher-like tessellation (Figure 4). Shape of seahorse was designed by one of the authors (Ikegami). This was produced with the laser beam processing machine. In this teaching material, the whole pattern can be decomposed into unit pieces like as a 2D jigsaw puzzle. The visually handicapped person can understand the shape of a unit piece by touching.

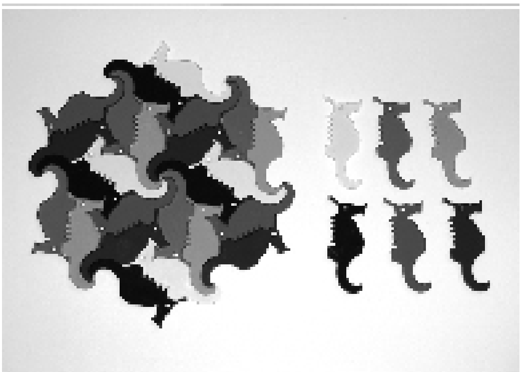


Figure 4: Escher-like tessellation, “Seahorses” (Laser beam processing)

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