CG Image Generation of Developmental Origami Model of Hypercube

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ABSTRACT

A four-dimensional space is a space whose fourth axis is perpendicular to a three-dimensional space. In a four-dimensional origami we fold a solid material along flat planes in a four-dimensional space. We will show a developmental wire-frame model of hypercube and construct it from its development. Its development is regarded as a four-dimensional origami with a front and a back side. Defining the four-dimensional CG methods as shading and painter's algorithm in the three-dimensional CG methods, we will show CG images of constructing developmental origami of hypercube from the development.

INDEX TERMS: I.3.3 [Computer Graphics]: Picture/Image Generation—Display Algorism

1 INTRODUCTION

An origami has much to offer as an instrument for experimenting with scientific and educational ideas. A four-dimensional origami is an analogue of the well-known origami folded in a three-dimensional space [1]. This is folded in a four-dimensional space where an additional fourth u-axis is perpendicular to a usual three-dimensional xyz-space (from now on, we will abbreviate "n-dimensional" by "n-D").

Figure 1 shows a model of this 4-D space where the basal plane presents the 3-D space. We call this 3-D space the u=0 hyper-plane. Miyazaki showed some figures of constructing a four-dimensional cube from its development which consists of eight congruent cubes [1]. This 4-D cube has not both front and back sides of a material for the sake of simplicity. First we will present a developmental wire-frame model of 4-D cube. When the side cells around the base cell are folded along their fold planes, a projection of the wire-frame model on the u=0 hyper-plane gives the same figure as shown by Miyazaki [1]. Secondly we will define a front and a back of an origami material in a 4-D space [2]. For CG image generation of 4-D objects, we use 4-D painter's algorithm. We may construct a view space by using the stereogram.

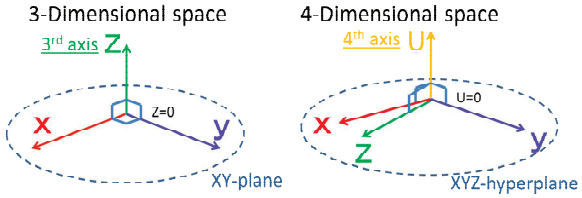

Figure 1. 3-D space and 4-D space

2 DEVEVOPMENTAL ORIGAMI MODEL OF 4-D CUBE

Figure 2 shows a developmental wire-frame model of 4-D cube. Note that a desk on which the development is laid corresponds to the u=0 hyper-plane. The 4-D cube consist of eight cubes, where both top and bottom bases are red and the other cubes are around the bottom base. A boundary between two cubes is a fold plane. When the side cubes around the base are folded along their fold planes, its projection of the wire-frame model on the u=0 hyper-plane is the same as one of the figures shown by Miyazaki [1].

Let us take a solid in a u=0 hyper-plane and move this solid a bit downward in the direction of the u axis. In this pair of solids, we regard the upper solid as a front and the lower one as a back and define its normal vector n as a direction of the relative movement (0,0,0,1). We will call such a pair of solids a 4-D origami [2].

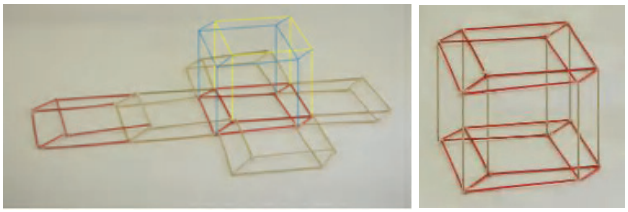

Figure 2. Developmental wire-frame model of 4-D cube

4-D painter's algorithm is a method of projecting 4-D objects on a view space which is 4-D analogue of a view plane. Shading and shadowing methods are applicable to 4D objects. Note that there is only one point of intersection where a line of light and a hyper-plane meet. Figure 3 shows CG images of during a folding process of 3-D origami cube which are analogue of ones of 3-D origami cube.

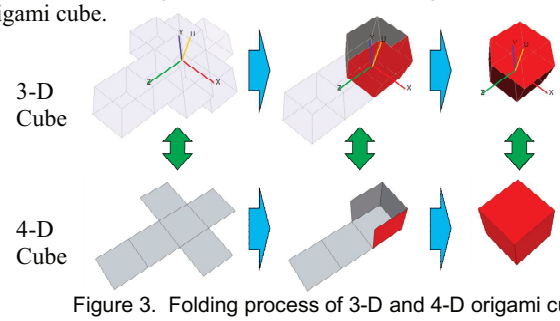

Figure 3. Folding process of 3-D and 4-D origami cube

3 CONCLUSION

CG images of a construction of 4-D cube from the development are intuitively understood by using the developmental wire-frame model of 4-D cube. Using 4-D CG methods we have generated CG images of a developmental origami model of 4-D cube. Those give us a good understanding of 4-D object and space.

REFERENCES

[1]K. Miyazaki. Four-dimensional origami. In *Proceedings of the Second International Meetings of Origami Science and Scientific Origami* (Shiga, Japan, Nov 29–Dec 2, 1994), pp.51–61. Seian University of Art and Design, March 1997.

[2]A. Inoue et al. CG image generation of four-dimensional origami. In *The Journal of the Society of Art and Science*, volume 4, pp.151–158. December 2005.

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The 21st International Conference on Artificial Reality and Telexistence
November 28-30, 2011, Osaka, Japan
ISSN: 1345-1278