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Petaloid Folding of General Triangles for Combinatorial Smocking Design

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Abstract

Smocking is a handicraft technique of sewing and making pleats to produce shapes over the surface of cloth, and has been widely used in clothing and fashion. However, it is not easy to combine several pieces of smocking without wrinkles on cloth, since it is necessary to satisfy constraints on angles among pleats. For instance, regular polygons have been widely used in smocking, since admissible twist angles can be easily determined in terms of the number of vertices. However, it has been difficult to utilize more generalized shapes for combinatorial smocking design. For the type of smocking which corresponds to petaloid folding in Origami, this paper proposes petaloid folding of general triangles so that combinatorial smocking without wrinkles can be realized. We derive the admissible twist angle of any triangle to realize petaloid folding in a closed form in terms of the angle and size of the triangle. Since the size of triangle can be reflected in our derivation, it is possible to produce the intended shape of smocking for the specified size of cloth. Based on the derived twist angle, we propose two classes of combinatorial smocking design by utilizing non-regular triangles and regular polygons. The proposed approach is implemented using GeoGebra, and it is validated through several pieces of handcrafted combinatorial smocking.

Keywords: Smocking; Origami; Petaloid folding; Twist angle

1 Introduction

Smocking is a handicraft technique of sewing and making pleats to produce shapes over the surface of cloth. It consists of cloth pulled into tight folds, that are held in position with decorative stitches. Since beautiful shapes can be created over the surface of cloth, smocking has been popular and widely used in clothing and fashion. Examples of smocking are shown in Fig. 1.

When designing a combination of several pieces of smocking, it is necessary to combine the corresponding crease patterns to realize the consistency among pleats; otherwise, wrinkles among pleats will appear on the surface of cloth. However, when the shape of the produced smoking is restricted to regular polygons, satisfying the consistency is not easy due to the restrictions of twist angles of regular polygons. Apart from smocking, periodically connecting the twist foldings has been studied in Origami tessellation [1, 9].

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(a) Basic smocking (b) Italian smocking (c) Lattice smocking

Fig. 1: Examples of smocking

However, the polygons represented in the crease pattern of Origami are not necessarily produced in the folded shape [1, 9]. Thus, it is difficult to utilize this approach to produce the intended shape of smocking over the surface of cloth. Furthermore, in order to produce smocking over the specified size of cloth, it is necessary to characterize the admissible twist angle in terms of both angles and size of the shape. Thus, characterization of twist angle solely in terms of interior angles [8] is not suitable for combinatorial smocking design.

This paper proposes petaloid folding of general triangles so that combinatorial smocking design without wrinkles can be realized. We derive the admissible twist angle of any triangle to realize petaloid folding in a closed form in terms of the angle and size of the triangle. Especially, since the size of triangle can be reflected in our derivation, it is possible to produce intended shape of smocking over the surface of the cloth without wrinkles. Based on the derived twist angle, we propose two classes of combinatorial smocking design without wrinkles by utilizing non-regular triangles and regular polygons. The proposed approach is implemented using GeoGebra, and it is validated through several pieces of handcrafted combinatorial smocking. The results suggest that, in addition to the reported classes of combinatorial smocking design, the proposed approach can contribute to enabling other classes of combinatorial smocking design.

2 Smocking Design in terms of Origami

2.1 Smocking

As shown in Fig. 1, smocking enables to create beautiful shapes on the surface of cloth by sewing down the intersection of folded pieces. In general, smocking can be categorized into the following three types: (1) Basic smocking (Fig. 1(a)), (2) Italian smocking (Fig. 1(b)), (3) Lattice smocking (Fig. 1(c)). Among these types, flattened patterns can be produced over the surface of cloth in Lattice smocking. We focus on lattice smocking in this paper.

The overview of production processes in smocking is shown in Fig. 2. The locations for sewing are specified in the smocking pattern. For producing smocking with cloth, the pattern is first copied onto the cloth, and the copied locations on the cloth are sewed with a thread. Then, all the sewed locations on the cloth are pulled together into one point, and tied at the end of the thread. Finally, the induced pleats by sewing are flattened so that the shape can be created on the surface of the cloth.